

Deep Sea 2003: Conference on the Governance and Management of Deep-sea Fisheries

Part 1: Conference reports

1–5 December 2003

Queenstown, New Zealand



Cover photo:

Fishing trawler *Austral Leader* in heavy weather in the southern Indian ocean.
Courtesy of Captain Geiri Petursson.

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Deep Sea 2003: Conference on the Governance and Management of Deep-sea Fisheries

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1–5 December 2003

Queenstown, New Zealand

Edited by

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Foreword

Deep Sea 2003 was a response to the increasing exploitation of high-seas deepwater fisheries and the need to identify effective means of regulation to protect those fisheries and their environment. Technological development and market demand has both exacerbated these problems while increasing the opportunity and desire to exploit deepwater fisheries at increasingly unsustainable levels.

Experts from 36 countries and all disciplines and interests, including commerce, government, science and environmental groups, from national and international organizations contributed their expertise. Discussions were free-ranging and considered deep-sea management problems and solutions without being limited by the need to agree on a single formal conference declaration.

Participants defined clear outcomes as the basis for future deliberations on effective governance arrangements that could be successfully implemented in deep-sea areas. The breadth of these outcomes reinforces the complexity of the Deep Sea 2003 undertaking and the task ahead for all those involved, or interested, in deep-sea fishing.

These Proceedings provide the presentations, papers and discussions and many of the papers supporting posters presented at Deep Sea 2003. They identify the future actions required, both at the national and international level, based on the problems that characterize the management of existing deep-sea fisheries. It has been prepared by the enormous efforts of Dr Ross Shotton of FAO.

The organizers are most grateful to the sponsorship received from organizations representing all disciplines and companies and departments who permitted their staff to provide time and effort in support of the various Deep Sea 2003 organizing committees as well as the four Workshops held prior to the main conference.

John Annala
Conference Convener
Ministry of Fisheries
Wellington, New Zealand¹

¹ Present address: Gulf of Maine Research Institute, Portland, Maine, United States of America.

Abstract

The first of these two-volume Proceedings contains papers presented at Deep Sea 2003: Conference on the Governance and Management of Deep-sea Fisheries that was held in Queenstown, New Zealand from 1 to 5 December 2003. They include the Conference opening statements and the keynote addresses for the seven theme sessions, which covered the topics of (i) environment, ecosystem biology, habitat, diversity and oceanography; (ii) population biology and resource assessment; (iii) harvesting and conservation strategies for resource management; (iv) technology requirements; (v) monitoring, compliance and controls; (vi) review of existing policies and instruments; and (vii) governance and management. A review by a group of selected experts on these themes, as presented at the Conference, is also provided and gives their personal views. The perspectives of the Conference Steering Committee, as regards the general conclusions of the Conference, are provided in terms of what are considered necessary to address the issues of deep-sea fisheries governance and management and the programme elements that must be undertaken if deep-sea fish resources are to be sustained, their habitat protected to ensure its productivity and appropriate concern of protection of deep-sea biodiversity.

The second volume of the Proceedings consists of two parts. Authors who presented posters at Deep Sea 2003 were invited to provide more detailed papers, based on their posters, for the Proceedings and the papers of those authors who have done so are at the beginning of the volume. The subsequent part contains papers presented at four workshops held at the University of Otago, Dunedin from 27 to 29 November 2003, the week prior to the main Conference in Queenstown. These workshops addressed the topics of (i) assessment and management of deepwater fisheries; (ii) management of small-scale deep-sea fisheries; (iii) conservation and management of deepwater fisheries; and (iv) bioprospecting in the high seas.

Shotton, R. (ed.)

Deep Sea 2003: Conference on the Governance and Management of Deep-sea Fisheries.

Part 1: Conference reports. Queenstown, New Zealand, 1–5 December 2003.

FAO Fisheries Proceedings. No. 3/1. Rome, FAO. 2005. 718p.

Preface

The issues of deep-sea fisheries have, to a considerable extent, crept up and ambushed those responsible for governance and management of these resources where, indeed, clear responsibility for this role could be assigned. On the one hand, the management community has been preoccupied with the daily concerns of managing traditionally (over-) exploited fish stocks; on the other they may have been, and in most management jurisdictions are, severely constrained in their ability to obtain the institutional resources (people and funds) to proactively address newly arising and future management concerns. Further, many of the deepwater fishery resources are relatively small, even if valuable on a unit-weight basis. And the number of fishing operators, and thus the number of flag states involved in these fisheries, has been limited. Rapid advances across a wide spectrum technologies (e.g. underwater acoustic capabilities, satellite gravimetry and global position fixing) have resulted in the capacity to exploit fisheries resources that before have been unavailable to fishing gear and hence not vulnerable to harvest. Also, it has not helped that many of the deepwater species, as many of the papers in these proceedings eloquently describe, have biological characteristics (slow growth, episodic recruitment, aggregating behaviour, etc.) that make them particularly vulnerable to overexploitation.

Thus, a major motivation for convening Deep Sea 2003 was the realization by many States, intergovernmental organizations, industry groups and civil society organizations that technological development and market demand were resulting in deepwater fisheries being exploited at increasingly unsustainable levels. In tandem with this was the recognition that existing regulatory regimes, based primarily on the 1982 Law of the Sea agreement¹, are proving incapable of effectively regulating these fisheries, many of which occur exclusively as high-seas stocks and others as straddling and transboundary resources.

The idea for the conference was first raised among a group of participants at a preparatory meeting for a Southwest Indian Ocean Fisheries Commission in Reunion in February 2001, most notably from the FAO and the New Zealand Ministry of Fisheries. Following two years of discussions in Wellington, Canberra and Rome the delegations of New Zealand and Australia brought the concept for the Conference to the floor of the 25th session of the FAO Committee on Fisheries (COFI) in February 2003. The COFI supported the concept of the Conference, which was to have as its primary sponsors the Ministry of Fisheries, New Zealand, the Department of Agriculture, Fisheries and Forestry, Australia with funding support from the Fisheries Research and Development Corporation, Canberra and technical cooperation of the Fisheries Department of the FAO, Rome. The COFI requested that the Conference organizers report on the outcome of the Conference to the 26th session of COFI, to be held in 2005.

An explicit objective of the Programme Committee for Deep Sea 2003 was that it embrace all disciplines and interests involved in deep-sea fishing – industry, governments and international regulators, marine legal scholars, fisheries scientists, national and international environmental groups as well as staff employed by regional fisheries management and intergovernmental organizations. This the conference achieved through a programme of structured theme sessions within a framework of

¹ The United Nations Convention on the Law of the Sea. Signed at Montego Bay, Jamaica, 10 December 1982, it entered into force on 16 November 1994.

formal reporting and ultimately a synthesis through a “report back” to the Conference that provided the prognoses of a carefully selected group of thinkers from government, academia and industry. This theme structure has been maintained in the reporting in these proceedings.

The conference participants, from 36 countries, presented a broad cross section of expertise and, with rare exceptions, participated in a personal capacity. This enabled a free exchange of views and ideas, unrestricted by the need to remain within the bounds of institutional policies or ideologies and it was gratifying to the Conference Programme and Steering Committees to see the successful fusion of ideas and experiences, views and counter-views, which emphasized the complexity of what had been undertaken by the meeting.

The governance of these deepwater, and thus mainly high-seas, fisheries has essentially been based on a convention built on three international conferences held over the period 1958–1982. They were of such extent and importance that the careers of many legal officers in ministries of external affairs centred on the preparations and follow-up of these meetings. My introduction to these issues was as a graduate student at the University of British Columbia. Dean George Curtis of the UBC Law School gave the four of us in his course on international fisheries law in 1971, the year of his retirement, what was almost a personal tutorial. Dean Curtis had participated in both UNCLOS I and II and it was my first indication of the sense of achievement that was felt by those who participated in the series of UNCLOS meetings – the third of which was then yet to be held. Despite this, it would be difficult to conceive of the negotiation of a similar legal instrument today given the current threats to the effective governance and sustainability of the high-sea fisheries and the growing understanding of the need for strong user rights if the disaster of open-access fishing is to be avoided. Hence, it was interesting to discover the existence and divergence of two streams of views during Deep Sea 2003, between those who sincerely felt that reopening these negotiations would be counter-productive and what must be done was to build on the existing foundations, and those to the contrary who felt that the existing legal foundations, as provided by UNCLOS III, were so flawed that a new management regime structure was going to be necessary if there were to be any hope for the world's high-seas fisheries.

None of the papers presented in these Proceedings have been ‘refereed’ – the authors’ papers are published as they have expressed their views and experiences no matter what they assert. I have, however, spent considerable efforts attempting to establish a more uniform style of presentation. I have learned that lawyers love footnotes (e.g. of the form ‘[See Art. 16/v. Para I]’), which is fine but it greatly increases demands for space (there are more than 1 000 pages in the proceedings). Their preference I have had to balance with that of economy. Reference to the 1982 United Nations *Convention* on the Law of the Sea has been abbreviated to “LOSC” to avoid confusion with the three *Conferences*, UNCLOS I, II and III, following the style recommended by Edeson (2000)². ‘States’ in their ‘Flag’, ‘Port’ and other unspecified forms and ‘Contracting Parties’, etc. have all been diminished to ‘state’, ‘flag’ or ‘port’ and ‘contracting party’, though I finished the editing process with the view that this is probably a minority editing practice. I beg the indulgence of authors who carefully scrutinize how their papers (there were 112 of them) have been presented in this regard.

Other editing challenges were alternatively interesting or frustrating. It took until the middle of the editing process to decide upon “armourhead” as opposed to “armorhead” (for *Pseudopentaceros richardsoni* and *Pseudopentaceros wheeleri*), a decision made no easier by the use of both spellings by some authors. My decision on

² Edeson, W.R. 2000. Confusion over the use of “UNCLOS”, and references to other recent Agreements. *Int. J. Mar. & Coastal Law* 15(3):415-421.

the latter practice reflects British spelling – FAO practice – of ‘armour’ while many readers may more easily recognize the fish by its other common name – ‘boarfish’. Other editing practices are dictated by my institution’s publishing conventions, e.g. ‘1 000’ and not ‘1000’, 10 ‘percent’ and not 10%, etc. – practices intended to otherwise occupy an editor’s evenings.

In addition to the main Conference contributions, those presenting posters at Queenstown were also invited to submit papers based on their posting. This, many have done and these are included in a second volume.

The four and a half days scheduled for the conference meant that discussions and treatment of issues and problems would necessarily be synoptic, and thus render difficult addressing all problems in detail. Hence, it was decided to hold several workshops on topics of specific relevance to the Conference theme. Four such workshops addressed the themes of:

- i. Assessment and Management of Deepwater Fisheries
- ii. Management of Small-Scale Deep-Sea Fisheries
- iii. Conservation and Management of Deepwater Chondrichthyan Fishes and
- iv. Bioprospecting in the High Seas

They were held concurrently in Dunedin at the University of Otago, from 27 to 29 November, just prior to Deep Sea 2003. Because of the relevance of these workshops to the Conference’s objectives, those presenting papers in the Dunedin meetings were invited to provide a paper based on their presentation for inclusion in the Proceedings. For various reasons few papers were provided by participants to the Workshop on Assessment and Management of Deepwater Fisheries but there are many contributions from the other three workshops.

These Proceedings follow the publication of the Conference Report (FAO 2003³), which summarizes the presentations and discussions of Deep Sea 2003 and identifies where the Conference thought future action, both at the national and international level, was needed to address problems that characterize the management of existing, and future, deep-sea fisheries. The verbal proceedings are given in that report. Interested readers are encouraged to refer, in tandem, to the Conference Report, copies of which are available on request, together with these Proceedings.

From a perspective 18 months subsequent to the Conference, the lack of agreement on avenues for management action and slow pace in achieving improvements in governance, relative to the effects upon the resources continues to emphasize the reasons and justification for the convening of Deep Sea 2003. Any progress in resolving these problems will require renewed commitment to the difficult challenges of achieving consensus on actions. Perhaps, it may not be direct human intervention that saves the high seas deepwater resources, but rather the compelling economics of bunker costs arising from >\$60 a-barrel-oil that result in fuel costs of more than \$5000 a day for high-seas factory trawlers. This, tied to declining catch rates, may achieve what has proven beyond the efforts and interventions of lawyers and fisheries managers.

The advent of Deep Sea 2003 was possible only through the generous support of a number of sponsors who provided either direct financial support to the activities of Deep Sea 2003 or made available staff whose organizational work was essential to the Conference’s success. Here, the New Zealand Seafood Council deserves particular recognition for allowing Dr Kevin Stokes to participate as a Steering Committee member and Programme Committee Convenor, and for Ms Sandra Diesveld who ably managed the Conference Secretariat. Their efforts were complemented by those of Ms Eidre Sharp-Brewer as Conference Director. The conference also benefited from the wisdom and energy of Dr John Annala, then Chief Biologist with the Ministry of

³ FAO 2003. Report on Deep Sea 2003, an International Conference on Governance and Management of Deep-sea Fisheries. FAO Fish. Rep. No. 772. FIRM/R772. 84pp. Rome.

Fisheries in Wellington, New Zealand and at the Gulf of Maine Research Institute, Portland, Maine, USA. A complete list of the members of the Steering and Programme Committees and Conference sponsors follows.

Steering Committee

The Steering Committee was responsible for the overall direction of the conference, its organization and content. Members were:

Dr John Annala, Conference Convenor Ministry of Fisheries, Wellington, New Zealand

Dr Ross Shotton, Food And Agriculture Organization, Fisheries, Rome, Italy

Mr Glenn Hurry, Agriculture, Forestry and Fisheries, Canberra, Australia

Dr Kevin Stokes, Seafood Industry Council, New Zealand Convenor – Programme Committee

Ms Kylie Paulsen, Fisheries Research and Development Corporation, Canberra, Australia

Mr Geoff Rohan, Australian Fisheries Management Authority, Australia

Dr Malcolm Clark, National Institute of Water and Atmospheric Research, New Zealand

Dr Richard Tilzey, Bureau of Research Services, Canberra, Australia

Dr Ian Knuckey, Australian Fishing Industry

Mr George Clement, New Zealand Fishing Industry

Dr Alan Williams, CSIRO, Hobart, Australia

Ms Kristina Gjerde, International Union of Conservation Nations

Dr Denzil Miller, CCAMLR, Hobart, Australia

Ms Eidre Sharp-Brewer, Conference Director, Wellington, New Zealand

Programme Committee

The Programme Committee undertook the detailed development of the conference themes, including selection of the keynote speakers, and reviewed the papers and posters offered for presentation. Members were:

Dr Kevin Stokes (Convenor) Seafood Fishing Industry Council, New Zealand

Dr Eugene Sabourenkov, CCAMLR, Hobart, Australia

Dr Malcolm Clark, National Institute of Atmosphere and Water Research, New Zealand

Environment, ecosystem biology, habitat and diversity, oceanography

Dr Chris Francis, National Institute of Atmosphere and Water Research, New Zealand

Population biology and resource assessment

Dr Keith Sainsbury, CSIRO, Hobart, Australia

Harvesting and conservation strategies for resource management

Dr Ian Knuckey, Fishwell Consulting Limited, Australia,

Technology Requirements

Mr Geoff Rohan, Australian Fisheries Management Authority

Monitoring, Compliance and Control

Dr Marcus Haward, University of Tasmania, Hobart, Australia

Review of Existing Policies and Instruments

Mr Grant Bryden, Ministry of Foreign Affairs and Trade, Wellington, New Zealand

Governance and Management Arrangements

Dr Ross Shotton, Food and Agriculture Organization, Rome, Italy

The Way Ahead

The Conference was only possible because of the generosity and commitment of the various sponsors. Their logos are reproduced in the beginning of these proceedings and it is highly appropriate to note the gratitude owed to these organizations for enabling Deep Sea 2003 to be convened.

On a personal basis, I hope to continue my involvement in deepwater fisheries 'affairs' through the Programme of Work established for my Service in the Fisheries Department of the FAO and, in particular, follow developments, past, present and future, of the deepwater fisheries in the Southwest Indian Ocean. I look with interest to what may happen in the deep south of the Pacific.

The major task of preparing the various papers for publication of the Proceedings, as well as much of the follow-up correspondence with contributors, has been undertaken through the hard work of my secretary, Ms Marie-Thérèse Magnan, FIRM, FAO, Rome for which I am most grateful.

Ross Shotton
Editor, Conference Proceedings
Marine Resources Service
Fisheries Department
FAO
Rome, Italy

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Summary report and conclusions

1. CONFERENCE THEME REPORTS

1.1 Theme 1: Environment, ecosystem biology, habitat and diversity, oceanography

Issues and problems

Talks and posters on this theme covered a wide range of topics including physical oceanography, oceanographic variability, habitat mapping, canyon productivity and deepwater biodiversity research. The presentations covered a wide range of geographical areas and taxa.

The effects of a range of oceanographic factors on fisheries were highlighted. An important factor that was identified is the variability of deep-sea fisheries habitats, which appear greater than has typically been assumed. The currents, ultimately driven by the weather, interact with the seabed to form a variable and dynamic deepwater fisheries habitat. Thus, deep-sea habitat variability occurs on a range of scales and affects the distribution and biology of deep-sea fish species.

Many important biological characteristics of deep-sea species and deep-sea ecosystems were noted. Deepwater fishes exhibit a wide variety of life history strategies including adaptations for long-lives and slow growth, but much variability among species is apparent. Thus, it was stressed, the productivity and vulnerability of different deepwater species to overfishing will vary. Vertical migration of mesopelagic fishes is an important means of energy transport from surface, photic waters to deeper levels, which reduced the impact of low *in situ* productivity on resident fish populations. Despite this, low food availability limits deep-sea productivity.

Advances in fishing technologies and efficiency mean that deep-sea species now have few refuges from fishing. However, the increased precision of fishing operations may also hold potential for sustainable management of deep-sea fisheries. Fish that escape from fishing nets and discards are unlikely to survive and, therefore, the effects from fishing on target and non-target species are not represented solely by the catch that is retained.

One of the characteristics noted that distinguishes many deepwater species was the importance of spatial scale. Deepwater fisheries often targeted highly localized aggregations so that prosecution of the fishery proceeded, at first, as a progression of highly targeted aimed trawls, perhaps of a few minutes duration, resulting in a series of serial stock depletions followed by a period of extensive trawling of low density fish populations. Estimates of population sizes based on raising small areas that are sampled as a fraction of the total habitat area are susceptible to scaling errors. However, if data of depletion studies were carefully collected, the results may be applicable to other areas to provide estimates of abundance.

Needs for moving ahead

It was noted that administrators must recognize the variability of deep-sea fisheries habitats, despite the scale and long-term nature of some of these changes that makes them so difficult manage. Appropriate scales should be used in decision making for different aspects of management and it is important to adopt an ecosystem approach to address environmental effects on deep-sea fisheries and especially the effects of deep-

sea fishing on the environment. This approach should address trophic linkages and energy flows, bycatch and fishing impacts on the benthos, the importance of spatial scale to ecological and oceanographic processes, distributions of habitats and species, and production processes.

Innovative uses of technology – including *in situ* analytical, and laboratory studies – can reveal much about deep-sea species and ecosystems, which are generally difficult to study. Appropriate use of this technology will allow evaluation of the effects of environmental variability and its changes on fisheries. Though collecting detailed information over large areas of the deep seas is costly, there are opportunities for fisheries managers to work with the fishing industry and others to collect the required information and it was clear from their representatives at DEEP SEA 2003 that the fishing industry was willing to collaborate with resource analysts and facilitate such data collection. There was agreement that a synthesis and review of current information gathering programmes and projects on a global basis would assist those who are involved in trying to provide a coherent and integrated source of information. One such programme was the Census on Marine Life.

1.2 Theme 2: Population biology and resource assessment

Issues and problems

Presentations during this theme session drew from a range of deep-sea fisheries examples to highlight current issues and developments in the understanding of population biology and resource assessments. From the presentations during this theme it was possible to identify essential information requirements for undertaking assessments of deep-sea fish resources. Among the sorts of information needed were:

- clear articulation of management objectives and identification of the information required by management to achieve their objectives
- accurate and timely catch data, provided by, e.g. logbook and marine observer programmes
- time series of abundance indices based on a variety of methods
- species' stock structures and related distributional information
- life history information needed for resource management – maximum age, fecundity, growth rates, age and size at maturity, etc.
- population age-frequency information and
- knowledge of density-dependent processes – recruitment, growth, maturity, etc.

Presentations noted that many of the functional requirements for management of deepwater resources were similar to, or identical, with those of traditionally exploited species in shallower habitats. However, the usual problems that are encountered tend to be more extreme and thus more difficult to resolve, not least because of the often great depth ranges involved which, e.g. exacerbates the difficulties involved in doing resource surveys, or the extreme ages of some deepwater and other fish population biology characteristics.

Needs for moving ahead

The papers presented during this theme session highlighted a number of directions for future biological investigations and avenues for development of resource assessment techniques for deep-sea species. Stock resource assessments need to avail themselves of a range of technologies and analytical methods. The results from such surveys should explicitly consider uncertainties and alternative interpretations of information. However, it was stressed that modelling is not a substitute for analyses based on good quality and sufficient amounts of data, collected following acceptable scientific procedures.

It was noted that more information on predator-prey interactions and energy flows is needed to understand the dynamics of deepwater fish stocks and improve their management. For example, are deepwater species “sustained” by advected organic material and if so, to what extent? There is also a need in management to consider mixed-species fishery assemblages rather than focusing on single-species perspectives and assessments. And, information must be obtained on a wide range of species – even those that are not currently subject to exploitation. It was agreed that there is considerable potential for the improvement of data collection through collaboration between fishery resource analysts and the fishing industry. Such cooperation would be important for ensuring the credibility, with industry, of data that are used in assessments and setting of TACs. Where possible, verification of operations data by marine observers should be encouraged.

Participants were informed that there is potential to use methods of meta-analysis for data-poor and developing fisheries. Use of this technique may help to show how to avoid repeating the same mistakes that were made in harvesting decisions in the early years of other deepwater fisheries. Examples include predicting abundance and distribution from physical oceanographic characteristics and inferring productivity from life-history parameters. Meta-analyses may also help in better evaluation of management options such as using deep-sea marine protected areas (MPAs) as a means of conservation. Of particular importance is the issue of what to do when there is insufficient data to provide confident scientific advice on which to base management decisions. The question of what managers and decision-makers should do in such situations was left unanswered.

The Conference agreed that future research will need to support the move toward ecosystem-based management, application of the precautionary approach and multi-species management. Increased collaboration between scientists will also be important if the data needed for management is to be obtained in a cost-effective manner.

1.3 Theme 3: Harvesting and conservation strategies for resource management

Issues and problems

Papers in this theme described experiences in managing a variety of deepwater fisheries. A number of issues and problems were identified.

Experience has shown that it is easy to over-estimate the productivity of deep-sea fisheries – as demonstrated by many situations of excessive initial harvesting rates despite managers trying to be precautionary in some cases. This was partly a result of the lack of information about the productivity of deep-sea fish stocks and may, in part, also result from the “delusional optimism” of scientists, managers and decision-makers. Institutional inertia may result in retention of existing management measures despite their poor performance and the need for change. An example of a weak information situation is that of the difficulty of distinguishing the effects of fishing down of a stock from those of the fishing down of intermittent fish aggregations, fish dispersal or other behavioural effects.

Critical to management of deepwater fisheries is the development of a strategy that covers all aspects of the fishery, from the science through to selection of policy choices and including a framework for implementation and governance. It was noted that there are successful and functional examples of all of these management components as well as many cases of non-functional programmes that fail to achieve their requirements. Implementation of a management strategy requires appropriate governance – something that is lacking in most deep-sea fisheries in high seas areas. Without an effective governing agency it will be difficult to increase management capacity, implement the precautionary approach, develop effective science programmes

and protect marine areas. One commonly neglected component of implementing a management strategy that was noted was the assessment of environmental risks posed by a deep-sea fishery.

The importance for management strategies to incorporate both ecosystem and precautionary approaches was stressed and while a number of fishery management agencies have adopted the precautionary approach, few of them have implemented it in a comprehensive manner. The CCAMLR provides a good example of practical implementation of the precautionary approach although it was noted that this has taken 20 years and is still a work in progress. An important element of the precautionary approach is to ensure that fisheries are developed in a phased, controlled manner. Development stages can include setting management and conservation principles for reviewing and experimenting in the exploration and establishing of new commercial fisheries. There exist a number of examples of such strategies for developing fisheries.

Evaluation of management strategies gives the opportunity to test tactics prior to implementation of a fishery or a harvesting protocol. Such approaches involve agreeing on objectives and goals, setting evaluation criteria and comparing different strategies on a quantitative basis using, if necessary, simulation techniques. Importantly, such approaches allow stakeholders to consider the various management trade-offs in an explicit and quantifiable manner.

Suggestions for the Way Ahead

The examples presented to the Conference clearly showed the need for the immediate development of strong management frameworks to be widely applied to deep-sea fisheries. They should include a strategy evaluation, external input from experts, risk assessment, and national and international governance frameworks for resource management. New tools that enable better strategy assessment should be applied and these should include phased fishery development strategies, ecological risk assessment, management strategy evaluation, and use of external references.

1.4 Theme 4: Technology requirements

Issues and problems

Deep-sea science is largely technology driven – mostly from developments for geophysical and military applications. The deepwater fishery management community needs to look at technologies from all other sectors for use in fisheries. Fisheries and biological applications are often under-funded and in many cases there is insufficient and unreliable data to support decision making. The focus of future efforts must be to provide the information necessary for management. Four main areas were identified where new technology can help management of deep-sea fisheries.

- i. In respect of data, technological advances enable catch data to be made available almost instantly. Such technology also allows more precise information describing fish abundance – both relatively and absolutely and provides additional information on species distribution (including environmental “hot spots”), and benthic habitats. Fish metric information is important for management of deep-sea fisheries but modellers often do not effectively use all such available information.
- ii. There are particular opportunities for collection of oceanographic information by collaboration with the geophysics sector.
- iii. The major development of stock assessment models, computer capability, and modelling wizardry has significantly changed the nature of stock assessments over the last 20 years.
- iv. There have been significant developments in the nature of scientific platforms available for fisheries research. Examples include:

- instrumented commercial fishing vessels (management authorities are only just starting to use this opportunity)
- autonomous underwater vehicles and remote-operated vehicles, which are being used more extensively and, though still expensive, their costs are falling
- manned submersibles
- landers and floaters
- instrumented moorings for geophysics-oceanography and
- satellites.

Technological developments have allowed major advances in scientific methods and surveillance of fisheries. Participants were told that advances in geo-location have changed all types of marine-related research. There have been major advances in multi-frequency and broadband technology acoustics and in reducing associated problems such as measurement of fishes' backscattering cross sections, bottom-echo related shadow zones and improved species identification. Multi-beam mapping is becoming common and improvements in underwater camera and video technology are changing the way all think about deep-sea habitats. Advances in capture technology (e.g., smart, instrumented nets and habitat-friendly fishing equipment) are opening the way for significantly reducing the environmental effects of fishing. Electronic tagging of fish and vessels provides opportunities for new research, and satellite monitoring of vessel positions has enhanced the extent of fisheries compliance.

Suggestions for the Way Ahead

The session concluded that deep-ocean science must become more collaborative among all stakeholders and across all borders, among institutions and between disciplines and commercial activities. It is necessary to be innovative to lower costs of data collection and analysis. New technology, if used correctly, would facilitate stakeholder involvement in data collection such as the use of acoustic fish-resource surveys by commercial vessels during or between fishing operations. However, managers, it was stressed, should be wary of relying entirely on virtual data in making management decisions.

1.5 Theme 5: Monitoring, compliance and controls

Issues and problems

Achieving acceptable levels of compliance with fishery regulations is an essential component of any effective management regime. Therefore, fisheries management regimes must include strategies to achieve individual, industry and state compliance. Without the necessary incentives to comply, enforcement will be expensive and, or, problematic. Experience shows that fishers' compliance is best achieved through maximizing voluntary compliance together with imposing an effective deterrent - "the big stick". Further, compliance must comprise more than just enforcement; rather it must be an inherent part of all components of the management system.

Vessel monitoring systems (VMSs) can be used to both detect and deter offending. Until recently, it was unclear if VMS evidence alone was sufficient to support a prosecution. The Conference heard that in a recent case in the USA the court found VMS data to be accurate and reliable. This did not prove that illegal fishing has occurred but it did provide a precedent for the acceptance of the reliability and accuracy of VMS information as an evidentiary tool. It was noted that there is a wide range of surveillance tools, types of vessels and technology available to detect and deter offending and ensuring the inter-operability of these systems is an important consideration since this reduces costs.

The ability to detect and prosecute fishery offenders retrospectively offers additional opportunities to detect and deter offending. However, this approach requires specialist

skills and expertise and thus training. However, real time monitoring is still needed to detect activities by fishers operating without legal authority and those whose vessels do not carry VMSs. It was noted that the opportunity for legal fishing operators to report on possible illegal, unreported and unregulated fishing (IUU) operations may prove a cost-effective contribution to surveillance, especially in remote areas such as the Southern Indian Ocean.

Compliance and enforcement was noted to be growing increasingly complex and sophisticated as the nature of fisheries crime is such that it evolves to continue to evade detection. As a result, specialist multi-disciplinary teams are being employed. To ensure effective investigations, compliance and enforcement officers need to work cooperatively with researchers and fisheries managers. Consideration must be given to the incentives and penalties associated with management regimes since these have an important effect on compliance. The importance of educating the judiciary on the necessity of enforcing fishery regulations and the consequences of the environmental effects should this not be done was also noted as a means of encouraging them to impose adequately deterrent, though justifiable, penalties.

Inconsistency in sentencing was noted as a major impediment to deterrence, as it turns the court experience into a lottery rather than a certainty. One example of such inconsistency is whether the environmental impacts of illegal fishing are appropriately taken into account by the judiciary when the resulting levels of sentencing are lenient.

Suggestions for the Way Ahead

In respect of compliance by fishers, there is a need to ensure appropriate expertise is available to enforcement agencies. It is also important to educate the judiciary on the significance of the environmental and fishery impacts to encourage the setting of sufficiently deterrent penalties. Issues that were identified as involved were:

- the principle of State self-interest
- the principle of perceived merit and
- the principle of capacity to comply.

It was stressed that it is important to aim at achieving a regime that remains equitable and fair over time.

1.6 Theme 6: Review of existing policies and instruments

Issues and problems

Descriptions of management approaches for deep-sea fisheries by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), and the European Community, and orange roughy fisheries in Namibia, New Zealand, and the South Tasman Rise were presented. In all cases, management problems were found to exist though there were success stories too.

The CCAMLR has been working for many years on management measures for deepwater fisheries that embody ecosystem and precautionary approaches. The Commission has developed practical mechanisms to apply these approaches and this work is continuing. In contrast, the European Community has only recently attempted to manage fisheries in particularly deepwaters despite earlier scientific recommendations from the International Council for the Exploration of the Sea (ICES).

The South Tasman Rise orange roughy fishery management agreement between Australia and New Zealand, which was described, contains an innovative decision rule that recognizes alternative resource status hypotheses that allow for the assumption that there maybe intermittent aggregations of the fish. The default harvesting rule is to set the total allowable catch based on the worst-case scenario. This allows for increases in catch levels should a more optimistic hypothesis be shown to be correct.

Management of Namibian orange roughy was designed from the start of the fishery to incorporate a precautionary approach. Catch limits were area-specific, an areal spread of fishing effort was required, and harvest decision ‘triggers’ were established to respond to when new aggregations of fish were found. However, catches and catch per unit effort (CPUE) declined and, over time, it was realized that even the precautionary catch limits were too high. Two of the three fisheries were closed for a period. The lesson here was that extreme caution is required when using initial estimates of biomass based on little information. However, the future management of these fisheries looks promising.

Major changes in estimates of abundance of New Zealand orange roughy fisheries were reported due to changes in assumptions used in the assessment methods, the data collection methods used, and changes in the methods of analysis during the development of these fisheries. This led to questions about the credibility of the assessments because of new data and the availability of new analytical techniques for what were the world’s first major orange roughy fisheries. Reliable biomass estimates were not available until the 1990s, at which time appropriate management measures were implemented. As with Namibia, despite the best intentions, permitted catch levels was set too high causing a reduction in biomasses to undesirable levels of a number of stocks.

Experience is showing that it should be possible to manage larger orange roughy stocks sustainably, but for smaller stocks this may prove more difficult. Meta-analyses of seamount fisheries were proving useful for setting initial guidelines for new fisheries. It was noted that information on the impact of fishing on recruitment would not be available for at least 20-30 years. Concerns were raised whether the property-rights approach in New Zealand was appropriate for orange roughy fisheries due to absence of considerations of wider environmental values and the propensity to “mine” the resource due to its low production rates and thus low rates of sustainable yield.

Suggestions for the way ahead

Experience shows that high levels of precaution are required to manage deep-sea fisheries if sustainable fisheries are to be achieved. Advice needs to properly reflect the known uncertainties in the data and allow for potential unknown uncertainties. Several participants noted that deep-sea marine protected areas may prove a valuable tool in protecting deep-sea biodiversity in the areas of these fisheries.

1.7 Theme 7: Governance and management

Issues and problems

While there was general agreement of the need to improve multi-lateral governance of deepwater resources, varying views were expressed as to the “what?”, “where?”, and “how?” in making such improvements. In relation to “what?”, a decision must be made on whether changes in methods of governance should focus on deep-sea fisheries alone or on all activities that may affect the deep sea - especially its biodiversity. In this regard it was noted that a wide range of anthropogenic activities might affect the conservation of deep-sea biodiversity. In relation to “where?” the views of the participants ranged from an exclusive focus on the high seas, to that of including the continental margins and national EEZs. However, it was noted that conservation concerns will apply to both the high seas and EEZs, especially where straddling deepwater stocks are present. In relation to “how?” there was a convergence of views that it should be done within the framework of the UNCLOS but a variety of legal mechanisms were suggested. Options that were identified included (a) new binding treaties, (b) new soft law agreements, (c) amendment of the LOS from 2004 and (d), implementation of new agreements.

Each option has advantages and disadvantages including the length of time taken to achieve an outcome, the enforceability of agreements and the likely level of support by States. It is possible that pursuing a number of options simultaneously would allow the most progress to be made. There may also be a need for interim and longer-term solutions.

A number of suggestions were made concerning improving the performance of regional fisheries management organizations (RFMOs). These included different forms of peer review of RFMOs, and to make an organization (e.g. the COFI, or the Meeting of Regional Fishery Bodies, which meets in association with COFI), accountable for coordinating RFMOs and facilitating cooperation between them on this issue.

Many noted that too few countries have signed the United Nations Fish Stocks Agreement¹ and the FAO Compliance Agreement² to be confident that they will be implemented though it was agreed that broader ratification and implementation would go a long way to improving governance of high-seas fishing areas. It was noted that IUU fishing on the high seas is not in fact illegal if the respective flag states have not signed the relevant regional agreement. Therefore, it may be difficult to exclude non-party fishing operators from these fisheries. Further, the ability to coerce non-party States by trade sanctions may be limited. It was agreed that States should look for points of leverage to deal with flag of convenience States. It was also suggested that the value of high-seas deep-sea trawl fisheries may not be as high as generally portrayed and that deep-sea catches make only a small contribution to the world's food security. Therefore, the consequences of restricting such fishing may be relatively small overall, although for particular countries it may be significant.

In order to secure cooperation from non-party states it will be important to address the allocation of fishing rights and benefits – especially among developing countries. Currently there is no global oversight to determine, or regulate the priority of access to harvests and to ensure that benefits are shared equitably.

It was also further noted that among the wide range of issues affecting the world's marine fisheries, concerns about the management of deep-sea fisheries has been relatively recent and the issues to be addressed in this regard are not the most crucial. However, there was agreement that fishing pressure on deepwater stocks would continue to grow and that it was generally easier to implement effective management regimes before the emergence of crises over the sustainability of resources and the need for emergency management and regulatory actions.

1.8 Synthesis and the way ahead

The purpose of this, the last panel session of DEEP SEA 2003, was to provide a range of syntheses of the Conference presentations anchored from three of four general perspectives. The first three panellists presented their views as active administrators of fisheries, one of the panellists works in a national department of fisheries, the second in a regional marine-orientated ecological consortium and the third as the chief administrator of a regional fisheries body. Their presentations were followed of those by three lawyers, staff at respectively at an intergovernmental marine organization, a global conservation and biodiversity body and a university renowned in the field of marine law. Last, and certainly not least, two fishing company executives, one

¹ *The United Nations Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks* (in force as from 11 December 2001).

² *The FAO Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas*. The agreement entered into force on 24 April 2003 with the acceptance by Republic of Korea as the 25th depositor of the instrument. As of 14 October 2004, the total number of instruments of acceptance, including one international organization, stood at 29.

the chairman of a major national fishing industry group, both widely known as leading advocates of enlightened approaches by the industry to matters of fisheries management, provided the perspective of those who must “meet a payroll”.

To provide focus to the Way Ahead and Wrap-up Sessions the moderator asked the speakers to specifically address:

- what needs to be done
- how we might go about doing it
- informing decision makers
- how we may attract and secure funding for programmes
- identifying the international and regional scope of what is to be addressed and
- what must be done to identify, articulate and document the future process?

Because these presentations did not form part of the formal proceedings of the Conference and will not be in the Conference proceedings, their presentations have been given particular emphasis in this Report.

An Administrator's View I: – Dr M Sissenwine, National Marine Fisheries Service, USA

Important Science and Governance Issues

Dr Sissenwine's perspective posed the question, based on the few decades experience, are deep-water fisheries just beginning, or are they coming to an end – a sunset or sunrise? He noted (a) the opportunity that deep seas provided of economic benefits, food and employment, (b) the risk, of overcapacity and economic loss from stock failures, damaged ecosystem and lost public confidence in the relevant management agencies and (c), the challenge of economic viability for fisheries should management costs be internalized.

In this context he concluded that certain deepwater fisheries have been profitable and sustainable – so far and, certain other fisheries have been sustained, though little is known about their profitability. Some of the fisheries are unregulated, but where there has been regulation, it does not assure sustainability or profitability.

He noted the long-lived nature of deep-sea species, thus allowing them to sustain only low rates of fishing mortality. He also noted that, as demersal fisheries, they are often associated with a three-dimensional habitat that is susceptible to degradation when impacted by fishing gear.

His presentation also noted that many assertions were commonly accepted but that it was uncertain what confidence one could have as to their truth, e.g. that the deepwater stocks were vulnerable, that their fisheries were characterized by high degrees of biodiversity and endemism and that deepwater fisheries pose a particular threat to the functionality of their associated ecosystems. The distinction was made between *inappropriate fisheries management* and *inadequate fisheries management*. Also, there was a need for clarity in considerations of the effectiveness of marine protected areas between that of providing for habitat protection, maintenance of biodiversity and the needs of fisheries management.

In his presentation he recognized that management had often failed or functioned poorly: Fisheries often started without appropriate authorization so that information on fishing activities was not collected and control were not implemented, even where this might have been possible. Where it was, assumptions about stock productivity were optimistic resulting in the need for subsequent reductions in fishing activity. In the absence of necessary data, stock assessments were, at times, inconsistent and, for whatever reason, had a strong single-species orientation.

In looking ahead, it was stressed that progress in improving the science in support of the management of deepwater stocks and their governance must move in parallel and at several scales – national, regional and global. The science must better address issues

of spatial scales, the dynamics of fish aggregations, their ranges and stock structures. Lack of knowledge about these topics was largely responsible for uncertainty about the validity of common assertions about deepwater fisheries. For example, how can we know that deepwater stocks are vulnerable to overfishing without knowing the relationship between aggregations that are fished and their stocks? In terms of management science, the challenge is to develop strategies that are robust uncertainty and that complement appropriate operational procedures and management evaluation procedures. On a global institutional basis, this will require embracing existing initiatives such as the FAO Strategy for Improving Information on Status and Trends of Capture Fisheries, and global scientific programmes such as the Census of Marine Life whose scope goes far beyond that of only fisheries. This challenge can profit from existing organizations on which they can build and, indeed, it may be time to consider a new era of international deep-sea expeditions.

In terms of the challenges for governance Dr Sissenwine noted that many critical initiatives are in play, e.g. implementing the FAO Agreement on Compliance, embracing the Ministerial initiative on “IUU” fishing, finding acceptable dispute resolution mechanisms and preparation of technical guidelines for the management of deep-sea fisheries. Existing protocols too, need to be given effect, e.g. the FAO Code of Conduct and the Precautionary Approach in national EEZs, by RFMOs and on the high seas. States and RFMOs need to find ways of regulating deep-sea fishing so that it occurs only when authorized and is subject to ecological risk assessment and precautionary development plans. Means must be identified to require all vessels fishing on the high seas to be equipped with vessel monitoring systems. And, independent audits of the performance of RFMOs will help identify substandard practices, but here a question left by Dr Sissenwine was, will governments find the political will?

In terms of protocols, the Conference identified the question of the sufficiency of existing arrangements and whether the UNCLOS, the UNFSA, and existing RFMOs provided the necessary basis to successfully address the challenge? Or, Dr Sissenwine asked, must the UNFSA be extended, or new RFMOs created, or should there be a UN resolution call for a moratorium on highseas deepwater fishing? If marine protected areas are to be part of the way forward, then a new arrangement may be called for by which they can be implemented. He went so far as to raise a question about the viability of freedom of the high seas when it comes to responsible governance of high seas fisheries.

The way forward, in Dr Sissenwine's view, could be an FAO Technical Consultation on deep-sea fisheries to appropriately address these issues and to define how important deep-sea fisheries are and whether resolving the management problems of these fisheries can avoid the legacy of the freedom of the high seas.

The Way Ahead: An Administrator's Perspective II – Dr Carlos Verona, DALTEC, Argentina

Dr Verona noted the Sisyphean³ task faced by those attempting to manage fisheries resources and those especially those found in deep waters. This metaphor he complemented with a quotation from Shakespeare – “*Being unprepared, our will became the servant to defect...*”⁴. His summary stressed the importance of the effective integration of all the elements of a fishery – the activity of fishing, the characteristics of the fishing grounds, interpretation of the events and results of fishing, the processing of information, the gaining of intelligence complemented by management that was

³ Sisyphean, according to tradition, betrayed the secrets of the gods and chained the god of death so the deceased could not reach the underworld. He was punished by the gods who condemned him to ceaselessly rolling a rock to the top of a mountain, whence the stone would fall back. They thought this futile and hopeless labour to be the worst punishment.

⁴ Macbeth. Act II. First Scene. Shakespeare, 1623.

effective, responsible and accountable. Further, these activities, he noted, were also involved a reverse integration with subsequent elements recurring in their effects on those that were earlier.

He endorsed discussions by Conference participants that the RFMOs should be provided all means to strengthen their activities. This might be done using such tools of strategic planning as:

- SWOT Analysis
- vision and mission articulation
- strategies assessment
- time horizons' analyses and
- analysis of legal compliance, client satisfaction, conformity with internal quality standards and continuous improvement.

In this context, Dr Verona noted that the International Standards Organization had prepared a standard (ISO 9000:2000⁵) that specifies requirements for a quality management system where an organization:

- i. needs to demonstrate its ability to consistently provide products that meet customer and applicable regulatory requirements and
- ii. aims at enhancing customer satisfaction through the effective application of the system, including processes for continual improvement of the system and the assurance of conformity to customers and application of regulatory requirements.

He extended his presentation by noting the interplay of prophecy, perceptions, the need for mental models and their interpretations, the need for action and the likely effects and consequences.

CCAMLR – Quo Vadis: View from a RFMO – Dr Denzil Miller

Dr Miller focused his perspective of future governance issues on one of the most pressing issues confronting the members of the CCAMLR – the development of IUU fishing in the CCAMLR area, the challenges it posed and the solutions the Commission had identified to pursue. In describing these issues he drew on his experience as the Executive Secretary for the Commission, an organization of 23 member countries⁶.

In this task, he noted that the CCAMLR, as a regional fishery body, faced a variety of institutional issues. These he summarized as follows.

- *Loss of interest; complacency among some important stakeholders; erosion of priorities in the face of other global issues*

In the face of the persistence of many other global problems it was proving difficult to maintain interest and commitment to resolving the problems that the CCAMLR confronted. New emergencies and crises had arisen and diverted attention from finding solutions to those that had not already been resolved. An example has been the global attention given to the consequences of the "War on Terror". An effective response to this challenge required continuing emphasis on 'Service Delivery' by the Commission and the allocation of resources to promote public and political awareness of the need to resolve existing problems.

⁵All requirements of this International Standard are generic and are intended to be applicable to all organizations, regardless of type, size and product provided. Where any requirement(s) of the Standard cannot be applied due to the nature of an organization and its product, they can be considered for exclusion. Where exclusions are made, claims of conformity to this International Standard are not acceptable unless exclusions are limited to requirements within Clause 7, and such exclusions do not affect the organization's ability, or responsibility, to provide product that meets customer and applicable regulatory requirements.

⁶ Brazil, Chile, European Community, France, Germany, India, Italy, Japan, Korea, Norway, Poland, Russia, South Africa, Spain, Sweden, Ukraine, U.K, USA and Uruguay. Bulgaria, Canada, Finland, Greece, Netherlands, Peru and Vanuatu are parties to the Commission.

- *Status threat*

Many of the issues that confront the CCAMLR within its mandate fall, at least partially, within the mandate of other regional fishery organizations, United Nations agencies and inter-governmental and non-governmental organizations. This can result in an erosion of the perceived ability, or mandate, of CCAMLR to address issues that fall within its range of competency and which are also the objective of such organizations. One such example was the role of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in listing species whose management falls within the purview of CCAMLR. Issues such as these require that CCAMLR members and its staff make a sustained effort to inform decision-making by relevant parties and assist in appropriate self-promotion by CCAMLR of its role. They also participate in the activities of related organizations to ensure CCAMLR's competencies are recognized and its mandate is well understood.

- *"Internal friction"*

CCAMLR consists of a fairly large number of members and one perception is that some members tolerate IUU fishing. This issue must be addressed through moral persuasion, the building of consensus among the Commission's members and by promoting support for penalties, such as the loss of landing and product discharge rights by those shown to have acted illegally or who have dishonestly reported their fishing activities. Related issues have been those of increasing compliance with regulations and the corresponding political will of members to do so – a function of the priority they assign to supporting the Commission's activities.

- *Shared mandate*

The CCAMLR is not the only organization that has international competencies in its mandated region and thus, in certain cases, it must consider its activities in relation to the activities of others. One such situation arises from *The Protocol on Environmental Protection to the Antarctic Treaty* (the Madrid Protocol). The CCAMLR's different approach to similar issues and problems may arise from its philosophy that reflects the Commission's particular emphasis and view, but it remains cognizant of the competition for limited resources from others and the need to consider their perspectives. The response of CCAMLR has been to promote and participate in dialogue where needed and to exchange staff and officer holders with corresponding organizations, e.g. the Chairman of CCAMLR's Scientific Committee has participated in the work of the Committee on Environmental Protection of the Antarctic Treaty programme.

- *Funding Constraints*

The increasing demands of the CCAMLR to service an expanding repertoire of problems face the constraints of limited funds. One consequence is an increasing shortage of new workers to address both existing and new problems and programmes. The response to this situation has been to implement a programme of education and outreach to improve dissemination of information. To mitigate this problem, the Commission has been endeavouring to source special funds and the possibility to have access to the proceeds of successful prosecutions for fishing infractions in its region of competence.

- *Transparency of the CCAMLR Process*

Because of the long-time commitment and involvement of most participants in the CCAMLR process there was been a view that the Commission acts as a 'Closed Shop' with a consequential perception that there is a lack of transparency as to how the Organization operates and how decisions are made. Again, the Commission's response has been to implement a programme of outreach, self-promotion, education and dissemination of information through an explicitly designed communications policy.

The Commission also faces a number of practical challenges. Among these is inadequate enforcement of regulations, though this has been mitigated by improved co-operation between members, notably Australia, South Africa and the United

Kingdom. While such developments have been welcome, there is awareness that for many important fish stocks that have been depleted, this action has been too little and too late. Other issues that the CCAMLR faces, not unlike many other fisheries bodies, is the role of consensus in coming to agreement on important policy and operation decisions and the unavoidable complexity of many of the regulatory requirements. Two such initiatives are the Catch Documentation Scheme for Patagonian toothfish and the introduction of precautionary catch limits in management decisions.

It was noted that more effort must be addressed to improve the knowledge base for decision making in what are commonly situations of considerable complexity. This includes the fields of technology, science and the management of uncertainty. In tandem with the expansion of factors being considered has been increased expectations of delivery of concrete results by the Commission and the need to expand considerations to include that of economic values and intangibles such as heritage value. This in turn has lead to the need to address the categorization of benefits. Other concerns in relation to governance have included the issues of member's self-interest, the capacity of the Commission to fulfil its mandate and means of assessing its performance through appropriate methods of appraisal.

Governance and International Institutions – Mr Michael Lodge, International Seabed Authority, Jamaica⁷

Mr Lodge, by way of his wrap-up presentation reviewed the mandate and concerns of the International Tribunal for the Law of the Sea. He noted that this institution was a specialist tribunal established to deal with disputes arising out of the interpretation and application of the 1982 Convention on the Law of the Sea.

Mr Lodge provided a succinct review of the current Objectives of High-Seas Fisheries Governance, which he saw as embracing the following critical points.

- International management of currently unregulated high-seas fisheries – many such fisheries remained unmanaged, not least because there was no current management regime or operational agreement by which harvesting of these fishery resources could be regulated.
- Conservation of high seas biodiversity – as many at the Conference had noted, there was an urgent need to implement means of protecting high-seas flora and fauna, especially where threatened by regulated and unregulated fishing operations.
- Promotion of marine science – it had been repeated several times at DEEP SEA 2003 that in many cases the knowledge required to confidently manage human activities on the high seas was weak or lacking and this situation required a new global initiative of ocean exploration, which would require greater commitment and more resources.
- Appropriate regulation of activities related to “bio-discovery” – exploration and commercialization of the unusual physiological and genetic heritage of the deep seas was raising legal issues that remained to be resolved.
- The legal regime applicable to the “Area”- the high seas, EEZ, continental shelf and continental margin – each of these areas, which may contain stocks of similar species, is subject to different legal conditions and may require their own particular approach.

What was needed, Mr Lodge noted, was an appropriate Methodology, which might be achieved through a Resolution on a Declaration of Principles. Such a Declaration should require:

⁷ Current address: Ministerial Task Force on IUU Fishing, OECD, Paris, France.

- a universal application of the UNFSA principles to all high-seas fish stocks
- the prohibition of destructive fishing methods and, or, gear types pending an agreement on the international regulation of deep-sea fisheries on the high seas
- a commitment to a broad-based international programme of marine science that would benefit all with an interest in high-seas marine affairs and
- the establishment of an international process to consider options for the regimes that would regulate high-seas fisheries and marine scientific research, and design and implementation of mechanisms for the protection of high seas biodiversity.

For this what was required was a particular Strategy for Governance of Fisheries. This would involve:

- expanding the FAO Code of Conduct to cover deep-sea fisheries
- expanding the coverage of regional fisheries management organizations so that their mandate covers the regulation of deep-sea fisheries in accordance with UNFSA model
- undertaking a performance audit of such regional management organizations to identify where management performance is deficient and why
- undertaking a global review of the accountability of regional fisheries management organizations, perhaps by the FAO or the United Nations and
- reviewing the mandate and the potential of the International Seabed Authority to determine if this organization might have a role in which it might contribute.

He noted that the 1955 Rome Technical Conference on the Conservation of the Living Resources of the Sea had addressed many relevant issues in the context of ocean exploration and in addressing high-seas fisheries issues. Many important issues were debated and in particular it was agreed that conservation and management of high-seas fisheries resources should only be done through international cooperation in research and regulation. Further, the best way of achieving this would be through establishing regional conventions based on the geographical and biological distributions of the marine fish populations concerned.

In terms of a Strategy for Ocean Exploration, Mr Lodge informed of the need to ensure that:

- the collection of samples for scientific and commercial purposes and associated activities should be sustainable and subject to environmental impact assessments
- a consistent approach at both the regional and global level to conditions for access and sharing of benefits should be followed and
- there should be access to the data, scientific knowledge and information obtained from high-seas ocean exploration regarding intrinsic scientific values in lieu of sharing of economic benefits.

In terms of a strategy for high-seas biodiversity, he felt it important that high-seas areas of particular scientific interest be identified for intensive international study and conservation, possibly using the International Seabed Authority as a mechanism for regulating such activities. In addition, the results should be used as the basis for global regulation to prevent and, or, minimize the loss of high-seas marine biodiversity.

A Global Perspective – Ms Kristina Gjerde, Environmental Lawyer and High Seas Policy Advisor, IUCN Global Marine Program

In establishing a framework for her presentation, Ms Gjerde noted the comprehensive structure of international agreements, governance mechanisms and declarations that were relevant to deep seas fishing activities beyond national jurisdiction. These institutions and agreements reflect global commitments to protect living marine resources and preserve the marine environment based on ecosystem-based and precautionary approaches. These include:

- the *United Nations Convention on the Law of the Sea* (UNCLOS)
- Agenda 21, Chapter 17 and the *Rio Declaration on the Environment and Development* adopted at the United Nations Conference on Environment and Development (UNCED) in 1992
- the *Convention of Biological Diversity*, created at the same Conference
- the *FAO Code of Conduct for Responsible Fisheries*
- the United Nations ‘*Fish Stocks Agreement*’ relating to highly migratory fish stocks and straddling fish stocks
- the World Summit on Sustainable Development of 2002 and
- various United Nations General Assembly resolutions.

In this context, the *Convention on Biological Diversity* has particular relevance to the discussions of the Conference in the context of protecting the deepwater benthos beyond national jurisdiction. Article 3 of the convention requires Parties “to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or to areas beyond the limits of national jurisdiction.”

For its part, the *United Nations Fish Stocks Agreement* requires Parties to:

- i. prevent overfishing
- ii. minimize the impact of fishing on non-target, associated and dependent species and ecosystems
- iii. protect habitats of special concern
- iv. apply the precautionary approach and
- v. protect biodiversity in the marine environment.

Despite this framework of responsibility for protecting habitats and biodiversity beyond national jurisdiction from fishing and other activities, the United Nations General Assembly has noted with increasing concern the need to improve the management of risks to deep sea biodiversity. In 2003, in Resolution 58, Paragraph 51 the UNGA “.....reiterates its call for urgent consideration of ways to integrate and improve, on a scientific basis, the management of risks to the marine biodiversity of seamounts, cold water coral reefs and certain other underwater features...” Thus, Ms Gejerde noted, there was clearly a need for urgent action to address the impacts of high seas bottom trawling on vulnerable deep sea environments, particularly seamounts and cold water corals.

However, before deep sea bottom trawling on the high seas can be effectively and sustainably regulated, there were several ‘gaps’ that require attention in (a) the field of fisheries biology, (b) institutions of governance, (c) enforcement of regulations, (d) participation by those with a stake in this issue and (e), application of current understanding of deep-seas ecosystems and biodiversity to deep-sea fisheries.

In terms of the science that is required, previous sessions of this Conference have demonstrated that fisheries biologists are only beginning to understand what they do not know. Information is lacking on what fish stocks are targeted and where; what their biomass- recruitment relations are; the extent and importance of bycatch (which is known to include particularly vulnerable and rare deepwater sharks and rays); knowledge of the deepwater fisheries habitat and how it is affected by fishing; and the nature of these ecosystems and their associated biodiversity. There is clearly a need for a comprehensive assessment of deep-sea ecosystems, biodiversity, affected species and their resilience to human impacts. It is also essential to better understand the relationships between deepwater ecosystems and pelagic species and ecosystems.

In terms of the gaps in governance, Ms Gjerde noted that large parts of the oceans lacked a competent authority to regulate bottom fisheries, and in other areas, the authority had not yet been exercised. The level of commitment required to address unsustainable fishing levels and destructive fishing practices appeared to be lacking, other than perhaps in the Southern Ocean under the CCAMLR. There was also a record of poor compliance by fishing operators on the high seas accompanied by an

inability of institutions to enforce regulations in such situations. Gaps in enforcement could arise from inadequate flag-State control over ships under their jurisdiction compounded by the inability of other states to enforce conservation measures on the high seas.

Another “gap” was that of effective participation by relevant stakeholders. There is a need to involve all relevant stakeholders, including non-users, but few mechanisms exist to ensure their effective participation. Thus scientists and others are forced to resort to ‘Statements of concern’ issued to the United Nations General Assembly. A recent example of this was a statement of alarm over the impacts on high-seas bottom trawling on cold-water corals and seamounts signed by over 100 scientists attending two expert symposiums on deep-sea biology and cold-water corals earlier in 2003.

Compounding this was the “gap” in scientific expertise, well noted in discussions at the Conference itself on the impact of deep-sea bottom trawling on seamounts. Despite a scarcity of seamount research and a poor understanding of benthic ecology, a great deal was already known that should be taken into account. The OASIS project (Oceanic Seamounts: An Integrated Study - a project funded by the European Commission) has documented seamounts as important breeding and feeding grounds for pelagic and demersal fish. Results of this and other programmes have shown that the deep-sea floor hosts vast numbers of benthic animals (e.g., hard, soft and horny corals, sponges, sea lilies, sea squirts) and provides habitat and food for many other animals. Many seamounts show high levels of species endemism and others may enable species to spread across ocean basins by facilitating dispersion. They may also provide refuges for relict species. An example of the prolific species diversity of seamounts is shown by one study of the deep-sea fauna off New Caledonia. More than 2000 species have so far been recorded, of which more than half were previously undescribed. This should have been a major topic of discussion at the conference, but there were no plenary presentations – only one poster in the foyer.

Ms Gjerde noted that advancing conservation and sustainable use of deepwater fauna beyond national jurisdiction will require action in the short, medium and long term. In the short term, leadership could be provided by the few states involved in deepwater fishing (only 11 or 12). They should:

- consider declaring a freeze on this fishing practice
- seriously consider their duty and capacity to conduct sustainable fisheries in these regions and how to conserve deep-sea biodiversity
- establish precautionary measures for new and existing fisheries and
- establish MPAs and representative networks of MPAs in national waters and on the high seas

Coastal states could provide leadership by seeking to protect the sedentary resources of their outer continental shelf (where this extended beyond the 200 nm exclusive economic zone) from the impact of high seas bottom trawling. They could, for example, take a case to the International Tribunal for the Law of the Sea. Concerned States could also support UNGA resolutions on conservation of biodiversity, equity and sustainability of high seas bottom fisheries. Campaigns to inform the public could be complemented by education of consumers.

In the medium term, the UNGA should act to establish global conservation and management measures for unregulated fisheries emphasizing the duty of States to conserve and cooperate in the management of high-seas bottom fisheries. The UNGA should also better define and improve the conditions for control of what are now unregulated fisheries. This could be done by ensuring the rapid establishment of “arrangements” to regulate existing or emerging high seas bottom fisheries. There is also a need to document global catches and monitor trade in high-seas species. Full implementation of the 1993 FAO Compliance Agreement and FAO IPOA on IUU are essential. And, any unregulated fishing as defined by the FAO Plan of Action on

Illegal, Unreported and Unregulated Fishing should be recognized as “piracy” and stopped.

A second suite of medium term actions should involve extension or application of the principles and provisions of the UNFSA to all high-seas fish stocks, including bottom fish stocks, and not just highly migratory fish stocks and straddling fish stocks. Together with the *FAO Code of Conduct for Responsible Fisheries*, it provides a strong basis for ecosystem based management, precaution (i.e. risk aversion), habitat protection (e.g. through area closures and marine protected areas (MPAs)), and imposition of gear restrictions to eliminate destructive fishing practices.

A third level of medium-terms actions would involve reforming and upgrading RFMOs to incorporate the ecosystem-based and precautionary management principles of the UN Fish Stocks Agreement and FAO Code of Conduct. This could be done through mechanisms such as a system of peer review of RFMO operations. Standards for review could be based on the provisions of the UN Fish Stocks Agreement, the FAO Code of Conduct, FAO International Plans of Action (IPOAs), and the United Nations principles of Governance. It should be recognized that assistance or incentives may be needed to expedite this internal evaluation process. This could include a system of NGO scoring and/or a white list/black list approach based on how the RFMOs were performing.

In the long term, Parties to UNCLOS should consider establishing an implementing agreement or agreements for high-seas biodiversity conservation and institutions through which this could be achieved. These should ensure that modern governance and management principles and practices (e.g. precaution, conservation, sustainable use, equity in participation of stakeholders, transparency in methods of operations and accountability to those affected) apply equally to all high seas activities. Funding could be based on the “user pays” principle.

Such an implementing agreement could:

- coordinate and oversee existing institutions and agreements, e.g. those of the International Seabed Authority, the International Maritime Organization and regional fisheries management organizations
- regulate any remaining ‘orphan’ fisheries – those to which no regional regulatory regimes apply
- provide oversight for new and emerging uses of the deep seas
- develop codes of conduct and, or, regulations for activities capable of affecting high-seas biodiversity, e.g. cable laying and marine scientific research
- enable effective enforcement
- establish a framework for establishing high-seas marine protected areas and
- build institutional and national capacity for management and enforcement.

Long-term action is also needed to address the issue of public trust, or stewardship, of the high seas. This might take place through some form of council whose objectives would be to (a) preserve the natural capital, e.g. fish stocks or bio-diversity, (b) ‘save’ or invest the interest and (c), protect the interest of the beneficiaries – our children and our children’s children and the oceans upon which they depend.

In closing, Ms Gjerde stressed that given the lack of knowledge about deep-sea ecosystems, species and the long-term effects of fishing impacts, there is an urgent need to apply a precautionary approach to ensure sustainable use and conservation of deep-seas biodiversity and its environment. It will require all to work together towards these essential goals.

An International Legal Perspective – Professor Moritaka Hayashi, Waseda University, Japan

Professor Hayashi, in his prognosis of the way ahead, used an analogy that had been developed in an earlier presentation, that was whether progress in improving the

institutions of governance of the deepwater fisheries of the high seas would be best done through the 'front door', 'back door' or 'side door'.

A *Front Door* approach would be equivalent to that of a binding treaty and here there were various ideas as to how to proceed. One approach would be to expand the remit of existing regional fisheries management organizations, or, perhaps, to establish a Global Fisheries Organization. Here an important question would be whether to restrict the mandate of such an organization to fisheries only or to endow it with a mandate for governance of wider aspects of oceans use. He also noted that if ocean stakeholders wanted a mechanism or regime that could manage high-seas marine protected areas, then a new arrangement or agreement would be needed. In this case, one possibility was that of a Global Trust. This was not a new idea and 30 years ago there was much discussion along these lines in terms of the *Common Heritage of Mankind*⁸. However, while this may be an ideal solution it could involve a long time to implement. Despite this, all these options are possible.

A *Back Door* approach would make use of the various mechanisms allowed by 'soft law'. In this context, among various ideas that have been put forward is that of using the United Nations General Assembly to declare and, or, adopt principles of oceans use, though experience has shown that it has been notoriously difficult to get agreement on what are appropriate actions. Professor Hayashi thought this to be a useful approach, but also noted that achieving a moratorium on deepwater fishing through the United Nations would be unlikely as it would require a consensus on the part of the Assembly - something that was unlikely. In pursuing a soft law mode, the FAO could do much through development of guidelines and a new code of conduct that recognized the particular circumstances of high-seas deepwater fisheries.

A *Side Door* approach would be one that involved amending the UNCLOS. However, he stressed that he thought this approach to be particularly delicate (i.e. re-opening the various articles of the Convention for debate). Rather, he was of the view that we should continue to think about possible measures or arrangements of a practical nature to resolve the issues arising as a consequence of the gaps in the Law of the Sea Convention.

In looking ahead, Professor Hayashi thought it would be appropriate for the main sponsors of DEEP SEA 2003 to take the outcomes of Conference to the Committee on Fisheries of the FAO and appropriate forums at the United Nations. The FAO might commence a new series of consultations and expert meetings on issues that were within its remit. It was also felt that the importance of the regional fisheries management organizations must be recognized and deep-sea fisheries issues could be well addressed through their meeting in Rome at the FAO in March 2005.

An Industry Perspective – I: Martin Exel, Austral Fisheries Pty. Ltd, Australia

Mr Exel, drawing on his managerial experience in operating high-seas fisheries within the requirements of existing management regimes stressed three requirements for all those with a stake in responsible governance of deepwater fisheries:

- get real
- get frustrated and
- get together.

In coming to terms with the illegal, uncontrolled and irresponsible operators of many deep-sea fishing companies prosecuting Patagonian toothfish on the high seas, and within national EEZs when they could, the Coalition of Legal Toothfish Operators

⁸ Proposed in 1967, this philosophical idea challenged the basis of existing regimes governing globally important resources and proposed major changes to the way the world applies the existing norms. As such, the concept of the Common Heritage of Mankind involved a critical re-examination of the well-established principles and doctrines of classical international law, such as acquisition of territory, sources of international law, sovereignty, equality, resource allocation and international personality.

(COLTO) ‘got real’. The members of this voluntary industry coalition recognized that complaining to each other and to those struggling with the mandate to address these issues was not effectively confronting those fishing operators who were doing the wrong things – legally! COLTO stresses their view that their Governments must assert control over high-seas fisheries. In the case of conservation groups, it is essential that they too ‘get real’ and figure out which ways work effectively and which ways are counter-productive and work against stakeholders who share common objectives. And, all who share the concerns over IUU operators and suffer their consequences must work together, within their own sectors and with others in the other sectors – industry, conservation and government.

He acknowledged that the Industry needs to recognize that some of its activities are bad and that there are some crooks within its ranks. Mr Exel challenged all present to ‘get frustrated’ as stakeholders’ passion is needed to resolve the problems that exist. Initiatives can be hard to sustain – ISOFish, an Australian NGO dedicated to saving the toothfish, worked well at first but then lost its passion and stopped.

Finally, Mr Exel stressed that those involved must ‘get together’. No individual group of stakeholders has all the answers but together they can create a solution. And, while extremists do not produce solutions – they do provide passion. By combining these elements Mr Exel believes that all stakeholders can get results – together. Deepwater habitats can be protected, IUU fishing can be eliminated, and sustainable fisheries can be ensured for present and future generations.

An Industry Perspective – II: Mr Dave Sharp, New Zealand Seafood Industry Council

In his presentation Mr Sharp noted that New Zealand has much experience of all types with deep-sea fisheries and that the New Zealand experience was that most deepwater fisheries management regimes within EEZs have the opportunity to remedy past mistakes made by their management. In New Zealand, Industry has a growing high-seas deepwater fishery that is strictly controlled. All catch must be reported; all vessels must have vessel monitoring systems and carry marine observers if required. These fisheries are *Legal, Regulated and Reported!*

The New Zealand industry recognized, and stressed, that they want to contribute to the progress in the management and governance of deepwater fisheries and that they are eager to play their part. He further noted that those at the Conference had heard much about the negative consequences of the various deepwater fisheries, but he felt that there was a need to acknowledge the positive advances and contributions made by the industry as well. As such, while the Industry may be part of the problem it can also be part of the solution.

He identified a wide range of ways in which the industry can, and does, contribute to responsible management of deepwater fisheries. These included:

- assisting in accurately defining the problems – in this way all can assist in addressing them and
- making the industry available to collect scientific information.

The Industry recognizes the need for effective management of fisheries on the high seas and in the Southern Hemisphere fishing countries have been and are willing to work together. Mr Sharp also identified policies that the industry believed would promote good governance of these fisheries. He believed that, where possible, there was a need for explicit fishing rights as in these situations fishers respond well to the incentives they provide for responsible fishing behaviour. He was of the view that a moratorium on high-seas deepwater fishing would not resolve the management issues that remain to be addressed. But, the Industry was of the view that there was a need for an effective high-seas compliance regime – something that did not exist at present.

He noted that the problem of IUU operators remained but there was no excuse not to make a start in confronting the problems they pose and identifying and implementing the solutions needed to resolve this problem. In doing this, he noted that fishing industries around the world had seen the benefits of global industry cooperation and their experience was that peer pressure is effective in mitigating this problem. He also noted the need for the Industry to reach out and work cooperatively with governments, environmental groups and others in civil society. As such, the Industry was aware that they do not have all the answers to the problems they faced but he stressed that they are willing to listen and contribute to the solutions.

An Administrator's View III: Mr Geoff Richardson, Australian Fisheries Management Authority

In this summary, the point was stressed that many issues confront governments in their approach to administration of deepwater fisheries. Among these are the gaps in the international frameworks for regulation of high-seas fisheries, and the need for the government's own mechanisms for monitoring deep-sea areas, both within EEZ and on the high seas, for fisheries and marine conservation.

The challenges are clear: in moving forward it was apparent that there is no single solution or 'magic bullet' – rather much frustration. The challenges to be confronted will require a suite of actions. Such actions will include:

- successful implementation of existing agreements
- further consideration of appropriate trade measures and port state controls
- development and implementation of guidelines to regulate new and exploratory fisheries
- addressing specific flag -state issues such as
 - definition of the criteria for defining a genuine link between states and owners of fishing boats and fishing enterprises
 - improving the nature of cooperation between States and RFMOs
 - addressing the capacity of developing countries to administer vessels under their flag when they operate in high-sea deepwater fisheries
- giving a greater emphasis to issues of monitoring, control and surveillance of high-seas fisheries
- giving more immediate attention to the protection of high-seas biodiversity including addressing the issues that are would be involved in the implementation of marine protected areas in high-sea areas
- discussing the issues of governance in appropriate governmental forums starting with the COFI in 2005
- ensuring that this issue is on the agenda of the COFI meeting and is discussed in appropriate forums at the United Nations
- anticipating the recommendations of the Ministerial Task Force and responding in an appropriate manner
- managing deepwater resources within national EEZs in a sustainable manner, i.e. leading by example and
- avoiding definitions of depth zones of the deep sea that create problems in terms of vertically straddling stocks.

2. END-OF-CONFERENCE PERSPECTIVES OF THE STEERING COMMITTEE

2.1 Introduction

As DEEP SEA 2003 proceeded, it became progressively clearer that the concerns of those at the Conference could be grouped into:

- i. issues of management and compliance that are common to all fisheries, inshore and offshore and

- ii. those that, if not unique to deepwater fisheries, were mainly the concern of this type of fishery.

Common Issues and Problems

- It was recognized that despite the difficulties in obtaining appropriately detailed information on the prosecution of the world's deepwater fisheries resources, it was apparent that they were being subjected to intensive fishing effort and that in many cases, stock biomasses had been reduced to levels that could not sustain current rates of harvesting, if indeed they were still sustaining commercially viable fisheries.
- Coupled with concerns over the viability of many deepwater fisheries were concerns for the protection of the associated marine habitats. Bycatch recorded in deepwater fisheries sometimes includes long-lived benthic fauna.
- It was noted that existing arrangements for the governance of many deep-seas fisheries resources had failed to protect these resources and ensure that their potential benefits would be sustained. In this context, if future management mechanisms were to be effective in sustaining the deepwater fisheries, then the general view was that it was beyond the capacity of existing arrangements for governance to ensure the effective management of many deepwater fisheries and alternative approaches to their governance are necessary.
- Resolving existing deficiencies in governance of deepwater resources will require embracing a variety of new approaches, including those with long-term, short-term and medium-term perspectives. These approaches may be affected through more effective implementation of mechanism agreed to in existing accords on fisheries arrangements while other approaches may require further international negotiation and agreement. Many of the conservation organizations noted the need for a short-term interim prohibition on high seas bottom trawling until such arrangements were in place to serve as a spur to rapid action.

2.2 Future activities

A continuing theme of discussions and presentations at DEEP SEA 2003 was to advance efforts at addressing the many weaknesses, if not failures, of management, governance and institutions that had been identified and discussed during the period of the Conference. A number of specific programmes were identified and these are summarized in FAO (2005)⁹. These address the issues of Strategic Objectives and a way forward, and Operational Issues and a Time Frame for Addressing Deep-sea Fisheries Governance and Management Challenges and programmes recommended for implementation (Section 2.3). The proposals could generally be classified as those consisting of (a) reinforcing ongoing initiatives, (b) implementation of new measures but using existing instruments and (c), those that envisage the creation of new management regimes and protocols with particular emphasis on areas of the seas that are not currently subject to some form of *effective* management protocol. These proposals ranged from operational activities such as improving data collection, to considerations of strategic issues, e.g. how access to high-seas resources may be better addressed to common benefit and the need to revisit issues that time has shown were inadequately address at the Convention responsible for the current Law of the Sea agreement.

It was beyond the objectives and nature of the Conference to identify how these initiatives might be funded, but participants were aware that this was an issue that would need to be satisfactorily addressed.

⁹ Report on DEEP SEA 2003, an International Conference on Governance and Management of Deep-Sea Fisheries. Queenstown, New Zealand 1–5 December 2003. *FAO Fisheries Report*. No. 772. Rome, FAO. 2005. 84p.

2.3 Programmes recommended for implementation

2.3.1 Background

During DEEP SEA 2003, a number of possible initiatives that were in need of attention and that would advance the theme of the Conference were raised. Many of the suggested activities are listed in the following sections as much to stimulate continued discussions as to what may contribute to better governance and management of deepwater fisheries as to identify positive steps that may be taken in the near future. The actions proposed below do not reflect any formal conclusions of the Conference, but the Steering Committee believes that it is useful to list them as they ought to provide a sound basis to provide direction for planning future initiatives.

2.3.2 *The need for information concerning past deepwater fisheries*

Many deepwater demersal fisheries were not sustainable and no longer support active fisheries. Many of these fisheries occurred when there was neither little international obligation to collect information with the detail that is needed for effective resource management purposes nor a well developed understanding of the importance of doing this. Further, in times past, many countries had neither the national legal basis, nor the interest, in insisting that their vessels operating on the high seas, and which were often based offshore and landed their catch into distant ports, provide more than the minimum catch and effort data required by the port authority at the point of discharge. However, such information is essential if resource analysts are to understand the reasons for the current status of deepwater stocks. Thus, a globally-coordinated effort is needed to document past deep-sea fishing activities. This would require determining the nature of past catches in terms of their species composition, the possible past age structure of the unfished resource, the fish-stock origins and an attempt at estimating the fishing effort that has been expended. The current status of deepwater fishing and fish stocks should also be determined on a global basis together with an estimate of the amount of fishing effort currently being expended. This information would be usefully collated in a single document or readily accessible database.

2.3.3 *Securing and archiving information concerning extant deepwater fisheries*

While many states now legally require their flagged vessels to report full information on their high-seas fishing operations, this is not the case for all deepwater fishing countries. A range of reporting requirements exist, which at their minimum result in only summary operations data being provided to authorities at ports of product unloading. Further, this information is often ambiguous, e.g. many discharge manifests fail to distinguish between the different possible types of product – whole, H&G, fillets, etc., complicating interpretation of the data. Such problems further complicate, if not prevent, efforts to analyze the effects of fishing on deepwater fish stocks and to determine the resource status. Further, even when such information has been collected it must be rapidly made available in appropriate detail for stock assessments and provision of harvesting advice. Many national fisheries authorities fail to do this. Immediate efforts are required to ensure that data and related information on current high-seas deepwater demersal fisheries are recorded in appropriate formats and in sufficient detail, preferably by fully implementing existing agreements or through negotiation of new arrangements.

2.3.4 *Evaluation and documentation of deepwater fishery resource management standards and practices*

Experiences described at DEEP SEA 2003 indicated much progress had been made in improving stock assessment methods and harvesting strategies in some regions, so as to improve the sustainability of deepwater fisheries. But, it was clear that much remained

to be done. Further, it was recognized by the Conference that progress had been highly uneven among different management regimes. It was noted that a global review and evaluation of regional harvesting strategies that considered stock productivity, harvesting rates and included agreement on appropriate management of risk would be of considerable benefit, especially for new developing deepwater fisheries.

2.3.5 Bycatch issues

Fishery bycatch occurs in many deepwater fisheries, including bycatch of long-lived benthic invertebrate fauna, but the extent of bycatch varies among fisheries and locations. Except when vessels carry marine observers, little information has been collected and made available for assessing the impact of deepwater fishing on such bycatch species. A coordinated global effort is needed to ensure that deepwater fishery bycatch data are collected, archived, analyzed and reported. Based on such information, improved assessments of the effects on bycatch of deepwater fisheries should be undertaken in a globally-coordinated manner so relevant knowledge becomes available, archived and shared among those involved.

2.3.6 Evaluation of status and threats to deepwater fisheries habitat

Several Conference presentations and interventions emphasized the damage, past and present, that inappropriate bottom trawling can do to marine fish habitats and the potential harm this may cause to future recruitment of commercially-exploited deepwater species. Many instances of damage to benthic fauna have been documented and a broader assessment of this problem is needed together with an evaluation and implementation of mitigating measures. This would include development of environmentally safe and selective fishing gears as called for by the UNFSA and the FAO Code of Conduct and protected or areas closed to fishing or certain types of gear, and proposals for jurisdictional mechanisms to ensure compliance with any protective or remedial measures.

2.3.7 Review of the global coverage of management of deepwater fisheries

No current inventory of deepwater stocks and their fisheries that remain unregulated by a fisheries management organization exists. Nor is there current information on a global basis of deepwater resources that may be within the management jurisdiction of a regional fisheries body but which remain unmanaged and, or, unregulated. Such an inventory, if prepared, could complement an assessment of existing and, or, potential, concerns as to the sustainability of deepwater fisheries resources, fish habitat quality or issues relating to conservation of deepwater biodiversity.

2.3.8 Management of seamount fisheries

The Conference was informed of the particular features of seamounts - isolated seabed features, often characterized by unique or rare benthic invertebrate and fish communities. It is believed that the current flows around and over seamounts result in increased localized productivity that enhances fish stock recruitment success. Thus, seamounts are of particular importance both for their fisheries and for their biodiversity. The number of seamounts in the world is unrecorded but may exceed 100 000 depending how such features are defined. Perhaps more than half of all seamounts occur in high-seas areas. Many seamount fisheries have been depleted while the sustainability of other seamount fisheries remains a concern. Considerable damage to the benthos by fishing gear has been recorded on many seamounts, though only a small number have been examined. Fisheries associated with seamounts may benefit from specialized attention that draws on existing expertise in countries already managing such fisheries. Such efforts could also identify means of mitigating the effects of demersal trawls on benthos and means of protecting vulnerable areas. Such an

effort could also examine the potential benefits from selecting a number of seamounts to become protected marine areas. Should there be grounds for doing so, a global programme should be developed to implement such a proposal.

2.3.9 Strengthening the capacity of Regional Fishery Bodies to manage deepwater resources

The importance of RFBs that have a mandate for management of deepwater fisheries is clear. However, the management of many such fisheries may not be addressed by such bodies. In some cases this may result from the lack of legal and, or, technical competence to do so. A global assessment of the role and mandate of existing regional fisheries bodies and, or, a performance audit would identify where assistance may benefit improving the regional governance of deepwater resources. This review should identify deepwater fisheries for which there are no management agreements or in management areas where there are no conservation measures to address damage caused by deepwater fishing. Such a review could include:

- identification and documentation of the problems relating to management of deepwater resources under the mandate of the respective fisheries organization
- analysis and documentation of the organization's institutional capabilities and
- documentation of the organization's capacity to undertake management action.

Such a peer review could determine where the need exists to expand the mandates of relevant RFBs to encompass ecosystem-based management of deepwater fisheries. Where new RFBs or arrangements are necessary, the benefits of preparing a handbook that addresses the specific management needs of deepwater fisheries, not least development of appropriate harvesting strategies and documenting relevant information and experiences of existing deepwater management situations. The review should also identify where potential overlap of mandates for management of deepwater resources occurs, either in terms of management areas and, or, of regulated species.

2.3.10 Review of the current legal regulatory framework for deepwater fisheries

Many participants at DEEP SEA 2003 noted that existing arrangements for the governance of deepwater fisheries had often failed to protect the fish resources. Among reasons for this was (a) failure of the 1995 Fish Stocks Agreement to address the conservation and management of discrete high seas fish stocks, (b) the failure of States Party to the 1995 Fish Stocks Agreement to apply it to straddling deep seas fish stocks; (c) the poor implementation and non-specific nature of marine biodiversity obligations that apply on the high seas and (d), the incomplete regulation of deep-sea fisheries at global and regional levels. Thus, a review of the implications and potential for reform of the international legal regime for high seas fisheries was considered to be timely. It was thought that such discussion may offer guidance to States considering possible amendments under the procedure of Article 312 for the 1982 United Nations Convention on the Law of the Sea (UNCLOS) and for the 1995 United Nations Fish Stocks Agreement which is to be reviewed in 2006. Other, perhaps more complex, issues that were also identified as potentially benefiting from analysis and review were (a) means for establishing access rights to deepwater fisheries and how such entitlements may be defined, implemented and amended, (b) ensuring responsible flag state performance, (c) enhancing RFMO capacities to effectively manage deepwater resources and (d), improving enforcement capabilities.

2.3.11 Development of a Code of Practice for management of deepwater fisheries

Given the particular management requirements of deepwater fisheries, many Conference participants believed it would be useful to prepare a management code of conduct for such fisheries. The recommendations as to how these fisheries may be managed should build on the results of the other possible post-Conference activities mentioned above.

Such a code may have to address the differing circumstances affecting governance protocols found within EEZs, those applying to shared stocks, those applying to straddling stocks and those applying to fish stocks found exclusively on the high seas. An issue directly associated with such concerns is the method of setting total allowable catches and procedures for formalizing the management of risk in these procedures. Such a Code should address the operationalizing of Precautionary Approaches to decision making regarding harvesting strategies and decisions in the context of deepwater fisheries.

Conference programme

Sunday 30 November 2003

5.30 to 7.30pm Welcome and registration, Millennium Hotel, Queenstown

Monday 1 December 2003

Time	Session
8.45am	Delegates assemble in Conference Room for the Maori welcome ceremony or <i>powhiri</i> . The <i>powhiri</i> removes the <i>tapu</i> of the <i>Manuhiri</i> (visitors) to make them one with the <i>Tangata Whenua</i> (home people). It is a gradual process of the <i>Manuhiri</i> and the <i>Tangata Whenua</i> coming together.
9:00–10:15am	<p>Powhiri and welcome addresses from:</p> <ul style="list-style-type: none"> • His Worship Clive Geddes – Queenstown Lakes District Mayor • Mr Dave Sharp – New Zealand Seafood Industry Council Ltd • Dr Changchui He – United Nations Food and Agriculture Organisation • Rt. Hon. Damien O'Connor
10:45–12:40pm	<p>Setting the Scene</p> <p>Presentations on perspectives of the major issues facing the governance and management of deep sea fisheries by:</p> <ul style="list-style-type: none"> • Rt Hon Simon Upton – OECD Round Table on Sustainable Development • Mr Alastair Macfarlane – New Zealand Seafood Industry Council Ltd • Mr Matt Gianni – Environmental Consultant • Dr Wendy Craik – Australian Fisheries Management Authority • Mr Michael Lodge – International Seabed Authority • Mr Volker Kuntzsch – Unilever
1:45–3:20pm	<p>Theme 1: Environment, Ecosystem Biology, Habitat and Diversity, Oceanography</p> <p>CHAIR – DR ANDY ROSENBERG – UNIVERSITY OF NEW HAMPSHIRE, USA.</p> <p>Keynote – Dr John Gordon – Environmental and biological aspects of deep-water demersal fishes.</p>



- 3:50–5:00pm
- 1.1 – **Carter, L. & M. Clark** – Form, flow and fisheries – seeking the relationships between bathymetry, oceanography and fisheries.
 - 1.2 **Thresher, R.** – What the coral told us: scales of oceanographic variability relevant to deep water fisheries.
 - 1.3 – **Williams, A., B. Barker, R. Kloser, N. Bax & A. Butler** – A seascape perspective for managing deep-sea habitats.
 - 1.4 – **Uiblien, F., M. Youngbluth, C. Jacoby, F. Pages, M. Picheral & G. Gorsky** – *In situ* observations of deep-water fishes in four canyons off the Georges Bank, NW Atlantic
 - 1.5 – **Belyaev, V.A. & V.B. Darnitsky** – The effect of seamounts and above-water archipelagos on ecosystems of the Pacific Ocean
 - 1.6 – **Bergstad, O. & T. Falkenhaus** – Patterns and processes of the ecosystems of the northern mid-Atlantic (MAR-ECO) – an international census of marine life project on deep sea biodiversity
 - 1.7 – **Yarincik, K.** – The Census of Marine Life: Providing basic science to the user-community
- 5:15 – 6:15pm
- Poster session
- 7:00–10:00pm
- Leave Millennium Hotel for Welcome Dinner at Gibbston Valley Winery hosted by Austral Fisheries Pty, Australia



AUSTRAL FISHERIES PTY. LTD.

Tuesday 2 December

Time

Session



8:30–10:10am

Theme 2:

Population and Resource Assessment

CHAIR – DR JOHN MCKOY – NATIONAL INSTITUTE OF WATER AND ATMOSPHERIC RESEARCH, NEW ZEALAND

Keynote – Dr Andre Punt – The challenges of and future prospects for assessing deep water marine resources: experiences from Australia, New Zealand, South Africa and the United States.

2.1 – Large, P. & O. Bergstad – Deep-water fisheries resources in the Northeast Atlantic: Fisheries, state of knowledge on biology and ecology and recent developments in stock assessment and management.

2.2 – Japp, D. & A. James – Potential exploitable deepwater resources and exploratory

- fishing off the South African coast and the development of the deepwater fishery on the South Madagascar Ridge.
- 10:40–12:00am
- 2.3 – **Clark, M.** – Counting deepwater fish: challenges for estimating the abundance of orange roughy in New Zealand fisheries.
- 2.4 – **Machete, M., R. Ahrens, T. Gomes & G. Menezes** – Modelling the distribution of some fish species in seamounts of the Azores.
- 2.5 – **Clarke, M.** – A life history approach to the assessment of deepwater species in the Northeast Atlantic.
- 2.6 – **De Olivera, E., N. Bez & G. Duhamel** – Local fishing efficiencies estimated from observers' recordings of Patagonian tooth fish.
- 2.7 – **Girad, M., K. Mahe, E. Aubert & A. Biseau** – Preliminary results of a research programme carried out in close collaboration between scientists and fishermen.

1:00–3:00pm

Theme 3:

Harvesting and Conservation Strategies for Resource Management



CHAIR – DR KEITH SAINSBURY – COMMONWEALTH
SCIENTIFIC AND INDUSTRIAL RESEARCH
ORGANISATION, AUSTRALIA

Keynote – Dr Andy Rosenberg – Between the Devil and the Deep Blue Sea – the challenges of managing deep sea living marine resources.

Second Keynote – Mr Simon Cripps – Conservation of deep-sea fish stocks and ecosystems.

- 3.2 – **Butterworth, D. & A. Brandao A.** – Experiences in Southern Africa in the management of deep-sea fisheries
- 3.3 – **Constable, A. & S. Nichol** – CCAMLR: a case study for ecosystem-based management.
- 3.4 – **Francis, C., V. Haist & K. Stokes** – Management strategy evaluation can help fishery managers and industry.
- 3.5 – **Boutillier, J. & G. Gillespie** – combining 2 papers – A phased approach to fishery development in the Deep Sea, and A Case study for Tanner Crab.
- 3.6 – **Rivas, D.** – The challenges for management of the orange roughy fishery in Chile.
- 3.7 – **Gunn, J. & R. Cade** – Ecological risk assessment, New Zealand hoki fishery.
- 3.8 – **Bax, N., R. Tilzey, K. Sainsbury, J. Lyle, T. Smith & S. Wayte** – Deepwater orange roughy fisheries.
- 3:35–4:55pm

- 3.7 – Gunn, J. & R. Cade** – Ecological risk assessment, New Zealand hoki fishery.
- 3.8 – Bax, N., R. Tilzey, K. Sainsbury, J. Lyle, T. Smith & S. Wayte** – Deepwater orange roughy fisheries.

5:00–6:00pm

**Theme 4:
Technology Requirements**

CHAIR – MR IAN KNUCKEY – FISHWELL CONSULTING LTD, AUSTRALIA

- Keynote – Dr Amos Barkai** – Use and abuse of data in fishery management.
- 4.1 – Kloser, R.** – Observation technologies for sustainable deepwater orange roughy fisheries.
- 4.2 – Hampton, I., M. Soule & G. Clement** – Use of commercial vessels for the acoustic estimation of orange roughy biomass on the Chatham Rise, New Zealand.

6:00–7:00

Poster session

7.30–11.30pm

Kiwi Country Night dinner hosted by the Hoki Management Company, Squid Management Company and Orange Roughy Management Company



**Wednesday 3 December
Time**

8:30–10:35am

**Session
Continuation of Theme 4**

- 4.3 – McClatchie, S., R. Coombs, G. Macaulay, A. Dunford & R. Barr** – Review of the recent advances in deep seas fisheries acoustic surveys.
- 4.4 – Segura, M., M. Ramirez, A. Guardia & J. Atiquipa** – Achievements and advances in science through the use of the satellite monitoring technology applied to the industrial fishery in Peru.
- 4.5 – Cryer, M., K. Downing, B. Hartill, J. Drury, H. Armiger, C. Middleton & M. Smith** – Underwater digital photography as a stock assessment tool for *Metanephrops challengeri* on New Zealand's continental slope.

- 4.6 – Trenkel, V. & P. Lorance** – The contribution of visual observations to surveying the deep-sea fish community.
- 4.7 – Thiele, W.** – Technical requirements and prerequisites for deep water trawling.
- 4.8 – Lapshin, O. & V. Korotkov** – The results of deep sea fisheries development in Russia/ USSR and related scientific research.
- 4.9 – Malahoff, A. & C. Kelley** – An overview of research on Hawaiian bottom-fish populations using submersible, ROV and acoustic techniques.
- 11:00–12:30am**
- Report back and discussion.**
 CHAIR – KEVIN STOKES – NEW ZEALAND SEAFOOD INDUSTRY COUNCIL
- **Themes 1-4 – Dr John Gordon, Dr Andre Punt, Dr Andy Rosenberg and Dr George Rose**
 - **Pre-conference meetings in Dunedin:**
 - Artisanal and Small Scale Deepwater Fisheries – Dr Ross Shotton.
 - The Conservation and Management of Deepwater Elasmobranchs – Ms Sarah Fowler.
 - Bioprospecting – Dr Julia Jabour Green.
 - The Assessment and Management of Deepwater Fisheries – Dr Kevin Stokes.
 - CoML Workshop on Seamounts and Undersea Canyons – Dr Karen Stocks.
- 1:30–3:15pm**
- Theme 5: Monitoring, Compliance and Control**
 CHAIR – MR DAVE WOOD – NEW ZEALAND MINISTRY OF FISHERIES.
- Keynote – Mr Stephen Stuart** – Creating and implementing an effective deterrent.
- 5.1(a) – Kuruc, M.** – VMS evidence proves the case in court.
- 5.1(b) – Botwin, B.** – Technology solutions and international opportunities for improved maritime domain awareness.
- 5.2 – Lugten, G., S. Bache & R. Warner** – Prosecuting fisheries law breaches – the "roughly" end of compliance.
- 5.3 – Riddell, A.** – Gearing for optimal compliance at State level.
- Theme 6: Review of Existing Policies and Instruments.**
 CHAIR – DR MARCUS HAWARD – UNIVERSITY OF TASMANIA, AUSTRALIA
- 3:45–5:20pm**
- Theme 6 Keynote – Dr Douglas Johnston**
 – Towards a high seas management regime: Vision and reality.

- 6.1 – Molenaar, E.** – Global, Regional and Unilateral Approaches to Unregulated Deep-Sea Fisheries.
- 6.2 – Hedley, C.** – International law and deep-sea fisheries.
- 6.3 – Sabourenkov, E., D. Miller & D. Ramm** – CCAMLR's approach to managing Antarctic Marine Living Resources

Thursday 4 December
Time

Session

8:30–10:20am

Continuation of Theme 6

- 6.4 – Clarke, M. & K. Patterson** – Deep sea fisheries management: the approach taken by the European Community.
- 6.5 – Serdy, A.** – Schrodinger's TAC – Superposition of alternative catch limits from 2003 under the South Tasman Rise orange roughy arrangement between Australia and New Zealand.
- 6.6 – Wallace, C. & B. Weber** – The devil and the deep sea. Economics, institutions and incentives: the theory and the NZ quota management experience in the deep sea.
- 6.7 – Annala, J., M. Clark, G. Clement & J. Cornelius** – Management of NZ orange roughy fisheries – a deep learning curve.
- 6.8 – Oelofsen, B. & A. Staby** – The Namibian orange roughy fishery: lessons learnt for future management.

11:50–11:30am

Continuation of Theme 6

- 6.9 – Johnston, P. & D. Santillo** – Conservation of seamount ecosystems: application of an MPA concept.
- 6.10 – Verona, C., C. Campagna & J. Croxall** – Sea and Sky: The Patagonian Large Marine Ecosystem Program. Integrating the continental shelf reality with the deep sea potentialities.

11:35–12:30pm

Theme 7: Governance and Management

CHAIR – MR GRANT BRYDEN – NEW ZEALAND
MINISTRY OF FOREIGN AFFAIRS AND TRADE

Keynote – Dr Moritaka Hayashi – Governing Deep Sea Fisheries: Future Options and Challenges.

- 7.1 – Miller, D.** – Conventions and protocols – SEAFO, MHLC and SADC.
- 7.2 – Balton, D.** – Managing living marine resources multilaterally: what works, and what doesn't work.

1:30–3:30pm

- 7.3 – Constable A., C. Davies & A. Williamson** – A future management – can we learn from past mistakes?
- 7.4 – Wallace, C.** – Principles and criteria for management and governance of human impacts on the deep sea.
- 7.5 – Cox, A.** – Subsidies and deep sea fisheries management: policy issues and challenges
- 7.6 – Shotton, R. & M. Haward** – Managing the high seas – requirements for a Global High Seas Fisheries Trust.
- 7.7 – Westberg, A.** – Governance and management of living marine resources and fisheries on the continental slope and in the deep sea – issues and challenges.

4:00–5:15pm

Report Back and Discussion:

•**Themes 5-7 – Mr Marcel Kroese, Prof. Douglas Johnston & Mr Michael Lodge**

WORLD CONFERENCE ON DEEP SEA

FISHERIES – DR ROSS SHOTTON

WORKSHOP ON THE GOVERNANCE OF HIGH SEAS

BIODIVERSITY CONSERVATION – DR JOHN ANNALA

Special COML/OBIS Session – Presentations hosted by COML

5:15–6:30pm

The Census of Marine Life and the Ocean

Bio-geographic Information System:

Collecting and serving data on the diversity, distribution and abundance of marine life

1. Census of Marine Life: Overview of research and global partnership – K. Yarincik
2. A Demonstration of the Ocean Biogeographic Information System – K. Stocks
3. Biodiversity of seamounts: A global field project – K. Stocks
4. Life on the Mid-Atlantic Ridge: First Views from the Mir Submersible Dives – M. Vecchione
5. History of Marine Animal Populations – A. Rosenberg

Friday 5 December
Time

Session

9:00–10:30am

The Way Ahead

CHAIR – DR ROSS SHOTTON – UNITED NATIONS FOOD AND AGRICULTURE ORGANISATION

Perspectives panel session:

DR MIKE SISENwine – NOAA FISHERIES, USA

DR CARLOS VERONA – WILDLIFE CONSERVATION

SOCIETY CONSULTANT, ARGENTINA

DR DENZIL MILLER – CCAMLR

11:00–12:00pm	MR GEOFFREY RICHARDSON – AFMA, AUSTRALIA MR MICHAEL LODGE – INTERNATIONAL SEABED AUTHORITY MS KRISTINA GJERDE – IUCN PROF. MORITAKA HAYASHI – WASEDA UNIVERSITY, JAPAN MR MARTIN EXEL – AUSTRAL FISHERIES PTY LTD, AUSTRALIA MR DAVID SHARP – NEW ZEALAND SEAFOOD FISHING INDUSTRY COUNCIL QUESTION AND ANSWER / DISCUSSION
12:00–12:30pm	Conference Synthesis: The Future and Closure Rt Hon Pete Hodgson – New Zealand Minister of Fisheries address

Welcome addresses

Hon. D. O'Connor

Minister for Racing

Associate Minister of Agriculture, Associate Minister for Rural Affairs,

Associate Minister of Immigration and Associate Minister of Health

New Zealand Parliament

Bowen House, Lambton Quay, Wellington, New Zealand

<gjp@sealord.co.nz>

Ladies and gentlemen, it gives me great pleasure to welcome you all to New Zealand and to the Deep Sea 2003 Conference.

I extend a special welcome to Dr He Changchui, FAO Regional Director for Asia, and the Right Honourable Simon Upton, Chair of the OECD Round Table on Sustainability. I trust that your time at the conference will be interesting, challenging and productive. I hope that you will also take some time to enjoy what this country – and particularly the Central Otago region – has to offer. With the world premiere of the film *The Return of the King* occurring today in Wellington, it is perhaps also appropriate to welcome you to Middle Earth. Many of the scenes in the *Lord of the Rings* trilogy were filmed in this region.

The Minister of Fisheries, Hon Pete Hodgson, has been closely involved with recent Government efforts to promote New Zealand's screen industry and our news media has dubbed him the Minister for The Lord of the Rings. He is on *Lord of the Rings* duty in Wellington today and has asked me to present this opening address on his behalf. However, Pete will be participating in the final two days of your conference and I know he is looking forward to interacting with you on the conference themes.

This conference comes at an important time for the management of deep-sea fisheries. Over the last few decades, there has been considerable progress in the management of fisheries – both within areas of national jurisdiction and in high-seas areas.

The United Nations Convention on the Law of the Sea has been in operation for over three decades, the FAO Code of Conduct for Responsible Fishing has been adopted, the UN Fish Stocks Agreement has come into effect, and an increasing number of regional fisheries agreements are either in place or under development. There have also been a number of agreements reached in the wider environmental field, some of which set targets for protection and sustainable management of marine fisheries.

But for all this progress, many of the world's fisheries are in poor shape and the prognosis is not good – especially for fisheries in high-seas areas and particularly deep-sea fisheries. We need to do much more if we want to enjoy the benefits these fisheries can provide and hand them on to our children in reasonable shape.

This conference is a forum for expert and technical consultation, for specialists to discuss freely the problems of managing deep-sea fisheries and the options for addressing them. I encourage you to put aside national perspectives and work to develop solutions that are relevant and workable across a broad range of fisheries.

There will be no negotiated conference communiqué. Instead, a report summarizing the conference sessions and discussions will be prepared by the organizing committee and presented to the FAO Committee on Fisheries¹. The results of the conference will

also contribute to the first review of the United Nations Convention on the Law of the Sea, expected to begin in 2005 and will undoubtedly be used by national and regional fisheries management organizations.

New Zealand's Minister of Fisheries, like many others, must frequently make decisions on issues related to deep-sea fisheries and therefore has a very real interest in the results of this conference and how they will be put into effect. On his behalf I would like to set out some specific challenges for conference participants. Most of the challenges are directed to a particular fisheries discipline, but are relevant, to some extent, to all disciplines and interests represented here.

The first challenge is to all conference participants. Management of deep-sea fisheries is so complex that only the commitment and cooperation of experts in a range of disciplines will make successful management possible. If ever there was an issue where a genuine multi-stakeholder approach is required, this is it.

Each of you represents a discipline that has a major contribution to make in managing deep-sea fisheries. But without contributions from the other disciplines, your efforts will be in vain. So I encourage you to acknowledge the importance of other disciplines, listen to each other, and work together to identify issues and solutions.

I want to offer two challenges to scientists: to develop more effective ways of providing the information necessary for managing deep-sea fisheries, and to maintain your independence. Deep-sea fisheries present us with major scientific challenges. We have limited information; obtaining information is often expensive; species may be long-lived; and environmental effects of fishing may take a long time to reverse.

In response to these challenges, I encourage you to consider how new technologies can be harnessed to provide the information we need at reasonable cost. How can you cooperate with the industry to obtain information from fishing operations in a cost-effective manner? What new models can you develop that function effectively with limited information? How can you cooperate with scientists from other countries to obtain necessary information?

A scientist's greatest tool is objectivity, the expression of findings or opinions according to some scientific methodology. That's how science presents itself as independent and disinterested. But that independence can be easily lost if scientists then become involved in advocacy. Every scientist has a right to lobby. But they should do so with a professional detachment, because that is how they will make their most powerful contribution.

I want to challenge fisheries managers to do more to develop effective governance arrangements for deep-sea fisheries – especially those in high-seas areas. We need governance arrangements that will ensure deep-sea fish stocks are harvested in a sustainable manner, that will protect the marine environment, and that will allow us to maximize the value we obtain from these fisheries. This is a significant challenge within each country's fisheries jurisdiction. It is a daunting challenge for deep-sea fisheries in high-seas areas.

In recent years, New Zealand has shared in some of the successes of cooperative management of deep-sea fisheries in high-seas areas. We have experienced some of the frustrations too. We have worked with other countries to improve management of deep-sea fisheries in the Pacific, Antarctic and Southwest Indian Oceans. But our efforts have been hampered by the lack of the sort of detailed international legal framework that exists for highly migratory and straddling fish stocks.

For some deep-sea fisheries there are no regional management agreements in place, nor any prospect of reaching an agreement. Even for fisheries where there is an agreement in place, companies from signatory countries can avoid their obligations by re-flagging in countries that are not signatories.

¹FAO. 2005. Report of the twenty-fifth session of the Committee on Fisheries. Rome, 7–11 March 2005. *FAO Fisheries Report*. No. 780. Rome. FAO. 88p.

IUU fishing also undermines the effectiveness of management under these agreements. These and other shortcomings in the governance of high seas fisheries remain a major challenge to achieving effective and sustainable management of deep-sea fisheries.

I have two challenges now for environmental NGOs: to maintain your credibility by using accurate information and to give credit where it is due. Environmental NGOs play important roles in the management of deep-sea fisheries. In particular, they give a voice to many members of our society who want the marine environment protected from adverse effects of fishing – and they often do so on meagre resources.

However, when NGOs present incomplete or incorrect information, they can end up working against themselves. An example is the consumer choice cards used to help consumers avoid products from unsustainable fisheries. Classifying all products from a particular species as “bad” or “unsustainable” simply is not good enough. It is misleading. It might highlight the poor management in some fisheries for that species. But it does little to reward or encourage those fishers operating in sustainable fisheries for that same species elsewhere.

I also want to challenge NGOs about their mode of operation. Environmental NGOs can work against industries and governments to raise awareness of issues and they can work with industries and governments to develop solutions. Both are important and I think both should be deployed, depending on the issue. Unfortunately, some NGOs over-use the first, oppositional mode of operation. The result is that they are seen less as fair critics of a decision than as reliable pessimists. The response from other stakeholders is often antagonistic. Far better, surely, to deploy the twin tools of credit where it is due and criticism where it is deserved. My main challenge to industry is to accept the obligations that go with the right to harvest fish – especially the environmental obligations.

Increasingly, the public is demanding higher standards of environmental performance. The New Zealand Government – among others – believes that protecting the health of the natural environment is a very important part of sustainable development. In the same way that you have to live with increasing product quality standards you should expect higher environmental performance standards. In part, these higher standards are a result of our rapidly increasing knowledge in this area. Until recently, the deep-sea environment and the environmental effects of deep-sea fishing have been largely invisible. New technologies now provide a window on this environment.

An example of such environmental research is provided by the recent New Zealand and Australian research expedition to the Tasman Sea. This two-week expedition resulted in the identification of at least 100 unrecognized fish species and 1 300 invertebrate species. If this number of new species can be found in a two-week expedition, one can only guess how many species – potentially vulnerable to the effects of fishing – remain to be identified.

It is pleasing to see industry involvement in a number of initiatives designed to improve environmental performance. I want to highlight two. The Hoki Fishery Management Company has worked hard to meet the requirements of the fishery's Marine Stewardship Council certification – after what was, in my view, a hesitant start. This shows the positive marketing results that can be achieved by managing fisheries sustainably. I understand that a number of other deep-sea fisheries are working towards MSC certification. I wish them well and I gently remind them that in this area, short cuts can end up taking longer.

Then there is seabird bycatch, in this the seabird capital of the world. Through Southern Seabird Solutions, industry, environmental NGOs, and government are working cooperatively to develop an innovative programme promoting fishing practices both in New Zealand and overseas that will drive that bycatch down.

Leading by example and highlighting good practices is a positive way to encourage change. The New Zealand Government is prepared to implement a comprehensive regulatory approach to seabird protection if the cooperative approach fails. In my view it will not fail.

I am sure there are similar initiatives in the countries represented at this conference and it is important to highlight examples of best practice. But my impression is that a lot more needs to be done to manage the environmental effects of deep-sea fishing.

So my challenge to industry is to work with governments and stakeholders to find optimal ways of achieving necessary environmental standards. I urge you not to re-flag your vessels to avoid your environmental obligations.

I also urge you to recognize the important roles that environmental NGOs play in managing deep-sea fisheries. Develop constructive relationships with those environmental NGOs that are willing to work with you. Involve them in your planning, listen to their concerns. There will be difficulties and you will not always agree. But you will gain a better understanding of their concerns, the public's concerns and the steps you can take to address them.

My final challenges are for decision-makers, myself included. There are a number of areas of fisheries management in which we are not doing a good job. I want to highlight three. First, we do not do a good job of involving stakeholders in the decision-making process. Intuitively, decision-makers do not want to involve stakeholders because it involves power-sharing – something that does not come easily. But effective involvement of all those with a genuine interest in a decision will lead to better decisions – and, importantly, better implementation.

Second, we should do more to consider the wider effects of our decisions. For example, it is easy to reduce fishing effort in fisheries under our jurisdiction by transferring it somewhere else. When that “somewhere else” is a country or high-seas area where overfishing is already a problem, or where environmental standards are lax, we have not solved the problem – we have merely displaced it. We should try to avoid exporting our problems.

The most important challenge for fisheries decision-makers – and my last for today – is to make decisions rather than postpone them. It is too easy to defer decisions when we want more information. But for many areas of fisheries management there will always be less information than we want. We should remember that, in many situations, waiting may ultimately make it impossible to make a good decision. The perfect is the enemy of the good.

This conference is ideally placed to help develop innovative solutions to the difficulties we face in managing deep-sea fisheries. The challenges are clear. The time to address them is right. Together, you have the knowledge and expertise needed to make progress. I wish you well in your endeavours.

He Changchui

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It is a special privilege for me to be here today to address the opening session of the Deep-Sea 2003 International Conference held in Queenstown, New Zealand. On behalf of Jacques Diouf, Director-General of the Food and Agriculture Organization of the United Nations (FAO), I would like to thank the government of New Zealand for inviting FAO to attend the conference. Indeed, we are extremely pleased to collaborate with the Ministry of Fisheries, New Zealand and the Department of Agriculture, Fisheries and Forestry, Australia in convening this important international event.

As the Assistant Director-General of the FAO Regional Office of Asia and the Pacific, I am particularly pleased that this important conference is held in the Pacific. Indeed the Asia-Pacific region is the largest fish producer in the world. Based on current FAO statistics, the region accounts for 43 percent of the world's capture fisheries production and 86 percent of the aquaculture production in 2001. Several recent studies have shown that these statistics, in fact, underestimate the importance of small scale fisheries in the region – especially fish coming from the vast inland waters of Asia –although production from some other fisheries may be over-stated.

The total value of the combined national exports of fish and fish products from developing countries in the region amounts to nearly \$US 17 thousand million, targeting markets in Europe, Japan and the USA. The fisheries sector in the region employs over 85 percent of the world's fishers and millions of families are dependent on fish and fishery products for their livelihoods, both as a source of animal protein and overall food security, as well as for income and livelihood security.

In a recent FAO publication, trends in catches of deep-water species were analyzed at the global level and by FAO Fishing Area. Whereas in the late 1970s annual deep-water catches amounted to little more than one million tonnes, in each of the four latest years (1998–2001) for which FAO data are available, catches have reached over 2.8 million tonnes with a maximum of 3.25 million tonnes in 2001. The quantities caught in recent years represent over 3 percent of the global marine catches and about one third of the total catches of species that were classified as oceanic, whether epipelagic or deep-water.

FAO leads the international effort to fight against hunger. It does this through sharing and making information and policy expertise that facilitates sustainable development accessible to all. The Organization also provides a neutral forum for nations to meet and build common understanding of major issues facing nations in building a world with food security. FAO works on behalf of its members – more than 180 – and collaborates and cooperates with thousands of partners world-wide to meet its strategic goals, also testing its knowledge through thousands of field projects right across the world.

In the field of fisheries, in addition to numerous technical cooperation programmes, FAO promotes the implementation of the Code of Conduct for Responsible Fisheries that was adopted by members in 1995. The code is an international instrument that

sets out the principles and international standards of behaviour to ensure sustainable development of fisheries and aquaculture. In support of the code, FAO has published a series of technical guidelines and has facilitated the development of a number of important International Plans of Action, including a plan to deter and eliminate illegal, unreported and unregulated fishing (IUU) and a plan to manage excess fishing capacity.

An underlying principle of the code and of particular relevance to this conference is that, although the world's oceans cover 70 percent of the globe, their resources are limited. FAO's latest assessment on the status of the world's fisheries reveals that about half of the world's marine fisheries are already fully fished – there is no room for further production increases. Another 25 percent are overfished – meaning that their potential yields and economic benefits are not fully realized. It is on this assessment that we must focus our efforts for deep-sea fisheries and their future during this conference.

The deep-sea resources are often seen as the last frontier of fisheries development. However, this is rather an unfortunate term since it gives the impression of vast untapped resources awaiting exploitation. It also paints a picture that it is only a matter of time until these resources also become depleted as fisheries expand its area of operations. It should also be kept in mind that various technological developments are making these resources ever more accessible for fishing activities even at great depths.

This scenario underlines the need to learn from past mistakes of uncontrolled fleet expansion, open access to fishing grounds and, in particular, the general lack of specific fishing rights. There is now sufficient collective wisdom and experience to ensure that we do not make the same mistakes that were made in the past. In this regard, the last frontier could be the turning point in fisheries development and management.

To resort to drastic measures, such as banning all fishing in these waters, would be excessive, unwarranted and, in the end, counterproductive. It is possible to fish sustainably, provided lessons of the past are heeded and addressed.

How to achieve this sustainable development through better fisheries management in the deep seas is, I hope, the outcome of this meeting – an outcome that will be very important to the future management of the world's fisheries resources. I am pleased to see so many experts and interested parties here in this wonderful part of the world and I wish the conference every success. To achieve this outcome, participants must be willing to share their experiences on the current status of the world's deep-sea resources, the best available information on their future potential and our collective understanding of the impacts of fishing on both the fish resources and their supporting ecosystems.

Before concluding, I should like to stress that FAO offers a neutral forum for open and informed debate on fisheries analysis, assessment and planning. It will work together with its many partners to ensure that the principles of the Code of Conduct for Responsible Fisheries can be implemented effectively for deep-sea fisheries. That is how the fisheries sector can best contribute to and cooperate with development partners such as FAO for food security and balanced nutrition.

I wish you a successful conference.

Thank you.

Setting the scene

Keynote address

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1. BACKGROUND

I want to talk today about illegal, unreported and unregulated fishing – IUU fishing – on the high seas and what might be done about it. When a problem attracts an acronym like this you know it has become institutionalized. And when the key words of the acronym are pregnant with legal significance you know it is an institutional minefield.

In a sense, there is nothing new to say about IUU fishing. This term of art in international maritime law circles continues to attract a gathering tidal wave of articles explaining the legal complexities in response to an ever-widening circle of negotiated ‘solutions’. I do not wish to rehearse the legal position in detail – I have done so in a paper I co-authored earlier this year for a meeting of the OECD Round Table on Sustainable Development that we convened to examine the problem (Upton and Vitalis 2003).

Laid out in our paper you will find, in loving detail, all you need to know about the contested boundaries of flag-state responsibilities, of port state possibilities and trade-related counter-measures. I do not make light of the complex legal setting in which high-seas fishing is conducted – the detail is important and I think, as a layperson, that I have as good a grasp of it as anyone. What I want to do in this paper is presume that the complexities are understood, but set them to one side for a moment and try to concentrate on the big picture in non-technical language.

Twenty years ago, the world community finalized the Law of the Sea. It was a mammoth undertaking, and one whose ratification by member states is still a work in progress. Not surprisingly, it has not been amended. To talk of doing so in the presence of those who painstakingly brought it into life is regarded as heresy. And in a world where multi-lateral solutions look, to say the least, no easier to negotiate, there are clearly powerful arguments against disturbing a status quo that has barely crystallized.

But if the Law of the Sea remains unamended, activity to strengthen the legal regime governing high-seas fishing has been unrelenting. The persistence of IUU fishing is certainly not a reflection of diplomatic lethargy. The last 10 years has seen an almost frenzied level of treaty-writing. Few areas of multi-lateral activity have seen so many closely related and sometimes overlapping initiatives pursued in quick succession. Negotiators have not been sitting on their hands.

Whether we are making progress is another matter. The level of activity may reflect, to some extent, shortcomings both in the strength of the legal norms that govern the global ocean commons and in the ability of multilateral processes to secure genuinely comprehensive sign-up. The complex and evolving web of binding and non-binding international instruments has undoubtedly changed the nature and the location of grossly unsustainable high-seas fishing. But it has not stopped it. Each new intervention potentially moves the problem somewhere else. And, there is no globally enforceable regime at this point that can put an end to the practice. We have instead a patchwork quilt of measures with differing geographical and legal reach.

The way forward will no doubt involve further complicated efforts to improve that reach and coverage. But before we lose ourselves in that complexity it is worth spelling out the tensions that have been internalized in the Law of the Sea. There are two universal premises that underlie the way UNCLOS deals with the high seas. One is the age-old doctrine of the freedom of the high seas, which has formed the basis of the law of the sea for more than 300 years and embodies the notion of open access to common resources that are beyond the jurisdiction and control of individual states. This is reflected in the solemn insistence that the high seas are immune from sovereign claims¹.

But the fact that sovereign claims will not be recognized does not mean the high seas are a sovereignty-free zone. This brings us to the second universal premise: that flags on boats create pockets of mobile sovereignty that attract all the immunities necessary to prevent the unwanted attentions of other flag states or inter-state organizations².

Put these two premises together and you have, in reality, a legal framework that erects a veil of sovereignty around fishing vessels which makes the enforcement of any internationally agreed rules dependent on the good will and resources of the flag state. All of the legal rules subsequently elaborated in FAO and UN instruments, which seek to spell out flag-state responsibilities and allow other states to intervene, are subject to these umbrella conditions. The veil of sovereignty conferred by flag status can only be legally pierced through the express consent of the flag state.

The result? Flag states that having no serious intention of enforcing whatever obligations they have undertaken, maintain an effective immunity for IUU fishing. It does not really matter whether or not they have gone beyond the Law of the Sea's relatively general provisions on the conservation of marine resources; if there is no intention or ability to enforce, IUU fishing will continue unimpeded.

Articles 116–120 of the Law of the Sea provide a perfectly adequate basis for action on the part of states that have a serious intention to halt bad fishing practices. While the FAO Compliance Agreement and the UN Fish Stocks Agreement undoubtedly create more exacting responsibilities and enhance the ability of responsible nations to make IUU fishing by others more difficult, they are in a sense speaking only to the converted, because it is not states but boats that go fishing. And in the absence of effective enforcement by flag states – never an easy task even for wealthy states who have signed the binding legal instruments – good intentions will remain just that. Besides, the hard fact of international law remains that if a boat flies the flag of a state that has not signed any of the legally binding conventions, other states have no legal basis to interfere with that vessel under those conventions.

All treaties subsequent to the Law of the Sea have been negotiated without prejudice to the veil of sovereignty in which it cloaks all flagged vessels. In short, there is some IUU fishing that, while being unregulated and unreported, is not, under international law, illegal. And it is that residual 'legality' that poses so many enforcement problems.

It is for that reason that I remain sceptical of the efficacy of trying to bring pressure to bear through the elaboration of increasingly detailed non-binding documents such as codes of conduct and plans of action. We run the risk of believing that texts are a substitute for action. Similarly, while further strengthening the resolve and coverage of regional fisheries organisations is clearly a priority, it can only take us so far. These measures, taken under the aegis either of UNCLOS or the more specific provisions of the 1995 UN Fish Stocks Convention, are all being pursued alongside vessels whose flags are those of states who (either explicitly or implicitly) exercise their right to authorize fishing on the high seas but choose not to enter into, and be bound by, conservation measures and/or enforce them.

¹UN Convention on the Law of the Sea, Article 89.

²Article 91 makes it clear that ships take the nationality of the flag they are entitled to fly and it is up to the flag state to impose any conditions on the right to fly its flag.

The search for points of leverage against IUU fishing proceeds against the reality that international law has underlined the status of the high seas as a global common to which individual sovereign states have been universally assigned access together with national responsibility for enforcement. At the same time, attempts to avert a 'tragedy' in that common (the rape of its fish stocks) have of necessity been conceived as regional co-operative initiatives between those who choose to join them. The challenge is to bring into some sensible relationship a top-down assertion of rights with a bottom-up attempt at management for the collective good before virtually all international fish stocks are depleted.

At the end of the day, as long as the world is not prepared to lift the veil of flag-state sovereignty and enquire into the effectiveness of the links that bind ships to states charged with requiring that they meet certain standards, we will fight IUU fishing with one hand tied firmly behind our backs. Most of our citizens would be amazed to learn that the Law of the Sea gives nations the right to intercept, on the high seas, boats that are engaged in unauthorized broadcasting, but not boats that are fishing in a way that is undermining the conservation of marine resources because they are theoretically under the control of a negligent flag state. I wanted to state that bluntly, because from time to time someone should, just to maintain a link with reality.

On the other hand, an equally realistic assessment would conclude that further modifying sovereign rights by treaty is not going to happen in a hurry. And it would be a mistake to see IUU fishing purely through a legalistic lens. The reality is that even within the inadequacies of current legal arrangements, there are a host of issues that can be progressed. These range across fields as distinct as trade measures to limiting market access for IUU product, the removal of subsidies for ship construction and the sharing of information between States and regional organizations that can improve enforcement and interception. In fact it is the sheer multi-faceted nature of the issue that frequently bewilders observers. Just where should the next step be taken? Which actions would secure the most leverage in trying to suppress IUU fishing? How could any campaign secure a co-ordinated response by agencies at global and regional levels that are responsible for just a part of the picture? Even if every country solemnly signed up to all the available conventions, how many would have the resources to carry out their responsibilities?

These were some of the issues, alongside the legal ones, we discussed in June at the OECD Round Table on Sustainable Development. It was an extraordinarily interesting meeting conducted under Chatham House rules with the full range of inter-governmental, commercial and NGO players present together with many Ministers of Fisheries. One thing became very clear; no single agency at any level is responsible for assembling all the pieces of the jigsaw. Despite the protestations of agencies like the FAO, the IMO and the UN Division for Ocean Affairs and the Law of the Sea, each has its own sphere of authority with limited ability to coordinate across boundary lines. There is nothing new in that – it mirrors the difficulties most countries experience domestically. IUU fishing may be an unambiguous source of concern to a fisheries ministry. But its relative importance to the government's legal advisers, its trade negotiators, its border protection services and (in the case of rich countries) development assistance agencies, is another matter.

Perhaps it was frustration with the fragmented treatment of IUU fishing that was one of the factors that lead the Ministers who attended the June meeting to promote and lead a Task Force that will, for the first time, seek to draw together in one piece of analysis, all the threads – legal, economic, technical and scientific – and propose a full menu of prioritized actions. The OECD Round Table has agreed to host the Task Force and I will be working with Ministers and some key stakeholders drawn from enforcement, academia, industry and conservation groups to generate some conclusions within 18–24 months.

I will shortly invite the Chairman of the Task Force, Rt Hon Elliot Morley, to provide a view from the top, but before he does let me just say a little about the potential significance of this initiative. You could be forgiven for saying – “not another task force” or “not another committee”, and the onus will be on us surprise you. But I want to suggest to you that this is a novel way of trying to advance a major international issue.

I have, over the last decade or so, had considerable exposure to the pace and ambition of international diplomacy on environmental issues. There is no shortage of declarations. But real progress is harder to come by. In truth, we have probably had far more grandiose ideas about what could be achieved through international negotiating processes than was ever realistic. Trying to bring the world on board is a daunting business and often means moving at the pace of the slowest and most sceptical party. Where there is doubt or uncertainty, or the stakes are enormous, that may be no bad thing. But if reluctance is allowed to mask outright neglect, then there is surely room for those who seek to make the case to move faster. International negotiations have a tendency to fall into comfortable rhythms, to become institutionalized. From time to time there is a need to reinvigorate them. And that does not have to be done from inside.

That is what is different about the Task Force we are announcing today. Despite endless international gatherings solemnly declaring that there is a need for ‘stronger political commitment’ on many issues on the sustainable development agenda, I am not aware of anyone being prepared to provide it. By taking an all-encompassing and strategic level brief that is not limited by institutional or disciplinary boundaries, Ministers are hoping to provide some focus to a critical global issue that suffers from a sprawling and unfocussed agenda. The active engagement of current Ministers who hold a warrant from their respective governments is almost without precedent. It is also a very direct and courageous reply to those who call for more “political will”.

Today we have five Ministers – Elliot Morley, M.P. (Minister for Environment and Agri-Environment, United Kingdom), Senator Ian Macdonald (Ministry for Fisheries, Forestry and Conservation, Australia), H.E. Undersecretary Felipe Sandoval (Subsecretaria de Pesca, Chile), Hon. David Benson-Pope (Minister of Fisheries, New Zealand), Dr Abraham Iyambo (Minister of Fisheries and Marine Resources, Namibia) – who want to take the lead in fostering the political will that so many people talk about. Wisely, these Ministers do not simply want to make some statements which can be dismissed as rhetoric. They want to know that the solutions they propose are practical and able to win, in due course, wide international endorsement. It will be my job to assemble a small team to provide them with the raw material they need. My ambitions are very simple: to produce an analysis of the issue that becomes the single point of reference for anyone wanting to enter the debate on IUU fishing in the future; and place the members of this Task Force in a position to engage their counterparts directly and personally on the basis of the best analysis available.

This is, if you like, a coalition of the willing. It is not a substitute for comprehensive multilateral action and it does not seek to undermine inter-governmental negotiations. These will continue in their own inimitable fashion and to their own timetables. Rather, the Task Force will be seeking to assist those processes through fresh analysis and committed leadership.

2. LITERATURE CITED

Upton, S. & V. Vitalis 2003. Stopping the High Seas Robbers: Coming to Grips with Illegal, Unregulated and Unreported Fishing on the High Seas, OECD Round Table on Sustainable Development.

Not IUU but LRR – a commercial fishing industry perspective

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1. BACKGROUND TO THE BUSINESS

Business requires profits to be sustainable. Risky business requires a profit premium to reward the risk. If an appropriate reward for risk (including a capacity to sustain anticipated failures) cannot be obtained, the business ends – one hopes before it collapses. For low-risk businesses – like selling infrastructure (roads, power, water) – a little profit all the time is good enough. For high risk businesses (developing new drugs, or exploring for undiscovered natural resources) – a large profit must be made each time the business succeeds in order to offset the frequent failures along the way. The less frequently reliable the profit reward is, the higher the profit must be when it does come. The riskiest businesses are criminal. Profits must be sky high, because the consequences of getting caught are oppositely devastating.

Moving into deep-sea based fisheries has been a natural progression over the last forty years arising from the desire to find better profits than those achievable from known fishing activities – or other business opportunities available for the capital. The risks have been, and are, many and varied, especially at the developmental stage. Overcoming the challenges have included identifying potential habitat, adapting and developing vessels, gear and skills to suit new habitats and be successful with new target species, identifying the marketable attributes of the new fish species that appear to have commercial potential, and finding customers and developing sustainable market demand for the new fish. All of these activities involve risk taking and the risks have on occasion been rewarded in new and profitable businesses. It is that record of commercial success that has brought us here this week.

Without orange roughy, oreo dories, toothfish, redfish, cardinal and really only a handful of other commercially valuable deep-sea fish, the exploration of the deep ocean would be much less advanced than it is today. It might otherwise simply be an interesting cul-de-sac of marine science, perhaps made occasionally accessible to the public by the likes of National Geographic or the Discovery Channel telling stories about Weird Fish.

We may still be at the beginning stage of exploring deep-ocean biodiversity, but I suggest (boldly) that we now know quite a lot about the prospects for commercially interesting deep-sea fishing, at least for fish that people are not only going to eat, but pay premium prices for, because of their superior eating qualities.

There may yet be other stocks of fish at even greater depths, but there is little evidence to suggest that those fish will be attractive for sale as food. The challenge for the future therefore is to make the deep-sea fisheries that we have identified into steady, sustainable businesses. That requires identifying and managing the risks facing, and even created by, fishing so that the resulting businesses can deliver sustainable and

long term production, satisfy a steady and reliable customer base and secure acceptable profits for long term investors.

In so doing, the risk profile of the business will be reduced and thus seeking high profit rewards would be overtaken by aspirations of steady profit. Primary among the risks to manage is the risk of depletion. Allocation and defence of secure rights to access the fisheries resources is a key tool for managing such risks.

Contrary to some of the recent statements by preservationist interest groups, deep-sea fisheries can be, and are being, managed sustainably. But at present these successes are all within or related to EEZs. This is hardly surprising as the mechanisms to secure and defend access rights in the high seas have yet to be developed and implemented.

2. WHAT HAS HAPPENED TO FREEDOM OF THE HIGH SEAS?

2.1 A geographic view

By displaying a globe, one can overcome the visual distortion of two dimensional map projections. Overlaid on the oceans are:

- The depth contour lines at 500, 1 000 and 1 500 metres
- The coastal state's EEZs
- The boundaries of in-force regional fishery management agreements (RFMAs) or other international agreements that affect fisheries, and
- The boundaries of proposed RFMAs.

The conclusion that one can draw from this visual display is that most of the potentially fishable deep-sea area is inside EEZs. Areas in the open oceans beyond the major continental shelf areas of the southern hemisphere are small and scattered. Many of these are also already within the boundaries of existing EEZs. The remainder are high-seas based. But some already fall, or will fall, within the boundaries of current or proposed demersal RFMAs.

2.2 A legal view

The freedom of the high seas for fishing is now a myth for vessels operating under the authority of responsible flag states. The post-UNCED Agenda 21 process of the last decade has seen to that with the development of new international law that transforms the optimistic hopes of UNCLOS III into binding measures. The key instruments are the *FAO's Compliance Agreement* and the *UN Fish Stocks Agreement*.

An example of the effect of this regulatory change on fishing operators is the outcome of a recent case of a New Zealand registered vessel that failed to obtain a high-seas permit and then landed rock lobsters trawled from a mid-ocean seamount when it returned to New Zealand. The crime was failing to obtain a high-seas permit as New Zealand is fully reflecting its international obligations in its domestic fisheries law. It was thus found to have been fishing illegally. The high-seas area fished was not subject to any agreement, at least as far as taking rock lobsters is concerned – so the fishery itself was unregulated. So in this case there was no crime in that. The vessel operator on coming into New Zealand port reported its catch and sought to discharge – so in this case the catch was reported. Fines totalling more than \$12 000 were imposed, and the vessel and catch with a combined value of \$160 000 were forfeited to the Crown.

3. CONVENTIONS THAT COUNT

3.1 United Nations Convention on the Law of the Sea

The 1982 United Nations Convention on the Law of the Sea (LOSC) now has 143 adherent parties. The USA is not one of them, although it is a party to other conventions that draw their authority from the LOSC. The LOSC provides the legal basis for Exclusive Economic Zones. In fisheries terms, the strength of the LOSC is its success in enabling coastal states, in particular, to define interests in spatial terms out to 200 miles. the LOSC has provided coastal states with a robust, prior exclusive

legal right to harvest living marine resources in return for exercising management responsibility.

The LOSC confirms a fundamental freedom to use the resources of the high seas. The limits on that freedom are weak. It sets a limited baseline requirement for states, on their own responsibility, to act responsibly and to co-operate with others in the management and utilisation of resources in the high seas. Through that obligation to co-operate, the LOSC indicates that the formation of regional agreements among states may be pursued to bring about sustainable fishery use. But the LOSC provides little basis other than altruism for states to exercise their obligations to act responsibly and cooperate one with another. The LOSC does not enable states as of right to obtain any allocation of secure interest in high-seas resources in return for exercising responsibility. The “tragedy of the commons” has demonstrated time and again the in-built certainty of failure when a right to access a common resource is not accompanied by a right to acquire a defined interest in that resource.

But the LOSC’s limited obligation on states to cooperate has nonetheless provided a legal basis for the formation of several regional fisheries arrangements concentrating on highly migratory stocks or in areas where the group of interested states were relatively self evident. Some RFMAs have consequently made allocations of catch opportunity for some fish stocks among their members.

Subsequent to the LOSC, United Nations members have sought ways to address the shortcomings of the high-seas elements of the LOSC. The two Conventions noted above, negotiated in the mid-1990s to address elements of the problem, have only recently come into force. Both were negotiated to finality within a short space of time following the conclusion of UNCED Agenda 21 process in the earlier 1990s. But both then appeared to struggle to obtain the minimum number of adherents to bring them into force. While now in force, both continue to lack the mass of support that the LOSC has, and their global effectiveness may be questioned as a consequence.

3.2 FAO Compliance Agreement

The FAO Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the high seas was approved in November 1993, but only came into force with the receipt of the 25th instrument of acceptance on 24 April 2003. The 26 parties include European Union, Japan, Norway, USA, Argentina, Canada, Mexico, Morocco, Namibia, Peru and Uruguay as parties with significant fisheries interests. Several other significant distant water fishing nations (DWFNs) are not parties. New Zealand also is not a party, but the *New Zealand 1996 Fisheries Act* imposes the disciplines required by the convention on New Zealand vessels and nationals.

3.3 UN Fish Stocks Agreement

The Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks came into force in December 2001 with the deposition of the 30th instrument of ratification. Since then the Convention has grown by a further six parties.

The states with significant distant water fishing interests, or aspirations in that direction, that are party to the Agreement include Ukraine, New Zealand, Brazil, Australia, Uruguay, Canada, Russian Federation, Iceland, Norway, Namibia, South Africa and USA. No Asian states apart from India, Sri Lanka and the Maldives, no European Union member state and, apart from Uruguay and Brazil, no countries from Latin America have yet ratified. The Convention is notable for the number of Pacific Island and other small island coastal states that have ratified. It may be surmised that coastal states, especially those whose EEZs form part of the migratory routes for highly migratory stocks, see advantages in adhering to a

convention that provides strong capacity for such states to assert interests in those stocks. DWFNs that catch most of the migratory fish appear to remain uncommitted.

3.4 Commercial implications

The outcome of the last ten years of review and updating of the international legal framework is the creation of binding obligations on adherents. The obligation of the LOSC on states to co-operate has been strengthened by the Compliance Agreement, which defines the responsibilities of flag states and elucidating what is meant by co-operation in the high seas. In the Fish Stocks Agreement a strengthened legal basis is provided for Regional Arrangements between DWFNs and coastal states to co-operate in the allocation of interest in, and management of, shared fish stocks.

For fishing enterprises registered with states that have ratified either or both Agreements, their activities must be expressly permitted by their authorities. They are subject to requirements to record and report fishing activity to those authorities and are, perhaps, required to carry official observers. They are required to allow their activities to be scrutinised by the authorities of other party states, provided those other Parties seek clearance from the flag state of the vessel being scrutinised. Commercially, the value of the measures is the provision of an authority to fish from the flag state. If the vessel operator complies with the conditions, its rights to the fish are safeguarded.

The creation of legal confirmation of access rights to fisheries resources may provide a basis for those rights to be further strengthened through agreements at a regional level by other like-minded states leading to allocation of catch rights among those states. It is then up to states individually as to whether they will further elaborate those national allocations to the enterprise level as secure catch rights.

But what of the responsibilities of non-party states and their vessels? Most fishing nations are parties to the LOSC and as a result bound by the LOSC requirements to co-operate. But if the LOSC 1982 is the only instrument that a state recognises, the vessels from those flag states may avoid having any significant impediment put in the way of their activities. It becomes very much an issue of voluntary adherence. And therein lies a key problem for responsible fishing operators operating under the jurisdiction of states that are parties to the FAO and the UNFSA Agreements and, or, are parties or observers of regional fisheries arrangements. Their security of access to fish stocks is constantly under threat of attenuation from vessels operating under the authority of non-party and non-co-operating states.

The primary reason for re-flagging is the presence of an uneven playing field. The reality of a commons is that, all else being equal, performance will be driven to move to the level required by the lowest common denominator. Legal, responsible operators require the state to intervene to defend the rights and obligations that the state has created. Where states are unable or unprepared to do so, the benefits of flagging to such states becomes either illusory, or paradoxically they may be attractive flags for less scrupulous operators.

4. IUU AND LRR

Defining illegal and unregulated and unreported fishing (IUU) requires that states and stakeholders know what *legal and regulated and reported fishing* (LRR) is. It is unfortunate that the three letters I and U and U have become linked together as an acronym of fishing. They are very different things – as the opening example of the recent New Zealand case demonstrated.

The fundamental issue is ‘illegal fishing’. But that requires understanding and agreement of what constitutes ‘legal fishing’. Between states the definitions vary widely in determining legal operation inside each EEZ’s state, and the consequences of acting illegally vary more widely still. When those rules are then applied to fishing vessels in the high seas, the differences can continue. Regional fisheries management

organizations (RFMOs) can determine common grounds – or at least a common set of expectations – for vessels of all Parties to an arrangement. But the frameworks of compliance that RFMOs have at present fundamentally rely on the capacities of flag state members. Where they vary, one from another, the opportunity can be created even for responsible owners to seek the least onerous, legal conditions to operate under.

Without a definition of ‘legal fishing’, there cannot be regulated fishing. Without a frame of regulation, it is unlikely that fishing results will be reported. The FAO Compliance Agreement requires parties to authorize their vessels to fish. In the absence of law to do so, the vessels that operate under those jurisdictions are in fact acting legally as far as their regulatory framework is concerned. So called Flags of Convenience offer the opportunity for *legal* but *unregulated* and *unreported* fishing. The need to develop international consensus on the removal of open registers and flags of convenience for fishing vessels is clear. This may be brought about most efficiently by ensuring that the developing countries that in the main offer this perceived “service” are provided with the financial and legal capability to pass the necessary fisheries law, defend it, and uphold it.

Legal responsible operators want these changes to be made. In this exercise of blame, the blame is on international incapacity and lack of political will – among bureaucrats and politicians. Perhaps it will not truly happen until the ballot box dictates that failure has political consequences for the governments concerned.

5. OTHER NEEDS

5.1 Is there a legal gap in the high seas?

In short the answer to the above question is yes! Sustainable harvests require a framework for determining what a sustainable level should be and then implementing actions necessary to ensure that participants deliver that result.

The high seas are outside spatial jurisdiction of sovereign states. Thus agreements on management must be between states disconnected from their geographic boundaries and be a result of consensus among the parties. The Parties need to have capacity for recourse to impose consequences on non-performers, both inside and outside the membership of any agreement.

The FAO Compliance Agreement sets a frame for national rather than collective responsibility among DWFNs. UNFSA ties interests to coastal states boundaries and as a result finds a basis for collective responsibility. The high seas are disconnected and all participants are, by definition, DWFNs. The legal capacity to secure the economic benefits arising from allocating rights to catch among parties to high seas RFMOs, as reward for defending sustainable management, may still elude fisheries arrangements solely in the high seas. Unless high seas RFMOs can legally defend stocks from fishing by non-parties, agreements are worth next to nothing.

5.2 The “do nothing” threat

Finally I want to comment on the growing pressure to set fishable deep-sea habitat aside into no-take marine protected areas – particularly in the high-seas – in order to protect the stocks.

Driven by advocacy, rather than science, the pressure to put fishable habitat out of reach of legal fishing is unlikely to be able to protect the scattered remote high-seas habitats from unscrupulous fishing. But it will be effective in removing legal and responsible fishers from those areas.

It seems clear to me that the challenge for states trying to defend remote patches of EEZ from pirate fishing – as in Australia’s Heard and Macdonald Island toothfish fisheries – is lack of a year round presence of legal operators. Thus the way is clear for others to come into the area and fish without detection.

The costs of defending isolated and remote patches of valuable habitat from predation are already enormous – as Australian industry and officials will confirm. But will states – and voters – be prepared to foot the bill for defence of areas once any legal economic benefit has been removed?

The contrary lesson to date may be examples such as the developing Antarctic toothfish fishery in the Ross Sea. For much of the year the habitat is protected by ice and is inaccessible. When it is accessible there is now a small fleet of legal operators present throughout. That legal presence is a deterrent to “illegal” operators chancing not getting detected and so far there is no evidence of illegal activity.

I do not have time to comment further on the no-take high-seas MPA pressure other than to note the lack of any legal basis for them. MPAs would cut across the fundamental basis for the Law of the Sea – a requirement to recognise the rights of all states and persons to use the resources of the high seas while obligating co-operation to ensure resources are conserved – in the ‘dictionary’ non-use sense of the word.

6. CONCLUSION

In order for the resources of the sea to be managed, states must have the capacity and will to implement legal frameworks that will control the inevitable alternative of depletion and failure.

The IUU problem can only be fixed by development of LRR frameworks. It is clear that the world is not prepared to see the remaining high seas brought under national jurisdictions in a sovereign sense. The LOSC alternative of relying on the altruism of states to act responsibly and require responsible behaviour from fishing operators with no guarantee of secure rewards must now be seen as a failure.

The obvious next step is to develop regional arrangements among willing parties. While regional arrangement must ultimately have the capacity to exclude non-co-operating states from the benefits of access to the resources concerned, this requires the cooperation of other non-parties who may be market or port states for the catch of non-parties to cooperate and exclude such catch from the benefits of market reward.

As yet the new international law passed in the last decade and only recently brought into force has not been adequately tested. The conventions have little more than the bare minimum of adherents enabling them to be brought into force. Much remains to be done to build confidence in the new international legal instruments. This will only come about through the development of new regional arrangements that put into effect the powers of the new international law. On the other hand, I see little need to have to develop yet more international law until the existing instruments have been adequately tested and found wanting.

The risk profile for commercial operations undertaking high-seas fishing must be reduced. The provision of secure, legally enforceable rights to the resources will enable this to be achieved. Until the risk/reward profile is “normalised”, the attraction of the perverse incentives of bonanza fishing will continue to encourage IUU fishing to the detriment of LRR operators.

High-seas bottom fisheries and their impact on the biodiversity of vulnerable deep-sea ecosystems: preliminary findings¹

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1. INTRODUCTION

The United Nations General Assembly in 2002 called upon relevant organizations “to consider urgently ways to integrate and improve, on a scientific basis, the management of risks to marine biodiversity of seamounts and certain other underwater features” within the framework of the United Nations Convention on the Law of the Sea. This report presents preliminary findings on the extent, location and current governance of high-seas bottom-trawl fishing as it affects these areas. It highlights the need for urgent action to protect seamounts, deepwater corals and other biodiversity hotspots from high-seas bottom trawling and to avoid the serial depletion of commercially-targeted stocks in these areas while knowledge gaps and governance gaps are addressed. The UN General Assembly can play an important role in addressing these issues.

The key findings presented in this progress report are as follows:

- Given the localized distribution and high degree of endemism associated with seamount ecosystems, a large fraction of species belonging to these ecosystems are particularly vulnerable to extinction.
- High-seas bottom-trawl fishing poses a major threat to the biodiversity of vulnerable deep-sea habitats and ecosystems.
- High-seas bottom fishing has often led to the serial, or sequential depletion, of targeted deep-sea fish stocks.
- Little is known about the distribution, abundance and dynamics of deep coral, seamounts and other vulnerable bottom ecosystems.
- There has been no systematic study of the geographic extent of bottom-trawl fishing in relation to vulnerable deep-sea ecosystems or the extent of its impact on these ecosystems.
- Despite the lack of systematic study, significant high-seas bottom-trawl fisheries take place along the continental margin where it extends beyond 200 nautical miles, and on seamounts, oceanic ridges and plateaus of the deep ocean floor. This type of fishing is likely to grow in coming years as deep-sea fish stocks within national jurisdiction are depleted and/or increasing restrictions are placed on fisheries within national jurisdiction.

¹ This report was prepared by Matthew Gianni for IUCN_The World Conservation Union, the Natural Resources Defense Council (NRDC) and WWF in October 2003. A more detailed and comprehensive report will be made available by early 2004. All information at this stage is preliminary and certain figures will require further analysis before completion of the final report. The purpose of this interim report is to inform discussions in the UN General Assembly.

- Virtually all high-seas bottom-trawl fisheries are presently unregulated insofar as their impacts on benthic biodiversity are concerned.
- Most high-seas areas are not covered by a regional fisheries management organization (RFMO) with competence to regulate deep-sea bottom fishing.
- High-seas bottom-trawl fishing at present constitutes only about 0.2 percent of global marine fisheries capture production (see Appendix).
- The overall annual value of high-seas bottom-trawl fisheries is not likely to exceed US\$300–400 million at present, a figure equivalent to approximately 0.5 percent of the estimated value of the global marine fish catch in 2001 (US\$75 thousand million) (see Appendix).
- The overall contribution of high-seas bottom-trawl fisheries to global food security is negligible.
- Fishing vessels flagged to only a dozen or so countries (most of which are OECD members) take 80–90 percent of the high-seas bottom-trawl catch (see Appendix).

A number of important gaps in knowledge and ocean governance must be addressed before the sustainability of deep-sea fish stocks and the protection of vulnerable deep-sea habitats and biodiversity from bottom trawling on the high seas can be ensured. These include the need for:

- immediate protection of seamounts, deepwater corals and other biodiversity hotspots from bottom trawling on the high seas to prevent further serial depletion of deepwater fish stocks and damage to the biodiversity of these vulnerable areas
- further identification of biodiversity hotspots beyond the 200 nm EEZ through mapping and sampling of vital seamount ecosystems and cold-water corals along continental margins and deep ocean areas under the high seas
- more complete and systematic data collection on high-seas bottom fisheries including data on catch, bycatch, and areas fished, as well as basic data on the biology of targeted species
- more complete information on the number of flag states and vessels involved in high-seas bottom fishing, and ensuring their reporting to the appropriate international bodies
- the adoption of international management measures for high-seas bottom-trawl fisheries in keeping with ecosystem-based fisheries management and the precautionary approach, for example through
 - determining which of these fisheries are straddling stock fisheries and thus subject to the UN Fish Stocks Agreement (UNFSA)
 - ensuring that regional fishery management organizations (RFMOs) at present competent to regulate these fisheries do so consistent with the principles and provisions of the United Nations Fish Stock Agreement (UNFSA)²
 - establishing new RFMOs consistent with the principles and provisions of the UNFSA to regulate these fisheries where management regimes do not currently exist
 - extending the competence of existing RFMOs to these fisheries, again consistent with the principles and provisions of the UNFSA, notably where target species currently regulated by the RFMO are associated with vulnerable benthic ecosystems and/or
 - establishing an international regime for deepwater fisheries on stocks and associated species found exclusively on the high seas which, at a minimum, incorporates the principles and provisions of the UNFSA and
 - the establishment and implementation of effective mechanisms for monitoring, compliance and enforcement for high-seas bottom fisheries, including the elimination of IUU fishing.

² “Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks”.

It will also be important to resolve the issue of a coastal state's authority to protect the benthic biodiversity of its legal continental shelf (and continental margin) from the impact of high-seas bottom fishing. Further protection may be achieved through the development of long-term approaches and tools, including the establishment of marine protected areas, consistent with international law and based on scientific information, for the protection of vulnerable deep-sea ecosystems and biodiversity under the high seas.

2. THE BIODIVERSITY OF THE DEEP SEA

Most biologists agree that the deep sea constitutes a major reservoir of the earth's biodiversity. Estimates of the number of species inhabiting this area range between 500 000 and 100 million. The deep sea starts beyond the shallower continental shelf and includes the slope and rise of the continental margin as well as mid-ocean ridges, seamounts and plateaus of the deep ocean floor. Much, if not most, of this habitat lies beyond 200 nautical miles from shore³.

Seamounts are increasingly recognized as having large numbers of endemic species – isolated islands or island chains of biodiversity beneath the surface of the sea. Because of the slow growth and restricted distribution of many of the species associated with seamount ecosystems, they are considered particularly vulnerable to human impacts and the risk of extinction. More than 30 000 seamounts over 1 000 metres high are estimated to exist in the world's oceans. Many additional features of several hundred metres or more are believed to exist along continental margins and oceanic ridge systems⁴. While the locations of the 1 000-metre-plus seamounts are generally known, much less is known about the location of these smaller features.

The number of coral species known to inhabit the deep sea is now greater than the number found in shallow and tropical seas. Deep-sea coral 'reefs', like their shallow water counterparts, have been found along the continental slope throughout the world's oceans and are known to support rich and diverse assemblages of marine life. Deep coral reef structures found in the Northeast Atlantic may be up to 10 000 years old. Knowledge of the location, abundance and dynamics of these features remains limited.

3. DEEP-SEA FISHERIES

Deep-sea fisheries are generally considered to be fisheries conducted for bottom dwelling species below 400 m on the continental slope, seamounts, deep-sea ridges and plateaus and associated underwater features. With current technologies, these fisheries take place down to depths of approximately 2 000 m.

Many deepwater fish species are highly vulnerable to overfishing because of their unique biology and adaptation to deep-sea environments. The biology and life history of species targeted or caught as bycatch in deep-sea fisheries are often poorly understood or not understood at all. Basic information needed to determine the level of exploitation that these fish populations (stocks) can sustain is lacking in many cases. Deepwater fisheries are often characterized as 'serial' or 'sequential depletion' fisheries because fishing vessels find and deplete a stock, then move on and repeat the practice. Little is known about the recovery times for these populations. The problem of stock assessment is greatly exacerbated in deep-sea bottom-trawl fisheries, which take varying quantities of numerous species of fish, as opposed to more selective forms of fishing.

³ Where the continental margin (submerged prolongation of the land mass of the coastal state) extends beyond 200 nm from the baseline of the territorial sea, this forms part of the coastal state's legal continental shelf, whose outer limits are defined in art. 76 of the UN Convention on the Law of the Sea. The coastal state exercises sovereign rights for the purpose of exploiting the natural resources of its legal continental shelf. For living resources, these consist of organisms belonging to sedentary species, as defined in Art. 77.4. The United States, for example, states in its law that a number of varieties of coral, crab, mollusks and sponges are included within the sedentary species subject to US continental shelf jurisdiction.

⁴ These are sometimes referred to as seamounts or variously as hills, knolls and mounds.

4. THE IMPACTS OF BOTTOM FISHERIES ON VULNERABLE DEEP-SEA ECOSYSTEMS

The environmental or ecosystem impacts of bottom fishing in the deep-sea are characterized as two-fold. One is the impact of the removal of large quantities of biomass (fish populations) from the food web of 'food-poor' or low energy environments characteristic of the deep-sea. The other is the physical impact of fishing on ocean-bottom ecosystems, primarily coral, sponge and other filter feeding species that often provide the basic structure of seamount and other ecosystems and which are also found along continental slopes, canyons and ridges throughout the world's oceans.

The three major gear types used in deep-sea bottom fishing – gillnets, longlines, and bottom trawls – are all believed to have some degree of impact on corals and other bottom-dwelling organisms. Bottom trawling, however, is considered to be the most damaging by far and is the most common gear used in deep-sea bottom fishing throughout the world. Its destructive impact has been clearly documented in a number of areas of the Northeast Atlantic and Southwest Pacific Oceans, both on seamounts as well as along the continental slope⁵.

Despite several decades of bottom-trawl fishing in deep-sea areas, there has been no systematic study of its geographic extent, and little is known about the full geographic extent of its impact on deep-sea ecosystems. It difficult to disaggregate the amount of high-seas bottom fishing that actually takes place on seamounts, cold water corals and other vulnerable deep-sea ecosystems from available information. Nevertheless, catch information from the FAO and various regions of the world indicates that extensive deep-sea bottom trawling takes place. (See Appendix) At present, the majority takes places within national zones, but there are significant high-seas bottom-trawl fisheries along the continental margin where it extends beyond 200 nm, and on seamounts, oceanic ridges and plateaus of the deep ocean floor. This type of fishing is likely to grow in coming years as continental shelf and deep-sea fish stocks within national jurisdiction are depleted and/or increasing restrictions are placed on fisheries within national jurisdiction.

5. COMPETENCE TO REGULATE BOTTOM TRAWLING ON THE HIGH SEAS

While each coastal nation within its EEZ is responsible for fisheries conservation and has the jurisdiction to protect and preserve the marine environment, the protection and preservation of the marine environment beyond national jurisdiction and the conservation of high-seas living resources are the collective responsibility of all nations.

Moreover, high-seas marine living resources and biodiversity form part of the global commons. Who benefits from these resources, their contribution to world food security and the overall health of the world's oceans, and who suffers from unsustainable fisheries and damage to vulnerable deep-sea ecosystems, are important questions for the international community.

The RFMOs below have competence to regulate high-seas bottom fisheries.

- Northwest Atlantic Fisheries Organization (NAFO)
- Northeast Atlantic Fisheries Commission (NEAFC)
- Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and
- The Southeast Atlantic Fisheries Organization (SEAFO).

⁵ Deep-sea surveys conducted south of Tasmania in the Southwest Pacific have indicated a near total destruction of coral ecosystems on seamounts that have been subject to heavy trawl fishing. Damage to continental slope coral reefs from bottom-trawl fishing has been well documented in the Northeast Atlantic.

None of these organizations have regulated bottom trawling on the high seas for purposes of protecting vulnerable marine ecosystems⁶. SEAFO, however, has just entered into force, and NEAFC has only begun to regulate these fisheries. In all other regions, it appears that high-seas bottom fisheries are unregulated and largely unreported⁷. In fact, most high-seas areas do not have a management regime in place to regulate bottom fisheries⁸.

At the global level, the UN Fish Stocks Agreement, an implementing agreement for UNCLOS, elaborates rights and obligations for conservation and management of straddling-fish stocks and highly-migratory fish stocks. Moreover, it obligates states to assess the impact of fishing on non-target species and species belonging to the same ecosystem, minimize the impact of fishing on non-target species, protect habitats of special concern and protect biodiversity in the marine environment. In some regions, notably the North Atlantic, it appears that many of the stocks fished by bottom trawlers on the high seas are straddling fish stocks. As most of the vessels involved in high-seas bottom trawling in the North Atlantic are flagged to countries, that are, or will shortly be, parties to the UNFSA, it will be incumbent upon these states and relevant RFMOs to fully implement ecosystem-based fisheries management and the precautionary approach called for in the UNFSA. Similarly, in other regions, further research may indicate that bottom-trawl fisheries target straddling stocks, or that target species subject to the UNFSA and governed by RFMOs are associated with vulnerable benthic ecosystems and should factor them into conservation and management measures.

In addition, coastal states may be concerned that where the continental margin extends beyond 200 nm⁹, high-seas bottom trawling may adversely affect the biodiversity of these underwater areas and the 'sedentary' species, such as corals, over which they exercise sovereign rights. The right of a coastal state to protect biodiversity in general in this area is not clear, and in spite of the potential importance of coral-based ecosystems and habitat, there is no express right of a coastal state to conserve sedentary species. Arguably, it may protect these species and associated habitat from damage by high-seas bottom trawling, and it does have sovereign rights over direct exploitation of sedentary species of the shelf in the relatively rare instances when fishing vessels target them. The ambiguities regarding coastal state rights and duties vis-à-vis high-seas bottom fishing in this area need to be addressed.

As the competence to regulate bottom trawling on the high seas is presently limited, or in some cases inadequately exercised, the international community as a whole has the responsibility to explore this situation further and take appropriate action – not only under relevant international ocean agreements but also under a wider array of international instruments that now call for the conservation of biological diversity, a precautionary approach, and ecosystem-based ocean and fisheries management. In this regard, the UN General Assembly has the opportunity to play a key, coordinating role.

⁶ In the North Atlantic there has been some regulation of high-seas bottom-trawl fisheries in order to reduce impacts on other target species. Various nations regulate bottom-trawl fisheries within the EEZ, in some cases to protect habitat and/or other species.

⁷ It does not appear that other RFMOs have competence to regulate high seas bottom fishing, although further research may reveal that this is not the case.

⁸ The Division for Ocean Affairs and the Law of the Sea, Office of Legal Affairs of the United Nations, has compiled a set of maps illustrating bathymetric profiles, the 200-nautical-mile lines, the areas of competence of regional fisheries bodies (based on information provided by the FAO) and points indicating the location of seamounts. Website: <<http://www.un.org/Depts/los/index.htm>>

⁹ There are over 30 nations whose continental margins are known to extend beyond the 200 nm limit in the North and South Atlantic, Pacific, and Indian Ocean. See UN Document CLCS/11, 13 May 1999, at 3 and note 2.

APPENDIX

Regional summaries of high-seas bottom [trawl] fishing

1. INTRODUCTION

Precise information on the deep-sea bottom-trawl catch, the value of the catch and the proportion of the catch taken by fishing fleets in various parts of the world is not readily available. The FAO in its Report on the State of World Fisheries and Aquaculture 2002¹⁰ states: "It is difficult to assess the development of fishing on the high seas because reports to the FAO of marine catches make no distinction between those taken within EEZs and those taken on the high seas".

Among other problems in obtaining data is that official statistics often do not distinguish between fish caught by bottom trawling and other forms of bottom fishing and there are serious problems with under-reporting of catches and accounting for catches made by illegal, unreported and unregulated fishing. Nonetheless, a review of available catch and market data can provide an indication of the major players in these fisheries and a rough estimate of the value of the high-seas catch.

There is reasonably good information on high-seas bottom trawling and catches of deepwater species in the Northwest Atlantic and to a much lesser extent the Northeast Atlantic, although only from approximately 35 °N to the Arctic Circle (corresponding to the areas of application of NAFO and NEAFC). There is also good catch information for the Southern Ocean around Antarctica from countries that officially report their fishing activities, although there is a serious problem of unreported, unregulated and illegal fishing in that area. Some information on high-seas fishing in the Southwest Indian Ocean exists as a result of recent efforts to negotiate an agreement to manage the deep-sea fisheries that have recently developed in the region.

Data for the year 2001, the latest year for which catch data and market data are consistently available, provides a recent 'snapshot' of the extent and value of high sea bottom-trawl fisheries.

2. NORTHEAST ATLANTIC OCEAN – NORTHEAST ATLANTIC FISHERIES COMMISSION (NEAFC)

Throughout the 1990s, deepwater bottom fisheries expanded rapidly in the Northeast Atlantic. However, NEAFC has only begun to attempt to regulate high-seas bottom fisheries within the past two years. It appears that vessels from France, Spain, and Russia dominate the high-seas bottom-trawl fisheries, which take place on the continental margin, the Mid-Atlantic ridge and various banks and seamounts in the region, primarily for roundnose grenadier and blue ling. Vessels from New Zealand and possibly Ireland are also involved in high-seas trawling, the former fishing for orange roughy and the latter rapidly developing deepwater fisheries for a number of species.

The high-seas catch reported by NEAFC of deepwater species taken in bottom fisheries was slightly less than 15 000 t in 2001 with an approximate landed value of US\$26 million.

Overall, the catch of deepwater species in the entire North East Atlantic (excluding the blue whiting and redfish fisheries that are caught by 'mid-water' or pelagic trawl on the high seas) was approximately 150–200 thousand tonnes. It would appear that 10 percent or less of the bottom catch of deepwater species in the region was taken on the high seas with the remainder caught within the EEZs. Compared to the overall reported marine fish catch in the entire Northeast Atlantic Ocean (FAO Statistical

¹⁰ FAO Fisheries Department. The State of World Fisheries and Aquaculture, 2002. The state of world fisheries and aquaculture. Rome, FAO. 2002. 150p.

Area 27), which in 2001 was 11 164 413 t, the 15 000 t of reported catch from the high-seas bottom-trawl fishery would account for approximately 0.13 percent of the catch in the area.

There are a number of other species such as deep-sea sharks, which were caught in substantial quantities in deepwater bottom-trawl fisheries for which NEAFC has no data but which are variously reported by the International Council for the Exploration of the Sea (ICES), the European Commission, and scientific papers on deepwater fishers in the region. The total catch of these species in high-seas bottom-trawl fisheries may have been an additional 10 000 t or more above the reported catch. This, coupled with the general problem of under-reporting in the region, may mean that the deep-sea bottom-trawl fishery on the high seas of the Northeast Atlantic in 2001 could have been up to twice the reported high-seas catch, with a value of up to US\$50 million. Even so, the bottom-trawl catch on the high seas is a fraction of the overall catch in the Northwest Atlantic. Further, the catch is not likely to be sustainable – ICES reports that most exploited deepwater species are considered to be fished “outside safe biological limits”.

3. NORTHWEST ATLANTIC OCEAN – NORTHWEST ATLANTIC FISHERIES ORGANIZATION (NAFO)

High-seas bottom-trawl fisheries for cod, redfish, flounders and other flatfish have intensified significantly for the past several decades, primarily in the international waters of the Grand Banks (the so-called ‘nose’ and ‘tail’) and the Flemish Cap. However, the more ‘traditional’ fisheries have been largely depleted or collapsed and replaced by bottom-trawl fisheries for northern prawn and Greenland halibut (with some resurgence in fishing for redfish on the tail of the Banks). Russia, Spain, Portugal and Estonia catch most of the groundfish, which amounted to some 50 000 t in 2001. Northern prawns are fished on the bottom in international waters at depths of 200–700 m, with approximately 90 percent of the high-seas catch taken on the Flemish Cap. Norway, the Faeroes, Iceland, Latvia and Lithuania are the main countries involved in the fishery, in addition to Russia, Spain, Portugal and Estonia. Together, these nine countries took over 95 percent of the total high-seas catch of 60 000 t of northern prawns in 2001. The landed value of the northern prawn catch on the high seas was approximately US\$90 million.

A preliminary estimate of the total value of the high-seas bottom-trawl catch in the Northwest Atlantic in 2001, including the northern prawn and the groundfish fisheries, is approximately US\$180 million. The overall marine fish catch reported in the Northwest Atlantic Ocean (FAO statistical area 121) was 2 238 371 t in 2001. The estimated 110 000 t of bottom-trawl catch on the high seas represents approximately 5 percent of the total marine catch in the region.

4. SOUTHWEST INDIAN OCEAN

Bottom-trawl fisheries on seamounts and ridges in the international waters of the region developed rapidly in the late 1990s, primarily for orange roughy and alfonosinos. Statistics on the high-seas fisheries in the region have been compiled as a result of the negotiations, currently underway, to establish a regional fisheries management organization in the region. Five vessels were reportedly bottom-trawl fishing on the high seas in 1999; by 2000, up to 40 vessels may have been involved. The reported catch hit a peak in 2000 at 39 412 t of deepwater species, falling to 7 962 t in 2001. The fishery apparently declined even further in 2002 with most of the vessels having left the fishery because the catches were no longer economically viable.

In 2001, the majority of the reported catch appears to have been taken by New Zealand, Japan and Australia. However, only six countries reported catches in the

fishery although vessels from an additional eight countries were believed to have been involved according to FAO reports¹¹.

The estimated value of the reported high-seas catch for 2001 is approximately US\$8–9 million. Given the numbers of vessels involved, the unreported catch could be equal to the reported catch. The overall reported marine catch of all species in the Western Indian Ocean (FAO Statistical Area 51) was 3 948 676 t in 2001. The 7 962 t of fish reported caught by bottom-trawl vessels on the high seas represented about 0.2 percent, or one-fifth of 1 percent, of the total marine catch in the region.

5. SOUTHWEST PACIFIC OCEAN

There has been a significant fishery for orange roughy on the high seas outside of the New Zealand and Australian EEZs in the Tasman Sea (between New Zealand and Australia), south of Tasmania, and to the east of New Zealand in the South Pacific. According to information available from New Zealand, the high-seas catch of orange roughy by vessels from New Zealand and Australia in the region totaled almost 4 000 t in 2001. An additional 200 t of orange roughy were reportedly caught in the region by distant water fishing nations. Assuming this was caught on the high seas, the reported high-seas catch was approximately 4 100 t. Several thousand tonnes of alfonsinos are caught by New Zealand in the region, though it is unclear the extent to which any of the catch is taken on the high seas. It is worth noting that the overall catch of orange roughy in the region (both inside and outside the EEZs) has dropped from a high of almost 90 000 t in 1990 to approximately 14 300 t in 2001 according to FAO statistics.

This high-seas catch, combined with several hundred tonnes of oreos also reported caught on the high seas, would put the value of the catch of both species in 2001 at approximately US\$10 million. The overall reported marine catch of all species in the Southwest Pacific (FAO Statistical Area 81) in 2001 was 750 967 t. The high-seas catch of orange roughy and oreos represents about 0.6 percent of the total marine catch in the Southwest Pacific.

6. SOUTHERN OCEAN AROUND ANTARCTICA – COMMISSION FOR THE CONSERVATION OF ANTARCTIC MARINE LIVING RESOURCES (CCAMLR)

There is extensive deepwater fishing in the Southern Ocean, notably for Patagonian Toothfish. However, CCAMLR reports that no bottom-trawl fishing on the high seas of the CCAMLR area takes place, though a relatively small amount of bottom trawling for deep-sea species does occur within several EEZs in the region. Although there is good information on catches, there is a serious problem of unreported, as well as unregulated and illegal fishing in the region.

7. SOUTHEAST ATLANTIC – SOUTHEAST ATLANTIC FISHERIES ORGANIZATION (SEAFO)

There is little information currently available on the extent, if any, of high-seas bottom-trawl fishing in the region. Deepwater fisheries for orange roughy, alfonsinos, cardinalfish and oreos have developed over the past several years, although a review of the catch of deepwater species on the FAO FISHSTAT database lists virtually no catches by distant water fishing nations for deepwater species in this region in recent years, suggesting that little high-seas bottom-trawl fishing takes place.

¹¹ Report of the *Ad Hoc* meeting on management of deepwater fisheries resources of the Southern Indian Ocean. FAO Fisheries Report No. 652, 2001, and Report of the second *Ad Hoc* meeting on management of deepwater fisheries resources of the Southern Indian Ocean. FAO Fisheries Report No. 677, 2002.

8. SOUTHEAST PACIFIC

Deepwater fisheries for orange roughy, alfonsinos, cardinal fish and oreos have also developed over the past several years in the Southeast Pacific, but as with the Southeast Atlantic, a review of the catch of deepwater species on the FAO FISHSTAT database lists virtually no catches by distant water fishing nations for deepwater species in this region. There is a high-seas catch of Patagonian grenadier (hoki) in the region but it is not clear whether this involves any bottom-trawl fishing.

9. NORTH PACIFIC, THE CENTRAL ATLANTIC AND EASTERN INDIAN OCEAN, MEDITERRANEAN SEA

More research must be done to determine the extent of high-seas bottom fishing in these regions.

10. SOUTHWEST ATLANTIC

There is extensive bottom fishing by distant-water nations in the Southwest Atlantic. More research is planned to determine the extent of deepwater and high-seas bottom trawling.

11. SUMMARY

This information is preliminary and not all ocean regions have been thoroughly researched. At this stage, based on various assumptions used (which will be detailed in the full report) the estimate of the high-seas bottom-trawl catch for 2001 – the latest year for which data is consistently available – for the regions listed above is approximately 145 000–155 000 t valued at approximately US\$225–250 million. These figures were derived from reported catch and landing data from a variety of sources. The figure of US\$300–400 million may be closer to the actual value in 2001, taking into account possible catch in regions not yet researched (e.g. the Mediterranean) and including the value of IUU bottom-trawl catches on the high seas.

The overall volume of marine capture fisheries worldwide in 2001, as reported by the FAO, was 83 663 276 t. The overall value of global marine capture fisheries in 2001 was approximately US\$75 thousand million. The volume and value of the bottom-trawl catch on the high seas represents a fraction of a percent of the reported total marine capture fisheries in 2001, and even less when considering the overall volume of global fisheries production in 2001 (including freshwater and aquaculture production), which was approximately 130 million tonnes.

Improving international governance in the deep sea

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1. INTRODUCTION

I want to begin by speaking about how we might use and adapt existing governance mechanisms to improve the management of deep-sea fisheries on the high seas. This is not to disregard deep-sea fisheries on the continental slope, but it seems to me that the problems associated with fisheries within areas under national jurisdiction are far more tractable than those affecting high-seas fisheries. Then I want to talk briefly about the management of the deep ocean environment as a whole.

2. DEEP-SEA FISHERIES ON THE HIGH SEAS

No one who participated during the 1990s in the frenzied round of international negotiations aimed at addressing the problem of managing straddling and highly migratory fish stocks can fail to have a strong sense of *déjà vu* when it comes to managing deep-sea fisheries on the high seas.

As we all know, the result of that intensive diplomatic activity during the 1990s was a comprehensive suite of new ‘hard’ and ‘soft’ international law instruments aimed at addressing the weaknesses inherent in the regime for high-seas fisheries set out in the Law of the Sea Convention and establishing a global system of governance for high-seas fishing.

So why are we here? We might well ask ourselves what went wrong? Did we miss something out? Or, as seems more likely, are the problems simply a further indication that, despite all the rhetoric and all the words, there is a failure of commitment and will to implement the measures that we have agreed to.

The fact is that the problems currently facing deep-sea fisheries are not new. In so far as governance is concerned, the problem of managing deep-sea fisheries on the high seas is really no different from the management of any other high-seas fishery. While it is true that the problems are exacerbated in the case of deep-sea fisheries because deep-sea species tend to be characterized by slow growth and low productivity (and we also have an imperfect understanding of the biology of these species), problems of over-capacity, allocations, IUU fishing and compliance are likely to be the same as in high-seas fisheries for highly-migratory species and straddling stocks. We already have the tools to deal with these problems in the 1995 Agreement, the FAO Code of Conduct and the various IPOAs adopted by FAO.

Regrettably, with a few notable exceptions such as the new conventions for the Western and Central Pacific Ocean and the South-East Atlantic, the indications to date that these tools will be applied and enforced are not encouraging. It is, to say the least, unfortunate that, so far, only 36 states have signed on to the Agreement compared to

¹ The views expressed are those of the author and do not necessarily reflect the views of the Authority or any of its members.

117 that have become party to the 1994 implementation agreement related to seabed mining. Therefore, one of the first things we need to do is to urge all parties to the Law of the Sea Convention – especially important fishing nations like the European Community – to become parties to the 1995 Agreement.

But, as Simon Upton made clear in his presentation, just becoming party to an agreement is not enough by itself. Words have to be translated into action and this requires political commitment and action at national, regional and global levels. This is one reason why initiatives such as the Task Force announced earlier today are so important.

I want to suggest three areas of concrete action in which the debate on deep-sea fisheries might be moved forward this week.

First, there needs to be a recognition that the fundamental principles and measures for conservation and management contained in the 1995 Agreement (and elaborated upon in the FAO Code of Conduct) establish basic standards for fisheries management and should be applicable to all high-seas fish stocks – regardless of whether they may be classed as straddling or highly migratory.

Unlike some, I do not see the need for a further implementation agreement dealing specifically with high-seas fisheries. I believe that such an agreement would not only be difficult to negotiate, and would run the risk of diluting some of the provisions of the 1995 Agreement, but would also divert attention from the real issues before us – which are how to ensure better implementation of existing international instruments and how to deal effectively with the problem of IUU fishing. Further, given the advanced technological capability of the world fishing industry and the highly mobile nature of modern fishing fleets, it is more likely than not that by the time negotiations for a new agreement have been concluded, and decisions have been made and implemented, those decisions may come too late to prevent massive and irreversible damage to the stocks we are trying to protect.

Under Articles 117 to 119 of the Law of the Sea Convention, all states have the duty to cooperate to conserve and manage the living resources of the high seas. The only place in which that duty to cooperate has been elaborated is in the 1995 Agreement (reflected in the Code of Conduct). Surely it would be illogical, and inconsistent with ecosystem-based approaches to management, to apply the provisions of Articles 5 and 6 of the Agreement to straddling and highly migratory stocks and not deal with other stocks in the same way. Recognition of the application of the Agreement to all fish stocks at a political level, for example, by a General Assembly resolution to that effect, would go a long way towards broadening the scope of the Agreement and establishing a sound basis from which regional organizations might develop and apply more specific conservation and management measures to deal with the problems that are specific to deep-sea fisheries, such as bottom trawling and unregulated fishing on seamounts. This would be a far easier and more practical objective to attain than, for example, a global moratorium on bottom trawling or a new international agreement for the establishment of marine protected areas on the high seas, yet could achieve the same effect.

Second, regional fisheries management organizations must be made to be more effective. Where there are currently unregulated high-seas fisheries for deep-sea stocks, new organizations must be created to manage them, or the mandates of existing organizations extended to cover them. The role of RFMOs is of critical importance. In simple terms, the logic behind the 1995 Compliance Agreement is to create a situation where global rules are applied on a regional basis through regional organizations and those who do not play by the rules of the relevant RFMO may not fish.

Unfortunately, despite the 1995 Agreement, it must be said that some existing RFMOs continue to be ineffective, while others have not yet successfully addressed issues relating to compliance, IUU fishing, effective decision-making and the provision

of independent and unbiased scientific advice. In particular, no RFMO can effectively promote proper management if its decision-making methods are such as to frustrate the conservation and management goals of that organization. These weaknesses need to be addressed and it is essential to move more rapidly to the situation envisaged by the 1995 Agreement where effective management systems, which include effective mechanisms for dispute settlement, are in place for all international fisheries. There is no fundamental reason why existing RFMOs cannot be used to regulate deep-sea fisheries on the high seas including, if necessary, adopting scientifically-based criteria to designate closed areas around sensitive seamounts and prohibiting the use of certain destructive gear types.

Third, and this has been said already at this Conference, there has to be a collective effort to deal with the related problems of IUU fishing and free riders. In part this can be achieved by fully utilizing the existing tools to combat IUU fishing, such as coordinating global and regional high-seas vessel registers, vessel monitoring systems, port state measures, the use of trade measures and so on. But it is also essential that members of RFMOs take responsibility for the activities of their nationals. It is intolerable, for example, that members of RFMOs should commit to measures to set allocations and eliminate IUU fishing, but then provide incentives for their industry to reflag to non-members of the RFMO.

3. THE DEEP OCEAN ENVIRONMENT

But the deep sea is about much more than just fisheries. I believe it is also important for this conference to consider the broader issue of the management of the deep ocean as a whole. The deep sea provides the largest habitat on earth. It covers more than a third of the earth's surface yet our understanding of this vast and complex ecosystem is minimal. Every time a scientist makes some completely unexpected discovery in the oceans it is a reminder of how little we know about this critical environment. It is also a reminder of the tremendous untapped potential of the deep ocean both in terms of the minerals that lie on and under the seabed, as well as the diverse life forms found in association with hydrothermal vent systems, cold-water seeps and seamounts.

Since any management action must be based on sound scientific advice, the first imperative surely has to be to improve the state of scientific knowledge of the deep ocean, especially in critical areas such as deep ocean biodiversity, the sub-sea biosphere and the ecology of seamounts. We need to drastically alter the existing situation where tens of billions of dollars are spent on civil research into outer space and only a very small fraction of that amount on understanding the ocean.

The scientific issues that we have to deal with are issues of broad international interest that require collaborative research. The real problem is that no single nation has the financial, technological and intellectual capacity to undertake a global programme of scientific research of the magnitude that is required. To be truly effective, international collaboration on a vast scale is required, involving scientists, researchers, organizations and governments from around the world. We are beginning to see such programmes take shape. The Integrated Ocean Drilling Programme involving scientists from some 23 countries is designed to study geological and geophysical aspects of the seabed. On a more ambitious scale, the Census of Marine Life is a programme of international research involving more than 60 institutions from 15 countries for assessing and explaining the diversity, distribution and abundance of marine organisms throughout the world's oceans. Many other cooperative programmes, of various levels of complexity and formality, are also taking place, including through my own organization, the International Seabed Authority. We have recently engaged in cooperative efforts to develop a geologic model of the deep ocean floor and to study the gene-flow and species diversity across the abyssal plain. Yet the point is that these are all essentially sectoral studies and there is no global oversight mechanism in terms of determining

priorities, mobilizing the necessary political and financial commitments and sharing the benefits of such work. The relation between the various objectives, methods that may be used and strategic context in which this variety of requirement can be addressed are outlined in Figure 1.

The latter point is particularly important because it is essential, not only that such scientific studies be done, but also that the results must be shared between all nations, developed and developing, coastal and land-locked, on an equitable basis – for the fact is that economic development is directly linked to developments in science and technology.

The final thought I want to leave with you therefore is whether we need to think in terms not only of improving the system of international fisheries governance, but also of improving high-seas governance as a whole. Do existing concepts of jurisdiction and national sovereignty enable us to fully realize the potential of the deep oceans? Is it logical to have a different jurisdictional framework for marine scientific research on the high seas and in the seabed? How do we ensure that the legitimate expectations of developing states for a share in the benefits derived from advances in marine science and technology can be met without creating disincentives to innovation?

In short, the challenge is how to give effect to the ideal expressed in the Law of the Sea Convention – the constitution for the oceans – of a “just and equitable international economic order which takes into account the interests of mankind as a whole and, in particular, the special needs and interests of developing countries”.

FIGURE 1

Deep Sea 2003: The Way Forward

KEY OBJECTIVES	METHODOLOGY	STRATEGIES
International management of currently unregulated high seas fisheries	<ul style="list-style-type: none"> • Arrangement between interested states to elaborate voluntary conservation and management measures • Declaration of Principles (UNGA) 2004 <ul style="list-style-type: none"> ➤ Universal application of UNFSA ➤ Application of UNFSA principles to all high seas stocks ➤ Prohibit destructive fishing methods/gear pending agreement on international regulation of discrete high seas fisheries ➤ Recognition of High Seas fishing Protocol. 	<ul style="list-style-type: none"> ➤ Interested states currently fishing responsibly to take initiative to establish high seas fishing arrangement (2004) ➤ Expansion of FAO Code of Conduct to cover high seas stocks (FAO Technical Consultation leading to COFI 2005) ➤ Expand RFMO coverage to presently unregulated deep sea fisheries in accordance with UNFSA model ➤ RFMO performance audit. ➤ Increase global accountability of RFMOs, through biennial meeting of RFBs, FAO and UN. ➤ ITLOS action. ➤
Promotion of marine science (ocean exploration), not just fisheries science	<ul style="list-style-type: none"> ➤ Commitment to broad-based programme of ocean exploration with open access to results 	<ul style="list-style-type: none"> ➤ Process to identify high seas areas of particular scientific interest for intensive international study and conservation (possible mechanism through ISA)
Mechanism for conservation of high seas biodiversity	<ul style="list-style-type: none"> ➤ Establishment of time-limited international process to consider implementation of the regime for high seas fisheries, MSR and mechanisms for protection of biodiversity on the high seas. 	<ul style="list-style-type: none"> ➤ States to identify 10 – 20 deep sea areas as areas for protection. ➤ Use results of ocean exploration and study as a basis for global regulation to prevent / minimize loss of biodiversity ➤ Sample collection and associated activities to be sustainable and subject to EIA in every case. ➤ Consistent regional and global approach to conditions for access and benefit-sharing. ➤ Access to data, scientific knowledge and intrinsic values to be considered in lieu of economic benefit-sharing
Appropriate regulation of activities related to “biodiscovery”		
Regime applicable to the “Area”, high seas, EEZ, continental shelf and continental margin.	<p>Process may lead to LOSC amendment, UNFSA Protocol, implementation agreement, GA Resolution or other legal options, but important not to pre-empt outcome pending detailed consideration of options.</p> <p>Opportunity to feed into LOS/UNFSA review process.</p>	

Can deep-sea fisheries satisfy growing consumer demand for fish? Unilever's approach to sustainable fisheries

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The growth in global fish consumption puts ever increasing pressure on fisheries to ensure supply. And, as developing countries become more affluent, fish consumption is expected to increase even further. The landings from capture fisheries have remained relatively stable at approximately 90 million tonnes for some years now and no further increases are expected. The catches of the financially-lucrative groundfish species, e.g. Atlantic cod, Argentinian hake, and Russian pollock have more than halved within the last 15 years.

This increase in fish consumption and the decline in groundfish catches has resulted in a continuous expansion of aquaculture and an increasing emphasis on deep-sea fisheries as a source of supply. While aquaculture nowadays requires considerable scientific knowledge to be efficient and successful, this is not the case with deep-sea fisheries where large volumes of fish can be harvested provided the necessary equipment is available.

However, deep-sea fishes are too often based on species whose biology is not yet well understood. It is therefore essential that sufficient scientific data are gathered and an extremely precautionary approach is followed to guarantee the sustainability of harvests from such fisheries.

Unilever has pledged to buy all its fish and seafood from sustainable sources only. In order to progress towards that goal Unilever purchases from fisheries that have been certified by the Marine Stewardship Council, who have developed a system to rate the management of those fisheries that provides an indication of the sustainability of the fisheries it audits. Unilever may use fish from the deep sea once the scientific knowledge of such species is sufficient to implement stringent fisheries management, i.e. defining sustainable total allowable catches, allocating fishing quotas among the participants and ensuring effective controls.

THEME 1

**Environment,
ecosystem biology, habitat and
diversity, oceanography**

Environmental and biological aspects of deepwater demersal fishes

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1. INTRODUCTION

1.1 Deepwater fisheries

Some artisanal deepwater¹ fisheries, such as the hook and line fisheries for black scabbardfish (*Aphanopus carbo*) in the Atlantic and *Ruvettus* spp. in the Pacific have a long history. The more recent development of highly mechanized and efficient deepwater fisheries targeting new species, such as macrourids (grenadiers), armourhead (*Pseudopentaceros wheeleri*) and orange roughy (*Hoplostethus atlanticus*) in the Atlantic and Pacific can be traced back to the exploratory fishing by vessels of the USSR in the 1960s (Gordon 2001a). In the Atlantic the grenadiers, mainly the roundnose grenadier (*Coryphaenoides rupestris*) but also roughhead (*Macrourus berglax*), were the main target species and landings peaked in the 1970s. The fishery for roundnose grenadier revived in the late 1980s when French vessels began to target this species, and also several other deepwater species, on the European continental margin. The armourhead fishery on Pacific seamounts began in the mid 1960s, first by the USSR and later by Japanese trawlers (Humphreys and Moffitt 1999). The South Pacific fishery for orange roughy was developed by New Zealand in the 1970s (Clark 2001) and later by Australia in the 1980s (Koslow *et al.* 1994).

The global trend of increasing catches of deepwater fish has been analysed by Garibaldi and Limongelli (2003) using the available FAO statistics. They extracted all catch data on oceanic species and further subdivided these data into epipelagic (tuna-like species, oceanic sharks, cephalopods and krill) and deepwater species (including shrimps and crabs). The deepwater catch was about 2 percent of the total oceanic catch until about 1975. Thereafter it increased to a level of about 20 percent and in the most recent years 1998 and 1999, reached 33 percent at over 2 million tonnes. Gadiform fishes, especially blue whiting (*Micromesistius pouassou*), dominated the deepwater group.

It was the discovery of commercial quantities of orange roughy in the eastern North Atlantic in the early 1990s that generated significant interest in deepwater fisheries in European waters. This resulted in a symposium, organized jointly by the Sea Fish Industry Authority and the Scottish Association for Marine Science (SAMS), on the *Deepwater fisheries of the North Atlantic oceanic slope*, held in 1994 (Hopper 1995). In the introductory paper entitled *Environmental and biological aspects of slope-dwelling*

¹ The term deepwater is increasingly used to describe these fisheries in preference to 'deep sea' which can also describe distance from land.

fishes of the North Atlantic (Gordon, Merrett and Haedrich 1995) we addressed the following questions. (1) How do the physical features of the continental slope and shelf compare? (2) How does the physical environment of the slope differ from that of the shelf? (3) How do the demersal species assemblages on the shelf and slope differ from one another and are the latter basically different from the pelagic oceanic assemblage? (4) How do the basic distribution patterns (vertical and horizontal) of slope dwellers compare with their shelf-dwelling counterparts? (5) How does the vertical distribution pattern of fish biomass correlate with the trophic input to the oceanic environment? and (6) What is known about deep-sea fish population structure and breeding biology? In this paper I revisit these questions, slightly modified to embrace a wider global scale, to assess how much our knowledge has advanced over the last decade. In this context the proceedings of several recent international meetings on deepwater fishes and/or fisheries are relevant. These were the 1996 *Deepwater fishes* symposium of the Fisheries Society of the British Isles (McIntyre and Thorpe 1996), the ICES 1998 *Deepwater fish and fisheries* theme session (Gordon 2001b) and the NAFO 2001 *Deep-sea fisheries symposium* (Moore and Gordon 2003).

Deepwater fisheries are generally considered to be those that exploit fish or shellfish that habitually live at depths greater than 400 m. However, this is an arbitrary boundary since many species have ranges that extend from the continental shelf into deepwater. Others, such as the sablefish (*Anoplopoma fimbria*) of the northern Pacific, occupy the shelf as juveniles and the deepwater as adults. In the northeast Atlantic species such as ling (*Molva molva*), tusk (*Brosme brosme*) and anglerfish (*Lophius piscatorius*) are generally considered as species of the continental shelf but all are also found on the slope, especially the anglerfish which can be found at 1 000 m depth. There are also fisheries on the upper continental slopes for species with close affinities to shelf species such as the Cape hakes (*Merluccius capensis* and *M. paradoxus*) off southern Africa, the blue whiting (*Micromesistius*) fisheries in the northern and southern hemispheres, the deepwater redfish (*Sebastes* spp.) fisheries of the Atlantic and Pacific and the Greenland halibut (*Reinhardtius hippoglossoides*) of the North Atlantic and Pacific. In this paper the emphasis will be on the 'new' deepwater fish species.

1.2 Terminology

On the continental shelf fish and fisheries are usually classified as pelagic or demersal. In the deep sea the pelagic extends from the surface to abyssal depths and it is usual to divide it into three zones. The epipelagic zone includes all those fish living in the upper photic layer of the ocean, such as the tuna fishes. The mesopelagic zone spans the depth range from below the photic zone down to about 1 000 m and supports an abundant and diverse fish fauna, such as myctophids (lanternfish) and gonostomids (bristle mouths). Many mesopelagic fishes and invertebrates are diel vertical migrators. They migrate to the surface to feed at night and return to the depths during the day and in doing so form an important link in the deepwater food-chain (see Section 6). Some mesopelagic lanternfishes that form dense aggregations are, or have been, exploited in areas such as off South Africa, in the Arabian Sea and the Southern Ocean (Gjøsaeter and Kawaguchi 1980). The bathypelagic fishes occur from about 1 000 m down to abyssal depths and are generally highly adapted, often in bizarre ways, to life in a dark, food-poor environment. They are low in abundance and biomass and are never likely to have any commercial value. Typical examples are the deepwater angler fishes (family *Ceratidae*) and the gulper eels (family *Eurypharyngidae*).

In the deep sea the demersal fishes are generally divided into two categories, benthic and benthopelagic. The benthic fishes are those that have a close association with the seabed and include species such as skates, flatfishes and tripod fishes (*Bathypterois* spp.). Benthopelagic fishes are those that swim freely and habitually near the ocean floor and, in the areas where deepwater fisheries are commercially viable, they comprise most of

the exploited biomass. The demersal fishes are a diverse group and, for example, on the continental slope of the North Atlantic they are represented by some 57 families and at least 296 species (Merrett and Haedrich 1997). On the western Australian slope Williams, Koslow and Last (2001) recorded 108 families and 388 demersal species at depths between 200 and 1 460 m, but in other areas of the Pacific the numbers were considerably less (18–19 families and 85–199 species). As will become apparent below, relatively few of these species occur in sufficient quantities or are of a large enough body size to be of any commercial interest.

Benthic fishes were described above as those that are adapted to a life closely associated with the bottom. However, the distinction between benthic and benthopelagic is sometimes made on the basis of diet and can sometimes result in species of the same genus (e.g. *Coryphaenoides*, family *Macrouridae*) being classified in the different categories (Koslow 1996). Koslow also recognized that there was another group of demersal fishes that aggregate in association with seamounts and other rugged topography. Examples of such “seamount-associated” fishes are orange roughy, armourhead and alfosinos (*Beryx* spp.). Koslow (1996) compared the metabolism and life-history patterns of these aggregating species with those of the dispersed benthic and benthopelagic species. The seamount associated fishes had higher metabolic rates and flesh with high protein and lipid contents and a low water content. The high quality of the flesh results in a high market value compared with other deepwater species.

This paper is not intended to be a comprehensive review of deepwater fish and their environment. It is thirty years since I caught my first deep-sea fish in the Rockall Trough, North East Atlantic, and I make no apologies for drawing heavily on my long experience and interest in that area to find examples to answer many of the questions. It should be read in conjunction with Gordon *et al.* (1995) because I have placed most emphasis on recent advances in our knowledge of the fishes and their habitat.

2. HOW DO THE PHYSICAL FEATURES OF THE CONTINENTAL SLOPE, SEAMOUNTS AND OCEAN RIDGES COMPARE WITH THE SHELF?

Deepwater fisheries can occur on the continental slopes, around oceanic islands and on and around seamounts or ocean ridges. The characteristics of some of these areas are shown in Table 1.

TABLE 1

Comparison of some physical features of the shelf, continental slope, seamounts and ocean ridges.

Modified from Gordon <i>et al.</i> (1995) and Merrett and Haedrich (1997) using data from Sündermann (1986)				
	Shelf	Slope	Seamounts	Ocean ridges
Nominal depth distribution	0 – 200 m	200 – 2 000 m		
Proportion of total world ocean area	7.5%	8.8% 200 – 1 000 m (4.4%) 1 000 – 2 000 m (4.4%)		
Gradient	< 1: 1 000	>1:40 (30-60)		
Width (km)	Few >300	Few to 150	2 – 100	2 000 – 4 000
Height (km)			>1 000	1 000 – 3 000
Length (km)				56 300 – 64 400
Relief (m)	20 m	locally 2 000 m (associated with canyons)		
Depth (m)			0 – 2 000	0 – 5 000

Seamounts are underwater mountains with heights of more than 1 000 m. Those between 500 and 1 000 m and less than 500 m are known as knolls and hills respectively. It is estimated that there are about 30 000 seamounts in the Pacific Ocean, about 1 000 in the Atlantic Ocean and an unknown number in the Indian Ocean (Morato 2003).

In our 1995 paper (Gordon *et al.* 1995) we showed how the new technology of satellite navigation and track plotters had greatly increased the efficiency of the deepwater fishing process. Since then technology has continued to advance with greatly improved fish detection and trawl net monitoring systems, which in conjunction with high resolution mapping (swath bathymetry) means that there are fewer refuges for fish in the world's oceans. The draft report of the World Conference on Deep-Sea Fishing held in Vigo 2003 refers to "surgical" fishing technologies – i.e. a precision targeted trawling. From the conservation viewpoint a positive aspect could be the use of the same technology to avoid unwanted catch and reduce incidental impact on benthic environments. The same report noted that fishing on steep seamounts was not possible with current technology as 20-30° slopes are the maximum that currently used gears can handle.

We also drew attention to the fact that increasing efficiency (often referred to as technology creep) has implications for catch and effort statistics. Many of the stock assessments of the deepwater species of the northeastern Atlantic (ICES area) that have been carried out since 1998, are based on French commercial trawl catch per unit of effort (CPUE) data. These data were selected from a sector of the French fleet that had used similar trawling techniques since the start of the fishery (Lorance and Dupouy 2001). Great care has to be taken when using time-series of CPUE data that make no allowance for increasing efficiency during the development of the fishery.

Research surveys often use different trawl gears to target specific species or to sample differing bottom topographies. A study of the deepwater fishing impacts in the Rockall Trough demonstrated the difficulty of combining data from different trawls (and depths) into a unified time series of CPUE (Basson *et al.* 2002). In fact it was only possible to compare pre- and post-fishery data for one species, the roundnose grenadier, and two broad groupings of exploited and unexploited species.

The technology of longlining has also continued to improve. For example, Bergstad and Hareide (1996) have documented a century of development in the Norwegian longline industry. Reis *et al.* (2001) has described changes in the black scabbardfish fishery off Madeira and shown how the increasing efficiency and effort has resulted in a decline in CPUE. The systems for automatically shooting and hauling lines are becoming more widely used and automatic baiting, and even the automated replacement of damaged hooks, is increasing the overall efficiency of the operation. The increasing accessibility of this technology is changing the patterns of many artisanal fisheries.

3. HOW DOES THE PHYSICAL ENVIRONMENT OF THE SLOPE, SEAMOUNTS AND OCEAN RIDGES DIFFER FROM THAT OF THE SHELF?

In our 1995 paper we described the physical environment of the continental slope with particular reference to the long time series of hydrographic studies in the Rockall Trough. At these temperate latitudes a seasonal thermocline forms during the summer and stratifies the water column. The breakdown of the thermocline during the winter and early spring redistributes the nutrients that fuel the seasonal blooms of phytoplankton production. Almost all the energy reaching the deep sea is derived from this surface primary production.

While the seasonal breakdown of the thermocline is an important factor at temperate latitudes it is not the only factor responsible for enhanced primary productivity along continental margins. In the tropics and sub-tropics the water column is usually permanently stratified and surface productivity is low. However, in areas where there are strong offshore winds surface water is displaced offshore and is replaced by colder,

nutrient rich water from below the thermocline, which results in high, often seasonal, primary productivity. This phenomenon is known as upwelling and there are five major areas of coastal upwelling; off Peru and Chile, off California, off North West Africa, off Namibia and South West Africa and in the northwestern Arabian Sea. Apart from these major areas, localised upwelling can arise at the fronts separating major water masses or in association with eddies.

The waters above and around seamounts can be highly productive and support (or have supported) major fisheries for aggregating species such as armourhead, orange roughy and alfonso. Oceanic currents impinging on the seamount and causing localised upwelling (“Taylor” columns) have often been associated with the high productivity of seamounts (Koslow 2001). However, it now appears that this alone would be inadequate to sustain the observed fish aggregations. It is more likely that it is the diurnal vertical migration of organisms being intercepted by seamounts and their physical aggregation by currents that provides the food to sustain most of the fisheries (Koslow 1997, 2001; Rogers 1994).

There is often enhanced biological enrichment around oceanic islands caused mainly by the interruption of the current flow forming eddies and a wake of disturbed flow (Barton 2001). Around higher islands the disruption of wind flow may also result in upwelling of deepwater.

Most established or developing deepwater fisheries are in areas where there is high surface productivity caused by one of the mechanisms described above. However, the existence of an exploitable biomass ultimately depends on this energy reaching the deep sea. There are some notable exceptions to this generalization. This topic is discussed in more detail in Section 6.

4. HOW DO THE DEMERSAL SPECIES ASSEMBLAGES ON THE SHELF AND SLOPE DIFFER FROM ONE ANOTHER AND ARE THE LATTER BASICALLY DIFFERENT FROM THE PELAGIC OCEANIC ASSEMBLAGE?

In our answer to this question in 1995, we divided the oceanic pelagic fauna into two groups, above and below 400 m. The shallower pelagic fauna had close affinities with shelf fishes, while the deeper pelagic species had a quite separate composition and might be termed true deep-sea species. Comparing the two pelagic zones with the demersal showed that there was little overlap of fish species. Only one pelagic family, the myctophids, has been commercially exploited. The commercially exploited species of the demersal assemblage comprise only a small part of the total species richness. The important families include the Squalidae (sharks), Rajidae (skates), Macrouridae (grenadiers), Gadidae (lings and forkbeards), Moridae (morids), Lophiidae (anglerfish), Trachithyidae (orange roughy), Scorpaenidae (redfish and scorpionfishes) and Pleuronectidae (Greenland halibut).

The high diversity of the slope fishes has important implications for fisheries where only relatively few species are of commercial value. Fishing gear selectivity is important if high discard rates are to be avoided. Few if any fish brought to the surface and subsequently discarded will survive. It is also generally considered that there will be a high mortality of fish escaping through the meshes of trawl nets while being towed on the bottom because they have fragile skins lacking in mucus. It is doubtful if the increasing use of trawl selectivity methods such as square mesh panels or use of grids in shallow waters will, if used in deepwater, have any significant conservation value if the fish that escape do not survive. Longlining is often promoted as a more selective fishing method but key commercial species, such as orange roughy and roundnose grenadier, are not caught by this method and the high bycatch of sharks is a major concern.

In well studied shallow-water areas, such as the North Sea or the Gulf of Maine, we have a good overall impression of the inter- and intra-annual changes in the structure of the total fish assemblage and how it varies with habitat and by depth. This knowledge

is greatly enhanced by the use of many different fishing gears all of which catch a different portion of the total assemblage. In the deep sea the amount of sampling has been relatively small and has often been limited by season, depth or gear type. Even in an area such as the continental margin to the west of the British Isles (Rockall Trough) that has been scientifically sampled for more than 100 years (Gordon 2003), our concept of the assemblage may be biased by the use of relatively few types of sampling gear that have been used. The most frequently used sampling method has been the bottom trawl (beam or otter) and this immediately puts a constraint on the type of habitat that can be sampled, i.e. a fairly flat and relatively smooth seabed.

In the Rockall Trough we have used three different research trawls to sample the fish assemblages. One was similar to a commercial trawl, but with a smaller overall mesh size; the other was a small shrimp trawl which was fished either on single or paired warps. Table 2 shows the five top ranking species in the 1 000 m bathymetric zone expressed as a percentage of abundance and of biomass. This shows quite clearly the differences in catchability between gears. It is also apparent that relatively few species comprise a high proportion of the total abundance and biomass. This also applies to all other bathymetric zones surveyed in the Rockall Trough (Gordon and Bergstad 1992) and in the Porcupine Seabight (SW Ireland) (Gordon *et al.* 1996).

There have been relatively few longline surveys in the Rockall Trough where the total catch has been recorded (Connolly and Kelly 1996, Stene and Buner 1991). In contrast to the bottom trawls the catches were almost entirely composed of gadoids, morids and deepwater sharks.

TABLE 2

The relative numerical abundance and biomass of the top five species in the 1 000 m bathymetric zone of the Rockall Trough by gear type

Granton trawl		Semi-balloon trawl (paired)		Semi-balloon trawl (single)	
Numerical abundance					
Species	%	Species	%	Species	%
<i>Coryphaenoides rupestris</i>	39.7	<i>Coryphaenoides rupestris</i>	53.1	<i>Synaphobranchus kaupi</i>	46.4
<i>Alepocephalus bairdii</i>	33.6	<i>Aphanopus carbo</i>	9.6	<i>Coryphaenoides rupestris</i>	21.6
<i>Lepidion eques</i>	6.7	<i>Lepidion eques</i>	7.4	<i>Nezumia aequalis</i>	13.0
<i>Nezumia aequalis</i>	5.7	<i>Nezumia aequalis</i>	7.2	<i>Lepidion eques</i>	8.6
<i>Halargyreus johnsonii</i>	2.9	<i>Alepocephalus bairdii</i>	6.7	<i>Chimaera monstrosa</i>	5.0
Others (29 spp.)	11.4	Others (22 spp.)	16.0	Others (28 spp.)	5.4
Biomass					
Species	%	Species	%	Species	%
<i>Alepocephalus bairdii</i>	56.5	<i>Coryphaenoides rupestris</i>	40.3	<i>Coryphaenoides rupestris</i>	29.9
<i>Coryphaenoides rupestris</i>	22.5	<i>Alepocephalus bairdii</i>	17.0	<i>Alepocephalus bairdii</i>	17.8
<i>Centroscymnus coelolepis</i>	9.7	<i>Aphanopus carbo</i>	15.4	<i>Molva dypterygia</i>	15.9
<i>Chimaera monstrosa</i>	3.4	<i>Centroscymnus coelolepis</i>	6.7	<i>Lepidion eques</i>	12.4
<i>Deania calceus</i>	1.8	<i>Molva dypterygia</i>	6.4	<i>Nezumia aequalis</i>	5.3
Others (29 spp.)	6.1	Others (22 spp.)	14.2	Others (28 spp.)	18.7

5. HOW DO THE BASIC DISTRIBUTION PATTERNS (VERTICAL AND HORIZONTAL) OF DEEPWATER FISHES COMPARE WITH THEIR SHELF-DWELLING COUNTERPARTS?

In the 1995 paper we discussed the vertical and horizontal distribution patterns in the North Atlantic based on the atlas of deepwater demersal fishes of the North Atlantic compiled by Haedrich and Merrett (1988). We noted that there were considerable differences in the depth range of individual species, ranging from more than a thousand metres to a very restricted few hundreds of metres. Examples are the cutthroat eel (*Synaphobranchus kaupii*), which has a very large depth range and also exhibits a well marked 'bigger-deeper' trend (Gordon and Mauchline 1996) and the tripod fish (*Bathypterois dubius*) which has a very restricted range (Merrett *et al.* 1991a). The 'bigger-deeper' phenomenon, where juveniles tend to live at shallower depths than adults is of widespread occurrence in deepwater demersal fishes (e.g. Merrett *et al.* 1991b). There was no evidence to support any pronounced zonation of deepwater demersal fishes. Instead, there was a gradual replacement of species although in a number of investigations the rate of change tended to be greatest at around 2000 m depth (Merrett and Haedrich 1997). However, zonation of fish assemblages can occur and is usually associated with physical phenomena. For example, on the continental slope off Norway there is a relatively sudden transition from warmer Atlantic water to cold Arctic water with virtually no similarity between the fish faunas of the two water masses (Bergstad *et al.* 1999).

Gordon *et al.* (1995) noted the importance of a knowledge of depth distributions for the rational exploitation of deepwater species. Commercial fishing may not affect fish in the whole depth distribution of a species and this needs to be taken into account when carrying out stock assessments. The overlapping depth ranges of many species makes it difficult to select for target species and avoid an unwanted bycatch on non-target species. Discard levels are generally high in the mixed fisheries of the northeastern Atlantic and can amount to up to 50 percent of the total catch by weight at some depths. Data from research trawls with small mesh can be used to estimate the quantity of escapees from commercial trawls. In the Rockall Trough these have been estimated to be from about 66 to 86 percent by number and 10 to 45 percent by weight of fish entering the trawl (Gordon 2003). It is probable that there will be a high mortality among these escapees.

The number of species in any given depth zone also changes with depth and usually decreases rapidly below about 1500 m. Gordon and Mauchline (1990) estimated total fish abundance and biomass by combining the results from different gears used in the Rockall Trough. They found a clear peak in both abundance and biomass of demersal fishes at mid-slope depths (1 000–1 500 m). This phenomenon has been observed in many other areas and the probable link to food chains will be discussed in Section 6. These peaks are not universal and, for example, in the Norwegian basin demersal fish biomass decreases exponentially with depth (Bergstad *et al.* 1999). Off Western Australia there was little change in demersal fish biomass with depth (Williams, Koslow and Last 2001).

We also noted that the vertical distribution of deepwater demersal species in the water column was poorly understood. This was a result of the difficulty of using large midwater trawls at depth. There has been little progress in this field and it remains a matter of conjecture whether some of the unknown life history stages of species such as black scabbardfish and deepwater sharks might occur in midwater.

One area where there have been significant advances since 1994 is in the field of *in situ* observation of deep-sea fishes. Priede and Bagley (2000) have reviewed the use of autonomous unmanned landers for *in situ* studies of behaviour. While much of the deep-sea pioneering work was carried out at abyssal depths there have recently been investigations of continental slopes, for example in the Porcupine Seabight

(northeastern Atlantic) (Priede *et al.* 1994, Bagley *et al.* 1994), on the Patagonian slope (Collins *et al.* 1999) and in the Mediterranean (Jones 1999)

While the investigations of fish behaviour using landers mainly relate to species that are attracted to bait, observations from manned submersibles or remotely operated vehicles (ROVs) provide valuable insights into the relationship between the fish and their habitat. However, fish disturbance by noise or light while being observed can be a significant problem.

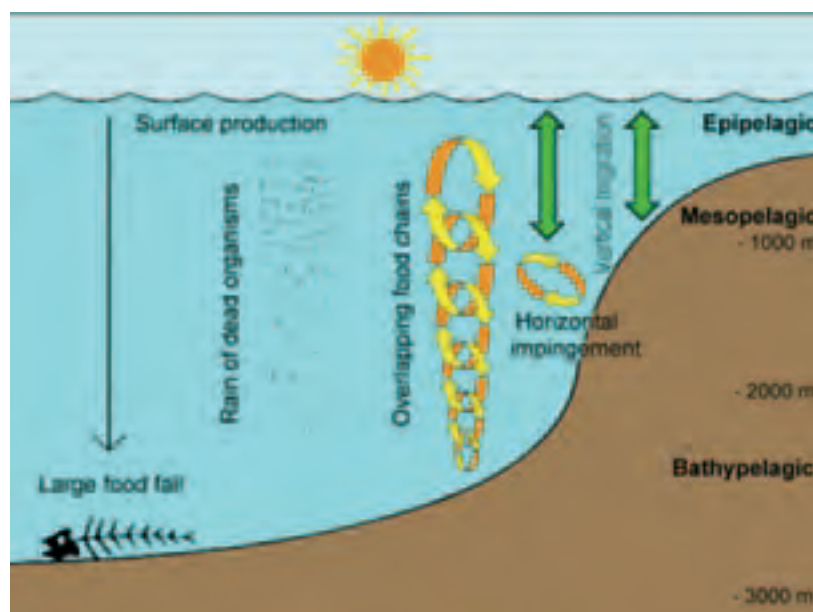
In 1996 and 1998 the French manned submersibles *Cyana* and *Nautilie* were deployed on the continental slope of the Bay of Biscay at depths between 400 and 2 000 m. Their observations have resulted in new information on fine-scale habitat selection and behaviour of several deepwater species (Lorance, Latrouite and Sécet 2000, Lorance *et al.* 2002, Uiblein *et al.* 2002, 2003)

In August 2002 the French ROV (Victor 6000) was used to visually estimate demersal fish abundance at three contrasting areas at depths between 1 200 and 1 500 m in the Bay of Biscay. The areas differed in topography, current conditions and previous fishing activity. The abundance estimates were compared with those estimated from a baited camera and from the catch of a commercial trawler that fished the same area after the ROV transect (Trenkel *et al.* 2002). The visual observations provided a wealth of information on fish behaviour in relation to habitat.

6. HOW DOES THE VERTICAL DISTRIBUTION PATTERN OF FISH BIOMASS CORRELATE WITH THE TROPHIC INPUT TO THE OCEANIC ENVIRONMENT?

The source of food for deepwater fishes is almost entirely derived from primary production in the euphotic zone. An exception is the specialized fauna associated with chemosynthesis around hydrothermal vents. The food chain from phytoplankton, herbivores, carnivores and ultimately to deep-sea demersal fishes can vary in complexity and as the number of stages in the food chain increases so the energy available to demersal fish decreases. The classical concept of a rain of detritus and, or, overlapping pelagic food chains implies in a decrease in the biomass of plankton, micronekton and benthos with increasing depth.

FIGURE 1
Vertically migrating mesopelagic fauna impinging on the slope are an important food source for deepwater fishes



However, as noted above many studies have shown that the biomass of demersal fish often peaks at midslope depths of around 1 000 to 1 500 m (Gordon and Mauchline 1990, Merrett *et al.* 1991a, Koslow *et al.* 1994). Unless the turnover rates of benthos are high, and there is no evidence that they are, then the benthic biomass on the midslope could not support the observed biomass of demersal fishes (Gordon *et al.* 1995)

Gordon *et al.* (1995) listed the following factors that might contribute to the enhanced demersal fish biomass; an increase in primary production along the shelf-slope break, slope currents and tidal effects and impingement of pelagic organisms, both horizontal and vertical, around the oceanic rim. There have been many studies on the diets of deepwater fish species (see Gartner *et al.* (1997) for a review) and these show that in most areas where there are exploited, or potentially exploitable, demersal fish, their diet consists predominantly of pelagic or benthopelagic fish and invertebrates. There is increasing evidence that it is the impingement, vertical or horizontal, of the vertically migrating mesopelagic fauna onto the slope (e.g Mauchline and Gordon 1991, Williams and Koslow 1997) or around seamounts (e.g Rogers 1994, Koslow 1997) that sustains the high densities of exploitable fishes on the midslope. The daily vertical migration of midwater organisms therefore provides the energy required to sustain deepwater fisheries.

The important fisheries of the shallow continental shelves are all in areas where there is high surface productivity such as mid-latitudes, upwelling areas or around oceanic islands. This high productivity is fuelled by the essential nutrients being brought to the euphotic zone by winter mixing of the water column, upwelling of deep, nutrient rich water, or the interruption of ocean currents around islands. If the important deepwater fisheries depend on the efficient transfer of energy produced at the surface then these fisheries should also be in areas where there is high surface productivity.

Perhaps the best known example of the link between surface productivity and deepwater fish communities relates to abyssal fish in the North Atlantic. The fish communities at about 4 000 to 5 000 m depth on the Porcupine and the Madeira Abyssal Plains were compared by Merrett (1987, 1992). In the Porcupine area there is a seasonal thermocline and its breakdown in the winter provides nutrients for the spring phytoplankton bloom. There is a permanent thermocline over the Madeira Abyssal Plain and the low nutrient levels result in low surface production. The effect of these differing features has quite a dramatic effect on the demersal fish communities. The fish of the Madeira Abyssal Plain are of small adult body size, negatively buoyant and feed mainly on epibenthic or benthic organisms. By contrast the fish of the Porcupine Abyssal Plain are of large body size, neutrally buoyant with greater mobility and are predominantly benthopelagic feeders. It is the latter type of benthopelagic fish that is exploited on the slopes but the biomass at these abyssal depths is low and would not support a fishery.

If we now extrapolate these findings to the continental slopes we find that most of the existing deepwater fisheries occur in areas of high surface productivity. Most of these fisheries are on the upper and mid-slopes down to about 1 000 to 1 500 m where there is a peak of demersal fish biomass (see Section 5). This corresponds to the daytime depth of the vertically migrating mesopelagic fauna supporting the hypothesis that it is the efficient transfer of energy from productive surface waters by the impingement of the mesopelagic fauna on the slope of the continental margin, seamounts or islands that sustains the fisheries.

In the North Atlantic the most productive deepwater fisheries are along the highly productive oceanic rim from about the Gulf of Maine around to the Iberian Peninsula. The seamounts of the Reykjanes Ridge and the Mid-Atlantic Ridge have been exploited for many years and there are deepwater fisheries around the oceanic islands such as Madeira and the Azores. There have been several research surveys of the continental slope off the eastern United States (Haedrich and Merrett 1988,

references cited therein). There is decreasing productivity from north to south and hence no significant deepwater resources. Trawl and submersible survey investigations on the slope off Cape Hatteras (35 °N) revealed a strikingly different fish fauna from that of a nearby area, comprising small-sized individuals, which Sulak and Ross (1996) termed 'Lilliputian'. There was a high fish density and a low number of benthopelagic feeders reminiscent of an area with low surface productivity. However, the surface productivity was similar between the two areas and the suggested explanation for the Lilliputian fauna was that the Hatteras middle slope has an unusual hydrographic convergence resulting in virtually no net current flow. The organic flux from surface waters accumulates in the area and results in episodic hypoxia at the sediment surface.

The high productivity of the Norwegian Sea supports important shelf and oceanic epipelagic fisheries, but the deeper continental slope, comprising cold Norwegian Deepwater, has no important fisheries. At the transition between the warmer Atlantic water and the cold water there are fisheries for some species, notably Greenland halibut and redfish (*Sebastes* species) (Bullough *et al.* 1998).

There are no significant deepwater fisheries in the sub-tropical or tropical North Atlantic. There is good descriptive information on the fish assemblages of the West African slope including the upwelling area (Golovan 1978, Merrett and Marshall 1981, Merrett and Domanski 1985) but detailed quantitative data is lacking. It is possible that the initial Russian exploratory fishing never developed into a fishery because of the dominance of alepocephalid fishes in the catch (Golovan and Pakhorukov 1975). These fishes have a watery flesh and are of little interest for human consumption.

The Mediterranean is a subtropical semi-enclosed sea and is unusual in having a very stable temperature of about 13 °C from below the thermocline to abyssal depths. Surface productivity is generally low but is elevated in frontal areas such as the Balearic Basin. Deepwater crustacean fisheries for high value species, such as *Aristeus antennatus* and *Aristaeomorpha foliacea*, are important. The fish bycatch is generally quite low. The main deepwater fisheries are on the Catalan Slope in the Balearic Basin, and the Ionian Sea.

In the South Atlantic the deepwater fisheries are centred on the slope off South West Africa and on the edge of the Patagonian shelf. Off South West Africa, in the Benguella upwelling, the slope fisheries are dominated by the Cape hakes, kingclip (*Genypterus capensis*) and in recent years orange roughy. The high seasonal productivity of the Patagonian shelf extends onto the slope where the dominant catches are of southern blue whiting (*Micromesistius australis*), the Patagonian Grenadier² (*Macruronus magellanicus*), the pink cusk eel (*Genypterus blacodes*) and, more recently, the Patagonian toothfish (*Dissostichus eleginoides*). The potential of deepwater fishing off Southern Brazil in the area of the sub-tropical convergence has recently been investigated (Perez *et al.* 2003).

Although there is high seasonal surface productivity in the northern part of the North West Pacific the only important deepwater fisheries are on the upper slope for Pacific ocean perch (*Sebastes alutus*) and some scorpion fishes. Recent surveys of the deeper slope off the northern Kuril Islands, and southeastern Kamchatka suggest a fauna reminiscent of the Norwegian Sea dominated by benthic feeding fishes such as lycodids (Orlov 2003, Tokranov and Orlov 2002). The slope of the northeast Pacific, which is influenced by the high seasonal productivity in the north and the Californian upwelling in the south, has more important deepwater fisheries dominated by the scorpaenid fishes of the genus *Sebastes* and *Sebastolobus*, the sablefish and the Dover sole (*Microstomus pacificus*). Deepwater fisheries on concentrations of the armourhead and the alfonsino (*Beryx splendens*) around seamounts in the Central Pacific were heavily exploited in the 1970s to the extent that they are now virtually commercially

² *Macruronus* spp. are members of the hake family and should not be confused with macrourid fishes which are frequently referred to as grenadiers

extinct. In the southwest Pacific the productive waters, characterized by Antarctic Intermediate Water, around New Zealand and its extensive underwater plateaus and also off southeastern Australia support important deepwater fisheries for southern blue whiting, blue grenadier (*Macruronus novaezelandiae*), oreosomatids and orange roughy. The Chilean upwelling area of the southeast Pacific also supports considerable deepwater fisheries for Patagonian grenadier, southern blue whiting and Patagonian toothfish.

The only deepwater demersal fishery of any significance in the Indian Ocean was the short-lived fishery for orange roughy that developed around seamounts in international waters (FAO 2001, 2002). A scientific study of the fish communities off western Australia (Williams, Koslow and Last 2001) is of interest in relation to the link between surface productivity and the potential for slope fisheries. The low overlying productivity caused by downwelling of water, initially low in nutrients, results in a diverse fauna of small, typically benthic species and with no evidence of the midslope peak of biomass characteristic of exploited areas.

In the Southern Ocean the important demersal deepwater species is the Patagonian toothfish. Although the overall seasonal surface productivity is high in this area the fishery tends to be concentrated around islands such as the Falklands, South Georgia, Heard, Macdonald and Kerguelen. However some areas with high production such as the Antarctic peninsula are unproductive for fishers, especially toothfish (D. Agnew, MRAG, London; pers. comm.).

7. WHAT IS KNOWN ABOUT DEEP-SEA FISH POPULATION STRUCTURE AND BREEDING BIOLOGY?

Gordon *et al.* (1995) noted that bimodal length distributions were a common feature of deepwater fish and invertebrate populations. This arises in long-lived and/or unexploited populations where the exponential decrease in growth rate with increasing age results in a stacking of older age classes by size class.

The age of fish is generally estimated by counting growth rings on hard parts such as scales, otoliths, vertebrae or fin rays. In shallow-water temperate latitudes these growth zones tend to be annual and can be validated, by tagging, chemical marking, daily growth rings, edge analysis, etc. The basis for the zones is the differential seasonal growth rates resulting from the direct effect on metabolism of changes in physical variables such as temperature or day length or indirectly by the effect of these parameters on food supply and, or, quality. Growth zones or checks can also result from the influence of other factors that affect the metabolism of the fish, such as spawning. For the true deepwater fish that spend their whole life cycle in an environment of constant darkness and temperature it is interesting that most have well marked growth rings. The reason for changes in the growth of the hard parts of these deepwater fishes is unknown but is probably related to either the availability, or the quality, of their food. Validation of the annual nature of the growth zones in deepwater fish is difficult because live fish are not available for tagging or marking experiments. Age estimation in orange roughy, generally considered to be a slow-growing, long-lived species, has been reviewed by Tracey and Horn (1999). The ages of juvenile fish, up to three years, have been validated by comparing seasonal changes in the type of growth at the otolith margin and peaks in the length frequency distributions of juvenile fish. Otolith margin analysis has also been used to validate the annual nature of growth zones of juveniles of several macrourid fishes (Coggan, Gordon and Merrett 1999, Gordon and Swan 1996, Morales-Nin 2001, Swan and Gordon 2001).

The extrapolation of the growth zones of juvenile fish to adult fish can be difficult as the zones become narrower and tightly packed and the otolith shape changes with growth. To view these growth zones it is often necessary to section the otolith. Changes in the growth axis with age can make the growth zones of the otolith difficult

to interpret, as was shown for larger-sized roundnose grenadier by Bergstad (1990). Where the growth zones can be counted in whole otoliths there can be a discrepancy between these counts and those from sections. A good illustration of this is in the black scabbardfish where higher ages are estimated from sections (Morales-Nin *et al.* 2002). However, in this study the interpretation was made more difficult because of a lack of juvenile specimens, no clear seasonal growth patterns at the otolith margins and the possibility of spatial/stock differences. It was considered that sectioning may have revealed additional, non-annual growth zones leading to an overestimation of age.

The great longevity of orange roughy (up to about 140 years) is controversial. Smith *et al.* (1995) demonstrated the differences in age estimates between whole and sectioned otoliths and using radiometric techniques obtained ages comparable with those obtained from sectioned otoliths. Radiometric ageing, which uses the disequilibria between ^{210}Pb and ^{226}Ra , had previously been used to estimate the ages of long-lived, shallow-water species (See Gordon 1998 for a review). However, the radioactive decay process involves the gas Rn and a key assumption has been that that the otoliths have been impervious to gas loss. Gauldie and Cremer (2000) have demonstrated gas loss from orange roughy otoliths and questioned the validity of the high age estimates. Radiometric ageing has also been used by Andrews *et al.* (1999) to validate ageing of the Pacific grenadier (*Coryphaenoides acrolepis*). They addressed the problem of Rn loss and suggested that it did not occur *in vivo*. Kastle and Forsberg (2002) found evidence, although not conclusive, that Rn did not escape from Pacific halibut otoliths.

Although the “jury is still out” on the question of particular old ages of deepwater species it is worth noting that the old ages often cited in the literature are the maximum reported ages. For example, although ages of up to 70 years have been reported for roundnose grenadier most of the fish in the commercial landings are less than 30 years.

In our 1995 paper we noted that fishing down the accumulated biomass of larger fish with a high age and/or size at first maturity could have important consequences in reducing recruitment. We also noted that there was evidence to suggest that some deepwater fishes may not breed every year. Many shelf species attain maturity while they are growing relatively fast and we suggested that deepwater fishes might channel their resources into reproduction only after growth had effectively ceased. Merrett (1994) comprehensively reviewed the breeding biology of deepwater species of the North Atlantic and although there have been new studies on individual species there is still a lack of basic information. The eggs and larvae of deepwater fishes and their distribution in the water column continues to be poorly understood.

8. CONCLUSIONS

8.1 Validity of generalizations

Deepwater fishes are long lived and slow growing, have a high age and large size at first maturity and have a low fecundity. This sentence, or a variant of it, is frequently used in the context of deepwater fisheries. Almost invariably, the statement is coupled with the orange roughy. The question that is seldom addressed is how valid is this generalization? In the context of the mixed trawl fisheries of the northeast Atlantic, ICES asked its *Working Group on the Biology and Assessment of Deep-sea Fishery Resources* to rank the main species in terms of vulnerability relative to two species with a longer history of exploitation, redfish and Greenland halibut. The criteria for this exercise were longevity, growth, natural mortality, fecundity and length or age at first maturity where data were available. Table 3 summarizes the conclusions (the full details for each of the criteria and the sources are published in ICES (2001)). ICES emphasizes that the underlying data are of variable quality but, nevertheless, believe that the main

TABLE 3

Ranked vulnerability of deepwater species based on life history parameters using redfish and Greenland halibut as reference species. 1 – most vulnerable, 5 – least vulnerable (Modified from ICES (2001)).

Species	Vulnerability
Squalid sharks	1.5
Orange roughy (<i>Hoplostethus atlanticus</i>)	1.6
Roundnose grenadier (<i>Coryphaenoides rupestris</i>)	2.4
Redfish (<i>Sebastes</i> spp.)	2.6
Greenland halibut (<i>Reinhardtius hippoglossoides</i>)	3.2
Greater silver smelt (<i>Argentina silus</i>)	3.3
Tusk (<i>Brosme brosme</i>)	3.8
Black scabbardfish (<i>Aphanopus carbo</i>)	4.0
Blue ling (<i>Molva dypterygia</i>)	4.0
Ling (<i>Molva molva</i>)	4.0
Red (Blackspot) seabream (<i>Pagellus bogaraveo</i>)	4.3
Alfonsino (<i>Beryx decadactylus</i>)	4.7
Alfonsino (<i>Beryx splendens</i>)	5.0
Greater forkbeard (<i>Phycis blennoides</i>)	?

pattern is robust. These data indicate, that at least for the mixed fisheries, we should be cautious about making broad generalizations about the life history patterns of deepwater fishes.

Are there any additional questions that have arisen in the intervening years that need to be addressed? There are probably two that warrant increased research effort, which I address in the following sections.

8.2 Stock identity

The first question is related to management/assessment units and stock identity. Often, the statistical data on landings and effort are provided for areas that have little relevance to the distribution of the stock. This has been a particular problem in the northeast Atlantic where the long established ICES statistical Sub-areas and Divisions were devised for shelf fisheries and are inappropriate for deepwater species. Assessments are carried out on statistical units that in many cases have little relevance to the biological stock. With the notable exception of orange roughy in the South Pacific (Smith *et al.* 2002) there have been surprisingly few studies on the genetics of deepwater species. Many deepwater species have wide, even global, distributions and for effective management more information is required on stock structure so as to define appropriate management units. New technologies such as otolith microchemistry might provide additional information on stock discrimination (Edmonds *et al.* 1991, Swan *et al.* 2003a,b)

8.3 Environmental effects of fishing

There are increasing concerns about the ecosystem effects of fishing activity, made all the more obvious by the new technologies described in Section 5. Koslow *et al.* (2000) reviewed the available information on the impacts of deepwater fishing and drew attention to the lack of knowledge of the effects at the level of fish assemblages and on predator-prey relations. The recent study of the pre- and post-fishery impacts of deepwater fishing on the fish communities in the Rockall Trough has yielded new insights and also highlighted some of the problems associated with the use of historical data (Basson *et al.* 2002). Gordon (2003) summarized the available information on fishing impacts in the Rockall Trough. The global perspective is given by Koslow *et al.* (2000), who drew attention to the impacts on deepwater habitats, especially seamounts. The destruction of cold-water corals and their associated fauna by fishing gears has

become a sensitive issue so that many countries, including New Zealand, Australia, Canada, Norway and most recently the European Union, have acted to protect some areas. However, there has been little research on the effect of trawling on deepwater soft sediments (Cryer *et al.* 2002) yet we know that the visible effects of bottom trawling are all too evident (Roberts *et al.* 2000, Trenkel *et al.* 2002). The effects of the removal of top predators and the frequently high levels of discarding on the ecosystem and for biodiversity are largely unknown.

8.4 The need for caution

The questions posed in 1994 remain equally as valid today and in revisiting them it is clear that there have been some considerable advances in our knowledge of the biology of the individual fish, the assemblages and their role in the ecosystem. It is also evident that the deepwater fisheries have developed considerably in recent years and, in many instances, there are serious concerns about their future sustainability. Haedrich, Merrett and O'Dea 2001) demonstrated how science has lagged behind the boom and bust of the fishery and unfortunately this is still all too often the case today. Food supply, which decreases with depth, influences most of the life history traits of the deepwater species. Deepwater fish populations cannot be expected to support the levels of exploitation that have been applied to shelf populations.

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A seascape perspective for managing deep-sea habitats

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1. INTRODUCTION

Sustainable use of the deep seabed off southeastern Australia is presently a focus for marine planning agencies, conservation groups, fishery managers and user groups including the offshore fishing industry. An important stimulus for this focus is Australia's Oceans Policy (Commonwealth of Australia 1998) which is being implemented through Regional Marine Plans (RMPs) (NOO 2003) that include a National Representative System of marine protected areas (ANZECC 1999) so as to encompass many areas of continental shelf and slope seabed. In addition, and largely independently, an expanded control of the offshore fisheries of the region's South East Fishery (SEF) through spatial management is signalled by a range of fishery-specific management planning by the Australian Fisheries Management Authority through bycatch action plans, strategic fishery assessments and ecological risk assessments. Ecologically sustainable development in the SEF, including spatially based management concepts, is also the focus of conservation NGOs (e.g. Ward and Hegerl 2002), and ecologically-sound fishing practices are supported by the strategic plans of peak industry associations, including the trawl sector.

At present, however, the information needs of this spatial policy focus considerably exceed our existing knowledge of the large offshore seabed areas. This is particularly the case for the outer continental shelf and continental slope that support a considerable and expanding fishing effort, but which are largely unseen and their ecosystems poorly understood. In the vast area to be managed by the first RMP ($> 2\,000\,000\text{ km}^2$), the two exceptions are a group of cinder cones (now the Tasmanian Seamounts Reserve) and an area of continental shelf (the Twofold Shelf bioregion) studied by Koslow *et al.* (2001) and Bax and Williams (2001) respectively. Nonetheless, those studies, in common with those undertaken elsewhere (e.g. Langton, Auster and Scheider 1995), demonstrated the multiple spatial scales at which seabed habitats and biodiversity exist, and therefore the multiple scales at which structures and functions of marine benthic ecosystems are organized. Understanding these patterns at the landscape scale is now recognized as essential to successfully managing natural resources for objectives such as biodiversity conservation and ecologically sustainable development (Simberloff 1998; Roff and Taylor 2000, ANZECC and BDAC 2001). Therefore, one of the needs for effective and integrated spatial planning on the deep seascape off SE Australia is that of identifying the spatial scales at which information is required.

2. METHODS AND DATA SOURCES FOR HABITAT CLASSIFICATION

Here we provide a multi-spatial scale perspective for habitat distribution on the upper continental slope – the seabed region bounded approximately by the 200 and 700 m isobaths – and review briefly the relevance of each scale to scientific survey (especially mapping), habitat use, and habitat management. We do this by describing a variety of

seabed habitats that make up 150 km² of a large terrace at the SE margin of the Big Horseshoe Canyon (the Big Horseshoe Canyon SE terrace) collected as part of a larger habitat mapping survey (Kloser, Williams and Butler 2001a, b). Summary details of habitats come from Williams *et al.* (2004). A framework for our multi-spatial scale classification of habitats is provided by a hierarchical scheme being adopted for spatial planning by the Regional Marine Plans (NOO 2003; Williams and Bax 2003a). A hierarchical classification of “habitats” is effectively used as a surrogate for the hierarchy of ecological units and processes. The scheme applied to the SER recognizes a series of nested, pseudo-spatial ‘Levels’ for the structure of habitats, each reflecting the influence of characteristics and processes acting at different scales (Table 1). It is mainly under development by V. Lyne and P. Last of CSIRO Marine Research, Hobart. In addition, explicit spatial scales for habitats are defined according to the scheme of Greene *et al.* (1999).

3. HABITAT SCALES AND LINKS TO SURVEY, USE AND MANAGEMENT (TABLE 1)

3.1 Provincial scales

Provinces are the first level in the classification scheme, and they divide Australia’s SE Region of more than 2 000 000 km² into large areas based on regional patterns in fauna (CSIRO Marine Research 2001) and physiography. Our study area falls within the easternmost Province 3 off the SE Australian continental margin. It is a *Level 1* habitat of some 500 000 km². Within the province, *Biomes* defined by major community types and physiography separate the continental slope from the adjacent continental shelf and continental rise at *Level 2* in the classification scheme (Table 1). Off SE Australia, the upper continental slope is a 3 000 km long sinuous ribbon of seabed that averages only 7.2 km in width as it winds around the continental margin immediately seaward of the shelf break between depths of about 200 and 700 m.

Depth is the strongest environmental correlate of fish community structure in the deep temperate Australian marine environment (see references in Williams and Bax 2001b), and the southeastern upper slope is defined biologically as a *Sub-biome* at *Level 2b* (Table 1). It has a distinct demersal fish community that differs markedly to those at the adjacent shelf-break and the mid-slope (CSIRO Marine Research 2001, Last *et al.* 2005).

At the largest habitat scales, biogeographic provinces, biomes and sub-biomes provide the context to view the habitats of the Big Horseshoe Canyon SE terrace. Their attributes are the large scale environmental variables of latitude, depth and hydrology (at several scales) that correlate with the distributions of marine communities (biodiversity) and fishery resources (Bax and Williams 2001 and references therein). The Big Horseshoe Canyon SE terrace can therefore be visualized as making up part of a habitat restricted to the approximately 300–600 m depth zone on the upper slope in the eastern province of the SE region. Its communities include a suite of large benthic and benthopelagic fishes, including the commercially-exploited pink ling where it occurs at its peak population abundance, and is targeted by the offshore fishing fleet made up by trawlers and ‘non-trawl’ boats fishing with hook and line, gillnets and traps. As a result of the narrowness of this depth zone it has a relatively small area overall (11 250 km²), and a correspondingly small fraction of the South East Fishery (SEF) region, i.e. 5 percent of the 227 340 km² of the area used for fishing outside coastal waters defined as from 3 nm from shore to 1 300 m depth.

3.2 Megahabitat scales (km to 10s of km and larger)

Geomorphic features at large megahabitat spatial scales and the biological communities they support are represented at *Level 3*, the next level in the habitat classification scheme as Major Biogeomorphological Units. The study area represents one of these units: the

TABLE 1

Benthic habitats from the Big Horseshoe southeast terrace classified in the hierarchical habitat classification scheme proposed for Australia's marine environment

Spatial scale follows Greene *et al.* (1999). The relevance of each level of habitat is described in relation to mapping by scientific survey, use by its fauna and commercial fishing, and for the implications of these attributes for marine resource managers. (Data from Williams *et al.* in review).

Classification level	Habitat description	Spatial scale	Relevance to ecology, mapping, use and management
1: Province	Eastern province of south-eastern large marine domain	provincial	Regional ecosystems delimited by biogeographic and physiographic features
2a: Biome	Continental slope (SEF) (200 – 1 500 m depth range)	provincial	Primary division of regional ecosystems by physiography (especially depth) to broadly define distinct community types and physical environment
2b: Sub-biome	Upper continental slope (200 – 700 m depth range)	provincial	Secondary division providing depth boundaries for community structure, and composition of species and life history stages Suites of species targeted by particular fishing methods/ fleets
3: Major biogeo-morphological units	Big Horseshoe SE terrace	large mega-habitat	Boundaries for local ecosystem structures and processes, e.g. topographic features, enhanced productivity, biological aggregations Mapping of entire units using swath acoustics may be cost-effective Large individual fishing grounds with multi-sector activity Areas amenable to spatial management based on broadly defined goals
4: Primary biotopes	* Elongate rocky banks interspersed with sediment patches (sloping flank of canyon) * Patchy mosaic of mixed substrata: 'hard' and 'soft' seabed types (terrace) * Sediment in large clear patches (terrace)	mega-habitat	Habitat values defined by coarsely resolved physical attributes and associations with communities and individual species Spatial extent (approximate boundaries) of general bottom types (textures) resolved by swath acoustics (acoustic facies) Differentiation of fishing grounds used by specific fishing sectors Areas amenable to specific management goals, e.g. for fishery habitat
5: Secondary biotopes	* Outcropping sedimentary clstones * Subcropping sedimentary clstones * Debris/rubble of cobble/boulder clasts * Debris/rubble of gravel/pebble clasts * Highly irregular calcareous muddy sands * Unrippled calcareous muddy sands	meso-habitat	Fine scale resolution of habitat boundaries/ patch structure by 'ground-truth' targeted physical sampling of acoustic facies Associations define essential fish habitat, e.g. for spawning, nursery, feeding, etc. Features known and targeted by individual fishers from particular sectors Specific management goals set, and performance criteria evaluated based on monitoring at this level or lower
6: Biological facies	* 15 based on video observations	macro-habitat	Community dominants identified by targeted biological sampling Fine scale resolution of community boundaries/ habitat associations Biodiversity distributions mapped Impacts of fishing recognised in photographic images Monitoring of fauna for management performance assessment
7: Microhabitats	* 7 based on video observations	micro-habitat	Precise role of habitat detailed Impacts of fishing quantified Monitoring of individual animal attributes such as density, size and growth rate

terrace being the western extent of sediment plain that extends eastwards. Additional *Level 3* habitat units are represented by the other regions that bound the study area: the main arm of the Big Horseshoe Canyon that extends rapidly to 850 m depth to the west, the shelf break escarpment characterized by a series of slumps, scarps and steep slopes in the approximately 200–300 m depth range to the north, and the mid-slope (> 700 m depth) to the south. While submarine canyons are prominent features of the continental slope seabed off SE Australia (NOO 2003, p. 54), with over 100 primary or tributary canyons estimated to intersect the 300–600 m depth zone in the South East Fishery region, Big Horseshoe Canyon is distinctive in forming one major arm of Bass Canyon, the region's largest canyon. Within the restricted upper slope habitat, the Big Horseshoe SE terrace is therefore an example of a habitat of 150 km² existing in a location that is unique with respect to its topography and hydrodynamic climate.

This scale represents the largest units of the continental shelf and slope that can be mapped cost-effectively by swath acoustics and 'ground-truth' sampling (i.e. over a period of days) (Kloser *et al.* 2002). Swath acoustics provide complete mapping coverage of the seabed (Exon and Hill 1999) and enables visualization at scales of 10 km², as well as production of maps based on detailed bathymetry and seabed textures. This allows scientific sampling to be targeted at particular seabed features or textures (Kloser *et al.* 2002). Habitats at this scale may correspond to locally distinct ecosystems such as canyons that are defined by topography and, or, locally defined circulation, and may support enhanced productivity and biological aggregations e.g. Big Horseshoe Canyon (Bax and Williams 2001). As such, habitats at this scale are correlated with the general distribution of fishing grounds and the study area is an example of a large multi-sector fishing ground. Vulnerability may be assessable at this level based on knowledge of geological properties of habitats and impact studies made at finer scales. Collectively, these factors identify major geomorphological units at large megahabitat scales as the largest operational scale for managing anthropogenic habitat use.

'Acoustic facies' (Kloser *et al.* 2002) form mosaics at smaller megahabitat scales (1 km–10s of km), and are the equivalent of *Primary Biotopes*, or *Level 4* units, in the proposed Australian scheme (Table 1). Three types of acoustic facies form the Big Horseshoe Canyon SE terrace: (a) large areas of homogeneous flat seabed characterized by low multibeam reflectivity which make up the majority of the area (approximately 101% of the 150 km²) and are interpreted *a priori* as 'Soft' substratum – sediments; (b) smaller interspersed heterogeneous areas characterized by relatively high reflectivity (six patches making up approximately 43% of 150 km²): interpreted *a priori* as 'Hard' substratum – i.e. consolidated material; and (c) a patch found on the western margin of the terrace of high acoustic reflectivity that occurs on a steep (to 15°) slope (~6 km² of the 150 km²): interpreted *a priori* as 'Rough' substratum – consolidated material exposed on steeply sloping seabed.

During sampling with a video camera to observe these acoustic facies (see below), a total of 85 individuals of adult pink ling were observed; they were strongly associated with structured microhabitats provided by the rough habitat (microhabitats detailed below) and had approximately 30 times higher density of individuals on this primary biotope than the other two.

Primary biotopes, existing at megahabitat scales, make up the *major geomorphological units* and are the appropriate scale at which to understand habitat values, the interaction of users with the seascape, e.g. fishing effort and catch, and for scientists to direct scientific sampling of habitats (Bax and Williams 2001). Of particular importance is that photography and physical sampling confirmed that habitats at this level were successfully differentiated by multi-beam acoustics as their general distributions corresponded well to the *a priori* designation of 'Soft', 'Hard' and 'Rough' substrata in backscatter maps. Because these data can be mapped at sea, targeted sampling at finer scales can be planned and implemented in 'real-time'.

Such information allows interactions of fishers with fishery habitat to be understood at the level of primary biotopes, for example, the two types of fishing grounds that make up the Big Horseshoe Canyon SE terrace. The first of these is a mosaic of sediment and consolidated material that makes up most of the terrace that slopes gently between 300 and 600 m depth over a horizontal distance of about 9 km. This area, being clear of rough rocky 'reefs', provides good access for trawlers to catch a suite of upper slope species including pink ling. At the western margin of the terrace at the same depth range, the upper edge of a relatively steep slope forms the second ground type. This habitat descends to the base of the canyon at 850 m depth and is composed of patches of rough rocky bottom that emerges from surrounding sediments. It can be fished by static gears targeting a range of species, particularly pink ling, but does allow limited access to trawls. Although the exact boundaries of fishery habitats occurring at this level may be ill-defined – often representing transition zones between sediments and areas of rock reef – they provide the basis for estimating percentage areas of habitats at a scale relevant to spatial management planning. For example, management goals that specify target areas of habitat types to be contained within fishery closed areas or biodiversity conservation reserves.

3.3 Mesohabitat scales (10 m to 1 km)

Adding 'ground-truth' sampling to acoustic facies provides habitat resolution at the next level – *Secondary Biotopes at Level 5*. Ground-truthing includes observing the predominant elements of physical substrata and geomorphology and their fine-scale distribution using video and evaluating the composition of substrata from physical collections. Six *Secondary Biotopes* were identified at the Big Horseshoe Canyon SE terrace (Table 1). Sediments consisted of homogeneous calcareous muddy sands that form large unrippled patches to approximately 1 300 m in length at the shallower terrace sites and irregular (bioturbated) patches to approximately 900 m in length at the deeper sites. Rubble and debris of extensively burrowed claystones, mostly composed of gravel and pebble sized clasts, but some of cobble or boulder size, formed mosaics of numerous smaller patches to approximately 660 m in length. These were interspersed with sediments mainly around the southern perimeter of the terrace. Exposed sedimentary claystone rock on steep slopes at the western margin of the terrace forms relatively small patches (to 243 m in length) of subcrop and outcrop in distinct elongate horizontal ridges interspersed with patches of sediment and rubble or debris.

Level 5 is the minimum resolution level necessary for resolving habitat boundaries and patch structure for monitoring, and therefore mapping, during surveys because the high spatial variability encompassed at larger scales will obscure identification of impacts on habitat resulting from its use, as well as any benefits such as restoration resulting from management intervention. This is the basis for establishing animal–habitat associations at lower levels of habitat description and provides a resolution at which to understand the significance of habitat types, such as what defines 'essential fish habitat' (i.e. what limits populations in any way, *sensu* Steneck *et al.* 1997 and references therein). Optimizing the 'ground-truth' – targeted physical sampling of acoustic facies – is important for the execution of cost-effective surveys (Kloser *et al.* 2002).

Mesohabitat scale is also the size of seabed features that experienced fishers are familiar with and operate on. Their knowledge at this level is the basis for successfully targeting their fishing effort at features that result in aggregation of certain species in commercial concentrations (Bax and Williams 2001). Knowledge of habitat variability at this scale is therefore necessary for management areas to be defined without unnecessarily excluding fishers from important parts of larger fishing grounds. Sector-specific (gear-specific) fishery management intervention at this scale could correspond to clearly delineating claystone-based habitats at the western edge of the Big Horseshoe Canyon SE terrace.

3.4 Macrohabitat scales (1m to 10s of m)

Biological Facies, Level 6 in the scheme, at the macrohabitat scale are described by the conjunction of information on the dominant fauna with that on the physical seabed structure. Fifteen predominant biological facies were observed on the terrace. These included a sedentary fauna composed mostly of low (< 10 cm) encrusting sponges, anemones and sand-dwelling sponges that were the primary epifaunal inhabitants of unrippled muddy sands. Infaunal bioturbators – including ranellid gastropods and *Latreillopsis petterdi* – appeared to be abundant on the highly irregular (bioturbated) muddy sands. A mobile fauna including hermit crabs was also frequently observed. Small encrustors and erect epifauna were the most commonly observed biological facies associated with claystone debris or rubble. Beds of small sponges were also attached to this substratum where it was present on the steeply sloping seabed, and to debris or rubble composed of larger cobble and boulder sized clasts. The facies representing the greatest density of epifauna, the largest-sized individuals, and possibly the greatest biodiversity, were beds of small and large sponges associated with subcropping and outcropping claystone rock on the steeply sloping seabed.

Spatial management in the marine environment is ultimately directed at the biological inhabitants of habitats – to conserve biological diversity and local ecosystems or protect particular species (often commercial fishes for fishery management). Understanding animal-habitat associations will therefore require surveying at macrohabitat (and microhabitat) scales because these are the scales at which animal distributions vary, impacts can be recognised and quantified, and at which monitoring must occur.

3.5 Microhabitat scales (< 1 m)

Microhabitats, Level 7, represent the lowest level in the hierarchy. Those observed by video during the study are crevices, cracks edges and ledges associated with rocky outcrops and subcrops, irregular features such as pits and mounds associated with bioturbated sediments, and erect epifauna – mostly sponges – also associated with rocky outcrops and subcrops. The abundance of crevices, cracks, edges and ledges results from the combination of high seabed slope (to 15°) that exposes claystone, which is buried in sediment on flatter bottoms, and the pronounced up-slope dip, or tilt, in the rock that results in the down-slope rock faces being slightly elevated. These are the structured microhabitats with which high densities of pink ling were associated. Much of the claystone exists as detached flat boulders; those visible (not embedded in sediment) averaged 144 cm by 78 cm in size with the largest being 220 cm by 150 cm (n = 25).

Observing and understanding fishing impact must also occur at these scales. Video observations showed physical impacts occur when bottom trawls ‘hook-up’ on claystone boulders (or ‘slabs’) by turning and moving loose pieces. There is evidence of fishing impacting the habitat of the fish being targeted, that is at least partly irreversible. Understanding of vulnerability therefore relies on surveying at macrohabitat and microhabitat scales with extrapolation to primary biotope or geomorphic unit scales by mapping, or to provincial scales based on knowledge of regional geology (Bax and Williams 2001). The key attribute for understanding the impact on rocky claystone habitats is that these rock types are sedimentary and therefore friable, forming loose claystone boulders (‘slabs’), many of which are only partially embedded in sediments. They form large, although unquantified, fractions of mesohabitats and they, together with their attached epifauna, are movable or removable by trawls.

Targeted harvesting of aggregated pink ling populations on rocky habitat by static fishing methods is another form of impact and knowledge of such habitat associations may be necessary for meaningful stock assessment off southeastern Australia (Thompson in review). Off southern Africa, the combination of targeted trawl and demersal longlining resulted in severe depletion of kingklip (the closely

related *Genypterus capensis*) (Punt and Japp 1994). While it is not known whether the different methods were targeting different habitats, Punt and Japp reported that reduced trawl catches were attributed by trawl operators to the systematic removal of the aggregated kingklip spawner stock by longline fishing. The relevance of information on multi-scale habitat distributions and species-associations to spatial management in the SEF is that at present (2003) the fishery is experiencing a large expansion in longline effort and an areal expansion of trap fishing to target pink ling at the same time trawl effort is expanding on the upper slope. The consequence is that all habitat types used by pink ling will be commercially fished and many of them with increasing effort.

Assessing the success of conservation measures requires repeated surveying to monitor changes in size and abundance of epifauna, and the distributions of mobile habitat features – particularly sediments. In deepwater, this must be done at microhabitat scales by photography in conjunction with near-seabed acoustic mapping.

4. FISHING INDUSTRY'S KNOWLEDGE OF HABITAT DISTRIBUTIONS

Habitat distributions at 'intermediate' scales – mega- and mesohabitat – are not known for the vast majority of the continental shelf and slope seabed around southeast Australia. Techniques for using surrogate variables to reliably predict the distributions of habitats and components of biodiversity at these scales are under active development (Kloser *et al.* 2001b) but substantial resources are required before scientific mapping at intermediate scales can be extrapolated over large areas.

However, these are the scales at which commercial fishers know the seabed and their working maps, typically in vessel electronic trackplotters, in the context of the hierarchical classification framework being used for the SER (Table 1), are a mix of Levels 3–6 in the habitat classification scheme. The utility of fishers' mapping data, if collected in the right form, is as it can possibly provide interpreted habitat information (distribution, boundaries, sizes, generalized geology and community types) at megahabitat scale or finer. As well, fishers collectively have near-complete coverage for the continental shelf and slope (from about 100 m out to about 1 300 m depth) at provincial scales.

A project between the CSIRO and the trawl and non-trawl sectors of the southeast Australian offshore fishing industry (Williams and Bax 2003b) was started in 2001 with the explicit aim of incorporating fishers' knowledge of the seascape into strategic management planning. Industry executives supported the project primarily because they viewed it as a way to participate directly in the forthcoming, but then unspecified, spatial management process. It was argued that with their information systematically collected and rigorously evaluated fishers would be able to critically evaluate proposed spatial management plans, and push for management agencies to have clearly defined and measurable aims for their proposed management options. Equally importantly, these data provide industry with a synoptic view and a more detailed understanding of the habitats types that sustain the productivity of their fisheries. There is support to use these data to contribute to both the initial identification and subsequent selection of MPA sites. However, although involvement of industry data in this way has clear potential to enhance conservation, fishers remain uncertain about the consequences for them and therefore are uncertain about how, or indeed whether, to contribute their data.

5. CONCLUSIONS

We provide examples to illustrate a range of relevant spatial scales at which information on deep seabed habitats exists (Table 1) and suggest that it is the *collective* understanding of these scales – the seascape perspective – that enables specific management goals to be defined and their success to be evaluated. However, our examples are from one of the few surveys of deep shelf and slope habitats off Australia and it is unlikely that additional areas will be surveyed over the range of spatial scales needed in the timeframes

(months to a few years) during which wide-ranging spatial management intervention is being planned for the Australian Marine Jurisdiction. Another prospective way of understanding habitat distributions at a regional scale would be through partnership with the offshore fishing industry. Fishers' mapping data, if collected in the right form, could provide interpreted habitat information at useful spatial scales for the continental shelf and slope (from about 100 m out to about 1 300 m depth) with 'provincial scale' coverage. Including fishers' knowledge in spatial management planning for a seascape best known to them is perhaps the best way to gain their acceptance and understanding of conservation objectives and for these to deliver fishery benefits through informed management of fishery habitat.

6. ACKNOWLEDGEMENTS

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***In situ* observations of deep-water fishes in four canyons off the Georges Bank, NW Atlantic**

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1. INTRODUCTION

The distribution and behaviour of fauna living in the area of highly structured continental slopes deserve special ecological interest as the physical conditions arising from interactions between topography and hydrology should impose considerable influences on the relationships among animals living close to the bottom and those in the adjacent pelagic region. Deep-sea canyons may stimulate benthopelagic interactions in particular through upwelling events, that transport larvae of bottom-dwelling fauna into the open water or enhance the horizontal transport and trapping of vertically migrating organisms on to the shelf (Tommasa *et al.* 2000). Further, downslope currents associated with the tidal cycle may transport nutrients to deeper waters where they may be used by benthic, benthopelagic and “pseudoceanic” fauna in the areas of submarine canyons. The ecological significance of benthopelagic interactions in the areas of steep, structured slopes with increased biomass, productivity and variation in local diversity has been emphasized in recent studies in the Canary Islands, Eastern Central Atlantic (e.g. Uiblein *et al.* 1996, 1998, Bordes *et al.* 1999, Uiblein & Bordes 1999, Ramos *et al.* 2001, Wienerroither 2003, 2005).

Behavioural studies of deep-sea macrofauna are rare and deserve more attention in the future as they can reveal important ecological relationships and distinct adaptations among individual species or populations. For example, recent *in situ* investigations of steep slopes and canyons in the Bay of Biscay, North-east Atlantic, have revealed significant inter- and intraspecific differences among seven demersal fish species in habitat use, activity level, locomotion behaviour and disturbance response (Uiblein *et al.* 2003).

This paper presents preliminary information on identification of midwater and demersal fishes to the lowest possible taxon, their spatial distribution and abundance patterns and their behaviour in four deep-water canyons. Data were collected with a manned submersible and an underwater video profiler. The basic study question was: “Does increased transport of organic material towards the bottom of deep submarine canyons enhance local aggregation and benthopelagic interactions of fishes?” Differences among canyons in sedimentation rates should be reflected in local fauna composition, distribution and behaviour.

2. METHODS

During the cruise in September 2002 a total of 24 submersible dives were conducted in four canyons off the Gulf of Maine (Figure 1; for further information see also: <http://www.at-sea.org/missions/maineevent3/synopsis.html>). During descent to the bottom (≈ 900 m depth) and ascent to the surface, the vertical distribution of mesopelagic fishes and other macrofauna was recorded. In six dives (Table 1), after arrival at the bottom, the immediate surrounding was explored for a short time period to record occurrence, abundance and behaviour of demersal fishes and epibenthic invertebrates. Fish identifications and behavioural activities were based on direct observation through the sphere of the submersible as well as video recordings.

The distribution patterns of particular matter were obtained from vertical transects with an underwater video profiler (UVP, Figure 2). The UVP is a self-contained, battery-driven system that collects – among other data – optical information about the size, shape and abundance of objects larger than $60\ \mu\text{m}$ at a rate of 12–25 Hz (Gorsky *et al.* 2002).

3. RESULTS

A total of 21 fish taxa encountered in 10 dives (Table 1) were videotaped and their behaviour analysed (Tables 2, 3, 4). The most frequently observed pelagic taxa were myctophids followed by nemichthyids and serrivomerids, paralepidids, and the Atlantic eelpout (*Melanostigma atlanticum*). Myctophids, nemichthyids and *Melanostigma atlanticum* ranged vertically down to the benthic boundary layer and were in some instances encountered immediately above the bottom (Figure 3). Considerable differences in vertical distribution of these fishes occurred between day and night as well as among canyons (Figure 3).

The bristlemouth (*Cyclothone* sp.), which is supposed to be the most abundant fish taxon, could not always be readily identified because of its relatively small size and cryptic coloration. However, *Cyclothone* were observed frequently in the water column as well as close to the bottom. Also myctophids and macrozooplankton taxa including the siphonophore

FIGURE 1
Location of the four canyons investigated

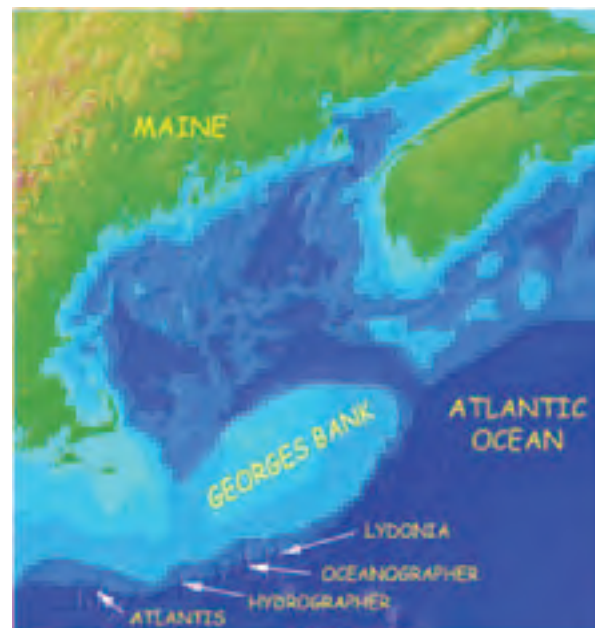


FIGURE 2
Configuration of the underwater video profiler

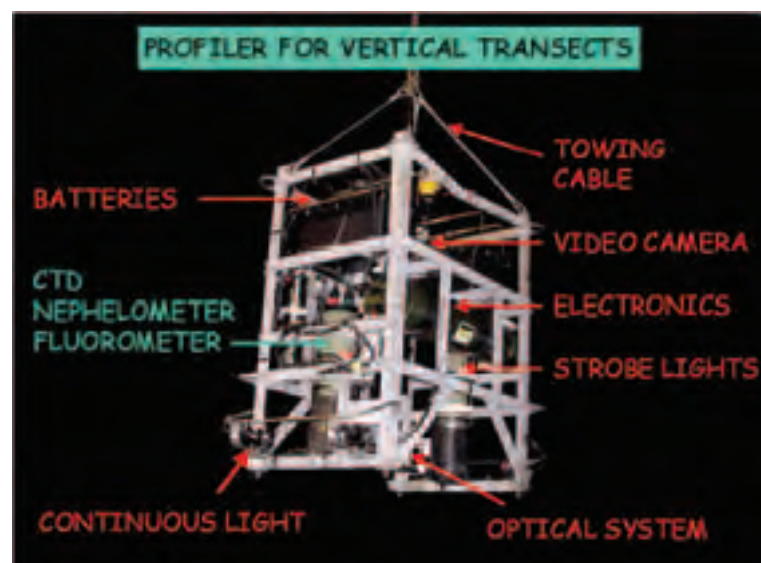


TABLE 1

Summary of canyon dives with the Johnson-Sea-Link submersible during which video recordings for behavioural studies of fishes were obtained

A – Atlantis Canyon, H – Hydrographer Canyon, L – Lydonia Canyon, O – Oceanographer Canyon; dives used for exploration of the bottom are emphasized in bold

Dive Nro.	4471	4474	4475	4479	4482	4485	4489	4492	4494	4496
Date	4/9/02	6/9/02	6/9/02	8/9/02	10/9/02	14/9/02	19/9/02	20/9/02	21/9/02	22/9/02
Start	13:14	13:02	20:42	20:34	12:59	20:28	13:13	20:31	19:28	17:07
End time	16:23	16:45	00:12	23:51	13:07	23:49	16:30	23:38	22:16	20:30
Latitude	40:21.67	40:21.61	40:20.43	40:20.60	40:01.92	39:56.02	40:18.50	40:18.70	40:02.99	39:56.05
Longitude	68:08.80	68:08.86	68:08.18	68:08.54	69:02.09	70:16.26	67:41.06	67:38.84	69:02.22	70:16.028
Canyon	O	O	O	O	H	A	L	L	H	A
Depth of dive (ft)	2850	2255	3000	3000	aborted	2863	3006	2956	2842	3005
Bottom depth (ft)	2850	2255	3000	3000		2863	3006	2956	2842	3005

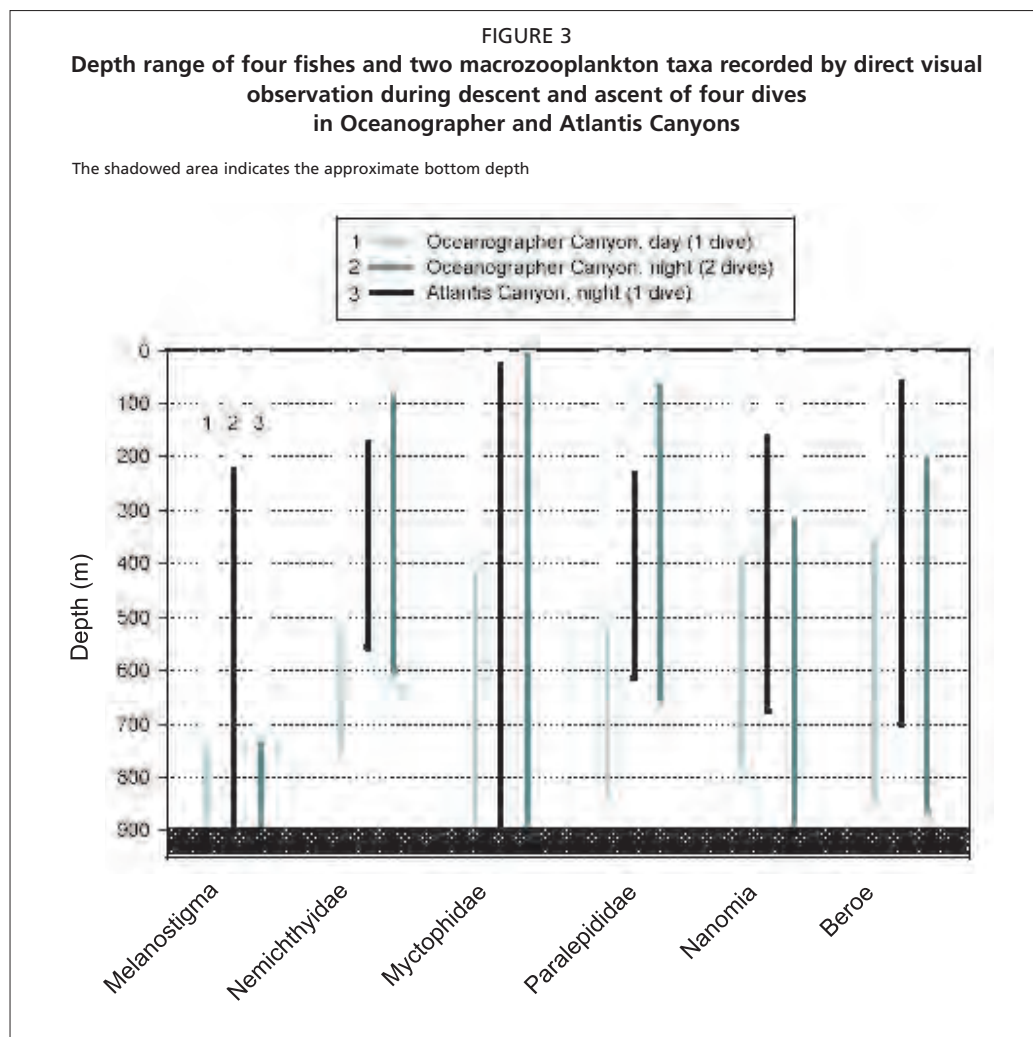


TABLE 2
List of videotaped fish taxa ordered according to open water or
bottom occurrence p/b – open water/bottom

For abbreviations of canyons see Table 1

Fish taxon	Nr.	Canyon	Depth (m)	Occurrence
<i>Petromyzon marinus</i> (Petromyzontidae)	1	L	ca. 100 m	p
<i>Argyropelecus</i> sp. (Sternoptychidae)	1	A, H, L, O	526	p
<i>Chauliodus sloani</i> (Stomiidae)	1	H, O	465	p
Other Stomiidae	4	A, H	603	p
Paralepididae	1	O	535	p
Myctophidae	Many	A, H, L, O	entire water column	p
Nemichthyidae	8	A, H, L, O	295-859	p
Serrivomeridae	1	A, H, L, O	773	p
<i>Melanostigma atlanticum</i> (Zoarcidae)	11	A, H, L, O	792-913	p, b
<i>Apristurus</i> sp. (Scyliorhinidae)	2	H	857	b
<i>Centrosymnus coelolepis</i> (Dalatiidae)	2	A, O	915	b
<i>Centrosyllium fabricii</i> (Dalatiidae)	2	H	859	b
Chimaeridae (<i>Hydrolagus</i> sp.?)	1	A	894	b
<i>Synaphobranchus</i> sp. (Synaphobranchidae)	> 20	A, H, L, O	861	b
Other Anguilliformes	1	A	894	b
Notacanthidae	1	H	866	b
<i>Merluccius</i> sp. (Merlucciidae)	1	H	861	b
<i>Phycis chesteri</i> (Phycidae)	5	A, H, L,	861-893	b
<i>Coryphaenoides rupestris</i> (Macrouridae)	1	H	866	b
<i>Coryphaenoides</i> sp.	1	L	901	b
Other Macrouridae (<i>Nezumia</i> sp.?)	1	H	859	b
<i>Glyptocephalus cynoglossus</i> (Pleuronectidae)	4	O	919-926	b

TABLE 3
Distribution of demersal fish taxa among canyons

Taxa with intraspecific aggregation formation emphasized in bold

Genus/species	Atlantis	Hydrographer	Lydonia	Oceanographer
<i>Apristurus</i> sp.		X		
<i>Centroscymnus coelolepis</i>	X			X
<i>Centroscyllium fabricii</i>		X		
Chimaeridae	X			
<i>Synaphobranchus</i> sp.	X	X	X	X
other Anguilliformes	X			
<i>Notacanthidae</i>		X		
<i>Merluccius</i> sp.		X		
<i>Phycis chesteri</i>	X	X	X	
<i>Coryphaenoides rupestris</i>		X		
<i>Coryphaenoides</i> sp.			X	
other Macrouridae		X		
<i>Glyptocephalus cynoglossus</i>				X
Total number of taxa	5	8	3	3

Demersal fish taxa showed clear differences in occurrence and formation of aggregations among canyons (Table 3). The highest diversity was encountered in Hydrographer canyon. Deep-sea scavengers consisting of two shoaling shark species (*Centroscyllium fabricii*, *Apristurus* sp.), aggregations of cutthroat eels (*Synaphobranchus* sp.) and solitary longfin hakes (*Phycis chesteri*) were observed in close proximity at distances of less than one metre to each other. Patchy distributions of *Synaphobranchus* sp. and *Glyptocephalus cynoglossus* were observed in Atlantis Canyon and Oceanographer Canyon (Figure 5) respectively. In Lydonia Canyon only three taxa and no intra- or interspecific aggregations of demersal fishes were observed.

(*Nanomia cara*) and the ctenophore (*Beroe* sp.) were observed close to the bottom in some dives (Figure 3).

The fishes encountered in the water column showed different activity patterns and the more active ones, in particular myctophids, showed disturbance responses to the submersible. Several stomiids (e.g. *Chauliodus sloani*), nemichthyids and Atlantic eelpouts (*Melanostigma atlanticum*) remained completely inactive and the latter were often observed drifting motionless with the body moving completely passively in the open water. Specimens of the Atlantic eelpout could be collected easily using the suction system and samplers on the Johnson-Sea-Link submersible and were transferred to glass tanks for further observation in shipboard laboratories (Figure 4).

FIGURE 4
Atlantic eelpout (*Melanostigma atlanticum*) collected with the Johnson-Sea-Link in Oceanographer Canyon (dive nr. 4471) in a tank on board of R/V Seward Johnson



Among the most frequent behaviour shown by the demersal fishes were active forward locomotion in sharks and cutthroat eels and a completely inactive “resting” behaviour observed in a shark, a chimaerid, and two hakes, longfin hake, *Phycis chesteri* (Figure 6), and *Merluccius* sp. (Table 4). Cutthroat eel specimens were active showing typical anguilliform forward locomotion or lateral drifting on or above the bottom. Similar observations had been made earlier during submersible dives in the NE

FIGURE 5
Witch flounder (*Glyptocephalus cynoglossus*) in Oceanographer Canyon,
dive nr. 4475



FIGURE 6
Longfin hake (*Phycis chesteri*) resting on the bottom in Hydrographer Canyon,
dive nr. 4494



Atlantic (Uiblein *et al.* 2002). Some individuals showed a disturbance response, most probably reflecting a reaction to the light and sound of, and in some cases also to increased turbulence produced by the submersible (see also Uiblein *et al.* 2003). During the dive in Atlantis Canyon, up to seven deep-sea eels could be observed simultaneously through the sphere of the submersible.

TABLE 4

Observed locomotion behaviour and response to submersible in demersal fish taxa

Fish taxon	Locomotion behaviour	Response
<i>Apristurus</i> sp.	Forward locomotion	No
<i>Centrosymnus coelolepis</i>	Forward locomotion	No
<i>Centrosyllium fabricii</i>	Forward locomotion	Yes
<i>Chimaeridae</i>	Stationary on bottom	No
<i>Synaphobranchus</i> sp.	Forward locomotion, close to bottom	Yes
Anguilliformes	Forward locomotion, close to bottom	Yes
<i>Notacanthidae</i>	Forward locomotion, close to bottom	No
<i>Phycis chesteri</i>	Stationary on bottom, inactive or station holding	No
<i>Merluccius</i> sp.	Stationary on bottom, inactive	No
<i>Coryphaenoides</i> sp.	Drifting or station holding above bottom	Yes
<i>Macrouridae</i> (<i>Nezumia</i> sp.?)	Forward locomotion, close to bottom	Yes
<i>Glyptocephalus cynoglossus</i>	Stationary on bottom, inactive	No

4. DISCUSSION AND CONCLUSIONS

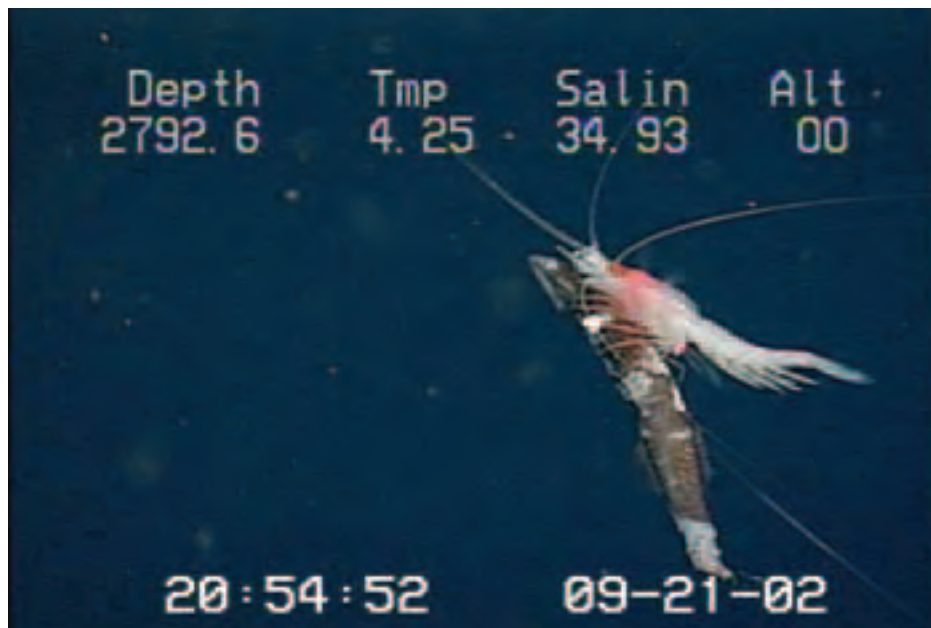
Both mesopelagic and demersal fishes showed variation in species composition and spatial distribution within and among the four deep-water canyons. Differences in vertical zonation may be largely related to diurnal migration activities among the pelagic species. In the benthic boundary layer close associations were observed among pelagic and benthic fauna and aggregation formation in demersal fishes. The major factor inducing such distribution patterns may be allochthonous food input that should be rather high in this zone due to particle sedimentation both from the water column and the adjacent slopes (Keller & Shepard 1978, Noble & Butman 1989, Parmenter *et al.* 1983).

The formation of a scavenger assemblage close to the bottom in Hydrographer Canyon may be closely associated with increased food abundance as suggested by the high turbidity (Youngbluth *et al.* 2003). The impression of high scavenging activity in Hydrographer Canyon is also enhanced by the discovery of a yet unidentified pelagic shrimp in the open water a few metres above the bottom that carried a dead *Cyclothone* (Figure 7). Also in the Oceanographer Canyon particle concentration and fish density close to the bottom was relatively high. No aggregations occurred in Lydonia Canyon and there was a low demersal fish diversity. This result is consistent with a less active canyon with regard to particle concentration.

The inactive behaviour observed in several demersal fish species may reflect sit-and-wait foraging, passive predator avoidance or metabolic relaxation strategies that should be particularly successful on highly structured bottoms of deep-sea canyons. For instance, a dense aggregation of orange roughy (*Hoplostethus atlanticus*, Trachichthyidae) was recently discovered residing mostly inactively on the bottom of a slope canyon in the Bay of Biscay, NE Atlantic (Lorance *et al.* 2003). Apart from serving as foraging habitat or a refuge (Yoklavich *et al.* 2000), canyon bottoms may also be used by demersal fishes for spawning (Uiblein *et al.*, 1996, 1998, Murdoch *et al.* 1990) or egg-brooding (Drazen *et al.* 2003).

In conclusion, deep submarine canyons may play a biologically important “interactive role” as a source and sink habitat for the surrounding shelf, slope and pelagic areas. Future studies should investigate the overall faunal composition and the spatial and trophic interactions in the boundary layer in more detail using submersibles, moored cameras, acoustic surveys, and sediment traps among other methods. Consideration

FIGURE 7
Pelagic shrimp carrying a dead *Cyclothone* sp. close to the bottom
in Hydrographer Canyon, dive nr. 4494



should also be increasingly given to long-term ecological monitoring and sustainable management of marine resources in the area of deep-sea canyons.

5. ACKNOWLEDGEMENTS

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Features of oceanography and ichthyofauna composition on the Emperor Ridge

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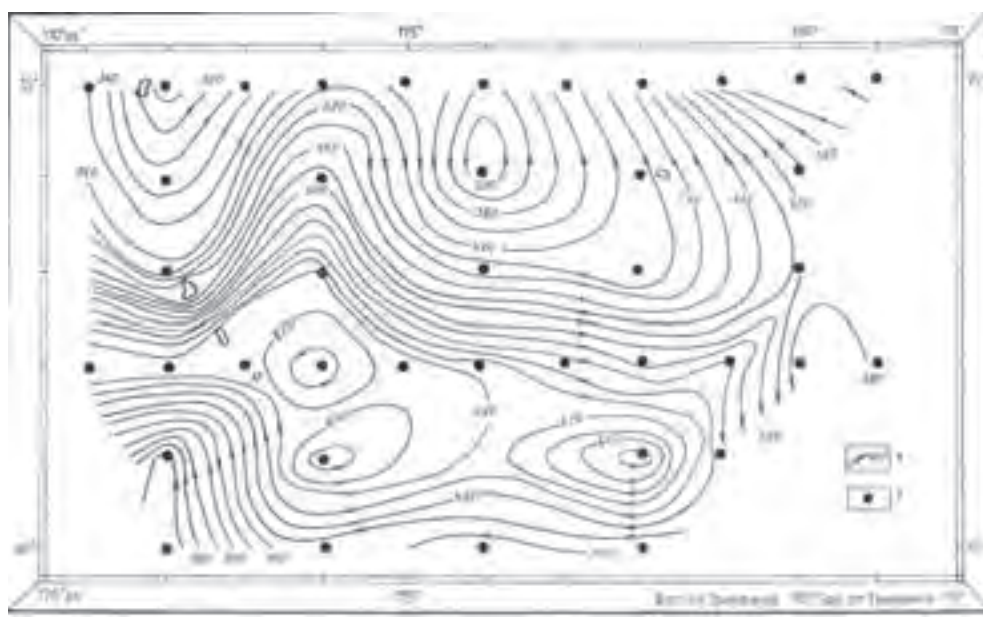
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1. INTRODUCTION

The area investigated is located in the east of the North-West Pacific (FAO Statistical Area 61) and includes the northwest branch of the Hawaiian Ridge (Figure 1). The Emperor Ridge is one of the largest morphological structures of the oceanic floor, separated from the Hawaiian Ridge, 5 000–5 400 m deep and about 30 nm wide. The Emperor Ridge extends 1 600 nm and is 40–140 nm wide. The length of the Hawaiian Ridge is over 1 900 nm.

USSR vessels fished on the Emperor Ridge and northern Hawaiian Ridges in 1968 after discovering abundant aggregations of pelagic armourhead (*Pseudopentaceros richardsoni*) in 1967. Fishing was good for several years and annual catches of pelagic

FIGURE 1
Ocean floor topography of the oceanographic survey region, R.V. Raduga and diagram of geostrophic circulation in the period 6 February–7 March 1974 near the Hawaiian Ridge



armourhead peaked in the 1970s at over 150 000 t. The population abundance has been declining since 1973 and harvesting by USSR's fleet stopped in 1976 though Japanese fishermen continued fishing for some years.

At the same time the TINRO (Pacific Research Fisheries Centre in Vladivostok, Russia) organized scientific expeditions to undertake oceanographic and biological investigations in this area. They determined that the ichthyofauna of the thalassobathyal region was poorer than that of the continental slopes of the Asian continent; shelf species were absent and bottom species were not numerous. Eighty-six bottom and near-bottom fish species occurred in trawl catches on the Emperor Ridge and 150 species north of the Hawaiian Ridge. Trawl catches taken on seamounts of the Hawaiian Ridge consisted of many species without any prevailing forms. The greater the depth the fewer the number of species. Only one or two species predominated in trawl catches in the north of the Hawaiian Ridge, which provided 95 percent of the pelagic armourhead from 1968 to 1974. From 1968 to 1977 the Russian fleet harvested 800 000 t from the summits of seamounts. Thus, the fish catch in the thalassobathyal was 29 t/km² (Boretz and Dartnitskiy 1983) and was much higher than for other fishing

grounds in the ocean (Table 1).

The decline of pelagic armourhead abundance was accompanied by catches of increasing importance of less abundant species. For example, slender beryx, dory (*Oreostomidae*), rosefishes, cardinal fishes (*Epigonus* spp.) were significant on the Kinmei and Milwaukee seamounts. Catches of slender beryx peaked at 60 t/haul with mean catches of 0.1–5.0 t/haul at the Lira seamount.

Longline fishing of slender beryx on the Milwaukee seamount by Japanese fishermen began in 1972–1973. Other targets of longline fishing were butterfishes and giant skillfish (*Erilepis zoniter*). For example, more than ten Japanese and Korean boats fished on the Lira seamount in the summer of 1982; catches of beryx and mirror dory were 150 kg a bottom net. The Japanese trawler *Aso-Maru* caught 0.1 to 2.0 t/haul during that year.

In the regions of the Emperor seamounts substantial concentrations of the epi- and mesopelagic *Maurolicus* were observed. Populations of Japanese mackerel (*Scomber japonicus*) dwell on the Kinmei and Milwaukee seamounts. Since 1973 the Japanese fleet harvested long-finned, big eye, yellow fin and blue fin tunas and marlins. In 1976 the catch of these species was 30 t/day.

TABLE 1
Catch of pelagic armourhead near the Emperor and Hawaiian Ridges by USST and Japanese fishing fleet, 1968–1981 (tonnes)

	USSR	Japan	Total
1968	46 000	-	46 000
1969	144 900	5 400	150 300
1970	136 200	4 100	140 300
1971	3 200	5 900	9 100
1972	79 300	34 700	114 000
1973	149 900	28 400	178 300
1974	16 400	23 500	39 900
1975	28 800	18 600	47 400
1976	5 400	25 800	31 200
1977	200	2 900	3 100
1978	-	900	900
1979	-	500	500
1980	-	1 800	1 800
1981	-	1 100	1 100

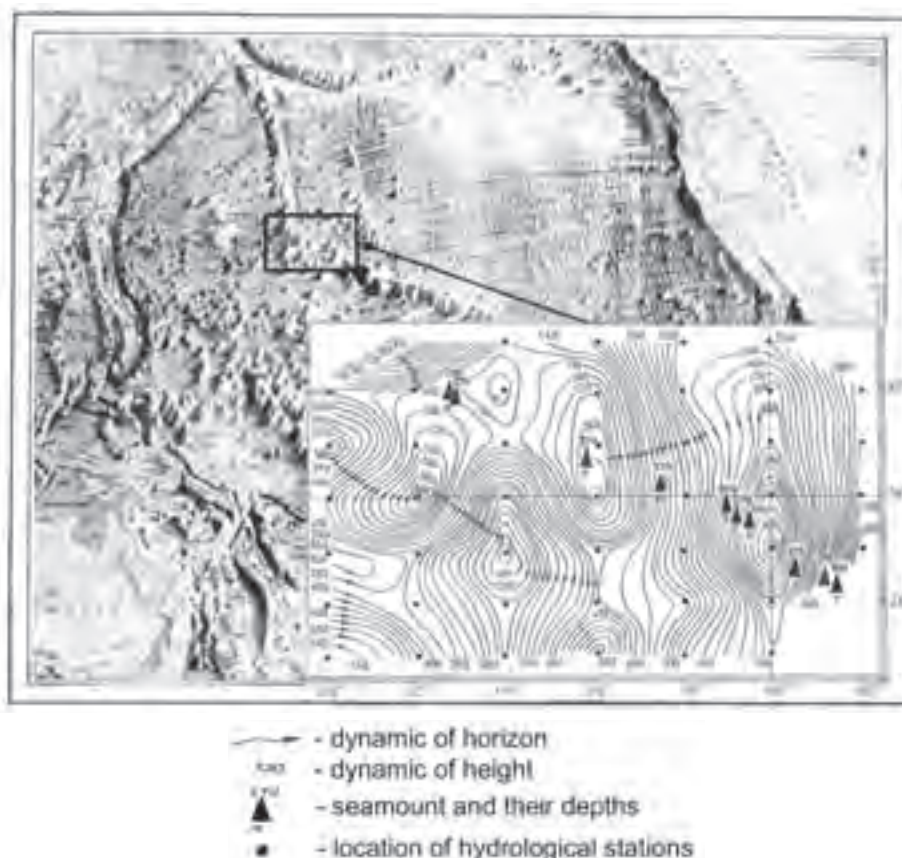
2. FEATURES OF LARGE-SCALED CIRCULATION OF WATERS AND TOPOGRAPHIC EDDIES ON THE EMPEROR SEAMOUNTS

The large-scale circulation in this area is determined by the Northern Subtropic Anticyclonic Circulation. Emperor seamounts are mainly influenced by the North Pacific Current whose central jet is located along the 40° N parallel. Hydrological conditions in the north of the Emperor Ridge are a result of the interaction of subarctic

waters and the Aleutian Current with seamounts. Based on findings of Japanese expeditions during 1957–1963 Ohtani (1965) reported that the Aleutian Current was divided into three branches north of the Emperor seamounts. One turns northward to the Bering Sea, the second deflects south along the axis of the ridge while the third crosses the ridge in the west moving towards Kamchatka. Expeditions by the **R.V. Argo** and **R.V. George Kelez** have found that large-scale eddies were produced in the north of the Emperor Ridge (McAlister, Favourite and Ingreham 1970). Analysis of oceanographic surveys periodically organized by expeditions of TINRO since the summer of 1968 south of the Emperor area and north of the Hawaiian Ridges confirmed the existence eddy systems of different scales above summits as well as around them. This is a typical feature of the water dynamics in this region (Darnitskiy 1979a, 1980a; Boretz and Darnitskiy 1983; Darnitskiy 1995, 2001).

Meso-scaled eddies are constantly observed in the background of the eastern transport of the North Pacific Current in the flow around the Emperor and North Hawaiian seamounts to the Hess rise. The position and structure of zonal flow in the region of the Emperor Ridge fluctuated strongly. For example, in 1979 the North Pacific Current was changed by the western countercurrent, which had not been observed earlier in this area. Both counter flows strongly meandered to produce mesoscaled eddies located between differently directed currents caused by the meridional shift of zonal mid-oceanic currents. As a result flows of the western direction of the North Wind Current were more northerly than the usual location 10° (Darnitskiy, Boldyrev and Pavlychev 1986) (Figure 2).

FIGURE 2
Geostrophic currents at the horizon 300 m near the Hawaiian and Emperor ridges,
February 1979 – as observed from the R.V.M. Tihy Tinro



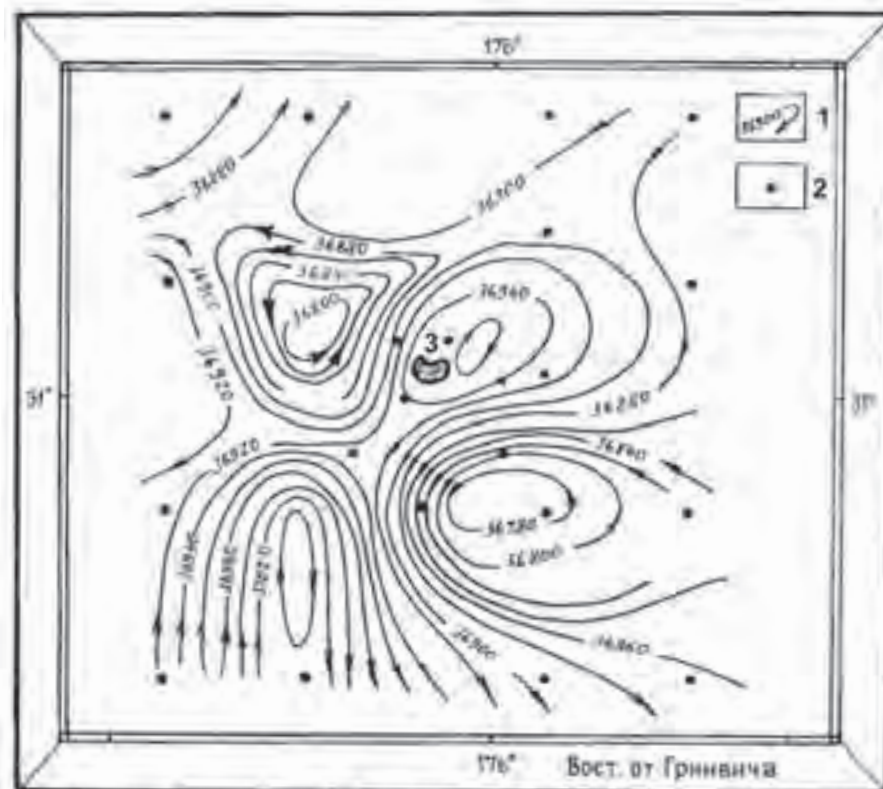
Analysis of survey results from the north of the ridge by the **R.F.V. Prometey** has revealed that the dynamics of waters trended to a meridional location of thermohalines above ridges. Waters of the Aleutian Current are generally located southward along 170 °E where the axis of the Emperor Ridge is located. The position of the cold wedge with low salinity waters extends to 4° 20' N (Darnitskiy, Boldyrev and Volkov 1984). The temperature drop in the North Subarctic Front was 4° (9–13°), that of salinity 0.8‰ (33.7–34.5‰). Thus, the dynamics of large-scaled currents during their interaction with seamounts tended to produce eddies of different scales when zonal trajectories deflected from their mean values by 5–100° and discrete current jets follow the axis of the ridge.

3. TOPOGRAPHIC EDDIES

The observed area is situated between latitudes 27–33 °N and 170 °E 180 and around longitude 178 °W and encompassed the Emperor and Hawaiian seamounts. Surveys covered the areas of the Kinmei, Milwaukee and Colahan seamounts and also six seamounts located in the 200 nm exclusive economic zone of USA. Their summits are located in depths of 160–390 m with a mean seated depths of 5 000 m. Figure 3 illustrates the dynamic topography of surface (from 1 000 dbar). An eddy structure of geostrophic currents field dominates the whole area of surveys.

It is noteworthy that there are eddy formations near the seamounts in deep layers where usually hydrophysical features are steadily distributed. Small-scale eddying is produced near summits. Small-scaled eddies occur if the horizontal scale is reduced to

FIGURE 3
Geostrophic currents at the horizon 500 m near the Colahan seamount
(The Hawaiian Ridge),
as observed from the R.V. Equator, April 1976



1-dynamic horizons 2-location of stations 3- Colahan seamount

several miles (Darnitskiy and Mishanina 1982). For example, according to data from the background survey, the mesoscale eddy of the anticyclonic vortex of 180×80 nm has been observed above the Colahan seamount. The eddy was 800 m deep and the power of the eddy was strongest at a depth of 50 m where the maximum dynamic anomaly is 3.0 dyne-centimetre. The small-scale survey data (with a spatial observation of 3 nm) shows that the horizontal structure of currents on the Colahan seamount is more complex. The strong anticyclonic eddy 600 m deep occurred on the southern slope of the Colahan seamount. On the eastern slope this eddy was cyclonic. The anomaly of the dynamic height in the core of the anticyclone is 4.7 dyne-centimetre; at a depth of 600 m it was 4.6 dyne-centimetre. The maximum anomaly between eddy cores was 4.8 dyne-centimetre at 100 m. In April 1976 the quasi-staggered symmetry of eddy field relative to the centre of gravity in the eddy system located on the summit of the Colahan seamount was well-pronounced. This system can oscillate relative to its centre of gravity.

Geostrophic velocities within the restricted area can increase by several cm/s to 3 m/s and more and are on average 110–160 cm/s (Darnitskiy 1980b). The numerous hydrological surveys carried out by TINRO revealed the influence of isolated seamounts of the Hawaiian Ridge on oceanological fields near the Colahan seamount under different atmosphere conditions and changing seasonal interannual and short-term conditions of the ocean and atmosphere (Darnitskiy and Zigelman 1986). The Colahan seamount is located at latitudes of $31^{\circ}02'$ N and $175^{\circ}54'$ E and is a flat-topped seamount 270 m deep. The area of summit surface with a depth range of 300 m is under 3 square miles. The area level surface is around 335–460 m.

An oceanographic survey in February 1972 revealed warm and cold eddies whose numbers and strength increased with depth. At a depth of 800 m about 5 thermal eddies were observed, the temperature in their cores ranged from 5.0 to 6.2 °C with alternation of warm and cold cores. The typical diameter of eddies at the same depth was 30–50 miles. Elliptic and irregular concentric-shaped eddies were observed at different depths. At greater depths the shape of eddy was changed and their cores have displaced horizontally. The eddy structure of field is characterized by the distribution of salinity, oxygen, phosphates and silicates near the summit.

Well pronounced elliptic anticyclonic eddies with a core and top velocity to the north of the summit have been observed in August 1973. The dynamic anomaly in the core of eddy relative to peripheral field of currents was 120 din.mm. The cyclonic eddy was weaker than the anticyclone observed on the south-east slope. The eddy circulation provided the redistribution of hydrochemical properties near the seamount. For example, the maximum difference in content of silicate at the 400 m level in cores of eddies with different indexes was 300 mkg/l.

In April 1976 four eddy systems were observed down to 1 000 m (Figure 4), the deepest level of observation. Horizontal velocities in different branches of the eddies ranged from 40 to 140 cm/s with a well-pronounced asymmetry in the maximum zone. From a depth of 300 m and to the greatest horizontal extent of observations four eddy systems be observed with salinity with closed cellular isohalines.

The transition layer of minimal salinity (33.7–34.2 psu) was strongly transformed by the activity of eddies and effects of boundary zones and a intermediate salinity minimum spread in the upper horizons and sunk in the lower layers (33.7–34.2‰) in concentric boundary layer covered the top of the seamount.

The same pattern of high and low concentrations of dissolved oxygen occurred in the intermediate level lenses. Values of oxygen, which were influenced by eddying ranged from 4.25 to 6.00 ml/l. At 1 000 m fluctuations of oxygen concentration, 0.50–1.75 ml/l, were strong and had the same cellular structure. Gradients in the concentration of oxygen in the water column at 1 000 m were inclined, for example, the 5.0 ml/l isoline passed through the vertical layer from the surface to 450 m and at a depth of 100 m in

the eddy core above the seamount summit. The oxygen concentration was 7.0 ml/l. In an eddy counter 3–5 miles distant the concentration of oxygen at this depth was only 3.5–4.0 ml/l (Figure 4A).

The distribution of phosphate concentrations on different horizons was also cellular. The main feature was strong upwelling of phosphates whose core was displaced south-westwards from the summit. The direction of upwelling phosphate isolines implied changes over 1000 m in the water column around seamount. The upwelling was more intense in the distribution of silicate. Isolines of silicate concentrations traverse the layer from 1000 to 100 m almost vertically and were not attenuated at the margins of the observations. Waters from intermediate depths to the upper 100 m layer above the summit had a high concentration of silicate. The concentration of silicate ranged from 0 to 310 microgram/l near the summit at the surface. The difference of silicate concentration 1000 m distant represented 1130–3000 microgram/l because of heterogeneity in the upwelling.

Surveys repeated in May–June 1977 revealed that the vertical axis of the anticyclonic eddy located above the summit can make sudden oscillations in the upper levels relative to centre of seamount when the wind direction changed. Geostrophic eddy velocities increased in June by 1.5–2 fold comparing with that found in May. The stratification of the upper 200 m layer was twice as large and in deeper layers the intermediate salinity minimum layer became thicker. In May the layer defined by the 34.1‰ isohalines was 150 m and was located 700–850 m deep. In June the layer was twice as great – 300 m and occurred at a depth of 600–900 m.

4. SYNOPTICAL CHANGEABILITY OF OCEANOLOGICAL FEATURES

Analysis of 1979 synoptical microsurveys on the Colahan seamount showed that the waters enriched by oxygen or nutrients changed, alternating in series according to the direction of the vertical velocity under the influence of counter rotating eddies.

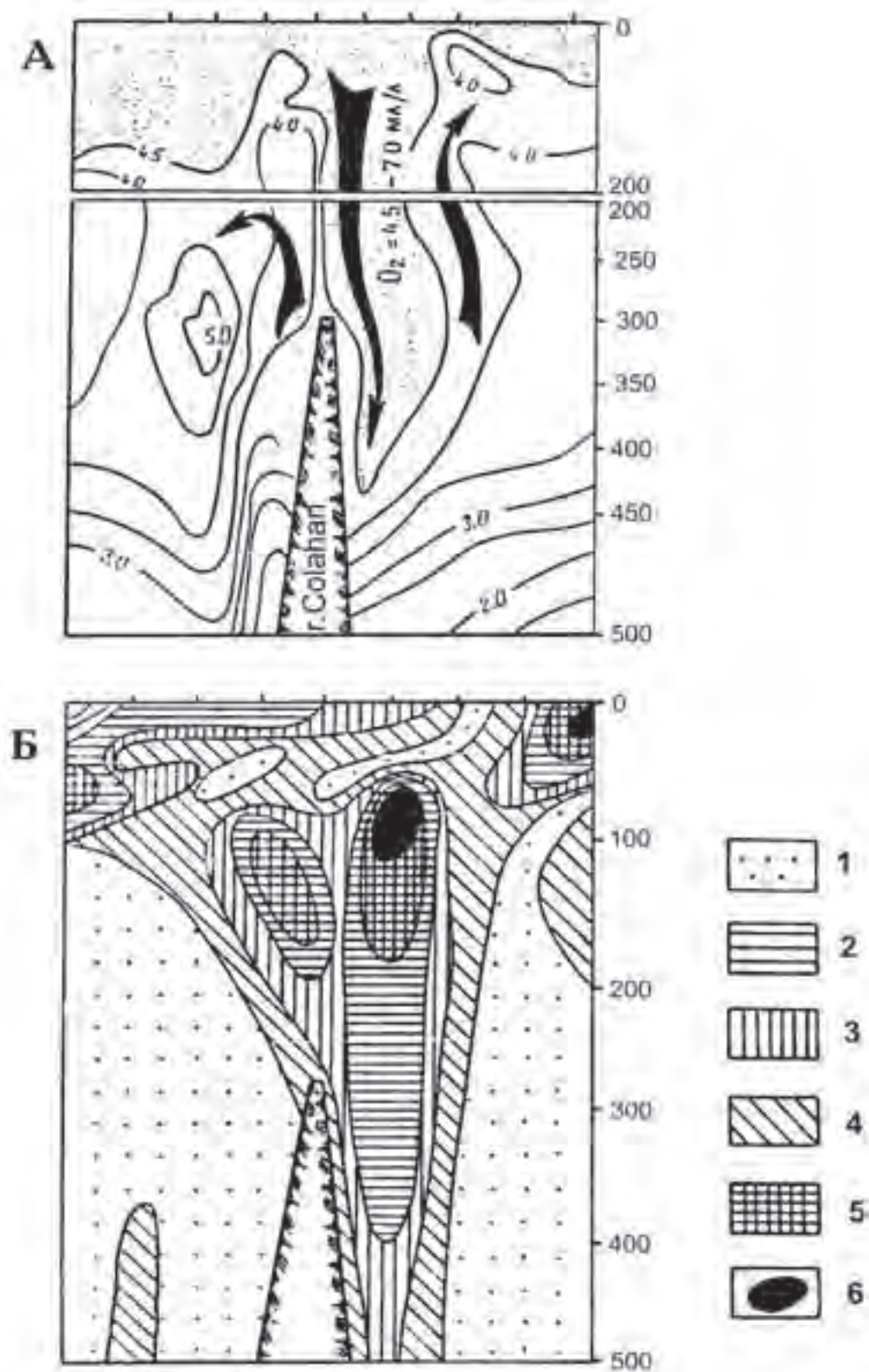
Cyclonic circulation above seamounts results in the 500 m surface column of water being enriched by nutrients; if circulation is anticyclonic, intermediate waters are enriched by well-aerated waters, their frequent alternation results in the formation of highly productive zones because of intensification of exchange process in biotic and abiotic matter. As a result high biomasses of plankton are generated and fish productivity of surrounding waters increases (Figures 4B and 5).

The variability of eddy fields leads to significant transformations in the water mass structure and redistribution of nutrients, oxygen and planktons with approximately quasi-synoptical periodicity. This pattern of current and water mass interaction with seamounts contours occurs in relation to other seamounts of the Hawaiian and Emperor Ridges, but the intensity of upwelling differs depending on the depth and size of the seamount tops.

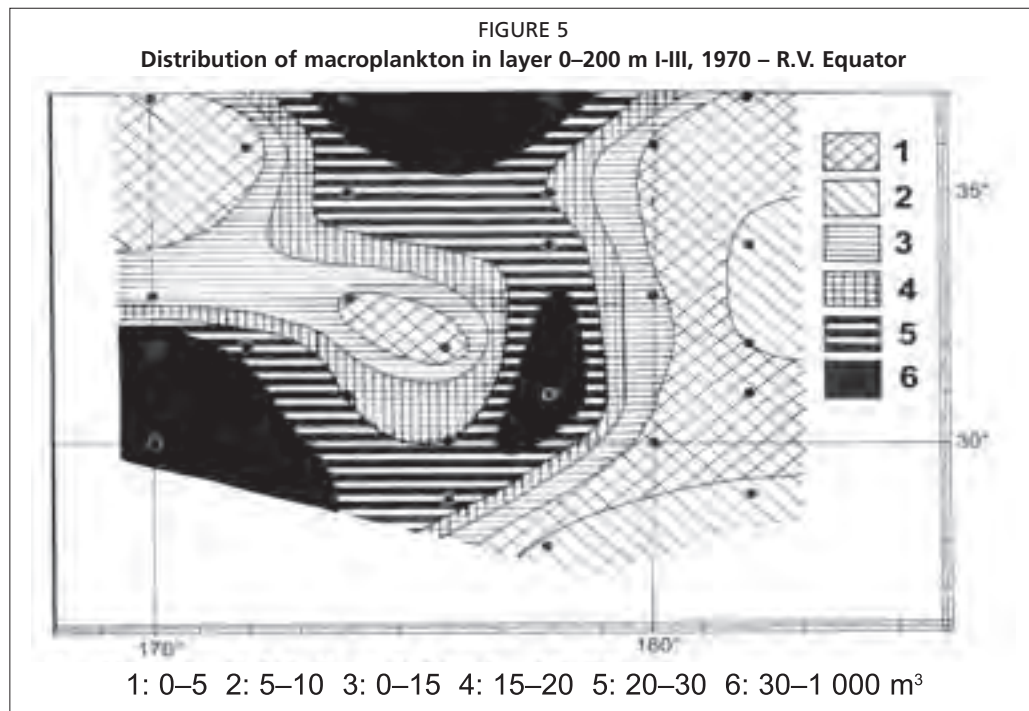
The increase of biological productivity in regions of seamounts provides two-dimensional dynamic formations such as Taylor eddies, which prevent the dispersion of nutrients and oxygen concentrations, and following fish spawning retains eggs and juveniles. When these are generated, their interaction with currents over seamount ridges forms quasi-ordered circulations providing habitats where lower trophic levels animals grow (Darnitskiy 1979b). Eddy intensity is strongest in the 300–500 m layer where flows interact with seamount summits. High-gradient zones can be clearly identified through temperature, salinity, oxygen and nutrients fields. High biomasses of meso- and macroplankton often occur in these zones.

Short-time fluctuations of fishing conditions occur above seamounts (Figure 6), as the result of the evolution of topographic eddy system, i.e. spatial-time transformations of eddy structure, as organisms need time to adapt to changing environmental conditions.

FIGURE 4
Distribution of dissolved oxygen (ml/l) above summit of the Colahan seamount
(A) and biomass (B) in April 1976 – R.V. Equator



Quasi-two-year periodicity in changes of areas covered by positive anomalies of surface temperature were observed in the North Pacific Current at times of interannual changes of water temperature in winter during 1967–1977. Maximal values were observed in 1967, 1969, 1971–1972, 1974 and 1976, and minimal values in 1968, 1970, 1973, 1975 and 1977. In 1971 there was an anomalous warm winter and anomalous cold winters occurred in 1970 and 1977. In summer maximal anomalies were observed in 1967, 1970, 1971 and 1973. Thus, in the study the quasi-2-year periodicity in interannual changes of water temperature over 10-year period was typical for different regions of the oceans as well as in atmosphere.



5. SPECIES COMPOSITION OF FISHES ON THE HAWAIIAN AND EMPEROR RIDGES

Fishes were collected from research trips using the **R.V. Academic Berg** (March–April 1969 and May–June 1970), **R.V. Gerakl** (March–April 1975) and **R.V. Equator** (February–April and July–August 1976). About 500 samples were collected in an area between 27 and 37 °N and 170 °E and 178 °W.

Almost all fishes caught were identified to species or because of poor conservation of samples, by genus or family using Kulikova (1960, 1961), Becker (1964), Belyanina (1974), Mukhacheva (1974) Parin and Novikova (1974), Parin and Sokolovskiy (1976), Fraser-Bruriner (1949), Matsubara (1955), Gibbs (1964), Grey (1964), Morrow (1964), Rofen (1966), Schultz *et al.* (1964) and other references. Several new species were identified by Yu.I. Sazonov (Searsiidae) and B.I. Fedoryako (Cheilodipteridae), Institute of Oceanology Academy of Science USSR (Sazonov 1976, Fedoryako 1976).

The fish inhabiting the Hawaiian and Emperor Ridges included 172 species belonging to 56 families. More than half of all species were from six families: Myctophidae, Gonostomatidae, Sternoptychidae, Melanostomiidae, Melamphaeidae and Bramidae. The rest of the 50 families are represented by single species (Table 2).

FIGURE 6
Average catch of pelagic armourhead in July 1975

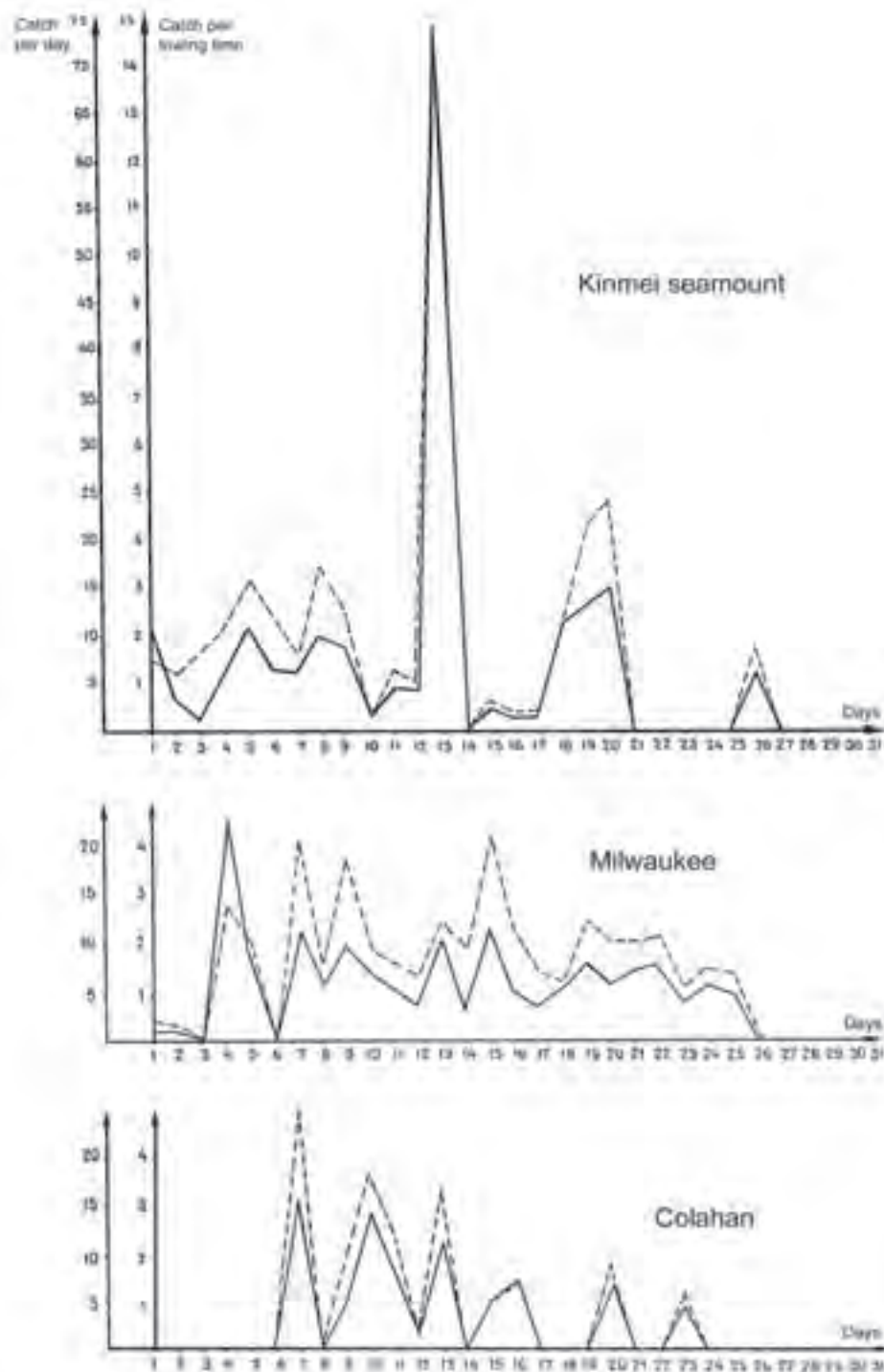


TABLE 2

Species composition of fishes on the Hawaiian and Emperor ridges

The stage of development and their habitat is indicated for each species as follows:

L – larvae, J – juveniles, A – adult, Ep – Epipelagial, Mp – mesopelagial; Bp – bathypelagial, Tb – thalassopelagial.

Family and species	Stage of development	Habitat
Gonorhynchidae		
<i>Gonorhynchus gonorhynchus</i> (Linnaeus)	L	Ep
Argentimidae		
<i>Microstoma microstoma</i> (Risso)	J	Mp
<i>Nansenia</i> spp.	J	Mp
Bathylagidae		
<i>Bathylagus pacificus</i> (Gilbert)	J	Bp
<i>B. ochotensis</i> (Schmidt)	J	Mp
Opisthoproctidae		
<i>Winteria telescopa</i> (Brauer)	A	Mp
<i>Dolichopterus</i> spp.	J	Mp
Gonostomatidae		
<i>Gonostoma gracile</i> (Gunther)	L-A	Bp
<i>G. elongatum</i> (Gunther)	L-A	Bp
<i>G. atlanticum</i> (Norman)	L-J	Mp
<i>Diplophos taenia</i> (Gunther)	J	Bp
Sternoptychidae		
<i>Argyropelecus affinis</i> (Garman)	J-A	Bp
<i>A. aculeatus</i> (Cuvier & Valenciennes)	J-A	Bp
<i>A. amabilis</i> (Ogilby)	J-A	Bp
<i>A. intermedius</i> (Clarke)	J-A	Bp
<i>A. sladeni</i> (Regan)	J-A	Bp
<i>A. offersi</i> (Cuvier)	J-A	Bp
<i>Sternoptyx diaphana</i> (Hermann)	J-A	Bp
<i>S. pseudobscura</i> (Baird)	J-A	Bp
<i>Polyipnus matsubarae</i> (Schultz)	J-A	Bp
<i>P. nuttingi</i> (Gilbert)	J-A	Bp
<i>Valenciannellus tripunctulatus</i> (Esmark)	J	Bp
<i>Maurolicus muelleri</i> (Gmelin)	J-A	Tp
<i>Argyripnus atlanticus</i> (Maul)	A	Bp
Photichthyidae		
<i>Vinciguerria nimbaria</i> (Jordan & Williams)	L-A	Mp
<i>V. attenuate</i> (Cocco)	L-A	Mp
<i>Ichthyococcus elongatus</i> (Imai)	L	Mp
<i>Cyclothone pacific</i> (Makhacheva)	L-A	Bp
<i>C. signata</i> (Garman)	L-A	Mp
<i>Margrethia obtusirostra</i> (Jespersen & Taning)	J	Mp
Melanostomiidae		
<i>Opostomias mitsui</i> (Imai)	J	Bp
<i>Pachystomias microdon</i> (Gunther)	J	Bp
<i>Photonectes albipennis</i> (Doderlein)	J	Bp
<i>Echiostoma barbatum</i> (Lowe)	J	Bp
<i>Eustomias</i> spp.	J	Bp
Chauliodontidae		
<i>Chauliodus sloani</i> (Bloch & Schneider)	J-A	Bp
Stomiidae		
<i>Stomias nebulosus</i> (Alcock)	J	Mp
<i>Macrostomias pacificus</i> (Fedorov & Melchikova)	J-A	Mp
Malacosteidae		
<i>Malacosteus niger</i> (Ayres)	J	Mp
<i>Photostomias guarnei</i> (Collett)	J	Mp
Idiacanthidae		
<i>Idiacanthus fasciola</i> (Peters)	J	Mp
Astronesthidae		
<i>Astronesthes indicus</i> (Brauer)	J-A	Mp
<i>A. cyaneus</i> (Brauer)	J-A	Bp

Family and species	Stage of development	Habitat
<i>A. lucifer</i> (Gilbert)	J	Bp
<i>A. chrysophecadion</i> (Bleeker)	J-A	Bp
Platyroctidae		
<i>Sagamichthys abei</i> (Parr)	A	Mp
<i>Holtbyrnia kulikovi</i> (Fedorov & Sazonov)	A	Mp
<i>Maulisia maui</i> (Parr)	A	Mp
Chlorophthalmidae		
<i>Chlorophthalmus japonicus</i> (Kamohara)	A	Tb
<i>C. proridens</i> (Gilbert & Cramer)	A	Tb
Notosudidae		
<i>Scopelosaurus</i> spp.	J	Mp
Myctophidae		
<i>Electrona rissoi</i> (Cocco)	A	Mp
<i>Hygophum reinhardti</i> (Lutken)	J-A	Mp
<i>H. proximum</i> (Becker)	J-A	Mp
<i>H. macrochir</i> (Gimther)	J-A	Mp
<i>Benthoosema suborbitale</i> (Gilbert)	J-A	Mp
<i>B. pterotum</i> (Alcock)	J-A	Mp
<i>B. fibulata</i> (Gilbert & Cramer)	J-A	Mp
<i>Diogenichthys atlanticus</i> (Taning)	L-A	Mp
<i>Symbolophorus evermanni</i> (Gilbert)	L-A	Mp
<i>S. californiensis</i> (Eigenmann & Eigenmann)	L-A	Mp
<i>Myctophum affine</i> (Lutken)	J-A	Mp
<i>M. asperum</i> (Richardson)	J-A	Mp
<i>M. punctatum</i> (Rafinesque)	J-A	Mp
<i>M. rufinum</i> (Taning)	J-A	Mp
<i>M. orientale</i> (Gilbert)	J-A	Mp
<i>M. auroaternatum</i> (Garman)	J-A	Mp
<i>Centrobranchus andreae</i> (Lutken)	J	Mp
<i>C. nigroocellatus</i> (Gunther)	J-A	Mp
<i>Diaphus coeruleus</i> (Klunzinger)	J-A	Mp
<i>D. termophilus</i> (Taning)	J-A	Mp
<i>D. adenomus</i> (Gilbert)	A	Mp
<i>D. agassizi</i> (Gilbert)	A	Mp
<i>D. anderseni</i> (Taning)	J-A	Mp
<i>D. brachycephalus</i> (Taning)	J-A	Mp
<i>D. chrysorhynchus</i> (Gilbert & Cramer)	A	Mp
<i>D. dofleini</i> (Zugmayer)	J-A	Mp
<i>D. elucens</i> (Brauer)	J-A	Mp
<i>D. fulgens</i> (Brauer)	J-A	Mp
<i>D. gemellari</i> (Cocco)	A	Mp
<i>D. nipponensis</i> (Gilbert)	J-A	Mp
<i>D. schmidtii</i> (Taning)	A	Mp
<i>D. rafinesquei</i> (Cocco)	A	Mp
<i>D. richardsoni</i> (Taning)	A	Mp
<i>D. signatus</i> (Gilbert)	J-A	Mp
<i>D. tanakae</i> (Gilbert)	J-A	Mp
<i>D. urolampus</i> (Gilbert & Cramer)	A	Mp
<i>D. weberi</i> (Taning)	J-A	Mp
<i>D. regani</i> (Taning)	J-A	Mp
<i>Notolychnus valdiviae</i> (Brauer)	A	Mp
<i>Lampadena nitida</i> (Taning)	A	Mp
<i>Stenobranchius leucopsarus</i> (Eigenmann & Eigenmann)	J-A	Mp
<i>Triphoturus micropterus</i> (Brauer)	J-A	Bp
<i>Lampanyctus regalis</i> (Gilbert)	J-A	Bp
<i>L. pyrosobolus</i> (Alcock)	J-A	Bp
<i>L. steinbecki</i> (Bolin)	J-A	Bp
<i>L. alatus</i> (Good & Bean)	J-A	Bp
<i>L. macropterus</i> (Brauer)	J-A	Bp
<i>L. jordani</i> (Gilbert)	A	Bp
<i>L. niger</i> (Gunter)	A	Bp
<i>L. festivus</i> (Taning)	J-A	Bp

Family and species	Stage of development	Habitat
<i>L. punctatissimus</i> (Gilbert)	J-A	Bp
<i>L. bensoni</i> (Fowler)	A	Bp
<i>Lepidophanes pyrsobolus</i> (Alcock)	A	Bp
<i>L. guenteri</i> (Good & Bean)	A	Bp
<i>Ceratoscopelus townsendi</i> (Eigenmann & Eigenmann)	J-A	Bp
<i>Notoscopelus japonicus</i> (Tanaka)	L-A	Mp
<i>N. elongatus</i> (Costa)	L-A	Mp
<i>N. hoffmani</i> (Fowler)	J-A	Mp
Scopelarchidae		
<i>Scopelarchus oxyderces</i> (Rofen)	J	Bp
<i>S. alcocki</i> (Rofen)	J	Bp
<i>Benthalbella dentata</i> (Chapman)	J	Bp
Evermannellidae		
<i>Evermannella indica</i> (Brauer)	J	Bp
<i>Coccorella atrata</i> (Alcock)	J	Bp
Paralepididae		
<i>Lestidiops mirabilis</i> (Ege)	L-A	Bp
<i>Lestidium proximum</i> (Harry)	L-A	Bp
Omosuridae		
<i>Omosudis</i> spp.	J	Bp
Rondeletidae		
<i>Rondeletia loricata</i> (Abe)	J	Bp
Muraenidae		
Gen. spp.	L	Tb
Caristiidae		
Congridae		
<i>Auosoma anagoides</i> (Bleeker)	L	Ep
<i>Anago anago</i> (Temminck & Schlegel)	L	Ep
Nemichthyidae		
<i>Nemichthys scolopaceus</i> (Richardson)	L-J	Bp
Gen. spp.	L-J	Bp
Scomberesocidae		
<i>Cololabis saira</i> (Brevoort)	L-J	Ep
Exocoetidae		
<i>Exocoetus obtusirostris</i> (Gunther)	J	Ep
<i>Cypselurus</i> spp.	L	Ep
Bregmacerotidae		
<i>Bregmaceros japonicus</i> (Tanaka)	L	Mp
Moridae		
<i>Lotella maximovitchi</i> (Herzenstein)	L	Tb
Macrouridae		
<i>Gadomus melanopterus</i> (Gilbert)	J	Tb
Brotulidae		
Gen. spp.	L	Bp
Anopeogasteridae		
<i>Anoplogaster cornutua</i> (Valenciennes)	J	Bp
Melamphaeidae		
<i>Poromitra crassiceps</i> (Gunther)	J	Mp
<i>Poromitra</i> spp.	J	Bp
<i>Melamphaes laeviceps</i> (Ebeling)	J	Bp
<i>M. unicornis</i> (Gilbert)	J	Bp
<i>M. suborbitalis</i> (Gill)	J	Bp
Berycidae		
<i>Beryx splendens</i> (Lowe)	J	Tb
Holocentridae		
<i>Diacoccus</i> spp.	L	Tb
Zeidae		
<i>Zenopsis nebulosa</i> (Temminck & Schlegel)	J	Tb
Lophotidae		
<i>Lophotus capellei</i> (Schlegel)	J	Tb

Family and species	Stage of development	Habitat
Trachipteridae		
Gen spp.	L	Tb
Macrorhamphosidae		
<i>Macrorhamphosus scolopax</i> (Linne)	J	Tb
Apogonidae		
<i>Howella parini</i> (Fedoryaco)	A	Bp
<i>Brephostoma carpenteri</i> (Alcock)	A	Bp
Bramidae		
<i>Brama japonica</i> (Hilgendorf)	L-J	Ep
<i>B. raii</i> (Bloch)	J	Ep
<i>Taractes asper</i> (Lowe)	J	Ep
<i>T. palatycephalus</i> (Matsubara)	J	Ep
<i>Collibus drachme</i> (Snyder)	J	Ep
<i>Caristius macropus</i> (Belloti)	J	Mp
Kyphosidae		
<i>Kyphosus</i> spp.	J	Mp
Pentacerotidae		
<i>Pentaceros richardsoni</i> (Smith)	J	Tb
<i>P. japonicus</i> (Doberlein)	J	Tb
Gempylidae		
<i>Gempylus serpens</i> (Cuvier)	J	Tb
<i>Nealotus tripes</i> (Jonson)	J	Tb
<i>Promethichthys prometheus</i> (Cuvier)	J	Tb
<i>Diplospinus multistriatus</i> (Maul)	J	Mp
Trichiuridae		
<i>Lepidophus caudatus</i> (Euphrasen)	J	Mp
<i>Benthodesmus</i> spp.	J	Mp
Scombridae		
Gen. spp.	J	Ep
Istiophoridae		
<i>Istiophorus platypterus</i> (Shaw & Nodder)	L-J	Ep
Stromateidae		
<i>Psenes pellucidus</i> (Lutken)	J	Tb
<i>Icichthys lockingtoni</i> (Jordan & Gilbert)	J	Tb
<i>Cubiceps</i> spp.	J	Mp
Tetragonuridae		
<i>Tetragonurus cuvieri</i> (Risso)	J	Mp
Scorpaenidae		
Gen. spp.	J	Tb
Bothidae		
<i>Engyprosopon hawaiiensis</i> (Jordan & Evermann)	J	Tb
Ostraciontidae		
<i>Ostracion</i> spp.	J	Tb
Molidae		
<i>Mola mola</i> (Linnaeus)	J	Ep
Oneirodidae		
<i>Oneirodes</i> spp.	L	Bp
Ceratiidae		
<i>Cryptosaras couesi</i> (Gill)	J	Bp
Linophrynidae		
Gen. spp.	L	Mp

The most diverse species were the lanternfishes (Myctophidae) represented by 58 species belonging to 16 genres. The most numerous were species of the genus *Diaphus* – 20, *Lampanyctus* – 10 and *Myctophum* – 6. Representatives of genres of this family though less diverse, however, could be more abundant and sometimes made a significant contribution to the catch. According to Becker (1967) 130 species of Myctophidae from the 190 described as occurring in the Pacific Ocean are mostly distributed in subtropic and tropic waters. The geographical position of Hawaiian and Emperor Ridges and their currents are the cause of the species diversity of Myctophidae in this region.

The North Pacific Current advects species from the Western Pacific such as *Diogenichthys atlanticus*, *Diaphus nipponensis*, *D. tanakae* and *Notoscopelus japonicus*. The North Trade Current enriches this region with *Myctophidae* from the East Pacific e.g. *Lampanyctus regalis*, *Triphoturus micropterus* and *Diaphus rafinesquei*. In addition the seasonal temperature conditions favoured the presence of typical tropical species such as *Myctophum orientale*, *M. rufinum*, *Diaphus fulgens* and boreal species such as *Electrona rissoi*, *Lampanyctus jordan* and *Ceratoscopelus townsendi*.

Many species of lanternfishes occurred in our collections that have not yet been identified. For example, V.E. Becker (1967) records only 13 species of lanternfishes in the region of the Hawaiian islands, a result of the poorly investigated ichthyofauna of the Hawaiian Islands and adjacent waters. The most deep-sea samples (80 stations) were collected by the **R.V. Albatross** at the beginning of the 20th century (Gillbert 1905).

A similar situation occurs for other families: Gonostomatidae are represented by 13 species which include *Diplophostaeonia*, *Maurollicus muelleri*, *Margrethia obtusirostra*, *Valencianellus tripunctulatus* and *Ichthyococcus elongatus*. The Sternoptychidae in the region of the Hawaiian and Emperor Ridges consists of ten species of which *Argyropelecus amabilis*, *A. ouersi*, *Polyipnus matsu-barai* and *Sternoptyx pseudobscura* were newly described from this area.

It is noteworthy that range records for the Evermannellidae (*Evermannella indica* and *Coccorella atrata* in our collections), had been limited to the Atlantic and Indian oceans (Sokolovskiy and Sokolovskaya 1975) till then. We also found rare deepwater fish such as *Macrostomias paciucus*, *Stomias nebulosus*, *Pachistomias microdon* and *Rondeletia loricata*.

6. INTERNAL WAVES ABOVE SEAMOUNTS AND THEIR INFLUENCE ON THE HYDROLOGICAL STRUCTURE OF WATERS

As a result of interaction of barotropic tidal waves with meso-scaled ocean floor irregularities above slopes and summits of seamounts internal waves are generated with tidal periods. These waves give rise to vertical transport of water masses like tidal fluctuations at sea level whose amplitude they exceed many times. As a result, seamounts periodically have lenses of intermediate water masses of different scales with well-pronounced anomalies relative to environmental background conditions.

Echo recording of commercial aggregations of marine organisms above seamounts often reflects a synchronous relation of horizontal and vertical migrations of marine organisms over a period of flood and ebb oscillations, which are mostly irregular and semi-diurnal.

Theoretical investigations have revealed that the interaction of short-term internal waves with a single cycle are characterized by the formation of isolated disturbances in amplitude in vertical velocity. The amplitude of movements of the boundary of water masses can be many orders of magnitude greater than the amplitude of tides at the sea surface. The transformation of barocline tidal waves in areas of single rise is characterized by a 2 to 3 fold increase in amplitude compared with their maximum values away from seamounts.

Data from two-hour observation from two- and three-day stations above the Hawaiian and Emperor Ridges in different seasons of 1972–1973 showed a range of temperature, salinity, dissolved oxygen, phosphate and silicate measurements were above summits of different size and seamount morphology in the upper layer of the ocean (Darnitskiy 1988a).

The experience of the commercial fleet revealed that maximum and average catches at different seamounts occurred because of different behavior of fish aggregations caused by different wave processes reflected in the diurnal oceanologic dynamics. For example, diurnal fluctuations of temperature changed by the order of 0.3 to 3.4 °C;

concentrations of silicate changed from 1.75 to 370 microgram/l and of phosphate from 14 to 50 microgram/l in 0–500 m layer.

In winter diurnal fluctuations of temperature in the upper quasi-homogenous layer were not significant, ranging from 0.34 to 0.49 °C. However, at depths of 75–100 m the amplitude of fluctuations peaked at 2.6–3.4 °C and was 2.1 ° at 150 m. Concentrations in many cases coincided in time but did not match the period of dissolved oxygen extremes connected with processes of biochemical consumption. Seamounts are characterized by high amplitude of daily changes of oceanographic properties. In winter, maximum amplitudes of water temperature occur in intermediate depths of 100–150 m; in summer maximum amplitude are displaced by 50–76 m because of the development of the seasonal thermocline.

Submarine observations of the Mid-Atlantic ridge show that aggregations of fish respond to tidal water movements changing their depths and their areas relative to bottom relief.

Rossby waves, wave disturbances on a planetary scale, can transport energy to seamounts by small-scaled topographic waves or small-scaled eddies in the geostrophic circulation field near seamounts on the Hawaiian Ridge (Darnitskiy and Mishanina 1982, 1987; Jansons and Johnson 1988). The transformation of large scale wave-eddy formations influences redistribution of oceanographic properties and marine organisms on the surface as well as in the water column near seamounts depending on the intensity of these processes and local features of the bottom relief.

Analysis of data from 10-day stations above the Lire seamount (36°48' N, 171°22' E) in the system of the Emperor Ridge has revealed waves with larger periods than daily tidal ones (Darnitskiy 1988b). During the period 23 June–3 July 1982 well-pronounced maxima of oxygen at depths of 30–50 and 200–300 m were observed with the highest changes (0.75–1.32 ml/l, s.d. $\sigma = 0.18$ –0.28) in the depth range of 50–100 m. The second maximum of amplitude (0.56–0.60 ml/l, $\sigma = 0.13$ –0.18) was observed in the depth range of 300–400 m. The third peak in the amplitude of changeability (0.65 ml/l, $\sigma = 0.12$) occurred at a depth of 200 m. The convergence of peak amplitudes of oxygen concentration in the vertical dimension is explained by periodically repeated vertical displacements of water masses along slopes of seamounts under the influence of wave processes i.e. topographic Rossby waves and Kelvin waves (Darnitskiy, Mishanina 1987, Darnitskiy 1988b).

The vertical haline structure near the Lira seamount is characterized by two extremes of changeability related to higher salinity at the surface (34.6–34.9‰) in the first case and an intermediate layer of lower salinity (34.02–34.13 psu) at the depths of 45–650 m in the second case. The amplitude of salinity changeability peaked in the upper layer of 0–100 m (0.23–0.29‰, $\sigma = 0.06$ –0.07) and in the layer 200–300 m (0.19–0.23‰). Peaks of concentration of salinity amplitudes did not match depths of extremes on vertical lines of salinity and were caused by wave phenomenon. The quasi-cyclical character of changeability in structure of salinity was also found in the vertical change of oxygen. In the upper 0–100 m layer, a 1–3 day periodicity was found during a 10-day period of observation. At 200–400 m depth, an intense deep-sea disturbance occurred on the fifth day after the upwelling of deepwaters occurred three times over the preceding 10-day period. Vertical displacements of isochalines reached 100–110 m in the intermediate layer at depths of 100–400 m in the second half of the observations. Thus, the deep structure of water mass changeability is more complex than in the upper nearly uniform layer!

Continuous 9-month monitoring of temperature and currents near the Bermuda islands allowed observations of internal Kelvin waves with periods of 1.1–1.9–2.2–3.8 days intercepted by the island (Hogg 1980). Methods of observations in the Emperor and Hawaiian regions did not determine wave periods. However, it is evident that

scales of internal wave periodicity are large, from 4-day tidal oscillations to 3-day Kelvin and Rossby waves. These data coincide with the results of Hogg's observation in the region of the Bermudan islands.

7. CONCLUSION

- i. The dynamics of large-scale currents interacting with seamounts are characterized by generation of eddies of different scales and deviation of current trajectories by 5–10° along the axis of ridge.
- ii. Topographic cyclogenesis¹ is stronger in subsurface and intermediate water masses interacting with seamount summits. In addition inverse eddies can be observed.
- iii. Deepwater eddies are well-pronounced in hydrochemical structure to depths 1 000–1 500 m and generates dynamic heatons.
- iv. Surveys by the **R.V. Vityaz** in 1956 found Japanese fishermen already knew of the fish aggregations on seamounts in the 1950s long before large-scale harvesting on the Emperor and Hawaiian Ridges began.
- v. Biological productivity is increased by internal waves located near seamounts that are blocked by seafloor relief and augment amplitudes many times, sometimes orders of magnitude, greater than background values.
- vi. The observed ichthyofauna consisted of 172 species belonging to 56 families.
- vii. More than half of all species found (55.8 percent) belonged to six families.
- viii. Seamounts are zones of high productivity, which are related to coastal ecosystems through current systems.

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¹ Cyclogenesis is the "process(es) forming a cyclone" (either a cyclonic (counter-clockwise) "storm" in the atmosphere, or a cyclonic (counter-clockwise) eddy in the ocean, (northern hemisphere in both examples). Subsurface cyclones may form due to a variety of processes, including conservation of potential vorticity, as a layer of water "shrinks" in height as it passes over a seamount.

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The census of marine life: community access to basic science

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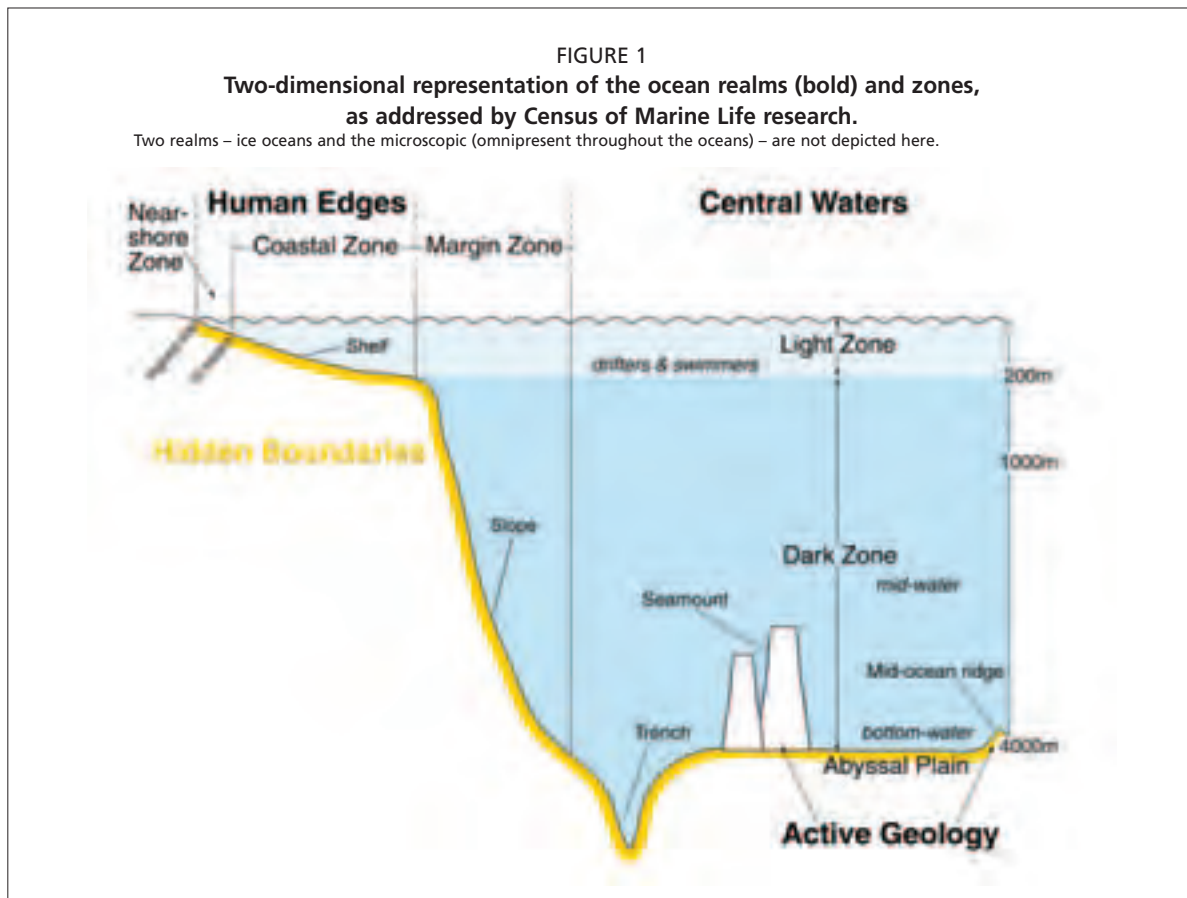
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1. INTRODUCTION

Investments made to explore space and distant planets are far greater than what have been spent to study oceans right here on earth. Is it any wonder then, that we know so comparatively little about them? Perhaps the most striking gaps in our knowledge of the oceans are in what lives there. Answers to questions of where and how many are needed, but we do not even know for certain what species are there. Science has only identified about 200 000 of possible millions of marine species believed to exist (O'Dor 2003). From what we do know, at the genetic level, the oceans contain the vast majority of all biodiversity, a resource whose importance society has only recently begun to realize. Efforts to successfully exploit, and sustain, marine biodiversity are hindered by our lack of knowledge.

Assessing what lives where in the oceans was once an impossible dream, but new technologies available to science make such an endeavor realistic today. The Census of Marine Life is a ten-year international research programme that takes advantage of this opportunity to assess and explain the diversity, distribution and abundance of life in the oceans – past, present and future. Because the ocean habitats span from the only intermittently underwater to depths of over 10 000 m, so the approaches to studying the ocean's life also varies. The Census tackles the unknown by dividing the ocean into six realms: human edges, hidden boundaries, central waters, active geology, ice oceans and the microscopic. Strategically, these realms are sub-divided into zones based on the types of technologies used to survey their marine life (Figure 1). There are currently seven zonal field projects underway and several more in development. These projects, regional to global in scale, are demonstrating techniques and standardizing protocols for observation of life in the oceans. Between 2005 and 2010, the Census will encourage additional sampling in all oceans using these protocols to achieve global comparison (Decker and O'Dor 2002).

Additional research components support the field projects to address issues of time and to develop tools for serving and analyzing biodiversity data. The History of Marine Animal Populations project is uncovering 'baselines' using a unique interdisciplinary approach to interpret changes in marine populations as recorded in historical archives. Computer models are incredibly useful for synthesizing and interpreting biodiversity data. The Future of Marine Animal Populations develops and tests computer models to facilitate analyses of the historical and current state of marine species and their interactions with one another, as well as enabling synthesis of a variety of data types and more reliable predictions on how marine populations may respond to stress from fishing and climate change. Finally, in order to archive and serve data and analytical tools, the Census is supporting the development of the Ocean Biogeographic



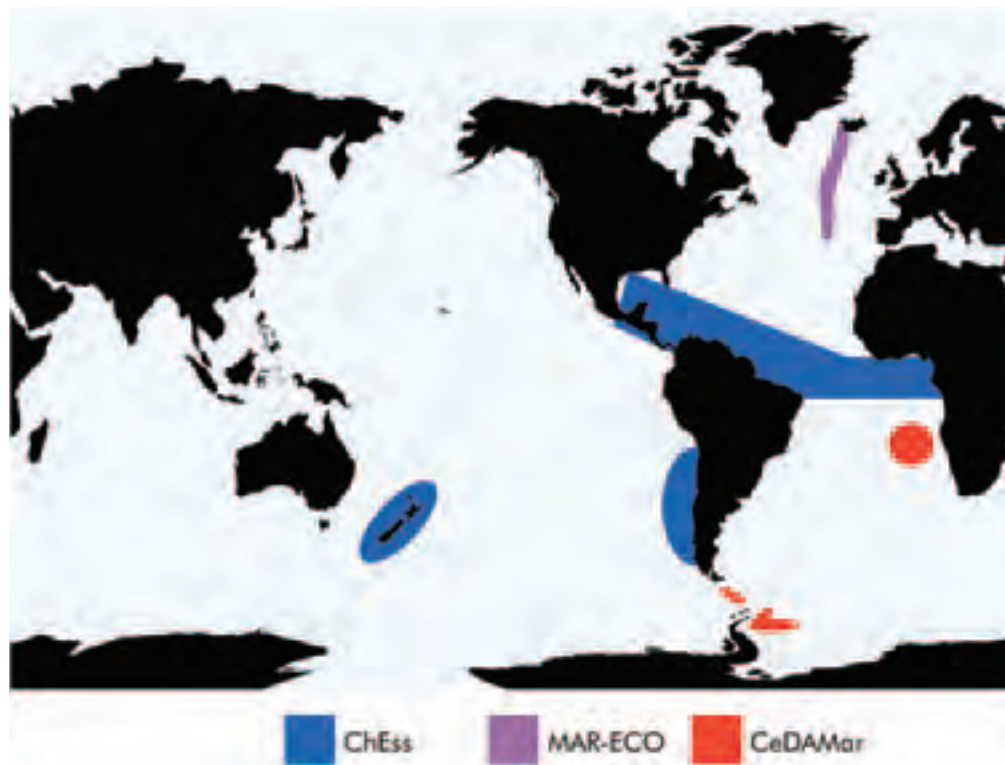
Information System, a web-based, publicly-accessible portal to global geo-referenced information on accurately identified marine species.

2. THE DEEP SEA

While the Census of Marine Life includes both coastal and deep ocean environments, for the purposes of this paper the focus will be on the deep-sea projects (Figure 2). The deep sea poses particular challenges to research because of its remoteness and the environmental conditions associated with that environment. So little is currently known about these ecosystems that estimates as to the necessary – or even possible – sampling resolution are difficult at best. The sediments of the deep-ocean floor, for example, are one of the most species-rich marine habitats; undescribed species are discovered in every expedition. Expeditions to date, though, have barely touched this expansive environment, making it also one of the least well known with estimates of species ranging from less than one million to five million (Grassle 2001).

The deep-sea projects of the Census are encompassed under several of the different realms. The first is the “hidden boundaries”, interfaces between major geologic boundaries that form unique habitats, such as the sediments of the abyssal plains, separating the basin of water from the oceanic crust. The project entitled Census of Diversity of Abyssal Marine Life, or CeDAMar, is aimed at documenting actual species diversity globally in abyssal plain sediments and determining what the controlling factors of biodiversity in the abyssal plains may be. For example, what is the role of primary production in the surface waters on deep diversity? Like all Census projects, CeDAMar will standardize approaches to surveying deep benthic marine life so that meaningful comparisons can be made between sites and studies. Target species are primarily small organisms like protists, crustaceans, and worms, in which the sediments are rich.

FIGURE 2
Map of the study area of the Census of Marine Life deep-sea field projects (in 2003)



The seafloor, however, cannot be solely characterized by these wide expanses of minimal topography. New earth has also been forming for billions of years and creating the isolated habitats of the realm of “active geology.” Because of their isolation these habitats offer tremendous opportunity for exploration, both in terms of locating the existence of a site and of studying its unique – and often highly endemic – fauna. Hydrothermal vents were not discovered until the late 1970s, and with that came the discovery of symbiotic tube worms. Scientists learned that this entirely new ecosystem received energy chemosynthetically from hydrogen sulfide emitted in the black “smoke” from the vents independent of surface organic production. Our understanding of hydrothermal vents and other chemosynthetic ecosystems (cold seeps, whale carcasses, sunken wood and areas of low oxygen associated with subduction zones) is limited to studies of only a few sites around the globe; there is still much unknown. The Biogeography of Chemosynthetic Ecosystems (ChEss) project will assess the diversity, distribution, and abundance of the species in chemosynthetic ecosystem and explain the differences and similarities from place to place at a global scale. ChEss will look at potential processes controlling biodiversity, such as larvae dispersal, topography and sea floor spreading (Van Dover *et al.* 2002).

Another product of active geology is seamounts. Many are geological ghosts of volcanoes and like vents and seeps, seamounts are often geographically isolated, providing a great opportunity to substantially increase our understanding of biogeography by looking at the similarities and differences in the communities between separate seamounts. Of the 30 000 or more seamounts around the world, only about 200 have been sampled. From those surveys, almost half of the species collected were new to science and likely to be endemic to their particular ecosystem. Increased exploitation of seamount fauna has put pressure on scientists to study seamounts. The Census has begun the development of a global seamount project that will synthesize existing

biodiversity knowledge and direct future field efforts towards a comparative ecology of seamounts, categorizing communities and developing proxies for generalized models that will enable us to predict properties of unexplored seamounts, a capability urgently needed for effective management of fisheries on seamounts.

Above the seafloor is the oceanic dark zone of the “central waters” where the Census project known as MAR-ECO (Patterns and Processes of the Ecosystems of the Northern Mid-Atlantic) aims at describing and understanding the patterns of distribution, abundance, and trophic relationships of the organisms in the deep pelagic, near-bottom and epibenthic habitats of the North Atlantic. Even in the dark zone, most animals rely on nutrients from primary production near the surface, which fall through the water column as marine snow. Images collected by the MIR submersibles on a recent MAR-ECO expedition to the Charlie Gibbs Fracture Zone (Mid-Atlantic Ridge) revealed surprisingly high concentrations of marine snow at over 4 000 m depth indicating the environment there may be able to sustain a high diversity of species. MAR-ECO surveys focus on macrofauna and megafauna, including fish, crustaceans, cephalopods and gelatinous zooplankton. Because of the depth and the often rough terrain associated with mid-ocean ridges, many traditional sampling methods (e.g. trawling) are not an option, so MAR-ECO must utilize innovative methods and technology to study and map the distribution of life there.

3. ACCESS TO DATA

While the pursuit of a global understanding of marine biodiversity is a laudable goal for the scientific community, there is a crucial societal need to implement effective policies to manage marine resources. The major advancement in basic scientific knowledge that will result from the Census, therefore, will be particularly useful if made publicly available. The Census requires this of all its projects and to facilitate the process, is supporting the development of the Ocean Biogeographic Information System (OBIS, <<http://www.iobis.org>>), a single web-based portal to geo-referenced data on accurately identified marine species collected not only by the Census but from a federation of data providers around the world. The federation ensures inter-operability, but each data contributor separately maintains the datasets and intellectual ownership over the data. OBIS is the marine component of the Global Biodiversity Information Facility.

The development of this dynamic, digital atlas began in 2000 with the funding of a feasibility demonstration to make interoperable eight authoritative data sets of particular taxonomic groups. As of November 2003, OBIS enables simultaneous searches of 19 inter-operable databases, which, in addition to the museum collections, include taxonomically resolved, geo-referenced datasets from genetic studies, time-series, continuous plankton recorders, the Food and Agriculture Organization's Catch and Aquaculture Production and, in the future, industry (e.g. petroleum, bioprospecting).

The data collected by modern ocean science has made OBIS a valuable resource for scientists and managers to identify what is currently known to live and where it lives in the oceans, but with the inclusion of the Census's historical and modeling components, it enables comparisons over hundreds of years. The History of Marine Animal Populations contributes ‘outside-the-box’ approaches to marine research, amassing taxonomically resolved distribution and abundance information from 100 to 500 year-old archives of fishing logs, tax records and recipes (Holm, Smith and Starkey 2001). The result is a historical baseline against which scientists can evaluate current distribution and abundance of marine populations.

With a baseline, projections about the future become more reliable. Though OBIS offers some modeling techniques useful for basic prediction, particularly in terms of marine invasions and, to a certain extent, climate change, the Future of Marine Animal Populations (FMAP) will test and contribute new cutting-edge biodiversity models to

the system. Initial models will focus on interpreting migration patterns from tagged animals, species interactions, and predictions of the effects of climate change and fishing pressure on populations (Worm *et al.* 2003).

OBIS is already a powerful tool with over one million records of some 5 000 unique marine species, which can be downloaded directly or overlaid on maps of physical oceanographic parameters. Based on the scheduled addition of datasets, OBIS will put at least 10 million records of all known species and their location online by 2007.

4. GLOBAL COOPERATION

A global programme requires global participation. In November 2003, researchers from 50 countries were involved in the Census. But, in addition to willing researchers, the success of the Census depends on global partnerships in governance and funding. An international Scientific Steering Committee oversees the conceptual goals and direction of the programme. They have designed the Census in such a way that its products will be of benefit to a wide range of users. The overall estimated cost of the programme is US\$1 billion, making the contribution of a wide range of sponsors important. Though there is some international funding available for this research, much of the sponsorship must be generated at national levels from traditional sources such as governmental agencies and philanthropic foundations. Sponsorship through funding or other services can also come from novel programmes led by industry that have vested interests in marine life (e.g. fishing, pharmaceuticals) or whose work in the ocean affects ecosystems (e.g. mining, petroleum production).

The task of raising funds for Census research is enormous and the ten-year timeframe makes it urgent. To accomplish it, national and regional implementation committees are being established around the world. As of November 2003, implementation committees are operating in Australia, Canada, Europe, Japan, South America and the United States. Developments toward creating a committee are underway in Russia, China, the Caribbean, the Indian Ocean, Sub-Saharan Africa and the WESTPAC region. There is interest in the New Zealand/South Pacific region though appropriate mechanisms must be identified.

These committees are comprised of scientists as well as representatives from conservation, management, industry and other ocean stakeholders to ensure effective implementation of the programme with legacies that will be understood and appreciated by global society. Even with the majority of the effort still ahead, the successes to date in engaging and organizing the scientific community makes Census a proven demonstration of the value of partnership and cooperation.

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Patterns and processes of the ecosystems of the Northern Mid-Atlantic (MAR-ECO project) – an international census of marine life project on deep-sea biodiversity

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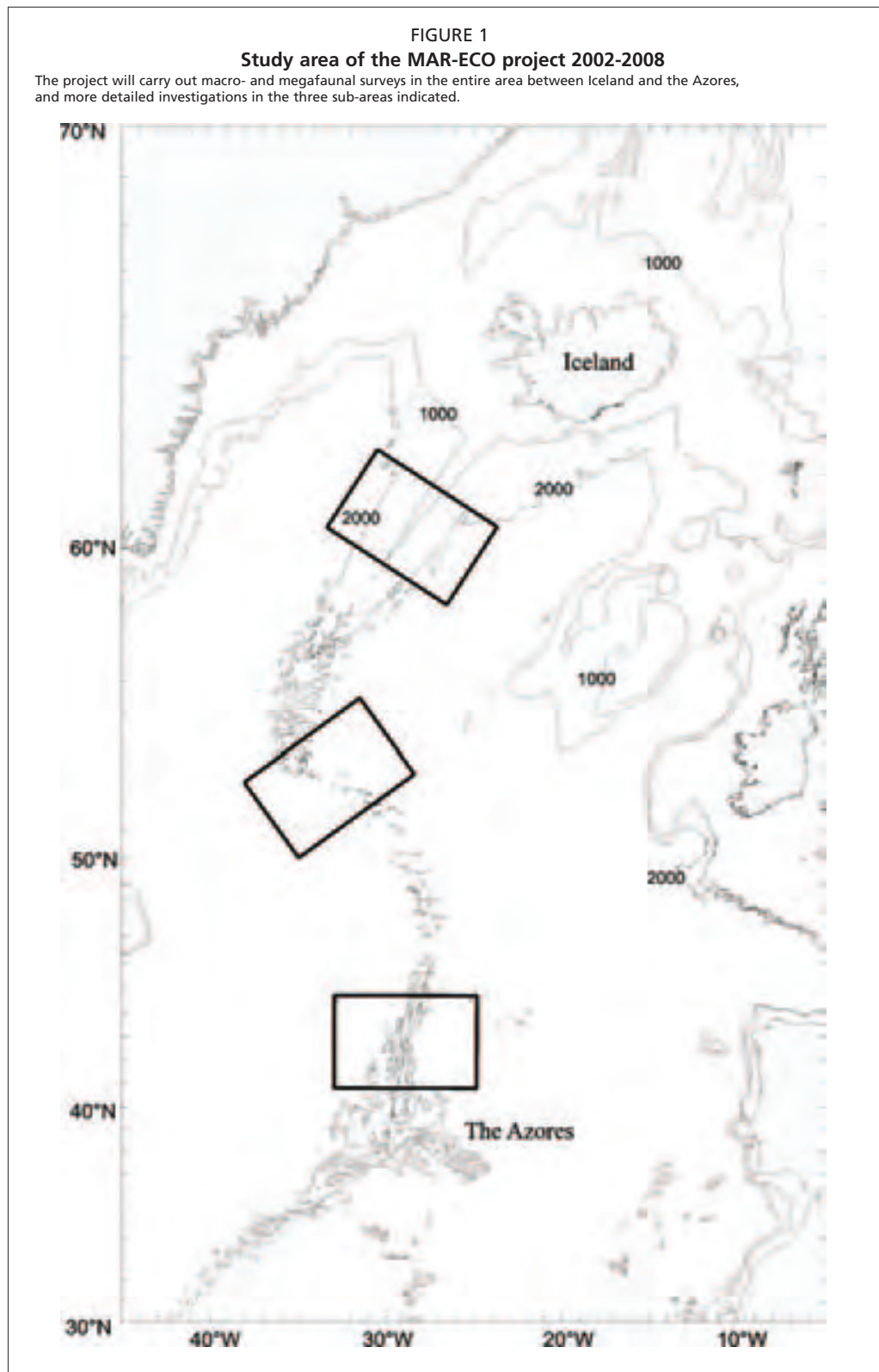
1. INTRODUCTION

Despite the wide distribution and extensive area of mid-ocean ridges (see e.g., Garrison 1993), relatively few previous investigations have been dedicated to the study of the animal communities inhabiting these vast areas of the world ocean. Ridges may have characteristic faunas, and they may also significantly influence the processes such as intercontinental migration and dispersion affecting slope and shelf biota. Compared with the continental shelf and coastal environments, the ecosystems of the mid-oceanic ridges are poorly known and exploratory activity will provide new knowledge on both previously described and undescribed species. However, providing well-documented new information on how mid-oceanic ridge communities are structured and sustained is a challenging task.

The MAR-ECO project (Bergstad and Godø 2002, <http://www.mar-eco.no/>), whose objective is the study of the mobile macrofaunal communities associated with the Mid-Atlantic Ridge between Iceland and the Azores, is one of the field projects of the Census of Marine Life programme (CoML, <http://www.coml.org>). The overriding goal is to describe and understand the patterns of distribution, abundance and trophic relationships of the organisms inhabiting the mid-oceanic North Atlantic and identify and model ecological processes that cause variability in these patterns. The study will focus on pelagic and benthic macrofauna and use innovative methods and up-to-date technology to map distributions, analyse community structure, study life histories and model trophic relationships.

2. BACKGROUND

The Mid-Atlantic Ridge (MAR) is the spreading zone between the Eurasian and American plate (Figure 1) is a part of a world-wide system of oceanic ridges. As a result of volcanic and tectonic processes, the ridge is continually being formed as the two plates spread at a rate of about 2 cm/yr. Between Iceland and the Azores the ridge extends over 1 500 nm, and it is characterized by a rough bottom topography comprising underwater mountain chains, a central rift valley, recent volcanic terrain, fracture zones and seamounts. The MAR has an important influence on the deepwater circulation of the North Atlantic, partly separating deepwaters of the eastern and western basins.



Globally the mid-ocean ridge systems represent major features of all oceans. In terms of surface area, the ridge habitats are vast compared with the shelf and slope habitats where most marine biological research has been focused to date. Hitherto, many deep-sea biologists have avoided ridge areas because of the cost of surveys and difficulties in using existing sampling equipment that could be readily damaged or lost. The exception is the exploration of chemosynthetic ecosystems, e.g. hydrothermal

vents, which have attracted considerable research effort (e.g. Van Dover 2000; see also the Inter Ridge home page <<http://triton.ori.u-tokyo.ac.jp/~intridge/>>). A number of expeditions have been devoted to such systems around the world, but few on the northern part of the MAR. Vent fields represent, however, a minor fraction of the ridge area and the influence of chemosynthetic production on the overall biological production along the ridges is probably small.

Most previous deep-sea studies have been conducted either just off the continental slopes or in oceanic basins and the understanding of the significance and influence of the mid-ocean ridges on composition and distribution of pelagic and benthic fauna is still negligible.

The knowledge of certain abundant and sometimes widely distributed taxa such as cephalopods and gelatinous plankton organisms is particularly incomplete. These groups are difficult to sample and traditionally their significance in pelagic ecosystems has been underrated. Such animals are characteristic in oceanic systems (Angel 1997) and there is evidence that these groups play major roles in the food-webs of the ecosystems near the ridges and in frontal zones associated with the major circulation features. Thus, the potential for new significant discoveries is particularly great for these groups.

The mid-oceanic ridges have slowly become fishing areas of an international fleet of trawlers and longliners, and many of the species targeted have life histories that make them particularly vulnerable to overfishing. Pelagic fisheries of the open ocean have been targeting tuna, swordfish and sharks that tend to be found near fronts, eddies and islands. Whales also occur in such areas. The significance of mid-ocean ridge ecosystems for long-range migrants such as whales and large epipelagic fishes (e.g. tunas and billfishes) is not clear.

Traditional demersal fisheries have been conducted on the MAR within the Azorean and Icelandic EEZs, for many decades by Iceland (Magnusson and Magnusson 1995), Russia and vessels from other eastern European nations (Trojanovsky and Lisovsky 1995). Many nations have carried out exploratory fishing in the 1990s, including the Faroes (Thomsen 1998), Norway (Hareide *et al.* 1993; Langedal and Hareide 1997) and Spain (Iglesias and Muñoz 2001). The reported landings from the area remain, however, relatively small and variable and few vessels find the ridge fisheries profitable.

Fisheries investigations have yielded valuable information on the distribution and abundance of fish, but have mainly considered species of commercial interest. Consequently, the exploratory fishing efforts of the past three decades have enhanced our knowledge of the MAR ecosystems, communities, and the processes that structure and sustain the ridge communities to only a limited degree. Few studies have aimed at providing basic taxonomic or ecological understanding.

Overall, the quantity and quality of the available information on ridge communities and their relation with adjacent basin communities and the slope faunas remains unsatisfactory. New technology and international collaboration makes a dedicated effort along the Mid-Atlantic Ridge feasible and timely although still challenging. In view of the global distribution of ridges, such efforts will provide information of great global interest.

3. MAR-ECO TASKS

Some basic overall questions are to be addressed by MAR-ECO:

- i. Are the MAR communities extensions of the communities inhabiting the North Atlantic continental slope regions?
- ii. Is the MAR a barrier between the pelagic fauna of the east and west North Atlantic basins? Is there a difference in species occurrence on either side of the MAR?

- iii. Do circulation features, such as the Gulf Stream, act as barriers between the northern and southern fauna? In the region of the Gulf Stream, what is the effect of eastward drift and import of material from the west?
- iv. What is the significance of individual seamounts within the ridge system?
- v. Is the trophic structure of the northern mid-Atlantic ecosystem similar to that on the slope regions of the eastern and western sides of the Atlantic?

A major challenge of the project is to overcome observation difficulties in distant waters at great depths and in rugged terrain. A central objective is to use modern remote sensing technology (e.g. with acoustics or optics) using advanced instrument carriers (e.g. towed vehicles, ROVs, etc. AUVs etc.), in addition to more traditional sampling and observation methods. The application and testing of new approaches, techniques and equipment is intrinsic to the MAR-ECO, and technological advances made in the deep-sea area may also prove useful in shelf waters. The focus provided by an international multi-disciplinary project in a challenging environment, such as the deep-sea, is a great motivation for technological innovation on many fronts.

The Science Plan available at <http://www.mar-eco.no/>, presents the three central tasks of MAR-ECO and a compilation of hypotheses to be examined.

Task 1: Mapping of species composition and distribution patterns

Theme 1: Identity distribution patterns of macrofauna

The traditional classification of the pelagic fauna into epipelagic, mesopelagic, bathypelagic, abyssopelagic and benthopelagic communities is generally accepted. However, along the mid-ocean ridge the complicated topography and the effects on the circulation system and production of seamounts and the passage of mesoscale eddies may substantially modify the picture. Many pelagic and benthopelagic animals tend to aggregate in limited areas. Study of behaviour, community integrity and the dynamics of such aggregations will be undertaken in selected geographic areas. An essential component of the project is the characterisation of the physical environment of the faunal aggregations, focusing specifically on current patterns, or frontal processes, that may advect and concentrate pelagic prey organisms.

Theme 2: Population genetics and dispersion studies

Some species found on the mid-oceanic ridges are associated with relatively isolated seamounts, but the same species may also occur along the continental slopes of the North Atlantic basin. It is of much importance from both a scientific and management point of view to know whether the populations along the mid-oceanic ridges are really isolated from others, and if not, how dispersion occurs. Insights into these questions will be obtained from studies of population genetics undertaken in collaboration with, and for comparison with, other projects working on the continental slope.

Task 2: Identification of trophic interrelationships and modelling of food web patterns

The deepwater fauna along, and adjacent to, the mid-oceanic ridges must somehow survive on the, generally limited, local surface production and on advected concentrations of phyto- and zooplankton. Two processes may be assumed to be particularly significant for the distribution and production of pelagic and demersal fauna on the mid-oceanic ridges and seamounts: vertical migration by epi-, meso- and bathypelagic organisms facilitates transfer of biomass and energy from the surface layer to deeper layers, and the current pattern around the seamounts may import and concentrate food. The oceanic macrofauna ultimately depends either on collecting the food near the surface or waiting for food particles to sink or migrate to a depth where they can be captured. The mesopelagic nekton has adopted the first strategy and performs extensive diel vertical

migrations. Benthic and benthopelagic animals rely more on utilising food supply from above through sedimentation and migration. The project will analyse how the ridge system affects the processes of energy and material transport in the vertical dimension. The determination of the trophic relationships among the demersal and pelagic animals is a central task for MAR-ECO.

Task 3: Analyses of life history strategies

The dependence on energy supplied from above or by advection probably limits turnover and production within the ridge community. Fauna inhabiting the mid-oceanic habitats must therefore have developed life history traits and ecology adapted to this limited production. It is often assumed that many of these deep oceanic species grow slowly, have long life-spans, high ages at maturation, low fecundity and limited mobility. Major efforts will be made to test these assumptions through new investigations of growth and life history traits and systematic comparison of the diversity of these traits between related taxa from different habitats (the better known fauna of the continental slope). Quantification of these life history traits is critical to establishing the relationship between biomass and production in the ridge ecosystem

4. ORGANIZATION, SCHEDULE AND FIELD EFFORTS

An International Steering Group organises and oversees the planning, financing and implementation of the project. Norway has taken on the secretarial duties for the project and the responsible co-ordinating institutions are the Institute of Marine Research (IMR) and the University of Bergen.

During the planning phase of MAR-ECO in 2001–2003 the International Steering Group stimulated the network of experts to formulate component projects and commit resources. Science plans for 10 component projects have been formulated and short versions are available on the website: <<http://mar-eco.no/>>. The 2003–2005 field phase has been initiated, and data and material from the first field season are available. Several countries have committed research vessel time and personnel to the project. The new Norwegian research vessel **G.O. Sars** will be at the centre of the international multi-vessel operations and the vessel will be used for a two-month cruise in the summer of 2004. The field work is to be followed by an analysis and synthesis phase in 2004–2008. Data will be incorporated in the CoML project Ocean Biogeographic Information System (OBIS) in 2005 and later. The completion of the project and a final synthesis is scheduled for 2008. It is anticipated that extensive material will be available for examination and further analyses also after this final year.

5. INITIAL FIELD EFFORTS

The work area of MAR-ECO is the waters associated with the mid-Atlantic Ridge between Iceland and the Azores (Figure 1), both the pelagic zones and near-bottom habitats on the flanks of the ridge to a depth of 3 500 m. The field investigations will comprise both large-scale zig-zag surveys of the entire area and more focused studies in three sub-areas (Figure 1). The strategy for large-scale surveying will be acoustic and intermittent multi-purpose station sampling.

In 2003 field sampling observations were made using vessels from Iceland, Russia, Germany and Portugal. The Icelandic vessel **R.V. Arni Fridriksson** conducted studies and sampling of mesopelagic fish and zooplankton in the northern end of the study area, the Reykjanes Ridge. The Russian vessel **R.V. Smolensk** and the German vessel **R.V. Walther Herwig** also conducted some sampling in the northern area. These efforts were extensions of an ICES co-ordinated survey of redfish (*Sebastes* sp.) in the Irminger Sea.

Perhaps the most remarkable effort was made by the Russian vessel, the **R.V. Mstislav Keldysh** and its manned submersibles MIR-1 and -2. This was a Russian-

US collaboration, and scientists from both countries made two double dives in the Charlie-Gibbs Fracture Zone (in the middle MAR-ECO Sub-area) to depths of 3 000–4 500 m, an area never before visited by man. Analyses of the observations and samples obtained are ongoing and detailed results will be presented elsewhere. However, preliminary analyses of videos recorded during the dives show the occurrence of many fish species, cephalopods and swimming holothurians, as well as diverse sessile macro- and megafauna dominated by suspension feeder. The density of “marine snow” and phytodetritus on the bottom appeared higher than expected, and a particularly interesting finding were high densities of juvenile macrourid fish and holothurians.

In the southern area, MAR-ECO benefits from activities of a German-led EU-funded project OASIS focusing on seamount ecosystems. Several cruises were made by Portuguese, German and UK vessels to the Sedlo seamount just south of the southern MAR-ECO Sub-area. Of particular interest were efforts to sample and study macrofauna by the Portuguese vessel **R.V. Archipelago** of the Azores. This vessel operates longlines and provides samples e.g. for studies of trophic ecology, fish genetics and hydrography.

6. THE MAR-ECO VISION

New information is required by governments and international bodies to design and implement environmental and fishery management plans for mid-oceanic systems. Designing relevant assessment and monitoring programmes, or indeed giving correct and relevant advice on actions to be taken, requires far more information than is available at present.

A major overriding aim of MAR-ECO is to provide society with well-founded knowledge of patterns and processes of the mid-oceanic ridge ecosystem. The ridge system is a global feature found in all oceans, but surprisingly few focussed studies have been conducted of such areas. New knowledge thus has a great value in itself, providing humanity with a greater understanding of the environment shared by all. The MAR-ECO objective is that, following the 2001–2008 project period, the identity, distribution patterns, food-webs, and life history patterns of the macrofaunal communities of the northern Mid-Atlantic Ridge and its flanks will be better understood and well known both to the scientific community and the interested public.

The website <<http://mar-eco.no/>> is the main source of updates, contact information, and documents relevant to the project.

7. ACKNOWLEDGEMENTS

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THEME 2

**Population biology and
resource assessment**

The challenges of, and future prospects for, assessing deepwater marine resources: experiences from Australia, New Zealand, Southern Africa and the United States

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1. INTRODUCTION

The traditional role of fisheries stock assessment has been to provide the “best estimates” of the biomass of a stock and a measure of its potential productivity. Surplus production models (e.g. Punt and Hilborn 1996) and Virtual Population Analysis (e.g. Pope and Shepherd 1985) were techniques that could be used in data-poor (only catch data and an index of abundance) and data-rich (catch data, an index of abundance and catch-at-age data for all years and fishing fleets) situations respectively.

The results from these techniques can be used to determine whether a stock is above or below a target level of biomass (e.g. the biomass at which Maximum Sustainable Yield [MSY] is achieved B_{MSY}) and whether catches are greater than the estimated MSY . In addition, they can be used to determine catch limits using catch control rules such as $F_{0.1}$ ¹ and $f_{0.1}$ ².

During the 1970s it was realized that the estimates from these methods could be both imprecise and biased. Imprecision arises because of the use of noisy data when fitting population dynamics models and bias arises because some of the assumptions of the population dynamics model (e.g. that CPUE is linearly related to abundance or that catchability has remained constant over time) are violated. Basing management decisions on the “best estimates” for biomass and MSY implicitly ignores the implications of both bias and imprecision. Therefore, if the catch limit is to be 30 percent of the estimate of current biomass, it is 300 irrespective of whether the biomass is estimated to be $1\,000 \pm 10$ or $1\,000 \pm 1\,000$. An even worse outcome is the use of evidence for imprecision (when it is assessed) to avoid reducing harvest levels when this is deemed necessary.

Recent evaluations of the ability of traditional methods of stock assessment to estimate quantities of management interest (e.g. Walters and Pearce 1996) suggest, for example, that estimating the biomass available to the fishery within ± 40 percent should be considered to be a relatively successful outcome. The ability to estimate the ratio of

¹ A reference point based on the value of fishing mortality, F , at which the slope of the yield per recruit curve is 0.1 (10 per cent) of its initial value; regarded as a conservative level of exploitation which allows for economic viability and a buffer against recruitment overfishing.

² The amount of fishing effort at which the slope of the yield versus effort curve is 10% of that at the origin.

current biomass to a reference biomass level is better (Punt, Smith and Cui 2002) and control rules exist that do not require any estimates of absolute abundance but instead rely on trends in biomass (e.g. Magnusson and Stefansson 1989).

The realization that assessment results may be both biased and imprecise led, in part, to the development of the Precautionary Approach to Fisheries Management (Anon. 1995). Although the Precautionary Approach deals with more than simply uncertainty related to assessments, it has caused fisheries assessment scientists to focus less on obtaining “best estimates” (although these are still central to the decision rules used to set harvest guidelines for U.S. fisheries) and more on quantifying the risk associated with alternative catch limits that do not satisfy some pre-agreed management objectives or to determine a set of models on which to evaluate the advantages and disadvantages of alternative decision rules.

The uncertainty associated with assessing a stock is directly related to the amount of data and understanding available for assessment purposes. The development of fisheries on the continental slope and in deeper waters has tended to parallel the change from providing “best estimates” to providing information that it is more consistent with the Precautionary Approach to Fisheries Management. However, assessing fisheries in deepwater poses some unique challenges. For example, many deepwater fisheries only started relatively recently with the consequence that the time-series of abundance indices are usually short and traditional methods for obtaining data on stock status, such as tagging, and ageing a large fraction of the catch, have not been applied. Deepwater fisheries are also among the most technologically challenging (and sophisticated); one consequence of this is that fishing efficiency can change rapidly over time, thereby potentially making commercial catch rates inherently unreliable as indicators of stock abundance.

The response of the fisheries assessment community to these challenges has been to develop methods of stock assessment that attempt to synthesize all of the available information into a single analytical framework and to express the results of assessments in probabilistic rather than best estimate terms. The results from studies of similar species in other parts of the world are being used to place prior distributions on the likely values for model parameters. These trends are being paralleled by the wider participation of a broad range of stakeholders in identifying and developing assessment scenarios. Each of these trends is now examined in some detail.

2. SYNTHETIC MODELS AND DEEPENING THE POOL OF MODELS

Deepwater fisheries are frequently data-poor in that data are often sparse (e.g. some length-frequency and catch-at-age information, and occasional survey estimates of relative abundance). In contrast, unlike fisheries that have been operating for many years, the information on historical removals tends to be more complete for deepwater species because, in general, fishing on the slope started relatively recently.

Of the two classes of model on which assessments have traditionally been based, surplus production models are better suited to situations in which a catch time-series and information on relative (or absolute) abundance is available because conventional Virtual Population Analysis methods usually require information on catch-at-age for all years.

Surplus production models can be criticized however for a lack of realism (Hilborn and Walters 1992) and because they cannot use information other than that contained in the relative abundance series. The latter is a major problem for data-poor situations because it could lead to a substantial fraction of the available information being ignored. Delay-difference models (e.g. Deriso 1980, Schnute 1985) overcome some of the problems associated with surplus production models because (subject to certain assumptions) they capture the impact of age-structure dynamics and can hence include information related to growth and natural mortality in assessments. Delay-difference

models can be structured to make use of a wider range of data types than surplus production models. For example, they have been extended to be length-structured so that they can be fitted to the moments of catch length distributions (Fournier and Doonan 1987). However, the assumptions that typically underpin delay–difference models (such as knife-edged recruitment and that the age-at-maturity equals that at-recruitment) may be violated to a substantial extent in actual situations.

Hilborn (1990) introduced the idea of fitting relative abundance information to age-structured models that start the population projections prior to the onset of fishing (so that the assumption that the stock was at its pre-exploitation size at this time is not likely to be violated substantially). This approach has been referred to as an age-structured production model (ASPM) by Punt (1994) who showed that the impact of adding age-structure to an assessment model was not necessarily particularly substantial (given sufficiently informative data on relative abundance). Nevertheless, age-structured production models do overcome several criticisms of lack of realism leveled at surplus production models because they include age-structure and represent biological processes such as growth, mortality, recruitment, etc. more explicitly. ASPM models form the conceptual basis for the bulk of the assessments of newly developed deepwater species because most more complicated stock assessment models such as those that underlie the “Integrated Analysis” approach to stock assessment include the ASPM approach as a special case.

The statistical catch-at-age analysis (or Integrated Analysis) method of stock assessment developed by Fournier and Archibald (1982) and Deriso, Quinn and Neil (1985) differs from traditional Virtual Population Analysis methods because it separates the development of the model for the population dynamics from that for the observed data. Integrated analysis forms the basis for the Stock Synthesis program (Methot 1990, 2000). Unlike Virtual Population Analysis there is no need for catch-at-age data for all years so this method of stock assessment can be applied when catch-at-age data are available for only a subset of the years of the assessment period. In fact, this method can be applied with only length–frequency data or no catch-at-age or length–frequency data at all. The ability to deal with situations in which there are missing catch-at-age data for some years is one of the main reasons that Integrated Analysis is currently the most commonly applied stock assessment technique for deepwater species off New Zealand, Australia, South Africa, and the west coast of the US. For example, all of the quantitative assessments of stocks in Australia’s South East Fishery are based on some variant of the Integrated Analysis method (Punt, Smith and Cui 2001).

A particularly important feature of the Integrated Analysis approach is that the analyst is not constrained by the structure of the data available for assessment purposes

TABLE 1
Summary of assessments of species caught to a substantial extent in fisheries on the continental slope of the US west coast

Species	Indices of abundance				Catch-at-age		Catch-at-length	
	Multiple fleets	Acoustic estimates	Swept-area estimates	Fishery CPUE	Survey	Fishery	Survey	Fishery
Pacific Ocean perch	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Darkblotched rockfish	No	No	Yes	No	Yes	Yes	Yes	Yes
Pacific whiting	Yes	Yes	Yes	No	Yes	Yes	No	No
Sablefish	Yes	No	Yes	No	Yes	Yes	No	No
Dover sole	Yes	No	Yes	Yes	No	Yes	Yes	Yes
Shortspine thornyhead	Yes	No	Yes	No	No	No	Yes	Yes

when developing the model of the population dynamics (Smith, Smith and Punt 2001). This allows the analyst to develop a range of alternative models regarding the population dynamics and the relationship between the data collected and the model predictions. McAllister and Kirchner (2001) conducted assessments of orange roughy (*Hoplostethus atlanticus*) off Namibia based on four alternative models for the cause of the change over time in the index of abundance while the assessment model developed for hoki (*Macruronus novaezelandiae*) off New Zealand includes two stocks, and fisheries and surveys in six areas (Francis, Cordue and Haist 2002). These two assessments also provide an illustration of the types of data used when applying Integrated Analysis (commercial catch rates, acoustic estimates of biomass, and swept-area estimates of biomass for orange roughy; and these three data types as well as survey and fishery age-composition data for hoki). Table 1 overviews the assessments of species caught in substantial quantities on the continental slope off the US west coast in terms of the data types included in the assessments. Length- and age-composition data are both included in some assessments when length but not age information is available for some years. These assessments therefore attempt to make use of as much data as possible.

The assessment of hoki off New Zealand referred to above is one of the first that explicitly allows for spatial structure. The trend towards including spatial structure in assessments is likely to continue as assessment scientists examine, for example, length- and age-structure and relative abundance data for spatial patterns. Such patterns are likely to be present when there is spatial heterogeneity in fishing pressure for species (such as rockfish *Sebastes* spp.) that do not exhibit long-distance movement.

Attempting to use all of the available data in a single analysis should lead to more accurate and precise estimates of management-related quantities. In general, the objective function minimized to find the values for the model parameters is a weighted function of the contributions from individual data sources. Unfortunately, it is not uncommon for the results of an assessment (both quantitative and qualitative) to depend on the weight placed on the different data sources. This is illustrated in Table 2 by the sensitivity of the results of the assessment of hoki off New Zealand to changing the weight assigned to the trawl and acoustic estimates of biomass. The reason for contradictory data is that the model of the population dynamics or of the relationship between one (or all) of the data sources and the model predictions is wrong. The sensitivity of the results to the weights placed on the different data sources can be disconcerting because it indicates that something is wrong but having multiple data sources to test for such sensitivity is better than the comfort that arises when only one data source is included in an assessment and no sensitivity analysis is possible.

Assessments based on Integrated Analysis frequently have many parameters, e.g. the assessment of Pacific Ocean perch (*Sebastes alutus*) off the US west coast involves

TABLE 2
Sensitivity of the posterior median estimates of biomass in 2002–2003

$B_{2002-03}$ in absolute terms and expressed relative to the average pre-exploitation biomass B_0 for two stocks of hoki off New Zealand, to the weights assigned to the trawl and acoustic data when conducting the assessment
(Source: Annala et al. 2003)

Scenario	$B_{2002-03}$ ('000t)		$B_{2002-03} / B_0$ (%)	
	East stock	West stock	East stock	West stock
Original	466	301	69	28
Upweight trawl biomass indices	259	259	46	25
Upweight both trawl and acoustic biomass indices	268	400	48	35

the estimation of some 253 “free” parameters – Hamel, Stewart and Punt (2003). The ability to conduct assessments based on the Integrated Analysis paradigm has increased substantially given that computers are becoming increasingly powerful and particularly given the availability of the AD Model Builder package³. The AD Model Builder package includes algorithms based on automatic differentiation techniques to compute the gradient of the function to be minimized. The use of automatic differentiation can dramatically reduce the time required to fit stock assessment models with many parameters (Schnute, Richards and Olsen 1998).

Although the trend towards more complicated multi-parameter models is almost certain to continue because it allows analysts the opportunity to include more hypotheses (e.g. that the selectivity of the fishery changes over time) as well as more sources of data in assessments, it is not necessarily true that the ability to make reliable predictions is improved by more complicated models. Unfortunately, research into optimal model complexity and how to select among alternative model formulations has lagged substantially behind the ease with which it has become possible to conceive new models and to fit them to data.

Prior to the availability of software to fit complicated models rapidly, analysts tended to conduct some analyses separately from the main stock assessment to estimate, for example, the growth curve. The results of these “supporting analyses” were then assumed to be known exactly when conducting the actual assessment. However, not including all of the data in the assessment has the potential to miss any trends in, for example biomass and recruitment, which these data suggest (Maunder 2001). Therefore, increasingly, assessment scientists are “integrating” all of the available data into the assessment and dispensing with the idea of supporting analyses. For example, the assessment of orange roughy in New Zealand’s QMA 3B conducted by Smith *et al.* (2002) estimated the growth curve within the assessment rather than estimating it externally as had been the case in previous assessments (e.g. Francis 2001).

3. MOVING FORMALLY TO A PROBABILISTIC FRAMEWORK

The requirement for scientists to provide information to managers on uncertainty about stock assessments and forecasts arises in part from Article 7.5 of the FAO Code of Conduct for Responsible Fisheries (Anon. 1995) which includes the recommendation: ‘States should apply the precautionary approach widely to conservation, management and exploitation of living resources ... In implementing the precautionary approach, States should take into account, *inter alia*, uncertainties relating to the size and productivity of the stocks, reference points, stock condition in relation to such reference points, levels and distribution of fishing mortality and the impact of fishing mortalities ...’. A similar phrasing can be found in Article 5(c) of the UN agreement on the Conservation and Management of Straddling Stocks (Sainsbury, Punt and Smith 2000).

There is a variety of sources of uncertainty when conducting assessments and examining the consequences of management actions. Francis and Shotton (1997) identify five sources of uncertainty.

- i. Process uncertainty (“process error”) arises from natural variability. The most common example of process uncertainty is variation in recruitment for environmental reasons.
- ii. Observation uncertainty arises through measurement and sampling error although deliberate mis-reporting (of catches for example) also constitutes a form of observation error.
- iii. Model uncertainty arises through a lack of understanding of the underlying dynamics of the system being considered.

³ © Otter Software (<http://www.otter-rsch.com/>).

- iv. Error structure uncertainty arises from the inability to correctly identify the sources of error when fitting models to data.
- v. Implementation uncertainty reflects the implications of the inability to fully implement management actions.

The need to compute measures of uncertainty is well recognized and considerable attention has been placed on developing methods for this, as reflected by the number of conferences and symposium sessions dedicated to the topic (Francis and Shotton 1997). However, several of the most commonly applied methods of stock assessment based on Virtual Population Analysis (such as Extended Survivors Analysis – Shepherd 1999) are not easily modified so that each of the above sources of uncertainty can be quantified.

Bootstrapping and Monte Carlo approaches (Butterworth, Hughes and Strumpfer 1990, Restrepo *et al.* 1992) can be used to quantify the uncertainty of model outputs and to form the basis for examining the consequences of alternative management actions for assessments based on Virtual Population Analysis. In contrast, methods of assessment based on Integrated Analysis usually represent the relationship between the data collected and the model predictions through a formal likelihood function. This means that it is possible to apply profile likelihood methods for determining confidence intervals and, in particular, Bayesian methods. The latter are increasingly becoming the method of choice for quantifying uncertainty when applying Integrated Analysis (particularly in Australia and New Zealand) and the number of Bayesian stock assessments of deepwater fish species has increased rapidly over the last ten years (e.g. Francis 1992; Smith and Punt 1998; Ianelli, Wilkins and Harley 2000; Punt *et al.* 2001; Francis *et al.* 2002; McAllister and Kirchner 2003; Hamel, Stewart and Punt 2003).

The use of Bayesian techniques when conducting fisheries stock assessments is desirable because *inter alia*, Bayesian methods provide a single framework within which various sources of uncertainty can be represented (in particular, both parameter and model-structure uncertainty), and because the results from a Bayesian analysis (the probabilities associated with alternative hypotheses) are exactly the information needed when providing scientific management advice to decision makers (Punt and Hilborn 1997, McAllister and Kirkwood 1998). However, the primary reason that most stock assessment scientists choose Bayesian over classical approaches is probably because it becomes possible to formally include knowledge from previous assessments (of species/stocks other than that of current interest) in a new assessment. Hilborn and Liermann (1998) argue that using data for well-studied species to inform data-poor species can be considered to be “standing on the shoulders of giants”.

In their assessment of Pacific Ocean perch off the United States west coast, Ianelli *et al.* (2000) developed informative prior distributions for several of the key parameters of their model. In particular, the prior for the steepness of the stock-recruitment relationship was taken from that developed by Dorn (2002) for rockfishes off the west coast of north America while that for survey catchability was also determined from a meta-analysis (Ianelli *et al.* 2000).

Liermann and Hilborn (1997) introduced hierarchical meta-analysis to fisheries assessment by conducting a meta-analysis of the impact of depensation at low stock size. In common with tabling estimates of a quantity for which a prior distribution is needed, hierarchical modeling is a technique that can be used to combine data from several independent sources (species/stocks) and represent the outcome in the form of a probability distribution for the quantity of interest. The basic idea is that each species/stock for which data are available has a different value for the quantity of interest but that species/stocks are interchangeable in the sense that the value of the quantity of interest for any given stock can be considered to be a random selection from an underlying distribution (which is the same for all species/stocks after account is taken of explanatory covariates). Hierarchical meta-analysis has now been used to examine the steepness of the stock-recruitment relationship (Myers *et al.* 2002,

Dorn 2002), the maximum rate of increase at low population size (Myers, Bowen and Barrowman 2002), the relationship between catch and abundance (Harley, Myers and Dunn 2001), survey catchability and selectivity (Harley and Myers 2001, Millar and Methot 2002) and carrying capacity (Myers *et al.* 2001).

The use of priors based on data for other species/stocks is not, however, without controversy. Reasons for this include the representativeness of the species for which data are available. For example, the bulk of the information related to the steepness of the stock-recruitment relationship is for three species *Clupea harengus*, *Gadus morhua*, and *Melanogrammus aeglefinus*. The posterior distributions for steepness for rockfish species derived by Dorn (2002) are centred at lower values than those determined from the stock and recruitment data for all species. Had assessments for rockfish species been based on priors derived from stock and recruitment data for all species rather than just those for rockfish species, the estimates of productivity would have been biased upward. The issue of representativeness is perhaps more problematic for deepwater species as these species tend to be data-poor (so the results of Bayesian assessments are affected more by the choice of the prior distributions) and because it appears that deepwater species are less productive than species found on the shelf and in inshore waters. One consequence of this is that assessment scientists conducting analyses for species off the US west coast have tended to avoid the use of priors based on meta-analyses and have instead made use of priors that are uninformative.

4. BROADENING ASSESSMENT GROUP COMPOSITION

The move towards attempting to incorporate as many data types as are available into assessments and to identify a range of alternative models rather than only one requires that assessments be conducted by groups of individuals rather than by a single assessment scientist. Each of the four regions considered in this review has assessment processes that are open to stakeholder groups in various ways. Of the four regions, stakeholder groups (which include managers, industry and conservation groups) probably have the greatest input into assessments conducted for the Australian Fisheries Management Authority (AFMA – the agency that manages fisheries resources on behalf of the Commonwealth Government of Australia) (Smith, Smith and Punt 2001).

In common with assessment groups in the US, New Zealand and South Africa, the primary role of the assessment groups established by the AFMA is to assess the stock or species in relation to its particular management objectives, describe the management implications, and identify the research and monitoring necessary to improve the assessment. These assessment groups do not make management recommendations nor do they attempt to reduce the number of alternative models to only one.

The AFMA assessment groups generally include a broad range of stakeholder groups. The interaction among the participants (although hard to quantify) is one of the major advantages of the process (Smith, Sainsbury and Stevens 1999). It assists with communication and usually leads to trust and mutual respect when what are often conflicting parties are dealing with difficult issues (Smith, Smith and Punt 2001). By participating in the assessment process, industry and managers gain a conceptual understanding of stock assessment and modeling. However, the assessment itself can also be improved through insights by industry on, for example, trends in fishery-dependent data. This is particularly important because stock assessment scientists spend a decreasing amount of time in the field. For some assessments in Australia, several of the hypotheses considered are based on suggestions by industry (Smith, Smith and Punt 2001).

The need for assessment groups to include broad participation of stakeholders is perhaps greatest for situations in which considerable reliance is placed on fishery-dependent data. For example, the assumptions that selectivity and catchability are constant over time is a standard assumption when conducting assessments. Violation

of these assumptions can lead to markedly biased results. However, these assumptions are only likely to be examined in detail when there is evidence in the form of auxiliary information that they are false, even though the results of meta-analyses suggest, for instance, that CPUE is unlikely to be related linearly to abundance (Harley *et al.* 2001). The experience of the author is that the presence of industry participants when conducting assessments is more likely to highlight reasons for changes over time in selectivity and catchability.

The need for a broad range of participants on assessment groups is even greater if the objective of the assessment is to provide the basis for an evaluation of harvest strategies. This is because harvest strategies have to be tested using models that represent 'the full range of uncertainties' pertinent to the fishery in question (Butterworth and Punt 1999) and having a large assessment group with broad participation and a diverse background is likely to promote discussion of a wide range of possible factors that might influence the dynamics of the fish population, its supporting ecosystem and the fisheries for it.

5. CONCLUDING REMARKS

This paper has focused on the assessments for deepwater species. However, many of the problems encountered when assessing deepwater species are also common to assessments of pelagic and inshore species, namely lack of appropriate data and understanding. As a result, many of the solutions outlined above are used when assessing data-poor pelagic and inshore species.

There are, however, some monitoring and assessment issues that appear to be specific to deepwater species. For example, the cost of conducting research and monitoring activities in deepwater habitats is substantially greater than in inshore habitats. Some of methods that can be applied relatively straightforwardly to shallow-water species (such as tagging studies and submersible-based indices of abundance) are either more difficult (and costly) or currently infeasible in deepwater habitats.

Assessments are currently conducted for those species that are the most important commercially. The costs associated with data collection in deepwater habitats means that any research targeted towards commercially less important species will yield less precise information and hence to imprecise assessments. There is, therefore, a need to look towards monitoring tools that are able to provide assessment-related information for a wide suite of species rather than just the major target species. This points, for example, to the need to collect length, age and abundance data for all species during surveys rather than for just a few target species. Given the likely lack of substantial amounts of monitoring data, the careful use of the results of meta-analyses is likely to be necessary for many species. One example of this would be to apply the posterior distribution estimated for the catchability coefficient for trawl surveys of rockfish off the US west coast to estimate the biomass of species for which data are not yet sufficient to base an assessment on. Further, the results from the meta-analysis of Liermann and Hilborn (1997), that depensation is more common in fish stocks than previously believed, means that assessments should regularly incorporate this as a possibility rather than ignoring it, which implicitly assumes that there is no probability of depensation at low stock size.

Many deepwater species are long-lived, slow-growing and relatively unproductive. Estimates of the maximum fraction of the exploitable component of an orange roughy population that can be harvested sustainably has been estimated to be less than 3 percent of that in a virgin state (Francis 2001). This suggests that, *a priori*, assessments of deepwater species should assume that productivity is likely to be low. This can be incorporated into assessments through the selection of prior distributions that give greater *a priori* weight to low productivity than high productivity scenarios. If the data suggest that productivity is higher than implied by the assumed priors, this will be reflected in the posteriors as data accumulate slowly. However, in the absence of

data suggesting higher productivity, the assessment results will be based primarily on scenarios which imply lower productivity.

This paper points to the following as being features of assessments of deepwater species in the future.

- Several alternative models will be included in assessments to attempt to capture alternative hypotheses for the population dynamics and the relationships between the data and the underlying dynamics; hypotheses regarding space and spatial structure will be emphasized to a much greater extent than at present.
- Only a very few of the model parameters will be pre-specified based on analyses of auxiliary information – rather most of the model parameters will be estimated within the assessment.
- Uncertainty will be quantified by means of Bayesian posterior distributions rather than by point estimates and the sensitivity of the results to changes to data weightings and the choice of priors will be employed commonly.
- Prior distributions will be developed for most of the parameters of typical population dynamics models based on meta-analyses. Assessments which are data-poor will therefore be “shrunk” towards *a priori* expectations rather than assessed using overly simple (and often optimistic) models/assumptions.

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Deepwater fish resources in the northeast Atlantic: fisheries, state of knowledge on biology and ecology and recent developments in stock assessment and management

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1. INTRODUCTION

Most deepwater fishes are long-lived, slow-growing, have a low reproductive capacity and are adapted to live in an ecosystem of low energy turnover in which major environmental changes occur infrequently. Deepwater fishery resources are, therefore, highly vulnerable to exploitation (Merrett and Haedrich 1997, Koslow *et al.* 2000, Anon. 2001) and deepwater habitats are sensitive and in need of protection (OSPAR 2000). Experience in the South Pacific and elsewhere has shown that deepwater fish stocks can be depleted quickly (Koslow *et al.* 2000) and that recovery can be slow (Anon. 2001). In most cases, reliable information on stock status and fisheries production potential has lagged considerably behind exploitation (Large *et al.* 2003). In the Northeast Atlantic this concern has been exacerbated by the fact that until 2003 most fisheries were completely unregulated.

Deepwater species in the Northeast Atlantic are not always clearly identified in ICES (International Council for the Exploration of the Sea) literature. This is largely because of operational decisions regarding the structure and development of assessment Working Groups (Gordon *et al.* 2003) and because some species are confined to deepwaters, defined as depths greater than 400 m, while others are also found in shallower waters on the continental shelf. The deepwater species referred to in this paper are those under the remit of the ICES Working Group on the Biology and Assessment of Deep-sea Fish Resources (WGDEEP) and include examples of the former, e.g. orange roughy (*Hoplostethus atlanticus*) and roundnose grenadier (*Coryphaenoides rupestris*), and of the latter, e.g. ling (*Molva molva*) and tusk (*Brosme brosme*).

Formalized collation and examination of fisheries and biological data of Northeast Atlantic deepwater species for assessment purposes began in 1994 when the ICES Study Group on the Biology and Assessment of Deep-Sea Fisheries Resources was first convened (Gordon 1998). In 2000, the group was re-established as an ICES Working

Group. Since 1994, the Group has reported annually to the ICES Advisory Committee on Fishery Management (ACFM). Much of the information presented in this paper has been derived from information contained in the Study/Working Group's reports.

2. OVERVIEW OF DEEPWATER FISHERIES IN THE NORTHEAST ATLANTIC

Comprehensive overviews of deepwater fisheries of the Northeast Atlantic are compiled every second year in the reports of WGDEEP. The reports also include tables of landings by species and ICES Sub-areas and Divisions. Recent reviews of historical trends were also provided by Gordon (2001) and Gordon *et al.* (2003). Hence only a brief account of historical trends and recent developments will be presented here.

Most current deepwater fisheries originated as artisanal fisheries off Portugal, southern Spain and the Azores, but also in the deep shelf areas off northern European countries, especially Iceland and the Faroe Islands. Many such fisheries using traditional gears (handline, longline) still exist, but most deepwater fish landings today are from highly mechanized longline or trawl fisheries. There has been a steady enhancement of vessel and gear technology and dedicated exploration of new grounds, often subsidised by national governments. The major expansion and industrialisation of deepwater fisheries started after World War II.

The present mechanized longline technology was mainly developed in the Nordic countries and longlining for ling, tusk and halibut (*Hippoglossus hippoglossus*) in deepwater has a history back to the 1860s (Bergstad and Hareide 1996). New grounds were explored in phases, and the modern longliner is essentially a factory ship of 100 feet or more long, equipped with automatic baiting systems (autoline) and storage facilities, permitting 6–8 week trips or more. Norway alone operates 50–60 such vessels, and the same technology has been adopted by many other nations, including the Faroe Islands, Iceland, Russia, Spain and Ireland.

Trawl fisheries developed mainly in the North Sea but, compared with longline fisheries, the expansion into deepwater occurred later, initially after major USSR exploratory effort in the 1960s and 1970s (Pechenik and Troyanovsky 1970, Troyanovsky and Lisovsky 1995). Western European fleets were encouraged to move into deeper water by the loss of opportunities in traditional shelf fisheries and it was French trawlers that started major commercial deepwater operations in the mid-1980s, fishing for blue ling (*Molva dypterygia*), roundnose grenadier and, later, orange roughy. German fleets concentrated mainly on redfish (*Sebastes* spp.) and the UK developed a longline fishery for deepwater sharks in addition to taking a bycatch of deepwater species in fisheries for anglerfish (*Lophius* spp.) and hake (*Merluccius merluccius*). Current trawl fisheries are mainly carried out by French, Spanish, Faroese, Irish and Scottish vessels. Russian and Polish vessels are also active, especially on the Mid-Atlantic Ridge and on slopes of the Rockall and Hatton Banks to the west of Scotland and Ireland. Deepwater trawl fisheries have not to any great extent been conducted in the southern parts of the ICES area, such as off Spain, Portugal, the Azores and Madeira, where longline fisheries persist.

Most artisanal and industrialized deepwater fisheries target benthopelagic species, primarily aggregating species or species that are easily attracted to bait. However, there are also fisheries with semi-pelagic or pelagic trawls for mesopelagic species such as blue whiting (*Micromesistius poutassou*) and greater silver smelt (*Argentina silus*). Some typical seamount fisheries for alfonso (*Beryx* spp.) are also semi-pelagic in nature. Many of the demersal trawl and longline fisheries are mixed fisheries and have large bycatches of non-target species.

It is currently impossible to provide a full historical overview of fleets, effort and landings of all the deepwater fisheries of the ICES area. In 2003, NEAFC initiated compilation of such data based on national statistics. Landings statistics compiled by ICES Sub-areas and Divisions (Figure 1) are considered to be relatively complete, but

a simplified overview for the period 1988–2002 is presented in Figure 2. The data from 2001 and 2002 are preliminary and may be incomplete.

There are relatively stable geographical patterns in the species composition of landings. In the northern sub-areas, ling and tusk remain the main target species and dominate the landings, and these two species are also prominent at Iceland and around the Faroe Islands. Overall, these species, plus blue ling, constitute about half of the total landings of deepwater species from the ICES area. West of the British Isles (Sub-areas VI, VII), roundnose grenadier, blue ling and orange roughy are prominent and to the south of this, black scabbardfish (*Aphanopus carbo*) and sharks are important. On the Mid-Atlantic Ridge (mainly Sub-area X), alfonsino is mainly fished in the south and roundnose grenadier in the north.

The major expansion of deepwater trawl fisheries was in the mid-1980s in Sub-areas V and VI and subsequently in Sub-area VII. Aggregations of blue ling were important initial targets and in many areas such aggregations were soon heavily exploited or depleted. Orange roughy fisheries started in the early 1990s in Sub-area VI, but after a few years landings dropped significantly. During the past few years orange roughy has mainly been taken in Sub-area VII, and the fisheries there are extensive but probably unsustainable. Another recent development is the expansion of fisheries on the most western bank off Europe, the Hatton Bank. On the Mid-Atlantic Ridge, alfonsino stocks around seamounts in international waters appear to be in a poor state (Anon. 2002a), and roundnose grenadier fisheries continue at low levels. Off the southern European shelf, traditional longline fisheries for black scabbardfish and sharks appear relatively stable and there are also new fisheries for blackspot seabream (*Pagellus bogaraveo*) off southern Spain. However, several decades ago the latter species was the target of Spanish and French fishery, producing annual landings of several tens of thousand tonnes. The resource was probably overfished and has never recovered.

3. CURRENT STATE OF KNOWLEDGE ON FISH BIOLOGY AND ECOLOGY

Knowledge of the biology and ecology of the target deepwater resources and communities remains limited, and the peer-reviewed literature is relatively small. Major international projects funded by the European Union or Nordic Council focusing on biology and ecology were conducted in the 1990s (e.g. Magnússon *et al.* 1997, Anon. 2000, Gordon 2001, Menezes *et al.* 2001), but research activity has since declined and now depends heavily on scarce national funding. ICES WGDEEP has compiled available information on growth and reproduction for most target species and tables and references are available in the reports and are not repeated here. The deepwater fish currently exploited range from extreme *K*-strategists, such as orange roughy and deepwater sharks, to relatively fast-growing and fecund species such as ling, alfonsino and blue whiting. Based on available information on life history strategies, it is possible to rank most species on an *r-K* scale, but the problem remains that too much of the information on basic biology is documented only in the grey literature. Further, data were too often collected from limited geographical areas compared with the known ranges of the species or communities (and even the known fishing areas), and there are many questions about their representivity. For some species there are major gaps in our knowledge of their basic biology. Age determination problems persist for many species and validation of age is required for most species.

In summary, priority areas for future research of immediate interest to stock assessment and management remain

- age determination and validation
- improved documentation and geographical distribution of information on growth, reproduction and mortality, and

FIGURE 2

Landings of deepwater species by ICES Sub-area and Division (see Figure 1)

'Others' include rabbitfish (Chimaerids), roughhead grenadier (*Macrourus berglax*), smoothheads (Alepocephalids), wreckfish (*Polyprion americanus*), deepwater cardinalfish (*Epigonus telescopus*), morids and bluemouth (*Helicolenus dactylopterus*). Note the different scale used for Sub-areas VI and VII in the bottom panel. Source: Anon. 2003.

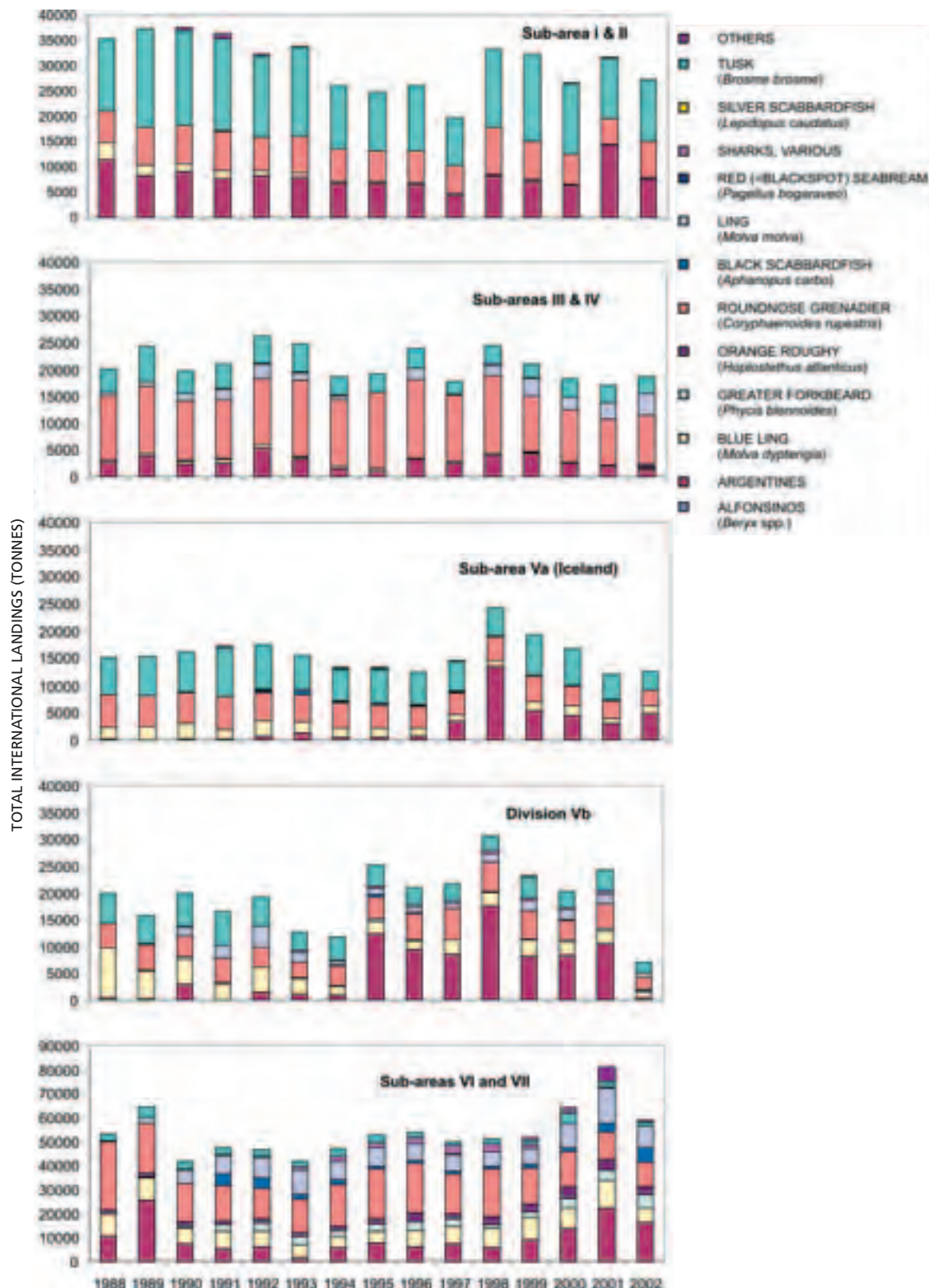
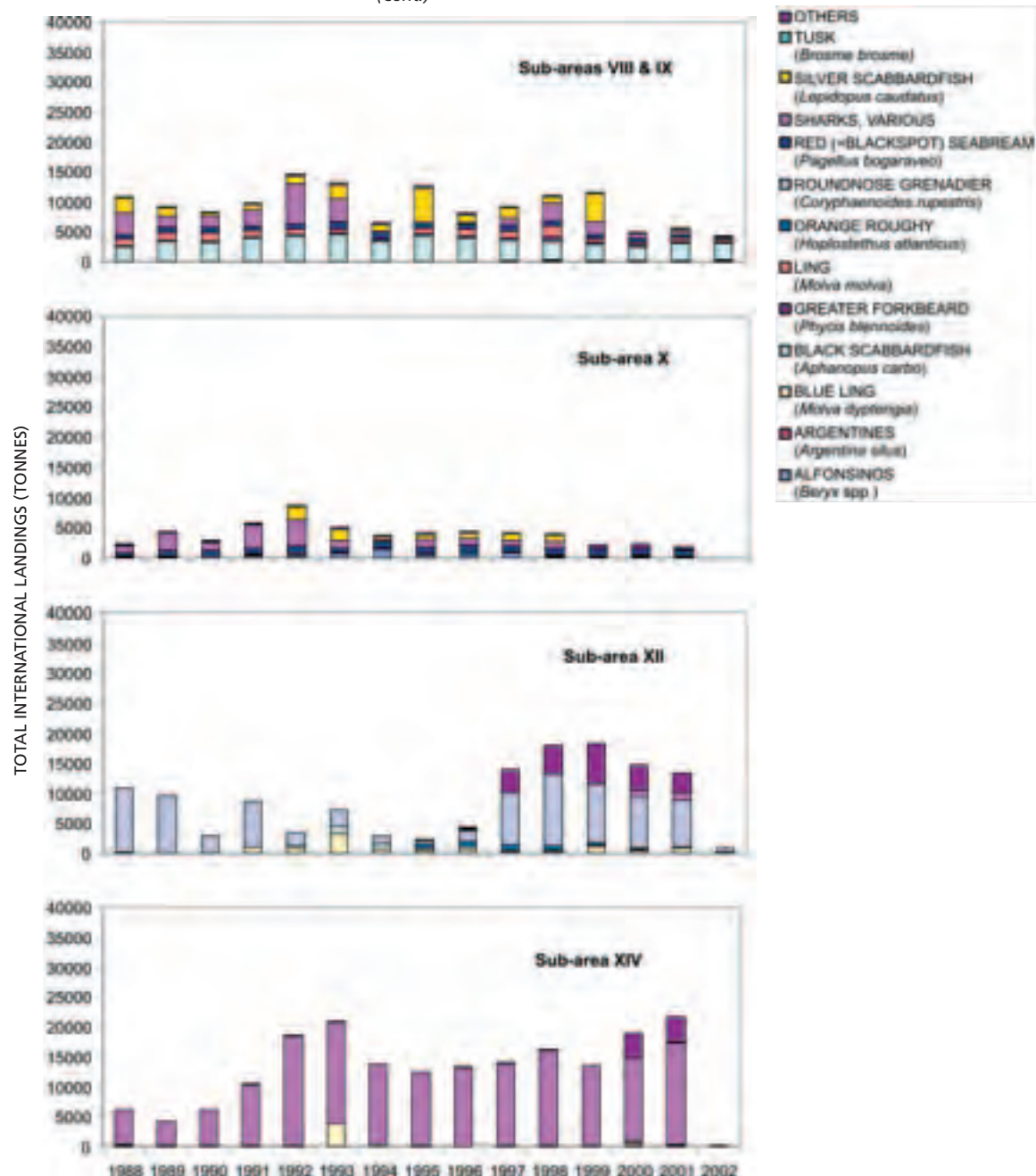


FIGURE 2
(Cont.)



- improved knowledge on past and present distribution (spawning and nursery areas, egg and larval drift, aggregation areas), and the identity and structure of populations and stocks (population genetics).

Many research projects have provided knowledge but, owing to limited duration and resources, a number of these studies were discontinued too early, in essence when they had reached a stage of maturity at which breakthroughs could have been made. There are major challenges for the future, and if current competence and new technologies and methods are adopted, it may be possible to fill knowledge gaps and discover much more.

Some recently published studies include investigations of behaviour and abundance using direct observations from submersibles (e.g. Uiblein *et al.* 2003) and the

application of otolith microchemistry analysis to study population structure (e.g. Swan *et al.* 2003). New initiatives such as the MAR-ECO project on the Mid-Atlantic Ridge has elements studying life history biology, ecology, and population genetics of fishery resources and also include comparisons with results from continental slope waters (Bergstad and Godø 2002). This, and other projects, may help revive deepwater fish research in the North Atlantic.

4. RECENT DEVELOPMENTS IN STOCK ASSESSMENT

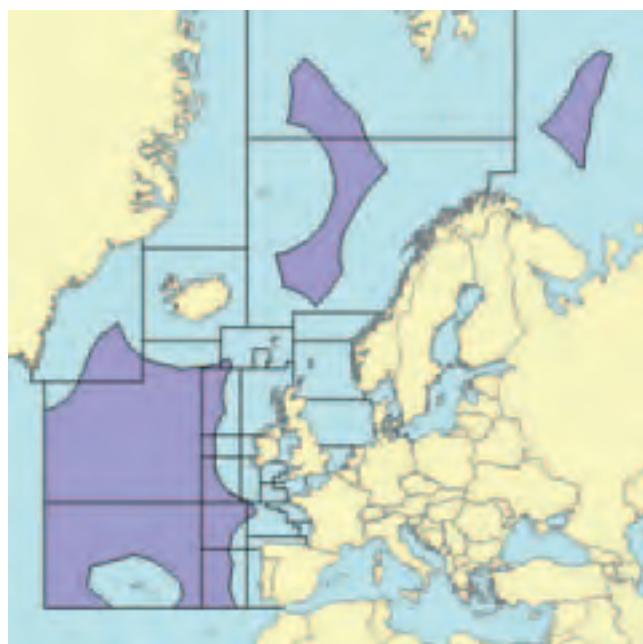
Stock assessments of the major commercially exploited deepwater species of the Northeast Atlantic were first attempted at ICES in 1998 (Anon. 1998), and the most recent assessments were carried out by WGDEEP in 2002 (Anon. 2002a). While progress has been made across this period, many of the problems experienced in earlier years still persist.

As described above, little is known about the stock structure of most species and for assessment purposes, stock units have been defined on the basis of current knowledge of species distribution and similarity of catch-rate trends among ICES statistical areas (Anon. 1998). Therefore, current stock units comprise individual or groups of ICES Sub-areas and occasionally ICES Divisions. This is far from ideal because ICES statistical areas were devised for the continental shelf and, in some instances, are completely inappropriate for delineating deepwater stocks. One solution would be for countries to report catch data by ICES statistical rectangle, allowing assessment scientists to aggregate data by whatever stock areas they deem appropriate. However, rectangle data may not be available historically for some series, and some countries may have confidentiality concerns related to the release of information from new and developing fisheries. A second option is to retain the existing ICES Sub-areas and Divisions, but to subdivide them into groups of rectangles on the basis of topographical features, depth and the spatial distribution of stocks. ICES and the Northeast Atlantic Fisheries Commission (NEAFC) (Figure 3) are currently exploring these options.

A further problem is that there are few fishery-independent surveys designed to provide time-series abundance data for use in assessments. Experience with assessments of orange roughy stocks off New Zealand and Australia has shown that assessments are likely to be more robust if a range of fisheries independent data are available, from acoustic, trawl and egg production surveys for example. Most deepwater surveys in the Northeast Atlantic have either been exploratory in nature or designed to collect biological data, and consequently assessments rely on abundance indices derived from commercial catch and effort data. These data are often sparse, are sometimes of poor quality and are not always available to WGDEEP.

No progress was made with assessments of ling and tusk in 2002 because effort and catch-per-unit effort (CPUE) series for the

FIGURE 3
NEAFC regulatory area (in purple)



Norwegian and Faroese fisheries could not be updated because of lack of reporting (Anon. 2002a). Problems were also encountered in assessments of deepwater stocks to the west of the UK, nearly all of which rely on abundance indices derived from catch/effort data from the French deepwater trawl fleet, the dominant fleet in these fisheries. Prior to 1999, these indices, which are of reasonably good quality and date back to the early 1990s, were calculated using fishing effort directed specifically at deepwater species. However, in 1999 the French national database was reformatted and the data could not be accessed. As an interim measure, revised time-series data based on total rather than directed effort were presented at WGDEEP in 2002. While there was some agreement on historical trends for most stocks between the old and new series, estimates of annual CPUE for 2001 were extremely high for both black scabbardfish in Sub-area VII and deepwater sharks, mainly Portuguese dogfish (*Centroscymnus coelolepis*) and leafscale gulper shark (*Centrophorus squamosus*) in Sub-area VI. These values indicate a dramatic recovery of these stocks in a single year, almost back to pre-exploitation levels but this was considered to be unlikely given current understanding of their stock dynamics. WGDEEP will review this position when it meets in 2004. It is anticipated that the French time-series based on directed CPUE, fully updated to include values from 1999 onwards, will be available to the Group then.

The methods used in assessments are largely determined by the availability and characteristics of fisheries and biological data. In addition to CPUE data from commercial fishing vessels, for most stocks the only other time-series data available are of total international landings. Options for assessment methods are therefore somewhat limited and the main method used has been depletion modelling using surplus production and modified DeLury models (Anon. 1998, 2002a). These models provide estimates of current and virgin exploitable biomass from which a 'depletion ratio' can be calculated for each stock. A full description of the strengths and weaknesses of the methods, particularly in relation to deepwater stocks in the Northeast Atlantic, is provided by Large *et al.* (2003). Varying degrees of success have been experienced, largely depending on the degree of contrast in abundance data and the length of time-series data available. Frequently the fit of the models has been poor, resulting in population estimates with wide confidence limits. Under these circumstances ICES advice on the state of stocks has been based on depletion ratios calculated by use of a smoothed time-series of CPUE from commercial fishing vessels as an index of exploitable biomass. These data frequently show a strong and persistent decline, and the latest ICES scientific advice is that most stocks are harvested outside safe biological limits (Anon. 2002b).

It is recognized that there is a need to expand the range of methods used in assessments to include methods used on deepwater stocks in other parts of the world (Large *et al.* 2003). The use of stock reduction models, which have been applied widely in assessments of deepwater stocks off New Zealand and Australia, is currently under investigation (Large 2002). These methods use biologically meaningful parameters and information for time delays attributable to growth and recruitment to predict the basic biomass dynamics of age-structured populations without requiring information on age structure. Therefore, they can be considered to be a conceptual hybrid between dynamic surplus production and full age-based models (Hilborn and Walters 1992). The model that has been trialed is part of program suite (PMOD) developed by Francis (1992, 1993) and Francis *et al.* (1995). Investigations have largely been restricted to studies of orange roughy in ICES Sub-area VI and results have been similar to those obtained from surplus production and modified DeLury models. Current exploitable biomass is estimated to be around 25 percent of virgin biomass and this is consistent with data from the fishery. The model also provides an estimate of the annual mean catch that can be taken, consistent with a 10 percent probability of spawning stock biomass (SSB) falling below 20 percent of virgin SSB. In New Zealand and Australian

fisheries this catch is termed the maximum constant yield (MCY). Estimates of MCY for orange roughy in Sub-area VI indicate that sustainable catches may be as low as 1.5 percent of virgin biomass, probably <100 t per annum. This contrasts with annual catches taken in the early years of the fishery of up to 3500 t. Stock reduction models are being tested on other stocks in preparation for the WGDEEP meeting in 2004.

Opportunities to use a wider range of assessment methods, including length- and age-based methods, are limited. Although some progress has been made in length and age sampling of commercial deepwater landings, time-series data are available for few species and are often too short (<5 years) or incomplete (missing years) to use in assessments. Moreover, length composition data rarely exhibit any multi-modal structure or evidence of modal progression and length-based assessment methods, which rely on a strong link between modal length and age structure, are therefore unlikely to be suitable. It is possible that time-series catch-at-age data for ling at the Faeroes (ICES Division Vb) and red (blackspot) seabream at the Azores may soon be sufficient to attempt virtual population analyses using abundance indices from Faroese longliners and an Azorean longline survey, respectively. Further, if problems with age determination of blue ling can be overcome and the biological sampling of roundnose grenadier continues, age-based assessments of these species may be possible in future (Large *et al.* 2003).

The only information currently available on the level of fishing mortality (F) in deepwater fisheries is from estimates of total instantaneous mortality rates (Z) calculated from catch curves fitted to annual length or age compositions of species for which estimates of natural mortality (M) are available. Such analyses assume that F, M, catchability and recruitment have remained constant over time and only provide information on the scale of F, whether it is high or low, rather than accurate estimates. Critically, the depletion and stock reduction models currently used in assessments do not provide any information on the relationship between F and catches. This situation has important implications for fisheries management.

5. RECENT DEVELOPMENTS IN FISHERIES MANAGEMENT AND THEIR IMPLICATIONS

Almost all deepwater fisheries in the Northeast Atlantic were, until 2003, unregulated. Exceptions included fisheries where individual countries introduced national management measures for specific species, licensing of vessels fishing for greater silver smelt in Norwegian waters for example, and where for historical reasons individual species have been assessed and managed internationally, Greenland halibut (*Reinhardtius hippoglossoides*) and redfish for example. Most other fisheries, and particularly those on the high seas, followed or, on the basis of available data, appeared to be following, a boom-and-bust trajectory. Typically, exploratory fishing identified new fisheries and these were fished down outside safe biological limits over varying time-scales: short – <5 years, for species associated with seamounts and other topographical features, orange roughy for example, and longer, perhaps 20–30 years, for more widely distributed species such as blue ling. Again, there are exceptions to these patterns. For example, the long-standing, artisanal, longline fisheries for black scabbardfish off the Portuguese mainland and Madeira is considered, on the basis of available evidence, to be sustainable. In overall terms, however, fisheries management bodies in the Northeast Atlantic, as in many other parts of the world, have been slow to follow the Precautionary Approach (Garcia 1994) and bring in management measures for deepwater fisheries. In this paper we will not review the reasons for this but will concentrate on the content and likely efficacy of management measures recently introduced.

In January 2003, the EU introduced Total Allowable Catches (TACs) for some species (EC 2002a), and, as a first step towards effort management, a vessel licensing

scheme with aggregate power and capacity of deepwater fishing vessels capped to levels observed in the years 1998–2000 (EC 2002b). These measures apply to EU vessels fishing in EU and international waters. In addition, NEAFC has introduced a temporary freeze on effort in deepwater fisheries in the Regulatory Area from 1 January 2003 and is currently developing further management measures.

The attractions of using TACs as a fisheries management instrument are well documented (Cochrane 2002). Most fisheries are shared internationally and managers and politicians find TACs attractive because they provide a simple mechanism for the allocation of national quotas. Moreover, establishing track records for national quotas is more straightforward because historical landings data are often more readily available than effort data. Notwithstanding this, managing deepwater fisheries in the Northeast Atlantic solely by TACs and quotas is unlikely to be successful because the relationship between catches and fishing mortality is not known, and a reduction in TACs may not result in a commensurate reduction in fishing mortality. The TACs recently introduced by the EU, although for some species significantly lower than recent total international landings, may not have a strongly positive conservation effect because most stocks are declining and catches may drop because of falling catch rates rather than because of reductions in fishing mortality. Also many commercially important exploited species, such as deepwater sharks, alfonsino and greater forkbeard (*Phycis blennoides*), are not covered in the TAC Regulation.

A further concern is that TACs will lead to more discarding in mixed fisheries. In many deepwater fisheries, catches consist of a range of deepwater species or, as on the continental slope west of the UK, a combination of deepwater and continental shelf species such as hake (*Merluccius merluccius*) and anglerfish (*Lophius* spp.). In these fisheries, TACs for different species can be taken at different rates, leading to increased discards of over-quota species by vessels fishing on under-subscribed species. This will lead to increased fishing mortality on deepwater species because all discarded fish die as a result of changes in pressure as they are brought to the sea surface and also, in trawl fisheries, because of abrasion in nets (most deepwater species lack a mucus covering and are susceptible to damage by abrasion). Non-commercially important species taken as bycatch will also die, and so fishing, and trawling in particular, can have a considerable impact on the wider deepwater fish assemblage.

Managing deepwater fisheries in the Northeast Atlantic by effort control also has advantages and disadvantages. The main advantage is that reductions in fishing effort would have a proportionate effect on fishing mortality, and allow management of fisheries in the absence of any knowledge of the relationship between fishing mortality and catches. Regulation of species-specific effort may be appropriate for directed fisheries, but in mixed fisheries, fleet- or gear-specific measures may be required (Anon. 2003). An important disadvantage of effort control, however, is that in a restrictive effort regime, fishers may respond by increasing the efficiency of fishing and fishing gear, a process known as ‘technological creep’. Improvements in gear design, fish-finding and navigation equipment can be important drivers of improvements in fishing efficiency in coastal artisanal deepwater fisheries, whereas in high-seas fisheries the development of fishing gear and fishing techniques is ongoing. Modest increases of between 2 and 4 percent a year will lead to a doubling in fishing efficiency in about 36 and 14 years, respectively. The effects of technological creep can be minimised by monitoring vessel and gear characteristics and limiting change, but this approach stifles innovation, requires extensive data collection, and is unlikely to be fully effective because fishers will always try to find some way of ‘getting an edge’ over other fishers and particularly over management regulations (Pope 2002).

Fisheries management bodies in the Northeast Atlantic recognize that technical measures such as mesh size regulation and selectivity grids are unlikely to be effective

for deepwater fisheries because of the unusual shape and size of some species and also because a high proportion of fish entering trawls and subsequently escaping through meshes will be subject to abrasion and die (Connolly and Kelly 1996, Koslow *et al.* 2000). They are also aware that the use of closed areas may be appropriate for protecting spawning concentrations, of blue ling for example, and that no-trawl zones may protect fish species and coral communities associated with seamounts. However, these features can be widely scattered geographically and, although satellite monitoring would help, a patchwork of closed areas may be extremely difficult to effectively enforce. ICES is currently collating available information on these features (Anon. 2003), but data from dedicated scientific surveys are sparse. Moreover, high-resolution data from commercial vessels is difficult to obtain because of confidentiality concerns of skippers and vessel owners, particularly in new and developing fisheries.

Therefore, the best way to manage these fisheries may be by a combination of fishing effort and catch controls and closed areas/no-trawl zones. Compared with fisheries on the continental shelf, more emphasis should be placed on fishing effort, given the restricted nature of results from stock assessments and the problems with managing mixed fisheries by TACs. However, factors affecting fishing efficiency will have to be closely monitored. The management measures introduced by the EU and NEAFC are, therefore, a step in the right direction. However, they are not sufficiently rigorous in their scope and content to reduce exploitation to sustainable levels. Most deepwater stocks were identified as outside safe biological limits in 1998, so capping effort at levels observed between 1998 and 2000 will do little to conserve stocks. Further, capping effort at current levels, as applied by NEAFC, will do even less. The boom-and-bust cycle, seen in many fisheries, will simply continue.

A major weakness of the management introduced measures is that little provision has been made to control and regulate new and developing fisheries. Current ICES advice is that *'fisheries be permitted only when they are accompanied by programs to collect data and expand very slowly until reliable assessments indicate that increased harvests are sustainable'*. A condition of the EU licensing scheme is that member states must submit a sampling plan for deepwater species that includes the deployment of scientific observers on vessels. This is an important first step that will lead to increased availability of fisheries and biological data for assessments, although NEAFC have yet to decide whether or not a similar scheme should be introduced for non-EU vessels fishing in international waters. However, new fisheries will continue to be identified and developed with a minimum of regulation and control and, most importantly, without any assessment of sustainable fisheries production potential. Until these issues are resolved and real steps taken to drastically reduce fishing effort across most stocks, few deepwater fisheries in the Northeast Atlantic are likely to be biologically sustainable. If fisheries management bodies do not grasp the nettle the only major force likely to reduce the level of fishing effort will be economic, i.e. when stocks become mined out and fishing becomes economically non-viable. This pattern can already be seen in stocks of orange roughy, a species highly vulnerable to exploitation and possibly an early indicator of future trends.

6. ACKNOWLEDGEMENTS

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Potential exploitable deepwater resources and exploratory fishing off the South African coast and the development of the deepwater fishery on the south Madagascar ridge

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1. INTRODUCTION

The evolution of deepwater fisheries in the Southern African context has been poorly documented. In this paper we present our account of the development of deepwater fishing off the Southern African continental shelf, including the high-seas demersal fishing effort in the southeast Atlantic Ocean, the eastern Indian Ocean and the area directly south of the South African coastline. We provide an opinion on the commercial availability and potential of the main deepwater species in these areas.

2. TIME FRAMES

The development of South African interests in deepwater exploitation is relatively recent. However in this report we identify convenient periods of activity in the deepwater sector off the Southern African sub-continent as follows.

- Up to 1989, including the effort prior to the introduction of the South African 200 mile fishing zone (EEZ) in 1977, the introduction of quota management of the South African hake fishery from 1978 and the disbanding of the International Commission for Southeast Atlantic Fisheries (ICSEAF) in 1989 (just prior to Namibian Independence).
- From 1989 to 1994 including the transition period in which Namibia took control of their national fisheries and the change in political dispensation in South Africa after which the process of a new fisheries policy was initiated.
- From 1995 to 2000, including the ratification of the 1982 United Nations Convention of the Law of the Sea by Namibia and South Africa with the subsequent formation of the regional fisheries agreement Southeast Atlantic Fisheries Organisation (SEAFO) and the High Seas Fisheries Agreements including the Straddling and Highly Migratory Fish Stocks agreements.
- From 2000 to present – deep-sea fishing effort in the Indian Ocean.

Each of the time frames specified above have relevance to the development of high-seas fishing in the Southern African context as they imposed different fisheries management and political regimes on national, regional and international fishing operators.

3. HIGH-SEAS EFFORT IN THE SOUTHEAST ATLANTIC UP TO 1989

Effort directed at groundfish resources both on the continental shelf and on the high seas in the Southeast Atlantic is poorly documented. South Africa extended management of their regional fisheries, through the declaration of a 200 mile EEZ in 1977. South African fishing effort was contained within its own national boundaries and little bottom-trawl effort off the continental shelf was reported. Rights holders in the bottom-trawl sector targeted mostly the Cape hakes (*Merluccius capensis* and *M. paradoxus*), the biomass of which was steadily improving under a conservative management regime, so there was no incentive to seek alternative potential resources.

Namibian fisheries on the other hand were being managed through the collective efforts of the ICSEAF signatory states of which South Africa, Spain and the USSR were prominent. The significance of this was that it permitted the introduction of distant water fleets, (particularly Spain and the Soviet Block countries) into the region. At the time there was no coordinated effort to manage the high seas adjacent to the territorial waters of Namibia (formerly South West Africa). Research in the form of swept-area biomass surveys were conducted in the ICSEAF period and South African records at this time reported occasional large incidental catches of orange roughy (*Hoplostethus atlanticus*) in Namibian waters. Circumstantial evidence also pointed to large catches of orange roughy been taken by Russian trawlers in the vicinity of the hake trawling grounds. In addition to large amounts of hake and other bycatch species, it is believed that these incidental catches of orange roughy were processed into fishmeal (the processing and markets for orange roughy were not yet fully developed).

In addition to the mostly unreported or misreported catches off the Namibian coast, the exploratory efforts of the Russian international fleet, known as AtlantNIRO, were obtained when evaluating the historical catch records for the proceedings leading to the formation of the Southeast Atlantic Fisheries Organisation (SEAFO) (Japp 1999). Target species were alfonso (*Beryx splendens*), orange roughy (*Hoplostethus atlanticus*), armourhead (*Pseudopentaceros richardsoni*) and cardinal fishes (*Epigonus* spp.). The USSR exploratory fleet systematically trawled seamounts and banks along the mid-Atlantic ridge (Figure 1, reference points 1 and 2) extending southwards from the Azores along the Walvis Ridge as far as the Tristan da Chuna Island complex. Documents translated (from Russian) of these exploratory trips are explicit, describing exact locations, the nature of each feature and the identification of targets and species composition of catches. There is no doubt that large volumes of deepwater species were caught and conservative estimates are that at least 50 000 tonnes was caught in the period 1975 to 1979.

4. HIGH-SEAS EFFORT IN THE SOUTHEAST ATLANTIC FROM 1989 TO 1994

From a fisheries management and political perspective this was a critical period for the Southeast Atlantic. Namibia obtained independence in 1990 and immediately exerted control over their fisheries resources. Foreign fishing fleets were effectively removed from the region. Further, South Africa no longer influenced the research and management of the Namibian fisheries. At the end of the period, South Africa also moved into a new political order and initiated the development of a new fisheries policy from 1994 which took several years to establish.

Although Namibia controlled effort within their EEZ, foreign-flagged vessels operating on the high seas in waters adjacent to their border was not discouraged as utilisation by foreign vessels of Namibian ports was a much needed economic boost for the region. Reported high-seas landings were however minimal and poorly recorded (mostly small quantities of alfonso). Towards the end of the period, increasing interest in deepwater stocks was being shown by South African operators.

Several reasons for this are suggested including

- the development of markets for deepwater species (particularly orange roughy and alfonso)
- worldwide recognition of the potential of deepwater resources
- threats of limit on hake quotas (South Africa)
- development of deepwater fishing techniques and
- deployment of excess capacity in the hake fishery.

In June 1994 the first application was submitted to the South African fisheries management authority (Sea Fisheries Research Institute) for an exploratory deepwater fishing right. With the subsequent granting of a single exploratory deepwater permit, a deepwater vessel was deployed in the South African EEZ specifically to conduct exploratory fishing for deepwater resources. This resulted in the discovery in late 1994 of the deepwater oreo dory resource on the southern tip of the Agulhas Bank in 700–1 100 m (Figure 1, reference point 4). Although considerable effort was deployed, indications were that orange roughy abundance off the South African coast was restricted to the west coast extending from the cape point northwards to the Namibian border. Catches (Figure 1 (separate file) of orange roughy were however limited to very small quantities with no definite indications of aggregations or areas with the potential for larger quantities.

5. EXPLORATORY DEEPWATER FISHING OF SOUTH AFRICA AND NAMIBIA FROM 1995

5.1 The beginnings

Interest in deepwater fishing off South Africa and Namibia acquired increasing momentum in this period. Extensive research (side-scan sonar) and trawl surveys were conducted mostly by a single operator. The South African management authority issued more deepwater permits (5) to local operators between 1995–1997. In this period specific legislation was introduced prohibiting the landing of deepwater species caught inside the South African fishing zone without a permit.

5.2 Effort off South Africa

Several South African operators activated their permits. Few, however, designated boats full-time on deepwater fishing and instead only used their vessels as capacity in their hake-directed fleet became available. Some permit holders fished the Walvis Ridge, particularly Valdivia Bank. Small volumes of orange roughy and alfonso were reported. Pelagic armourhead were also targeted and a few large landings from Valdivia were reported (Japp 1999). Within South African waters, effort continued on the oreo dory (Figure 1, reference point 4) and some effort was also directed westwards into the South Atlantic. Catches of deepwater dory were however limited to smooth dory (*Pseudocyttus maculatus*), warty dory (*Allocyttus verrucosus*) and spikey oreo (*Neocyttus rhomboidalis*). The fish caught were generally small by comparison, for example, to catches of similar deepwater dory species off New Zealand and Australia (Ward *et al.* 1996). Because of the limited area being fished, management considered of restricting effort and setting precautionary catch limits on the deepwater dory stocks.

This management never materialized. South Africa was going through an intensive period of fisheries policy development and rights-based concerns, mostly focused on transformation of the fishing industry. Under threat of losing their bread and butter (hake) resources, most trawler operators with the capital and resources capable of taking the risk of conducting costly deepwater research were reluctant to put any further effort into the fishery. Of the five deep-sea permit holders, three consolidated for a period and fished using a single vessel, while the others continued to fish intermittently.

Despite the rights-based concerns in the South African fishing industry, there were still operators interested in developing South Africa's deepwater fisheries. The state management authority (*Marine and Coastal Management*) issued the last deepwater permits in 1998 and then called for applications on a more formal basis for 1999. Applications were submitted by numerous operators – these applications were however not processed and subsequent follow-up requests by potential operators have never been considered by the MCM.

The status of the South African deepwater fishery therefore remains uncertain, although the MCM have indicated that applications for a range of new and exploratory fishing rights will be called for in the near future.

5.3 Effort in Namibian waters

Advances in deepwater fishing off Namibia in this period was much more positive than in South Africa. Namibia had established a policy and management framework that encouraged exploratory fishing for new resources. The development of the Namibian orange roughy fishery is now well known and beyond the scope of this paper. In summary however, the South African operator responsible for the initial research thrust in South African waters in 1994 and 1995 identified Namibian waters as having potential and acquired an exploratory deepwater permit there. From 1995 four orange roughy grounds were identified and exploited under a management regime in Namibia (Figure 1, reference point 3). Despite management efforts and catch restrictions however, the catch rates in Namibia rapidly declined and although the fishery is still active, it is restricted to a relatively small catch with the periodic closing of several of the quota management areas (QMAs).

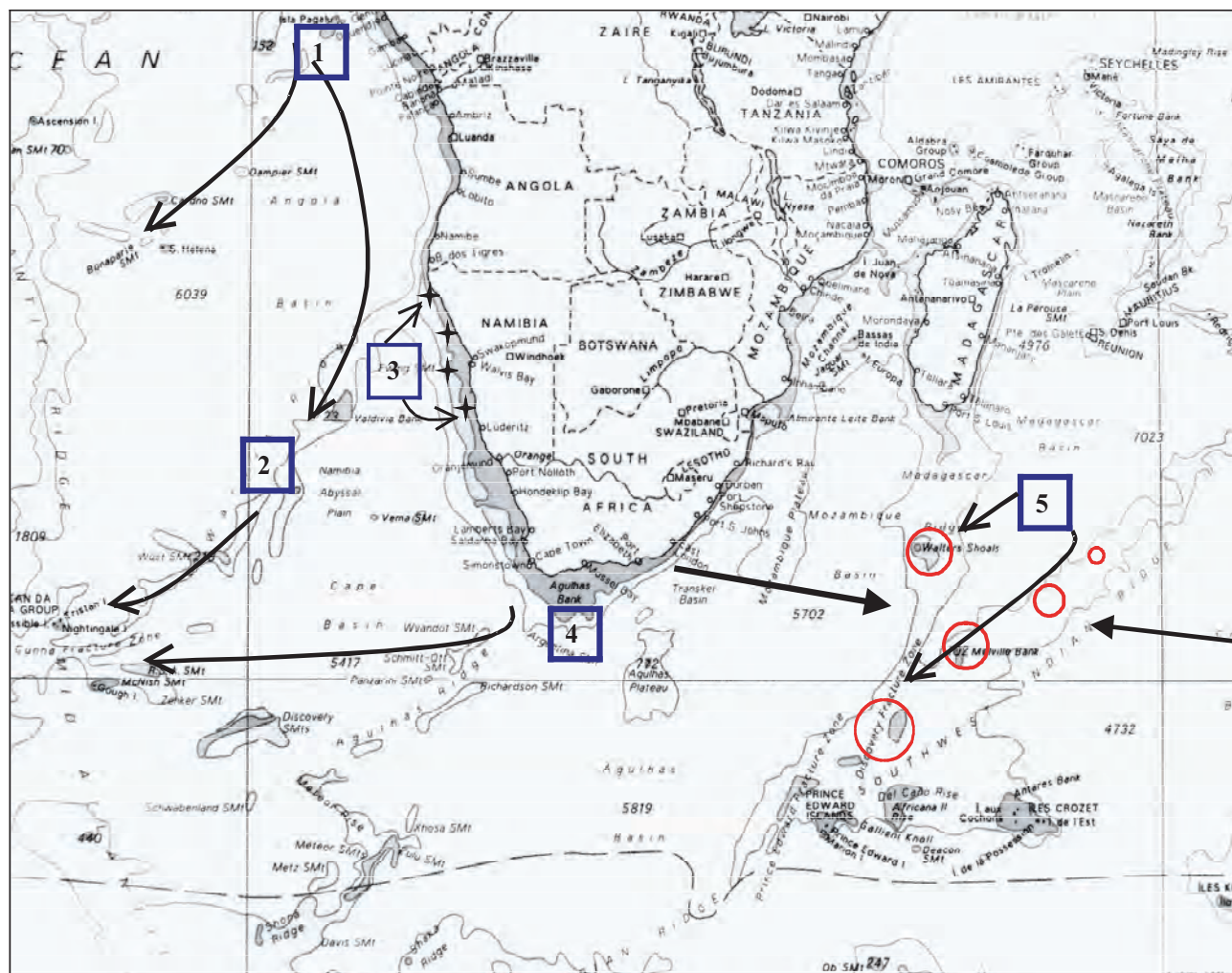
The development of the Namibian orange roughy fishery involved the pioneering use of side scan sonar technology. The technology was employed to identify potentially suitable orange roughy habitat – seamounts, drop offs, canyons. This technology facilitated the development of all four main fishing grounds in Namibia. Further, this technology played a major role in the development of the South West Indian Ocean Fishery.

6. DEVELOPMENT OF THE INDIAN OCEAN DEEPWATER FISHERY

From 1996 greater interest was being shown in the potential for fisheries in the high seas, particularly from established Australian and New Zealand operators some of whose vessels had conducted exploratory fishing westwards into the Southern Indian Ocean. In this regard exploratory effort was directed at areas south and east of Madagascar (Figure 1, reference point 5 and ringed areas). South African operators also began to fish more aggressively in the high seas. South Africa had introduced a new fisheries policy and the rights of many of the established companies were under threat of either removal or reduction. South Africa also encouraged high-seas development through the issuing and control of high-seas permits (a process encouraged by the United Nations Convention on the Law of the Sea and subsequent high-seas and straddling-stocks agreements). In this regard the targeting on orange roughy by South African boats on the Tasman Rise in 1999 was a wake up call not only for the South African authorities, but also in the international context with regard to bilateral arrangements between New Zealand and Australia and the management of high-seas resources adjacent to coastal states.

Prior to the South African campaign to the Tasman Rise in 1999 there had been a well organized, low profile campaign conducted by New Zealand operators in the Indian Ocean to explore for, and develop, deepwater resources in the Indian Ocean. The campaign made use of historical catch information from the Russian exploratory fleets of the 1970's (as reported for the Southeast Atlantic) and the new side scan sonar technology that had been pioneered successfully in Namibia and New Zealand.

FIGURE 1
Development of deep-sea fishing in the Southeast Atlantic, Southern and Western Indian Oceans up to 2003



The exploration, which commenced in 1998, was extensive, covering areas from the Madagascar Ridge (including Walters Shoals), South West Indian Ocean Ridge, and the Discovery, Indomed and Galleini Fracture Zones in the west to the Ninety East Ridge and Broken Ridge in the east (Figure 1 refers). The campaign – essentially one vessel – was successful in locating commercial quantities of alfonsino and orange roughy.

Independently of the New Zealand campaign, an Australian operator was also conducting exploratory fishing in the South West Indian Ocean. As fate would have it, the New Zealand (1), Australian (2) and South African (2) vessels returning from the Tasman Rise all came upon each other in the latter half of 1999. This chance meeting on the high seas immediately sparked competition for fish off the limited grounds that had been identified in the South Indian Ocean.

The increased profile of the fishing activity in the SW Indian Ocean soon drew interest from deepwater operators around the world. The initial five vessels were soon joined by Korean vessels that had been active on the Tasman Rise. By the end of 1999 the fleet had doubled to 10–12 vessels from six or seven flag states. By mid-2000 more than 35 vessels from more than 13 flag states were reportedly operating in the South West Indian Ocean.

The fishery peaked in 2000/2001 with catches in excess of 15 000 tonnes of orange roughy being landed at various ports in Australia, Indonesia, Mauritius, Seychelles, Mozambique, South Africa and Namibia. As in the early days of the Australian and New Zealand orange roughy fisheries, there were many reports of vessels queuing to shoot their gear on productive tow lines with occasional large catches reported (Figure 2).

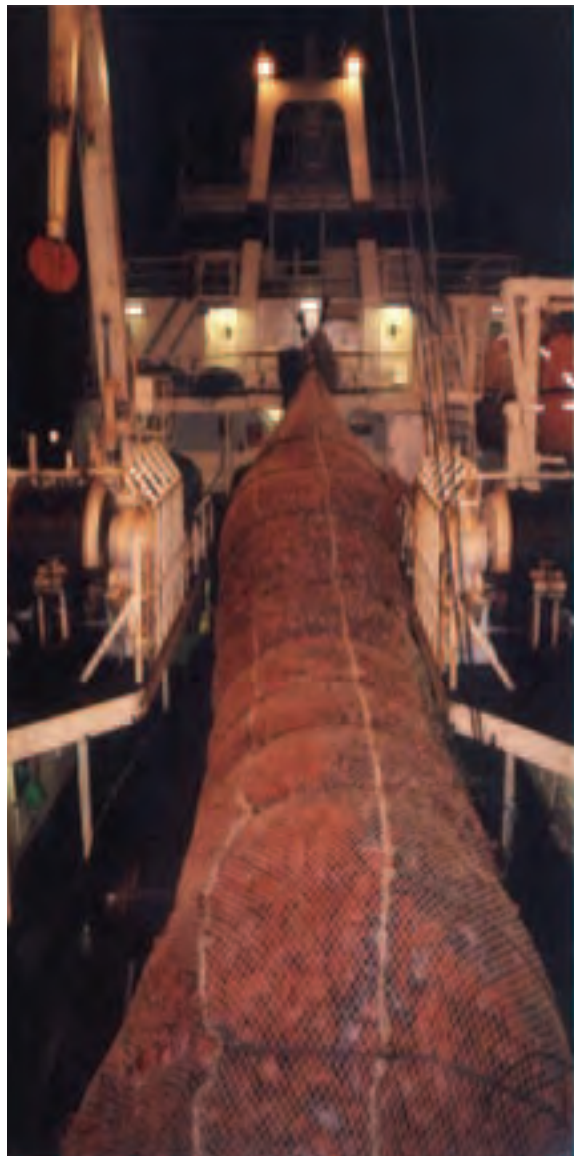
The labile environmental conditions on many of the seamounts being targeted resulted in catches being sporadic at times with the effect of environmental fluctuations on fish availability being exacerbated by the high level of fishing activity. This forced operators to diversify their fishing and target other species, particularly alfonsino, boarfish and bluenose.

Orange roughy catches declined significantly in 2001, and more so in 2002. The large fleet that had built up in 2000, dissipated, as rapidly as the catches declined and by 2002 the fleet comprised probably no more than 15 vessels, at the most. By mid-2003 the fleet was approximately 8 vessels, which included the original New Zealand, Australian and South African operators.

It is clear that success in this fishery comes down to experience, preparation (cf. New Zealand campaign) and the ability to ride out long periods of low catches.

FIGURE 2

Typical haul of 70 t of orange roughy made on a vessel in 1999 on the Indian Ocean Ridge



7. POTENTIAL FOR THE DEVELOPMENT OF NEW DEEPWATER FISHERIES OFF SOUTH AFRICA

We conclude that the economic potential of a deepwater fishery exists off South Africa both within the economic zone and the adjacent high seas. Results to date have indicated suitable species availability, but the true economic potential needs to be investigated through renewed exploratory effort. The obvious species would be deepwater dory, although the availability of orange roughy also cannot be excluded.

Potential deepwater stocks are probably most likely to be found on the West Coast where the current, bathymetric and habitat characteristics are likely to be suited to their life history strategies. The Benguela Current system off the West Coast is, however, dominated by an upwelling regime with highly variable bottom temperatures and periodic anoxic water. These conditions are likely to affect known orange roughy (and other deepwater species) behavioural regulators (such as temperature preferences). South African operators have, however, been progressive in their approach to deepwater fishing with the development of techniques and good use of available technology (as indicated by the development of the SW Indian Ocean fishery).

The potential for deepwater resources off the South African south and east coasts is less promising with the strongly-flowing Agulhas current influencing not only the behaviour of deepwater fish species, but also making deepwater trawling difficult. Grounds, including significant amounts of deep-sea corals exist, which would complicate fishing, and the potential for deepwater species in these areas remains to be fully investigated.

We conclude therefore that fisheries management in South Africa should be more progressive and supportive of deepwater exploration. Few dedicated deepwater operators willing to commit to exploratory deepwater fishing exist in Southern Africa and in this respect, the experience and influence of those that do, as well as other supporting deepwater nations, should be recognized. Fisheries managers in South Africa have the advantage of the experience of deepwater fisheries in other parts of the world, and in particular the recent demise of the Indian Ocean resource, is one example. Deepwater fisheries are, however, costly and high-risk operations, and in this context unlikely to attract new or inexperienced South African fishers.

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Counting deepwater fish: challenges for estimating the abundance of orange roughy in New Zealand fisheries

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1. INTRODUCTION

Orange roughy (*Hoplostethus atlanticus*) are an important commercial fishery species in several parts of the world. These fisheries are comparatively recent, developing around New Zealand in the late 1970s, and subsequently in Australia, the North Atlantic off the Faroes and Scotland, Namibia, Chile, and the Indian Ocean (Francis and Clark 2004).

Orange roughy is a deepwater species, occurring at depths between 500 m and 1 500 m. Because of this, they cannot be kept alive easily and studied in tanks, or tagged and returned. The water conditions in which they live feature high pressure and low temperature so aspects of their biology and ecology are still not well understood. They can form very dense, and predictable, aggregations, and these can be over a range of habitat – from flat bottom to canyon edges to the tops and sides of hills, and importantly, often over rough ground. The species can be highly vulnerable to overfishing, but slow to recover from it. It means that estimating abundance is critical to successful management, especially in the early years when the virgin stock can be rapidly fished down.

General methods of determining fish abundance have been described frequently and reviewed in fisheries texts and journals (e.g. Saville 1977, Sissenwine, Azarovitz and Suomala 1983), but there have been few published accounts of survey results for deepwater species like orange roughy. Clark (1996a) described some elements of performance of abundance estimation methods applied to deepwater species in New Zealand, and Branch (2001) extended this with Namibian fishery results. Since then, data and technology improvements have occurred, and the conduct, or understanding of the efficacy, of some methods have developed.

In this paper, the work of Clark (1996a) is updated. Four methods used in measuring stock size of orange roughy in New Zealand waters are briefly described and their effectiveness discussed: trawl surveys, acoustic surveys, egg production surveys and analysis of commercial catch and effort data. Combinations of methods, and indirect estimation procedures are also considered. The intention in this paper is not to describe these methods in detail, as the general methodology is the same as that used for shallow water species and is covered by Clark (1996a). Rather, the aim is to focus on specific features and aspects of the methods relevant to the particular characteristics of orange roughy and similar deepwater species.

2. TRAWL SURVEYS

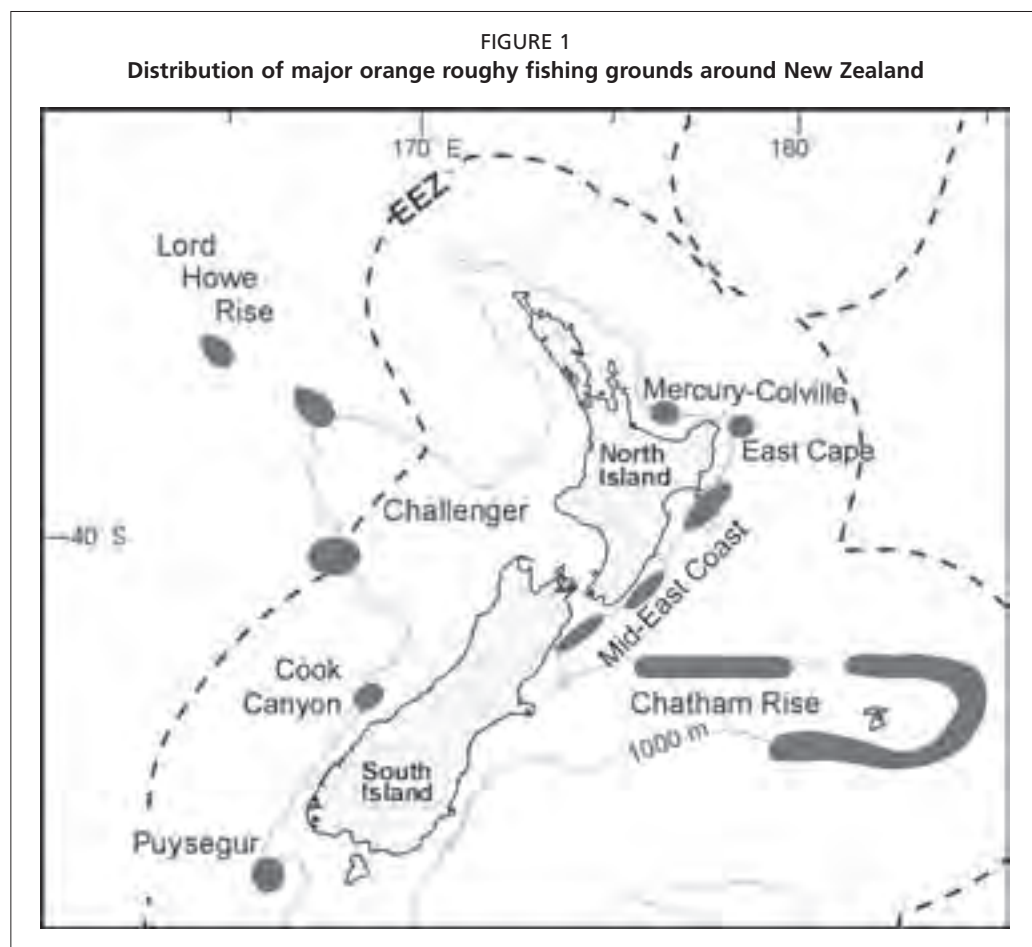
2.1 Survey design

Swept-area trawl survey methodology is widely used and well documented (e.g. Grosslein 1979, Doubleday and Rivard 1981). In most New Zealand deepwater surveys, a two-phase stratified random design has been employed (after Francis 1984). Trawls are carried out random positions, or a combination of position and depth, parallel to the depth contour, over a fixed distance. These tows are repeated each year in some surveys, or new random stations are generated for each survey. In areas where fish occur on seamount or 'drop-off' features, modifications are made to the standard survey design (Clark 1994, 1996a). Stratification is typically based on narrow depth bands, and is also done around such seamount features, because orange roughy form dense aggregations in localized areas.

In the early years of fishery development, a guide to the level at which to set catch limits was urgently needed by managers. Swept-area estimates have been used as absolute biomass, despite poor knowledge of fish herding by, or escapement from, the trawl gear. As time series were built up, indices were used as measures of relative abundance (Francis 1992, Clark 1995).

2.2 Trawl survey descriptions

Time series of trawl surveys have been carried out in five New Zealand orange roughy fisheries: the Chatham Rise 'spawning box', Challenger Plateau, East coast of New Zealand, Puysegur Bank and Bay of Plenty. Locations of the main fishing grounds are shown in Figure 1.



The Chatham Rise 'spawning box' has been the most exploited and researched orange roughy fishing ground. Trawl surveys were the main method of monitoring abundance over the period from 1984 to 1994 (Anderson and Fenaughty 1996). Overall, the indices from the Chatham Rise surveys through the 1980s showed a consistent declining trend. The variance of the survey estimates was generally low and the trend in indices was consistent with an observed contraction in the distribution of fish concentrations (Clark *et al.* 2000), and together with a relatively good fit of the indices to orange roughy computer models, gave confidence in the estimates of biomass.

However, surveys in 1992 and 1994 showed increasing levels of uncertainty in the biomass index, as the coefficient of variation (CV) increased from typically less than 20 percent in the 1980s to 34 percent in 1992 and 67 percent in 1994. The situation of a shrinking area of high fish density is consistent with an increasing CV, as in using the same stratum boundaries there is an increase in the 'hit-or-miss' situation. The area was also closed to commercial fishing in 1992 and this could have led to an increase in fish concentration as heavy fishing pressure may disrupt the formation or stability of aggregations (Clark and Tracey 1991). The differing results in 1992 and 1994 from previous surveys appear related to a changing pattern of fish distribution, relative abundance and availability. The trawl survey technique is thought to have worked well at tracking abundance during the 1980s, but started to fail with the changing fish distribution in the early 1990s. The need for tight stratification when small concentrations occur, or a large number of tows (many with high catch rates) in a short period when the distribution of fish is stable, limits the application of the technique in the present situation. Thus, the time series has now been discontinued.

Surveys in other areas have also shown strong trends. The Challenger Plateau winter survey indices decreased dramatically between 1987 and 1989, which was a time when commercial catch rates also dropped and the fishery showed signs of overexploitation (Clark and Tracey 1994). Similarly, in the Puysegur Bank region there have been substantial decreases in indices between consecutive surveys (Clark 1996a), although different vessels and timing limit the usefulness of the comparisons. Results from non-winter trawl surveys off the east coast have been difficult to interpret. Surveys between 1992 and 1994 showed little contrast in the index values, despite commercial catch rates in the main fishing season decreasing substantially and a subsequent stock assessment showing the period to be one where the stock size had fallen (Field *et al.* 1994). Variance was still reasonably high, and it is possible that the wide area survey was mainly tracking consistently low densities of dispersed fish, with an occasional catch from pockets of feeding aggregations scattered on hill and drop-off features through the area. Trawl surveys in the western Bay of Plenty covered several hill features where orange roughy were known to spawn, and where most of the catch was taken in the 1990s (Clark 1996b, Clark and Field 1998). The time series was established as part of an adaptive management programme (Starr, Clark and Francis 1996). Survey indices showed a strong decline, and although there is uncertainty about a possible change in environmental conditions affecting the fish, there is little sign of any improvement, and the area is currently closed to targeted orange roughy fishing.

Trawl surveys have advantages over a number of other fishery-independent methods. They do not require a specific research vessel, or highly specialized scientific equipment, there is a well-established methodology and survey design, and results can be produced quickly. However, conditions of bottom type and fish distribution must be suitable for the technique to work. Orange roughy often aggregate over rough seafloor, and at high densities such that rapid gear saturation can occur and not provide an accurate catch rate measure.

comm.). In these cases, separation of orange roughy from other species is important for reliable measurement of biomass. The target strength of these other species is often poorly known, but they are generally higher than orange roughy. Therefore, a small number of other species can dominate the backscatter and swamp that of orange roughy. Use of multiple frequencies (Kloser *et al.* 2000), phase-change and chirping techniques (Barr and Coombs 2001) are recent advances in species discrimination that can overcome some of the inadequacies of using the species mix from trawl catches for interpreting acoustic data (Kloser, Williams and Koslow 1997).

Weather can also limit the use of acoustic assessment methods. Rough sea conditions can cause an extensive bubble layer to form under the vessel (and its acoustic transducer) as it pitches and rolls. This attenuates acoustic signal and results in a broken data record that makes it difficult to identify the seafloor and distinguish fish echos. In relatively calm seas, over flat bottom, hull-mounted systems may be satisfactory, and they may also be acceptable in worse weather if running with a following wind or swell. However, a towed body may be needed to get the transducer below the sea surface and clear of such disturbance. These towed bodies containing the transducer can still be towed relatively quickly, at depths of 50–100 m below the surface.

4. EGG PRODUCTION METHODS

4.1 Survey methods

There are two egg production methods which have been used to estimate spawning biomass of orange roughy.

- i. Annual egg production (AEPM) (Saville 1964, Picquelle and Megrey 1993)
This method estimates biomass by dividing the annual egg production in the survey area (which is the sum of daily planktonic egg production estimates made through the spawning season) by the product of the weight-specific annual fecundity of the females and the proportion of females.
- ii. Daily fecundity reduction (DFRM) (Lo *et al.* 1992, Lo *et al.* 1993)
Biomass of spawning females is derived from division of the daily planktonic egg production in the survey area by the weight-specific daily fecundity of females.

4.2 Survey description

Egg production surveys have been carried out on three New Zealand orange roughy spawning grounds: Ritchie Banks (in 1993 and 1995) East Cape (in 1995) and Northwest Chatham Rise (in 1996). In all areas, the DFRM was the main method used. Details of the surveys are given by Zeldis *et al.* (1997) and Francis, Clark and Grimes (1997) and are summarized by Clark (1996a).

Several important problems were identified during New Zealand egg surveys and subsequent analysis of data. Advection of older eggs out of the survey area often limited the range of egg ages able to be included in the analysis. Original survey boundaries were sometimes not large enough. Extensive hydrographic work needs to be carried out before the egg survey to measure current direction and speed, and enable estimates of egg drift to be made, aiding definition of the extent of the survey area and appropriate strata.

On one of the fishing grounds there was possible turnover of fish during the survey, which affects the applicability of the DFRM method. There was evidence that fish were leaving the spawning area before spawning had finished, which meant that spent fish were under-represented in trawl samples by about 40 percent.

A major problem was encountered with analysis of data from East Cape and Northwest Chatham Rise surveys in that the estimate of egg mortality (Z) from several subsurveys completed were negative (i.e. younger eggs were less abundant than older eggs) (Francis, Clark and Grimes 1997). The extremely localized production of eggs

typical of orange roughy spawning grounds is generally of benefit for egg production surveys, but in this case it appears that the release of eggs was from such a small area, that within the central stratum younger eggs were sampled less frequently than the older eggs which had become more dispersed. Temporal patchiness in spawning (i.e. pulses of egg release) also seems to have contributed to the problem. To resolve this frequent and intensive sampling was required in the central stratum.

Egg production techniques have the potential of giving a measure of absolute biomass. However, because the distribution of orange roughy eggs is patchy, results typically have a high variance. In addition, the survey design and data analysis can be complex. The AEPM approach is likely to be more robust than DFRM, in that turnover does not affect results. However, AEPM surveys require sampling to occur over most of the spawning period, which can involve 4–6 weeks of vessel time. Specialized equipment and experienced staff are needed. But, there is a fine balance between the need to sample the core area intensively (to minimize the problem of negative estimates of total mortality Z) yet cover a sufficiently large area to sample older eggs before they are carried by advection beyond survey boundaries. Trawling during the survey, and subsequent examination and analysis of fecundity data, is also relatively time consuming and resource intensive. An additional trawl survey is needed prior to the egg survey to estimate the sex ratio, and proportion of females that are not going to spawn that year and hence not join the spawning aggregations. These factors make the technique relatively expensive.

5. COMMERCIAL CATCH AND EFFORT DATA

5.1 Data and analysis

Catch and effort data are routinely collected from commercial fishing operations in New Zealand. In standardized analysis of orange roughy CPUE, multiple regression techniques are used. Variables such as fishing year, season, area, nationality, vessel size, and vessel power are regressed against the log of CPUE (generally catch per tow or catch per vessel day). The model incorporates all the factors affecting catch rate and the resultant year effect is used as an annual abundance index.

A generalized linear model (GLM) is fitted following Allen and Punsley (1984) as modified by Doonan (1991), Vignaux (1992, 1994), and Francis (2001a). Variables that best predict catch rate are selected by a forward stepwise procedure. At each step, the predictor which produces the maximum decrease in the Akaike Information Criterion (Akaike 1974) is added to the model.

A feature of some orange roughy fisheries is their “hit-or-miss” aimed-trawling nature, and up to 30 percent of targeted tows may record no orange roughy catch. In such cases two separate GLMs can be fitted: a “normal” model for tows with non-zero catches, and a “binomial” model for all tows (estimating the probability of a non-zero catch). These two models are then combined multiplicatively.

The robustness of CPUE analyses is often affected by empty or missing data quota cells. As more variables that could affect catch rate are included, the more incomplete the matrix becomes. Comparability between years can be affected as effort levels decrease with quota reductions, and the fishing effort is more concentrated at certain times of the year. Often, seasonal effects are poorly estimated, and so analyses are carried out on subsets of the data, such as that for winter-only (e.g. Clark and Anderson 2003, O’Driscoll 2003, Anderson 2003).

5.2 Description of results

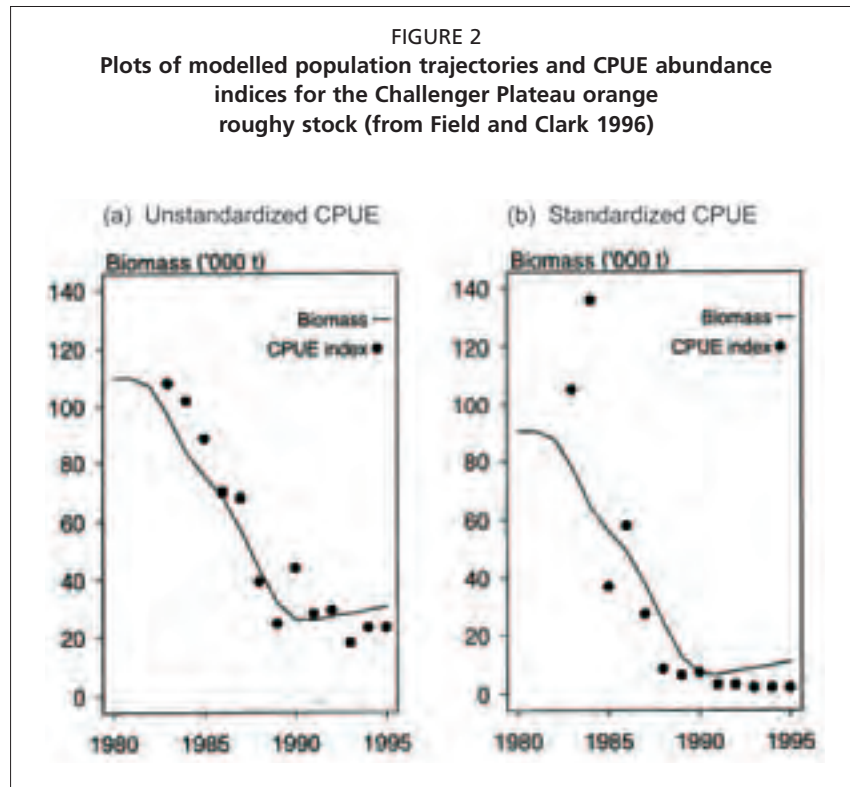
Regression analysis of CPUE data generally explains between 20 and 50 percent of the variance. The variance of the CPUE indices is poorly known, but thought to be relatively high. In New Zealand stock assessments, such data are typically assigned a CV of 30 percent.

Strong trends have been evident in CPUE of most New Zealand orange roughy fisheries. A commonly-observed pattern is that CPUE indices are relatively high in the first few years of a fishery, and then decrease sharply to low levels. Relative to the modelled stock trajectory, indices are above the line early, and below the line in later years. This “hyperdepletion” is demonstrated in Figure 2 for the Challenger Plateau. It is currently being investigated in greater detail through a CPUE meta-analysis (A. Hicks, University of Washington, Seattle, USA, pers. comm.). This is likely to be caused in part by the ability of fishers to target aggregations successfully and maintain high catch rates, especially during spawning in winter, even though stock size is decreasing.

Monitoring of commercial catch and effort data is an important aspect of assessing changes in most orange roughy fisheries. However, it is felt that CPUE may not track abundance accurately, although it does give valuable information on general trends in stock size.

A further important feature of orange roughy distribution relevant to CPUE analysis is that fish in some areas aggregate strongly on small seamount-type features. With increasing coverage and availability of Global Positioning System (GPS) navigation in the late 1980s, the ability of fishers to locate and direct fishing operations on such features increased. Thereby, the efficiency and effective fishing power of vessels increased through technology. Improvements in trawl gear are also a common problem in CPUE analysis and in New Zealand the type of net and ground-gear used has changed between the 1980s and late 1990s.

Changes in vessel composition of the fleet can further complicate the use of CPUE data. Individual vessel factors are an important part of standardized analyses. However, different skippers on the same vessel are widely thought to have a major bearing on fishing success. Skippers move between vessels regularly, and so it is a difficult aspect to incorporate. In recent years, quotas have been reduced, and this has changed the number and type of vessels in the fisheries, as well as their fishing patterns. The mode of fish processing has generally changed in the larger vessels from head-and-gut to fillet production. This affects the “target” catch rate, as the factory operation producing fillets at sea is slower than a head-and-gut operation, and is served by smaller catches. These all add to further confuse direct comparability of CPUE data between years.



6. COMBINED METHODS

There is no single method that stands out as being the magic answer for measuring abundance given the wide range of situations in which orange roughy fisheries occur around New Zealand. All have advantages and disadvantages, depending on the characteristics of the individual fishing grounds and fisheries (Table 1). For example, the aggregation behaviour of roughy is a problem for trawl and CPUE techniques, but facilitates acoustic and egg production surveys. Great depths can make acoustics surveys expensive where deep-towed systems are needed, and also limits tagging as an assessment method. Rough bottom can preclude trawling (both research trawl survey and commercial fishing), steep slopes can be difficult for acoustic methods, and so on. Table 1 does not try to be a comprehensive pros-and-cons summary, but serves to demonstrate that no single method is a complete solution.

TABLE 1

Summary of some of the factors that can affect the suitability or efficiency of various methods to estimate abundance of deepwater species

(+ = positive factor for use of that method, – = negative factor)

Factors	Trawl	Acoustic	Egg	CPUE	Other
Aggregations	–	+	+	–	
Depth		(–)			tagging
Rough bottom	–			–	
Mixed species		–		(–)	
Steep bathymetry	–	–	+	–	
Longevity					cohort analyses
Spawning dynamics			–		
Commercial vessel use	+	?	–		
Large area to survey	–	(+)	–	+	

Where resources and data permit, improved (or at least more confident) estimates of biomass can be obtained by combining results of several techniques, and most New Zealand stocks have several data sources (Table 2). The indices from these different methods are treated as separate inputs, and are not combined into any single multiple-source index, because we have no understanding of how the various measures can reasonably and appropriately be combined.

TABLE 2

Data sources used in combination for stock assessment of New Zealand orange roughy

	Trawl	Acoustics	Egg	CPUE
Chatham Rise (NE)	Yes	Yes		Yes
Chatham Rise (NW)		Yes	Yes	Yes
Puysegur Bank	Yes			Yes
Mid-East coast	Yes	Yes	Yes	Yes
East Cape			Yes	Yes
Mercury-Colville	Yes			Yes

The stock assessment for the Northeast Chatham Rise fishery (Francis 2001b) used abundance indices from CPUE, trawl surveys, and acoustics estimates (Figure 3). The indices are in broad agreement and removing one estimate makes little difference to the estimated status of the stock. Concerns raised about individual methods were reduced by the consistency

of the multiple data sources. However, in contrast, a recent stock assessment of the Mid-East Coast fishery (Anderson, Francis and Hicks 2002) included CPUE, egg survey, acoustic survey, and trawl survey indices. Estimates of biomass were relatively similar

for a number of model runs where one data source was excluded, but there was an appreciable difference between results that excluded the acoustic estimate (low biomass) or excluded the CPUE (higher biomass) factor (Table 3). This raised the issue of the relative weightings given to a long relative time series (CPUE) versus a single absolute estimate (acoustics-based). No consensus has been reached on this, although a conservative management approach has been taken until further survey work has been done.

7. INDIRECT METHODS

Where there is no information on stock size, from either research survey or commercial catch-effort data, then experience from other fisheries may be useful. A "Seamounts Meta-analysis" has been carried out in New Zealand (Clark, Bull and Tracy 2001) where physical attributes and catch data of deepwater fisheries were compiled for 77 seamounts

in the New Zealand region. Characteristics of location, depth, size, elevation above the seafloor, age, continental association, geological origin, distance offshore and from surrounding seamounts, and degree of spawning were defined. These were then analysed as independent variables against the minimum orange roughy population size estimated from the historical level of catch taken from seamounts to investigate whether they could be useful predictors of likely safe catch from newly found seamounts. Seamount location (latitude), geological association (whether continental or oceanic), depth of peak and slope were all useful explanatory variables in predicting likely orange roughy biomass. However, a secondary result of the study was that the biomass of orange roughy associated with any single seamount feature was low, between zero and 15 000 t, with most less than 3 000 t. This means that the long-term sustainable yield from such features is of the order of 300 t, or less, a year.

8. DISCUSSION

Measurement of fish biomass is a difficult task. Deepwater species provide additional challenges to the normal techniques used in measuring abundance, due to their depth distribution and aspects such as aggregating behaviour and distribution in areas of steep bathymetry.

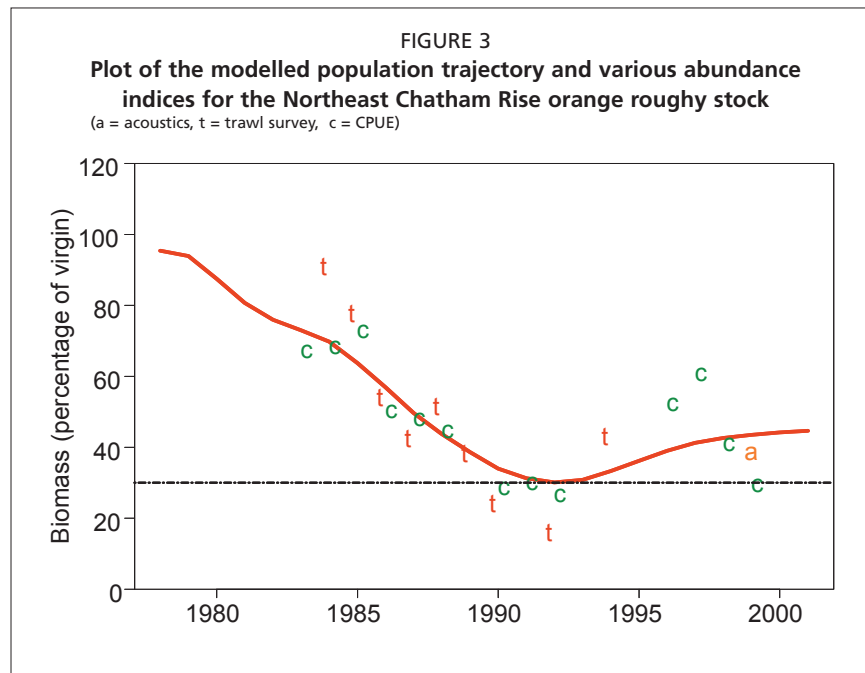


TABLE 3
Percentage change in abundance estimates of orange roughy with changes in assumed values of target strength of orange roughy and bycatch species (from Table 11 of Doonan *et al.* 2003)

Target strength change	Abundance change (%)
Orange roughy	
Lower intercept by 3 dB	+23
Increase intercept by 3 dB	-20
Other species	
Lower intercept by 3 dB	+59
Increase intercept by 3 dB	-38

Four major methods of measuring biomass have been used in New Zealand orange roughy fisheries. Others have been tried (e.g. stereo camera techniques for calculating fish density) but have been unsuccessful. Each of the methods described in this paper has advantages and disadvantages, depending on the characteristics of the particular fish stock under study and the resources available to carry out research.

Trawl survey and CPUE methods have been applied to produce relative estimates and time series of data have been used in stock reduction analyses to estimate true biomass. Egg production and acoustic techniques have given absolute estimates. Attempts to convert trawl area-swept catch rates into absolute abundance have been unsuccessful in New Zealand (e.g. Clark 1995, Francis and Clark 2004) and Namibia (Branch 2001), and absolute estimates from acoustics are also uncertain (e.g. Boyer and Hampton 2001, Boyer *et al.* 2001, Bull *et al.* 2000, Kloser, Williams and Koslow 1997).

In general, it appears abundance is best measured by time series, which will generate relative abundance indices. This, however, assumes the gear used performs in the same way each year, which may not always be true. Characteristics of distribution and abundance of orange roughy can change over time. A technique might track abundance well for several years, but become limited if aggregation patterns change. This appears to have occurred on the Chatham Rise. We have little understanding of outside influences (e.g. environmental fluctuations, recruitment levels or variability) that could cause availability or catchability to vary between years, and this can affect our interpretation of changes in biomass indices between years. However, use of data in a relative sense is probably at this stage of our knowledge more justifiable than the large uncertainties that would exist from assuming we know how to correct our trawl performance or acoustic or egg survey measurements into true biomass. Wherever possible, a combination of methods is desirable.

With new and developing orange roughy fisheries, careful examination of all available information on habitat type, fish distribution patterns and characteristics is needed to ensure an appropriate technique is applied to estimate abundance. Ideally, an absolute measure would be available at the start of a fishery, so that catch levels in the fishing-down phase, and the longer-term target catch, can be planned. However, with deepwater species, it is particularly difficult to measure biomass from a single survey, and a method using fishery-independent relative indices might be required. The high vulnerability of species like orange roughy to overfishing, and their subsequent slow recovery, mean that development of new fisheries should be carefully controlled and surveys to measure abundance should be undertaken as early as possible. Typically, orange roughy stocks have proven smaller than originally hoped-for, or believed, and the rate of development of, and capital investment in, the fisheries has often been too high. Early management must be conservative and precautionary.

9. ACKNOWLEDGEMENTS

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Modelling the distribution of two fish species on seamounts of the Azores

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1. INTRODUCTION

Seamounts are biologically distinctive habitats of the open ocean exhibiting a number of unique features (see Rogers 1994 for a review). They are characterized by the presence of substantial aggregations of deep-bodied fishes in the water column (Boehlert and Sasaki 1988, Koslow 1996, 1997, Koslow *et al.* 2000). These aggregations are supported in the otherwise food-poor deep sea by the enhanced flux of prey organisms past the seamounts and the interception and trapping of vertical migrators by the uplifted topography (Tseytlin 1985, Genin, Haury and Greenblatt 1988, Koslow 1997). The discovery of these fish aggregations coincided with declines in shallow-water traditionally exploited stocks (Watson and Pauly 2001) and led to seamounts being increasingly targeted by trawlers throughout the world's oceans (e.g. the massive, but short-lived, fishery for pelagic armourhead (*Pseudopentaceros wheeleri*) in the North Pacific; the development of orange roughy and oreosomatid fisheries in the waters around New Zealand and southeastern Australia and subsequently in the North Atlantic (Rogers 1994, Clark 1999, Koslow *et al.* 2000) and elsewhere. Deep-sea seamount fish communities are highly susceptible to overfishing because they are long-lived, slow growing species with late maturity and low recruitment rates (Koslow 1997, Rico *et al.* 2001). Thus, when managing such fisheries, caution is required to reduce the risks of overexploitation (Clark 2001, Morato 2003).

2. THE AZOREAN FISHERY

The Azores (located in the region of 36–40 °N, 24–32 °W) are the most isolated Archipelago of the North Atlantic (Santos *et al.* 1995) with nine islands spread along a tectonic zone running WNW-ESE (Figure 1). Fishing activity started with the colonization of these islands during the 15th century and fish constituted one of the main human subsistence resources (Menezes 1996). In the last two decades the situation has changed with artisanal exploitation having been successively replaced with commercial fishing (Santos *et al.* 1995). As a consequence, the abundance of several species, and thus the catch rates of the commercial fleet, have started declining over the last few years, while fish stocks have already displayed sign of intensive exploitation (Menezes 2003).

Since no trawl fishery operates around seamounts in the Azores, bottom longlining that targets demersal and deepwater species comprises the most important fishery for the local economy. In fact, even though this fishery does not exceed 5 000 tonnes a year,

they still represent a considerable value (Silva and Krug 1994, Silva, Krug and Menezes 1994, Krug 1995, Menezes 1996). The blackspot seabream (*Pagellus bogaraveo*) has traditionally been the main target species of this fishery, but in recent years several other species, such as the alfonsino (*Beryx splendens*), have also become important.

Most of these species are

confined to seamounts, offshore banks and upper-slopes of the islands where bottom longlining occurs down to 1 000 m depth. Despite the large area (1 million km²) of the Azorean Exclusive Economic Zone (EEZ), the potential area for commercial bottom longlining occupies only approximately 3 percent of the zone.

Little is known about the number of seamounts, their characteristics or their associated fish populations despite the importance of seamounts for local fishing activities. The purpose of this paper is to (a) identify seamounts in the Azorean EEZ, (b) compile information about seamounts' characteristics, i.e. location, minimum and maximum depth, area of the summit and the seamount, elevation above the seafloor and distance to the nearest seamounts, etc. and (c), estimate some indices of relative abundance using the CPUE of two fish species (alfonsino and blackspot seabream) at several seamounts. Because the size, degree of isolation (Menezes 2003) and slope (Clark, Bull and Tracey 2001) of the seamounts are, among other physical features, important ecological determinants of the abundance of exploited seamount fish populations, this work will include (d), a preliminary attempt of modelling alfonsino and blackspot seabream abundances in seamounts using the above-mentioned physical characteristics as predictors variables. These models can be shown to be useful for predicting the abundance of seamount-inhabiting fish species, especially in data-deficient situations.

3. METHODS

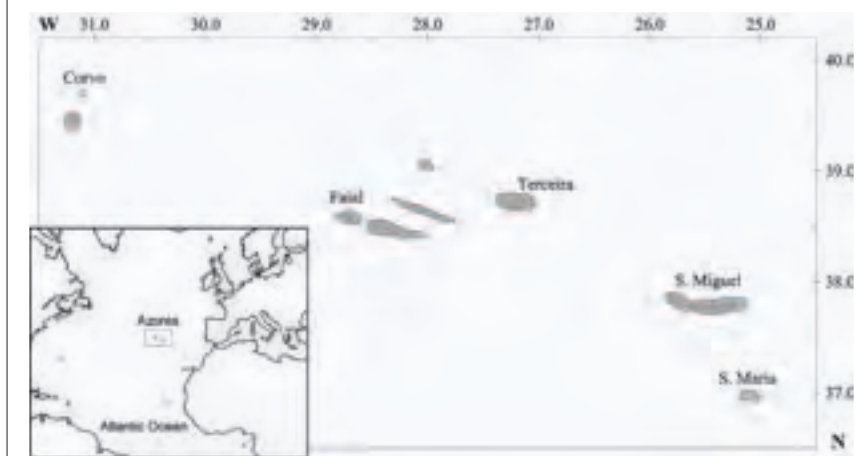
3.1 Seamounts' physical characteristics

The seamounts around the Azores considered by this study were identified using bathymetric contour maps. Only those that satisfied the following criteria were considered:

- i. having the peak shallower than 1 200 m depth, the limit above which most commercially important fish communities inhabit (Menezes 2003)
- ii. having an elevation above the seafloor greater than 100 m (as described by Clark *et al.* 2001) and
- iii. having a distance from adjacent seamounts greater than 2 nautical miles (nm) and ability to determine that the catch is from single seamount (Clark *et al.* 2001).

Bathymetric data used to estimate depth contour maps were taken from the "Global seafloor topography from satellite altimetry and ship depth soundings" database (Smith and Sandwell 1997, <<http://topex.ucsd.edu/sandwell/sandwell.html>>).

FIGURE 1
Map of the Azores in the North Atlantic context



A Kriging method was used to interpolate data and build bathymetric contour maps using Surfer 7.05 (Surface Mapping System Golden Software Inc.). Areas and distances were estimated using MapViewer 4.00 (Thematic Mapping System, Golden Software Inc.).

The characteristics chosen to describe seamounts were: (a) latitude and longitude of the centroid of the seamount, (b) minimum depth, (c) elevation (i.e. depth range between the peak and base of the seamount), (d) base area, ($Area_{base}$: for seamounts with a base deeper than 2000 m, the area of base was taken as the area of the 2000 m contour), (e) a slope index (see below) that represents the average steepness of the flanks of the seamount, and (f), distance to nearest seamount (nm).

3.2 Relative abundance indices

Relative abundance indices (using catch per unit effort) were estimated for alfonsino and blackspot seabream from data collected in 2002 by observers on board two 27 m commercial bottom longline vessels, the *Cidade Celestial* and *Íris do Mar*, from 34 fishing events on eight seamounts in the Azorean EEZ. CPUEs were estimated as the number of fish ($CPUE_n$) and catch weight (in kg; $CPUE_w$) of fish per 1 000 hooks.

3.3 Multiple regression models

Multiple linear-regression models were used to estimate abundance indices for alfonsino and blackspot seabream based on the following assumptions: (a) exploration rates are similar on all seamounts, (b) all longline fishing sets target both species on all seamounts sampled and (c), longline catch rates (CPUE) are an indication of relative abundance of each species on each seamount.

Multiple regression models were computed having the indices of fish abundance ($CPUE_n$ and $CPUE_w$) as dependent variables and the physical seamounts characteristics as independent variables. The resulting equations that had better fits were used to predict the index of abundance for the two fish species on the seamounts for which there were no data.

At this stage, only three physical characteristics of seamounts (predictors) were taken into account for multiple regression models:

i. *Area of the seamount shallower than 850m ($Area_{<850}$)*

The area of the seamounts is known to limit the abundance of alfonsino (Vinnichenko 1997). Since blackspot seabream is highly dependent on benthic habitats (Morato *et al.* 2001), seamount area might also affect their abundance. Thus, it is expected that the larger the area of the seamount, the higher the values that the abundance index might display. Since these two fish species are known to occur within the top 850 m of the water column (Menezes 2003), for the purpose of this study the area of the seamount shallower than 850 m was considered.

ii. *The slope of the seamount (Slope)*

Slopes of seamounts are positively correlated with the biomass of some seamount aggregating fish (Clark *et al.* 2001). Thus, the abundance index of alfonsino is expected to increase with a corresponding increase in slope of the seamount. In the case of seabream, such relationship may not hold true. The average slope of the flanks of the seamounts were estimated as $\text{Arctangent}[\text{elevation}/\sqrt{(\text{Area}_{base}/\pi)}]$ expressed in degrees.

iii. *Distance to the nearest seamount (Dist.)*

The degree of isolation of a seamount may affect fish abundance (Menezes 2003) and thus, the distance (nm) to the nearest seamount was estimated from bathymetric contour maps. The majority of seamount fishes form local populations (Vinnichenko 1998), that, in general, remain throughout their life cycle in the vicinity of the seamount (Clark *et al.* 2001, Vinnichenko 1998). Exchange of genetic material among populations probably occurs only during the

early life-history stages through passive dispersion of eggs and larvae by currents. However, blackspot seabream display ontogenetic changes in habitat preference with juveniles inhabiting the waters of island shelf, whereas adults move to deeper waters and to offshore seamounts (Menezes 2003, Morato *et al.* 2001). In general, the abundance index is expected to increase with a corresponding decrease in distance from neighbouring seamounts.

4. RESULTS

4.1 Seamounts physical characteristics

Overall, 136 seamounts were identified from the bathymetric contour maps. The depths of their peaks ranged from close to the surface to approximately 1 200 m, while their base depths ranged from 550 to 2 000 m (Figure 2). Seamount mapping revealed a mean elevation of 460 m (SD = 351m), with mean peak of 813 m (SD = 298m) and mean depth at base of 1 273 m (SD = 309 m). Most of the mapped seamounts had an elevation between 100 and 300 m (Figure 3). Thus, our study included 17 underwater mountains with heights above 1 000 m referred to as seamounts, 37 between 500 – 1 000 m referred to as knolls and 85 with elevations lower than 500 m referred to as hills. This classification is based on the US Board of Geographic Names (1981) in Rogers (1994).

The base area of Azorean seamounts ranged from 1.39 to 6 000 km² (mean = 337 m², SD = 720 km²). However, seamounts with a base area smaller than 200 km² were more numerous (Figure 4). The slope index of the seamounts ranged from 0.85 ° to 9.82 ° (mean = 3.68 °, SD = 1.94 °). Slopes ranging from 2 ° to 5 ° were more common (Figure 5).

With the exception of four isolated seamounts (Dist. = 35, 43, 58 and 61 nm) all 132 other seamounts have at least one seamount within 15 nm. The distance between seamounts ranged from 2 nm (predefined) to 61 nm (mean = 5.75 nm, SD = 7.33 nm), with most values occurring within 2 and 5 nm (Figure 6).

CPUE_n and CPUE_w for alfoncino ranged from 0.08 to 11.19 fish per 1 000 hooks and from 0.23 to 9.65 kg per 1 000 hooks respectively (Table 1). For blackspot seabream, CPUE ranged from 0.0 to 20.14 fish per 1 000 hooks and from 0.0 to 16.18 kg per 1 000 hooks respectively (Table 1). Seamounts with higher CPUEs were Cruiser and A3 for alfoncino, and Cavala and A3 for blackspot seabream.

4.2 Multiple regression models

The preliminary multiple regression models developed using the variables of slope, Area_{<850} and Dist. are summarized in Table 2. The large standard errors associated with the estimated parameters denote weak relationships with the abundance indices; thus caution should be applied when interpreting the results:

- i. $\text{Ln}(\text{CPUE}_n)_{\text{alfonsino}} = -5.947 + 0.00019 \cdot \text{Area}_{<850} + 1.106 \cdot \text{Slope} + 0.490 \cdot \text{Dist}$
- ii. $\text{Ln}(\text{CPUE}_w)_{\text{alfonsino}} = -4.909 + 0.00027 \cdot \text{Area}_{<850} + 0.966 \cdot \text{Slope} + 0.404 \cdot \text{Dist}$
- iii. $\text{Ln}(\text{CPUE}_n)_{\text{seabream}} = -1.827 + 0.00018 \cdot \text{Area}_{<850} + 1.207 \cdot \text{Slope} - 0.142 \cdot \text{Dist}$
- iv. $\text{Ln}(\text{CPUE}_w)_{\text{seabream}} = -2.620 + 0.00047 \cdot \text{Area}_{<850} + 1.134 \cdot \text{Slope} + 0.076 \cdot \text{Dist}$

The regression analyses explained a high degree of the variability in the data ($R^2 > 0.75$) with the exception of the $\text{Ln}(\text{CPUE}_w)$ for seabream ($R^2 = 0.46$) (Figure 7). The equations with better fits were for alfoncino [$\text{Ln}(\text{CPUE}_w)$] and for blackspot seabream [$\text{Ln}(\text{CPUE}_n)$]. These were used to predict the indices of abundance on the seamounts (Figures 8 and 9) for which we had no data.

5. DISCUSSION

This work was the first attempt to identify the seamounts in the Azorean EEZ and thus confidence in the results is still weak owing to the data deficient situations. The

FIGURE 2

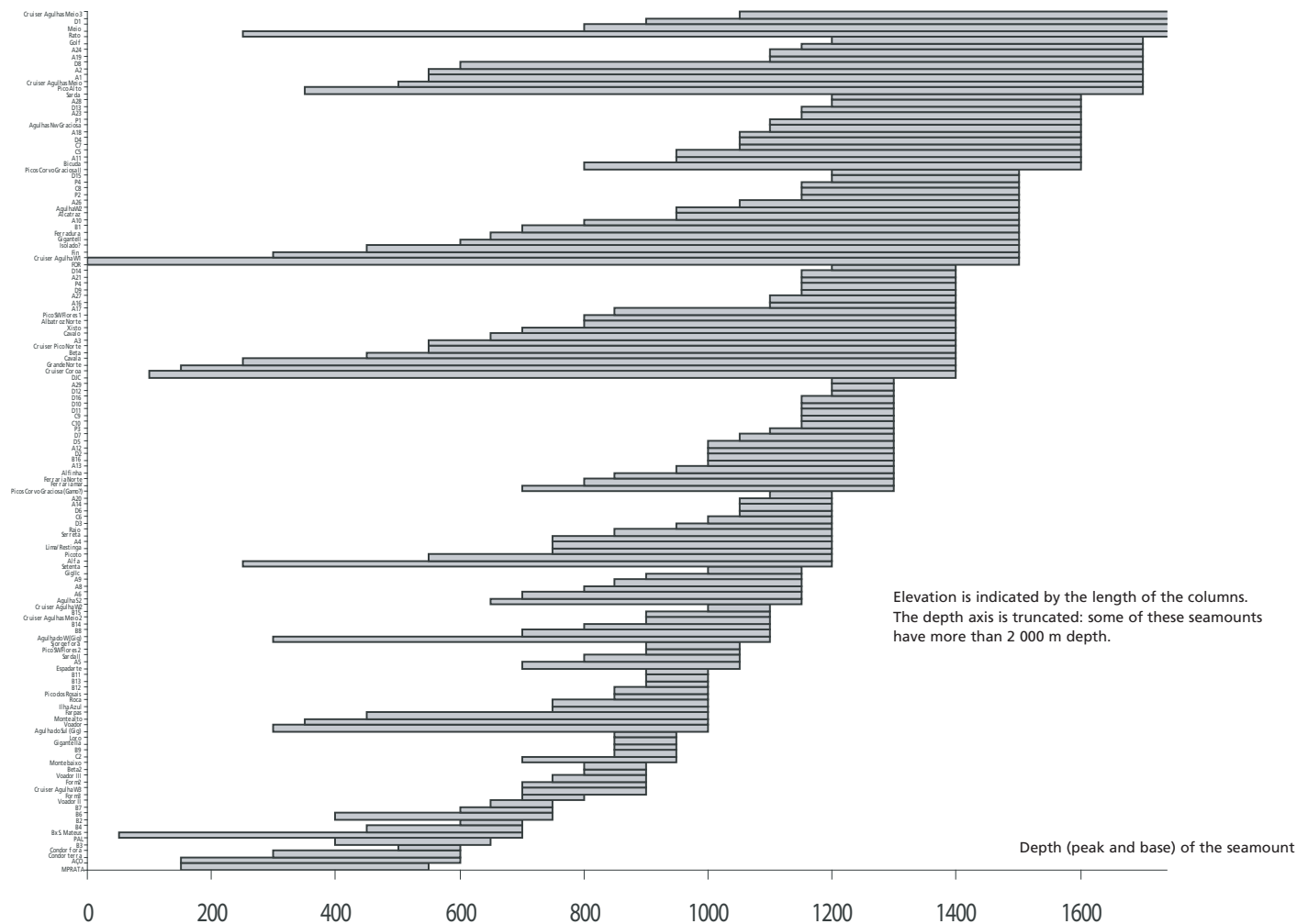


FIGURE 3
Frequency of seamounts elevations

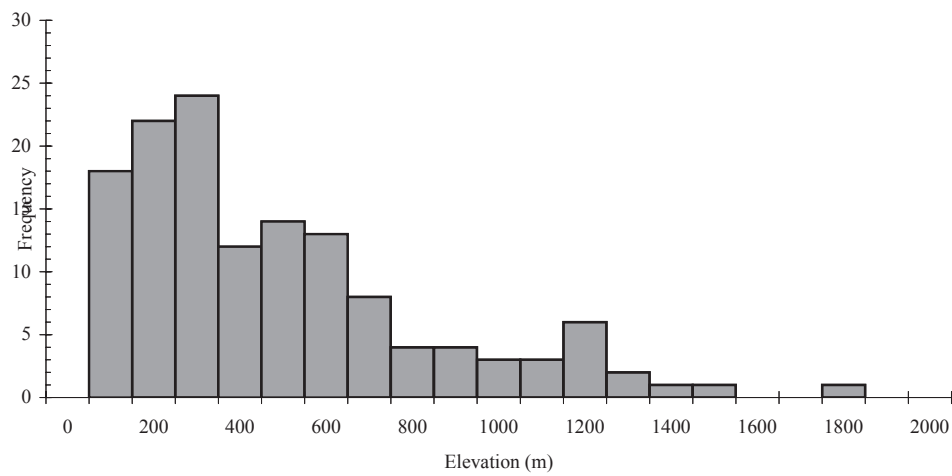


FIGURE 4
Frequency of area of the seamounts' base

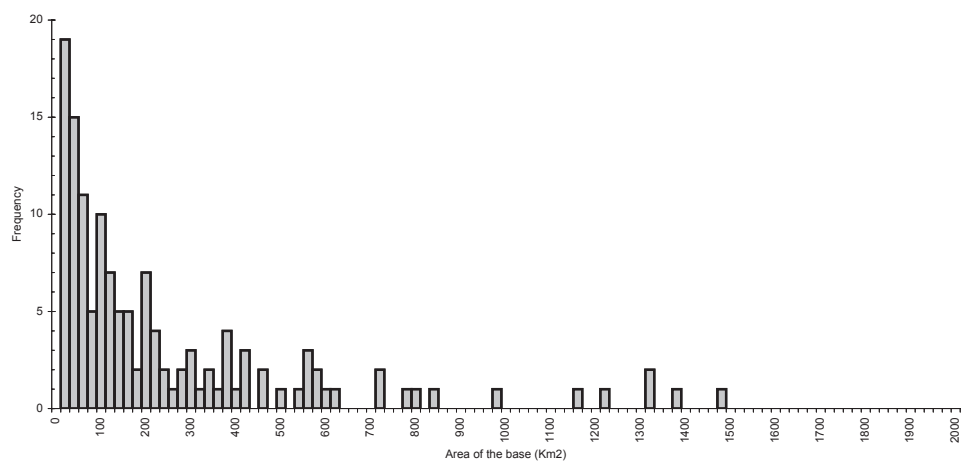
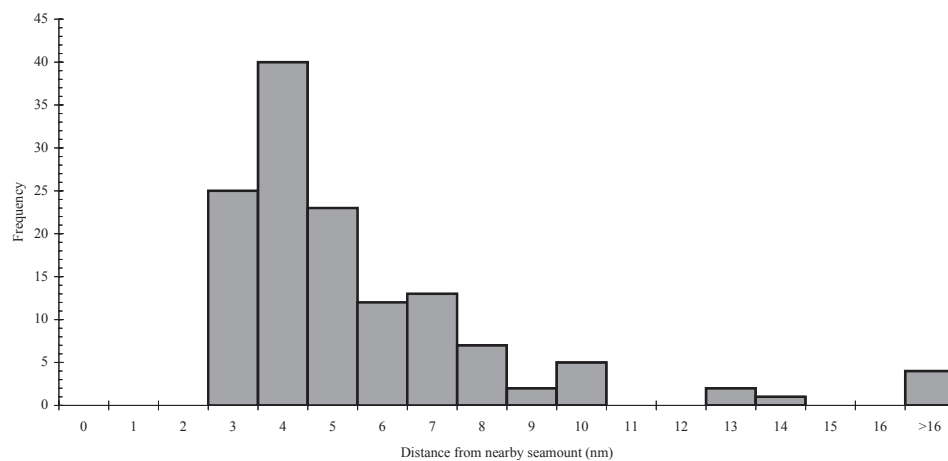


FIGURE 5
Frequency of the seamounts' slopes



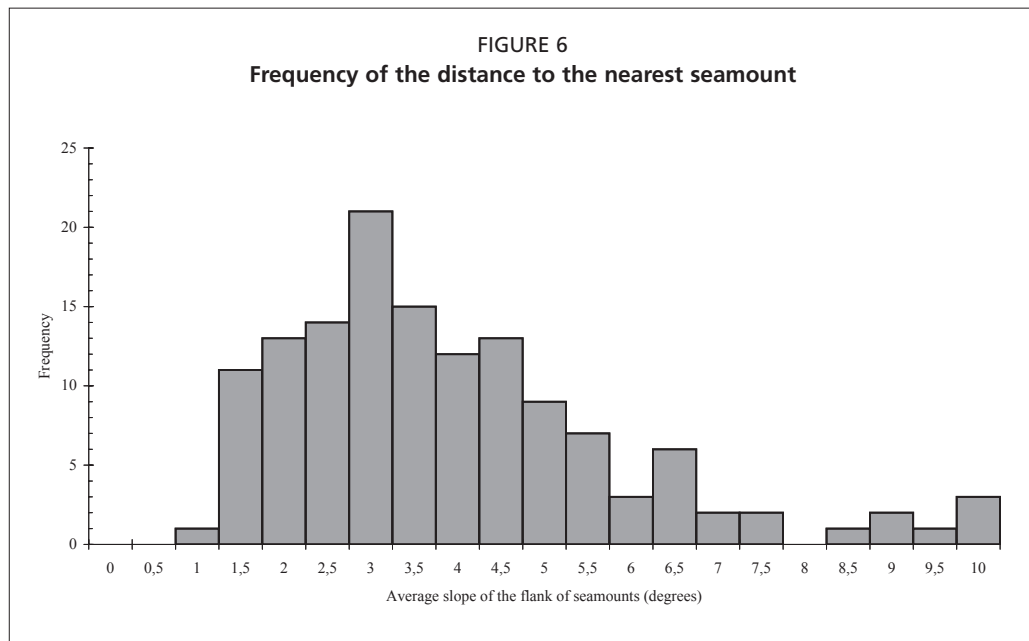


FIGURE 7
Plot of Ln (predicted vs Ln observed values)

(a) $\text{Ln}(\text{CPUE}_{\text{se}})$ for alfonsino ($R^2=0.770$) (b) $\text{Ln}(\text{CPUE}_{\text{se}})$ for alfonsino ($R^2=0.850$)
(c) $\text{Ln}(\text{CPUE}_{\text{se}})$ for seabream ($R^2=0.752$) (d) $\text{Ln}(\text{CPUE}_{\text{se}})$ seabream ($R^2=0.461$)

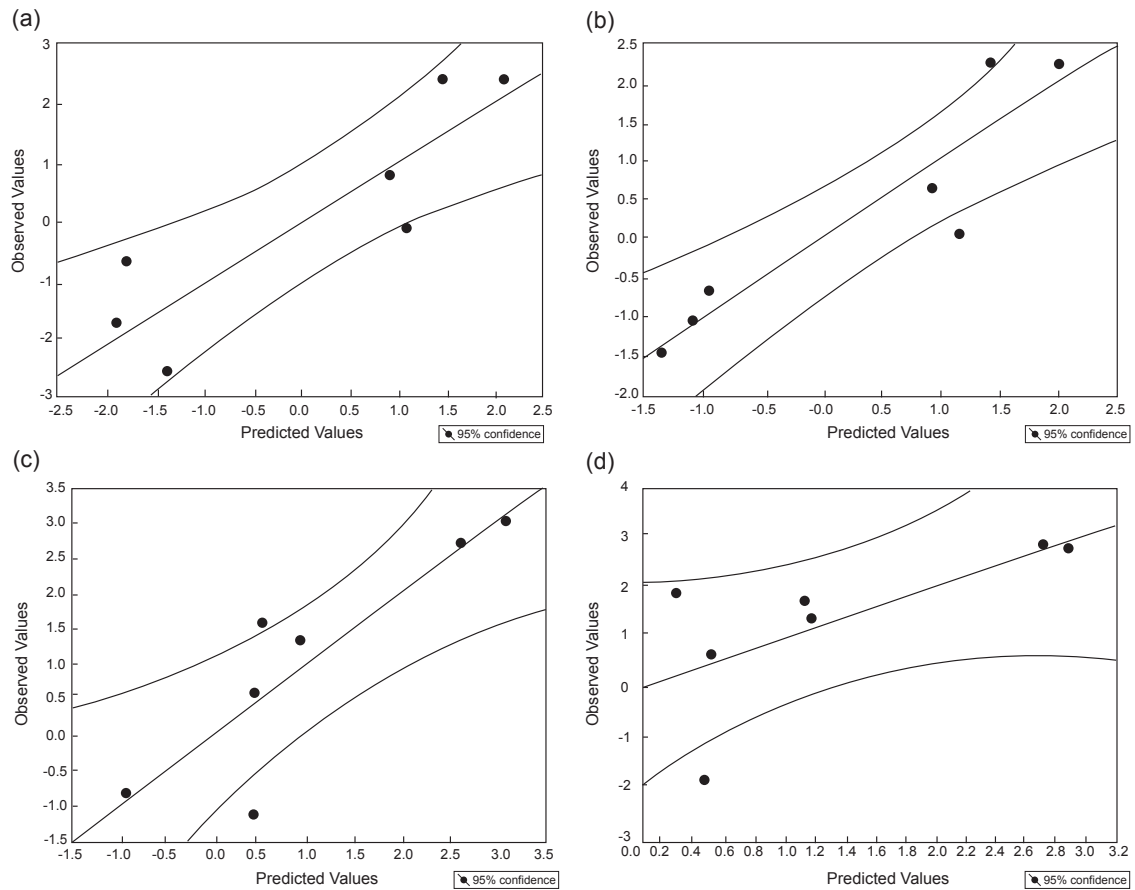


TABLE 1

Data used for deriving multiple regression models to predict abundance indices of two fish species for seamounts lacking CPUE data

Seamount names are: (a) Princess Alice, (b) Sarda, (c) Cavala, (d) Cruiser Coroa, (e) A3, (f) Monte alto, (g) Monte baixo and (h), Voador. The $CPUE_n$ is in number of fish per 1 000 hooks and $CPUE_w$ in kg of fish per 1 000 hooks. **Depth₀** and **depth_b** are depths of the peak and the base respectively. **Elev.** is the elevation of the seamount from the base to the peak. **Slope** is the average slope of the flanks of the seamounts. **Dist.** is the distance to nearby seamount.

Name	Lat.	Long.	Depth ₀	Depth _b	Elev.	Base area	Area _{<850 m}	Slope	Dist.	Alfonsino		Blackspot seabream	
			(m)	(m)	(m)	(m ²)	(km ²)	(°)		CPUE _n	CPUE _w	CPUE _n	CPUE _w
a	37.89	29.28	50	700	650	1471.0	3461.0	1.72	3.03	0.17	0.35	1.80	3.93
b	37.44	33.23	350	1 700	1350	5999.7	838.0	1.77	9.68	2.18	1.95	0.42	1.84
c	38.35	30.7	450	1 400	950	447.9	110.3	4.55	4.07	0.90	1.11	20.14	15.68
d	34.16	30.29	150	1 400	1 250	765.1	433.6	4.58	5.87	11.17	9.60	0.00	0.00
e	37.4	32.11	650	1 400	750	306.8	18.7	4.34	5.32	11.19	9.52	14.66	16.18
f	37.25	31.48	450	1 000	550	590.7	392.7	2.30	4	0.08	0.53	0.32	0.16
g	37.45	31.19	700	950	250	119.4	60.2	2.32	3.2	0.50	0.23	4.83	6.33
h	37.56	30.75	350	1 000	650	521.3	148.0	2.89	5.5			3.86	5.32

TABLE 2
Statistics of the preliminary multiple linear regression

	Alfonsino		Blackspot seabream	
	$CPUE_n$	$CPUE_w$	$CPUE_n$	$CPUE_w$
Intercept	– 5.947 (2.394)	– 4.909 (1.510)	– 1.827 (2.300)	– 2.620 (3.341)
Slope				
Area _{<850}	0.19E ⁻³ (0.54E ⁻³)	0.27E ⁻³ (0.34E ⁻³)	0.18E ⁻³ (0.47E ⁻³)	0.47E ⁻³ (0.69E ⁻³)
Slope	1.106 (0.484)	0.966 (0.305)	1.207 (0.501)	1.134 (0.728)
Index Dist.	0.490 (0.241)	0.404 (0.152)	– 0.142 (0.217)	0.076 (0.315)

S.E. in parenthesis.

method used to identify seamounts, seafloor topography from satellite altimetry and ship depth soundings, lacked resolution and thus, prevented the identification of some seamount peaks or even the whole seamount. A better, but costly, solution would be to perform extensive *in situ* depth soundings that would provide good bathymetric data for the estimation of seamounts depths (peak and base), areas and slopes. In addition, because the estimates of catch-per-unit effort were based on data for only 34 fishing events and eight seamounts and were gathered by commercial fishing boats, they lack robustness and encompass a high degree of uncertainty. To surpass these limitations, it would be desirable to expand the ongoing research fishing cruises to a larger number of seamounts in the Azores. Another weakness of this work is that some assumptions may not hold true. This is mainly the assumption that the exploration rates are similar for all seamounts. Thus, it would be desirable to include an extra parameter in the multiple regression models (e.g. a dummy variable) to express the degree of exploitation of the seamount. Moreover, the variability in fish abundances could be attributed to more physical parameters, apart from those included in this study. When taking these concerns into account, the multiple regression models presented here should be treated with caution.

The sea-bottom topography of the Azores region is complex mainly because of them increased tectonic and volcanic activities. This study showed that the Azores region is apparently dominated by ‘hills’. However, it is necessary to point out that our study did not consider all underwater features (e.g. base depths < 2 000 m, peaks < 1 200 m) and that some of the criteria used to identify seamounts established *a priori* may have biased the analysis.

Since the main topographic feature of the Azores are ‘hills’, and not ‘seamounts’ or ‘knolls’, it is likely that the study area may support a less conspicuous population of seamount aggregating fishes compared to that known for areas with similar topography in the world’s oceans (Vinnichenko 1999). Moreover, the mean peak depth (estimated at 813 m) was deeper than the maximum depth where the greatest abundance of the fish species studied is known to occur. This implies limited habitat availability for the two fish species in the region and, as a result, limitations in the area where the traditional bottom longline fleet could operate, as has been advocated by several authors, e.g. Menezes (2003). This is particularly the case for the Azorean fishing fleet, which, with the exception of few developing deepwater fisheries for *Aphonopus carbo* and *Chaceon affinis*, fishes to a maximum depth of 600 m. These fishing grounds represent less than one percent of the entire Azorean EEZ (Menezes 2003).

In the study area, most seamounts displayed gentle slopes ranging from 2° to 5°, which implies the existence of habitat favourable to benthic-dwelling fish species. Indeed, the blackspot seabream tends to inhabit gentler sloping areas and exhibits

FIGURE 8
Plot of the estimated index of abundance (kilos of fish per 1 000 hooks) for Alfonsino in the seamounts in the Azores.
Area of the circles proportional to the natural logarithm of the $CPUE_w$

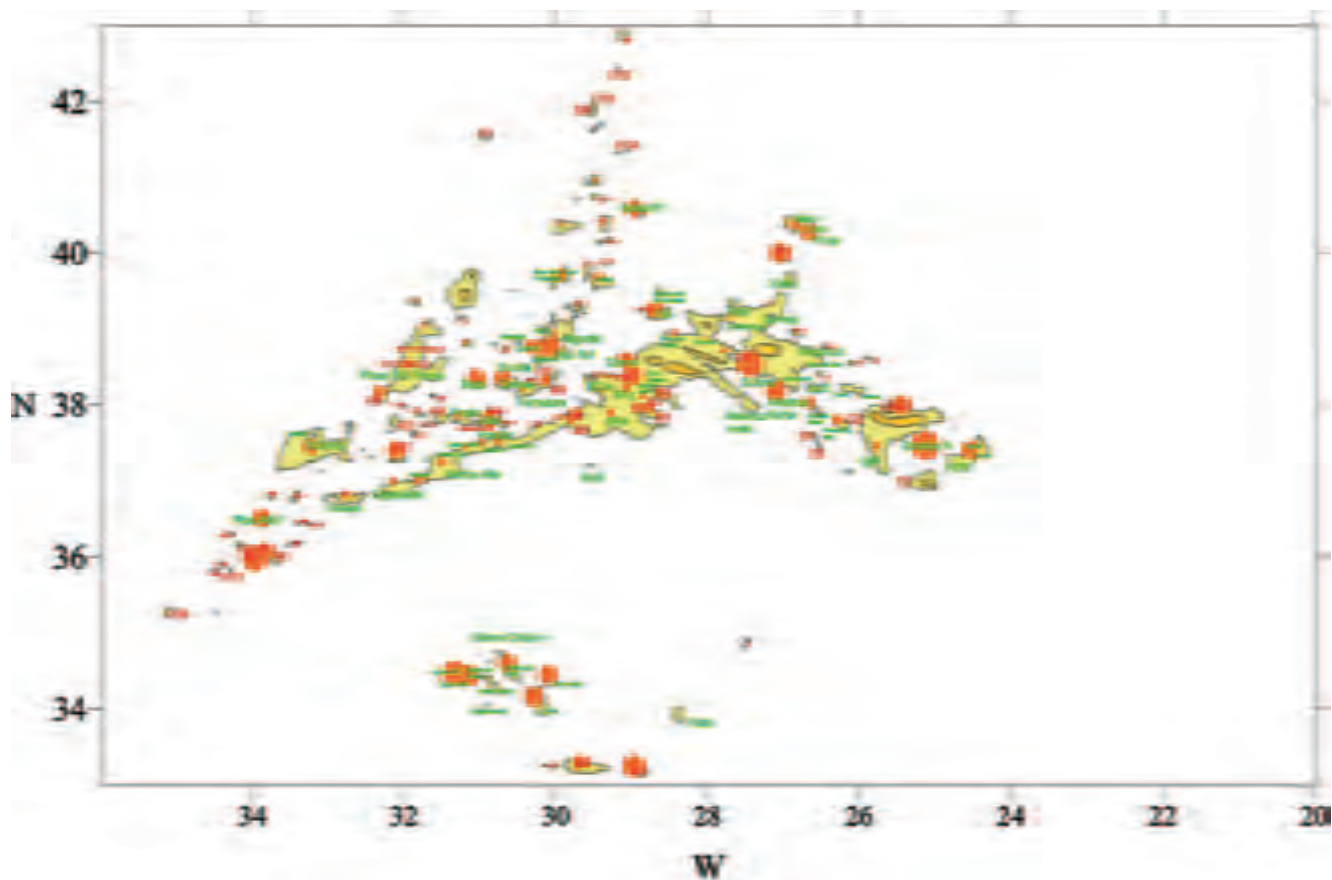
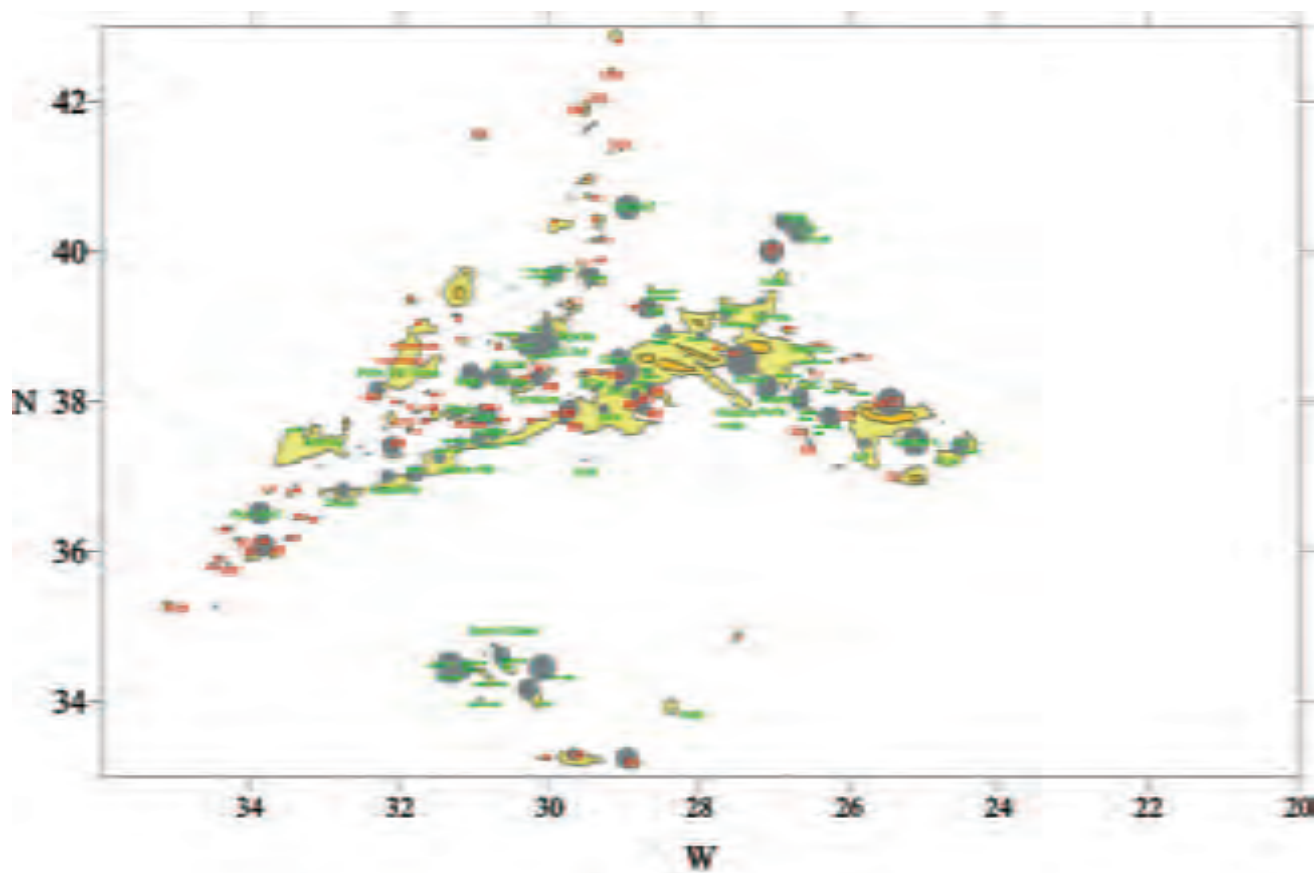


FIGURE 9
Plot of the estimated index of abundance (number of fish per 1 000 hooks) for Blackspot seabream in the seamounts in the Azores. Area of the circles proportional to the natural logarithm of the CPUE_n



a higher association with the benthic habitat, where it feeds on fish and benthic invertebrate such as ophiurids (Morato *et al.* 2001). In contrast, gentle slopes may not provide favourable conditions for alfonsino, since it tends to aggregate along intermediate slopes of seamounts and feeds in the water column on the flux of prey organisms that pass the seamounts (Morato-Gomes *et al.* 1998) in a similar way to orange roughy (Clark *et al.* 2001).

Most of the mapped seamounts in the Azores can hardly be considered isolated since the distance among them ranged from 3 to 5 nm. For those fish populations that tend to migrate among seamounts, it is probable that the study area may provide favourable conditions for their dispersal. This may be particularly true for some demersal fish species, such as the blackspot seabream, which migrate from coastal waters surrounding islands to offshore seamounts during different stages of their life cycle (Menezes 2003, Morato *et al.* 2001). On the other hand, the lack of isolated seamounts may not provide favourable conditions for alfonsinos. This may be particularly true because isolated seamounts are likely to have a greater enhancement of primary production caused by the particular local hydrographic conditions (Genin and Boehlert 1985, Dower, Freeland and Juniper 1992, Odate and Furuya 1998, Mouriño *et al.* 2001), which results in increased prey densities (Boehlert and Genin 1987). Such food resources attract fishes, such as the alfonsino (Morato-Gomes *et al.* 1998), that prey on macroplankton and nekton. Therefore, the degree of isolation should play an important role in the formation of different habitat types, which attract fish species possessing different attributes and life strategies. For instance, overexploitation of isolated fish communities that lack the ability to migrate among seamounts could result to local extirpation of fish stocks (Menezes 2003). Thus, the degree of isolation should be seriously considered when developing management plans for seamount fisheries. The lack of isolated seamounts along with the gentle slopes of Azorean seamounts and other factors may explain the low abundance of fish aggregation species found by Vinnichenko (1999) on these seabed features.

6. CONCLUSIONS

Deepwater fisheries in general, and seamount fisheries in particular, are usually characterized by a boom and bust sequence (Koslow *et al.* 2000) with the targeted fish stocks showing signs of overexploitation within approximately ten years of the beginning of the fishery. This was the case for the orange roughy fishery off New Zealand, Australia, and the North Atlantic (Branch 2001), the pelagic armourhead fishery over seamounts in international waters off Hawaii (Sasaki 1986), and the blue ling (*Molva dipterygia*) fishery in the North Atlantic (Bergstad, Gordon and Large (s.d.)). Since fish stocks that aggregate around seamounts can be rapidly depleted, maintenance of seamount fisheries has depended on the discovery of unexploited seamounts.

There is a rising concern about threats to seamount ecosystems in the EEZ of coastal states and the high seas; and several countries, such as Canada, Australia and New Zealand, have begun to take action to protect such 'fragile' communities. In the Atlantic however, no action has been taken so far; yet, the 'Oslo and Paris' (OSPAR) Commission has listed seamounts as threatened habitats that require urgent conservation action. The developing 'OSPAR Marine Protected Areas' programme could provide some insight towards such an objective. In addition, seamounts dominated by hard substrata present in the EEZs of European Community country-members (e.g. Portugal) may also qualify as protection sites under the European Habitats Directive (1992, Natura 2000 code 1170 "reefs" in the Interpretation Manual of European Union Habitats EUR 15/2). Further action could include changes in fishing practices, such as switching from trawling (where this method of fishing is undertaken) to longlining, in order to minimize destruction of seabed habitats and associated fauna.

7. ACKNOWLEDGMENTS

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A life history approach to the assessment of deepwater fisheries in the Northeast Atlantic

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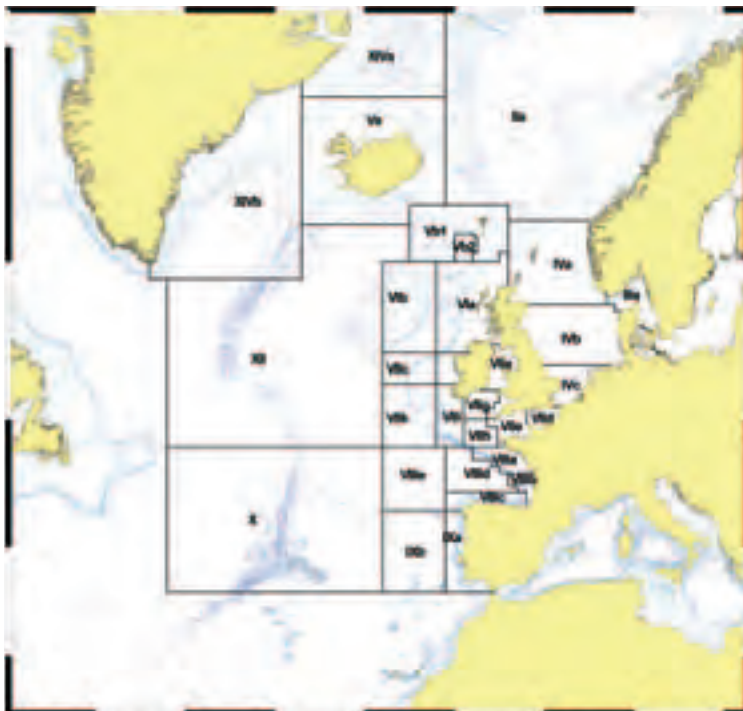
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1. INTRODUCTION

It has been generally stated that deepwater fishes cannot sustain high levels of exploitation because of their characteristic slow growth, longevity and low reproductive output. However deepwater fish species display a wide variety of life-history strategies, occupying diverse positions along the *K-r* continuum. Many teleosts display intermediate or conservative life-history characteristics, but the squalid sharks are more stringent *K*-strategists. Data were used in life-history analyses to assess the sustainability of these mixed-species deepwater fisheries. While there may be scope for compensatory changes in fecundity such scope is likely to be limited, especially for sharks.

The International Council for Exploration of the Sea (ICES) defines deepwater fisheries as those in waters deeper than 400–500 m. Such fisheries have developed rapidly in recent years in ICES Sub-divisions VI and VII (Figure 1). This rapid expansion is due to the decline (or indeed collapse) of many traditional stocks. Some of these deepwater fisheries are long established, for example the Norwegian longline fishery for ling (*Molva molva*) and tusk (*Brosme brosme*) (Connolly, Kelly and Clarke 1999) while others are by now well established, for example the pelagic trawl fisheries for blue whiting (*Micromesistius poutassou*) and greater argentine (*Argentina silus*) (Gordon

FIGURE 1
Map of ICES Sub-areas and divisions, NE Atlantic



2001). Others have developed in the last 10 years but are now quite advanced, such as the French mixed-species trawl fishery (Charuau, Du Pouy and Lorange 1995) and the Spanish deepwater longline fisheries for sharks, forkbeard (*Phycis blennoides*) and mora (*Mora moro*) (Pineiro *et al.* 2001). In most recent years further expansion of fishing to grounds such as Hatton Bank for Greenland halibut (*Reinhardtius hippoglossoides*), blue ling (*Molva dypterygia*) and sharks (Langedal and Hareide 2000, Pineiro *et al.* 2001) have taken place, and a new fishery for orange roughy west of Ireland has developed in most recent years.

Despite the established nature of many Northeast Atlantic deepwater fisheries, data for routine stock assessments are sparse and the lack of adequate, up-to-date information has prevented stock assessments being carried out in ICES since 2000 (Anon. 2002). Most deepwater fisheries in this area are mixed-species fisheries and this leads to problems in assessment and management. Though most deepwater species conform to the general K-selected life history mode, there is considerable variation within these mixed species assemblages in terms of vulnerability to overexploitation (Clarke *et al.* 2003). Dulvy *et al.* (2000) highlighted the dangers of exploiting a mixed-species assemblage; the local extirpation of the most vulnerable species may proceed unnoticed as happened in the case of common skate (*Dipturus batis*) in the Irish Sea. Various authors have used basic life history information as a tool in assessing the resilience of species to exploitation (Brander 1981, Jennings, Reynolds and Mills 1998). The ICES Advisory Committee on Fisheries Management took a simple approach and ranked deepwater species in the NE Atlantic according to a range of life history variables and used this to illustrate the differing risks associated with stock depletion in these species. A more complicated approach was taken by Smith, Au and Show (1998) who calculated “intrinsic rebound potentials” for 26 shark species, incorporating density dependence terms in their analyses. These authors point out that even simple life history data are difficult to collect, so the maximum benefit should be obtained from them.

Most deepwater fisheries developed recently. But already there is strong evidence from around the world that such fisheries may not be sustainable. It is unclear whether roundnose grenadier (*Coryphaenoides rupestris*) in the Northwest Atlantic will ever recover (Atkinson 1995) and there is evidence that many stocks of orange roughy (*Hoplostethus atlanticus*) in New Zealand have followed a similar fate (Clark 2001). It is clear that assembling data needed for conventional management will take a long time, in fact often longer than a deepwater fishery might be expected to last (Haedrich, Merrett and O’Dea. 2001). Management should ideally be based on population dynamics, including fisheries-dependent and fisheries-independent data, for example catch numbers at age and abundance and biomass indices collected on an annual basis. Yet for deepwater species this sort of information is mostly lacking. While great efforts have been taken to collect and refine time-series of catch and effort data, this process is only slowly allowing for assessments to be carried out. For deepwater stocks much of the data available relate to life history of target species. The objective of this paper was to demonstrate that even basic life history information can, in itself, provide a framework for the advisory process for deepwater fisheries.

2. MATERIALS AND METHODS

Life history parameters and derived variables for the main deepwater species presented by Clarke *et al.* (2003) were augmented with data from the literature (Table 1). The basic parameters were maximum size (cm), maximum age, Brody growth coefficient (K), natural mortality (M), length at maturity (L_{50}) and age at maturity (Age_{50}). The ratios of size and age at maturity to maximum size and age were derived. These ratios provide a more meaningful indication of when in the fish’s growth, or life span, maturity actually is attained.

TABLE 1

Life history parameters of the deepwater and continental shelf dwelling species derived from Irish Marine Institute studies

The parameters are: maximum size and size at 50% maturity (cm), maximum age and age at 50% maturity (yrs), Brody growth coefficient (K) in yrs^{-1} , ratio of size and age at 50% maturity to maximum observed values and the instantaneous rate of natural mortality (M). Maximum size and age are as observed in these studies.

Species	Sex	L_{max}	Age_{max}	L_{50}	Age_{50}	K	L_{50}/L_{max}	$\text{Age}_{50}/\text{Age}_{\text{max}}$	M
<i>Argentina silus</i>	F	45	36	26	4	0.14		0.11	0.13
<i>Aphanopus carbo</i>		118	32						0.14
<i>Coryphaenoides rupestris</i>	M	23*(106)	50	10*(48)		0.13	0.43		0.09
<i>Coryphaenoides rupestris</i>	F	24*(111)	60	12*(57)	10	0.1	0.5	0.16	0.08
<i>Centrophorus squamosus</i>	F	145	70	128	44		0.88	0.62	0.07
<i>Centrophorus squamosus</i>	M	122	53	102	25		0.83	0.47	0.09
<i>Deania calceus</i>	F	119	35	105	27.5	0.07	0.86	0.78	0.13
<i>Deania calceus</i>	M	109	31	58	19	0.13	0.78	0.61	0.16
<i>Helicolenus dactylopterus</i>	M	38	43	26	15.5	0.06	0.59	0.36	0.11
<i>Helicolenus dactylopterus</i>	F	39	37	23	13	0.09	0.58	0.35	0.12
<i>Clupea harengus</i>									
Celtic Sea stock	F	33	11	20	1	0.56	0.59	0.09	0.42
<i>Scomber scombrus</i>	F	46	21	29	1.5				
Western/southern stock						0.34	0.63	0.07	0.22
<i>Gadus morhua</i>	F	100	10	50	2				
Irish Sea stock						0.43	0.5	0.11	0.46
<i>Eutrigla gurnardus</i>	F	39	21	18	1.5	0.21	0.46	0.08	0.22

* Length measurements for *Coryphaenoides rupestris* are pre-anus length, with total length in parenthesis. All other measurements are total length apart from *Eutrigla gurnardus* which are fork length.

Longevity and length data for ling and blue ling were obtained from Bergstad and Hareide (1996). Size and age at maturity data for ling, blue ling and tusk were obtained from Magnusson *et al.* (1997), using median of male and female values. Longevity and length data for tusk were obtained from Magnusson *et al.* (1997) and an estimate of M from Anon. (1996). Maximum age of orange roughy and cardinalfish (*Epigonus telescopus*) were taken from Talman *et al.* (2002). For orange roughy, an estimate of M, L_{50} and maximum size were taken from Branch (2001), and references therein. For greater forkbeard, longevity and growth data were obtained from Casas and Pineiro (2001) and an estimate of M derived from data therein using the technique of Rikhter and Efanov (1976). Maturity data for this species were obtained from Kelly (1997). Life history data on blue whiting were obtained from routine sampling programmes underway in the Irish Marine Institute, while an estimate of M was obtained from Anon. (2003). The life history data above, were used to rank the main deepwater species in order of increasing conservatism in life history mode. The most conservative species was assigned the lowest rank for each life history trait.

The economic value of each species was calculated from records of average prices in Ireland (Marine Institute 2003) and used to rank the species in order of price a tonne. Species that form aggregations that are targeted by the commercial fisheries were assigned ranks of 1, and those that are, in general, dispersed were assigned a rank of 2. Along with the economic value of the species this information can be used to highlight which species are more vulnerable in terms of attractiveness to fishing.

These data were used to derive further biological variables for these species. The ratios of size and age at maturity to maximum size and age were derived. These provide a more meaningful indication of when in the fishes' growth, or life span, maturity actually is attained. Estimates of natural mortality in this study (Table 1) were obtained using a method that assumes that this is the rate required to reduce a recruited population to 1 percent of its initial value (Annala and Sullivan 1996). In the present case, maximum age was taken to be the greatest observed age in samples. Estimates of fecundity and age at maturity were used to derive the potential rate of population increase the surrogate r' – (Jennings, Reynolds and Mills 1998) as follows

$$r' = \ln(\text{fecundity at length at 50\% maturity}) / \text{age at 50\% maturity}$$

Fecundity at size at maturity was used for greater argentine and roundnose grenadier, but for the sharks, mean observed ovarian fecundity was used because there was no evidence of increased fecundity with size (Clarke 2000, Girard and Du Buit 1999). Age at maturity was not estimated directly for the sharks but predicted from the von Bertalanffy growth function for birdbeak dogfish (*Deania calceus*) and from mean length at age in the case of leafscale gulper shark (*Centrophorus squamosus*).

A Beverton and Holt (1957) yield per recruit analysis was done for two hypothetical species, one with a *K*-strategist life history, and the other with a more *r*-selected mode. This model assumes that fish growth is expressed by the von Bertalanffy growth function and that mortality is exponential (Ricker 1975).

3. RESULTS

Length and age data of the deepwater species are presented in Table 1 along with those of the shelf species. Maximum age attained (longevity) by these deepwater species varies. The shortest-lived species was forkbeard attaining ages of 9 years. The species that was estimated to reach the greatest age was leafscale gulper shark, attaining an age of 70 years. Roundnose grenadier was another long-lived species (60 years). Species with intermediate longevity were, in decreasing order, blue-mouth redfish (*Helicolenus dactylopterus*) (43 years), greater argentine (36 years), birdbeak dogfish (35 years) and black scabbardfish (*Aphanopus carbo*) (32 years). The maximum ages reported were as determined from the studies outlined above. Apart from the work carried out for roundnose grenadier (Gordon, Merrett and Haedrich *et al.* 1995) and

grey gurnard (*Eutrigla gurnardus*) (Connolly 1986) where marginal increment analysis was employed, these studies did not include any validation of the age estimates that were obtained.

Greatest age at 50 percent maturity was recorded for blue-mouth redfish (15.5 years) though maturity was attained by this species at a smaller size than the other species except for forkbeard. Forkbeard reached maturity at smaller size and age than any of the other species. Greater argentine (4 years) also matures early, while roundnose grenadier matured later (10 years). The deepwater species were longer lived than the shelf species and thus the estimates of natural mortality for the deepwater species were lower. The Brody growth coefficients (K) of the deepwater species indicate that they grow more slowly, reaching asymptotic size at a lower rate than the shelf species. Species displaying fastest growth, in terms of the Brody growth coefficient (K) from the von Bertalanffy growth model was forkbeard, followed by greater argentine. While roundnose grenadier displayed slow growth, the slowest growing of all species examined was blue-mouth redfish, displaying slower growth than the shark birdbeak dogfish. Though blue whiting reaches over 50 percent of maximum length before maturity, it matures at a relatively young age and is fast growing compared to the others ($K = 0.19$) (Table 2).

A more useful biological parameter than length or age at which 50% of the population reaches maturity is one that provides an indication of the age for the species when it reaches sexual maturity. Table 1 presents length and age at 50% maturity as ratios of maximum length and age in each case. Maturity was reached at largest proportion of maximum size in the case of the leafscale gulper shark (83 and 88% for males and females respectively). The other sharks also mature at high proportions of their maximum length. Roundnose grenadier mature at around 50% of maximum length but in terms of age at only about 18% of maximum. Blue-mouth redfish also attained maturity at an advanced size, though at an earlier percentage of maximum age than roundnose grenadier. The shelf dwelling species all reached sexual maturity at relatively small size and early age; in all cases first maturity was reached at less than 2 years. In contrast, of the deepwater species only roundnose grenadier matured at less than 50% of maximum size. Contrasting patterns of maturity with respect to age are also apparent. The shelf dwellers all matured in the first 12% of their life spans. Apart from roundnose grenadier the deepwater species reached maturity between 20 and 70% of their life spans. Fecundity estimates were only available for two of the teleosts. Greater Argentine females in the range 26.5–45 cm total length had fecundities in the approximate range 4 478 to 16 284 ova. Roundnose grenadier in the range 63–95 cm TL had fecundities in the approximate range 11 000 to 55 000 ova.

Table 2 presents the above data, combined with additional data from various literature sources, to present an overall picture of the varying life histories in the deepwater fisheries. Orange roughy was the most valuable species (2 603 €/t). Most of the remaining true deepwater species commanded lower market prices, between about 1 100 € and 1 500 €/t. The pelagic deepwater species had much lower market prices. Combined with the behavioural ranking, the economic data give some indication of vulnerability. For example, a high-value aggregating species such as orange roughy offers considerable incentive to fisheries. Combined with its conservative life history mode, these characteristics render it particularly vulnerable to exploitation.

The potential rate of population increase for four deepwater species and four shelf dwelling species is presented in Table 3, in order of increasing rate. These values show that the deepwater species all have slower rates of population increase than the shelf-dwelling species. The lowest rates of all are those of the sharks.

The Beverton and Holt yield per recruit simulations show some important differences between fisheries based on K - and r -strategists. K -strategist-based fisheries produce maximum yield at lower rates of fishing mortality than those based on

TABLE 2

Life history and economic parameters for deepwater species taken in fisheries west of Ireland and Britain

The parameters are: maximum size and size at 50% maturity (cm), maximum age and age at 50% maturity (yrs), Brody growth coefficient (K) in yrs^{-1} , ratio of size and age at 50% maturity to maximum observed values, the instantaneous rate of natural mortality (M) and market price (€/tonne). The behavioural rank is (B) = 1 for dispersed species and 2 for those forming aggregations that are fished upon.

Species	Sex	L_{\max}	Age_{\max}	L_{50}	Age_{50}	K	L_{50}/L_{\max}	$\text{Age}_{50}/\text{Age}_{\max}$	M	€/t	B
<i>Centrophorus squamosus</i>	F	145	70	128	44		0.88	0.62	0.07	1 389	1
<i>Hoplostethus atlanticus</i>	F	69	180	52	35	0.06	0.75	0.19	0.05	2 603	2
<i>Epigonus telescopus</i>	u	60	38							1 270	2
<i>Helicolenus dactylopterus</i>	F	39	37	23	13	0.09	0.58	0.35	0.12		1
<i>Deania calceus</i>	F	119	35	105	27.5	0.07	0.86	0.78	0.13	0	1
<i>Coryphaenoides rupestris</i>	F	24	60	12	10	0.1	0.5	0.16	0.08	1 206	1
<i>Aphanopus carbo</i>		118	32						0.14	1 533	1
<i>Brosme brosme</i>	u	90	20	42.5	9		0.47	0.45	0.11	1 138	1
<i>Molva molva</i>	u	169	20	67.5	6		0.40	0.30		1 247	1
<i>Molva dypterygia</i>	u	120	30	50	7		0.42	0.23	0.15	1 273	2
<i>Phycis blennoides</i>	F	75	14	32	3.2	0.08	0.43	0.23	0.12	1 122	1
<i>Argentina silus</i>	F	45	36	26	4	0.14		0.11	0.13	118	2
<i>Micromisteus poutassou</i>	u	42	13	22.5	1.5	0.19	0.54	0.12	0.2	99	2

TABLE 3
Surrogate potential population replacement rate for four deepwater species compared with 4 continental shelf-dwelling species, calculated as fecundity at L_{50}/Age_{50}

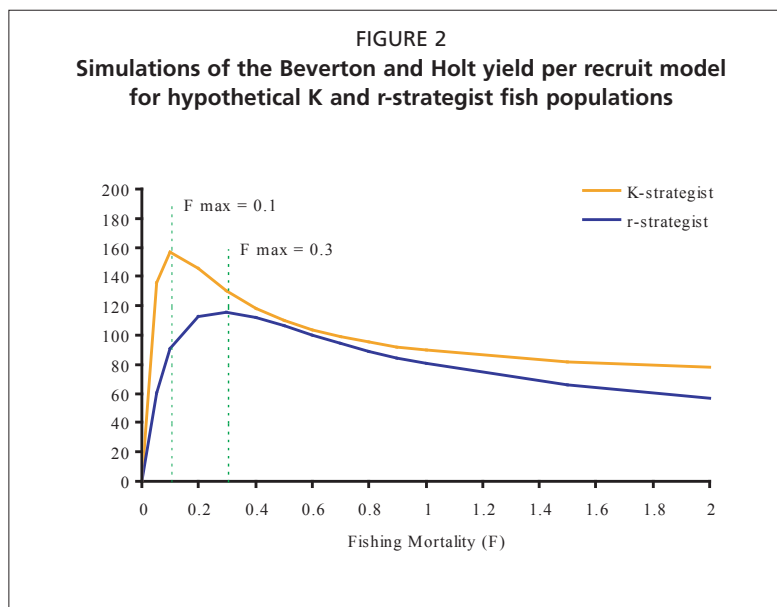
Species	Fecundity at L_{50}	Age_{50}	r' ln (fecundity at L_{50}/Age_{50})
<i>Centrophorus squamosus</i>	8	44	0.05
<i>Deania calceus</i>	13	26	0.10
<i>Coryphaenoides rupestris</i>	13 083	10	0.95
<i>Argentina silus</i>	4 478	4	2.10
<i>Eutrigla gurnardus</i>	14 347	1.5	6.38
<i>Gadus morhua</i>	913 780	2	6.86
<i>Clupea harengus</i>	40 879	1	10.62
<i>Scomber scombrus</i>	235,673	1.5	12.37

r - strategists (Figure 2). Thus, r -strategists may be harvested at higher rates of fishing mortality than those based on K -strategists. The parameters used as inputs to this analysis are given in Table 4.

TABLE 4
Parameters used to fit Beverton and Holt (1957) yield per recruit model for hypothetical K and r -strategist species

Instantaneous rate of natural mortality M , the Brody growth coefficient K in yrs^{-1} and the asymptotic weight in grams W_{∞} from the von Bertalanffy growth function.

	K -strategist	r -strategist
M (natural mortality)	0.09	0.2
K (Brody growth coefficient)	0.08	0.37
W_{∞} (g)	2000	700



4. DISCUSSION

The percentage of maximum length at which maturity is reached was greatest in the case of the sharks (78–88%), which agrees with mean values calculated for elasmobranchs by Frisk, Miller and Fogarty (2001). The deepwater teleosts matured at lower percentages of maximum length with the values for roundnose grenadier and forkbeard less than 55% and in the range for the shelf-dwelling species. The shelf-dwelling species appear to reach sexual maturity while somatic growth proceeds. The ratio of

age-at-maturity to maximum age represents the portion of time and growth that takes place before the adults invest in reproduction. Again, the sharks had the highest values, indicating that they live most of their lives before they mature. These contrasts between shelf and slope species agree well with published studies; Gordon *et al.* (1995) notes that slope dwelling fish only mature when somatic growth has slowed or ceased, indicating that on the deepwater slopes, energy is available for growth or reproduction, but not both (Merrett and Haedrich 1997). Estimates of the Brody growth coefficient (K) for the deepwater species predict moderate to low rates of growth to asymptotic size.

The ratios of age at maturity to maximum age for sharks are similar to those reported for shelf elasmobranchs by Frisk, Miller and Fogarty (2001). These authors tentatively suggest that compensatory responses to exploitation may explain earlier maturation in the sharks relative to other – unexploited – vertebrate classes. However, the high likelihood that these species have gestation periods of more than one, and perhaps more than two, years (Girard 2000) coupled with the possibility that they have prolonged periods of rest between reproductive events (Clark and King 1989, Clarke, Connolly and Bracken 2001) might indicate that the scope for compensatory change is limited. There have been reports of density dependent changes in fecundity in the shelf-dwelling squalid shark spiny dogfish (*Squalus acanthias*) (Gauld 1979). However Portuguese dogfish (*Centroscymnus coelolepis*) and birdbeak dogfish do not develop subsequent batches of oocytes during gestation. This seems to support the view that the scope for compensatory changes in deepwater sharks is more limited than might be the case for their shelf-dwelling relatives.

The dangers of not validating age have been illustrated by Beamish and McFarlane (1983). The errors in ageing the Pacific ocean perch (*Sebastes alutus*) led to a management strategy that was less conservative than was prudent, given the great longevity and low natural mortality of that species. In the absence of tagging data, natural mortality is often estimated using the techniques of Rikhter and Efanov (1976), or Hoenig (1983) or is based on maximum age attained by a stock or species (Annala and Sullivan 1996). The problems with using these approaches may be illustrated with reference to black scabbardfish (*Aphanopus carbo*). Morales and Carvalho (1996), using whole otoliths, found ages of up to eight years while the results reported in this study from sectioned otoliths were up to 32 years. The resultant differences in estimates of *M* from the method used in this study, 0.57 and 0.14 respectively, give quite different results about the maximum yield of this species. Again, the need for validation of age is underlined.

Available data on reproduction in teleosts further strengthens the contrasts between shelf and slope. Roundnose grenadier and greater argentine produce small numbers of large eggs (Kelly, Connolly and Bracken 1996, Ronan, Bracken and Malloy 1993) that are characteristic of species inhabiting low-energy environments (Ekau 1991). There are difficulties in translating these fecundity data into annual egg production estimates. There have been several studies of reproduction in roundnose grenadier, but the results have been contradictory. Their spawning is prolonged throughout the year (Allain 2001, Bergstad 1990, Gordon and Hunter 1994, Kelly *et al.* 1996, Magnusson and Magnusson 1995), however Kelly *et al.* (1996) found this species to be a determinate spawner, though Allain (2001) considers fecundity to be indeterminate and that the number of egg batches produced each year is unknown. Spawning in greater argentine proceeds throughout the year (Magnusson 1988, Ronan *et al.* 1993) though there may be seasonal peaks in spawning intensity (Anon. 1995b). There is no published information on the nature of spawning in this species. Differing spawning strategies complicate comparisons between shelf and slope teleosts. The grey gurnard has an asynchronous strategy, spawning repeatedly throughout the breeding season (Connolly 1986). The Atlantic mackerel (*Scomber scombrus*) also has a protracted spawning period (Anon. 1999). Thus, these species spread their reproductive effort over time to counteract environmental variability by adopting a “bet hedging” strategy (Lambert and Ware 1984). This approach accommodates environmentally induced poor recruitment by increasing the temporal scale of reproductive output relative to that of the environmental fluctuation (Merrett and Haedrich 1997).

The deepwater sharks have much lower fecundities than the slope-dwelling teleosts, but share similar values with shelf-based relatives such as spiny dogfish (*Squalus acanthias*) (Holden and Meadows 1964). These species produce a small number of well-developed young, with a better chance of survival. This tends to

support the idea that stock-recruitment relationships are more defined in these viviparous elasmobranchs than may be the case for many teleosts.

This study illustrates the differences in growth and reproduction between shelf and slope species. These differences might be illustrated using the concept of the K - r continuum. K -strategists tend to inhabit environments where there is little fluctuation, they achieve success by attaining large size, deferred reproduction and producing smaller numbers of more developed offspring (Begon, Harper and Townsend 1996). However there has been much criticism of the K - r concept. Stearns (1992) examines the evolution of life history traits and suggests that earlier authors had tended to consider that so-called K -strategists evolved under density-dependent conditions, while r -strategists evolved in density-independent conditions, a theory that he considers incorrect. Boyce (1984) states that this theory should only be applied to density-dependent models, a point which Stearns (1992) also makes. The deficiencies in this concept should be noted. The use of the model in the current study is by way of an simple generalization of the dichotomy in life-history strategies in these species, and does not consider the selection pressures on individual organisms that produced these traits.

The intrinsic rate of natural increase (r) is the rate at which a population increases in size per individual in unit time. It is calculated as the mean number of offspring produced by an individual in its lifetime divided by the average time between the birth of an individual and the birth of the first offspring of that individual – cohort generation time (Begon *et al.* 1996). Given the uncertainties in reproductive biology of deepwater teleosts and elasmobranchs, it was not possible to calculate r . However, following the method of Jennings, Reynolds and Mills (1998), a surrogate value – the potential rate of population increase (r') – was derived from the available data for four deepwater species and four shelf species. In this approach, fecundity at age at maturity provides an index of reproductive output and age at maturity an index of cohort generation time (Jennings, Greenstreet and Reynolds 1999). Ranking the species according to r' suggests that the sharks are least resilient to fishing, followed by the slope teleosts. The shelf dwellers display markedly higher rates of potential population increase. There are no published estimates of the intrinsic rate of population increase (r) for the shelf species in this study. Jennings, Reynolds and Mills (1998) state that r could not be calculated for such species because available data were from stocks that had already been exploited, and reduced life-spans would bias the estimates. These authors suggest that r' is a useful surrogate, and produced estimates of this parameter for a range of shelf species. The parameter r' incorporates the fecundity at L_{50} , a surrogate for the mean annual egg production and Age_{50} , a substitute value for cohort generation time. Due to uncertainties in the estimates of annual egg-production (see above), r was not calculated for the deepwater species, and the surrogate estimate (r') was used instead.

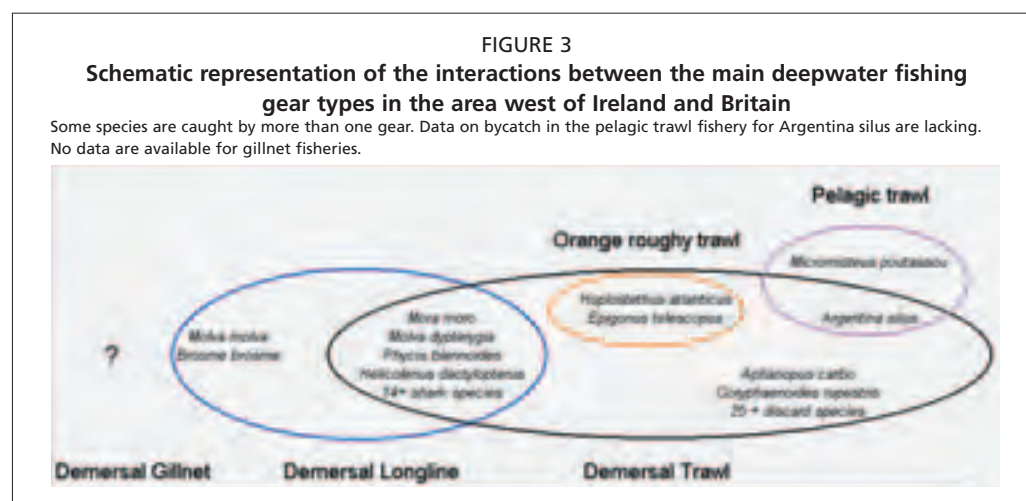
Hoenig and Gruber (1990) suggested the possibility of ranking species according to their resilience to exploitation, based on life history characteristics. Smith, Au and Show (1998) calculated “intrinsic rebound potentials” for 26 shark species, incorporating density dependence terms in their analyses. Brander (1981) ranked skate species according to the total mortality the populations could withstand without collapsing. This approach was also taken by Walker and Hislop (1998) for North Sea skates. Smith *et al.* (1998) note the difficulties in obtaining all the necessary data, therefore it seems prudent to maximise the usefulness of such information for assessment purposes.

These estimates of potential population increase suggest that these deepwater species are less resilient to fishing pressure and that they will respond more slowly to decreased exploitation than those on the continental shelf. The deepwater sharks share their low rates of increase with shelf-dwelling sharks (Smith, Au and Show 1998, Walker and Hislop 1998) but the possibility that the deepwater sharks have long gestation periods of two or more years (Girard 2000) and the likelihood that they have prolonged resting

periods between reproductive events (Clark and King 1989, Clarke, Connolly and Bracken 2001) may indicate that these deepwater elasmobranchs are more vulnerable than their shelf-based relatives.

However, life history models are limited in their application for stock assessment purposes, and provide only a static view of the population that does not consider possible density-dependent factors. More importantly, this method does not allow any direct measure of how to set management targets. But, these methods can be a useful aid in situations of poor fisheries data. Combined with data on trends in abundance, they can highlight the potential of particular species to recover, if fishing effort is reduced. They can be used to classify species in a fishery along a continuum of relative resilience to exploitation. Another application is to provide informed decisions about prior distributions of the rate of increase for surplus production models.

Most deepwater fisheries on the continental slopes of the ICES area are multi-species in character, with the possible exception of the pelagic trawl fishery for greater argentine (though data from this fishery are lacking). Figure 3 illustrates the interactions between the main gear types in terms of the main species in the catch.



Roundnose grenadier is taken in the multi-species trawl fisheries with a range of species including greater argentine, deepwater sharks, black scabbardfish, blue ling and other species (Charuau, Du Pouy and Lorange 1995). Longline fisheries on the upper slopes target ling and tusk (Anon. 2000) while in deep waters another longline fishery targets mora, forkbeard and the sharks (Pineiro, Casas and Banon 2001). The diversity of species in longline catches is less than from trawl, but sharks tend to dominate the discards from longline harvests (Connolly and Kelly 1996). Orange roughy is taken in the mixed trawl fishery along with roundnose grenadier, and also in a directed fishery using specialised trawl gear, along with the cardinal fish.

Management of these fisheries should consider the vulnerability of each of the species. The ICES Working Group on the Biology and Assessment of Deep-sea Fisheries Resources has ranked the main deepwater species in order of their vulnerability, based on various life history parameters. In relation to these multi-species deepwater fisheries the question arises, how can a range of species be managed when they have a range of differing life history traits, though generally conforming to the *K*-strategist mode?

The simulations based on Beverton and Holt's (1957) yield per recruit model (Figure 2) show some important differences between species with what might be termed *K*-strategist life histories and those with *r* strategies. Fisheries based on *K*-strategists (such as the deepwater species in this study) achieve maximum yields at

lower rates of fishing mortality (F) than those based on r -strategists. Thus r -strategists (analogous to the shelf-dwelling species) can sustain higher fishing mortalities. The resilience of these species can be gauged by r' or preferably the intrinsic rate of population increase r . But depending on the rate of fishing mortality some species may decline, while others may sustain that level of exploitation. The lack of species-specific abundance indices may explain why, for example, well-known species such as the common skate almost disappeared from the Irish Sea (Dulvy *et al.* 2000) while other skates were more resilient to fishing. This highlights the dangers of exploiting multi-species assemblages without taking into account the differing life-histories of the species involved. Framing management objectives may involve choosing the most vulnerable species and setting reference points for fishing mortality based on guidelines based on the precautionary approach. According to the results of this study and the ICES report on deepwater fisheries (Anon. 2001) the most vulnerable species in the exploited deepwater assemblage in the waters west of Ireland and Scotland are the deepwater squalid sharks.

Haedrich, Merrett and O'Dea (2001) stated that management plans for deepwater fisheries cannot follow those developed for traditional shelf stocks. Indeed this statement could apply to traditional stocks also. The usual approach of providing single species advice for each species has been seen to be flawed and is now being changed. ICES is now aiming at providing advice on fisheries, rather than single stocks. The current advice for Irish Sea demersal fisheries, for example, is that fisheries should only proceed when there are no catches of cod or whiting (ICES 2003). This advice is based on analytical catch-at-age assessments that are not possible with deepwater species. However, basic life-history data can be used to produce fleet-based assessments of risk and support fisheries-based advice.

To frame fisheries-based advice for deepwater species, the first step should be to determine the species relationships in each fishery and for each depth range. This analysis can be used to evaluate the current and advised TACs, or effort levels. In other words, a TAC of 1 000 t for roundnose grenadier would entail certain amount of sharks, blue ling, black scabbard and orange roughy, for example. The life history analyses provide guidance on which species are most at risk, and can be used by managers to decide on which species are priorities for management decisions. Then a series of scenarios can be run, based on catch or effort levels for the species that have been deemed as priorities. Such an approach, along with incorporation of technical interactions, could underpin fishery-based management advice for mixed-species deepwater fisheries.

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Local fishing efficiencies estimated from observers' recordings of Patagonian toothfish (*Dissostichus eleginoides*)

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1. INTRODUCTION

The growing capacity of fishermen to repeat fishing operations at some known locations thanks to, for instance, precise maps of past activity and global positioning systems (GPS) is becoming more apparent as fine-scale information on fishing activities becomes available. Aggregated declarations at the level of statistical square levels hides the fine-scale information and the possibility to analyze small-scale fishing strategies. When available, information on fishing effort such as observers' declarations or vessel monitoring system (VMS) reports may indicate that the tendency of specific-area repeat fishing is sometimes frequent (Rijnsdorp, van Mourik Broekman and Visser 2000). In this paper, we are concerned by the fact that small-scale fishing tactics may interfere in the relation between commercial catch per unit effort (CPUE) and indices of abundance and potentially reduce the relevancy of mean CPUE for resource analysis purposes. The relationship between CPUE and abundance can be biased (e.g. Hillborn and Walters 1987, Rahikainen and Kuikka 2002) as it is the product of several processes such as schooling behaviour of fish, variation in catchability, interactions between fishing vessels and spatial distribution of fishing effort.

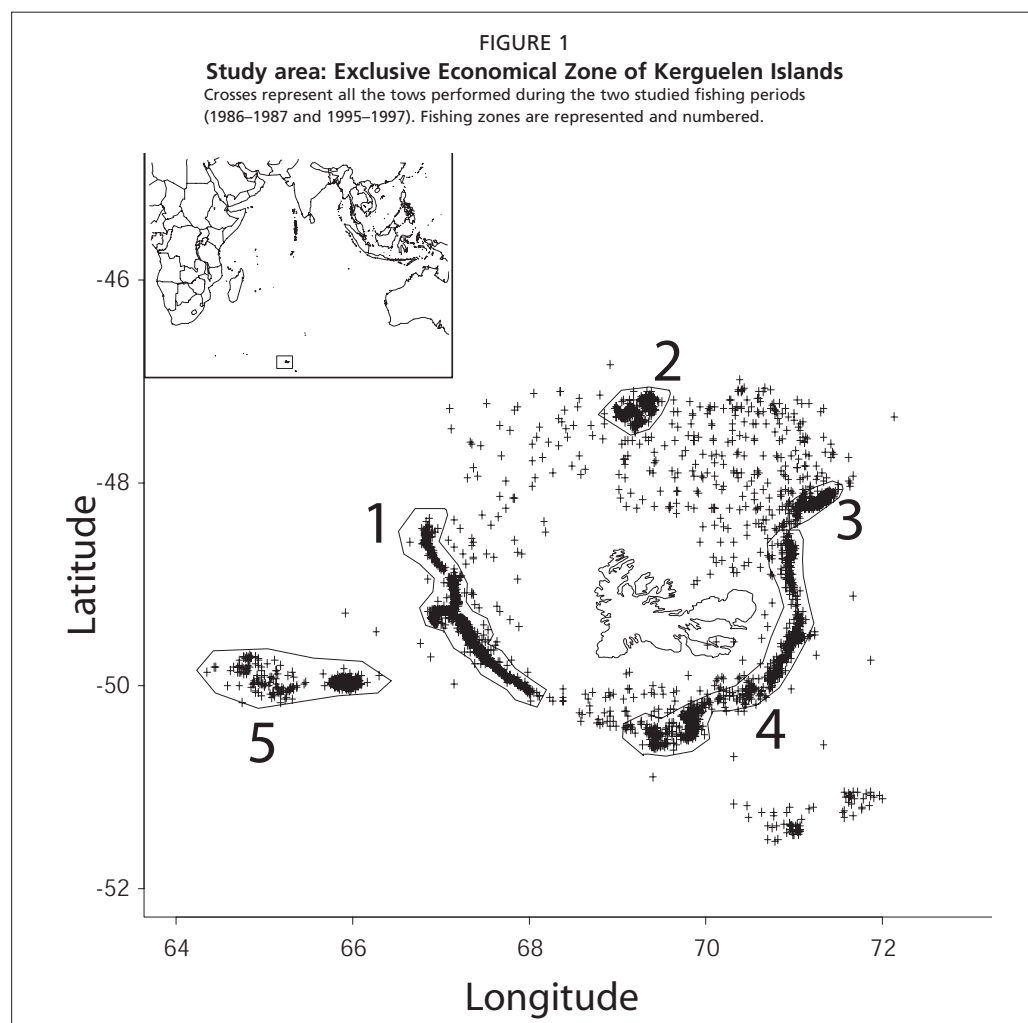
In this paper, we consider the trawl fishery for Patagonian toothfish (*Dissostichus eleginoides*) off Kerguelen Islands in the Indian sector of the Southern Ocean. In spite of difficult conditions of exploitation, the fishery increased until the end of the 1990s. The fishery can be characterized in the context of this paper by the fact that (a) it is mono-specific – toothfish alone is caught, (b) fishermen do a lot of repetitive tows and (c), management rules changed a few years after the fishery started, switching from global to individual quotas. Making use of the spatio-temporal distribution of tows, Bez, De Oliveira and Duhamel (in press) showed that a mean depletion effect of 5 to 10 percent per tow exists under repetitive fishing for toothfish. This local depletion is stronger for icefish (*Champsocephalus gunnari*) and grey rockcod (*Lepidonotothen squamifrons*). However these local depletion effects are weak and the fluctuations observed around the decreasing trends can be attributed to changes in the fishing efficiencies from one tow to the next. The objective of this paper is to use the repetitive fishing to estimate fishing efficiency distributions and to interpret their changes with regards to the change in regulations.

Here, “local fishing efficiency” measures the capacity of a unit of effort to catch fish effectively accessible to fishing (Gascuel 1993). As with all components of catchability, the local fishing efficiency should be estimated with CPUEs based on the same underlying fish abundance, which is never possible. Robson (1966) circumvented this difficulty by assuming homogeneity of fish density over quadrats. Laurec (1977) used geostatistical tools to account for the differences between two CPUEs when using them. Here, we use the territorial behaviour of toothfish and the existence of a series of repetitive fishing to build ratios of consecutive CPUEs to estimate fishing efficiency probability distributions.

2. SURVEY AREAS

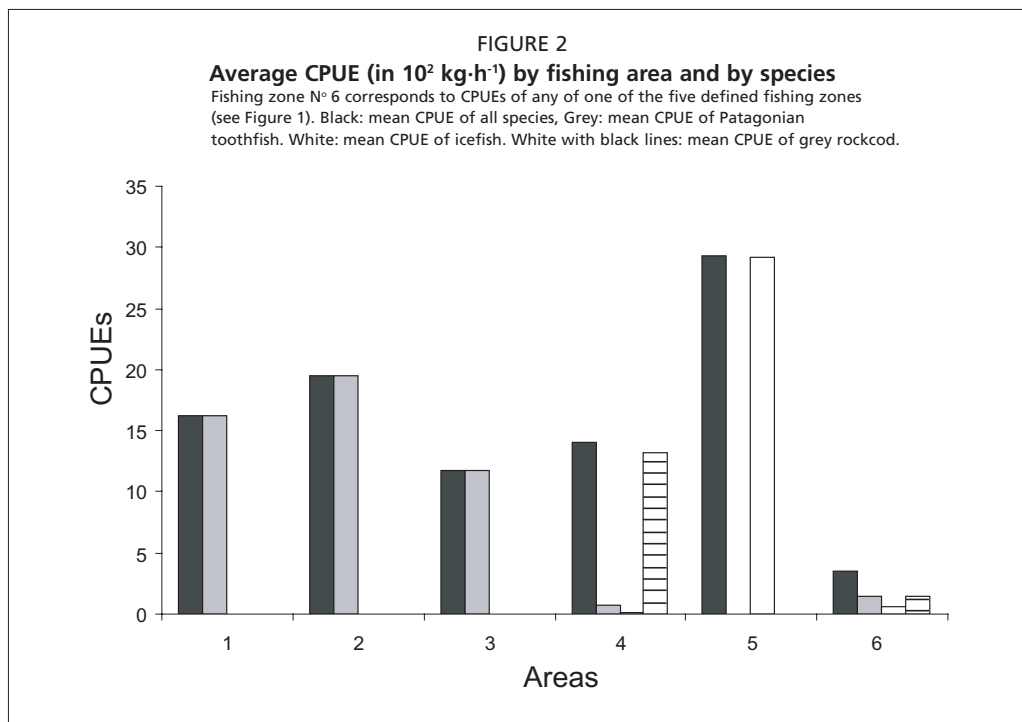
Two periods of the Patagonian toothfish trawl fishery are considered in this paper: (a) the beginning period of the exploitation (1986–87) under global quota, and (b), the full exploitation phase (1995–1997) under individual quotas. During the first period, 12 vessels were operating (mainly in the fishing zone N° 1, Figure 1). During the second period, only two vessels were fishing switching between fishing zones 2 and 3 (Figure 1).

The Patagonian toothfish is a predatory demersal deepwater species (Duhamel 1981, 1992). Its range is the Southern Ocean and the tip of South America. It undertakes long distance migrations of more than 2 000 km (Williams *et al.* 2002) during its life cycle. However, it may also be a territorial fish and we assume that it does not move during a small period of time, i.e. one or two days.



The presence of observers on board each boat allowed us to obtain accurate and precise information on tow coordinates, with a precision of 1 nm, tow durations and catches. CPUEs were then precisely georeferenced and expressed in hundreds of kg/hour ($10^2 \text{ kg}\cdot\text{h}^{-1}$). Catches from tows shorter than 15 minutes have been removed from the dataset. Such short tow durations usually indicate a problem in the trawl behaviour (damaged gear, winches breakdowns, etc.).

Three species of fish were caught: Patagonian toothfish, icefish and grey rockcod. However the spatial distributions of each species was distinct (Figure 2). Each species is fished in a specific area and without overlap with the others. Five fishing areas have then been delimited (Figure 1), the first three being specific for toothfish. Catches located out of these five specific areas have been assigned to a supplementary area, noted as Area 6.

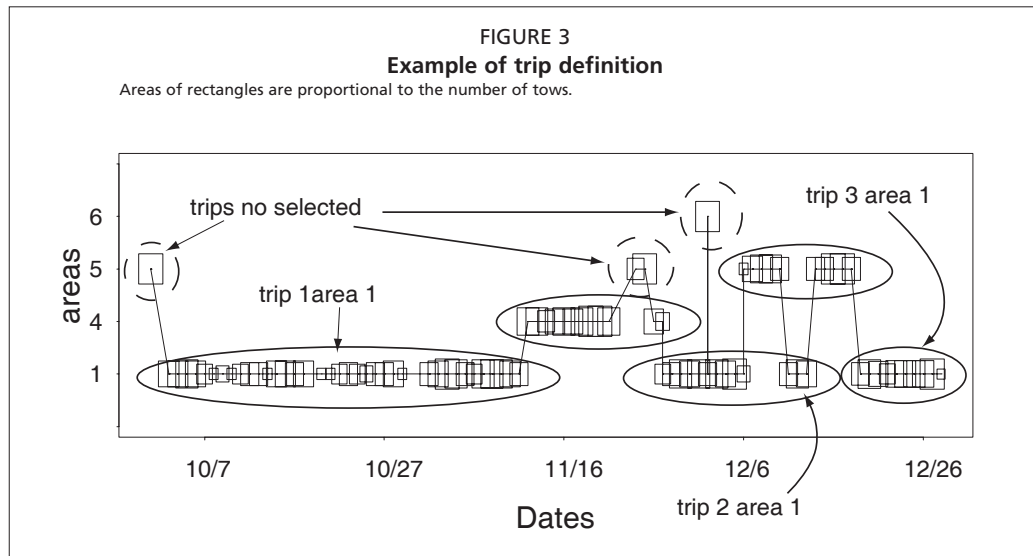


Prospected areas for Patagonian toothfish have changed over time. Area 1 was more exploited during the first fishing period. This area is dangerous for fishing gear, which resulted in the displacement of the fishery towards two new areas for Patagonian toothfish (Areas 2 and 3) in the late 1990s.

3. METHODS

3.1 Definition of trips

Each fishing season of each vessel has been divided into trips. These consist of sequences of CPUEs performed by a specific vessel in a given fishing area provided that these sequences last more than two days (Figure 3). For each trip, we searched for co-located tows, i.e. at the same location. For each trip, a percentage of co-located catches is then computed.



3.2 Definition of series of co-located CPUEs

A series of repetitive fishing operations have been defined so that: (a) each series comprises at least three non-zero CPUEs, (b) the maximum distance between all CPUEs of a series is one nautical miles and (c), the maximum time lag between two consecutive CPUE is two days. We denote by $U_{i,j}$ the j^{th} CPUE of the i^{th} series, with $j \in [1, L_i]$ where L_i is the length of the i^{th} series (Table 1). Given the constraints used to define the series, $L_i \geq 3$. All series have been standardized to their average making possible the comparison between them of:

$$U_{i,j}^r = \frac{U_{i,j}}{\frac{1}{L_i} \cdot \sum_{j=1}^{L_i} U_{i,j}}$$

For each fishing period averages profiles of standardized series were then calculated as follows:

$$\bar{U}_j^r = \frac{\sum_{i=1}^{N_j} U_{i,j}^r}{N_j}$$

where N_j = the number of available observations at rank j .

We forced series to get at least three observations: $N_1 = N_2 = N_3 > N_{j>3}$.

TABLE 1
Notations

Notation	Meaning
i	Number of a data series
L_i	Length of the i^{th} data series
j	Rank number in a series; $j \in [1, L_i]$
$U_{i,j}$	j^{th} CPUE of the i^{th} series
m_i	Average value of the CPUEs of the i^{th} series
$U_{i,j}^r = \frac{U_{i,j}}{m_i}$	j^{th} CPUE of the i^{th} series relative to the mean of the series
N_j	Number of available CPUEs at rank j
\bar{U}_j^r	Mean relative CPUE of rank j

Notation	Meaning
z_i	Fish density at the beginning of series i
$\Phi_{i,j}$	Local fishing efficiency for series i and rank j
$R_{j+1,j}$	Ratio between two successive CPUEs

3.3 Local fishing efficiency

We considered the reference situation where swept area is constant within series and where no immigration and/or emigration of fish occur during a series. In this case, if we denote z_i as the fish density at the beginning of each series and $\Phi_{i,j}$ as the fishing efficiencies of each tow, the first two CPUEs of a series are given by:

$$U_{i,1} = \Phi_{i,1} \cdot z_i$$

$$U_{i,2} = \Phi_{i,2} \cdot (z_i - \Phi_{i,1} z_i) = \Phi_{i,2} (1 - \Phi_{i,1}) \cdot z_i$$

so that after j repetitions:

$$U_{i,j} = \Phi_{i,j} \cdot \prod_{k=1}^{j-1} (1 - \Phi_{i,k}) \cdot z_i$$

The ratio $R_{j+1,j}$ between two successive CPUEs is:

$$R_{j+1,j} = \frac{U_{i,j+1}}{U_{i,j}} = \frac{\Phi_{i,j+1} \prod_{k=1}^{k=j} (1 - \Phi_{i,k}) \cdot z_i}{\Phi_{i,j} \prod_{k=1}^{k=j-1} (1 - \Phi_{i,k}) \cdot z_i} = \Phi_{i,j+1} \cdot \frac{(1 - \Phi_{i,j})}{\Phi_{i,j}} = \Phi_{i,j+1} \cdot \Psi_{i,j}$$

$$\text{with } \Psi_{i,j} = \frac{1 - \Phi_{i,j}}{\Phi_{i,j}}$$

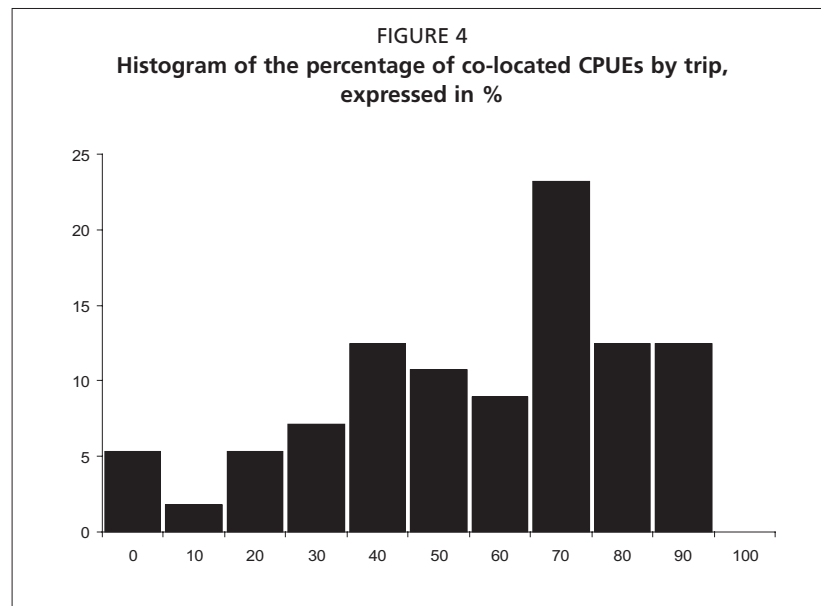
In the simple case where the fishing efficiency is constant, the model is that of an exponential depletion. Departures from this simple model imply that the fishing efficiency is variable and it is then modeled by a random variable, Φ .

The ratio of two consecutive CPUEs, $R_{j+1,j}$ is only dependent on the fishing efficiency. It is also considered as a random variable R . Bez, De Oliveira and Duhamel (in press) developed a method to estimate the probability density function of the fishing efficiencies from the experimental histogram of these ratios. The basics of this method consider that Φ follows a Beta distribution with unknown parameters n and p . These are estimated by the best fit of the p.d.f. of R to the histogram of the observations $R_{j+1,j}$.

4. RESULTS

4.1 Quantitative importance of re-fishing

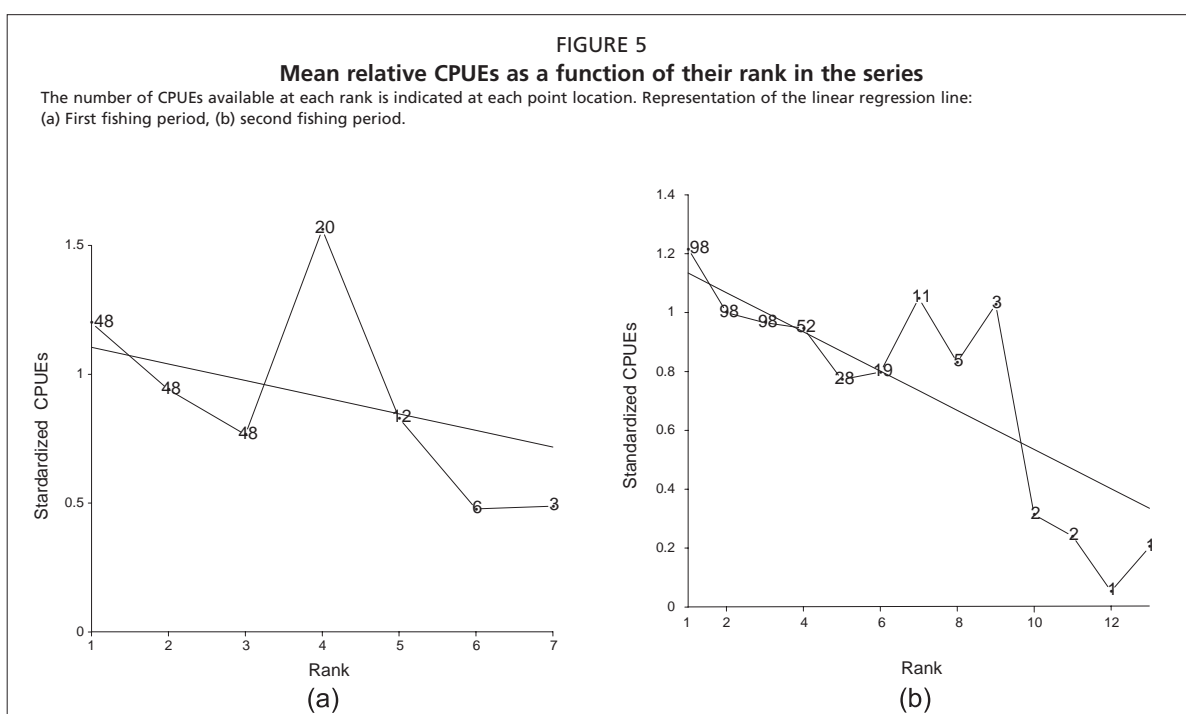
Trawlers operating in the Kerguelen fishery realize a high percentage of co-located catches when targeting Patagonian toothfish. On average, half of the catches performed during a trip are co-located. Thus, of 100 tows, 50 will be done at a geographical location that has never been visited before and will not be fished again after that particular tow during that trip. The other 50 will be, at least, positional replicates (duplicates, triplicates, or more). The percentage of co-located tows ranges from 0 to 87 percent (Figure 4) and the majority of them are above 60 percent, which is a clear indication



that re-fishing is an important fishing strategy in this deep-sea fishery and that looking at the statistical properties of the co-located CPUEs is a key for the understanding of the dynamic of this fishery. Series of co-located CPUEs include 15 percent and 24 percent of the CPUEs realized in the first and second fishing periods respectively. This indicates that the proportion of successive replicates, which was significant at the beginning of the fishery, increased over the fishery's history.

4.2 Local depletion

We have established 48 data series in the first fishing period and 98 in the second. The largest series had 13 observations. Amongst these 146 series, not all present showed a decreasing profile. Some do not exhibit any trend and others show an increase. However, relatively to their mean values, series of CPUEs exhibit a mean depletion effect over repetitive trawls (Figure 5). Average rates of depletion for Patagonian



toothfish are 4 percent for the first period (Figure 5a) and 7 percent (Figure 5b) for the second period. Strong fluctuations exist around the trends. In particular, for the first period the fourth point of the mean profile departs clearly from the others, even though it is based on 20 observations (Figure 5a). The rate of depletion without this point is 10 percent.

4.3 Local fishing efficiency: Patagonian toothfish

CPUE indices for Patagonian toothfish have been used to estimate the distribution of fishing efficiency for each of two trawling periods. Trawl durations were remarkably stable over repetitions. They do not show any trend, either increasing or decreasing (Figure 6) and we may assume that the area swept is constant within series. Experimental histograms of the ratio between two consecutive CPUEs $R_{j+1,j}$ present differences between the two periods (Figure 7) which induces differences in the estimated probability density functions of the fishing efficiencies for the corresponding periods (Figure 8). At the beginning of the fishery, fishing over efficiencies were spread over a large range of values (from 0 to 0.9) being, on average, equal to 0.28. After 10 years of exploitation, fishing efficiencies were uniformly smaller ranging from 0 to 0.4 and equal to 0.11 on average (Figure 8).

When data permit, the same procedure was applied to the results from individual

vessels with the objective of distinguishing between more and less efficient boats. This was possible for vessels No. 19 (in the first period (Figures 9a and 10) and second periods (Figures 9b and 10)), 29 (first period, Figures 11a and 12) and 54 (second period, Figures 11b and 12). Vessel No. 19 appears to be indicative of the mean behaviours in the fishery as its fishing efficiency resembles that of the set of fishing vessels, i.e. with a wide distribution of efficiencies during the first fishing period and a restricted distribution during the second period (Figure 10).

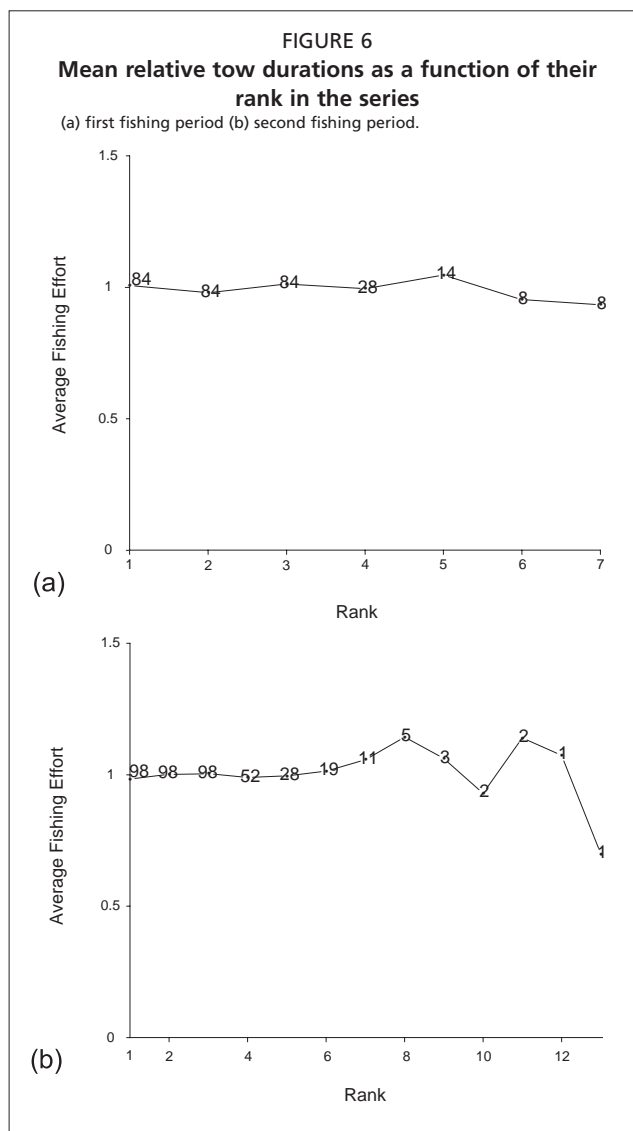


FIGURE 7
Ratio between two consecutive and co-located CPUEs of Patagonian toothfish

Experimental histogram (the number of observations per class is indicated) and model (dotted line). Values for parameters n and p are indicated: (a) first fishing period, (b) second fishing period.

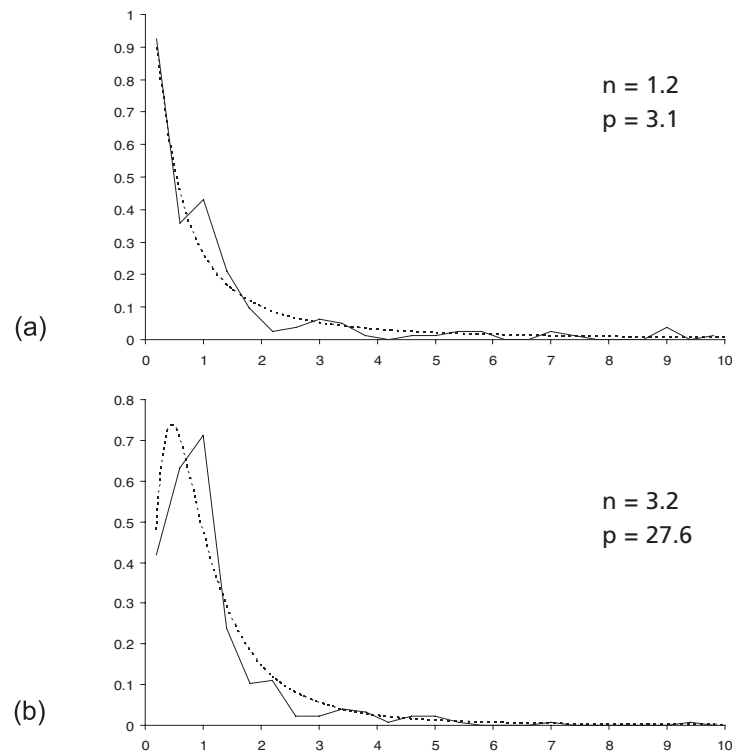
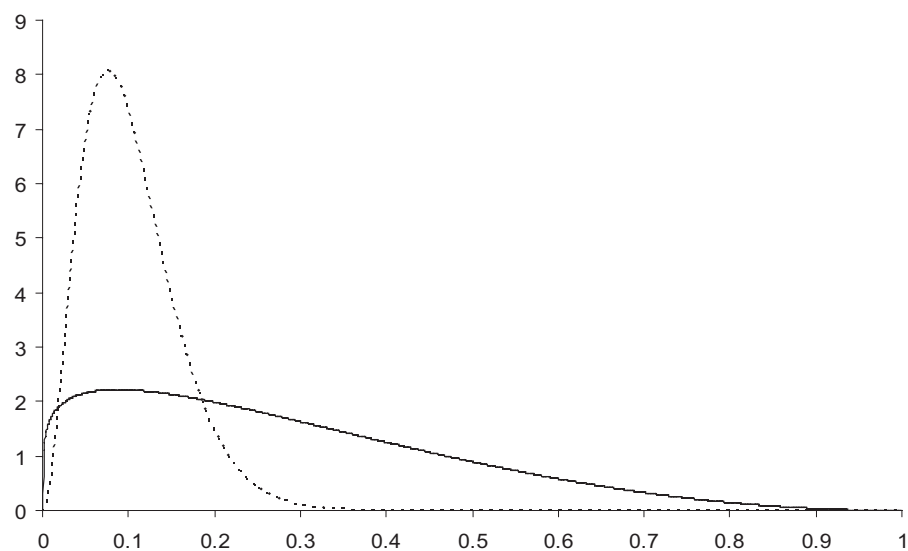


FIGURE 8
Estimated fishing efficiency probability density functions for the first fishing period

(continuous line) and for the second fishing period (dotted line)

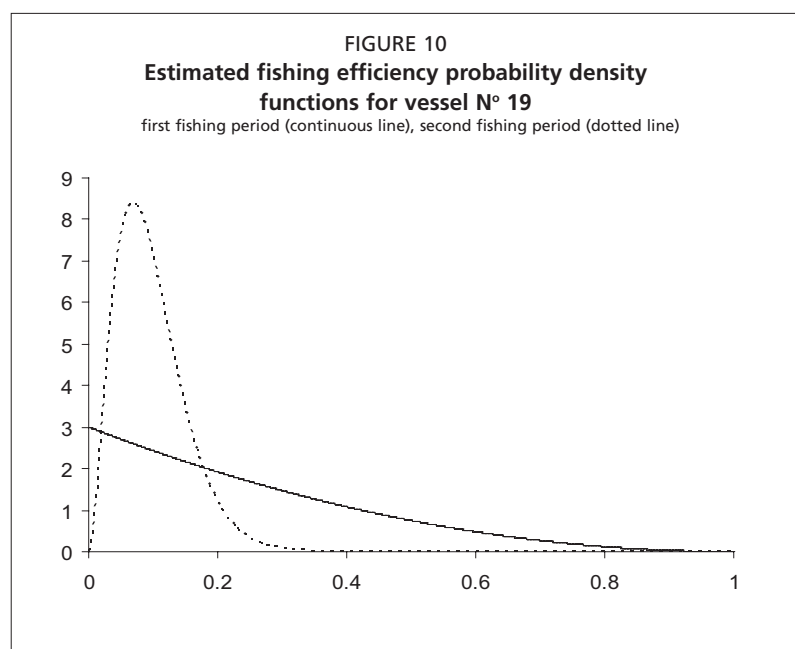
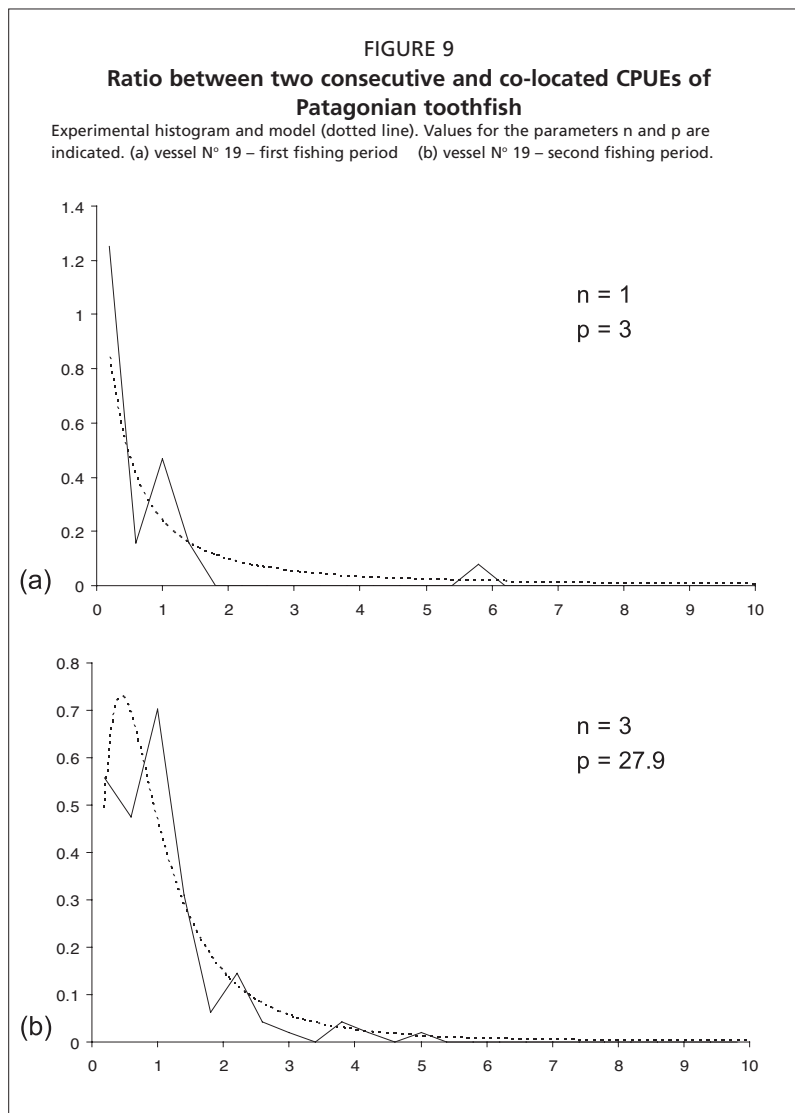


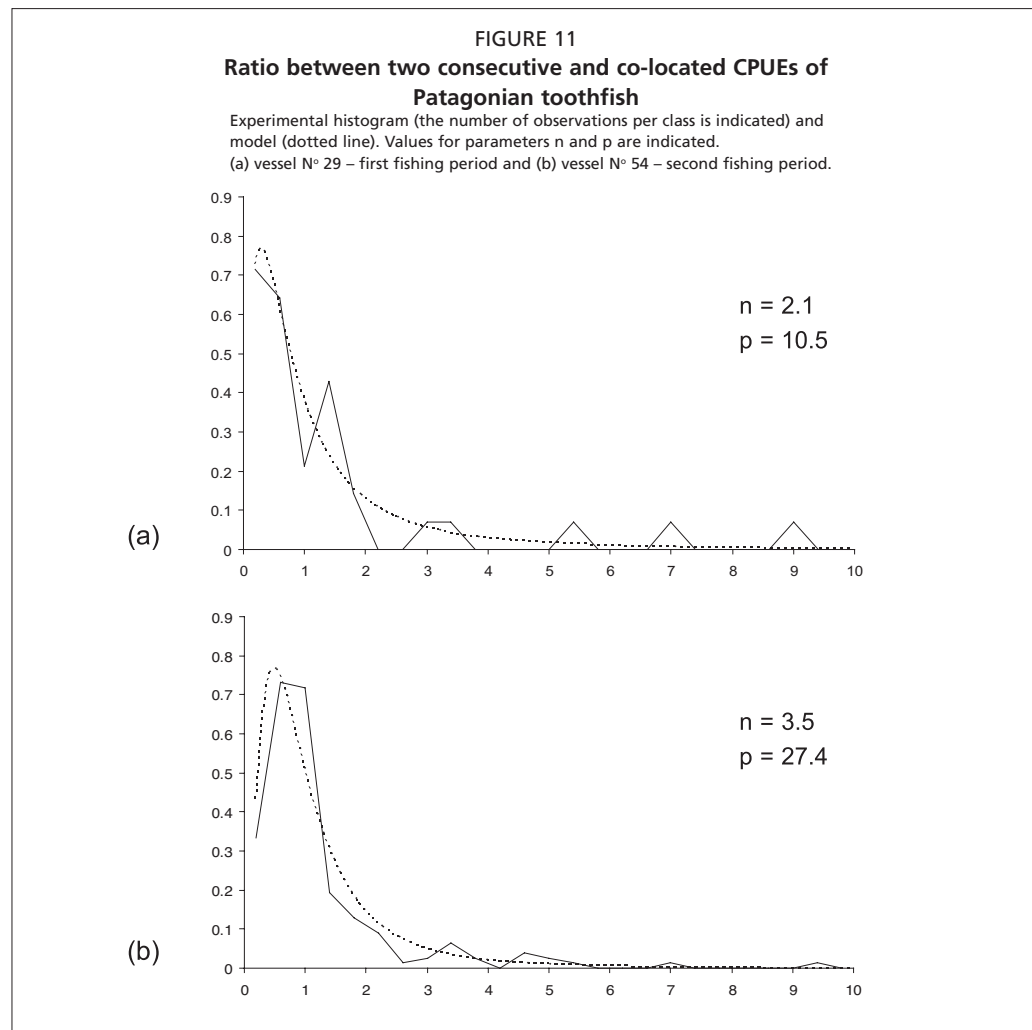
5. DISCUSSION

5.1 Sensitivity of the results to assumptions and to working parameters

We observed that the depletion effect was less and less clear when extending the spatio-temporal window used to build data series. For instance, the mean depletion effect was no longer visible when including tows more than two days apart and/or five nautical miles apart, instead of the 2 days x 1 nm window used in this study. Together with the fact that not all the series show a depletion effect and that some series even show increasing tendencies; this is an indication that the depletion effect is weak. But, to our knowledge, this is one of the few cases where this concept has been demonstrated with actual field data. However, it is often postulated *a priori* and included in bio-dynamic models (e.g. Maury and Gascuel 2001). Rijnsdorp *et al.* (2000) working on beam trawlers in the North Sea found a 10 percent decrease in CPUE over periods of 48 hours for flatfish fisheries. We failed to quantify the recover time partly because we could not control the sampling scheme (fishing grounds left out by a given vessel after a sequence of repetitive fishing are usually not left unfished long enough before fishing by other vessels start fishing).

The weakness of the depletion effect is also an indication that the use of tow-by-tow observers' declarations need be compulsory. Aggregated data would not have allowed observation of this phenomenon. Relaxing the





spatio-temporal window will enable including short spatio-temporal variability, which can be either large or small depending on the targeted species. The impact of this additional variability is as large as the studied signal is weak. The temporal variability is linked to the dynamics and to the mobility of the fish. The territorial behaviour of Patagonian toothfish is responsible for a high heterogeneous spatial distribution on a small scale.

Cells with zero-value CPUEs prevent the computation of a ratio. Ratios with a zero CPUE at the denominator have been grouped into a 'maximum' class, which was not used during the statistical analysis. However, only 7 percent of the CPUEs used in the series are null valued, which largely reduces the impact of this problem.

The use of successive CPUEs to analyze local depletion phenomenon is based on the assumption that there is no emigration and immigration of fish from, and into, the fishing area between two successive catches. This assumes that Patagonian toothfish do not move over a period of two days. Thus, all the fluctuations observed in the series of CPUEs around the exponentially decreasing reference model have been interpreted as owing only to variability of fishing efficiency. This simplistic assumption made it possible for the analysis to proceed further, but it means that an increase in CPUEs from one particular tow to the next has been interpreted as an increase of fishing efficiency rather than a movement of fish into the swept area. No biological field observations are available to support this assumption. However, Patagonian toothfish is known to be territorial and to make long migrations on a yearly basis (Williams *et al.* 2002).

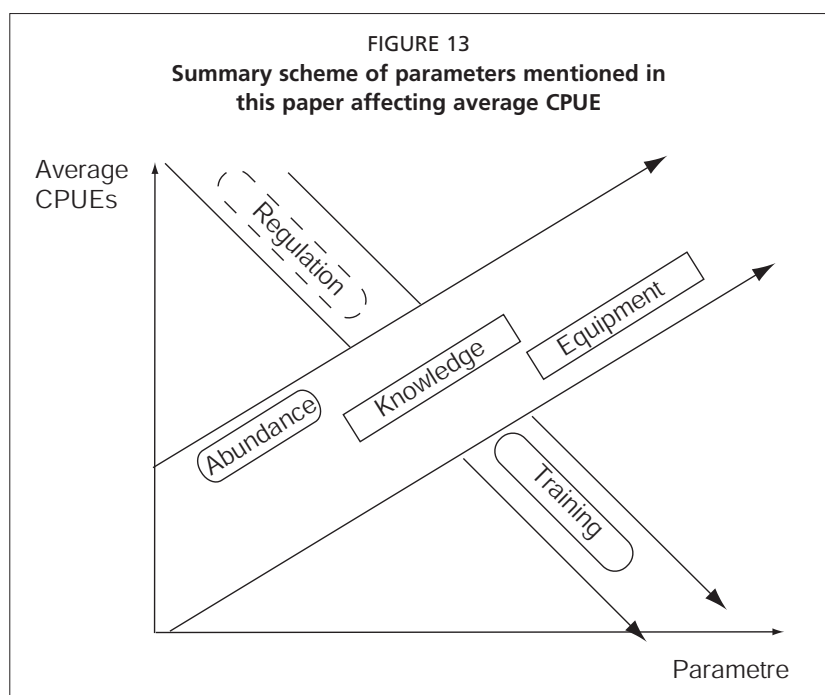
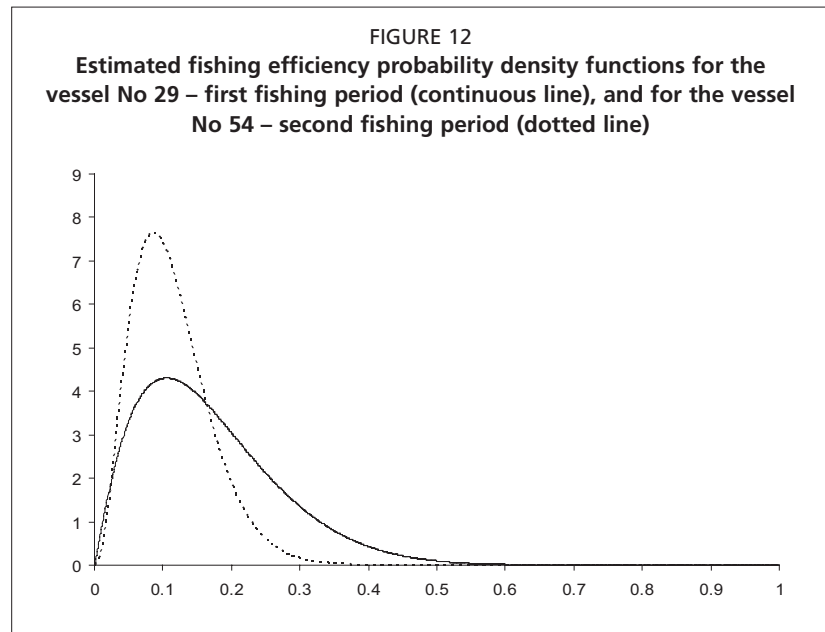
The fishing efficiency has been modeled based on a random variable that can also be justified by the nature of what a fish capture is. Fish capture is dependent on

several parameters, which are mainly uncontrolled or unknown. Their mixture at a macro scale results in apparent randomness in the fishing efficiency. The method used in this study makes it possible to estimate the p.d.f. of the fishing efficiency as opposed to an estimate of the fishing efficiency for any single tow. Based on the methods developed by Carle and Strub (1978), we could have used the series of CPUEs to estimate the fish density at the beginning of each series. However, this would have required that individual series all had a consistent depletion effect, which was not the case.

A false idea of the sensitivity of the estimations of n and p can be found in Bez, De Oliveira and Duhamel (in press). It appears that slightly divergent fits of the histogram of R_{ij+1} may induce large differences in the distribution of the fishing efficiency, i.e. in the parameters n and p . Still, the difference between the distributions of fishing efficiencies observed between the two fishing periods is large enough to indicate a real change.

5.2 Fishing efficiency, fishing regulation and fishing tactics

Generally speaking, the heterogeneous distribution of fishing effort is partly due to the skippers' fishing strategy (e.g. cooperation or competition) and can bias the linear relation between abundance and CPUEs. In this study, the strong repeated fishing strategy that is evident is associated with a slight local depletion effect (5 or 10 percent decrease a tow on average). When this happens, co-located CPUE values are not representative of the general local abundance and depending on the intensity of local depletion and the frequency of repeated fishing, this effect could induce biomass underestimations. However, De Oliveira, Bez and Duhamel (2001) showed that in the case of the Patagonian toothfish fishery, this negative effect



was compensated by the preferential location of repeated fishing in areas of high toothfish abundance.

On average, fishing efficiency has decreased by half from 1986–87 to 1995–97. Between the two periods, ten years of exploitation took place and induced an overall depletion of the resource (Anon. 1997). Many studies show that the ‘catchability’ is negatively correlated to stock abundance (MacCall 1976, Pitcher 1995, Mackinson, Sumaila and Pitcher 1997). Learning mechanisms may also have taken place as toothfish is a long-living species. Meanwhile, selection of the fish most reactive against fishing gear is likely to have occurred. Overall biomass reduction and fish learning processes would favour a decrease of fishing efficiency (Figure 13).

Producing a contrary effect, fishermen’s knowledge about the area and fishing technology (new kinds of net, increase of the fishing gear size, etc.) would have improved between the two study periods. The development of GPS also increased the capacity of fishermen to return to a particular site where appropriate. These elements would favour an increase of fishing efficiency (Figure 13).

Evolution, or changes, in the management of a fishery modify the fishing behaviour of fishermen. For the Kerguelen fishery, during the first period, the fleet was constrained by a global quota. Fishermen were then seeking the maximum catches to get the maximum possible proportion of the TAC. During the second period, individual quotas were implemented so that each fisherman was assigned an allowed catch quota.

This change in the fishing regulation induced a more relaxed exploitation of the fishing grounds: fishermen took fewer risks and did not search for large catches even when fishing on hot spots. In this latter case, they favoured small (i.e. less efficient) but repetitive tows in order to provide the crew with more regular catches while maintaining the same total catches. Vessel No. 19, which operated in both periods, is an instructive example in this regard. Its technical characteristics and its crew have not changed between the two periods. Yet still, its fishing efficiency became smaller and more uniform.

5.3 “Re-fishing”

Fishermen try to optimize their behaviour with regards to the constraints imposed by the resource and the management. When considering commercial CPUE measurements as samples of a fish resource, one must keep in mind that the sampling objective of commercial boats will differ from that of sampling to estimate a stock abundance. Generally speaking, commercial sampling networks do not allow the analysis of spatio-temporal variability (Laloë, Gaertner and Ménard 2002). The contrast is obvious when comparing the proportion of replicates, i.e. fishing in the same place which is usually zero in scientific surveys, but reached 80 percent in some of the commercial trips reported in this paper.

The consequences of a reduction of fishing efficiency and of repeated fishing on the mean CPUE can be easily indicated, at least qualitatively. If the change in fishing tactics consists of spreading the same total catches over several tows and if the fishing effort needed to get the same amount of fish is smaller when doing one tow instead of several, then the mean CPUE will decrease even though the biomass has not.

This study also makes it possible to revisit the criteria used to select a reference fishery when standardizing CPUEs. When data permit, i.e. when p.d.f. of fishing efficiencies can be computed for different methods or vessels, the reference group can be selected among those with a more stable fishing efficiency.

6. CONCLUSION

Identification and analysis of a series of co-located CPUE measures show, on average, a depletion effect on the Patagonian toothfish stock. From these data series, a model of depletion has been constructed and the p.d.f. of local fishing efficiency has been estimated for each period. On average, fishing efficiency has decreased by half from 1986–87 to 1995–97 and the p.d.f. is less dispersed during the second period. This change has been associated with the change in the fishery regulation, from a global quota to individual quotas.

Each fishery can be described by different parameters, which evolve with time, e.g. fishery regulation, stock abundance, resource behaviour, fishers behaviour or strategies and boat equipment. The improvement of fishermen's knowledge of Patagonian toothfish and the improvement of fishing technology (e.g. GPS) are expected to increase fishing efficiency. To the contrary, a decrease in Patagonian toothfish biomass due to exploitation is expected to reduce fishing efficiency.

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THEME 3

**Harvesting and conservation
strategies for
resource management**

Experiences in Southern Africa in the management of deep-sea fisheries

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1. INTRODUCTION

The mid-1990s saw the development of an interest among South African and Namibian fishing companies in exploration to discover deepwater fisheries resources. However, no economically viable fishable concentrations were found off the South African coastline. In nearly a decade, only two fisheries of any substance have developed:

- for orange roughy (*Hoplostethus atlanticus*) off Namibia and
- for Patagonian toothfish (*Dissostichus eleginoides*) off the Prince Edward Islands, sub-Antarctic islands belonging to South Africa.

At first glance, neither of these fisheries appears a management success story. Severe declines in catch rates (CPUE) suggest greatly reduced abundances as a result of inappropriately high catch levels, primarily a consequence of IUU fishing in the toothfish case.

More recent evidence and analyses suggest, however, that the status of the resources in both fisheries may well be considerably better than the bleak picture painted by such earlier appraisals. This paper summarizes the history of the changing perceptions over time concerning the status of these resources, together with the resultant management responses and concludes with a brief discussion of the implications of these experiences for the management of deepwater fisheries in general.

2. THE NAMIBIAN ORANGE ROUGHY FISHERY

2.1 The developmental stage

Exploratory fishing for orange roughy in Namibia commenced in 1994. Although the species is present over the full length of the Namibian coast, primarily in the 500–1 100 m depth range, only four consistently fishable aggregations have been found (see Figure 1). *Hotspot* was located early in 1995, followed later by *Johnies*; the following year *Frankies* and then *Rix* were added. (Actually *Rix* was first located in 1995, but only confirmed to be consistently fishable the following year.)

Management controls on catches were first imposed in 1997. A biomass estimate of some 300 000 t was obtained from trawl data using the swept area method (Branch 1998). The associated 90 percent probability interval of some 200 000, 500 000 t took account of assessed extents of uncertainty in the various inputs required to compute the estimate. Some 60 percent of this biomass was estimated to be located outside the aggregations.

These results, coupled to population model projections of abundance under alternative possible future catch scenarios, led to an annual total allowable catch (TAC) of 12 000 t being set for 1997 (Branch 1998). The long-term fishing strategy intended at that time is shown in Figure 2: over a 14-year period the TAC would be reduced from 12 000 to 5 000 t (90 percent of MSY as estimated at that time) as the resource abundance was fished down towards its MSY level. This was seen at the time as a fairly conservative approach, because the population projections suggested that the “risk”, taken to be the probability the resource would be reduced to less than half its original size by 2010 (the end of the planned 14-year fishing down period), was only a few percent (Branch 1998).

A year later, at the start of 1998, the best estimate of abundance provided by the swept area method had been revised down to 225 000 t, and an independent estimate of 150 000 t from acoustic surveys had also become available (Boyer *et al.* 2001). Although these revisions increased the level of “risk” compared to that computed a year earlier, it was argued that the 14-year fishing down period (Figure 2) could be reduced if need be, and the TAC was maintained at 12 000 t.

2.2 Resource collapse

Figure 3 shows the catches eventually realized by the fishery. It is evident that these did not turn out to match intentions at the start of 1997 (Figure 2). In 1999 the TAC was reduced to 9 000 t, but was heavily undercaught. A year later the TAC was brought down to 1 875 t. Further, the *Frankies* aggregation had been closed to fishing in 1999 as an experiment designed to assist in discriminating between different hypotheses (discussed below) for the decline in the fishery (Boyer *et al.* 2001, Branch 2001).

What scientific evidence underpinned this drastic action by management? Figure 4 shows the abundance indices available for the three major aggregations at the start of 2000. (Note that the *Hotspot* aggregation is appreciably smaller than the other three; the individual fish at *Hotspot* are larger and likely belong to a different population than do the fish at the more southerly aggregations.) A consistent appreciable decline in these indices from 1997 to 1999 is evident for all three aggregations; the industry’s difficulty in catching the TAC in 1999 is not surprising, given the large drop in catch rate (i.e. CPUE). Three hypotheses were put forward to explain these declines.

FIGURE 1
The Namibian coastline showing the fishery locations of the four orange roughy aggregations

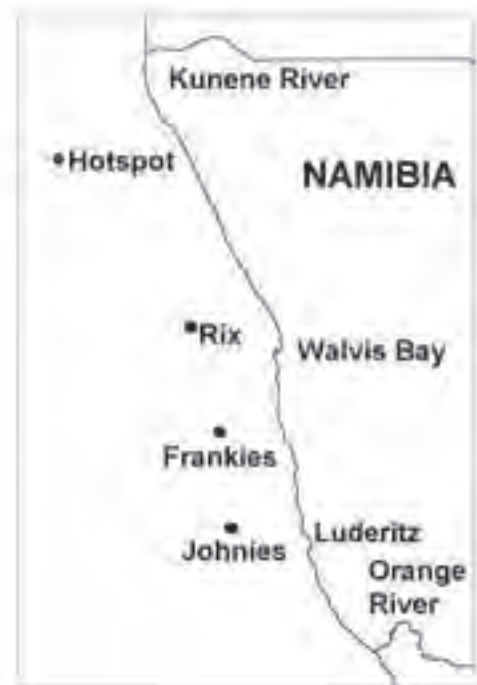
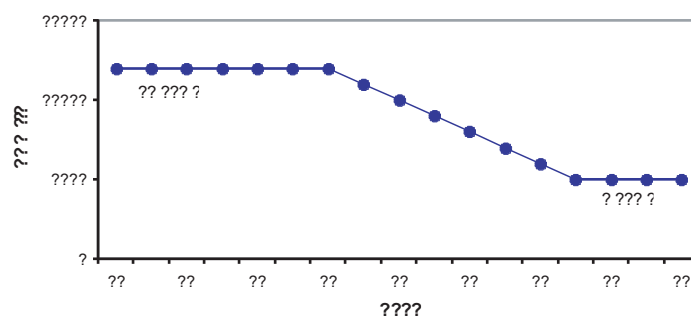
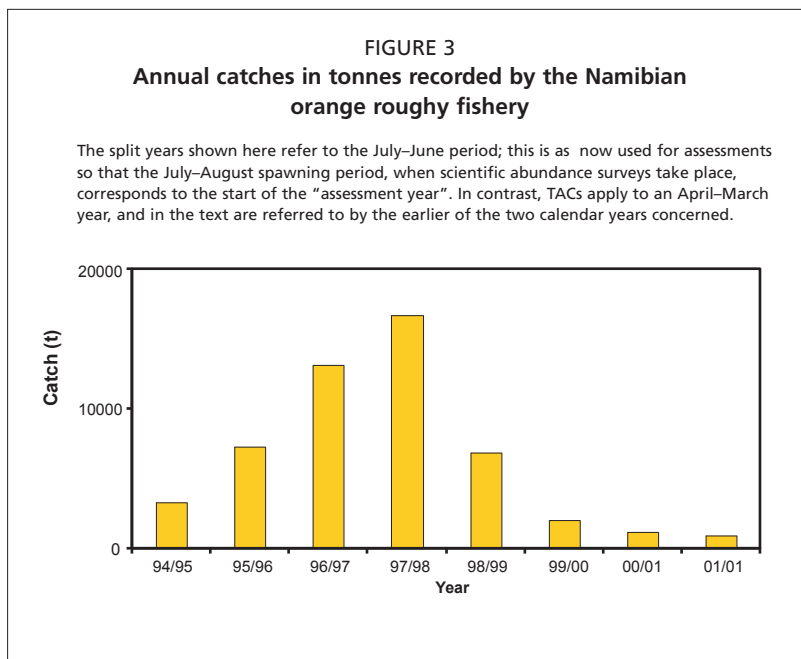


FIGURE 2
The fishing down strategy for Namibian orange roughy as planned in 1997

Over a 14-year period, a “soft landing” at a TAC of 90 percent of the estimated MSY was envisaged, with resource abundance still in excess of the MSY level at the end of the period.





i. *Fishing down*: lower index values reflected reduced abundance as a result of removals by the fishery.

ii. *Intermittent aggregation*: the proportion of the population to be found at an aggregation varies from year to year (although fish are present on the aggregations throughout the year, densities increase in the July–August period when spawning takes place).

iii. *Disturbance*: Repeated trawl tows over small areas (the sizes of the aggregations range from about 400 to as little as 50 nm²) discourage continued fish aggregation,

either because of disturbance to the fish caused by the trawls themselves, or damage done to the habitat by trawling.

Clearly the reductions shown in Figure 4 could reflect some combination of all three of these mechanisms. The decision to close *Frankies* to fishing had the intent of providing a better basis to assess the relative roles played by each. However, in deciding upon the 2000 TAC, a precautionary approach was adopted: it was based on assessments conducted under the assumption that the drops in the abundance indices were the result *entirely* of catch-induced reductions of actual abundance.

There were reservations about the defensibility of such assessments at the time. The acoustic surveys provided estimates of biomass in absolute terms. Even when allowance was made for plausible errors in values of the factors contributing to these estimates, the declines from their absolute (tonnage) values in 1997 (see Figure 4) were too large to be statistically compatible with the hypothesis that fishery removals alone were responsible. Nevertheless the TAC was kept low in following years pending independent evidence becoming available to support the alternative hypotheses ([2] or [3]).

2.3 A brighter future

Abundance indices maintained their generally low values in 2000 and 2001. However the 2002 acoustic survey of *Frankies* produced a remarkable result: an estimate almost at the same level as the 1997 high point (see Figure 5). This provided the independent evidence sought that the actual declines in abundance caused by fishing removals could not be as great as earlier trends in abundance indices had suggested.

Since *Frankies* was the fish aggregation at which fishing had been (almost entirely) suspended, this new evidence did not permit an hypothesis of intermittent aggregation to be distinguished from one of disturbance. Nevertheless assessments were revised using a method that made allowance for different proportions of overall abundance being present at an aggregation each year (Brandão and Butterworth 2003) and under the assumption that the distribution of these proportions estimated for *Frankies* applied also for *Johnies* and *Rix*. The results of these revised assessments are compared to those under the “catch-induced only” hypothesis in Figure 6, which shows that these revisions lead to a much more optimistic picture of the current state of the resource.

Acoustic surveys have continued only at Frankies because of target identification problems at the other aggregations; the swept-area trawl surveys have proved practical only at Johnnies as Rix has insufficient trawlable area and the high degree of aggregation of schools at Frankies leads to high variance estimates.

Table 1 lists results from these revised assessments, which reflect an increase in the estimated overall MSY from 1 620 to 2 750 t. In consequence the TAC for 2003 was increased to 2 650 t and a part of the *Frankies* aggregation has been reopened to fishing.

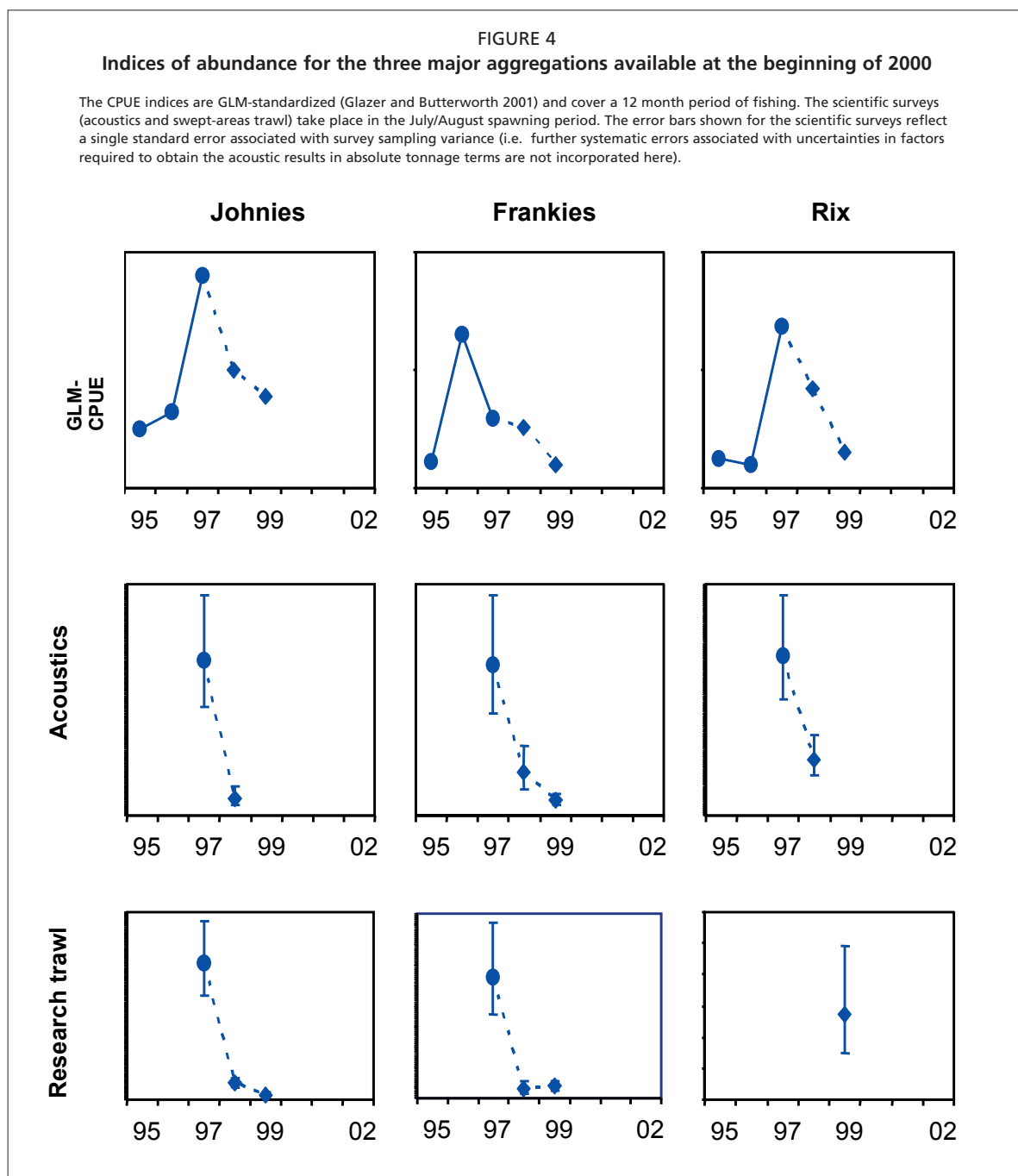
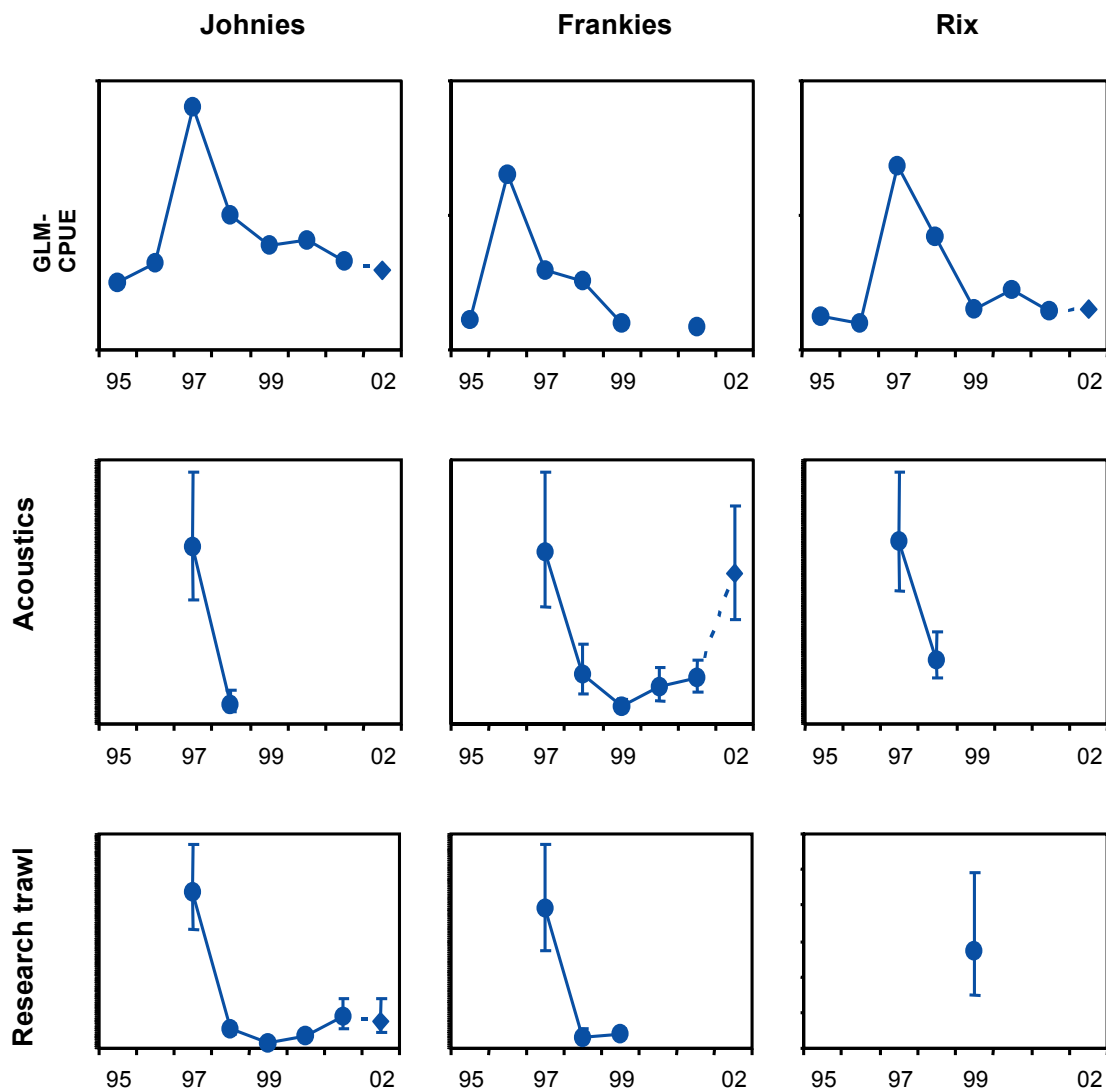


TABLE 1
Fishing area biomass and yield estimates

Estimates obtained for pre-exploitation spawning biomass (B_{initial}), spawning biomass at the start of 2002 (B_{2002}), their ratio and MSY under two hypotheses: (a) that declines in indices of abundance reflected only catch-induced reductions in true abundance, and (b) that differing proportions of overall abundance are present at aggregations each year. Units are in tonnes.

Aggregation	Catch-induced only				Intermittent aggregation			
	B_{initial}	B_{2002}	$B_{2002}/B_{\text{initial}}$	MSY	B_{initial}	B_{2002}	$B_{2002}/B_{\text{initial}}$	MSY
Johnnies	19 300	3 900	0.20	470	46 800	31 200	0.67	1 040
Frankies	19 700	6 400	0.32	470	38 300	24 800	0.65	880
Rix	25 100	15 900	0.64	580	29 500	20 400	0.69	670
Hotspot	4 300	400	0.10	100	8 000	4 000	0.50	160
Total	68 400	26 600	0.39	1 620	122 600	80 400	0.66	2 750

FIGURE 5
Indices of abundance as in Figure 4, but now extended to show information available at the beginning of 2003



3. PATAGONIAN TOOTHFISH OFF THE PRINCE EDWARD ISLANDS

3.1 Devastation by IUU fishing

The sub-Antarctic Prince Edward Islands are located to the southeast of South Africa (Figure 7). Figure 8 shows the estimated catch history for the toothfish fishery in the region (Brandão *et al.* 2002). Even given the inevitable uncertainties associated with estimating the size of illegal catches, it is starkly obvious that these operations have had a major impact on the resource, effectively before legal South African operations commenced.

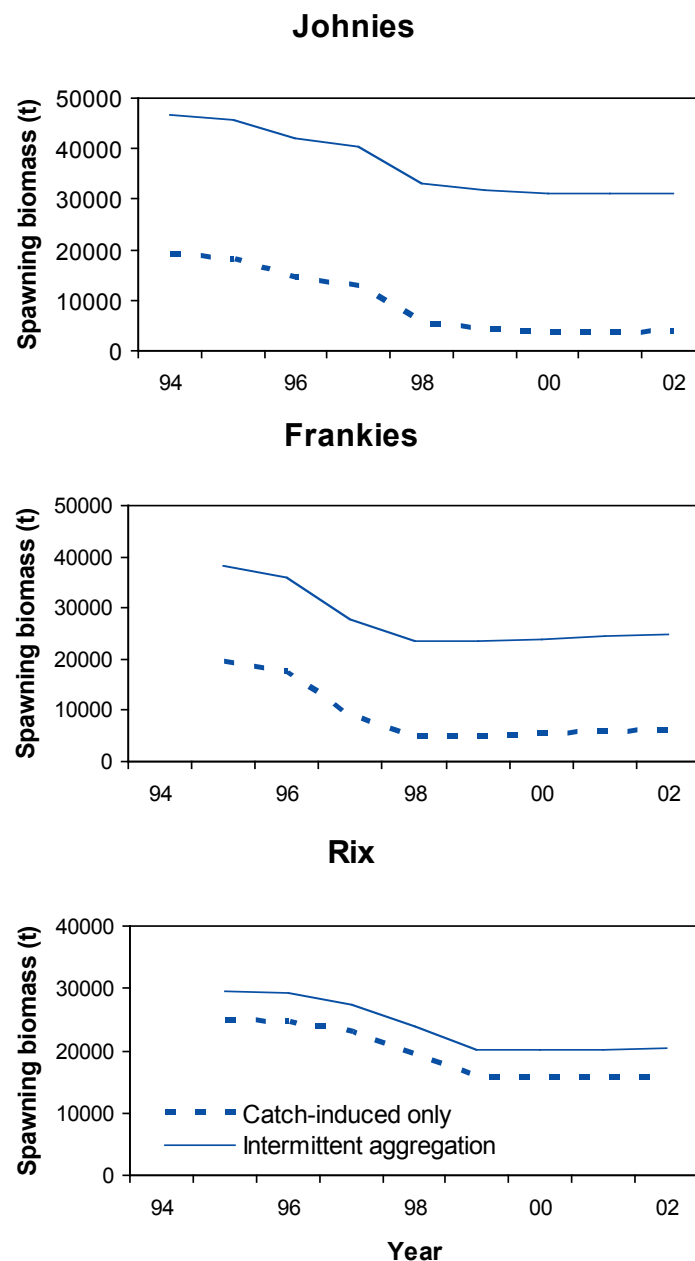
The CPUE trend from legal operations shows a marked decline, and an assessment based upon these data indicates the resource to be reduced to less than 10 percent of its pre-exploitation spawning biomass. At best the resource would be able to sustain an annual catch in the vicinity of a few hundred tonnes for only the immediate future (Figure 9).

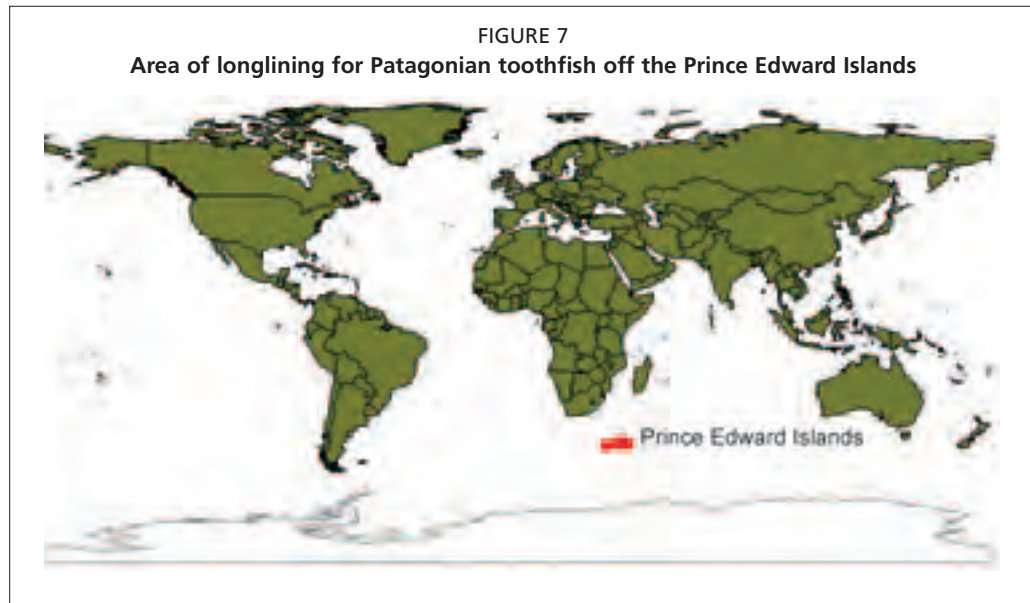
Why allow any legal fishing to continue on a resource that seems so depleted? The answer lies in the need to deter further illegal fishing. Frequent visits by patrol vessels to an area so far from South Africa would be too expensive. Thus the only practical deterrent is the presence of legal operators in the area. The scientific and management challenge, therefore, is to set a TAC that is small enough not to further deplete the resource, but large enough to offer South African companies sufficient economic incentive to send their vessels to the area.

3.2 Is the resource really so depleted?

There are a number of reasons why the current stock status indicated by Figure 9 may be overly pessimistic. For example, sperm and killer whales have learnt to remove fish from the longlines as they are hauled, which renders more recent CPUE values lower than appropriate for direct comparison with earlier levels.

FIGURE 6
Assessments of spawning biomass trends at the three major aggregations under the "catch-induced only" and "intermittent aggregation" hypotheses for the declines in indices of abundance



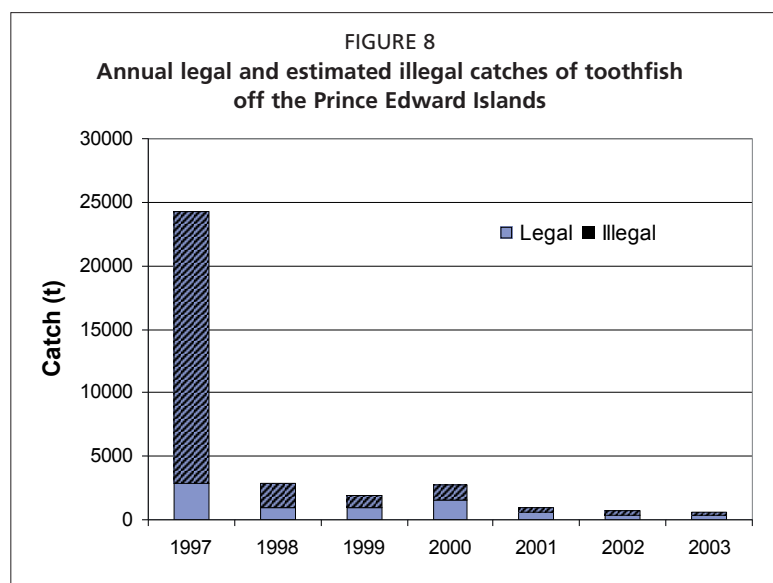


The most important caveat arises from the information available on the length structure of the legal catch. The top panel of Figure 10 shows the catch-at-length distributions predicted by the population model underlying the calculations for Figure 9. As a result of the heavy early fishing, the reduction in numbers of older (larger) fish should have produced a shift towards smaller fish in the catch from 1997 to 2003. Yet when the actual observations are compared (Figure 10, lower panel), there is little indication of such a shift.

If these catch-at-length data are taken into account when assessing the resource, an appreciably more optimistic appraisal of current status emerges. For the most straightforward forms of assessment, the CPUE and catch-at-length data are fundamentally incompatible. A better understanding of how fish size varies with location (notably depth), and of how fishing areal distribution patterns may have changed over time, is needed before it may become clearer whether it is the CPUE or catch-at-length data that are providing a more reliable picture of current resource status. Further analyses are also required to investigate whether the trends in catch-at-length data could perhaps be explained by a period of poor recruitment shortly before the fishery commenced, or by density dependent somatic growth.

4. GENERAL LESSONS

Deepwater species are typically long lived so that annual productivity may be no more than a few percent of their biomass. This means that recovery from appreciable resource depletion will be slow (see for example Figure 9). Even



though annual sustainable yield levels are therefore only small percentages of resource abundances, it is important that these levels not be exceeded by too large an amount in the early stages of a fishery to avoid unintended excessive depletion. This suggests the need to be conservative in setting TAC levels during these early stages, as initial estimates of abundance will inevitably be subject to large errors. With the wisdom of hindsight, the opening TACs in the Namibian orange roughy fishery were likely set too high.

On the other hand, for a variety of reasons, catch rate declines in these fisheries may well overestimate the extent to which fishing has reduced abundance. There is now clear evidence that this has been the case for the Namibian orange roughy resource and some suggestive indications that the same may apply for the toothfish fishery off the Prince Edward Islands. Further hindsight-assisted wisdom suggests that the TAC reductions in the Namibian orange roughy fishery as abundance indices dropped, although unquestionably necessary, were perhaps overly severe.

The possibility of intermittent aggregating behaviour, as seems to be the case for Namibian orange roughy, also has other important implications for management. Normally, situations where an industry is unable to catch its TAC in a year are interpreted as providing evidence that the resource is in trouble and that the TAC needs to be reduced. To the contrary, given intermittent aggregation, failure to land the full TAC should be the expectation rather than necessarily a concern. Pressures that may

FIGURE 9
GLM-standardized CPUE trend from the legal toothfishery off the Prince Edward Islands (shown by the dots)

The solid line shows the trend in exploitable biomass obtained by fitting an age-structured production model to these data. Future projections under annual catches of zero, 400 and 800 t are also shown.

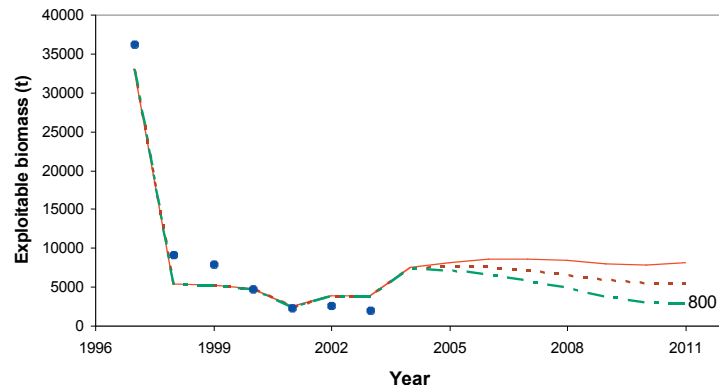
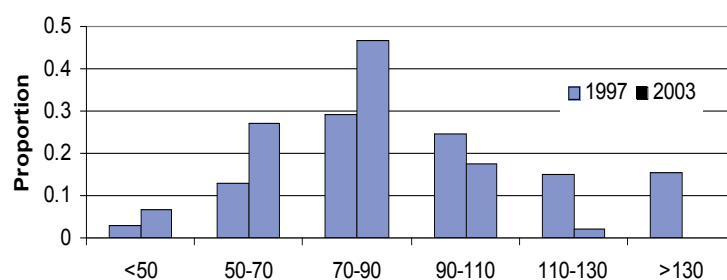


FIGURE 10

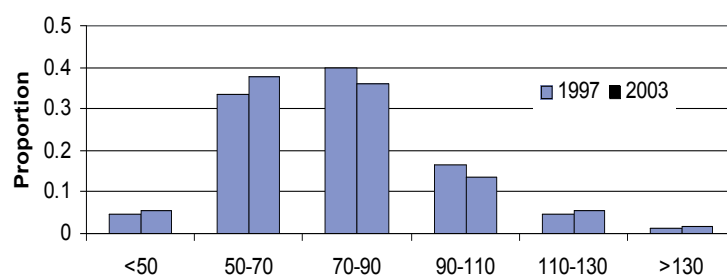
Predicted and observed length distribution

The upper panel compares the length distribution of the toothfish catch predicted by the model of Figure 9 for 1997 and 2003. The lower panel shows the corresponding distributions actually observed. The length units are in cm.

Predicted length distribution



Observed length distribution



force the industry to increase their available fishing effort to be able to land the TAC in years of low catch rates, and hence achieve only poor economic returns, need to be avoided. Instead, management flexibility is required so as not to preclude greater catches in years when a greater proportion of the fish aggregate.

5. ACKNOWLEDGEMENTS

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A phased approach to fishery development in the deep sea – a case study for the grooved tanner crab (*Chionoecetes tanneri*)

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1. INTRODUCTION

Developing a sustainable fishery requires that fisheries managers have a good understanding of the social, economic and biological issues and risks. There are numerous examples of fisheries developing rapidly in response to the economic factors, the “supply and demand” side of the equation, without either an understanding or plan of achieving an understanding of the social and biological consequences. This often results in a “boom and bust” type development with severe social and biological consequences. An example of this in British Columbia was the rapid growth and decline of the abalone fishery. Extraction of this resource is now prohibited to all users and the species is now listed as threatened under Canada’s recently implemented Species at Risk Act (Jamieson 1999, Campbell 2000).

In 1990, Fisheries and Oceans Canada (DFO) put a moratorium on new invertebrate fisheries on the Pacific Coast of Canada because there were not the resources necessary to ensure that new fisheries had management and assessment frameworks in place that would allow them to develop in an economic, social and biologically sustainable manner. In 1995, the moratorium was lifted and a Memorandum of Understanding (MOU) on the Development on new fisheries was signed between the Federal Government of Canada and the Provincial Government of British Columbia. The goals of this MOU (Phillips and Lauzier 1997) were to:

- i. diversify British Columbia fisheries and seafood production to ensure conservation of stocks and realize the optimal sustainable use of fisheries resources and fish culture
- ii. encourage a competitive business approach to fisheries and aquaculture diversification, and maximize marketing opportunities
- iii. diversify the seafood sector in British Columbia to promote employment opportunities, foster community development and secure social and economic stability and
- iv. encourage public and private sector cooperation in fisheries diversification, including new arrangements between regional communities, harvesters and growers.

To achieve these goals, DFO developed a Pacific Region draft policy on New and Emerging Invertebrate Fisheries. This draft policy was produced to provide staff and proponents with a consistent, inclusive approach in the development of management rules for new and emerging invertebrate fisheries. Hand-in-hand with the development

of this policy was the adoption of a phased approach (Perry, Walters and Boutillier 1999) to the biological assessment framework. The draft regional policy along with elements of the phased approach to assessment have subsequently been incorporated into the approved national policy and a regional implementation plan for new and emerging fisheries.

This paper outlines the processes that were followed and evaluates the success of the implementation of these policies in developing management and assessment frameworks for a deep-sea fishery for the grooved Tanner crab (*Chionoecetes tanneri*). It will also comment on the unique problems that arise because of the deep-sea nature of this fishery.

2. MANAGING THE PROCESS

There are a number of economic, social and biological principles within the implementation framework that form the basis for a managed process for development of a new or emerging fishery. From a social and economic perspective the principles deal with issues related to aboriginal people's access; transparency of the management procedures for allocation; and shared accountability and responsibility for insuring a sustainable fishery. The biological principles place conservation as the primary objective while ensuring that a precautionary approach is used in fishery development. In addition there is to be full accounting of all the ecological impacts of the proposed fishery. Finally, the framework requires a scientific base for assessment of the impacts of the fishery on the target species and the associated ecosystem.

The framework outlines a four-phase process to ensure that the development of a new fishery is consistent with the above biological principles. This process was originally described and adapted from work published by Perry *et al.* (1999). The phases of development areas follow.

- i. *The Review Phase.* This phase entails summarization of all known biological, distributional and fisheries related information on the target species and from similar species from similar habitats. A thorough review of the literature and all available data sources should provide some of the basic parameters necessary to develop a cautious, risk-averse approach to the development of a new fishery.
- ii. *The Experimental Phase.* This phase entails conducting experimental fisheries to assess abundance, distribution and productivity to determine if the stock and ecosystem can be exploited in a sustainable manner. This includes acquiring information either lacking or identified as potential risks during the Review Phase. This phase can be designed to meet a variety of needs including: testing assessment methodologies, evaluating the impacts of the fishery and adapting management strategies to test biological assumptions.
- iii. *The Exploratory Phase.* This phase consists of exploratory fisheries outside the experimental areas to assess whether the stock can support an economically viable fishery.
- iv. *The Commercial Phase.* This is the formal establishment of a fishery by developing and implementing a comprehensive integrated fishery management plan.

Upon completion of the Review Phase, a set of recommendations are sent to managers through the Pacific Scientific Advice Review Committee (PSARC). This information is then distributed to the fishing industry and First Nations' stakeholders along with an invitation to submit requests to participate in the experimental phase. The successful candidates then work with the Provincial Government and processing sector to develop a processing and marketing strategy and enter into the Experimental Phase of the fishery. The results of the experimental components of this phase are evaluated through the PSARC and the assessment framework is modified if the information does not answer the original questions or additional questions have arisen as a result of the new information. At the end of the Experimental Phase there is either

a recommendation for expansion or rejection of requests for the fishery to enter the next phase. As the fishery progresses through the successive phases, additional requests for participation are solicited. During the selection process, priority is given to those that meet the social principles outlined as well as recognition of the contribution of the initial proponents if they are still interested in pursuing the fishery.

3. THE CASE STUDY

3.1 Present status

The grooved Tanner crab fishery is presently in the experimental phase of development and as such the review can only deal with the progress to date. At this point in the process the only participants in the fishery are the Tanner Crab Fisherman's Joint Venture Association (TCFJVA), a collective of several interested fishers and other industry proponents.

3.2 The review phase

In 1997 Phillips and Lauzier (1997) summarized the biological, habitat and distributional information as well as information from other jurisdictions on fisheries sustainability and management strategies employed for this and another congeneric species, *C. angulatus*. This review led to a suite of recommendations that provided the context for the Experimental Phase in the development of this fishery. Critical to the development of the Experimental Phase (Boutillier *et al.* 1998) were the findings and recommendations as follows.

- i. Fisheries for these and other related animals have a strong history of failure.
- ii. Conventional management control systems that solely depend on size, sex and season (the 3Ss) decision rules are successful with respect to growth over-fishing but do not adequately address recruitment over-fishing concerns.
- iii. Assessment of fishery dependant catch-per-unit-effort data would benefit from the early imposition of standardized fishing gear.
- iv. All sources of mortality must be accounted for including bycatch of crab in other fisheries in the area.

3.3 The experimental phase

A research assessment framework for the Experimental Phase of the development of a grooved Tanner crab fishery was then proposed and peer reviewed (Boutillier *et al.* 1998). The intent of the framework was to address the issues raised in the Review Phase and develop the fishery in a way that met the biological principles outlined in the Policy above. The FAO guidelines on the precautionary approach to capture fisheries (FAO 1995) state that "research is required to help formulate biological objectives, targets and constraints regarding the protection of habitat, the avoidance of fishing that significantly reduces population reproductive capacity, and reduces the effects of fishing on other (e.g., non-target) species." In trying to develop an assessment programme that adhered to the Precautionary Principles, the framework focused on providing a better understanding of the resource, a better understanding the fishery effects, a validation of the assessment methodologies and pre-defined decision rules.

It was important in the management of the implementation of the Experimental Phase of the fishery to have a set of pre-defined conservation decision rules. For the targeted Tanner crab fishery these decision rules included: limited entry; gear type restrictions; expected production potential estimated within defined limit and target reference points; the 3Ss restrictions; limited area openings; data and observer requirements; and a reporting structure.

An assessment framework for the Experimental Phase was designed which used four sources of data to address questions regarding

- i. distribution and abundance of the grooved Tanner crab
- ii. identification and, where possible, quantification of the effects of direct and indirect fisheries on the resource and its ecosystem
- iii. verification of the assumptions and estimates used in establishing F -based precautionary reference points, and replication and testing of the assessment methods.

3.3.1 Data sources used in the assessment framework

3.3.1.1 Types of surveys

The four sources of data used in the assessment framework were (a) fishery independent trawl surveys, (b) fishery independent trap surveys, (c) fishery dependent observer data from the targeted trap fishery and (d), fishery dependent observer data from other fisheries prosecuted in the same area.

3.3.1.2 Fishery independent trawl surveys

Annual fishery-independent swept-area trawl surveys were planned over a four year period. Each was of three weeks duration and were planned to cover the 400 to 2 200 m depth range of systematically-determined sampling strata along the B.C. shelf slope. Gear breakdowns and other problems have prevented this work from being completed at this time. These surveys provided distributional data and swept-area biomass density estimates, which were used in the calculation of crab biomass indices. The surveys also provided important biodiversity data on the associated organisms occupying the same region. In addition, they provided unbiased biological information on size and sex of the animals as well as a better understanding of depth distribution and range of the Tanner crab by size and sexual condition.

3.3.1.3 Fishery independent trap surveys

A series of systematic fishery-independent trap surveys of the entire coast were completed by industry using standard traps, bait and where possible, soak-times. These intensive surveys provided synoptic distributional information for the crab resource. Standardized trap catch-per-unit-effort data (CPUE) provided a ratio of relative abundance indices from trawl-surveyed index sites and non-surveyed areas. These ratios were used to estimate overall biomass. This synoptic survey allowed us to obtain qualitative and quantitative information on bycatch issues associated with a targeted trap fishery.

3.3.1.4 Fishery dependent observer coverage in the experimental targeted trap fishery

Fishery-dependent trap CPUE and biological sampling data in the experimental targeted trap fishery was collected by the fishing crew and certified observers. This information helped characterize commercial fishery effort and understand what components of the crab stock and ecosystem were being affected by the targeted trap fishery. This in turn provided information on the limits of using fishery dependent data in assessing the total population. Fishery dependent information from experimental areas that are purposely heavily exploited can provide an independent depletion estimator of biomass to validate other assessment methodologies. In addition, the experimental fishery provided product for market testing and a source of income for the industry to help offset some costs of fishery management and assessment (e.g. observer costs).

3.3.1.5 Fishery dependent observer coverage in other fisheries

Bycatch monitoring in other fisheries provided estimates of total mortality for the grooved Tanner crab resource. To understand the impact of the targeted crab fishery on the ecosystem, it is necessary to quantify the cumulative effects of other activities

that also affect the same system. Observer data from other fisheries were examined to qualify and quantify, where possible, the magnitude of the impacts on this slope ecosystem of the other fishing industry sectors.

3.3.2 Results to date of the experimental phase

3.3.2.1 Distribution and abundance of the animals

One of the important outcomes from the work conducted to date is a better understanding of the spatial and temporal distribution of grooved Tanner crabs by size category and sex. From initial work in the Experimental Phase, Gillespie *et al.* (in press) found that their depth distribution to be 400–1 460 m with the bulk of the adult population occupying the 600–1 200 m range during the summer months. Females tended to occupy a slightly shallower, narrower depth range than males with females not found below 1 160 m. Breeding aggregations occurred in the late winter in 600–800 m. Juvenile animals tended to be broadly distributed over a range of 600–1 600 m. There were no juvenile animals below 1 600 m although juveniles of the congeneric triangle Tanner crab (*Chionoecetes angulatus*) occurred from 1 200–2 000 m.

Geographically, the highest abundance of crab was found along the west coast of Vancouver Island. Centres of the highest concentrations appear to be in areas off the northern portion of the west coast of Vancouver Island.

A biomass estimate was required to establish decision rules for managing this fishery. Indices of biomass were calculated by combining the results of the index site swept-area trawl surveys with the coast-wide systematic trap survey data. Swept-area trawl surveys of the index sites provided estimates of density and biomass indices for the index areas along the coast. This density information was then extrapolated to non-trawled areas using a reference trap catch-rate ratios between trawled and un-trawled areas. A linear relationship was assumed in calculating extrapolated biomass indices between reference trap catch-rate ratios and density. We also assumed that survey catchability in all these surveys remained constant over years (Workman *et al.* 2002, Gillespie *et al.* in press).

3.3.2.2 Targeted and non-targeted fishery impacts

The targeted trap fishery caught high proportions of female and undersized male grooved Tanner crab. Catches of other animals were low in most areas of the coast with the exception of the more northerly areas which tended to have a high incidental catch of other potentially commercially-valuable crab species, primarily the lithodid crabs *Paralomis multispina* and *Paralomis verrilli*.

Total catch of grooved Tanner crab is quite large in the groundfish trawl and trap fishery. In the trawl fishery, bycatch is documented with 100 percent observer coverage. The duration of tows in commercial trawl fisheries is up to 7 hours and the abrasion and crushing on these soft-bodied animals would guarantee that mortality rates are close to 100 percent. Bycatch of grooved Tanner crab in the pot fishery for sablefish (*Anoplopoma fimbria*) is not well documented but the small amount of observer data that are available indicate that Tanner crabs are a common bycatch in this fishery. Although there are no data on survival of catch and release animals, in general the animals are in good shape when they are brought up. One might hypothesize that discard mortality in the sablefish pot fishery is potentially low if the crabs are handled properly since Tanner crabs from the targeted trap fishery are kept alive on the boats for a number of days prior to landing at processing plants. For the purposes of harvest decision rules for the targeted Tanner crab fishery, handling mortality from all fisheries is assumed to be 100 percent. As a result, bycatch discard mortality is estimated, in some areas, to exceed initial conservative catch limits for this species.

From an ecosystem perspective, grooved Tanner crab play an important role as a major prey item. Stomach analysis of fishes taken in the trawl survey catches shows that tanner crab is a major prey component of many of the larger fishes in this region. In addition, the index 'swept-area' trawl survey provided a new perspective of the biodiversity of animals that were associated with grooved Tanner crab. The most interesting result was that a large number of the animals encountered were either rare, represented new records, or in a number of cases, were newly defined species. There is little information available on most of the animals and in most cases there is a problem with their proper identification, never mind their biology or role in the environment. Finding the people and resources to identify these animals has been a major challenge, but to date we have been able to identify 114 species of fish and over 230 invertebrate taxa from deepsea Tanner crab surveys conducted between 1999 and 2003.

At least 19 species of fish were recorded for the first time from British Columbia waters by these surveys (Gillespie 1993, Mecklenberg *et al.* 2002, Peden and Gillespie, in press). Of these, two were sculpins (Cottidae and Psychrolutidae), two were eelpouts (Zoarcidae) and five were snailfishes (Liparidae). Further examination of material that has not been identified to date will add to this total. There were collections of at least 40 other fish species that either confirmed the species' presence in British Columbia (*i.e.*, were second or third records) or provided new distributional limits. The majority of these were eelpouts (eight species), snailfishes (five species) grenadiers (Macrouridae, five species) and skates (Rajidae, four species).

Three species of crab were recorded for the first time from British Columbia. Two of these species were galatheids (Galatheidae) and the third a decorator crab (Majidae). Additional information was also collected on the distribution and biology of two crabs known only from single records in British Columbia (Hart 1982), *Oregonia bifurca* (Majidae) and *Paralomis verrilli* (Lithodidae). Two species of the shrimp, *Pandalopsis glabra* and *P. ampla* (Pandalidae) were recorded for the first time from British Columbian water. Two species of pycnogonids were captured, but their specific identity has not yet been confirmed.

Although the trawl gear used in the survey was not designed to sample infaunal bivalves, 14 species have been recorded, including one species reported from British Columbia for the first time. A total of 16 species of cephalopods have been identified to date, including one species of deepsea octopus that had not previously been reported for British Columbia. In addition, three forms of *Benthoctopus* spp. were collected that have not yet been identified as to its species. The number of squid species will increase, as most gonatid squids were identified only to genus and wait until further identification can be completed.

Numerous examples of hydrozoans, anthozoans and sponges were collected and progress towards establishing confirmed identifications as to species is currently underway. Findings to date have identified at least three new species of black corals, *Antipatharia*, and one new species of octocoral, *Paragorgia* spp. Final descriptions of holotypes are being worked on by colleagues at the Smithsonian Institute.

Echinoderms were well represented in the samples with at least seven species of Holothuroidea, 47 species of Asteroidea, 20 species of Ophiuroidea, two species of Criidea and three species of Echinoidea, which were identified at the Royal British Columbia Museum. There is still a great deal more work to be done to get basic information and complete the identification of animals that we have collected from these deep regions of the ocean.

Accurate quantification of bycatch has become an issue for all fisheries in this deepwater region, especially the trawl fishery. There are also issues with respect to the quality of bycatch information from observer reports as it does not match the biodiversity information from crab trawl index surveys. It is quite understandable that the quality of observer data is lower considering the problems with identification, and

not detecting, or recording, rare or unusual animals due to sub-sampling protocols and extrusion of soft-bodied animals through the net. A review of the bycatch issues in the trawl fishery has been requested by senior DFO managers.

3.3.2.3 *Verification of assumptions and estimates used in the surrogate reference points and testing assessment methods*

Working in the deep ocean environment has provided a number of new challenges for standard assessment methods. For a swept-area trawl survey in the shallower range of depths, <1 000 m, a third wire net sonar or SIMRAD ITI net monitoring system was used to measure the opening of the net and net bottom contact time and distance to better calculate the area swept by the trawl. However, in depths >1 000 m, this equipment was not functional, so that the area swept was calculated from the time the net was on the bottom and the distance traveled using estimates of sink rate calculations to determine bottom contact time and assuming that the net mouth width remained constant.

The paucity of biological and fisheries information for many stocks has led us to identifying surrogate reference points for the fishing mortality (F_{MSY}) and stock biomass level (B_{MSY}) that produce maximum sustainable yield (MSY). A decision equating F to the natural mortality (M) of the animal was used as the decision to determine yields near the MSY (Gulland 1971). It has been suggested that the value of F should be a scaled value of M (i.e., xM) where x ranges from 0.2 (Garcia, Sparre and Csirke 1989) to 0.4 (Caddy 1986) or 0.5 (Gulland 1971). For the grooved Tanner crab fishery, we choose F at $0.2M$ to be used as a default proxy for F_{MSY} .

The biological estimates of growth and age used in estimation of M for the surrogate F -based reference point were initially set at levels typical of long-lived, slow growing animals (Boutillier *et al.* 1998). This approach is assumed to be overly conservative but there are still a number of questions unanswered with respect to the age and growth of Tanner crabs. Of particular interest is whether deepwater Tanner crabs have a terminal moult as this is known to occur in its shallow water congeners (Tester and Carey 1986, Somerton and Donaldson 1996) or whether they show some other form of growth pattern including 'skip molting' and it may be possible to use radiometric methods to estimate shell age (Nevissi *et al.* 1996). This biological information is critical to calculating an estimate of M for use in establishing an appropriate F -based reference point using the modified Gulland method.

It was hoped that biomass assessment procedures could be validated during the experimental phase, however, effort to date has been insufficient to produce a depletion estimate that can be compared to the trawl and trap index estimates.

3.3.2.4 *Other findings*

An examination of the health of the crabs from the trawl index area surveys has found a high prevalence of Bitter Crab Disease caused by infection with a parasitic dinoflagellate, *Hematodinium* sp. Although infection rates are relatively low in adult crabs, they are high in juveniles and as such could have a significant effect in determining year class strength (Gillespie *et al.* 2004).

3.3.3 *Recommendations and modifications to experimental phase*

Distribution and abundance information has been used to set the location and timing of the fishery to ensure that the potential impacts are managed in a way that minimizes risks. Targeted and non-targeted fisheries impacts are used to modify quotas and limit the areas of impact to prevent capture of bycatch species of concern. In the targeted fishery, we have recommended evaluation of gear modifications to reduce bycatch of female and undersized male crabs. In the non-target fisheries, focussed attention on the need to coordinate management and develop an ecosystem approach to all the

fisheries in this region that affect the continental slope. We are still seeking information for evaluating model assumptions and assessment methodology and will use this information to redesign the assessment framework as necessary. New information on the incidence of disease may provide information on stock structure as well as assist in understanding a mechanism that may control year- class strength.

As a result of this additional information gathered to date, the following modifications to the fishery were recommended.

- The targeted fishery be restricted to the west coast of Vancouver Island. This leaves large areas of the British Columbia coastal waters free of impacts from the directed trap fishery, allows the trap fishery to take place in areas that are lightly affected by non-targeted trawl fisheries and focuses the fishery on a relatively small area so that the effects of fishing on population dynamics can be assessed more quickly. It also excludes areas where there are concerns regarding bycatch of other crab species by the trap fishery.
- Commercial trap gear modifications will be evaluated to determine if the location of the escape ring or the use of collars is a practical solution to reducing the incidental catches of female and undersized male crabs.
- The season will open earlier to evaluate the impact on the stock as well as markets.
- Tagging will be evaluated to determine if it can be used to evaluate biomass estimation procedures or provide new life history information related to age, growth and moulting patterns.
- A depletion experiment will be attempted in an area to validate the swept-area trawl abundance estimation procedures.
- Senior managers have directed stock assessment personnel to assess bycatch and ecosystem impacts of the other fisheries in this region. The objective of this assessment is to provide the basis for an ecosystem-based management framework for all the deep-sea continental slope fisheries.
- Repeated annual swept-area trawl assessments will be carried out in fished and unfished reference areas.
- Effort standardization studies will be designed to examine the relationship between soak-time and catch-rate.
- All other restrictions and decision rules outlined above will remain the same.

4. EVALUATION

4.1 Criteria

The fishery was evaluated against the conservation principles in the National Policy on New and Emerging Fisheries to assess the effectiveness of this phased approach to achieving a sustainable industry. As the fishery is still in the Experimental Phase of development, the following is an interim assessment. The criteria used in the evaluation framework included:

- conservation not to be compromised; key scientific requirements include estimates of abundance, distribution, productivity
- all potential impacts or interactions to be assessed and
- prior to commencement of a fishery, fisheries managers to establish conservation standards, set conditions for harvest and monitor their application.

4.2 Conservation will not be compromised

Management of the targeted fishery addresses conservation in a manner that is consistent with the precautionary approach. Until the stock structure of Tanner crabs is better understood, the fishery is managed on a fairly fine scale to ensure that sequential overfishing does not occur. Tanner crab distribution is better documented and the experimental targeted fishery

will only be allowed to exploit a small portion of the available stock. Selection of the location of the fishery will depend on achieving commercially viable catches of grooved Tanner crabs while reducing the potential impacts of bycatch of other species. Other control (non-fished) areas will be monitored with fishery independent surveys in conjunction with the exploited areas to evaluate the fishery impacts. However, there may be a problem with harmonizing decision rules in the other trawl and trap fisheries in these control areas to ensure that the exploitation of grooved Tanner crab is stopped or significantly reduced, if necessary.

4.3 All potential impacts or interactions will be assessed

In general the potential impacts or interactions of the fishery are being measured but the ecosystem impacts have yet to be fully assessed. A detailed record of the identity, density and location of all species encountered is being made as part of the trawl survey. It will not be possible however to distinguish the impact of a targeted grooved Tanner crab fishery from the impacts of other fisheries occurring in the same areas. Information from this assessment framework can only be used to monitor ecological effects in the area from all fisheries combined. It is planned to present managers of other fisheries with biodiversity information from this assessment so that they can develop information standards that provide a more accurate assessment for partitioning ecosystem impacts by fishery.

The total weight of Tanner crab bycatch in other fisheries is accurately accounted for in fisheries that have mandatory observer coverage, however, crab bycatch will have to be estimated from historical observations for unmonitored fisheries. These data will be combined with the total landings and estimates of bycatch mortality from the targeted fishery to estimate total mortality. Estimated total removals are accounted for in the establishment of decision rules for the targeted fishery. Some areas are not available to a targeted fishery as bycatch from other fisheries meet or exceed the present estimates of production potential. Bycatch in the non-targeted fisheries are not controlled and so, total catch in some areas from these trawl and other trap fisheries often exceed the recommended allowable catch.

Although no formal data have been gathered to date, limited qualitative examinations indicate that Tanner crab is a major component in the diets of many of the fishes inhabiting the continental slope. No modeling (e.g. EcoSim or EcoPath) of the implications of removals of Tanner crab from this ecosystem is planned at this time.

4.4 Establishment of conservation standards, setting conditions for harvest and monitoring their application

Prior to commencement of the experimental targeted Tanner crab fishery, decision rules for harvest rates were established. These decision rules were based on the most conservative estimates of natural mortality and crab production characteristics. In developing fishing plans the removal of animals from all sources were accounted for and mortality was assumed to be 100 percent from all sources. These decision rules will not change until there is greater certainty that the productivity and resilience of these animals is higher than initially estimated.

Harvest conditions for the targeted fishery were established and monitored. Monitoring of the targeted Grooved Tanner crab fishery revealed problems of bycatch of female crab and the harvest conditions have been modified to address this issue through the use of more effective escape and, or, exclusion mechanisms.

Within the assessment framework, the decision rules for the fishery are to be tested by comparing multiple biomass estimation procedures, evaluating the population responses to experimental fisheries using various exploitation rates and monitoring large non-fished control areas to explore natural variability of Tanner crab population dynamics.

A series of more intensive surveys are planned to compare assessment methodologies such as depletion experiment and tagging studies, and monitor and compare populations in both fished and unfished control areas.

5. CONCLUSIONS

This approach for the development of the grooved Tanner crab fishery has a number of benefits. Clear policy statements for this programme provide both a forum for fair and open decision making and unambiguous objectives that are understandable to both industry and government. This resulted in industry understanding and accepting the risks and true costs of fishery development and the efforts needed to control their fishery impacts. The programme compels industry to develop a business plan that takes the policy objectives and associated costs into consideration. The result is that capitalization and fishery development are slowed to a more cautious pace. Industry has been intimately involved in providing the assessment information required to ensure a sustainable fishery and there has been good interaction between the Tanner Crab Fisherman's Joint Venture Association and the Department of Fisheries and Oceans. Most importantly, the programme has allowed collection of organized and detailed biological information for grooved Tanner crabs prior to the onset of exploitation and allowed for experimental approaches in the earliest stages of development.

Some of the drawbacks to the phased approach are not unique to harvesting of Tanner crabs, but are common to most new and developing fisheries (Perry *et al.* 2005). The slow pace of development may be frustrating to industry, but it also allows fishery development to proceed over a time frame needed to demonstrate variability in market price, an important aspect of a business plan. The requirement that development be cost-neutral to the DFO has resulted in delays inherent in finding new funds and hiring and training new staff for the programme. It is perhaps unrealistic to assume that industry can support all of the development costs, thus it is imperative to the proper functioning of this system that sampling protocols are effective and cost efficient.

Major problems in the development of assessment information for this fishery have arisen because the deep-sea environment provides a unique and difficult ecosystem to work in. To date we have had difficulties in adapting standard assessment tools (trawl standardization, tagging, etc.) to working in this environment. In addition, the identification and biology of the animals and their function in this deep-sea ecosystem are poorly understood. At the most basic level, the taxonomic expertise necessary to identify the array of marine organisms that has been encountered is scarce and widely distributed throughout the world. There is a huge need to recognize this problem and push forward coordinated programmes to address gaps in taxonomic expertise at national and international levels.

The other major problem specific to this targeted fishery has been the inter-industry conflicts that exist in relation to fisheries on the continental slope of British Columbia. Inter-industry conflicts occur when management plans for different fisheries are not integrated. This generally occurs when policies and implementation plans are not well integrated between the different gear sectors. If left unresolved, these inter-industry conflicts can result in social, economic and biological issues that ultimately result in conservation problems and unsustainable fisheries.

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Ecological risk assessment of the New Zealand hoki fishery

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1. INTRODUCTION

In 2001 the New Zealand hoki fishery was awarded Marine Stewardship Council (MSC) certification under its Fisheries Certification Programme. This was awarded after an independent assessment of hoki fishery management practices against the MSC's *Principles and Criteria for Sustainable Fishing*. As part of its ongoing certification commitments, the Hoki Fishery Management Company (HFMC)¹ was required to undertake an ecological risk assessment (ERA) of its fishing activities.

This paper reports on the process of developing and applying a comprehensive ERA methodology, including the extensive stakeholder engagement process adopted by the HFMC. The more technical aspects of the risk analysis framework and the specific outputs of the ERA are available on the HFMC website <www.hokin.z.co.nz> .

2. THE NEW ZEALAND HOKI FISHERY

The hoki fishery is by far the largest of New Zealand's commercial fisheries representing more than half of the total tonnage fished under the New Zealand Quota Management System (QMS). It is a valuable resource for local and export markets earning over NZ\$300 million in annual exports and amounting to approximately 20 percent of the total annual exports from the sector. The major markets for hoki are the United States and Europe, while Japan and Australia are also important markets.

Hoki are found throughout New Zealand waters, but the main catching grounds are off the West Coast of the South Island, in Cook Strait and on the Chatham Rise. The fishery is managed under the QMS, which is designed to ensure sustainable use of fisheries resources while allowing economic efficiency in the industry by prescribing a strict limit on the amount of quota species that can be taken each year. This limit, the Total Allowable Commercial Catch (TACC), is based on biological data of the size of the resource and its productivity along with other information provided to the Government by stakeholders in the fishery. The TACC for the hoki fishery was set at 200 000 t for the 2002/2003 fishing year – the year that the ERA was undertaken.

¹ The Hoki Fishery Management Company (HFMC) is owned and managed by hoki quota owners. This commercial stakeholder group represents the hoki fishery and is the organisation that applied for, and received, MSC certification.

3. THE ECOLOGICAL RISK ASSESSMENT CONTEXT

While the primary purpose of the ERA was to meet MSC requirements, it also provided a opportunity to advance the environmental aspects of the proposed hoki fishery management plan – a new tool that provides for fisheries stakeholders to identify the objectives they want to achieve for a fishery, set out how they want to achieve those objectives and submit a plan to the Minister of Fisheries for approval.

Because of the emphasis on stakeholder engagement (under both the MSC and fishery plan frameworks) the ERA was viewed from the outset both as a structured way of assessing the impacts and ecological risks associated with the fishery *and* as a key vehicle for stakeholder participation in management of the fishery. The specific aims of the ERA were:

- i. to identify and characterize the ongoing impacts of the New Zealand based hoki fishery
- ii. to identify and characterize the ecological risks created by the ongoing impacts and
- iii. to engage hoki fishery stakeholders in the development and conduct of the ERA to ensure a comprehensive understanding of the relevant impacts, effects and risks associated with the fishery.

4. COLLABORATIVE DEVELOPMENT OF THE ERA METHODOLOGY

Despite requiring an Ecological Risk Assessment of the fishery, the Marine Stewardship Council provided the Hoki Fishery Management Company with little guidance on exactly what constituted an ERA. In addition, there were no off-the-shelf models that the HFMC could use to assess the wider ecological risks associated with trawl fisheries. This meant that the detailed methodology had to be developed by the HFMC with the assistance of contracted expertise².

In order to facilitate collective learning and foster stakeholder support for the Ecological Risk Assessment the methodology was developed through a collaborative process led by the 'Hoki ERA Group'. This group was convened by the HFMC and comprised representatives from HFMC, the New Zealand Seafood Industry Council, WWF New Zealand and WWF Australia, Ministry of Fisheries, Ministry for the Environment, Department of Conservation, Te Ohu Kai Moana and research expertise from independent science providers, including the National Centre for Fisheries and Aquaculture of the National Institute of Water and Atmospheric Research, a New Zealand crown-owned research institute.

The process took several months and involved a series of meetings where feedback on various drafts was provided to the consultants who refined the methodology to reflect the group's increasing understanding of what would be required to complete the ERA. Where required, the consultants also met with group members on a one-on-one basis to enable frank discussion of critical aspects of the methodology. At the end of the process all members of the group were able to support and endorse the selected methodology, which proved critical to the successful completion of the ERA.

Development of the ERA process followed the underlying risk management process as described in Australia/New Zealand Standard for Risk Management (AS/NZS4360). This standard gives a high level management process that defines the essential stages of risk assessment as context setting, scope, hazard identification, risk analysis, risk evaluation, risk treatment and review. This methodology was refined and adapted to reflect the need to assess risk to marine ecosystems and ecological processes.

The development process was informed by experience gained from a range of risk management and risk analysis projects in other industries and sectors, as well as

² The ERA methodology was developed for Hoki Fishery Management Company by URS New Zealand in 2002.

fishery ERA work carried out in other countries. A number of important factors were determined that were essential for success. These included the following.

- An ERA is not an environmental risk assessment and as such, the scope of the project and the definition of ‘ecological processes’ should be clearly stated and agreed to by the appropriate stakeholders.
- The risk methodology should include processes that document and justify the conclusions reached and clearly explain the underlying analysis including the veracity of the information, the relative and absolute levels of certainty, and list all assumptions made and simplifying steps used.
- Risk management responses should be determined by specific hoki fishery management objectives and remain independent of the risk assessment.
- For complex systems such as fisheries, a basic conceptual model for the various system interactions should be constructed.
- Stakeholders need to understand and accept the chosen methodology and process so that they can support both the process and the subsequent findings (and ideally, they will directly contribute to developing the methodology).
- Stakeholders who participate in workshops, expert panels, or other forms of consultation should be briefed adequately and have sufficient information to usefully contribute to the process.
- Stakeholders and others invited to participate in workshops should be sufficiently representative of the major stakeholder groups and between them should have the full range of required expertise.

5. SCOPE AND NATURE OF THE ERA

5.1 Risk assessment scope

The scope of the Ecological Risk Assessment was limited to identifying and characterizing effects and risks of fishing activities on the aquatic environment. The outputs sought were the identification of direct impacts, a relative ranking of those impacts and a characterization (with a relative ranking where possible) of ecological risks, rather than specific numbers or values attributed to risks.

It was agreed that the ERA should reflect the New Zealand regulatory environment and the QMS under which the fishery is managed. This resulted in a number of assumptions, for example, that the TACC for the fishery is set at a sustainable level. As a result the ERA considered the impacts on the hoki target stock and fish bycatch species in regard to the sustainability provisions of the QMS. Clearly a different set of assumptions may be required for fisheries not managed under a QMS environment.

Because specific management responses and mitigation options could only be identified *after* impacts and risks had been clearly identified and characterized, they were excluded from the scope of the ERA. In addition, it was important that the ERA focused on risk identification and characterization, and avoided prejudging the process by prematurely identifying management responses. Moreover, discussing mitigation responses too early in the process would confuse the characterization of risk as it is, rather than what it may be, or become, following mitigation responses. For these reasons it was decided that management responses would be determined by specific hoki fishery management objectives and that these should be determined in the context of the wider hoki fishery management plan and remain independent of the ERA.

Interestingly, as the process developed it became clear that the separation of mitigation responses greatly improved full stakeholder engagement and participation. This was largely because stakeholders did not feel that they were necessarily supporting, even if by association only, any subsequent management plan developed by the HFMC.

5.2 Biophysical scope

The biophysical scope of the ERA was set to include all biological components (i.e. hoki, bycatch species, marine mammals, seabirds, benthic environment and communities, etc.) within the hoki fishery marine environment. The ERA therefore included all marine mammals, sea birds, and the benthic environment and associated communities within the vicinity of the fishing grounds, as well as the hoki fish stock and associated fish bycatch species.

5.3 Characterization of impacts and risks

The ERA needed to address the full spectrum of impacts and risks associated with the fishery. For the purposes of the ERA a useful framework for understanding this broad spectrum of effects and risks was described as moving from the *micro* through to *meso* and finally to a *macro* scale as follows.

- *Micro*: Generally spatially and temporally discrete and not overly complex or uncertain attributes that can typically be ascribed to individual populations and species.
- *Meso*: More complex and less easily defined aspects that may be dispersed and exhibit longer term reaction to stress. Habitats, communities and other similar aspects tend to fall into this category.
- *Macro*: Multifaceted, complex, interrelated, spatially and temporally diffuse aspects that have inherently high levels of uncertainty and ‘ignorance’ associated with them. Ecosystems and ecological processes tend to fall into this category.

The broad range of components, interactions and systems required the application of a range of information processing methods. For the purposes of the ERA the information processing spectrum was described as follows.

- *Deductive analytical* processes – generally applied at the micro level where it is more likely that there will be relatively complete, and in some cases quantifiable, information.
- *Expert judgement* – generally applied at the meso level where information will tend to be weaker and there is likely to be little if any quantifiable information, and only a broad understanding of the inter-relationships and cause and effect.
- *Best endeavour* – generally applied at macro levels where high levels of uncertainty and possible ignorance requires drawing on best available information about the fishery, its interactions and our knowledge of ecological processes.

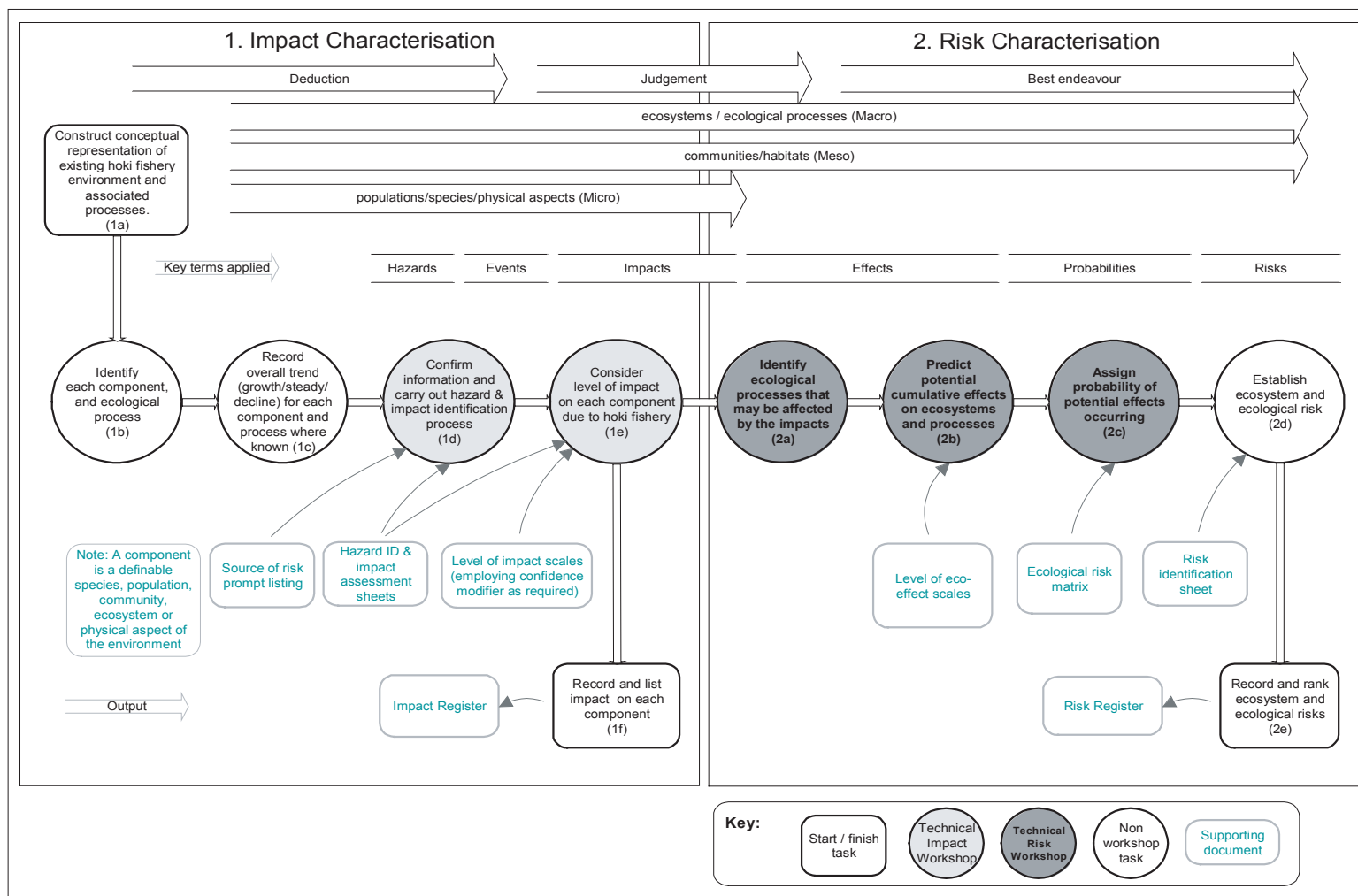
6. THE ERA METHODOLOGY

The ERA methodology is illustrated in Figure 1. It comprises two steps: an impact characterization followed by an ecological risk characterization. An impact characterization must be carried out prior to the risk characterization because there needs to be an understanding of the scale of immediate and on-going impacts directly and indirectly caused by the fishery, *before* the ecological risks associated with the hoki fishery can be assessed.

The hoki ERA therefore consisted of two distinct phases.

- i. *Impact characterization*. This considered the level and nature of the impact of the fishery on individual components associated with the fishery (i.e. hoki and bycatch fish species, marine mammals, seabirds, benthic environment and communities, etc.). A qualitative assessment process using an ‘order of magnitude’ type scale was employed to enable the determination of the impact level. Uncertainty was covered by the use of an alternative ‘precautionary’ scale where confidence in the characterization was low.
- ii. *Ecological Risk Characterization*. This phase aimed at building on the information gathered in the impact characterization to identify and consider the potential cumulative effects of the range of impacts on ecological processes and associated ecosystems, and the associated probability of those effects occurring. A range

FIGURE 1
Hoki fishery Ecological Risk Assessment Methodology



of possible impact scenarios were identified, each with a given probability of occurrence and a semi-quantitative analysis model employed. This enabled the total risk associated with each scenario to be systematically deduced.

An important documentary resource for both workshops was the report “*Potential interactions between New Zealand’s hoki fishery and key components of the marine ecosystem and associated processes*” (Livingston 2002). This report provided a conceptual overview of the fishery and its interactions. It comprised a summary of the key aspects of the fishery, relevant oceanographic features of New Zealand waters, life cycle and stock movements of hoki, an overview of the hoki fishery and associated ecological processes, the role of hoki in the fish community, and feeding and food web interactions.

7. THE WORKSHOP APPROACH

7.1 Execution of workshop

The impact and risk characterization phases were largely carried out in two technical workshops – an impact characterization workshop and a risk characterization workshop. As with the overall methodology, the specific workshop format and processes (including the impact and risk scales) were developed collaboratively with the ERA group. Both workshops were facilitated by the consultants, who also provided record keepers and technical risk expertise.

The workshop approach was chosen because it enabled the use of “expert” or professional judgement in the absence of detailed information on marine ecosystems and ecological processes and (especially) cause and effect relationships. The philosophy that underpins the “expert workshop” approach is that, by bringing together a range of professional expertise and creating an environment in which facilitated and structured discussion can take place, judgement based information can be generated.

For both workshops, all of the participants were fully briefed prior to the workshop to ensure that they had a good understanding of the ERA methodology and the role of the workshop. They were also provided with a range of resource material on the species or components and processes to be assessed at the workshop.

Workshop participants were asked to familiarize themselves with key information relating to their area of expertise prior to the workshop, but they were not required to undertake any additional information collection or research prior to the workshop.

7.2 Provision for observers at workshops

A crucial aspect of each of the workshops was the selection of workshop participants on the basis of their technical knowledge so that the required tasks could be completed. However, to enable full stakeholder involvement in the ERA, provision was also made for formal observers to attend the workshops. Observers did not participate directly in the workshop but were given the opportunity to make formal comment on the process by way of post workshop reports or comments on the day’s business. Feedback after the workshops confirmed that inviting observers to the technical workshops substantially enhanced the ability of stakeholders to observe and comment on the process and to better understand and interpret the impact and risk characterizations.

8. IMPACT CHARACTERIZATION WORKSHOP

8.1 Workshop methodology

The workshop to characterize impacts of the fishery brought together knowledge of the hoki target stock, bycatch fish species, marine mammals, seabirds, and benthic environment and communities. This knowledge was drawn from:

- observed impacts
- targeted research and science relating to the various components of the hoki fishery
- hoki fishery operational and management practices and
- other evidence as available.

The composition of the impact characterization workshop was determined by a mix of expertise, knowledge and experience (observed impacts, scientific, fishery operations) and, as far as possible, drawn from all stakeholder and sector groups (e.g. industry, environmental NGOs, government, etc.). The goal was for the overall group of participants at the workshop to reflect the full range of technical expertise required to address the nature of enquires being undertaken in the workshop. Special effort were made to include individuals with at-sea experience such as skippers and fishery observers, as well individuals with scientific backgrounds.

Workshop participants were provided with a list of seabird, marine mammal, fish and other species for consideration at the workshop. This list had been developed with input from the ERA group, along with advice from additional science providers recommended by the group. For each of the species under consideration at the workshop participants were asked to complete the following steps.

- i. Broadly describe the current level of knowledge.
- ii. Broadly describe the status and trend of the species component to the extent that this was possible.
- iii. Assess the mortality resulting from the all potential sources of hoki fishery effects (hazards)³; for example, fishing gear, fishing operations, pollution, etc. The assessment of the group was then recorded using the agreed component impact scale (see Figure 2). This provided for an assessment of the overall current impact of the hoki fishery on each species or components in terms of extent, intensity and reversibility of impact. Where there was significant lack of certainty, a low confidence ranking was used. Critical and important comments on the nature and scope of impacts were also recorded.
- iv. Identification of any gaps or omissions, e.g. additional species likely to be affected by the fishery. These were then assessed using the above methods.

An important feature of the workshop was that participants were asked to identify peer reviewers with specific expertise where this was considered necessary, and particularly where some individuals with specific technical experience had been unable to attend the workshop. The nominated peer reviewers were asked to review the workshop output to ensure that the best expertise was brought to bear on the issues under consideration.

The workshop output was formally recorded as a series of excel spreadsheets, which captured comments for each of the assessed components and their impact ratings⁴. Impacts were recorded for nine species of seabirds, the benthic environment and associated communities and the New Zealand fur seal. Impacts on the hoki target stock and fish bycatch species were considered in regard to the sustainability provisions of the New Zealand QMS, but were not formally characterized.

8.2 Impact scales and analysis

Impact and effect scales were used during the impact and risk characterizations (see Figure 1). The impacts were assessed in terms of extent, intensity, and reversibility (see Figure 2).

A 5-level 'order of magnitude' scale is used to designate the various descriptive summaries of the possible impacts (E to A). A second series of designations, applicable

⁴ Impact ratings are available on the HFMC website.

³ The ERA addressed fishery related impacts only. Impacts resulting from non-fishery hazards (e.g. oil spills and other human activities) were not considered.

FIGURE 2 Impact scale					
Features that can be affected:	Function, relative abundance, composition, structure, dynamics, behaviour, variation (beyond natural variation)				
Description on level of impact				Designation	
Descriptor	Extent	Intensity (degree)	Reversibility (time to recover)	confident	low confidence
Catastrophic	Across the whole of the component (species population, community or habitat)	Effective extinction, eradication or destruction of the component (species, population, community or habitat)	Irreversible highly uncertain recovery of the component or recovery inconceivable over a very extended time frame	A	A*
Severe	Across a substantial proportion of the component	Severe disruption or damage to the component	Long-term recovery of the component (many decades or so)	B	A*
Major	Across a large proportion of the component	Significant disruption or damage to the component	Component recoverable over a decade or so	C	B*
Slight	Across a small but discernable proportion of the component	Partial disruption or damage to the component	Rapid recovery of the component (within a year or so)	D	C*
Insignificant	No discernible impact on the component			E	D*

for component impact only is included for use where the workshop group feel that they have low confidence to the extent that a higher impact is conceivable. This second scale effectively results in a precautionary characterization of the ‘component impact’. Any lack of confidence at the risk characterization stage is accounted for by the use of a probability function.

8.3 Key fishery impacts

The impact characterization workshop identified the following impacts.

- Seabirds – Northern giant petrel, Campbell albatross, Black-browed albatross, White-chinned petrel, and Sooty shearwater all rated D; Chatham albatross rated D*; Salvin’s albatross, Buller’s albatross, White capped albatross were all rated C.
- New Zealand fur seal rated C*
- Benthic environments and associated communities⁵ – rocky bottom rated C**; Sands, shingles and sediments, Seamounts, and Canyons all rated C** when using bottom or near bottom trawls over existing trawls paths with gear not touching the bottom and A** for areas disturbed when the bottom is impacted. Mid-water trawls for all benthic environments were rated D**.

The remaining seabird, marine mammal and other species considered at the workshop all received an E rating. Thus a key outcome of the workshop was the identification of a relatively narrow suite of impacts that required mitigation.

⁵ Note that benthic environments were rated double * to indicate very low levels of confidence in the knowledge of the impacts.

9. RISK CHARACTERIZATION WORKSHOP

9.1 Workshop objectives and process

In essence, the risk workshop needed to consider long-term progressive consequences of the impacts identified and ranked in the first workshop; that is, the cumulative effects caused by the ongoing impacts. Because we could not predict future changes to the nature of fishing operations it was assumed that, for the purpose of the workshop, risks would be identified in regard to *current* fishing practice and activity, i.e. that over time there would be no change to fishing practices, areas, gears and amount of fishing effort.

The specific objectives of the workshop were

- i. to build on the impact workshop by identifying and assessing the potential risks relating to key ecological processes and interactions associated with those component impacts that were identified and assessed at the impact workshop as having higher than “insignificant” impact and
- ii. to identify information and, or, conceptual gaps that needed to be addressed in order to undertake a more comprehensive ecological risk assessment in the future.

The workshop progressed through a series of tasks as follows:

- i. identification and description of key ecological processes and, or, systems and major interactions relevant to the fishery
- ii. consideration of some potential impact and effect scenarios, based on current fishing activity and impacts⁶ and
- iii. preliminary characterization of the likelihood and potential ecological effect of some scenarios.

An important focus of the workshop was to identify any information or conceptual gaps that might limit the ability to fully characterize risks. This approach acknowledged that knowledge gaps were likely to result in an indicative or preliminary (rather than definitive) risk characterization.

9.2 Barriers to comprehensive ecological risk assessment

Not surprisingly, the workshop identified a number of barriers to completing a comprehensive risk assessment. Key barriers included the following.

- *Lack of a relevant (and nationally accepted) ecologically-based spatial characterization of the hoki fishery.* The absence of an agreed and accepted spatial characterization of the fishery proved a significant barrier to agreeing on an appropriate lens through which to assess effects on and risks to key processes. The difficulties of treating the fishery as a single entity meant that by default

⁶ Because there was likely to be little direct evidence of cumulative effects, which in most cases would be not be directly observable, they could not be predicated with certainty – unlike direct impacts that can be predicted in a deterministic way. Prediction of these longer-term cumulative effects therefore needed to include the probability of various scenarios occurring and in some cases a number of alternative scenarios. As scenarios cannot be known with certainty, consideration of the probability of alternative outcomes for any given set of impacts was an important part of the analysis. For each cumulative effect scenario there could conceivably be a range of probabilities, which were captured on a three point probability scale as follows.

Risk is generally defined as a function of the severity of a future event and the probability of that event occurring. When expressed quantitatively, this function is invariably interpreted as a product. The ecological effect scale used at the workshop was an order of magnitude scale with two defined reference points (E and A). The three-point probability scale was defined and quantified (Probable, ~80% chance, Possible, ~20% chance, and Improbable, ~ 5% chance) so that the scale could be manipulated mathematically.

To ensure consistency and accuracy, a simple semi-quantitative analysis was developed. The product of the two functions was then compared against an arbitrary four-step risk scale (High, Medium, Low and Negligible) to allow classification of the risks into priority categories.

we were trying to assess the entire New Zealand marine environment as a single ecosystem and this became overwhelming for the group. In the absence of any other available framework the group elected to characterize risks in the context of fishery management areas (i.e. Chatham Rise, Cook Strait, West Coast South Island, etc.), while acknowledging the limitations of this approach. Further consideration needs to be given to the relevant scale and definition of ecosystem boundaries in the context of ecological risk assessment. For example, can fishery management areas be meaningfully overlain on ecosystems? And, if not, how should the relevant scales be determined?

- *Lack of an agreed framework for considering ecological processes, the interactions between these processes and the key cause and effect relationships.* Again, in the absence of an accepted framework the workshop group elected to draw on the ecological process categorisation developed in the context of the Australian Oceans Policy work (i.e. energy sources, nutrient flows and biological production; energy flows and food webs; population dynamics; dispersal and migration; and physical and biological processes). Clearly further work is required to characterize and describe ecological processes in relation to the fishery; however, questions remain as to how far this can progress given the limitations in knowledge about critical aspects of ecosystem structure, integrity and health.
- *Lack of an agreed reversibility time frame.* Different workshop participants had different views as to what constituted an appropriate reversibility or recovery time frame in relation to the identified impacts. There were also different views on the extent to which current fishing practices have shaped the ecosystem and the likely effects of stopping the relevant practices on those ecosystems.

Given these significant barriers, the group agreed that only preliminary and indicative risk characterizations could be completed in the workshop and the focus should be on identifying gaps in our understanding, rather than completing definitive risk assessments. In this light, it was agreed that the impacts identified in the previous phase would constitute the formal findings of the ERA.

9.3 Next steps

Despite the barriers identified above, the risk characterization workshop marked an important milestone in terms of completing the ERA. In particular, it provided an opportunity to determine more clearly the information and conceptual gaps in our knowledge of ecological processes.

An important next step will be to compile a more comprehensive ecological description of the fishery, beginning with reviewing and interpreting existing information in the light of the requirements of ecological risk assessment. Areas that could usefully be developed further from the work undertaken at the risk workshop include identifying and describing:

- marine ecosystems associated with the hoki fishery, including appropriate (ecological) spatial scales and
- major ecological processes associated with the hoki fishery.

In considering the risk evaluation process it became apparent that it may be useful to focus on building a broader information base for *all* middle-depth species, rather than just hoki, especially given the interrelationships between different fish species and the interconnectedness of the middle depth fisheries. This may also open the way for more comprehensive impact and risk assessment of closely related middle-depth fisheries such as those for squid (*Nototodarus sloanii* and *N. gouldi*), ling (*Genypterus blacodes*), hake (*Merluccius australis*) and southern blue whiting (*Micromesistius australis*).

10. ECOLOGICAL RISK ASSESSMENT FINDINGS

The hoki ERA demonstrated that impact assessment is a useful tool for fishery management. The impact characterization phase of the ERA provided a robust process for determining, assessing and ranking fishery impacts. However, full ecological risk assessment in the marine environment continues to push the boundaries of current knowledge of complex and poorly understood ecological processes. Thus, while various components recorded an impact rating in the impact characterization phase of the ERA, *the potential ecological effect of these impacts is still unclear and will remain so in the absence of better information, or until we are better able to interpret the information we do have.*

The ERA therefore concluded that management responses should be precautionary in nature and directed at mitigating the impacts identified in the impact characterization phase of the ERA (i.e. impacts on some species of seabirds, fur seals, and benthic environments and communities) with the aim of reducing or eliminating any potential ecological risks at source. The underlying assumptions are that any component impact may have a potentially harmful effect on associated ecosystems and processes.

11. CONCLUSIONS

New Zealand hoki is the world's first large trawl fishery to gain MSC certification. To some extent the fishery has served as a test case for the MSC in developing certification requirements for trawl fisheries and especially for assessing the wider environmental impacts and associated ecological risks of these fisheries.

The ERA was an important first step in gathering together knowledge on the broader ecological impacts and risks associated with the fishery. The hoki experience provided an opportunity for all stakeholders (including government agencies, environmental NGOs, industry and the MSC itself) to participate in designing and applying a comprehensive ERA methodology.

The challenge now is to continue working to implement robust management responses aimed at mitigating the identified impacts and that are supported and endorsed by the various stakeholders in the fishery. The hoki fishery plan will serve as the vehicle for translating the increased understanding of ecological impacts gained through the ERA into specific operational responses within the New Zealand regulatory framework. For example, a seabird bycatch management strategy has been developed to respond to impacts identified in the ERA and it will also guide the HFMC's response to the government's recent *National Plan of Action to Reduce the Incidental Bycatch of Seabirds in New Zealand Fisheries* (MoF 2003), as well as forming a component of the hoki fishery plan.

The HFMC has demonstrated that it is committed to sustainable environmental practices in managing the hoki fishery. In doing so it is providing for effective stakeholder participation in the management of the fishery. However, running a truly multi-stakeholder process has at times proved challenging and has required the ongoing commitment of all parties to the process. Moreover, ongoing changes to the domestic regulatory framework (e.g. the parallel implementation of management measures such as fisheries plans, environmental management strategies, seabird mitigation plans of action, etc) has at times dissipated the HFMC's ability to focus on implementing the outcomes of the ERA. For this reason the HFMC is now seeking to streamline its operational requirements under the MSC process and the domestic management regime through a single business planning process.

Despite the various challenges encountered in developing and applying the ERA, and in moving through to the implementation phase, it is clear that the ERA has provided a useful mechanism and, perhaps even more importantly a process to examine

the wider environmental impacts of the fishery. Certainly, the ERA has proved an excellent vehicle for identifying the key impacts of the fishery and providing for broad stakeholder engagement in the management of the hoki fishery.

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Providing management advice for deep-sea fisheries: lessons learned from Australia's orange roughy fisheries

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1. INTRODUCTION

All over the world, in marine and freshwaters, on continental shelves and in deepwater, fisheries have been found, established and overfished. Recent statistics indicate that 18 percent of the world's fisheries are overexploited and a further 10 percent are significantly depleted (FAO 2002). Deepwater fisheries seem particularly prone to a boom and bust cycle (Miller 1999, Moore 1999). Overfishing does not seem to be limited by the stage of a country's development, the political system or the level of scientific advice. Indeed many examples of overfishing have occurred in the world's most developed countries under the auspices of well-established management structures and in spite of high standards of stock assessment.

One of the core reasons why we have often failed to manage fisheries for sustainability is uncertainty. It is the objective of this paper to examine how scientific uncertainty and mistakes in judgement, combined with management and implementation shortcomings, led to the decline of the Australian orange roughy fisheries, and in particular the Eastern Zone fishery. This is not to suggest that this fishery is a unique example of uncertainty and mistaken judgement. Unfortunately, there is no reason to believe that similar shortcomings do not exist in the management of all fisheries, other natural resources and any endeavor where humans are required to predict future events and their part in controlling it.

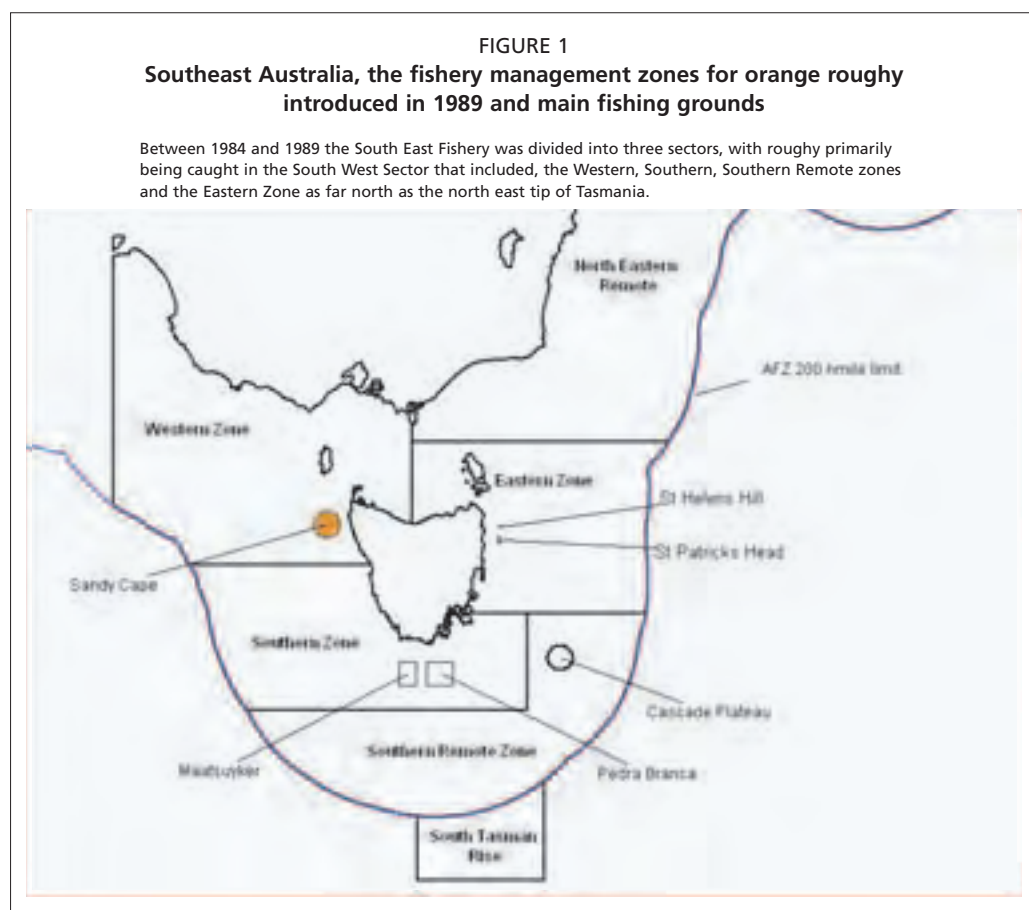
2. ORANGE ROUGHY

Orange roughy is a long-lived species with a maximum age of over 100 years. It is distributed throughout the temperate regions of the world's oceans at depths of 450 to 1 800 m (Branch 2001). They form dense spawning and non-spawning aggregations on topographical features such as seamounts, but are also widely distributed at low densities in other areas. Commercial fishing for orange roughy first began in New Zealand in 1979 and now trawl fisheries for orange roughy occur in Australia, New Zealand, the North-East Atlantic, Namibia and Chile, as well as on the high seas (Branch 2001).

3. THE AUSTRALIAN FISHERIES

Australian orange roughy fisheries can be conveniently divided into the five following categories. The examples provided do not include all Australian orange roughy fisheries but are representative of the scientific, industry and management issues that are faced.

- i. *Exploratory fisheries*, characterized by government subsidies and limited management controls, e.g. Sandy Cape 1986/87, Kangaroo Island 1988, Port Lincoln 1989, St Helens 1989–1992 (Figure 1).
- ii. *Fishing for catch and reserve sustainability*, characterized by well-defined strategies and performance criteria to be achieved through controls on total allowable catch (TAC) (e.g. Eastern, southern and western management zones 1993 – until 2004 or fishery failure).
- iii. *Recovery*, characterized by fishing at low levels to allow stock rebuilding while funding a well-defined monitoring strategy (proposed for St Helens 2004–?).
- iv. *Precautionary management*, characterized by caps on total catch prior to the fishery and fishing at a level that is unlikely to lead to produce an unregulated fishdown (e.g. Cascade Plateau 1996–ongoing).
- v. *Management under the 1982 United Nations Law of the Sea Convention (LOSC)*, characterized by internationally-agreed management of stocks that straddle national borders (e.g. South Tasman Rise 1997–ongoing).



In this paper we first provide the background to the fishery – the Type 1 exploratory fisheries – and then concentrate on the eastern zone (including St Helens) for a discussion of the failure to fish for sustainability (Type 2). Development of a Type 3 fishery – as against a failed Type 2 fishery where the hard decision to close has not been taken – will not be discussed here. The Cascade Plateau is discussed briefly as an example of precautionary management (Type 4). Type 5 fishery management, under

the LOSC did not eventuate before 2001 because of lack of ratification by a requisite number of countries. This delay in ratification led to failure to cap South Tasman Rise catches with Australian vessels taking advantage of delays in the bilateral agreement to continue fishing. In 1999 the agreed bilateral TAC (between New Zealand and Australia) was exceeded by New Zealand vessels, while unregulated fishing occurred by two South African and one Korean vessels. The South Tasman Rise fishery has not recovered to date.

3.1 Management objectives, strategy and performance criteria

Up to the mid-1980s fisheries off Southeast Australia were managed by the states, primarily through input controls. In 1985, the Australian Fisheries Service (AFS), a division of the Department of Primary Industries, took over management of the fishery for the Commonwealth. The South East Trawl Management Advisory Committee (SETMAC), which has participants from industry, management, science and (more recently) the World Wildlife Fund for Nature (WWF), was established.

Principal Commonwealth objectives in the management plan for the southeastern trawl fishery were (Australian Fisheries, August 1984):

- ensuring through proper conservation and management measures, that the living resources of the Australian fishing zone are not endangered by over-exploitation and
- achieving the optimum utilization of the living resources of the Australian fishing zone.

There was no formal assessment group for the South East Fishery (SEF) and the Demersal and Pelagic Fisheries Research Group (DPFRG) – an unfunded research advisory group – was asked to take on this task. But perhaps the most significant aspect of the Commonwealth plan, as presaged by a ministerial announcement on 6 July 1981, was that the fishery would become closed to operators without a licence, effective on 31 March 1985; licence applications would be judged on “a demonstrated commitment to the fishery” (Australian Fisheries, August 1981). New licences would only be available for particular development or exploration programmes at least until 1987. However, restricted temporary licences would be provided to three large trawlers to determine viability of deepwater trawling off Tasmania; they would not be able to fish in other parts of the South East Fishery. This restriction did not last for long and by 1990, 67 vessels would report catches of orange roughy from the southwestern sector (Wayte and Bax 2002), while the number of tows in the sector trebled between 1986 and 1990 (Tilzey 1994).

In December 1991 management of the SEF changed from primarily input controls to output control in the form of an individual transferable quota (ITQ) system. Again, the AFS relied for control on the DPFRG to provide stock assessments prior to establishing TACs for the 16 species placed under quota. For orange roughy, different TACs apply to the zones in the fishery where substantial catches of orange roughy had been taken (Figure 1). In 1992, management of the fishery passed from the AFS to a statutory authority, the Australian Fisheries Management Authority (AFMA). In 1993 AFMA developed general management objectives, strategy and performance criteria for the South East Fishery and established formal assessment groups to provide scientific advice to managers. Specific objectives – a target reference point of 30 percent pre-fishery biomass and a limit reference point of 20 percent – for the orange fishery were developed in 1994 following input from the assessment group and were applied to manage the eastern, southern and western zones. The 30 percent target reference point was endorsed by an international review (Deriso and Hilborn 1994). In 1995, a time frame for recovery to 30 percent pre-fishery biomass of 5–10 years was established by the AFMA and this time frame was made even more specific in 1996 so that recovery was required by 2004 (i.e. 10 years from the first strategic plan; Bax 1995). At the same

time the action of closing the fishery, if the limit reference point of 20 percent was reached, was removed. Closure became an option for the assessment group to consider and there was no agreed management action if 20 percent was reached. Also, a 1993 performance criterion, that industry would generally accept the assessment and TACs, was removed by the AFMA, although it remained a unspoken rule for the assessment group (which was run on consensus) and became critical in delaying implementation of the results from the 1997 assessment.

The 1993/95 strategies and performance indicators remain unchanged despite their being impossible to achieve with the 2002 eastern zone biomass being estimated at 7–13 percent of the prefishery biomass (Wayte and Bax 2002) – there appears to be no formal mechanism to change them. In 2003 the AFMA Board asked SETMAC why the eastern zone orange roughy fishery should remain open. This is a difficult question to answer in the absence of achievable management objectives. While international reviewers recommended the formal evaluation of management procedures to identify one that has a high probability of stock rebuilding – i.e. one that is robust to data and model uncertainty (Francis and Hilborn 2002) – there is no funding for this work. In lieu of this, the assessment group provided estimated time to a detectable increase or recovery of the fishery under different assumptions and TACs and provided a plan that would monitor recovery on a three-yearly interval, while providing semi-quantitative monitoring in the other years so that any further precipitous decline would be detected (Wayte and Bax 2002). It was agreed that monitoring would be funded by industry based on the success that the orange roughy industry had had with industry-funded research and assessment for the Cascade Plateau fishery, and given that other funding sources were no longer available for ongoing monitoring. The strategies and indicators for this approach have not been defined.

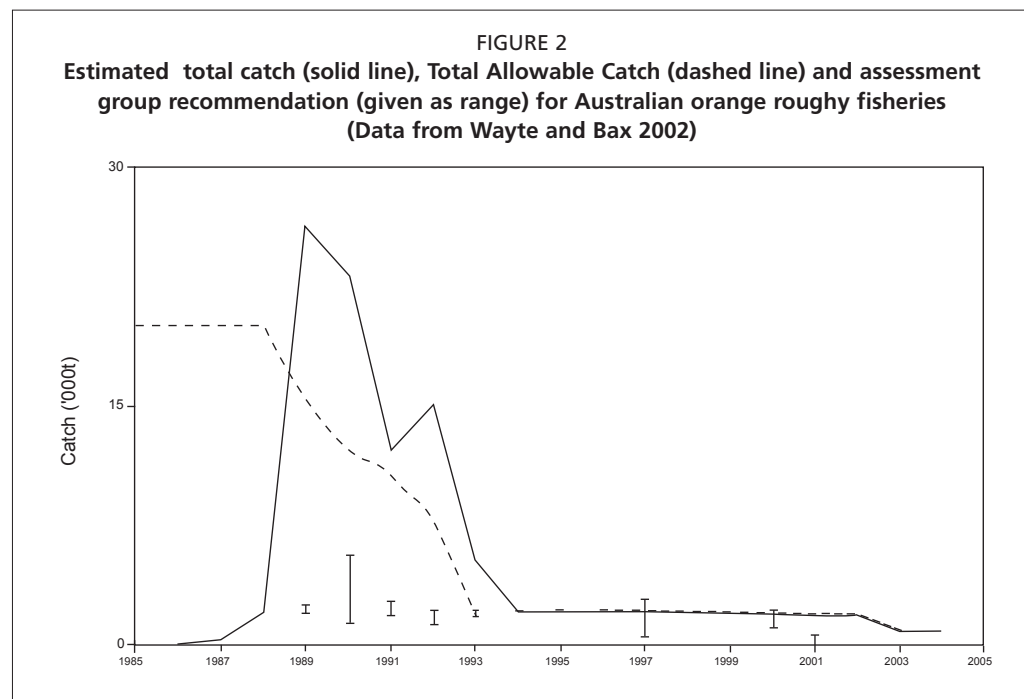
3.2 Exploratory fisheries

The exploratory period of orange roughy fishing in Australia extended from the mid-1970s to 1992. It was a time of significant changes for the South East Trawl (SET) fishery. Starting in the mid-1970s, and especially since the declaration of the 200-mile exclusive economic zone in November 1979, the Commonwealth Government developed a range of policies to provide Australians with increased opportunities to exploit fishery resources. These ranged from boat building subsidies to exploratory fishing programmes, particularly in the SW Sector (Eastern, Southern, Southern Remote and Western zones, shown in Figure 1) where, following the New Zealand experience, it was hoped orange roughy aggregations would be found (Commonwealth Minister for Primary Industry, Peter Nixon in Australian Fisheries, October 1982). Fishers were well aware that quotas were being used in New Zealand to protect orange roughy stocks from overexploitation. Many would have concluded that they had better be seen to be in at the beginning of any promising new fishery if they were to be assigned quota later. Meanwhile, new research catches of orange roughy produced headlines in Australian Fisheries (e.g. Wilson 1982a). The first promising catches of orange roughy were taken off western Tasmania by the **R.V. Challenger** in late 1981 (Wilson 1982b). Using commercial and survey data, Wilson (1984) estimated the orange roughy resource to be 51 600 t with an annual yield of $4\,125 \pm 1\,300$ t.

Exploratory commercial fishing for orange roughy commenced in 1982. Increased effort was produced by the granting of three restricted temporary licences to large trawlers (>32 m long) to encourage greater exploratory activity in the SW Sector (Tilzey 1994). The first substantial catches of orange roughy were taken off Sandy Cape, western Tasmania, in 1986 when a non-spawning aggregation was found (Figure 2). Several other non-spawning aggregations were found in this area and fished from 1986 to 1988. The number of shots increased by 50 percent over the same period as vessels moved in to the SW Sector from other areas of the SEF where overall the

number of tows declined 5 percent (Tilzey 1994). Based on area-swept methods it was concluded that 16 percent of the Sandy Cape and about 50 percent of the Beachport aggregations were removed in one year (Anon. 1988). These aggregations did not reappear a second year. Together with catches of dispersed orange roughy, landings ranged between 4 200 and 8 500 t per annum between 1986 and 1988. Early Australian catches were compared favourably with early New Zealand catches and the deepwater fishery was seen as entering a particularly “exciting phase” (Williams 1987). Scientific biomass estimates of hundreds of thousands to millions of tonnes in a small part of the area (Harden Jones 1987, Kenchington 1987) that would later be found to be mistaken can only have fueled the speculative fervor.

In June 1987, the AFS announced a 20 000 t catch limit, proposed a quota system and made an urgent request for an assessment of the resource. A preliminary (“inspired guesswork”) assessment, critically based on fishers’ observations and theoretical assumptions of packing density, suggested a biomass of 500 000 to 700 000 t between Sandy Cape and Cape Grim (Kenchington 1987). But because it was also assumed that roughy were more likely to be slow growing and long-lived (maximum age of 150 years; natural mortality = 0.03), and recognizing that the biomass could be off by a factor of 10 in either direction, Kenchington (1987) recommended an annual quota of 2 500 t and cautioned that optimum yield could be less than 1 000 t or more than 10 000 t. He recommended that the South East Trawl Management Advisory Committee (SETMAC) consider limiting catches during the fishing down phase¹, rather than having to face the disruption of a 90 percent reduction in quotas in five years time when the biomass built up over many years had been reduced and the fishery was reduced to the sustainable yield. He did however conclude that “this (limiting catches) is not a matter for biological analysis.” Kenchington’s 1987 assessment would never have an impact as after 5 000 t of roughy was taken from the Sandy Cape ground, primarily during a 90-day period in the summer of 1986/87, when catch rates remained at over 10–15 t/hr for 40 days (Merryl Williams in Anon. 1988). The fish did not return in numbers the following year and catch rates never went above the 1 t/hr background level.



¹ It may be symptomatic of the optimism of the time, that Kenchington (1987) used the term “fishing up phase” to denote the practice of removing the non-productive biomass to maximize long-term sustainable yield.

Further orange roughy ‘hotspots’ were discovered in the Great Australian Bight. In 1988, seven vessels fished the Kangaroo Island aggregation; next year 27 vessels fished the Port Lincoln aggregation. Fishers experienced a short duration of good catch rates and depressed prices and the approach was characterized as a “gold rush” (Australian Fisheries, July 1989). Orange roughy catches in the entire Great Australian Bight have rarely reached a quarter of the 1988/89 catches since 1990 (Wayte and Bax 2002).

Australian scientists reviewing the small early fisheries off Sandy Cape and Beachport (the latter was rapidly fished down following a research vessel getting higher than average catch rates during a scientific survey (Anon. 1988) expressed concern that apparently significant fractions of the virgin biomass had been removed and that the current fishing process could be expected to rapidly deplete an unproductive population. “The management implications of this should be examined in more detail” (Anon. 1987). Scientists went on to recommend that a further build up of catching power during this period of transient high catches was to be avoided making the point that, given the low mortality rates, “very little catch is forgone by slow development of the fishery” (original emphasis, Anon. 1988). A feedback management policy was suggested to quickly recognize signals from the fished resource and modify management actions accordingly.

By 1989 the expected large sustained catches had not eventuated, leading the Australian Bureau of Agricultural and Resource Economics (ABARE) to conclude that the rapid increase in fishing capacity, resulting from industry expectations of a greater sustainable yield than had so far been justified, was likely to remain a major long-term problem with fish stocks put under greater fishing pressure than could be sustained (Smith 1989).

The situation changed rapidly and six months later it became clear that the fishery was just beginning. The discoveries of non-spawning aggregations on hills off southern Tasmania and a major spawning aggregation on a seamount off St Helens on the east coast of Tasmania led to a dramatic increase in catches to 37 000 t in 1989 and 58 600 t in 1990 (catches corrected for misreporting and loss) (Figure 2). It was heralded as an “orange roughy bonanza” (Australian Fisheries December 1989), and represented the first aggregations in Australia that were not fished out in the first year (Lyle *et al.* 1989). Catches were substantially higher than the 20 000 t limit introduced in 1987, and the 15 000 t TAC introduced as an interim management strategy by the AFS in 1989 (Tilzey 1994) for which there was no Commonwealth monitoring or enforcement. Following intervention by the Tasmanian minister for primary industry, and amid concerns over the apparent fragile biology of this deep-sea species, management controls on orange roughy fishing were introduced by the AFS. The Government Industry Technical Liaison Committee (GITLC) was established to promote closer cooperation between industry and scientists and in so doing to develop a stock protection strategy (Ross and Smith 1997). Further increases in catch were then prevented by the creation of the Eastern and Southern Management Zones (Figure 1) and associated TACs.

Catches in the Eastern Zone were ‘limited’ by a 15 000 t TAC in 1989 which was designed to achieve a “safe fishing-down rate (5 percent of the initial stock size per annum).” (SETMAC 20, 9 November 1989). Unfortunately the biomass estimate of 300 000 t used to set the TAC was unsupported by either scientific opinion or GITLC, although it did result in a TAC approximately equal to the catch taken that year. The TAC was reduced to a contingency level of 12 000 t in 1990 (until further scientific information became available). Scientists did not consider this to be biologically conservative given that yields for south eastern Australia were likely to be substantially less than New Zealand’s total sustainable yield estimates of 15 000–20 000 t and unlikely to exceed 8 000–10 000 t (DPFRG 1990a). However, the 12 000 t limits caused some controversy with many fishermen concerned that their decreased share of the TAC due to more boats entering the fishery and low prices might make it impossible to keep

their boats at sea (Australian Fisheries June 1990). The number of boats landing orange roughy in Australia had increased 50 percent from 44 in 1988 to 67 in 1990 (Wayte and Bax 2002). In the same Australian Fisheries article, fisheries managers defended the TACs as being far better to 'err on the side of conservatism'.

The first quantitative acoustic estimates of the St Helens spawning aggregation were obtained in 1990 by CSIRO (Kloser, Koslow and Williams 1996). The spawning aggregation was estimated at 57 000 t (range 30 000 to 150 000 t), with an annual production of 2 700 t (range 1 300 to 5 500 t). Scientific advice was that the fishdown was almost complete (DPFRG 1990b). The group stressed the need for caution as only 1 to 3 percent of the adult virgin biomass might be able to be taken on a sustainable basis. The group drew attention to the severe depletion of the Challenger Plateau in New Zealand and consequent reduction in catches, and reiterated the need for caution in setting TACs, especially considering that TACs set too high would lead to collapse of the stock, while TACs set too low would result only in deferral of catch with little overall loss due to the long-lived nature of the species. TACs were reduced slightly to 10 700 t in 1991.

The 1990 acoustic survey result was reinforced by the 1991 survey and an independent egg-production estimate (Koslow *et al.* 1995). Survey results were independently reviewed at industry's request and led to the conclusions that the stock was depleted to between 34–67 percent of the initial biomass (i.e. potentially already below the then target level of 50 percent unfished biomass) and that the sustainable yield was likely to be in the range of 1 700 to 2 600 t (DPFRG 1991). The Group reiterated the need for caution given the long time required to recover from overfishing, whereas fish not taken this year would remain in the stock for many years. The 1992 TAC was reduced further to 7 423 t. This ended the exploratory stage of this fishery. The 1991 acoustic and egg production surveys of the St Helens spawning stock were repeated in 1992. The acoustic target strength estimate was revised downwards following advice from the independent reviewer, and the backscatter estimation algorithm adjusted following advice from the manufacturer. At the same time the area of the survey was increased to include fish echoes received away from the St Helens hill. The acoustic backscatter from other species was removed based on their abundance in a trawl survey and estimated target strength. Together, these four adjustments led to an overall 37 percent decline in the previous years' St Helens biomass estimates. An acoustic survey also took place in the Southern Zone (DPFRG 1992). Maximum likelihood stock reduction analysis models were developed based on Mace and Doonan (1988). These would later develop into a full Bayesian approach, which theoretically can take into account the full range of uncertainties related to models and parameter values, and enables the application of a formal decision-analysis approach to fishery management (Punt and Hilborn, 1997). Biomass for the Eastern Zone was estimated at 24–40 percent of pre-fishery biomass and sustainable yield at 1 200–1 500 t. If the fish in the Eastern and Southern zones were considered one stock then biomass was reduced to 12–40 percent pre-fishery biomass and sustainable yield to 2 100–3 000 t. The Group concluded that the 50 percent fishdown target that they had recommended for orange roughy in 1990 (DPFRG 1990b) had already been exceeded at St Helens.

Subsequent analyses of the catch data and discussion with industry suggested that catches (including that with burst nets, discarding and misreporting) for the four years 1989–1992 were 26 236, 23 200, 12 159 and 15 119 t, or 68 percent higher than the TACs (Wayte and Bax 2002). Subsequent analyses would also show that the fishing down target of 50 percent of virgin biomass repeatedly recommended by scientists had been exceeded. For example, at the end of 1992 the Eastern Zone biomass was 25–30 percent of prefishery biomass. The Australian Fisheries Management Authority (AFMA), a statutory authority, replaced the Australian Fisheries Service, a division of the Commonwealth Department of Primary Industries, in 1992. SETMAC remained the

management advisory committee responsible for orange roughy. An AFMA-appointed advisory group – often named the Orange Roughy Assessment Group (ORAG) – was initiated and included scientific, management and industry members. DPFRG, an independent group that had specifically excluded management and industry members, reverted to the review and coordination of research in 1993 – its original objective. One of AFMA's first objectives for Australia's South East Fishery was to ensure continuation of a sustainable fishery.

3.3 Management for sustainable yield

Eastern zone TACs were reduced markedly in 1993 to what was the upper range of the estimated sustainable yield – 1 500 t. Sustainable yields were less than had been previously estimated following downwards revision of the acoustically-derived biomass estimates. Allocated TACs would be a third higher after accounting for carryovers (uncaught TAC) from the previous year. This decrease in eastern zone TAC was substantially compensated by starting an “adaptive management experiment” or pulse fishdown in the southern zone, following the recommendations of the industry consultant. This resulted in a combined TAC of 13 000 t in comparison to a recommended sustainable yield of 2 100 to 3 000 t. The adaptive management experiment would ultimately prove unsuccessful because of misreporting of where catches were taken and the lack of a monitoring programme capable of tracking the fishdown, but southern zone TACs would remain well above the estimated sustainable yield for three years. The high TACs decided upon for the southern zone also ignored the risk that the fish in the eastern and southern zones were a single stock. As of 1993, the advice was that there was some mixing between zones, and a single stock could not be ruled out. The estimated catch in 1993 from the eastern zone was three times the estimated maximum sustainable yield and agreed TAC (Figure 2).

Precision of scientific advice improved slightly in 1993 with an extra year's acoustic survey and inclusion of an egg production survey (Koslow *et al.* 1995). The 1994 TACs allocated for the eastern zone fell within the estimated yield. However a special orange roughy workshop in early 1994 (CSIRO and TDPIF 1996) detailed the uncertainties associated with the assessment and industry requested an external review of the 1994 assessment. This occurred later the same year (Deriso and Hilborn 1994). The reviewers suggesting some improvements, but overall concluded that “the methods used to measure abundance and calculate stock trajectories are consistent with the best methods used elsewhere in the world” and the assessment itself was “much less ambiguous” than orange roughy assessments elsewhere (as all indices and assessments were consistent). Importantly, the new AFMA strategy of maintaining the stock at 0.3 of virgin biomass was found to be “consistent with what is known of ecologically sustainable development” and the reviewers recommended that the AFMA adopt a policy that would be expected to keep the stock above the 0.3 level 50 percent of the time in a five-to-ten year time horizon. This led to the codification of the management strategy of there being a ≥ 50 percent chance that the biomass was above 30 percent of the original spawning biomass, which later was refined to providing a 50 percent chance that the biomass would be above 30 percent of the original biomass in five-to-ten years (1995 assessment, Bax 1995), subsequently tightened to a 50 percent chance by 2004 (1996 assessment, Bax 1996). This was a significant departure from the original DPFRG advice that the target biomass should be “not less than half the virgin biomass”, but appeared to have some support in the fisheries literature, which suggested that a limit reference point of 20 percent was not unreasonable (FAO 1993). Importantly, industry agreed to the assessment after this review, accepting in the process the much lower TACs than had been set at the start of the fishery. The concerted exploration of new areas, such as the Cascade Plateau, was triggered by the reduced TACs for the eastern and southern zones.

In 1994, following on from the new management strategy the assessment group estimated the catch levels that would give a 50 percent probability of being above 30 percent pre-fishery biomass in 2004. The catch level of 2 000 t recommended by the assessment group for the eastern zone was adopted by AFMA as the 1995 TAC, while the combined-zones TAC remained double the recommended level, being still part of the, by now, discredited adaptive management experiment. By 1995 it was estimated that there was a 73–75 percent probability of the stock being below the 30 percent of prefishery biomass target (if the fish in the two zones were one stock). TACs in both the southern and eastern zones were set at the level required to reach the target biomass in 2004.

The 1996 assessment process raised further uncertainties. The industry consultant attending the meetings questioned the values of natural mortality being used in the assessment, especially as there appeared to be some bimodality in the only catch at age curves available. The assessment group could not determine which of the two natural mortality rates was correct (0.045 or 0.064) and henceforth it was decided that both would be reported in assessments. This had the unfortunate effect that under one scenario, reduction in the combined eastern and southern zones TAC to 2 800 t was essential if the strategic objectives were to be met, while under the other scenario no reduction from the 1996 TAC of 6 000 t was acceptable. The southern zone TAC 1997 was reduced to 4 000 t, above the 3 200 level recommended by the assessment group.

There was increased concern among scientists during the 1997 assessment that the 2004 target could not be met (Bax 1997). These concerns were due to a recently completed study on otolith shape, which added to the probability that fish from the eastern and southern zones were from a single stock (Robertson *et al.* unpublished ms). In addition, refinement of earlier acoustic abundance estimates, due to a redefined survey area (based on improved topography), manufacturer calibration error, and corrections to inconsistent assumptions of acoustic deadzone height for the earlier surveys led to reduced biomass estimates in recent years, but a higher biomass estimate for 1990 (Bax 1997). Further complicating the assessment was the apparent redistribution of fish between St Helens (the traditional main ground), and the nearby St Patricks Head so that catch and effort at the two areas was approximately equal (Figure 1). This cast doubt on the 1996 acoustic biomass estimate of the fish at St Helens derived from the first acoustic biomass estimate since 1992. Future population projections were no longer provided for the eastern zone alone and under the assumption of a lower rate of natural mortality a reduction in catches of more than 50 percent was required to meet management goals for the combined zones. Estimates using the higher rate of natural mortality indicated that no decrease in catch levels was necessary. Industry disagreed with the 1997 assessment results and included a separate position statement in the annual assessment report (Bax 1997). As a result, eastern zone TACs would not be reduced until 2001. Southern zone TACs were reduced to 1000 t but remained far above the catches taken.

Stock assessments were halted in 1998 and 1999 while the available assessment group resources were redirected to address industry concerns over the 1997 assessment. There was a continued shifting of effort to St Patricks Head and since 1999 catches there have been double those on St Helens (Wayte and Bax 2002). The assessment in 2000 had the agreement of industry that all that could be done had been done to address their concerns. However the assessment did not indicate the resource was in any better condition than estimated in 1997. Assuming natural mortality of 0.048, a zero catch (combined zone) or a maximum of 1 000 t (eastern zone alone) was all that could be taken. Under the higher rate of natural mortality (0.064) the existing catch of 2 000 t (eastern zone) or 2 350 t (combined zones) would meet the agreed management goals for the fishery. TACs for 2001 remained unchanged at 2 000 t for the eastern zone and 2 700 t for the combined zones.

Some of the ambiguity from reporting on two possible levels of natural mortality was reduced in 2001 by fitting the assessment model to the age composition data and, with catches being maintained at the same level as previous years, the outlook became steadily worse. While under some scenarios it was still possible that strategic objectives could be met, overall it was “increasingly unlikely that AFMA’s performance indicator can be met without a substantial reduction in the Eastern Zone TAC” (Wayte and Bax 2001). TACs for the following year were reduced by 10 percent following a SETMAC policy of not reducing TACs by more than 10 percent to reduce disruptions to industry and concerns over what effect displaced effort, especially from the larger vessels, would have on other already fully or over-exploited inshore fish species.

An additional age composition sample taken in 2001 further reduced assessment ambiguities (M was now estimated at between 0.039 and 0.042, instead of the range of 0.045 to 0.064 that had been used since 1996) and the 2002 assessment made it clear that, with less than 15 percent of prefishery biomass remaining, “the AFMA performance criterion for this fishery will not be met even with a zero catch.” (Wayte and Bax 2002). Additional modelling indicated that the eastern zone performance criterion would not be met for 6–17 years even with a zero catch, or 9–27 years with continued catches of 800 t. The 2002 TAC was set at 800 t, but notice was given that this would not necessarily be continued. Given the implications for industry of the 2002 assessment, a second international review was requested (this time by the assessment group). While the reviewers had specific recommendations on how the assessment could be improved, overall they found the assessment to be “consistent with world best practice”, and the stock to be “at a level of biomass that most biologists would consider too low” (Francis and Hilborn 2002). The reviewers gave support to 40 percent of prefishery biomass being a commonly accepted target biomass level, but stressed that what was most important was that the stock be demonstrated to be in the process of rebuilding.

Between 1993 and 2003, scientists had recommended that in aggregate between 10 000 and 18 000 t could be caught if AFMA’s performance criteria were to be met. Resulting TACs were always closer to the upper end of the range than the lower end. Over the same period, aggregate TAC was 20 000 t and actual catch 3 000 t higher.

3.4 Precautionary management

The Cascade Plateau is a rocky seamount 125 nm ESE of Hobart, Tasmania that has been fished consistently since 1996. A 1 000 t precautionary quota had been set for this fishery by SETMAC before consistent fishing began. As TACs for eastern and southern zones declined, a few operators (with larger vessels) started to explore the Cascade Plateau. In 1996 863 t were caught and in 1997 the 1 000 t trigger was reached by late April. AFMA closed the fishery and requested that the assessment group consider the Cascade Plateau stock status. In May of the same year a research and fishing proposal was developed by ORAG and submitted to AFMA to support development of a long-term management strategy for this fishery.

The research and fishing proposal was designed to be precautionary, in effect requiring demonstration that fishing on the Cascade Plateau would be ‘safe’ for the stock, instead of scientists having to prove that it would have an adverse effect. It was proposed that a controlled level of ongoing commercial fishing would be allowed monitored closely by scientific observers. A levy base was established to support a range of scientific studies leading to an acoustic or egg production biomass estimate of the spawning aggregation (e.g. Prince and Diver 1999, Prince and Diver 2001). Given this cooperative research approach, the 1 000 t trigger was increased to a 1 600 t TAC. To increase knowledge on the dynamics of orange roughy on the Plateau, the 1 600 t TAC was divided into four 400 t quarterly TACs providing year-round information and reducing the potential for fishing to concentrate on the spawning aggregation if the fishery were to start to decline.

From 1998 to 2003, the 1 600 t TAC has been caught, the spawning aggregation defined and delimited and a type of acoustic monitoring by industry vessels developed. Acoustic biomass estimation was not practical with the equipment available, although estimates of school volume gave some reassurance to ORAG that the aggregation was not in precipitous decline (Wayte and Bax 2002). As increasingly sophisticated acoustic equipment became used in the fishery, an acoustic estimate of the spawning biomass was made in 2003 using methods comparable to earlier scientific surveys in other Australian fisheries. The results of that survey will be available before the 2005 Cascade Plateau TAC is set.

4. DISCUSSION

Exploitation of Australia's orange roughy fisheries has been characterized by uncertainty in stock structure, standing stock and sustainable exploitation rates. Looking forwards, uncertainty is a somewhat benign and intellectually stimulating, if sometimes frustrating aspect of interacting with complicated systems. Looking backwards, uncertainty is error, misjudgment and wishful thinking.

Uncertainty is often understood as implying that there is range of possible values around the best estimate, and that this range is somewhat symmetrical, although not perhaps on an arithmetic scale. For this fishery, uncertainty has been characterized almost uniformly by overly optimistic interpretations of the present and future states of the fishery. Looking back at the history of scientific advice during the exploratory stage of the fishery, starting with Kenchington (1987) for the Sandy Cape fishery through to DPFRG for the St Helens fishery (DPFRG 1990a) catches of several thousand tonnes were recommended. TACs were set an order of magnitude higher and were either not enforced or failed to take into account lost and discarded fish, so catches were considerably higher.

At various and repeated, times during the exploitation of these fisheries fishery scientists and managers have made mistakes on where we were, where we were going, and how we were going to get there. In the exploratory stage of the fishery, misinterpretation of bottom features as fish shoals, taken together with high short-term catch rates, and a goldrush mentality to fishing in an almost unregulated fishery, led to unrealistic expectations and excessive transfer of capital into the fishery. This was no doubt influenced by the large orange roughy stocks that had been previously found and fished in New Zealand, declining catches elsewhere in the South East Trawl fishery and by the understanding among fishers that if quotas were introduced they would be based on catch history, so there was no time to lose in getting into their orange roughy fishery. Subsequently, during what should have been the sustainable fishery – after industry had agreed to much lower, but sustainable TACs – errors in acoustic biomass estimates and new data on stock structure and age composition led to recommendations for further decreases in TACs, that were implemented only after several years' delay.

The assessment group responsible for providing orange roughy advice still does not know where it is going with this fishery. At the start of the fishery, scientific advice was clear that biomass should not be reduced below 50 percent of prefishery biomass (DPFRG 1990b). This limit was soon passed and in 1994, AFMA, acting on advice from the assessment group, determined that 30 percent of prefishery biomass was the target, which was subsequently endorsed by international reviewers (Deriso and Hilborn 1994) and a timeframe to reach it was established (for fisheries already below 30 percent). Following revised scientific advice and the failure to manage to this target level, a rebuilding target of 40 percent of initial biomass was put forward by the assessment group and again endorsed by international reviewers (Francis and Hilborn 2002). This target has yet to be accepted by AFMA.

Last, even if there was agreement on a rebuilding target, there has been doubt about how to get there. Total allowable catches have been consistently set at, or above, the highest levels recommended by scientists and estimated catches consistently exceeded the TAC at the start of the Eastern Zone fishery. In addition, and despite DPFGR concluding that the “greatest danger to the resources and industry is... from a build up of catching power during the transient period of high catches” (Anon. 1988), there seems to have been no restriction on permits given to develop the orange roughy fishery and the number of shots trebled between 1986 and 1990 (Tilzey 1994). Scientists expressed their concern that their advice was often seen as overconservative, while Australia’s record on managing fish resources at the time did not seem overly conservative given that most resources were maximally exploited and some had collapsed (Kearney 1989). Either the scientists had not been conservative enough, or else managers, because of the uncertainty in advice, had not accepted that short-term gains or stability should be sacrificed in the interest of long-term resource conservation (Kearney 1989).

Part of the process of delivering effective management advice is to ensure that decision makers recognize the full range of uncertainty before they make decisions. Scientific uncertainty is just one component of epistemic uncertainty that incorporates the perceptual, intellectual, and linguistic processes by which knowledge and understanding are achieved and communicated. It is an important part of the process of how scientific advice (and associated uncertainty) on the status of a fishery gets translated into management action. Fisheries management is not unique in the difficulty of making reliable predictions. A recent paper spells out a story for business executives that will be only too familiar to those involved in managing the world’s fisheries:

“When forecasting the outcomes of risky projects, executives all too easily fall victim to what psychologists call the planning fallacy. In its grip, managers make decisions based on delusional optimism rather than on a rational weighting of gains, losses, and probabilities. They overestimate benefits and underestimate costs. They spin scenarios of success while overlooking the potential for mistakes and miscalculations. As a result, managers pursue initiatives that are unlikely to ... ever deliver the expected returns”

(Lovallo and Kahneman 2003).

It might be considered unrealistic to believe that we are able to predict the future with any accuracy – at least if we base our predictions solely on our own understanding of the local system. One way to bring in additional information and potentially improve our accuracy could be to bring in information from outside sources. In providing stock assessment advice, this could involve basing forecasts on how successful similar forecasts (by species, region or jurisdiction) have been in the past. In fisheries management, a precautionary approach would be to take best (unbiased) estimates from stock assessments and then adjust them on the basis of how successful others’ best estimates have been in the past. How would the history of Australia’s orange roughy fisheries have been different if we had taken the New Zealand prior experience in overfishing orange roughy, decided that their assessment science was not dissimilar to our own and therefore concluded that we should be more conservative than our best science recommended? Unfortunately this outside view is rarely popular, often being viewed as a crude analogy to superficially similar instances and is usually rejected in favour of the inside view which is seen as a serious attempt to come to grips with the complexities of a unique challenge. Neither approach can be expected to be perfect, however the outside view has repeatedly been shown to be more accurate in systematic research (Lovallo and Kahneman 2003). Looking towards the future we recommend that both the inside and outside views be used in providing management advice for deep-sea fisheries. In this way we can learn from the costly lessons that constitute much of our history in deep-sea fisheries management.

5. ACKNOWLEDGEMENTS

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THEME 4

Technology requirements

Use and abuse of data in fishery management

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1. THE INFORMATION WAR

“...Because $U(t)$ is a linear function of population biomass for $U(t) < \gamma K$, there are an infinite number of equilibrium solutions when the replacement line $U(t) = \beta B(t)$ coincides with the replacement line $U(t) = UB(t)/\gamma K$ [i.e. when $\beta = U(\gamma K)$]. ... Nevertheless, the relative equilibrium population size structure, N_j^ / N_{j+1}^* for all j , will be identical at all possible equilibria on the interval $0 < B(t) < \gamma K$ regardless of the harvesting strategy which maintains each equilibrium...”*

(Extract from a scientific document on the management of a deep-sea rock lobster stock by the authors of this article)

“Speak English!” said the Eaglet. “I don’t know the meaning of half those long words, and, what’s more, I don’t believe you do either!” (Lewis Carroll: Alice in Wonderland)

A new breed of high profile fisheries scientists is commanding increasing influence in the worldwide management of fish stocks. Like the knights of old on horseback, they fly around the world waving powerful computers like swords and dispensing mathematical models like magic potions. They use complex scientific jargon to communicate amongst themselves and are dismissive of others who are unable to understand or participate in their complex rituals. They recognize no masters and take no prisoners. They are the protectors of the sea and its fish. Uncontrolled fishers are their enemies and unsustainable utilisation is their war cry.

Many of these scientists have no biological background and little knowledge or interest in fisheries biology or ecology. Never having been exposed to the harsh and smelly realities of fishing or the challenges of running a competitive business, to them fishing is the manipulation of binary digits on their virtual fish stocks, productivity occurs at peaks on different probability curves and reality is defined by the minimum “negative log likelihood” parameter estimates that appear on computer printouts.

Some of these fisheries gurus treat fishers with great suspicion and contempt and use their scientific wizardry and skill to promote ideological or wider political objectives, while others regard themselves as the protectors of the environment from ruthless exploiters. Yet others sell their craft to fishing companies or fisheries associations in order to ward off harsh management decisions. The latter are often perceived to be biased or dishonest, and their scientific work is treated with suspicion by the established scientific community.

Not surprisingly, fishers frequently regard fisheries scientists as parasites who do not add value to the fishing industry, but rather impose additional costs through purposeless and unproductive fishing regulations and reductions in total allowable catches, quotas and regulated effort levels. As a rule fishers do not trust fisheries

scientists. At best they see no integrity in the scientific process; at worst they regard scientists as pawns of cynical political forces or radical environmental groups.

On the other hand the conduct of the fishing industry is questionable. There are good reasons why, in many circles, fishing is synonymous with illegal activity. The use of indiscriminative fishing gear kills large numbers of non-commercial species such as seabirds, seals, dolphins and indeed undesirable finfish species. Sharks are finned and released, doomed to a slow painful death. Where control is lax high-seas fish stocks are ruthlessly overexploited (e.g. as in recent high-seas Patagonian toothfish and orange roughy fisheries), and the pursuit of illegal high-seas fishing vessels by multinational enforcement efforts is a regular feature on many national news networks. Often catches are not honestly reported to management agencies and gear regulations are ignored.

The fishing industry receives a far greater share of public and scientific interest and comment than other more damaging exploiters and polluters of the environment. Farmers, miners and manufacturers associated with significant environmental degradation are often treated much more leniently than fishers. The intense public interest in fishing does not reduce the tension between the fishing industry and management authorities, and what should be a straightforward technical communication often deteriorates into an emotive debate where facts and science are combined with personal ideology, environmental conviction and political agenda. The often venomous e-mail exchanged between subscribers of internet groups like "fishfolk" demonstrates the level of emotion that is typically generated. The result is a chaotic cacophony, which is high on emotion and low on solutions.

This state of affairs can be partly attributed to the different philosophies governing science and fishing as occupations. Scientists are by definition 'scientists'. Fishing stories in their view are just that – stories. Scientists regard real life fishing experiences and views with considerable scepticism, a result of either not believing these narratives, or not knowing what to do with them. The reason is that the information content of these experiences is usually not properly quantified. Quantitative fisheries scientists only use and analyse information which is applicable to their mathematical models. Data which is readily incorporated into these models includes CPUE data, historic catch records, growth rate data, the data from scientific surveys of stock biomass trends, and the age and size structure of landings. Scientists are disinclined to take on the often thankless task of making sense of large amounts of unstructured or qualitative information which is not presented in the usual scientific format.

Scientists are also, by virtue of their discipline, extremely conservative. This has a lot to do with the basic personality types that opt for a career premised on the application of a rigorous discipline, in contrast to the flair and risk taking traits required to pursue a business, especially one in the fishing industry. Ideology also plays a significant role and there are a number of epistemologies, which in combination produce the final world view of modern day quantitative fisheries scientists.

One of these is the scientific ideology that one should, as a rule, favour the simplest interpretation of events as a basis for management, a rule immortalised as the maxim known as 'Occum's razor'. For example, prolonged poor catch rates should be treated as an indication of declining fish stocks, even if this is not proven. A further ideological principle is the Precautionary Principle, which came to prominence at the Earth Summit in Rio, requiring safe management measures to be taken in the face of uncertainty. In fact, any comprehensive and logically consistent treatment of uncertainty in scientific knowledge leads to the unavoidable scientific position that if the data upon which management is based are dubious or incomplete, then this has to be matched by a commensurate increase in the level of conservativeness in the basic management objectives and consequences.

Fishers, on the other hand, are hunters, who operate in an unforgiving environment. Their expertise is not neatly tabulated in columns of figures, but rather in a bag of

memories, experiences, other fishers' stories, legends and facts, all mixed together to form a picture with many hues and shades but little structure. Hardened by the high level of unpredictability associated with fishing, fishers prefer to treat poor catches as bad luck, or temporary environmental fluctuations, just like a drought after some years of good rains. They seldom accept that poor catch rates and diminishing catches are due to declining fish stocks.

2. IT'S ALL ABOUT INFORMATION

2.1 It's not about being conservative, it is about being ignorant

"It's all about information" says Cosmo (Ben Kingsley) in the movie *Sneakers* "The world isn't run by weapons anymore, or energy, or money. It's run by little ones and zeroes, little bits of data". While it is debateable that the world isn't run by weapons anymore, modern weaponry is also governed by these "little ones and zeroes" referred to by Cosmo as the binary stones of computer language. The real technical revolution of the twentieth century is, arguably, the development of information technology.

Fishers are by virtue of their occupation, conservative (the sea is unforgiving), protective of their data and suspicious of any new technology which could be used by scientists to control their operation. For these reasons, while they readily adopt digital technology for remote sensing and navigation, they are far less receptive to the incorporation of information technology into their operation.

Skippers do believe that data are important; the fact is that many of them are obsessive collectors of operational data. The problem is that most skippers see these data as a means to assist them to find fish. There is no appreciation of data as a strategic tool and hence there is little interest in the more complex aspects of data gathering and data analysis. The same applies to shore skippers and fleet managers – for them data are production sheets and quota reports. The reality is that few in the fishing industry understand the crucial role that information technology plays or could play in the management of their resources, and the significant impact it has on their business and livelihood.

2.2 Data and decision making

The face of fisheries management has changed considerably over the last 20 years. Ever-increasing computing power has allowed quantitative scientists to test and implement population models which were previously unmanageable. To quote from our own experience, a simple and short version of a size-structured model for the South African West Coast Rock Lobster resource spanning a time period of 20 years took about a week to run in 1990. A much more complex model simulating 130 years of the fishery with 20 year forecasts now takes about 85 minutes to run.

The importance of this leap in technical capacity is that fisheries scientists are able to employ increasingly realistic population models to explore different and realistic possibilities about population dynamics with considerable ease. Unfortunately, this creates a dangerous situation of hyper-rationality, in which the realism of the models tends to anaesthetize the critical faculties. Nevertheless, this advance in hardware and software has placed considerable power in the hands of quantitative scientists. This in itself would not be a problem if skippers and managers had an appreciation of the technological gap that has opened up between their knowledgebase and the knowledgebase used by management agencies and governments to manage fish stocks. Unfortunately, most fishers believe they should come out of their corner fighting and that they can wage this battle against modern "weapons" with sticks and stones. They often believe that they can outsmart quantitative fisheries scientists by providing them with partial, or worse, incorrect data. Both the presumption of the need to fight a battle, and their ability to wage it in their terms is counterproductive.

Managers in many fishing companies still fail to see the direct benefit they could, and should, derive from quantitative assessment work for day-to-day boardroom decision-making. Go to any financial service business and you will see that the entire business is linked to quantitative projections, mathematical models, risk assessments and other data driven decision aids. However, many fishing company directors will make huge investment decisions without once consulting a stock assessment scientist. The cost of such misconception and ignorance is enormous.

On another front there is a common misconception in the fishing industry that management authorities cannot, and should not, make management decisions when data and scientific knowledge are lacking. There are two problems with this view: (a) there will never be a time when we have complete knowledge of all biological, ecological, physical, environmental and other data relevant to the management of fish resources – so this is not a realistic expectation and (b), scientists must use whatever data they have to assess the state of the stock and its productivity. Consequently, when scientists feel that critical data are either not available or not reliable, their duty is to be extra cautious. This means that they should, under circumstances of uncertainty, give more weight to more conservative interpretations of the data – that is, those that assume resources are more depleted and/or less productive.

2.3 The link between data and public perception.

In a September 2003 issue of the *Economist*, an article suggests that “when disasters prompt new policies, the results may be disastrous”. It goes on to criticize the tendency by decision makers to respond to crises in an emotional and populist manner to satisfy headline grabbing journalists and a disenchanted public. Journalists and a number of scientists tend to refer to heavily depleted fish stocks in emotionally loaded terms coupled with demands for radical action. While many fish resources are indeed excessively depleted, there is an emotional overtone whenever fish resources are discussed. Often in these cases tall stories, supposition and a subjective interpretation and presentation of information is fed to the public as the real thing.

The reality is, of course, far more complex than this. Few have had any exposure to the basic concepts underlying renewable resources, and so do not appreciate that in order to exploit a resource on a renewable basis it is in fact necessary to deplete the resource biomass. Indeed, in order to optimally exploit fish resources the biomass must be depleted to between 30 and 50 percent of its pristine size. The public at large have no concept of the fact it is virtually impossible to fish commercially without severely reducing the number of large, older individuals in a population.

It is true that many fish resources in the world are badly depleted. And it is also true that fishers are often dismissive, indifferent or ignorant of fishing regulations and their underlying rationale. A boom and bust culture still prevails in the global fishing industry and “loopholing” fishing regulations is as prevalent and culturally acceptable amongst fishers as income tax evasion is amongst tax payers. Despite this, there is an increasing number of fishers and fishing companies, mainly in countries where fishing rights are secure, who are playing the game by the rules. Unfortunately the political ability of the fishing industry to lobby for their cause is diminishing rapidly, and as a result the biggest challenge for years to come is not going to be their ability to catch their allocation, but rather their ability to keep it. There are really only two options open for fishers if they have any hope to avert draconic regulations and significant cuts in their fishing allocations. Both options require high levels of investment in information gathering and management technology.

The first option is for fishers to become a reliable source of good quality data. The culture of hiding information from decision makers or other interest groups is no longer effective at avoiding public and scientific scrutiny. If anything, it adds fuel to the

general feeling that fishers cannot be trusted and as such should be intensively policed and managed.

The second option, to be used in combination with option number one, is for fishers to become equal, reliable partners in the technical debates about the determination of management plans and fishing regulations. Fishers need to accept the scientific process and to build capacity to meaningfully participate in this process. Failure to do so leaves the industry vulnerable to many “hostile” agendas, which are well versed at using the scientific process to good advantage. An example is the aggressive use by organisations such as the World Wildlife Fund (WWF) of scientific arguments aimed at promoting wildlife conservation goals. This is a fair and legitimate platform of engagement and arguably the most objective one (though not flawless as we shall see later). Any alternative is open to political and ideological abuse.

The risk of not being an honest “data broker” is far too great for the industry. A recent publication in the May 2003 issue of scientific journal *Nature* Ransom Myers and Boris Worms (Myers and Worm 2003) suggests that 90 percent of the world’s fish stocks have been removed by commercial fishing companies over the last 50 years. They suggest that the only way to confront the industry’s “irresponsible behaviour” and to save the world’s fish resources is to completely close large portions of the sea to fishing. Their call has the ear of many prominent scientists. For example, a group of British scientists lead by Professor Callum Roberts of York University (Roberts and Hawkins 2000) suggests that the world’s oceans are in crisis as a result of the massive over-exploitation of fish resources and the breakdown of the oceanic food web. They have suggested that as much as 40 percent of the marine environment should be closed to fishing if there is to be any hope of a recovery.

Debating the merits of such claims lies outside the scope of this article. However, our experience has been that such statements and sentiments find automatic acceptance and support from large sections of the scientific community and the general public. The protective, and often deliberately inaccurate, manner in which fishers record fishing data leaves a vacuum of knowledge that in the absence of reliable information, can be filled by rumours and allegations. In the game of rumours and vague allegations the fishing industry will always emerge as the loser. Only well documented and independently verifiable data can save the industry from public and scientific condemnation and from an economic catastrophe.

2.4 Real data versus model output

The management authorities on the other hand have at times used developments in information technology and computing power to cheaply replace proper fisheries science. Who needs to worry about real biological information, which is difficult and expensive to gather, when it is possible to simulate entire population life cycles using computer programmes, or when it is common practice to estimate environmental perturbations in the absence of any real environmental data and then use these in stock assessments?

In fact assessment models become so dominated by assumptions that in many cases they are more sensitive to subjective inputs, assumptions and “virtual data” than they are to the actual data. A South African example is the model assumptions about historic somatic growth rates for West Coast rock lobsters for a period over which no growth rate tagging data were recorded. Slight modifications of the historic growth rate assumptions can significantly alter the assessment model outcomes in ways that no reasonable change in the real input data would do. Another example is the role of natural mortality, more often than not a derived property rather than an empirical one, in assessment models. An example of the importance of natural mortality is the comparison of yield-per-recruit for trawled hake taken by trawl versus that taken by longline. The comparisons change dramatically under different natural mortality

assumptions. The lack of real data allows different interest groups to lobby for natural mortality values favourable to their cause.

It takes a lot of training for fisheries biologists to accept that it is acceptable to have biologically senseless assumptions in assessments in order to maintain their mathematical integrity. Examples include the growth rates of fish at size zero and the size of fish at a negative age. It seems however that no amount of training has been able to prevent stock assessment mathematicians from presenting biologically nonsensical output as a plausible reflection of reality. Champion amongst these latter outputs are estimates of recruitment. These are rarely observed directly or measured, but are regularly peddled by mathematical modellers. To the non-cognoscenti they seem to be a kind of buffer that are used at the discretion of the mathematical modeller to improve model fits, and then interpreted as a fair statement about reality.

In a high profile South African stock assessment model presently in use, the recruitment of the West Coast rock lobster was estimated to have collapsed in the middle of the 20th century to a level well below the unexploited population replacement line, for a period of some 40 years. According to this model, the resource was being driven to extinction regardless of the presence of a fishery. This, despite the same model indicating that the resource spawning biomass was close to pristine at the time of the suggested “virtual” collapse in recruitment. The reason for this feature in the model output was apparently the need to explain a phase of increasing CPUE in the 1980s. Since the catch and growth rate data were regarded as empirical and given, the model was left to “its own devices” to explain trends in CPUE and size and sex ratios. The best-fitted model produced the aforesaid massive decline in recruitment.

There is nothing wrong with such an approach as long as it is accepted that recruitment as used in the model is little more than a model-tuning artefact and that numerous other similar tuning variables could have been employed (under-reported catches, different levels of historic somatic growth rates, different levels of historic discard mortality, different degrees to which historic minimum size regulations were enforced, etc.). The first mistake is to fail to emphasize the arbitrary nature of the model assumptions. The second mistake is to fail to prevent these arbitrarily based model results from entering local fisheries science folklore. Experience shows that the longer the mistake is perpetuated, the longer it seems to take to rectify the situation and the longer that these fisheries folk tales resurface as objective facts at scientific presentations and discussions.

A disturbing phenomenon, a result of the hazy line where real data and virtual data meet, is that the model estimates referred to are presented to management bodies with the same weighting as real data. In the words of a South African industry member “thumb-sucked assumptions or model-fitted creations” get burnt into the institutional memory as real data or real events.

2.5 Double vision – same data two different interpretations

Another factor that for some reason seems to elude management authorities and scientists is that fishers do not as a rule optimize their fishing operations to achieve the maximum catch rate, but rather to achieve maximum economic rent (profit). Sometimes maximum economic rent coincides with maximum catch rate, but not as a general rule. When the two diverge, and a better size structure, species composition or fish quality is the overriding economic consideration, then the catch rate is bound to drop in response to changes in the logistics of the fishing operation. Unfortunately many scientists who are alert and responsive to real or perceived improvements in fishing efficiency (new electronic gadgets, skipper’s experience, new fishing gear, etc.) are slow, or in a state of denial when fishing becomes “inefficient” due to market driven logistic decisions by fishers. In such cases declines in catch rate are immediately linked to declining resource biomass and no attempt is made to tease out possible negative biases in CPUE.

Fishers, it should be noted, are often as guilty as scientists by their indifference or, worse, dishonesty in the manner in which they report their operations. Examples of such ‘oversights’ are failure to report discarded catches, the actual mesh size used, the target species or the true catch. There are however certain subtleties. A number of changes in the mode (gear, targeting strategy) of fishing are difficult to quantify and are therefore conveniently ignored by fisheries managers and scientists. A case in point is the common practice by fishers to move to less productive areas in order to catch favourable species or favourable fish sizes. Another is stopping fishing even when catch rates are high because company or factory daily processing quotas have been achieved. This fishing practice can increase the statistical weight (number of incidents) of low CPUE records in the database of catch rates.

3. A FEW EXAMPLES

3.1 Background

The following examples are case studies in which we were involved as scientific consultants to the fishing industry. They are described from our point of view. Many of the issues that are recalled here were, and still are, intensely debated. It is therefore likely that others involved in these debates will have different views and opinions. Nevertheless we have tried to be factual and impersonal, insofar as possible, in the presentation of the facts. Our purpose in presenting these case studies is to highlight the futility of failure to accurately record fishing data to the fisheries management authority, or alternatively to simply illustrate the pitfalls of paying insufficient attention to the strategic importance of data.

3.2 Pilchard fishing in Namibia

In 1994 a joint venture from South Africa and Namibia built a pilchard cannery at Walvis Bay, Namibia at the cost of about US\$ 8 million. This investment decision was based on industry-wide pilchard catches of about 90 000 t a year since 1988. The decision-makers were apparently unaware at the time of biomass surveys indicating an alarming and persistent decline in resource biomass since 1991. As a result, the company was taken by surprise when in 1995, a year after the cannery was completed, the Namibian pilchard TAC was reduced from 125 000 t to 40 000 t. In 1997 a further 50 percent reduction in the TAC was introduced. Since then the average annual TAC has been about 30 000 t, 30 percent of the production figure upon which the construction of the cannery was based. As a result the cannery is underutilised with a significant loss of money.

Simple attention to some of the details of the available scientific data, coupled with an understanding of some basic principles of the population dynamics of pilchard stocks, may have led to a different decision. This is a common mode of operation by fishing companies around the world, i.e. ‘first create the catching and processing capacity and then try to get the fish to justify it’. In this case, as with others, this leads to undue pressure on scientists to produce more favourable assessments or on politicians to override conservative scientific recommendations. In the Namibian case there was another unfortunate development. As it became clear that Namibian scientists would not increase the pilchard TAC, applications were made for licences to fish pilchard in Angolan waters just across the border, in full knowledge that this was, and still is, part of the same pilchard resource.

3.3 Somatic growth rates in the West Coast rock lobster resource

West coast rock lobster growth rates have been recorded in South Africa since 1968. Up to 1987, 20 sites were sampled sporadically for growth. Growth rates are estimated by measuring, tagging and releasing a few thousand lobsters (mainly males) just

before the moulting season. Tagged lobsters, which are later caught commercially, are measured for carapace length. From 1987 on a more regular tagging programme was established at six or seven regularly sampled sites. Lobster growth rates along the South African West Coast are known to be strongly area dependent and it was felt that it would not be statistically appropriate to use tagging results from pre-1987 samples. As such, the growth rate index, which was used in size-structured stock assessment models, was based solely on post-1987 tagging data. In 1994, three changes to the way that the growth rate index was calculated were made.

- i. The more scattered data from the much larger number (>20) of sporadically sampled sites for years 1968 – 1986 were incorporated into the analysis.
- ii. It was decided, based on aquarium studies, that lobsters can actually shrink in size and so a decision was made to include all zero and negative growth rates values which previously were discarded in the calculation of average annual growth rates.
- iii. Until 1994 measurements were recorded to the nearest millimetre but thereafter measurements were recorded to the nearest tenth of a millimetre.

These changes in methodology introduced a number of problems. One is the difficulty of obtaining annual indices of growth rate when there are no records of growth rate for the majority of year and site combinations. Another follows from the simple act of including zero and negative measurements in the growth rate data set. The concern is that, historically, zero and negative growth rate records may have been lost, leading to a positive bias in the historic mean annual growth rate estimates.

A further potential difficulty with the inclusion of zero and negative growth at large values was that these may in fact be the result of a no-moult, since the lobster was either tagged, released and recaptured before moulting took place, or tagged released and recaptured after moulting had already occurred. This concern was raised by the industry but was rejected by the South African management authorities who informed them that the moult state was recorded by well trained inspectors when recaptured tagged lobsters were handed to them. Consequently, the original tagging datasheets were examined and it was found that the moult state of tagged and recaptured lobsters was not recorded in real-time by inspectors, but was in fact judged from the recorded growth rate level. In short the moult state was an assumption and not based on independent empirical data.

In order to test the possibility that lobsters, that had not moulted were included in the growth rate database, a statistical test of the relationship between time-at-large and growth rate was carried out. The test revealed evidence for the dependence of growth rate on time-at-large, suggesting that lobsters which had not moulted were included in the database.

A number of methods were tested in order to exclude no-moult cases from the data set. The method preferred by authorities involves excluding 70 percent of the data. The resultant plot of interannual growth rates shows high pre-1987 growth rates, and post-1987 growth rates which are some 70 percent lower.

To date there is still unhappiness in the industry about the growth rate index used in the assessment model. There has been no clear biological and/or ecological explanation for the large decline in somatic growth rates indicated by the available data, nor why this decline in growth rate seems to coincide with the time of a change in sampling methodology. From an economic point of view, the assumed decline in lobster growth rate in recent years has doomed the resource to an unproductive state that has serious implications for the annual TAC. From a scientific point of view the loss of 70 percent of the data is of concern. From a logistic and monetary point of view, a large amount of effort and money has been wasted simply because data were not properly recorded and sampling methods have not been consistently applied.

3.4 West Coast rock lobster – size structure data supplied by the industry

In the early 1990s the catch rate of the South African West Coast rock lobster (*Jasus lalandii*) declined significantly. As part of a scientific debate, which was initiated to explore the reasons for this decline and to propose remedies, it was suggested that the exclusive harvest of large lobsters above the 89 mm carapace length minimum size was putting too much pressure on this relatively small component of the resource, given the reasonable assumption of a large stock of lobsters below the minimum size. The industry, keen to pursue this argument, volunteered to conduct a survey aimed at estimating the quantities of lobsters below the minimum size. The industry was aware of the implications of the finding of such a survey, especially the positive nature of a result indicating large numbers of lobsters just below the minimum size. For whatever reasons the survey results indicated an abnormally large frequency of lobsters on the 88–89 mm size range. It seems that somebody decided to record lobsters between 80 and 88 mm as 88 mm lobsters. If anything this was not much more than a white lie. No attempt was made to increase the total number of lobsters sampled, rather some inventive data massaging. The result was that when the size data were plotted, a distinct horn was created just below 89 mm. The end result of this exercise was that:

- all the data from the industry survey were discarded
- the industry lost credibility
- the entire survey program, which was initiated and initially designed by the industry, was taken over by the South African management agency, the Sea Fisheries Institute of the Department of Environmental Affairs and Tourism and
- the scientific deliberations regarding possible changes in lobster minimum sizes was sidetracked and ultimately delayed, since the credibility of claims and information, which were provided by the industry as part of the debate, were now questioned as well.

3.5 West Coast rock lobster – use of catch rate data as a biological or an economic index

Since 1995 there has been a substantial increase in the catch rate of West Coast rock lobsters by a factor of about four. This high catch rate has been associated with a relatively low TAC in relation to the industry's catching capacity. The high catch rate and the low TAC has transformed the entire way in which fishing companies have deployed their fishing effort. Since landing the TAC is not an issue, far greater emphasis has been placed on increasing the value of the catch and reducing fishing costs.

In other words the industry has been transformed from one which is volume driven to one which focuses on cost savings and product quality and value. As a result, fishing vessels have started to fish closer to home in order to save fuel and working hours, this, despite the fact that much higher catch rates can be achieved further afield. The sacrifice in catch rate in this case is insignificant in comparison to the operational costs saved. Fishers have also been instructed to target preferred lobster sizes – at present smaller lobsters are preferred as they fetch better prices in the Far East. This targeted fishing, which probably involves some selective discarding of large lobsters, also reduces the potential catch rate. Another issue associated with substantially improved catch rates are the problems caused for processing and marketing. If product comes in from the sea at a rate faster than can be processed or marketed, then skippers are instructed to restrict their daily catches. This is typically achieved by setting catch tallies which are considerably less than what could be caught if the total numbers of onboard traps are used. The problem is that skippers generally report the number of traps onboard and not the number of traps actual used and these erroneous trap values are then used in calculating the CPUE (catch (kg)/number of traps).

A further problem in the West Coast rock lobster fishery is that the CPUE calculations have no time unit. Consequently, changes in soak time which may affect catch rate are not recorded and presently the impact of different soaking periods on CPUE is not calculated.

The end result is the creation of contradictory perceptions about the resource, scientists versus fishers. Fishers say we never had it so good, scientists say, no, your catch rate trend is considerably less than you assume and there is no cause for celebration. Industry people are, of course, guilty by not accurately recording information (mainly the exact number of traps used) critical to a proper calculation of catch rate. However, on the management authority's side there seems to be a level of indifference to the collection and interpretation of factors which may be negatively biasing catch rates. The reason is simple. There is no biological risk associated with management decisions based on the assumption that the catch rate is lower than its real value, since if anything, TAC allocations would be more conservative and resource depletion less. A much keener investigative approach to possible biases in catch rate data seems to take place, however, when the agenda is factors that may be increasing efficiency in the fishery.

3.6 Namibian hake – survey biomass estimates

In 1996, following a decline in the commercial CPUE index since 1995 and a similar decline in the annual biomass estimate from scientific surveys, the Namibian management authorities felt that there was a need to take corrective action on the TAC. The problem was that the standard stock assessment methods (a surplus production model and, later, an age structured production model) suggested that the Namibian hake resource was large and growing.

Though there is, often, some discrepancy between different methods of estimation, the gap in this particular case was large. In 1995, for example, the survey estimate put the resource biomass at about 330 000 t while modelling work suggested a biomass of between 2.5 and 3.5 million tonnes. The TAC implications of these different assessments were, of course, significant. Since, at the time, the annual Namibian hake TAC was calculated as 20 percent of the fishable biomass estimate from the scientific survey, the TAC for a biomass estimate of 330 000 t was 66 000 t, less than 50 percent of the annual catch at that time. On the other hand the estimates from the stock assessment models produced an MSY of about 350 000 t and indicated that the resource biomass was well above the biomass required to produce MSY – B_{MSY} .

The commercial catch rate is notoriously unreliable since it suffers from numerous factors capable of influencing catchability¹ and hence biasing trends in CPUE in relation to resource biomass. Examples include an increase in fishing efficiency from the use of better fish tracking equipment, the use of gear with improved fishing efficiency and changes in fishing efficiency resulting from strategies to target particular size ranges.

Although the long term trend in commercial CPUE since 1990 was increasing, the recent decline in CPUE since 1995 was worrying. However the focus of attention in this particular debate was the interpretation of the annual fishing survey results involving the use of a dedicated research vessel, which at the time was virtually the only management tool for the Namibian hake resource. The prominence of this research tool raised some important questions about its validity, particularly whether it is possible for a combination of swept area and acoustic biomass estimates to be reliably used as an absolute estimate of resource abundance, or whether the survey results should only be used as a relative index of abundance. This debate led to a number of different investigations. One of these was to examine the quality of the model fit to a suite of

¹ Catchability in this paper refers to that fraction of the fish encountered by the gear that is actually caught, i.e. the vulnerability to capture – Ed.

observed data sets including the historic commercial catch rate, the post-independence catch rates, historic and post-independence catch-at-age and the scientific survey abundance estimates, and associated catch-at-age data, all using different values of q . A value of $q = 1$ (see footnote) means that the survey abundance estimate can be treated as an estimate of the actual abundance of hake. Values of q that are smaller than 1 indicate that the scientific survey's estimate of abundance is negatively biased with respect to the true value. A possible reason for this is that only a certain proportion of the hake within the sweep of the net are caught and/or detected acoustically. It is possible to leave it to the modeller to decide whether the survey can be used to estimate the absolute hake biomass or, if not, what percent of the biomass is detected by the survey, by treating q as a quantity to be fitted in the mathematical model. In this particular case the best-fitted estimate of q was between 0.25 and 0.30, implying that on average the survey abundance estimate is only 25 to 30 percent of the true biomass.

The other analytical approach that was followed was to critically examine the survey methodology and its application in order to determine the direction and scale of biases. An unfortunate by-product of the debate about the survey was the lack of cooperation by the survey operators with industry scientists.

An interesting side-issue in this particular case was the way the data were finally provided to the industry. It was found that the database, which was used to collect and store the data, was old and fairly primitive, and incapable of handling even a moderate number of sampling stations (~ 2000). As a result the entire survey period from 1990 to 1997 was stored in two different databases, resulting in a confusing duplication of station numbers (survey locations). Furthermore, catch information and corresponding cruise information could not be extracted simultaneously and some of the data seemed to be corrupted (either in the original database, or as a result of the data 'extraction' process). In many cases the final extracted data set lacked column headings or had short, cryptic headings. Many of the files were not properly delimited or not delimited at all and existed as a continuous string of information without any headings. A considerable amount of work and ingenuity was required in order to make any sense out of these data. Old published reports were used as a guide to locate column breaks and headings and specialized code was written to automate the data pre-processing exercise since there were many thousands of records to reconstruct. A few weeks of hard work was required for this job and during this period all attempts to obtain assistance from the data managers were unsuccessful. When data were finally available in a readable format, a number of rather worrying features emerged.

- i. The survey trawling gear had been entirely replaced during the survey period.
- ii. Different skippers were used during the survey period.
- iii. In many cases there had been serious mechanical problems with the trawl gear which was not reported to fisheries scientists and in some cases the catch and catch rate of these aborted shots had been included in the analysis.
- iv. The survey had not been conducted during the same months of the year each year.
- v. Large areas where hake was abundant (less than 100 m depth) had not been sampled at all and were therefore excluded from the total estimate of resource biomass.
- vi. One of the most damning findings regarding the survey was that night-time drags produced consistently lower resource density estimates than day-time drags. The two Namibian hake species (*Merluccius paradoxus* and *M. capensis*) are known to migrate up the water column at night to feed. Therefore consistent differences in catch rate between night and day are not unexpected when using trawl gear as the only survey tool. However the survey operators claimed that no hake could escape detection by acoustic sensors and hence there should be, on average, no discrepancy between the day-time results and the night-time results. In reality,

however, it was found that the day-time densities were consistently higher than the night-time densities, by an average amount of 48 percent. The most logical conclusion from this was that the acoustic device produced a negatively biased estimate of the density of hake above the headline of the survey trawl net.

In addition to these problems the scientific debate was confounded by attempts to over-interpret statistical fluctuations in the survey abundance as being due to specific recruitment, migration or fishing down effects. In general, particular annual fluctuations were being interpreted as real changes in biomass, while overall trends were being ignored.

An international workshop which took place in Swakopmund, Namibia in October 1997 tried to resolve the debate. By this time the TAC recommendation by the Namibian government scientists was 47 000 t, less than a third of the annual catch by the industry at the time (as a result of prior compromises between government scientists and decision makers).

The upshot of the workshop was that the majority of scientists felt it unlikely that the survey could accurately estimate the absolute abundance of the Namibian hake resource, and preferred an approach in which the survey abundance index was treated as a relative index of abundance only (i.e. this is where the assessment model estimates the value of q that is most appropriate for resource management).

General Linear Modelling (GLM), a method commonly used to generate standardised indices of abundance index by taking into account possible biasing factors such as the depth and month of fishing and the use of different sets of trawl gear, was used to analyse the survey data. The standardised abundance index failed to demonstrate a decline in the Namibian hake resource since 1990 although the final results did indicate a decline in the abundance of *M. capensis* since 1995.

The outcome of the debate was that a TAC of about 170 000 t was recommended and approved by the Namibian government. The following year the survey-based estimate of resource biomass was roughly 1.5 million tonnes. Since it was impossible to explain the sudden fivefold biomass increase in terms of recruitment, mortality and growth, the survey operators suggested that there had been a mass migration of hake from South Africa to Namibia. Coincidentally, the abundance of hake in South African waters was the highest recorded for years and considerably less than the 1.2 million tonnes that was claimed had migrated into Namibian waters.

To date (2003) the Namibian hake resource has yielded annual catches of about 200 000 t and while the debate regarding the real state of the resource continues apace, the industry seems able to land its annual TAC without any difficulty.

This story has two morals.

- i. The fate of the fishing industry in a modern, often hostile, political and scientific environment is ultimately dependent on the proper collection and interpretation of data whether this be survey data or commercial catch statistics.
- ii. Views, ideology and personal prestige plays a significant role in what should be a purely technical exercise. The only way to 'play the game' is to get involved in complex analytical issues at a level of competence that is equal to, or superior to, that of other participants and interest groups.

3.7 The South African hake fishery – codend mesh size

In 1974 and 1975 the South African hake fishery was experiencing extremely low CPUE levels as a result of resource overexploitation aggravated by the presence of foreign fishing fleets off the coasts of South Africa and Namibia. Economic margins in industrial trawl fisheries for species such as hake are generally quite small compared to fisheries such as abalone, rock lobster, squid and sole as harvesting costs represent a substantial proportion of the final value of end-product. The decline in catch rate and the associated increase in harvesting costs that occurred, particularly between 1968 and

the early 1970s, had a negative effect on the economic viability of the fishery. Industry representatives have confirmed that by about 1975 the industry was operating at a loss. The reduction in catch rate that occurred during the development of the fishery between 1955 and 1975 has been ascribed to a reduction in resource biomass due to overfishing, which resulted in sharp reductions in landings between 1972 and 1975, from 202 000 t to only 89 617 t.

The Sea Fisheries Research Institute of South Africa was the responsible fisheries management agency at the time. It recommended that the conservation of the resource would be best served by cutting the TAC and by increasing the mesh size of codends to allow for better escapement of sub-adult fish. The effective codend mesh size in the fleet, which included foreigners, was thought to be 90 mm, although a range of mesh sizes between 70 mm and 110 mm was in use. The recommended new minimum codend mesh size was 110 mm. This measure took legal effect on 1 July 1975. Prior to this time South African operators had been regulated by a minimum codend mesh size of 102 mm (the codend mesh size in the foreign fleet comprising a mix of Japanese, Spanish and Soviet vessels was not restricted by the 102 mm regulation (prior to 1975), and their codend meshes ranged in size from 70 mm to 120 mm, with an assumed average codend mesh size for the period prior to 1975 of 90 mm).

Of course, the additional escapement of small fish associated with the use of a larger mesh size was expected to lead to substantial declines in the commercial catch rate. Coupled with this, a fairly sharp increase in the mean size of hake landed was expected. However contrary to the logic underlying these expectations, two years later the following observations were made (the larger mesh size regulations took effect in 1976).

- i. The hake CPUE increased by 15 percent between 1975 and 1976 (4.66 to 5.35).
- ii. Between 1975 and 1976 the mean size of captured hake declined by 27 percent.
- iii. The total amount of hake landed between 1975 and 1976 increased by 61 percent, from 89 617 t to 143 894 t.

The reason behind this phenomenon was well known to management and industry personnel involved in the fishery. The economic impact of the legislated increase in the codend mesh size could not be absorbed by the industry without seriously threatening its economic viability. It was not possible to continue to use the 102 mm codends since there was effective enforcement of the minimum codend mesh size of 110 mm. The only solution for the trawlersmen and their skippers, whose earnings were directly linked to their fishing performance, was to make use of so-called “liners” and “panty-hoses”. These are small mesh inserts placed inside codends which reduce the intended escapement properties of the legal 110 mm mesh codends.

Of course, it would not have been possible to exactly replicate the performance of the old 102 mm mesh codends with the combination of 110 mm mesh + liner, and in all likelihood the liners resulted in an effective mesh size considerably smaller than 102 mm. It is well known that the use of liners was widespread and that the only company that attempted to comply with the new regulations went out of business. It is therefore quite conceivable that the combination of liner and 110 mm codend would result in (a) a larger catch rate than the 102 mm codend and (b), a smaller average size of hake landed, hence the observed increase in catch rate when the legal codend mesh size was increased.

The only people who were unaware of what was happening were the stock assessment scientists. For them, as is often the case, the new catch rate information was just new data. It is therefore not particularly surprising that, without knowledge of what was really happening at sea, these scientists concluded that the catchability of the resource (availability of fish to the fishery) was, paradoxically, larger at the 110 mm mesh size than at the old effective size of 90 mm (approximate value). They further

concluded that no effect or benefit for the resource could be detected as a result of the use of 110 mm codends.

Although one is tempted to treat this as yet another case of scientists being misled by poor data, the implications of this result was critical to the interpretation of future catch rate data. This is because, as a result of this analysis, the commercial catch rate time series was never corrected for the use of a mesh size considerably smaller than the assumed 110 mm. The problem for the industry was that:

- i. skipper logsheets reported the codend mesh size as 110 mm or larger, despite the illegal use of codend liners and
- ii. as catch rates started to improve (due to a significant cut in the TAC and the exclusion of foreign fleets from the South African EEZ after 1978) and the market demanded larger fish, the industry phased out the use of liners. This resulted in an increase in the mean size of fish caught and a dampening out of the rate of increase of the CPUE.

The result was that analytical work, oblivious to these important processes, concluded that the hake resource would not achieve certain rebuilding targets unless TAC reductions were implemented. Although, after much debate, the aforementioned TAC reductions were averted, the scientific management of the fishery has never really recovered from the impact of this debate. No amount of analytical work can undo the impact that the unreported and unauthorised use of liners had on the data used in the assessment process. Whatever corrections are implemented have to be conservative because, in the absence of real data, assumptions about when, where and for how long liners were used needs to be conservative in order to reduce the risk of attributing too much of the observed CPUE trend to this effect, thereby missing important biological signals about the resource. As a result, to date, there are still a number of rather dispiriting views about the State of the South African hake resource in the local marine scientific community. This has had an effect on TAC recommendations, at great economic cost.

Interestingly, the South African hake industry is at present engaging in another codend exercise that may have profound implications for its scientific management. This time however, the action is completely legal. Some skippers, in response to demand for larger fish due to lower processing costs and better prices, have voluntarily increased codend mesh sizes to as large as 170 mm.

Unfortunately, for a range of reasons, most skippers never report the actual mesh size used, even when this is entirely legal. This unreported increase in mesh size will probably lead to a reduction in catch rate with the potential to trigger the same vicious cycle all over again. That is, fisheries scientists are likely to use catch statistics in their assessment models oblivious to significant processes that have taken place at sea. The decline in catch rate is then interpreted as a decline in resource abundance and the industry will again have to explain to scientists that they have misreported their fishing gear information, and that the decline in catch rate is most likely the result of the increased mesh size and not a decline in resource abundance. This is going to sound too much like a fisherman's story, looks bad, causes a loss of credibility by the industry, and worse, it makes the stock assessments unreliable and unnecessarily conservative.

3.8 Trap restrictions in the South Coast rock lobster fishery

The South African South Coast rock lobster (*Palinurus gilchristi*) fishery began in 1973. Catches in this fishery increased dramatically from 400 t (all tonnages are in tail weight) in 1974 to close to 1 000 t in 1975 and then decreased to about 150 t in 1980. After the low catch of 150 t in 1980, catches increased, and in the 1984/85 fishing season a TAC of 450 t was set. Since the introduction of the 450 t quota in 1984/85 the fishery has been regarded as one of the most stable fisheries in South Africa despite the absence of minimum size restrictions and restrictions on the harvesting of females.

South coast lobsters are caught using small baited plastic traps attached to a long line (about 150 traps per line with line lengths of about 2 000 m). Initially each boat carried between 1 000 and 2 000 traps but this increased over time. Catches per trap in the South Coast rock lobster fishery are far less than in the West Coast rock lobster fishery and on average each trap catches about one lobster per three traps, compared to tens of lobsters per trap in the West Coast rock lobster fishery.

In the late 1970s new regulations restricting the number of traps per vessel to 1 800 were introduced. Not unlike the response by skippers in the trawl fishery (see above), skippers in the South Coast rock lobster fishery chose to ignore these regulations and continued to fish with a substantially larger number of traps. Nevertheless, as with their colleagues in the trawl fishery, skippers in the South Coast rock lobster industry only reported the legal number of traps. In 1987, following pressure by the industry, the restriction on the number of traps per vessel was removed.

With the removal of trap restrictions, effort reporting by the industry has gradually become more reliable. Since the CPUE of a set is defined as the catch divided by the number of traps, this “change of heart” by skippers has “increased” the number of reported traps with a concomitant decline in the CPUE. In 1991 this apparent decline in catch rate led the South African management authority to recommend a 10 percent reduction in the TAC. The industry were forced into the rather embarrassing situation of having to advise the authorities that the incorrect number of traps had been reported historically. Analyses demonstrated that if one uses the correct number of traps per vessel in the calculations (rather than the reported values), there is no real trend in the catch rate time series. Only after much debate and after the original skipper logbooks, accompanied by affidavits from the skippers, were used, was it agreed that the data from seven vessels, for which it was possible to verify the real number of traps used, would be used to determine CPUE trends.

This example, which is probably typical of many other fisheries, demonstrates again how skippers who have little appreciation of the role that logbook data plays in the overall management of their resource, can cause considerable damage to themselves and to the resource by trying to manipulate or “outsmart” the authorities. As you will see from the last section of this paper, the 1991 debate referred to here was just the forerunner for much more serious things to come, where again, short term economic considerations regarding the application and reporting of fishing effort almost brought this industry to its knees.

3.9 Effort reduction in the South Coast rock lobster fishery

Between 1991 and 2000 the standardized CPUE in the South Coast rock lobster resource fell by about 70 percent. During the same period the total fishing effort, measured as the number of trap-hours, where hours refers to trap soak time, increased approximately threefold. There are two main hypothesis about the processes underlying this trend.

- i. *Biological explanation:* The escalation of effort was, and is, the industry’s response to its inability to land its quota at the pre-1990 effort level. In other words the resource did indeed decline as suggested by the CPUE data.
- ii. *Explanation in terms of a change in fishing practice:* Following the removal of trap restrictions, the number of traps used in the fishery increased dramatically as skippers competed for a maximum share of their company’s quota. This led to effort saturation in which the efficiency of traps declined, reducing the CPUE.

The first option should not be dismissed lightly. It is quite common for fishers to explain negative trends in CPUE as anything but a decline in resource biomass. However, since the industry operated between 1984 and 1991 with a TAC of 450 t and with no indication of a decline in CPUE, and since the acceleration in fishing effort preceded the decline in CPUE (normally, in a TAC control fishery, increases in

effort follow declines in CPUE, rather than the other way around), there was reason to suspect that factors other than a reduction in resource biomass may have been involved.

The case for Option 2 demonstrates how actions by the industry, which are indifferent to the scientific process and to the way data are used in management, can lead to significant costs for the industry. Option 2 is based on the premise that the removal of trap restrictions in the late 1980s, coupled with a volume-based skipper commission system, induced skippers within the same company to adopt a race-to-catch fishing strategy, similar in many ways to fisheries in which there is an overall TAC, no individual quotas and the fishery is closed when the TAC is reached.

An aggravating factor was the purchase of large vessels by one of the fishing companies, Hout Bay Fishing. Each of these vessels was capable of carrying 6 000 traps, which is about three times the average of the other vessels in the fishery. Suddenly it made economic sense for skippers to load and set many thousands of traps in order to increase their income. This proliferation of traps had a number of consequences. One of these was that although the catch-per-vessel-per-day increased by about 30 percent, the catch per trap decreased by about 70 percent. An increase in the vessel's catching efficiency a day was the benefit sought by the skipper, but the impact on the trap CPUE had deleterious consequences for perceptions of the resource. In concept, the increase in the catch per vessel was achieved by increasing the number of traps worked per vessel. In order for this to be possible when there are declines in the trap catch rate, one simply has to outweigh any declines in trap efficiency by working a sufficiently large number of traps per day, or by increasing the soak time of traps. A common approach for a vessel working, say 2 000 traps a day using a soak time of 24 hours, is to switch to working 2000 traps per day at a soak time of 48 hours – this requires twice as many traps to be put in the water, but the additional catch due to a longer soak time offsets losses due to effort saturation effects, which may reduce the efficiency of traps.

The rationale underlying the process of effort saturation was that if the density of traps is increased, then, because more traps are competing for the same number of lobsters (assume similar areas for the purpose of a comparison), the catch per trap will decline, even though the total catch of all traps in the same area may be the same. This general effect can manifest itself if more traps are used per set, or if there are more sets in the water in an area even given the same number of traps per set, or even if sets are more frequent in time in a particular area.

In the situation where skippers start servicing many more traps than can be handled with a soak time of 24 hours by doubling, tripling or quadrupling the number of traps in conjunction with 48, 72 or 96 hour soak times, a large proportion of the ocean suddenly becomes unavailable to fishing, simply because of the physical presence of traps there already. As a result skippers are forced to start fishing more marginal areas where catch rates are not as good, or they have to continue fishing in the same area long after catch rates have declined to a low level, simply because alternative grounds are already occupied.

This effect of an increase in the number of traps on trap efficiency is referred to as effort saturation. The industry proposed that these factors may have caused a reduction in the catch per trap unrelated to changes or possible declines in resource biomass. Despite the fact that scientists failed to reach agreement on the reasons for the decline in CPUE during the 1990s, and despite the fact that a large scale experiment on effort saturation conducted during 1998 was inconclusive, all parties involved in resource management agreed that a reduction in fishing effort of between 30 and 40 percent, i.e. to its level in the 1990/91 fishing season, was desirable.

The responsible South African management agency, Marine and Coastal Management (M&CM), supported the proposed reduction in fishing effort because of their suspicion that excess fishing capacity in the fishery was being used for illegal fishing.

The industry supported it because it made economic sense (why finance an effort war between skippers), because it was clear to them that the fishery was over capitalized and because they held a strong opinion that effort saturation was negatively biasing the CPUE index.

The exact means of reducing fishing effort became a contentious issue and a number of mechanisms including a limit on the numbers of boats, a limit on the numbers of traps, closed seasons, fishing days and sea days were considered. Following a protracted process of consultation and negotiation, both the industry and M&CM agreed that each company would be allocated a fixed maximum number of sea days, calculated to be sufficient to land the company quota based on the stock assessment results obtained by assuming that effort saturation was indeed present in the fishery. Linked to this was agreement on a TAC of 340 t that was 40 t larger than the 300 t that would have been allocated based on stock assessments that ignored the possibility of effort saturation.

If the industry's claim about effort saturation was correct, then they would experience no difficulty landing their quotas and hence easily land the entire TAC of 340 t. If, however, the industry was wrong, it would fail to catch its allocation and the sea-day limitation would become active, protecting the resource from overexploitation. As a result just before the 2000/2001 fishing season the number of sea days were restricted to about 60 percent of the previous years average.

The results were dramatic. First, the duplicity of Hout Bay Fishing, the company that introduced large vessels in the early 1990s, was exposed. This company was apparently using its excess fishing capacity to harvest extra-quota amounts of lobsters. The restriction on the number of sea days made it impossible for Hout Bay Fishing to land these additional amounts of lobsters and hence to sustain its oversized fishing fleet. They therefore challenged the new permit regulations in court. Many dramatic events accompanied this legal process. Hout Bay Fishing's offices were searched and sealed off by police units, a number of employees and managers were arrested and charged, fisheries inspectors who aided and abetted the illegal fishing process were arrested and charged and numerous other irregularities by Hout Bay Fishing involving other resources were exposed. The company was closed and legal action was taken against its owners. On a more positive note the remainder of the fleet experienced no problem catching its share of the 340 t TAC with the considerably reduced number of sea days.

Three years later the annual TAC was increased after two years of significant increases in the annual catch rate – the first increase in the TAC in 20 years. One of the explanations for this recent increase in CPUE is that it was a response by the resource to the elimination of Hout Bay Fishing's illegal catches, which were as much as 30 percent of the total TAC. However, the increase in CPUE seems to be more dramatic than what could be explained by a reduction in fishing mortality of this degree. While it is still not possible to conclusively prove the effort saturation theory, it cannot be dismissed, and indeed modelling scenarios which include effort saturation seem to produce a better fit than those which do not.

This last example illustrates the main points of this article, since it includes almost all the elements of previous examples. It demonstrates the critical role that good quality data, coupled with innovative analytical approaches, can play in reducing costs in the industry (a much leaner industry is still able to land the TAC), changing scientific perceptions and perhaps most importantly, prevent illegal fishing. It demonstrates (a), that fishers who are ignorant about the basic analytical principles of fisheries management can ruin a highly regulated industry simply by "tricking" the scientific management machinery and (b), that management authorities should be willing to consider and to incorporate complex logistic dynamics and processes in their analyses. Fishing is a business whose objective is to maximize profits and not catch rate. As such it is inconceivable to assume that fishers who engage in fishing activities that reduce

catch rates will do so unless this increases their income. However the most important conclusion from this story is that the fishing industry has much more to gain by participating honestly in the technical management of its resources than to lose.

4. SOME CONCLUDING REMARKS

The moral of the above is simple and straightforward.

i. Fishers ...

- .. should stop treating operational data as a private property whose only use is to give them the edge while competing for best fishing performance.
- .. should start to recognize that data play a significant role in the management of the resource which sustains their livelihood and also to understand that misreporting of data for whatever reason (carelessness, intentional, or ignorance) is likely to hurt them when decisions are made with regard to their catch allocations.

ii. Commercial managers ...

- .. should realize that the industry has much more to lose than gain by not reporting data accurately. Managers should adopt a greater culture of openness with regard to operational data in their possession, even if this carries a risk (often more perceived than real) of exposing themselves to their competition.
- .. should encourage or enforce a culture of accurate recording and reporting among their skippers. These data should be the company's property (not the skippers') and should be used strategically for the company's internal needs and scientifically for the stock assessment and management process.
- .. should realize that active and accurate reporting of their data will do a lot to reduce the general hostility and distrust from the general public toward the fishing industry.
- .. should start to introduce scientific information and scientific know-how into their daily decision-making process. Commercial decisions made without scientific insight can result in uneconomic investment in infrastructure and inappropriate allocation of resources.
- .. should ensure that analytical techniques that are commonly used in other commercial sectors, such as data warehousing, data analysis and data mining become an integral component of the company's management.
- .. should accept that the scientific process is the only objective tool that can, and should, be used in the stock assessment process. They should engage in the scientific process in good faith and accept its outcomes.

iii. Government scientists ...

- .. should accept that commercial fishing is a business and is run to make profit. These do not always coincide with catch performance considerations.
- .. should realize that it is not the duty of fishing companies or fishers to prove their case when their arguments could lead to a less conservative management regime. Scientists should proactively explore ways and technical methods to quantify arguments that are relevant to the scientific process, regardless of their potential outcomes.
- .. should not feel threatened by the industry's demand for a completely open analytical process. They should subject themselves to the same "rules of engagement" that they demand from the industry with regard to accountability, access to information and acceptance of the scientific outcome.
- .. should not rely on modelling work as a "cheap" replacement for the on-going acquisition of accurate data and biological knowledge.
- .. should make a considerable effort to translate the scientific jargon and the scientific process to a language which is understood by all stakeholders regardless of their formal training.

- .. should recognize that there is a fundamental concern regarding the credibility of the scientific process due to the perception that it is often politically driven. Scientific data and scientific tools should not be used to promote political agendas when such agendas contrast with scientific understanding and experience.
- .. should separate the management process from the scientific process. Government scientists should provide information and advise technically but should not be directly involved in the formulation of management decisions.

iv. Some general remarks regarding the use of new technology in the fishing industry

The fishing industry should start seeing technology not only as a means of catching more fish but as a means to:

- .. streamline its operation by cutting costs and making fishing operation profitable without the need to catch too many fish
- .. reduce environmental damage which, in addition to the ecological benefit, will also help to give the industry respectability in the eyes of an increasingly conservation-conscious public
- .. optimize targeting and gear selectivity thereby reducing unintended bycatch and un-necessary discards
- .. add value to fish products so that the total catch value can be increased without increasing volume AND
- .. most importantly, bring twenty-first century data technology to both sea and shore operations in order to improve knowledge and management of fish resources.

5. LITERATURE CITED

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Achievements and advances in science through the use of the satellite monitoring technology applied to the industrial fishery in Peru

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1. INTRODUCTION

The abundance and availability of marine resources of commercial interest was one of the main reasons for fishing activity to be considered as an activity of common use or direct access in the world. The tendency of landings through time shows constant increases from 20 million tonnes a year in the decade of the 1940s, increasing to 60 million tonnes a year in the 1970s. The following years saw an annual rate growth of 6.5 percent as catches rose to 80 million tonnes in the 1990s.

These harvests led to a shortage and decrease of the catches causing the principle of free access to marine fisheries to be subject to changes, in particular by special influence of developing countries in developments that defended their Exclusive Economic Zones (EEZ) and the right of jurisdiction on the resources up to 200 nm offshore. This right was recognized in the 1980s through the Conference (UNCLOS III) giving rise to the United Nations Convention on the Law of the Sea (LOSC).

2. NEED TO IMPLEMENT A MONITORING SYSTEM OF THE FISHING FLEET

The present situation of populations of some marine resources in Peru, such as anchovy and sardine, is considered to be that of full exploitation and this is the main reason for the need to undertake good management programmes. Although the Instituto del Mar del Perú (MARPE) undertakes intensive monitoring of the fishing fleet, with catch sampling in ports or observers on board, it is not possible to fully monitor the fleet to determine fishing grounds and the sizes of the different fish species that are caught in the different areas. For this reason the Ministry of Fisheries opted to establish a remote satellite system of control that allows permanent surveillance of the whole industrial fishing fleet operating in Peruvian waters. Another reason for establishing this monitoring system was the conflict or interference, between the industrial and the artisanal fleets that compete on the same fishing grounds, and the invasion of the industrial fleet into prohibited fishing areas.

3. JUSTIFICATION

The merits of a satellite monitoring system of fishing fleets is noted in the FAO Code of Conduct for Responsible Fishing and Sustainable Fishing Resources and such a

system was established in Peru following the Supreme Ordinance N° 008-97-PE of the Peruvian Ministry of Fishery. It is directed mainly to the industrial larger scale fishing fleet operating in Peruvian waters under both national and foreign flags (R.M 100-2001-PE). Its purpose is to contribute to the adoption of fishing management measures and the responsible utilization of marine resources, as well as to complement the monitoring actions, control and surveillance of fish harvesting.

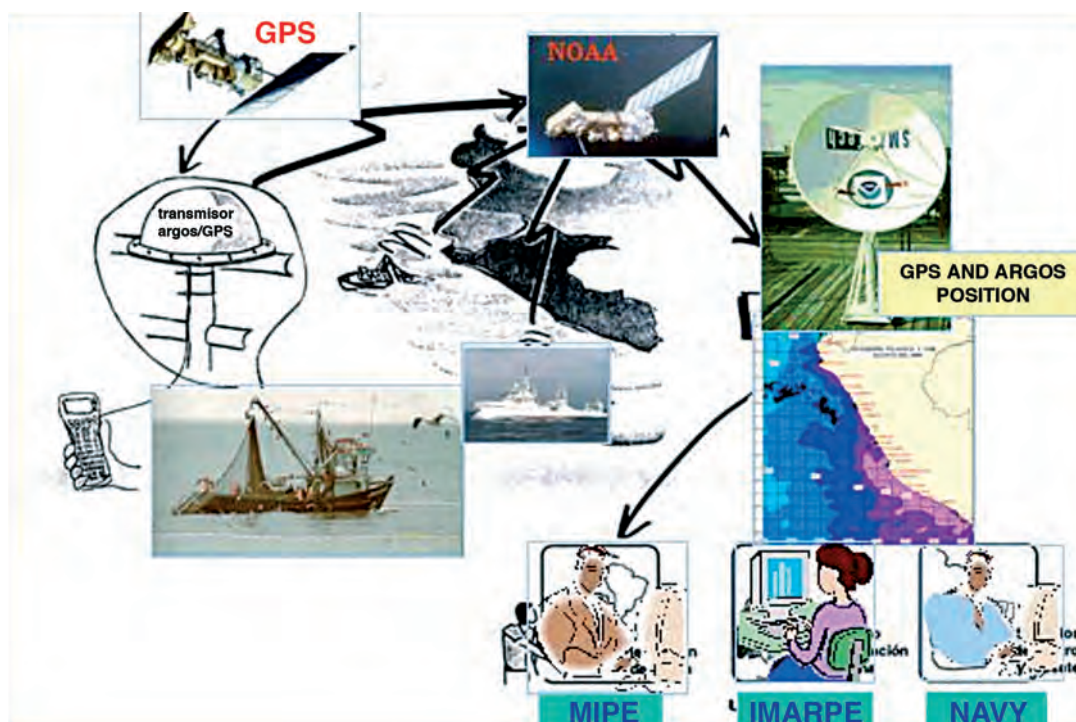
The service of monitoring the fleet is undertaken through the company CLS-ARGOS from France, which has a regional office in Lima, Peru. The owners of the fishing vessels assume the cost of the service. Ships are subject to fines if they enter a prohibited fishing ground. For example, the purse seine fleet dedicated to harvesting anchovy (*Engraulis ringens*), sardine (*Sardinops sagax*), jack mackerel (*Trachurus symmetricus murphyi*) and mackerel (*Scomber japonicus peruanus*) is forbidden to operate within five nautical miles of coast because this area is reserved exclusively for artisanal fishing operations. Another task is to direct and control ships with foreign flags outside of the 30mn limit from the coast and beyond a similar radius around offshore islands.

The system began in Peru in 1993 with the monitoring of the Japanese and Korean fleet operating with the Peruvian EEZ, which were targeting giant squid. The system was expanded to other fleets in 1999.

4. METHODOLOGY OF THE SYSTEM OPERATION

The fishing fleet monitoring system, ARGOS, operates using NOAA satellite platforms (Figure1). When NOAA satellites pass over the area of interest they receive data on the geographic position, tracking, course, speed of each ship, date and time sent from a transmitter installed on board the ship. The information is re-transmitted to the regional station in Lima, Peru after the passage of the satellite, approximately every 48 minutes, and is simultaneously sent to the respective users: the Vice-Ministry

FIGURE 1
Components and users of ARGOS satellite monitoring system



of Fishery, IMARPE and Coast Guard (Navy) via Internet. The data are then stored in a ORACLE database.

In IMARPE, the data are entered with software [MacPesca, MapInfo] and are classified by fleet type (purse seine, trawling, jigging, etc.). Then, different analyses are carried out for the determination of the locations of fishing areas, spatial distribution of marine resources and to correlate fishing activities with some oceanographic parameters.

At present around 985 vessels are monitored with the ARGOS system and include purse seiners, trawlers and squid jigging vessels, these last operate under foreign flag. It is possible for the system to handle another 350 purse seiners. In addition, the ARGOS system has available a transmitter Psion for handling reports.

5. INVESTIGATIONS RESULTS

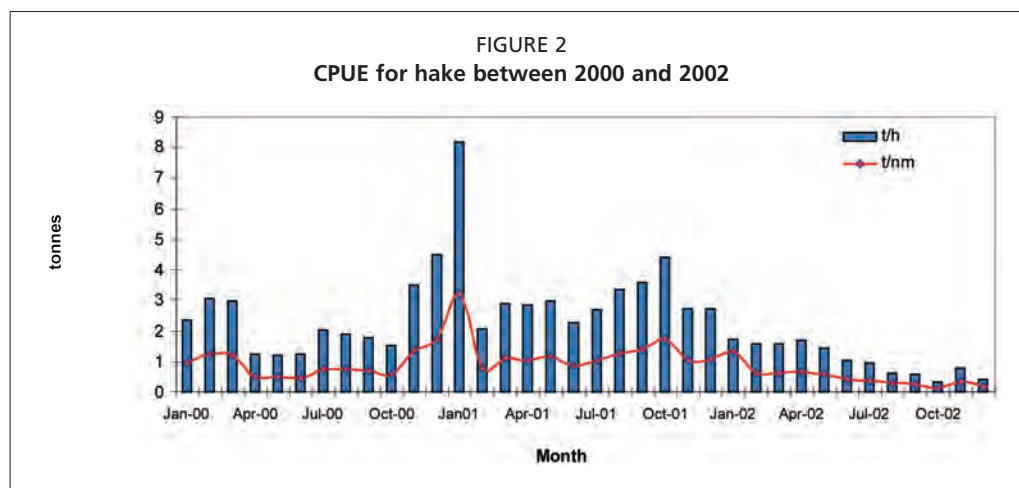
5.1 Fisheries covered

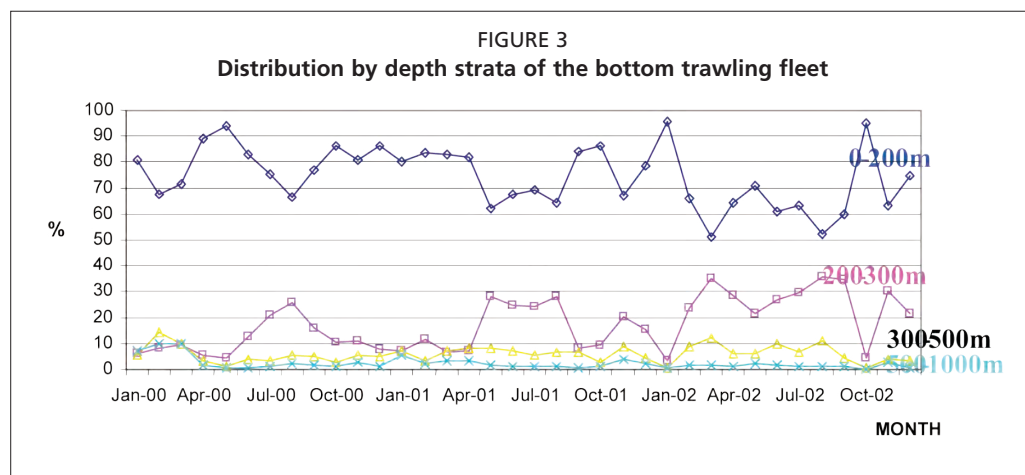
Since 1999, when the transmitters were installed on board the first ships and the subsequent expansion of the system until the year 2000 was completed, and subsequently to date, it has been possible to store a great quantity of information about fishing grounds. This has resulted in many interesting results during these four years about the activity and behaviour of the purse seine fishery targeting anchovy, the bottom trawl fleet for hake (*Merluccius gayi gayi*) and vessels jigging for giant squid (*Dosidicus gigas*) in relation to the distribution and variability in abundance of these species and oceanographic conditions. The following section shows results for the hake and giant squid fishery between 2000 and 2002.

5.2 Hake fisheries

The information gathered between 2000 and 2002 has allowed IMARPE to estimate the catch per unit of effort (CPUE) of hake in tonnes an hour (t/h) and tonnes per distance towed in nautical miles (t/nm). These data have shown a continuous fall in yields. The results show a minimum in the CPUE to have happened in October 2002 (0.3 t/h and 0.1 t/nm). The highest CPUE for smaller tows and distances occurred in January 2001, and was 8.2 t/h and 3.2 t/nm, respectively (Figure 2).

In regards to the depth strata where the bottom trawling fleet operated, it was found that the behaviour of fishing showed a seasonal pattern throughout the year that had not been appreciated. The biggest number of fishing operations was found to be between the nearshore and the 200 m isobath. However, a slight increase in operations of the fleet was observed in the depth range starting from 200 m (Figure 3). The results





showed the delicate situation of the hake population during these years and that if protection measures are not adopted, the biomass of this resource would be seriously affected.

5.3 Giant squid fishery

The giant squid industrial fishery in Peru has been carried out by Japanese and Korean flagged vessels since the early 1990s. The results of the satellite monitoring of these fleets between 2000 and 2002 show that their activity has varied over the fishing grounds from north to south, as a consequence of a warming period during the years 2000 to 2002. The centres of the fishing locations for these three years was located around the coordinates (05.2 °S and 81.9 °W; 13.8 °S and 78.5 °W), (14.9 °S and 76.8 °W) and (1.3 °S and 76.3 °W) in SST average values of 18.7 °, 19.1 ° and 20.2 °C, respectively (Figure 4).

The concentrations of the fishing operations were related to the locations of the coastal masses of cold waters (SST between 17 ° and 23 °C, salinity <35.1 ‰ ups). However the fishing localizations were not related to the best areas of chlorophyll concentration but rather around the borders of these areas, mainly in concentrations of 1 to 2.5 mg/l (Figure 5).

6. CONCLUSION

As a preliminary conclusion we believe that although giant squid is a pelagic resource with a very particular vertical behavior, moving to great depths at different times of the day and tolerating wide ranges of temperature, it also shows wide horizontal migrations that are possibly associated with oceanographic changes that affect to its food distribution.

FIGURE 4
Fishing grounds and centers of fishing operations for giant squid between 2000 and 2002

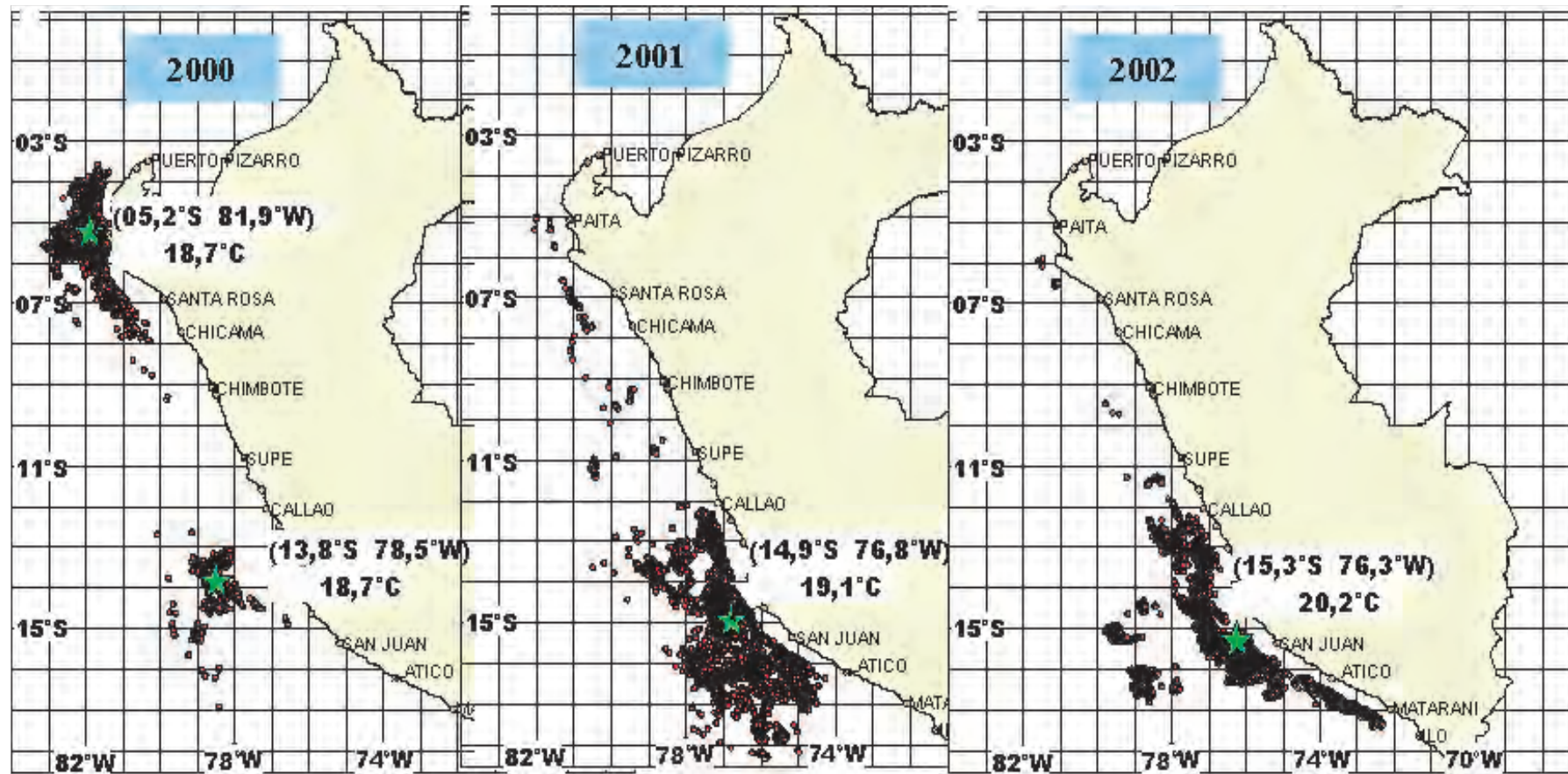
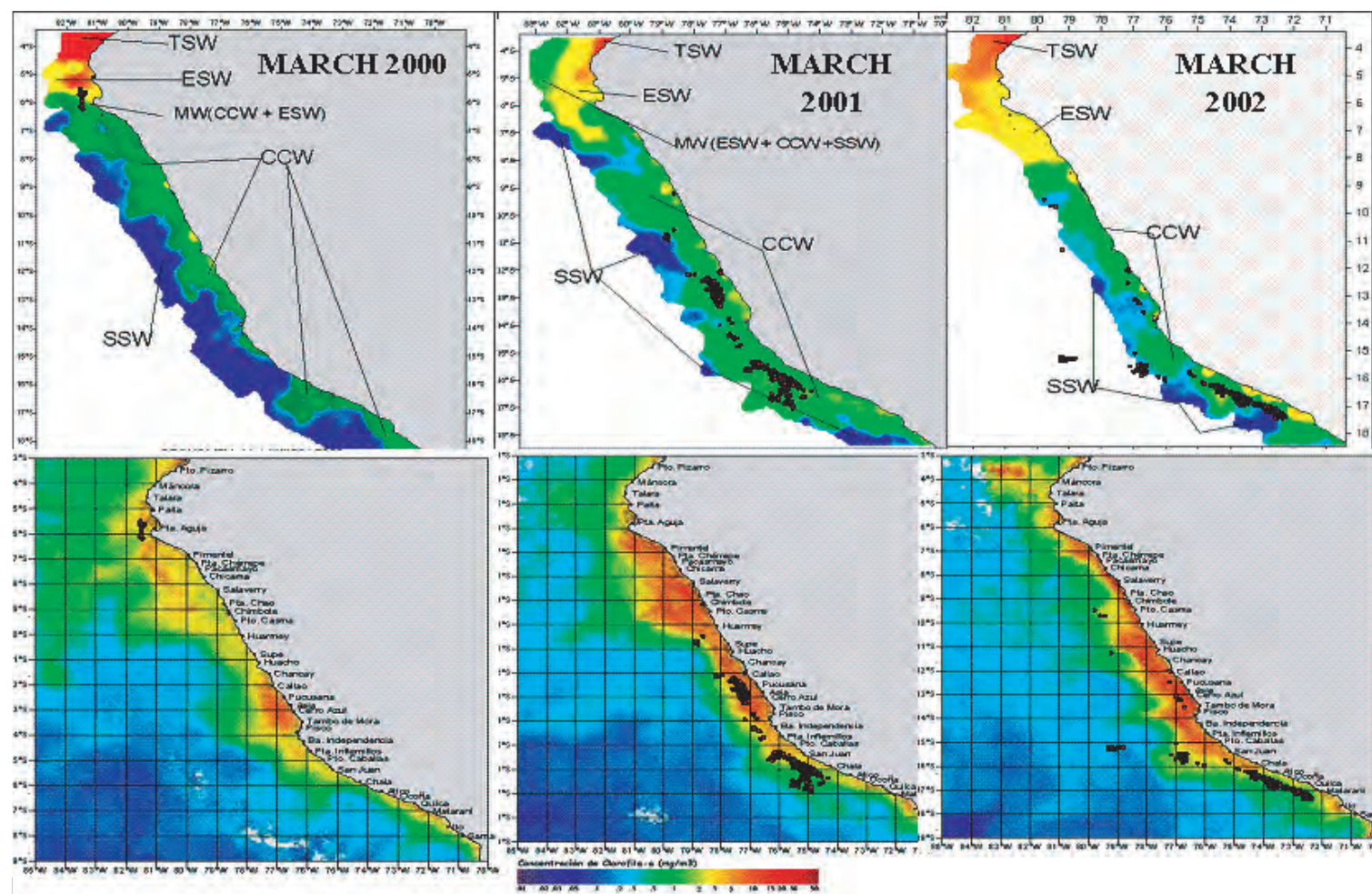


FIGURE 5
Relationship between giant squid distribution with water masses and chlorophyll *a*



Digital photography as a stock assessment tool for *Metanephrops challenger* on New Zealand's continental slope

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1. INTRODUCTION

Scampi (*Metanephrops challenger*), a burrowing nephropid crustacean, are found on suitably cohesive sediments on New Zealand's continental slope, predominantly in depths of 200–600 m. A trawl fishery, mostly using vessels 20–40 m in length that use double or triple trawl rigs of low headline height, it lands about 1 000 t annually. Catch rates vary by depth, among areas and among years. Stock assessments for this species have been hampered in the past by a lack of a reliable index of stock abundance. Both research trawl and commercial CPUE indices appear compromised by changes in vulnerability to capture, probably a result of changes in emergence behaviour. Following the apparent success of indices of abundance based on underwater video observations for several stocks of European scampi, (*Nephrops norvegicus*) (e.g. Tuck, Atkinson and Chapman 1994, Tuck *et al.* 1997, Marrs, Atkinson and Smith 1998), we developed a sturdy, reliable, self-contained digital camera system capable of operating to 1 000 m depth and deployable from relatively small vessels.

2. NIWA'S DEEPWATER DIGITAL CAMERA SYSTEM

2.1 Development and design rationale

Following successful trials observing scampi burrows with an emulsion-based underwater camera system, we developed a digital system with an emphasis on durability and the ability to be deployed in poor weather and over foul (rocky) ground. We designed our system to be essentially self-contained underwater and to be deployed using a trawl warp rather than a conducting cable or hydrographic wire. All equipment and pressure housings are contained within a protective stainless steel cage surrounded by sprung stainless steel buffers designed to cushion impacts against the ship or seabed and to minimize the chance of snagging rocky seabeds. We adapted off-the-shelf digital cameras (Minolta D'Image EX1500, 1344*1008 pixels, recently upgraded to Nikon Coolpix 5000, 2560*1920 pixels) to operate with a separate deepwater strobe and high capacity NiCad battery storage in purpose-built pressure housings. The camera is triggered using either a bottom contact switch (with a weight on a line of appropriate length attached) or using an interval timer. We estimate and maintain distance off-bottom using acoustic links based on the rugged and dependable Furuno CN22 trawl monitor system widely used in research and commercial fishing. Image files

are recorded in 24-bit colour using light JPEG compression, results in files of about 1.3 Mb each (although the recent upgrade to 5 megapixels increases this to about 4 Mb per image file). Image files are stored on compact flashcards (currently 64 or 128 Mb, to be upgraded soon to 512 Mb or more) within the camera. Other equipment carried on the camera cage includes parallel lasers (200 mm apart) to allow for image scaling and an acoustic “pinger” to allow for location and retrieval should the camera be lost at sea.

2.2 Deployment and data acquisition

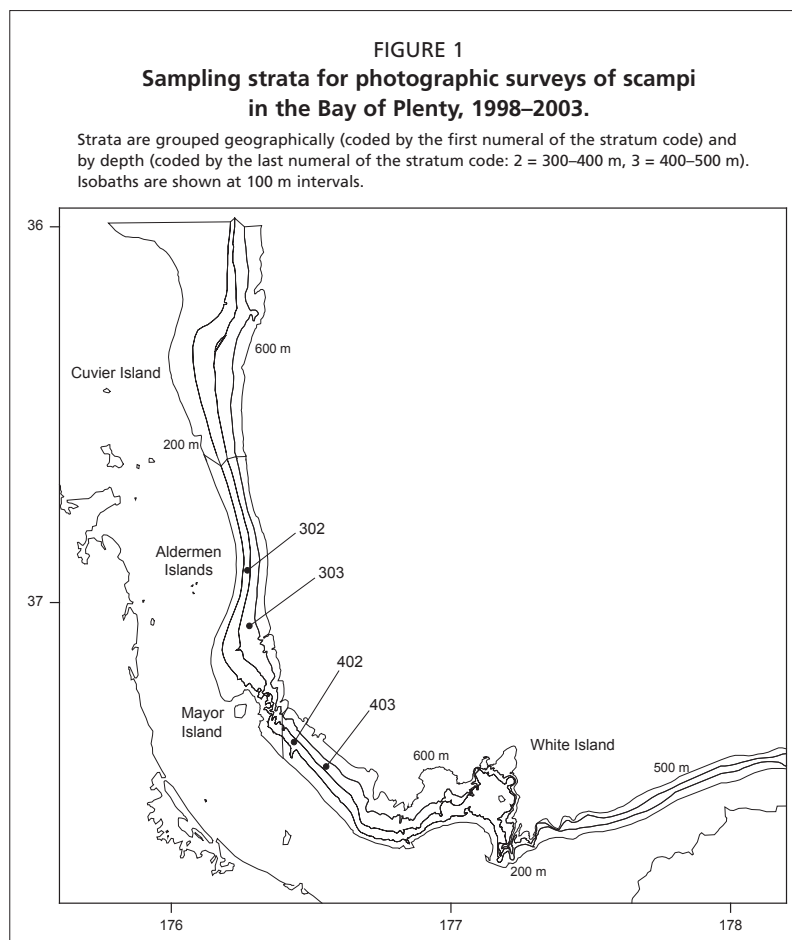
We take still photographs from 3–5 m off-bottom, depending on water clarity and sea state (especially swell), resulting in images of mostly 4–12 m². Typically, surveys consist of 600–1 000 images, spread among 20 or more stations (or transects) in 4–6 strata. Strata are defined on the basis of depth and geography (Figure 1). Photographs are taken as the ship drifts with the wind and tide and we try to separate photographs in time such that they are unlikely to overlap spatially. Transects are terminated if they drift outside the boundaries of the stratum. At the end of each transect the flashcard is removed from the camera and all images are downloaded to the hard drive of a dedicated on-board computer and backed up on CD-ROMs.

3. SCREENING AND COUNTING SCAMPI AND THEIR BURROWS

3.1 Image screening

We have developed a rigorous, standardized protocol for screening these images. An image is accepted for analysis if fine seabed detail is discernable and more than

50 percent of the image is visible (i.e. free from disturbed sediment, poor flash coverage, or other features – a good example is shown in Figure 2). The percentage of the frame within which the seabed is clearly and sharply visible is estimated and marked using polygons in “Didger” image analysis software. All emergent scampi and all burrow openings characteristic of *M. challengerii* are counted by each of three readers (selected at random from a team of six) working blind from one another. Each reader assesses the number of burrow openings using a standardized protocol (Cryer *et al.* 2003) which defines “major” and “minor” burrow openings separately (respectively, the type of opening at which scampi are usually observed, and the “rear” openings associated with most burrows). We also classify each opening (whether major or minor) as

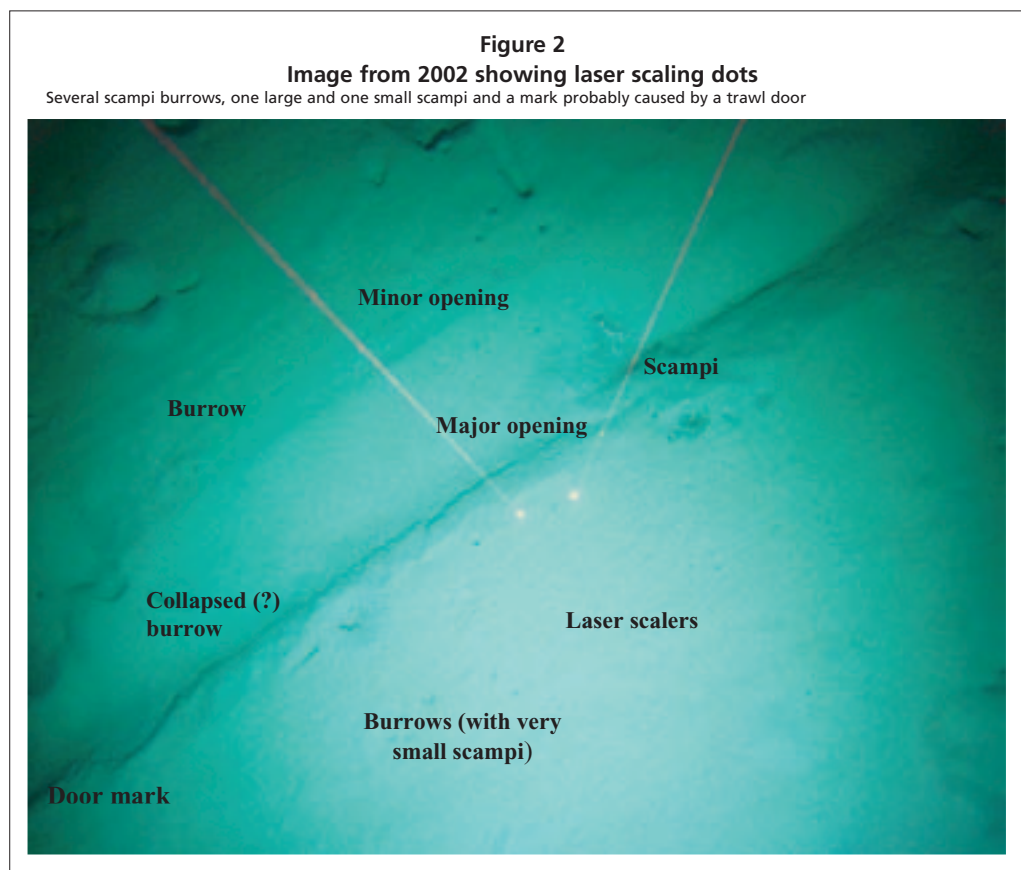


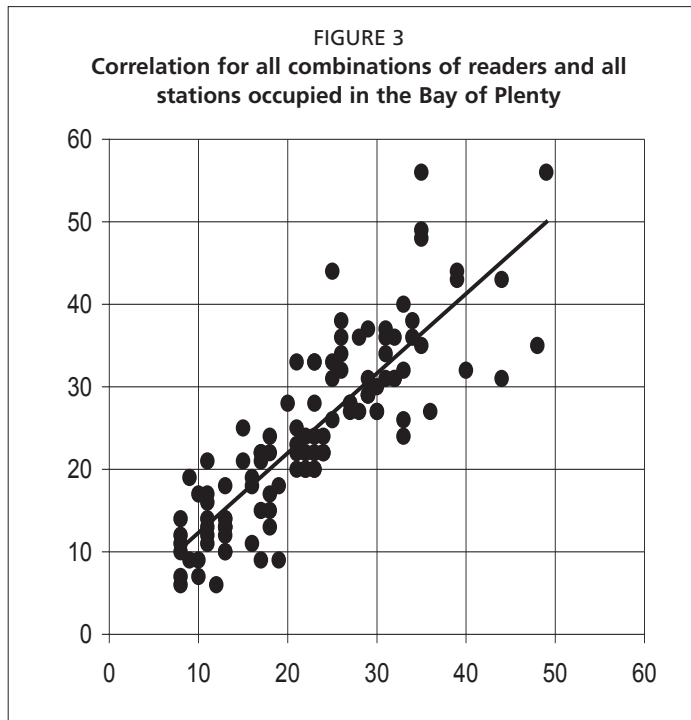
“highly characteristic” or “probable”, based on the extent to which each is characteristic of burrows observed to be used by New Zealand scampi. Burrows and holes which could conceivably be used by scampi, but which are not “characteristic”, are not counted. Our counts of burrow openings may therefore be conservative (assuming that burrow occupancy is high). All burrow openings and visible scampi scored by each reader are annotated on low quality (highly compressed) digital copies of the original image file to provide an “audit trail” and facilitate comparisons among readers.

The criteria used by readers to judge whether or not a burrow should be scored are, of necessity, partially subjective. We cannot be certain that any particular burrow belongs to *M. challenger*i and is currently inhabited unless the individual is photographed in the burrow. However, after viewing large numbers of scampi associated with burrows, we have developed a set of descriptors that guide our decisions (Appendix I). Using these descriptors as a guide, each reader assesses each potential burrow opening (paying more attention to attributes with a high ranking such as tracks on the surface, a shallow descent angle, and sediment fans for major openings) and scores it only if it is “probably” (not “maybe”) a scampi burrow.

Many assessments of the similar *Nephrops norvegicus* in ICES areas are conducted using relative abundance indices based on counts of “burrows” (rather than burrow openings) (Tuck, Atkinson and Chapman 1994, Tuck *et al.* 1997). We count burrow openings rather than assumed burrows because burrows are relatively large compared with the quadrat (photograph) size and accepting all burrows totally or partly within each photograph will result in counts that are positively biased by edge effects (e.g. Marrs, Atkinson and Smith 1998).

Once the images from any particular stratum or survey have been scored by three readers, any image for which the greatest difference between readers in the counts of major openings is more than one is re-examined by all readers (who may or





may not change their score). During this process, each reader has access to the score and annotated image files of all other readers. After re-assessing their own interpretation against the original image, all are encouraged to compare their readings with the interpretations of other readers. Thus, the re-reading process is a means of maintaining consistency among readers as well as refining the counts for a given image. The correlation of counts among readers is typically > 0.95 (Figure 3), and “reader bias” (relative to the average of the six readers) is < 10 percent.

3.2 Data analysis

Counts from photographs are analysed using methods analogous to those employed for trawl and other “swept area” surveys. To exclude a possible image size effect (burrows perhaps being

more or less likely to be accepted as the number of pixels making up their image decreases) those few (< 5 percent) images with a very small ($< 2 \text{ m}^2$) or very large ($> 16 \text{ m}^2$) readable area are excluded. The mean density (of major or minor openings or scampi) at a given station is estimated as the sum of all counts divided by the sum of all readable areas. For a given stratum, the mean density of openings and its associated variance are estimated using standard parametric methods, giving each station an equal weighting. The total number of openings in the stratum is estimated by multiplying the mean density by the estimated area of the stratum. The overall mean density of openings in the survey area is estimated as the weighted average mean density, and the variance for this overall mean was derived using the formula for strata of unequal sizes given by Snedecor and Cochran (1989):

$$\text{For the overall mean,} \quad \bar{x}_{(y)} = \sum W_i \cdot \bar{x}_i$$

$$\text{and for its variance,} \quad s^2_{(y)} = \sum W_i^2 \cdot S_i^2 \cdot (1 - \phi_i) / n_i$$

where $s^2_{(y)}$ is the variance of the overall mean density, $\bar{x}_{(y)}$ of burrow openings in the surveyed area, W_i is the relative size of stratum i , and S_i^2 and n_i are the sample variance and the number of samples respectively from that stratum. The finite correction term $(1 - \phi_i)$, is set to unity because all sampling fractions are less than 0.01. Estimates of abundance for the sampled strata are scaled by the overall mean density by the combined area of all the strata, assuming these to be without error.

The approach we have taken seems capable of generating at least two promising indices of abundance: a minimum estimate of absolute abundance based on the density of visible scampi; a minimum estimate of absolute biomass based on the foregoing and a photographic estimate of length frequency distribution; and an index of relative abundance based on the density of characteristic burrow openings.

Comparable estimates of relative abundance with estimated coefficients of variation (CVs) have been generated for surveys conducted in the Bay of Plenty, New Zealand, in 1998, 2000, 2001, 2002 and 2003. Separate indices have been calculated for major and minor openings, for all visible scampi and for scampi “out” of their burrows

(i.e. walking free on the sediment surface). However, only indices for major burrow openings and for visible scampi are presented here because these are currently thought to be the most reliable indices.

4. RESULTS TO DATE

4.1 Estimates of burrow density

The estimated mean density of scampi burrows (as indexed by their major openings) throughout the Bay of Plenty, in the 300–500 m depth range, varied from 0.08 m⁻² in 2000 to 0.13 m⁻² in 1998 (with CVs of 8–15 percent of the mean). Scaling to the sampled area (1 196 km²) results in abundance estimates of 94–154 million burrows or, assuming 100 percent occupancy, an identical number of animals (Figure 4).

4.2 Estimates of scampi density and minimum absolute abundance

The estimated mean density of all visible scampi (i.e. including those in burrows and those walking free on the sediment surface) varied from 0.010 m⁻² in 2001 to 0.025 m⁻² in 1998 (with CVs of 18–26 percent of the mean). Scaling these counts to the sampled area leads to abundance estimates of 12–28 million animals. Counting only the animals walking free on the sediment surface (i.e. those most susceptible to capture by trawl) greatly reduces the estimates (to 2–11 million animals, Figure 5) and greatly increases their CVs (to 25–62 percent).

4.3 Estimates of scampi biomass

Deriving estimates of relative or absolute biomass from estimates of abundance requires an estimate of the mean weight of individuals. Cryer and Hartill (1998) and Cryer, Hartill and Drury. (2001) estimated the length frequency distribution of visible scampi in 1998 and 2000, respectively and applied length-weight regressions to estimate average weight. They used the average predicted weight from male and female length weight regressions for animals up to 48 mm and the predicted weight from a male length weight regression for all larger animals. Their estimates of average weight for measurable scampi were 35.4 g in 1998 and 38.3 g in 2000. Scaling the abundance estimates for visible scampi in each year by the smaller of these

FIGURE 4
Estimated abundance (\pm one standard error) of major burrow openings from photographic surveys in the Bay of Plenty, 1998 to 2003

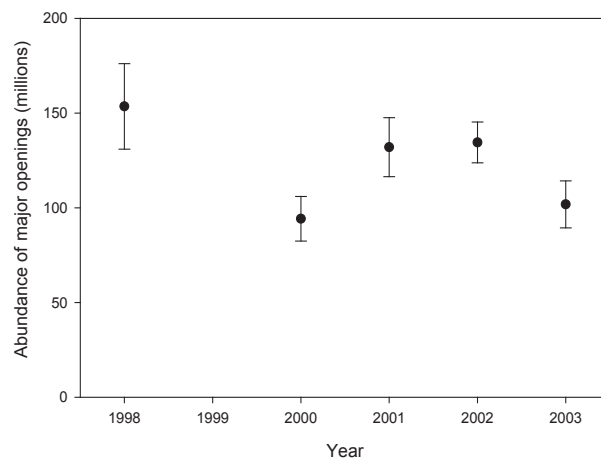
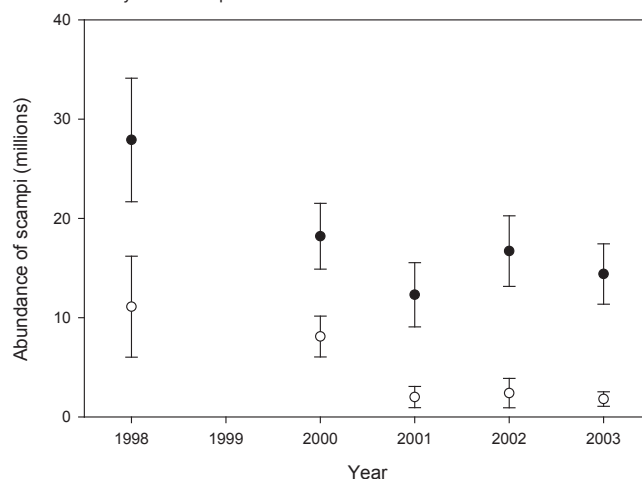


FIGURE 5
Estimated abundance (\pm one standard error) of visible scampi from photographic surveys in the Bay of Plenty, 1998 to 2003.

Closed symbols indicate all visible scampi, open symbols include only those scampi out of their burrows



two estimates leads to estimates of absolute biomasses (Table 1). These estimates are probably close to minimum estimates of biomass, although smaller estimates are conceivable if, for instance, the average size were to be considerably smaller in some years for which the mean weight has not yet been estimated.

Making further assumptions (e.g. that each burrow identified as a scampi burrow is occupied by a single scampi of similar average size to those visible), the estimates of major burrow openings can be used to estimate current biomass (Table 2). These estimates may be conservative because we score only those burrows that are characteristic of scampi and we know that scampi are sometimes seen in other types of burrows. Or these estimates may be optimistic because not all burrows may be currently occupied or because hidden scampi are, on average, smaller than visible

TABLE 1
Estimates of the biomass of visible scampi within the Bay of Plenty between 1998 and 2003 made using a mean average weight of 35.4 g

These estimates are probably close to estimates of "minimum biomass".

	All visible scampi		Scampi not in burrows	
	Biomass (t)	Min. CV	Biomass (t)	Min. CV
1998	988	22.3	393	45.8
2000	644	18.2	287	25.4
2001	435	26.3	71	53.5
2002	591	21.3	85	61.6
2003	509	21.1	62	40.9

TABLE 2
Estimates of biomass (t) of scampi within the Bay of Plenty between 1998 and 2003

These estimates are determined by multiplying the estimated abundance of major burrow openings by a mean average weight of 35.4 g. "Corrected" estimates have been adjusted to account for relative reader bias.

	Uncorrected		Corrected	
	Biomass (t)	Min. CV	Biomass (t)	Min. CV
1998	5 434	14.7	5 491	14.7
2000	3 335	12.5	3 423	12.7
2001	4 673	11.8	4 811	11.8
2002	4 761	8.0	4 538	8.1
2003	3 605	12.2	3 606	12.0

scampi. It is not currently possible to assess whether estimates of biomass made using our estimates of the density of major burrow openings are positively or negatively biased estimates of actual abundance.

5. COMPARISONS WITH OTHER DATA

Our "minimum" biomass estimates suggest that catch limits and current landings of scampi from the Bay of Plenty (120 t, Annala *et al.* 2003) could represent a substantial fraction of the biomass, 12.1–27.6 percent, depending on the year; it was 23.6 percent for 2003. Conversely, biomass estimates made from burrow counts suggest that fishing takes a relatively small fraction of total biomass, 2.2–3.6 percent with the 2003 estimate suggesting a 3.3 percent removal.

At this stage it is not possible to be certain which of these indices of abundance is the best indicator for scampi. An index based on the density of characteristic burrows should not be affected by changes in emergence behaviour in scampi and can be estimated using photographs taken at any time of day (although it would be badly affected by changes in occupancy rate). Results from photographic surveys before and after fishing on the Mernoo Bank, south-eastern New Zealand (Cryer *et al.* 2003), however, suggest that there may be seasonal changes in the density or characteristics of burrows as there is for *Nephrops norvegicus* (e.g. Tuck, Atkinson and Chapman 1994). This would militate against indices based on burrow densities estimated at different times of year. Indices of absolute abundance based on visible scampi are almost certainly conservative and will be affected by the seasonal and diel timing of photography because emergence behaviour is likely to vary daily and seasonally, e.g. Cryer and Oliver 2001.

The decline in our indices of visible scampi, especially between 1998 and 2001, in the Bay of Plenty is consistent with the decline in commercial CPUE observed since about 1995 (see Hartill and Cryer 2003 for unstandardized indices to 2002, and Cryer and Coburn 2000 for fully standardized indices to 1998, although the two are highly correlated). Conversely, our indices of probable scampi burrows have remained relatively steady, a trend that is not consistent with commercial trawl catch rates (Figure 6). This divergence might be expected because the light, "skimming" trawl gear used to catch scampi is most unlikely to be able to catch scampi that are hidden from view in burrows. Critical in this interpretation is the implicit assumption that the proportion of burrows occupied by scampi is constant among years. If burrows last a long time after they are vacated by a scampi, then this assumption may not hold; the density of burrows could remain constant even while the population was declining rapidly. We have no information on burrow longevity and this could be a fruitful area for future research.

6. FUTURE WORK

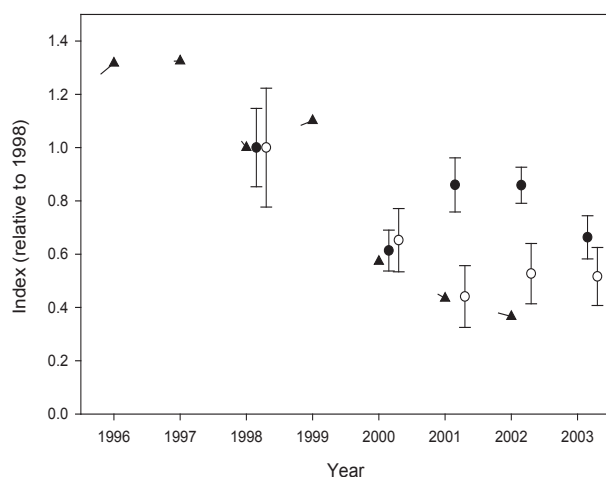
Since the inception of this fishery in the late 1980s, we have assembled indices of abundance based on photography, research trawl surveys, and commercial CPUE, multiple length frequency distributions based on photography and on measurements by observers on commercial vessels, and estimates of growth increments based on a tagging experiment and aquarium trials. The next step planned is to integrate these data in a stock assessment model, which will probably be length-based.

7. ACKNOWLEDGMENTS

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FIGURE 6
Comparison of some potential indices of relative abundance for scampi in the Bay of Plenty, 300–500 m depth, since 1996, all standardized to 1998 indices

Solid triangles and dashed line = commercial CPUE (Hartill and Cryer 2003)
solid circles = major burrow openings, open circles = visible scampi.
Error bars ± 1 standard error



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APPENDIX I

Rankings of criteria (1 being most important) nominated by each of the three readers for identification of major (top) and minor (bottom) openings of burrows of *Metanephrops challengeri*

Character	Reader 1	Reader 2	Reader 3	Mean rank
Major openings:				
Surface tracks leading from opening	1	2	1	1.3
Shallow descent angle	6	1	2	3.0
Sediment fan	2	3	4	3.0
Crescent shape	4	4	3	3.7
Part of linear system with minor opening	3	7	5	5.0
Smooth tunnel floor	5	5	7	5.7
50–180 mm wide at base	8	6	7	7.0
Well-maintained appearance	7	8	7	7.3
Minor openings:				
Narrow trench with long sides	1	1	1	1.0
Part of linear system, major < 800 mm distant	4	2	2	2.7
Long, straight surface track	2	3	4	3.0
Near to highly characteristic major opening	3	7	3	4.3
Smooth tunnel floor	5	5	6	5.3
Well-maintained appearance	7	4	6	5.7
Shallow descent angle	7	7	6	6.7
Half as wide as an associated major opening	7	7	8	7.3

The contribution of visual observations to surveying the deep-sea fish community

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1. INTRODUCTION

Since the development of manned deep submersibles (the bathysphere of Beebe in the early 1930s [Beebe 1933]; the F.N.R.S III in 1954, the Alvin in 1964 to 1 830 m; and the Cyana in 1969 to 3 000 m), scientists have had the ability to observe various components of deep-sea communities. The early scientific studies were primarily interested in natural history, such as collecting depth distribution and community composition data (e.g. Grassle *et al.* 1975). As any observation was provided information, a whole suite of observations were described and observations on behaviour of deep-water fishes and geological observations were sometimes reported in the same account as descriptions of the seabed and the associated benthic community (Fage 1958, Pérez 1958). Quickly the potential of visual observations for estimating population densities was recognized. However, fishes were much less studied than communities of fixed and mobile macrobenthos. This was mostly because the amount of data collected during dives of limited duration were too small to allow observation of significant numbers of fishes and although seldom mentioned, the high mobility of the fish fauna raised the question of the relevance of the observed number of animals. Nevertheless, some studies did evaluate the visual census approach by comparing density estimates obtained with submersibles with those from trawl or acoustic data, or with photos from camera sledges (Uzmann *et al.* 1977, Ralston, Gooding and Ludwig 1985, Krieger 1992, Adams *et al.* 1995, Cailliet *et al.* 1999). In recent years the use of submersibles in fisheries science has been enlarged to include the study of aspects of fish behaviour and small-scale species dynamics (Lorange, Latrouite and Séret 2000, Yoklavich *et al.* 2000, Uiblein, Lorange and Latrouite 2002, 2003). Another development has been the application of autonomous landers equipped with bait and camera systems to study the diurnal activities of deep-sea fish (Guennegan and Rannou 1979, Wilson Jr and Smith Jr 1984), population densities (Sainte-Marie and Hargrave 1987, Priede *et al.* 1994) and behaviour (Armstrong, Bagley and Priede 1992). At times landers and submersibles have been operated in tandem (Mahaut, Geistdoerfer and Sibuet 1990).

In this paper we review visual observation methods that provide quantitative information on species abundance and behaviour and their application for surveying deep-sea communities in support of sustainable management. We distinguish quantities relating to population ecology such as abundance estimates, habitat associations, demographic population structures and behaviour types from information on the

interactions of fishing operations with individual fish and the habitat. Quantification of 'catchability', or vulnerability to capture falls into the second category. This paper will focus on observation methods and conditions and consider the limitations of visual observations to provide the required information. We suggest where further technological developments seem promising or would merit being investigated. The examples chosen to illustrate the contribution of visual observations to surveying deep-sea fish are taken from two surveys: **Observhal** 1998 cruise using the manned submersible **Nautilie** and the **Vital** cruise 2002 using the remotely operated vehicle **Victor 6000** (Figure 1).

2. CHOICE OF VEHICLE

Several types of vehicles are available to survey deep-sea and continental slope habitats (Table 1). Each vehicle has its own advantages and drawbacks. Currently there exist worldwide only a handful of manned submersibles and remotely operated vehicles (ROV) that can dive below 1 000 m. Both types of vehicles have been used successfully for fisheries research programmes. Recent technological developments have concentrated on developing autonomous underwater vehicles (AUV) and the application of their use in fisheries, but to date AUVs have not been used for collecting visual observations on fish communities as current projects focus on acoustic data collection (Fernandes *et al.* 2003). We note that it is doubtful whether AUVs are adequate for visual observations, as videos are demanding in electrical power, which is a limiting factor for AUVs. Camera sleds and towed bodies have also been used in deep-waters to study fish abundances (P. Lorange unpublished data).

Manned submersibles are without any doubt the most flexible of vehicles for surveying deepwater communities. However, while they are appropriate for exploratory studies their efficiency is low as they deliver only a few observations a day at sea due to the limited operation time per dive. In addition while they provide good observation conditions for the scientist on board, obtaining quantitative data is difficult primarily as the field of vision is generally uncalibrated (see Section 3). Although it is possible to overcome this problem by calibrating the field of

FIGURE 1

French submersibles

Remotely operated vehicle Victor 6000. Top: operating up to 75 hours at 6 000 m. Manned submersible Nautilie. Centre: operating up to five hours at 6 000 m. Towed body Scampi. Bottom: operating up to ten hours at 6 000 m.

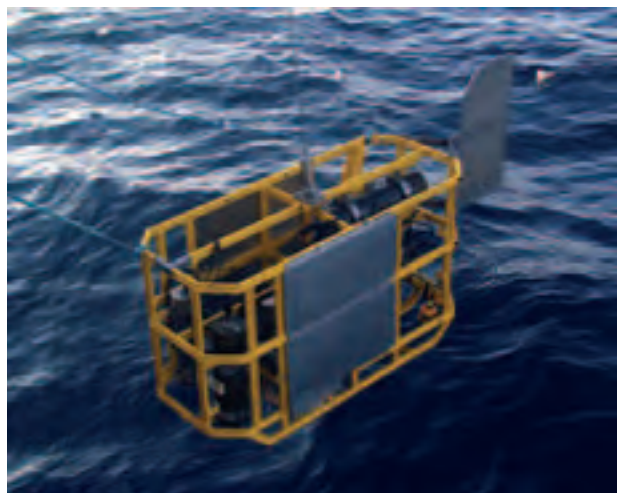


TABLE 1
Characteristics of different vehicles for surveying deep-water fish communities

Vehicle	Operating vessel	Dive duration	Exact route determination	Vision	Remarks
Manned submersible	big	hours	yes, pilots	observers (3D) photographs video (2D or 3D)	difficult to calibrate observation field
ROV	big	days	yes, pilots	photographs video (2D or 3D)	not usable in very rugged terrain
AUV	medium	hours-days	Pre-programmed route	photographs video ?	limitation of data storage and energy; high survey speed
Camera sled	medium	hours	No	photos video (2D or 3D)	near bottom fauna only; high survey speed
Towed body	medium	hours	No	photos video (2D or 3D)	difficult to calibrate observation field; high survey speed

vision and post-processing registered video records in a quantitative way, ROVs appear to be much more efficient than manned submersibles for surveying fish communities due to the longer observation time possible and consequently larger observed survey area that can be achieved. However, the ability of manned submersibles to survey rugged terrain should not be underevaluated. In contrast, the application of ROVs is limited in these situations as the cable connecting the ROV to the vessel can get caught on rocks and other bottom features. Similarly, telecommunication cables freely spanning canyons at some altitude from the bottom can be a problem for ROVs. Manned submersibles, therefore, might be the only option if steep canyons or areas of rough bottom require surveying. Indeed, being able to assess local relative population densities and species compositions in areas inaccessible to ROVs might be crucial for evaluating the refuge potential of a particular habitat or its suitability to become a marine protected area.

For both sleds and towed bodies, the fact that their trajectory cannot be altered, as it is dependant on the vessel course and speed, presents an important drawback. Currents are also a factor in affecting towed systems. In addition, they can only be operated close to the bottom in relatively flat environments where large rocks or debris are not present that can foul the vehicle. Thus sleds and towed bodies might be seen as a second option, although depending on the objectives of the study, they could be a cost efficient alternative to manned submersibles or ROVs.

TABLE 2
Types of observations obtainable with different vehicles.

* stereo-video system required

Vehicle	Abundance estimate	Demographic structure	Behaviour	Habitat association	Vulnerability to capture	Physical impact
Manned submersible	✓	✓	✓	✓	✓	✓
ROV	✓	✓	✓	✓	✓	✓
AUV	✓	*	✗	✓	✓	✓
Camera sled	✓	*	✗	✓	✗	✓
Towed body	✓	*	✗	✓	✗	✓

Independent of the type of vehicle chosen, the quality of the optic equipment determines the value of observations and their suitability to study various aspects of deep-sea ecology. Most vehicles can be equipped with photographic cameras, simple videos, or stereo-video systems. In certain cases several systems can be used simultaneously, e.g. simple videos or cameras might be used for surveying vertically down from the vehicle, while stereo-video is used for surveying forwards or sideways. High-resolution video systems should always be combined with digital video storage to allow optimal post-treatment of videos. Different vehicles allow collection of various types of visual observations suitable for different objectives. Table 2 summarizes what fisheries data can be collected by the variety of vehicles available. A detailed description of the data collection will be provided in the following sections.

3. COLLECTING QUANTITATIVE INFORMATION

The collection of quantitative visual observation from still photos, videos or by an observer, is only possible for near-bottom habitats as it requires accurate knowledge of the size of the observation field. An additional advantage of having the bottom visible is that it can increase contrast in the picture and hence facilitate animal detection. If the size of the observation field is unknown, population densities cannot be estimated, only relative abundances of different species or presence – absence data can be obtained. Various scientists have adopted different techniques to calibrate the observation field. Grassle *et al.* (1975) overlaid a perspective grid (Canadian grid) on their photographs. Auster, Malatest and Donaldson (1997) decomposed video images into successive trapeziums each measuring 0.35 m². Adams *et al.* (1995) and Trenkel, Lorange and Mahévas (2004) calibrated the width of the survey area at a certain time line, i.e. a virtual line was positioned on the video monitor (Figure 2a).

In order to maintain the calibrated observation field throughout the survey, all camera settings (zoom, pan and tilt angles) and cruising altitude have to be fixed. It is not difficult to fix the angle of a video or still camera. Keeping the cruising speed fixed at a chosen speed will insure bias due to detection problems remains constant (Trenkel, Lorange Mahévas 2004). Obviously, these calibration methods only work if the bottom slope is reasonably flat and the vehicle can advance parallel to the slope. Steep slopes or, much worse, large rocks or outcrops alter the observation field and this method of standardisation will fail. Unfortunately, it is not obvious how to measure, or even define, the observation field for rugged habitats (Figure 2b).

4. POPULATION ECOLOGY

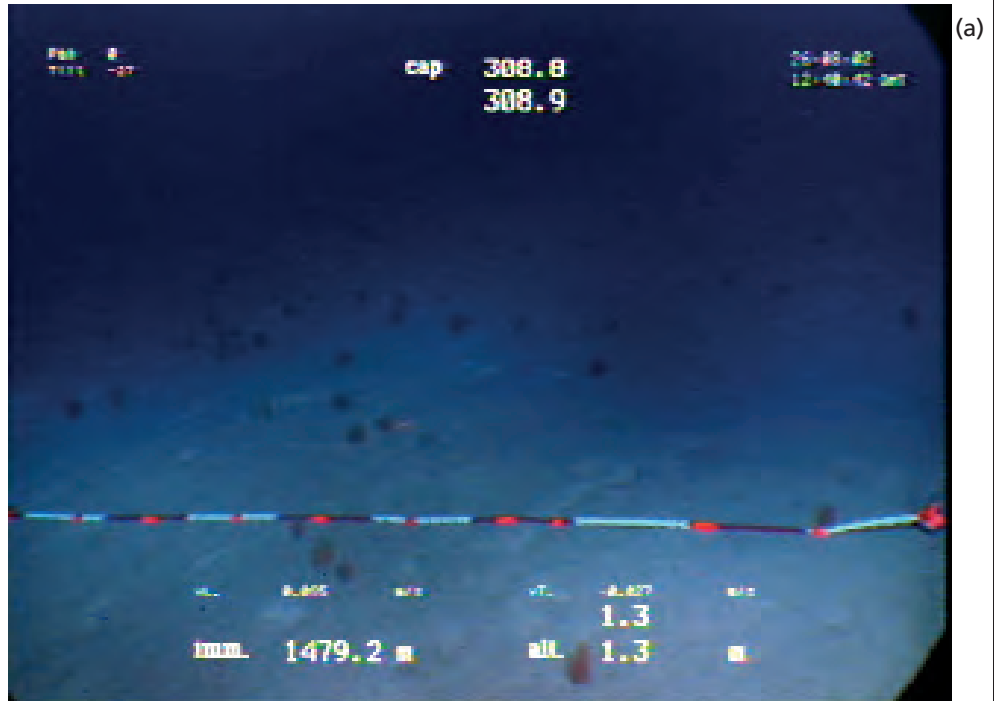
4.1 Abundance estimation

Many authors have used visual observations to obtain abundance estimates. To achieve these two methods have been used: strip transects (Adams *et al.* 1995, Trenkel 2003) and line transects (O'Connell, Carlile and Wakefield 1998). Strip transect methods consist of counting all animals encountered in a given survey strip (Seber 1982). Using quadrates, as shown by Grassle *et al.* (1975), equates to strip transects. For the line transect method, animals that are encountered are counted and their distance from the virtual transect line is also measured (Buckland *et al.* 2001). A detection function is fitted to the observations to estimate population abundance or density. In contrast to the strip transect method, it is not necessary to detect all animals for the line transect method, although generally it is assumed that all animals on the transect line have been registered. Measuring the distance of a fish from the transect line is straightforward if manned submersibles are used, as a sonar-gun can be pointed at the fish by the operator (O'Connell *et al.* 1998). In the case of ROVs more sophisticated equipment would be required and to the best of our knowledge this has not yet been attempted.

FIGURE 2

Top: Calibration of the width of the observation field (5m at the level of the chain) during Vital 2002 cruise. Bottom: Steep cliff in a canyon during Vital 2002 cruise

It is not obvious how to calibrate the surveyed area for this type of habitat.



(a)



(b)

Once abundance estimates have been obtained, the question of what proportion of a stock or population has been surveyed remains. It is well known that many deep-sea species spend much time in the water column. For example, roundnose grenadier (*Coryphaenoides rupestris*), black scabbardfish (*Aphanopus carbo*) and orange roughy (*Hoplostethus atlanticus*) are found high off the bottom (Nakamura and Parin 1993, Atkinson 1995, Koslow, Kloser and Stanley 1995, McClatchie *et al.* 2000). Some species also carry out diel migrations (Atkinson 1995). Hence density estimates for the same area can vary on a diel cycle. Trenkel, Lorange & Mahévas (2004) found significant day-night effects for population density estimates of orange roughy (*Hoplostethus atlanticus*) and roundnose grenadier.

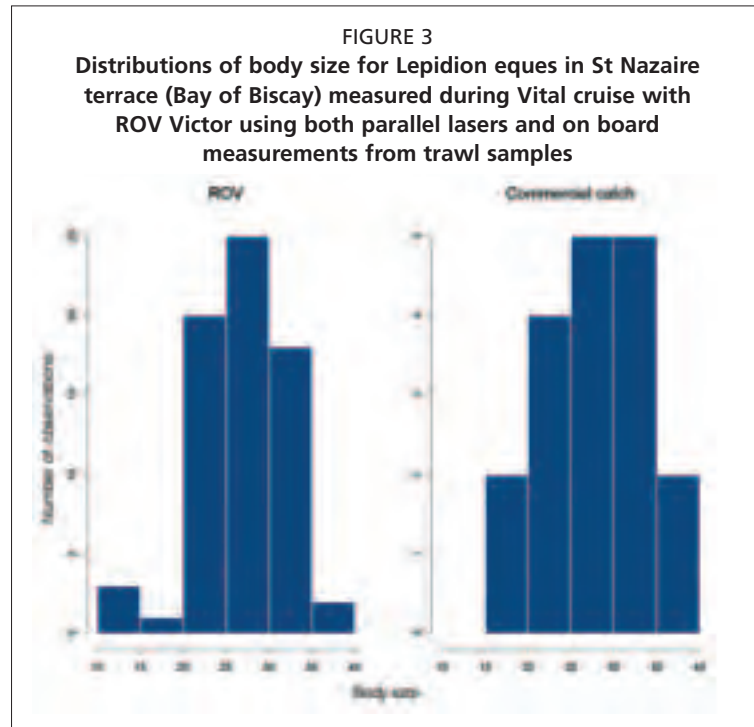
Avoidance of, and attraction to, the underwater vehicles is a further problem. Many researchers have noted reactions to approaching manned submersibles (Uiblein *et al.* 2002) and ROVs (Adams *et al.* 1995, Trenkel *et al.* (2004). Reactions at considerable distances have been documented (Koslow *et al.* 1995), however, it is difficult to assess how many individuals avoid the approaching vehicle at a great distance and hence are not detected. Directional swimming can also lead to biased abundance estimates due to the generally slow surveying speed; however if fish swimming velocity and direction is known, a correction for this bias is possible (Trenkel 2003).

4.2 Demographic structure

The deep-sea fish community includes a large number of small-sized species that may be numerically dominant. These are poorly sampled by commercial type trawls with large mesh sizes, that are used to sample commercial fish populations (Gordon 1986, Merrett *et al.* 1991, Gordon and Bergstad 1992). Even for larger species, trawl samples do not always provide a representative sample from the population length distribution due to mesh selectivity (escape of small or young individuals) and escapement of larger more mobile individuals (Godø and Walsh 1992, Walsh 1992). The impact of these factors might be reduced to acceptable levels by the use of small mesh sizes and appropriate survey speeds. As in other marine sampling applications, the real size distribution of local deep-water populations is generally unknown; hence it is impossible to validate the length distribution obtained from trawl samples. This is where visual observations can provide crucial insights.

The body size of fish or attached benthic species can be measured *in situ* in several ways. For simple camera systems, parallel lasers and measurements based on the focal point of the camera have been used (Rochet, Cadiou & Trenkel, in press). These methods require the positioning of the fish to be measured at a right angle to the focal axis. Flexed tails and continuous movements of the fish will bias these measurements.

Surprisingly, in contrast to the differences in population densities for North Atlantic codling (*Lepidion eques*) estimated by both the visual census data and trawl samples



during the **Vital** cruise, the length distributions derived from the two sampling methods were rather similar (Figure 3). However, given the small number of individuals caught and measured visually, this result might not be significant.

From our survey data results we note that estimating the size distribution of large commercial fish from ROV-recorded videos may be difficult for several reasons. First, commercial species tend to be observed in small numbers due to the low sampling intensity of the method. Second, several of these species are fast moving and are often seen passing quickly at the edge of the observation field and hence are not measurable. For large mobile individuals the use of stereo-video methods (Harvey *et al.* 2003) might be more promising. To date these have not been used for moving vehicles but only in static set ups, such as in connection with tuna aggregating devices.

Thus, visual methods can provide size distributions of small species, which will allow an assessment of the effects of fishing on these non-target species. Average length data of individual species as well as the fish community as a whole are important indicators for describing the state of an exploited community and for detecting changes that might be caused by fishing (Rochet and Trenkel 2003). These indicators may be especially relevant in the context of deep-sea communities as some length distribution data are available prior to the start of commercial exploitation. These data can provide an estimate of the “pristine” state of such communities, which will allow the setting of target reference points. This is a unique situation not often encountered for shelf populations, where the lack of knowledge of pristine states prevents the definition of such reference points.

4.3 Behaviour

Currently little is known about deep-sea fish behaviour. Most knowledge has been inferred from specimens taken from trawl samples where the morphology of fish has allowed inferences of their possible behaviour. For example, stomach content data shed light on fish locations in the water column and their foraging strategy (e.g. Mauchline and Gordon 1984a,b). In contrast to this indirect information, underwater vehicles allow the direct *in situ* observations of natural fish behaviour. In addition, they enable various types of reaction behaviours to be studied by observing their reactions towards the approaching vehicle. Along with the studies using solely underwater vehicles, fish reactions at trawl opening have also been observed directly by attaching cameras at various parts of the trawl (Hemmings 1973) and by using ROVs working in parallel with the trawl. An example of this based on ROV observations is given by Bublitz (1996) who categorized the reaction types of flatfish as that of direction change, including turning on their side or back and avoidance behaviour by rising upwards.

Individual behaviour has been studied by post-processing video records collected during the **Observhal** 1998 cruise (Lorance, Uiblein and Latrouite 2002, Uiblein *et al.* 2002, 2003). These authors characterized behaviour according to several variables: position in the water column, locomotion and activity mode. The study showed that in addition to having diverse shapes, adaptations, bioenergetics and diets, deep-water fishes have different natural behaviours. They adjust their behaviour to small-scale variations in habitat and environmental conditions.

Investigating how reaction behaviour might explain vulnerability to fishing is of major interest for both management and survey-based stock assessments. Some species, e.g. *Trachyscorpia c. echinata*, display almost no reaction to an approaching submersible. If this species behaved in the same way in front of a trawl, only individuals within the path of the net would be caught. In contrast, some individuals of roundnose grenadier and orange roughy have been observed slowly swimming in front of the manned submersible Nautile and the ROV Victor (Figure 4). Such behaviour might result in herding by a bottom trawl. If this is true, then these two species that strongly differ biologically and ecologically (Koslow, 1996) may have similar vulnerabilities to capture

by active fishing gears. Similarly, the high catch rates of smoothheads (*Alepocephalus bairdii* was by far most notable during the **Vital** cruise) and trichiurids (here *Aphanopus carbo*) probably result from their flight movement towards the bottom in reaction to the noise and motion of trawls. This flight movement was observed during the **Vital** 2002 cruise. It may be that the bottom is a refuge for benthopelagic fishes from predation. However, this flight strategy will increase such species' chances of being caught by bottom trawls. In contrast, large chondrichthyans such as chimaeras and squalid sharks that remain close to the bottom react strongly to manned submersible and ROVs, and some escape laterally (Lorange *et al.* 2000, Lorange, Trenkel & Uiblein 2005). It might be that similar behaviour in front of a trawl would result in reduced vulnerability of that species. In summary, the behaviour of deep-water species can have major implications for their vulnerability by bottom trawls and visual observations can provide unique information for studying this important component of their behaviour (see also Section 5.1 Catchability).

4.4 Habitat association

Individual spatial distributions and the definition of a species habitat may be considered at different scales. Catch records properly address the biogeographical scale and the large-scale depth and area distributions; as the area swept by a survey trawl will cover several hectares. For example, with a large orange roughy trawl of 30 m wingspread towed at 2 knots, an one-hour tow sweeps an area of more than 11 hectares. In contrast, fish habitat preferences might imply much smaller scales. It is well known that orange roughy form dense aggregations with low densities (Koslow 1997, Clark 1999, Clark *et al.* 2000). Observations from a manned submersible during the **Observhal** cruise have shown that these aggregations can be quite small (Lorange *et al.*, 2002) so that a single trawl tow may cover different habitats and fish densities. This phenomenon also seems to apply to other deep-sea species. The density of several species has been observed to vary at the macro-habitat scale spanning a few hectares (Uiblein *et al.* 2003). Individual fishes may select preferred locations at an even smaller scale of a few metres. This seems to be the case for deep-sea scorpionfish (*Trachyscorpia c. echinata*) or *Lepidion eques*, which were often seen associated with small bottom features such as stones or benthic fauna colonies during the **Vital** cruise (unpublished data, Figure 5), while *Neocyttus helgae* was mainly associated with vertical cliffs. Flat, sandy and unchanging seabed bottom types would provide less shelter than similar habitats with additional dispersed features. Small-scale bottom structures are likely to be a major factor for explaining local population densities of deep-sea fish species and might be crucial for community diversity. The importance of small-scale habitat features has been observed elsewhere. Auster *et al.* (1997) using an ROV found that juvenile silver hake densities were greater on bottoms with high amphipod tube cover compared to featureless grounds.

FIGURE 4
Grenadier moving from up in the water column toward the bottom
and remaining in front of the ROV (Vital 2002 cruise)

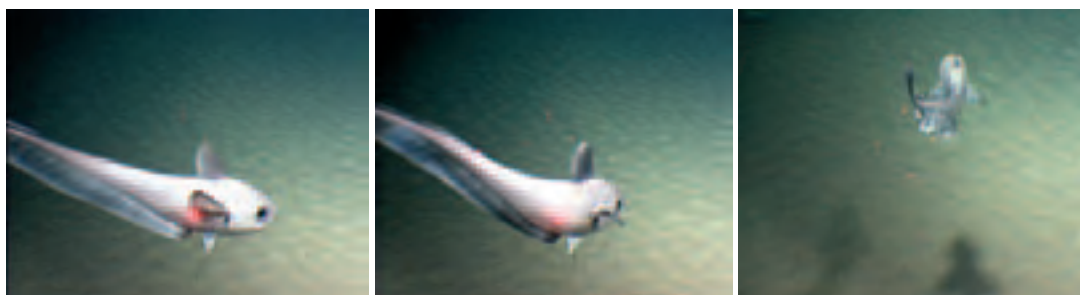


FIGURE 5

Species habitat associations, *Bathypterois dubius* (left) is associated with areas of strong current. This fish appears to use the small scale relief provided by ripple marks to optimize its ability to catch drifting particles; *Lepidion eques* (centre) and *Trachyscorpia c. echinata* (right) are often associated with stones and other bottom features.



Submersible observations revealed that rockfish were mainly associated with rugged habitats (Krieger 1992).

Strong habitat associations have implications for survey-based stock abundance estimation. In particular in order to increase the precision of estimates, it can be useful to use habitat characteristics to define homogeneous areas. Nasby-Lucas *et al.* (2002) used a high-resolution multibeam sonar for obtaining habitat information and submersible visual counts to estimate population densities by habitat type. Of course this approach requires detailed habitat knowledge for the whole population area.

5. EXPLOITATION

5.1 Catchability¹

Catchability is an important factor for both abundance indices derived from scientific trawl surveys and catch based stock assessments (Fréon, Gerlotto and Misund 1993). Visual observations from submersibles and ROVs have been used in two ways to obtain information on trawl catchability:

- i. direct comparison of visual based density estimates with trawl swept-area based estimates (Krieger and Sigler 1995, Somerton *et al.* 1999) and
- ii. estimation of the different components of catchability, such as (a) habitat preference, (b) differences in diel activity, (c) body position in water column, (d) body size, (e) patterns of spatial distribution (spatial randomness) and (f) reaction to the approaching vehicle (Trenkel *et al.* 2004).

Habitat preference can be considered on several scales. On a large scale the comparison of population densities on seamounts, terraces, canyons and other types of habitats determines preferences. On a finer scale, population densities in different types of habitats within these broad categories might also be considered. In terms of trawl catchability, it is the larger scale that is relevant, in particular the relationship between population densities in trawlable (terraces and sea mounts) and non-trawlable (canyon) areas. Note however, that ROVs in particular might encounter difficulties with surveying rugged canyons (see Section 3, Collecting quantitative information).

Diel activity patterns can be detected by surveying a given area around the clock. In order to separate diel patterns from other effects, ideally all other parameters such as depth and tidal condition should be kept fixed. The impact of diel variations in population densities can lead to complex patterns in catchability.

Body position in the water column affects what part of the population is accessible to a trawl and hence has an impact on catchability but also determines the accessibility

¹ The term ‘catchability’ in this context refers to the vulnerability to capture of fish that encounter the sampling gear – Ed.

to visual observations. If the vertical visual observation field is smaller than the vertical opening of a given trawl of interest, the obtainable information is incomplete. Nevertheless, the form of the vertical distribution gives an indication for the extent of this mismatch (Figure 6).

The type of spatial distribution affects catchability in as much as schooling species might have increased vulnerability to capture once detected. It also affects the variance of abundance estimates derived from trawl and visual observations. For visual observations the exact absolute location of each fish encountered is known provided accurate positioning systems are used. From these the distance between individuals can be derived (Figure 7). If individuals are randomly distributed in space, these histograms should follow an exponential distribution. This is the case for *Coryphaenoides rupestris* but not for *Synaphobranchus kaupi*, which shows signs of non-randomness (overdispersion). Alternatively, counts per transect line can be used to analyse the spatial distribution (Trenkel *et al.* 2004). When analysing spatial distributions, fixed effects due to, for example, depth need to be taken account of for both approaches. Trenkel *et al.* (2004) found that the type of spatial distribution (represented by the dispersion factor of the Poisson model for counts) was the most important explanatory factor across all species considered for modelling the ratio between visual census based density estimates and trawl based estimates.

Reaction to an approaching trawl has clear implications for catchability. The observation of reaction behaviour from videos has already been discussed in Section 4.3 Behaviour). The question remains of how relevant these reactions are towards an approaching ROV or any other vehicle used for determining reactions towards a trawl. Obviously the stimuli will differ, as trawls generally do not have lights. However, both make noise, which has been found to trigger reactions by orange roughy (Koslow *et al.* 1995). Thus for all intents and purposes, differences in reactions between species observed by underwater vehicles should be informative at least on a relative scale.

FIGURE 6
Vertical distributions (Vital 2002 cruise)

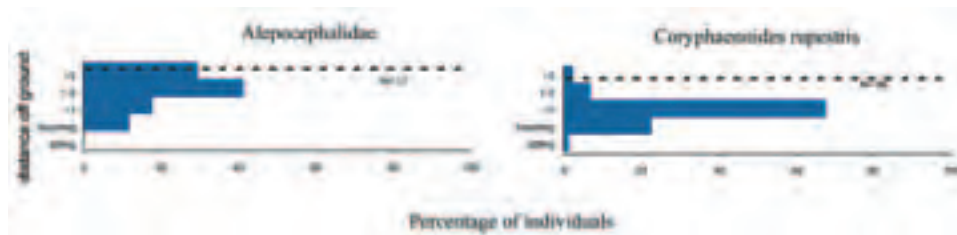


FIGURE 7
Distribution of distances between individuals observed during Vital 2002 cruise

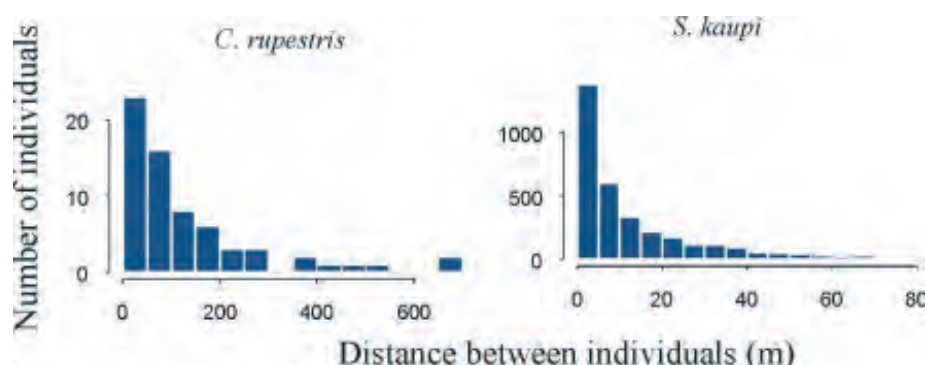


FIGURE 8

*Top:*Physical impact of trawling on deep-water seabed: heavily trawled area
Centre: Area with ripple marks where the effects of trawling could be quickly erased by the regeneration of ripple marks due to tidal currents
*Bottom:*Unfished sedimentary bottom with benthic fauna potentially sensitive to trawling



5.2 Physical impact

To assess the physical impact of fishing gears on the seabed it is necessary to survey large areas of fished seabed in order to catalogue gear marks, lost gears or parts of gear. It is likely that ROVs and benthic sleds are the most efficient vehicles for this task due to their capacity to sample large areas. Indeed, in shallow areas towed cameras have provided satisfactory results (Collie, Escanero and Valentine 2000). Unfortunately, the longevity of trawl marks on deep-water bottom is poorly known and may vary with depth, substrate, natural disturbance or activity of burying fauna. For example, it is likely that in areas with many ripple marks, trawl marks are quickly erased when tidal currents regenerate ripple marks. On areas without ripple marks, the processes that erase trawl marks are sedimentation (expected to be slow) and bioturbation whose efficiency at erasing trawl marks is unknown but should be proportional to the density of bioturbated marks.

We categorized trawl marks recorded by videos during the **Vital** cruise according to their size and aspect (recent or not) together with the substrate type (sand, mud, bioturbated or not, presence of ripple marks) and the density of large benthic macrofauna. The results clearly show that deepwater trawling strongly alters the first centimetres of sediments and reduces the density of fixed macrofauna (Figure 8). However, quantification of the degree of damage done by trawling is difficult as comparable images prior to exploitation are not available so that the changes in benthic density and species composition cannot be assessed. Finding comparable exploited and unexploited areas becomes difficult as fisheries have worked on all suitable grounds. During the **Vital** cruise we sampled two small terraces one being exploited and the other not. It was obvious from the results that the two terraces differed in terms of substrate and hence their natural fauna. As a consequence, the untrawled terrace could not serve as reference for the trawled terrace as initially hoped.

Although the absolute level of destruction caused by trawling cannot be evaluated, indices of the visible impact of trawling (e.g. number of trawl marks per unit of distance travelled) can be determined and related to macrofauna density, diversity and species composition. One important component of

the affected macrofauna are the cold-water corals. Their reefs are clearly sensitive to trawling as one single tow destroys almost all corals within the path swept by the doors. In Norwegian waters, trawling was estimated to have affected or destroyed 30 to 50 percent of *Lophelia* reefs (Fossa *et al.* 2002). Trawling for orange roughly in deeper waters has also been reported to destroy cold-water corals (Koslow *et al.* 2000, Clark 1999). ROVs and manned submersible are the only vehicles that can undertake non-destructive monitoring of cold-water corals. They are suitable for assessing the proportion of the reefs that is impacted and they might also allow observation of the regeneration/ recolonisation processes.

6. SOME SOLUTIONS TO CURRENT LIMITATIONS OF VISUAL OBSERVATIONS

This paper has concentrated on the contribution of visual observations to surveying the deep-water fish community. The alternative approach, in addition to trawling, are acoustic methods. However, acoustic and visual observations provide complementary observations on two different spatial scales for the same phenomena. Acoustic methods can detect fish reactions at large distances to an approaching video camera (Koslow *et al.* 1995) and a trawl (McClatchie *et al.* 2000) without necessarily providing species identification. Fishery research echo-sounders provide observations within a range of 50-200 m while visual observations are limited to about 10 m around the vehicle depending on turbidity and light conditions. Combining both systems would enable use of visual observations at smaller scales and acoustic information at larger scales. Visual observations would provide information on species composition and size classes while acoustic information would allow spatial extrapolation. In addition, acoustic methods can provide crucial information on vertical distributions above the range that is visually discernable.

A second area where further developments are important is that of absolute population density estimates. This could involve operating simultaneously underwater vehicles for visual observations, towed bodies or AUVs for acoustic information and scientific trawls. Currently there might be logistic limitations to carry out all three operations from the same research vessel. Hence, several vessels would be required which would make this a costly operation. In the short to medium term, it seems appropriate to consider using a fishery research vessel to operated an ROV or manned submersible for collecting visual observations together with a hull-mounted echo-sounder and to have trawl tows carried out from a commercial vessel. In the longer term, concomitant use of visual (e.g. ROV) and acoustic (e.g. AUV) vehicles is an attractive option. It should also be considered whether a sonar suitable for fish detection could be added to the ROV or manned submersible. In terms of improving visual observations, most advances are to be expected from the use of stereo-video systems. Such developments are currently underway at our institute.

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Technical requirements and prerequisites for deepwater trawling

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1. INTRODUCTION

With the establishment of EEZs (Exclusive Economical Zones) in the late 1970s, many of the far distant fishing fleets in Europe lost their traditional fishing grounds. The reaction of the fishing nations concerned were different. Some countries, such as Germany, reduced their fleets drastically while other countries looked for opportunities to fish under licence in the EEZs of coastal states; yet others tried to explore and exploit resources outside the EEZs in greater depths.

The last mentioned option was a real challenge, both for fishermen and scientists, stock assessment scientists as well as gear technologists as vessels, winches and some gear elements were inadequate for working in depths greater than 800 m.

Our research work as gear technologists focussed on three fields,

- i. elements of ground gears
- ii. otter boards and
- iii. warps

because these three trawl gear elements are the most important one for successful deepwater trawling.

2. TECHNICAL RESEARCH WORK FOR DEEPWATER TRAWLING

2.1 Ground gears

Because of the fact that the traditionally-used steel bobbins of different sizes start to implode in depths greater than 800 m, rubber bobbins of different sizes were used in Eastern Germany for experimental fisheries. Figure 1 shows the arrangement of a ground gear for a 90' bottom trawl.

One section of the ground rope consists of 11 big rubber bobbins, 44 small rubber bobbins and 10 lancasters (chains). The whole ground rope consisted of four such sections. The weight in air was around 400 kg and weight in water, around 150 kg. Of course, today the few remaining German trawlers also used rockhopper gears and several other ground fishing gear elements.

In the Polish distant water fleet similar investigations were made with bobbins similar to those shown in Figure 2. Those bobbins consisted of wood, with a heavy iron cover. In the middle section of the ground rope 12 bobbins were used and another 22 were inserted in each trawl wing.

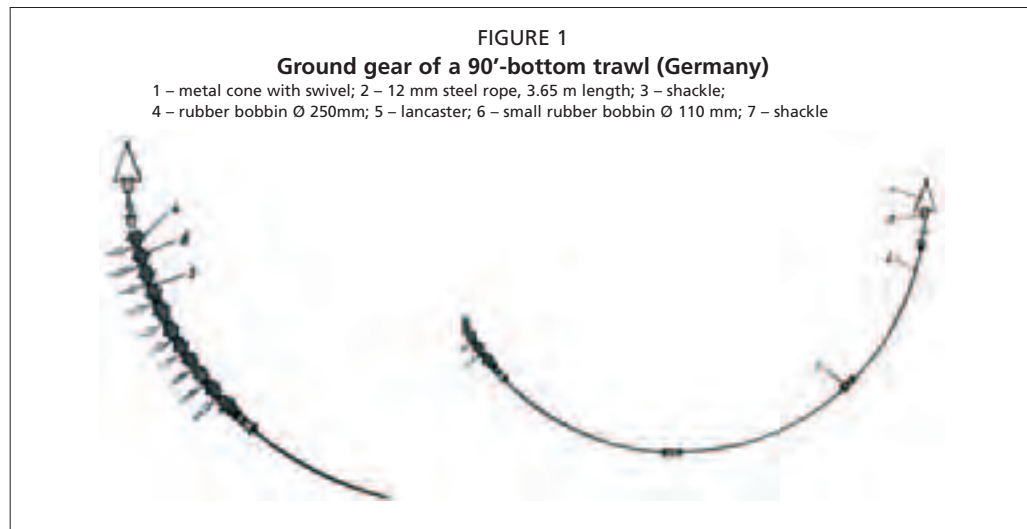
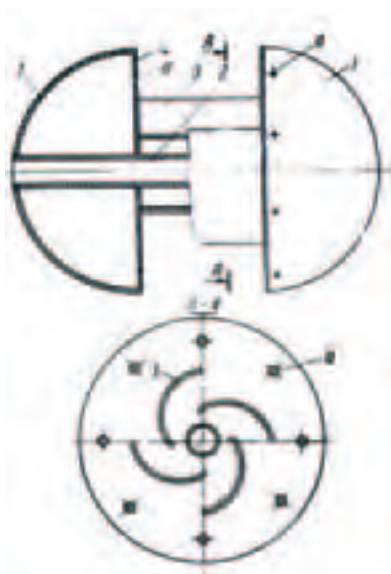


FIGURE 2
Wooden deepwater bobbin;
proposed by Polish scientists



FIGURE 3
Hydrodynamic bobbin

1 – half sphere; 2 – shaft; 3 – vane;
4 – cover; 5 – opening



The two different ground gear elements mentioned are so called static elements because they create the pressure on the sea bed only by their weight in water. Therefore it should be mentioned that a hydrodynamic bobbin was developed by the Russian scientist Karpenko. This bobbin creates downwards directed hydrodynamic forces by rolling over the bottom.

This bobbin consist of two half spheres, fixed on a shaft. Between the half spheres four vanes are fixed, shaped as a cylindrical segment. Openings go through the cover of the half spheres to add strength and avoid diverting the current.

During towing the current turns the bobbins and because of the “Magnus effect” a downwards-directed force is created. The size of this force is proportional to the towing speed. If the bobbin touches an obstacle (boulders, stones, etc.) it stops turning and the hydrodynamic forces become zero and the ground gear can rise more easily over the obstacle (Figure 3).

2.2 Otter boards

Otter boards used in deepwater trawling must fit specific requirements. To speed up the shooting process and for reaching maximum depths with a given warp length, they must sink quickly. Therefore otter boards for deepwater trawls should be heavy. And, because of the fact that the reachable depths depends on resistance of the trawl and otter boards, the drag of the otter boards used should be as low as possible.

And finally, taking into account the relatively long shooting process, the otter boards must have a high static stability to avoid unclear or twisted gears. Static stability is defined as the ability of the otter board to turn back to the original position in case of disturbance or perturbations. Not all otter boards used in bottom trawling fulfil such requirements and research has been undertaken to investigate these effects.

Comparative investigations were made with two types of otter boards on board the same vessel and using the same trawl. The first trial was made with oval-shaped three-nozzle otter boards (Figure 4) with an area of 5.5 m², weight in air of between 1 350 and 1 500 kg and a weight in water of between 1 150 and 1 280 kg.

The otter boards were adjusted to the smallest possible angle of attack ($\approx 35^\circ$). Figure 5 shows the hydrodynamic coefficients C_x (drag coefficient), C_y (lifting coefficient) and the quality factor k , defined as the quotient C_y/C_x . According to the abovementioned angle of attack of around 35° , the coefficients are $C_y = 1.0$; $C_x = 0.67$ and the quality factor $C_y/C_x = 1.5$.

This otterboard has a good hydrodynamic efficiency, but the main disadvantage is the low static stability resulting from using long warps. Several times during the trials the trawl became snarled. Therefore, it is not recommended to use oval shaped otter boards for deepwater trawling. Much better results were achieved with v-shaped rectangular otter boards of area, 5.5 m² and a weight between 1 350 and 1 550 kg (weight in water 1 150–1 320 kg accordingly) (Figure 6). With the smallest angle of attack of around 30° , the hydrodynamic coefficients of this type of otter boards were $C_y = 0.8$; $C_x = 0.5$ with a quality factor, $k = 1.6$ (Figure 7).

V-shaped otter boards have lower lifting forces, but also lower hydrodynamic resistance. The main advantage is the high static stability. This allows high running speeds of the warps during shooting, which reduces the unproductive time of the vessel.

Otter boards used for deepwater trawling must have a high static stability, which is influenced by the following main factors:

- hydrodynamic characteristics
- length and tension of warps and
- fixation coordinates of the doors.

Poorly adjusted trawl doors can be sensitive to hydrodynamic forces created by the warps and this can lead to an unstable run of the gear. The lower lifting force of v-shaped otterboards can be partly compensated through the use of differently twisted warps on the starboard and port side. This is discussed in more detail in Section 2.4.

FIGURE 4
Three nozzle otterboard

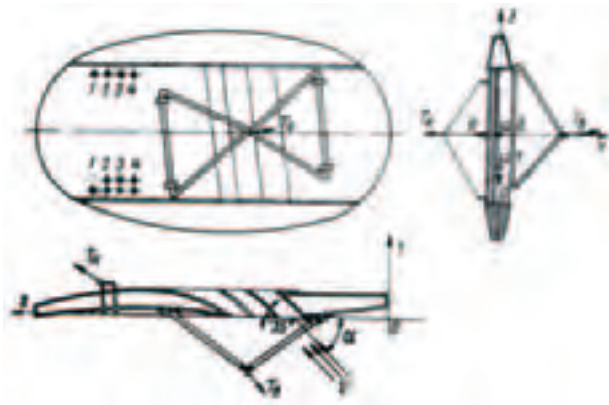


FIGURE 5
Hydrodynamic coefficients of
a three nozzle otter board

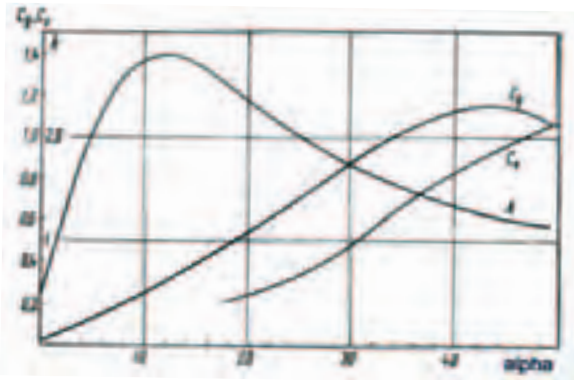


FIGURE 6
V-shaped otter board

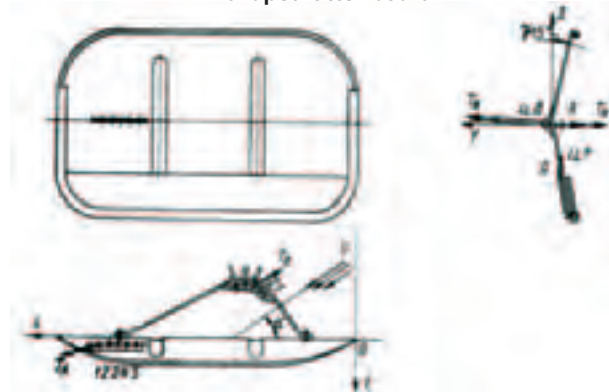


FIGURE 7
Hydrodynamic coefficients of
v-shaped otter boards

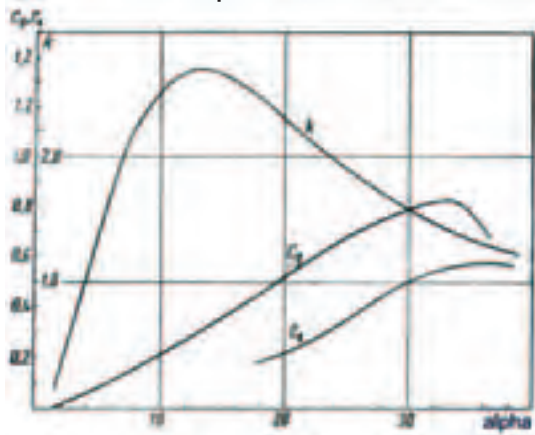
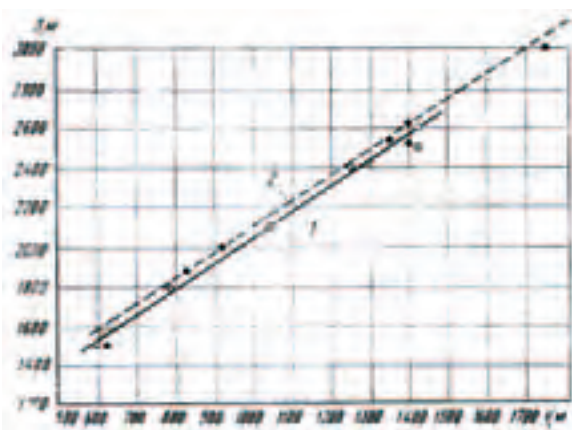


FIGURE 8
Dependency of warp length and towing depths
1 – Two warp system 2 – One warp system



Based on the results from these trials with different otter boards it was recommended that v-shaped otter boards be used for trawling in great depths. At present, most of the otter boards used for deepwater trawls are v-shaped, so our research results achieved several years ago have been confirmed.

2.3 Warps

2.3.1 One-warp systems

Trawlers not specially designed for deepwater trawling are equipped with winches of relatively small warp capacity. Towing speed and working depths are therefore limited. By use of a single warp system it is possible to nearly double the working depths for such vessels. Of course, the forces in the remaining warp will be higher and the shape of the warp during towing will be different. Figure 8 shows the results of practical trial with such a system

As shown in Figure 8 the warps run nearly parallel, the one warp system needs only around 50 m more warp length to reach the same depths. But the length of available warp is nearly double and operators can reach greater depths.

Handling of such system is easy and can be done according to Figures 9 and 10. Using such a system for stock assessment surveys is strongly recommended, in order to keep a constant trawl opening independent of warp lengths.

2.3.2 Some specific mechanical aspects

In the past, models for the calculation of warp shape and tension were strongly simplified. Most of the calculations were made under the assumption that

- warps are inelastic
- warps can only transmit traction, not bending forces, torsion moments and gross forces
- the shape of the warps is a straight line
- only drag and lifting forces are important for shape and tension, and
- hydrodynamic gross forces are not taken into account (Hahlbeck 1976).

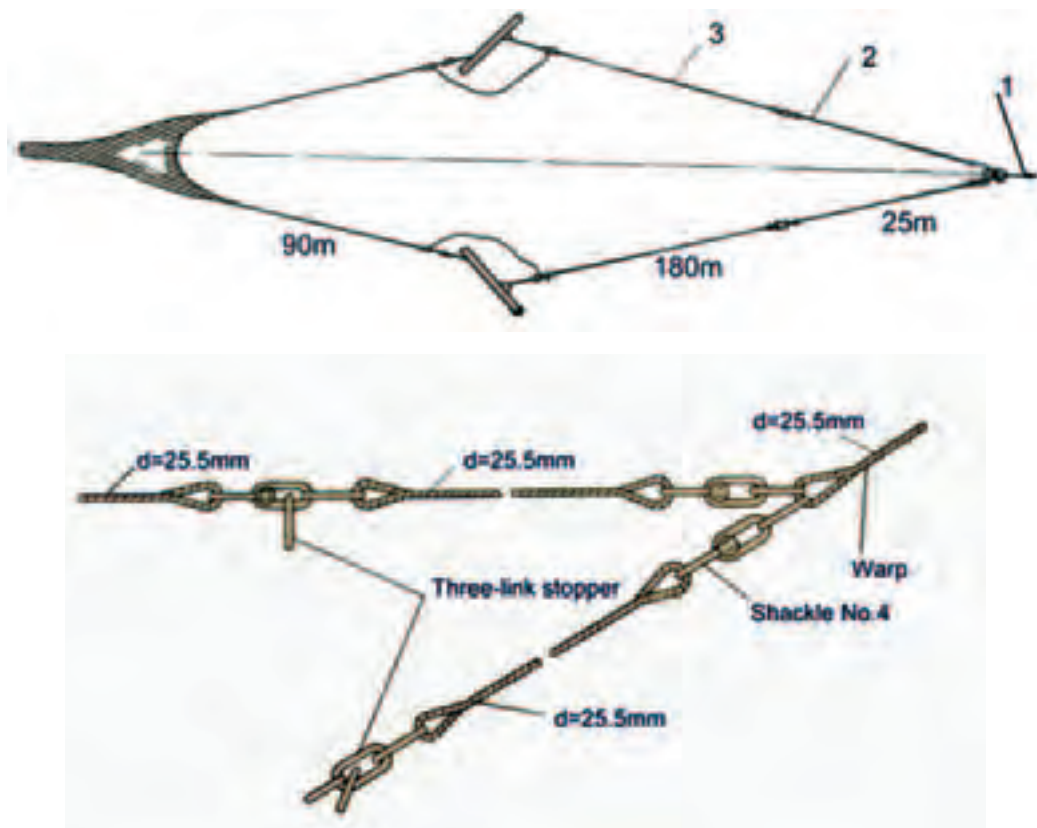
Such simplified assumptions are valid for short warp lengths.

With warp lengths over 1 000 m, the impact of the warps on the stability of the gear becomes more important. The weight of the warps also becomes an important factor. The ratio weight of warps/tension of warps increases, which leads to a change in the ratio warp length to trawl depth.

Additional hydrodynamic forces (gross forces) created by the warps must be taken into account. If the impact of such forces is ignored, it will result in

- asymmetric gear by unequally twisted warps

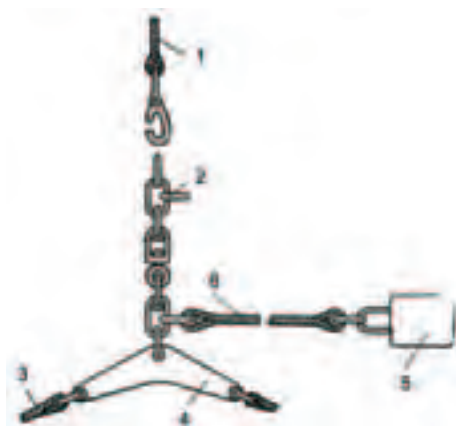
FIGURE 9
Arrangement of a one warp system



- instable otter boards, because of incidences of doors approaching critical angles of attack
- limited control over important gear performance parameters and
- loss of catch due to fouled gear (Niedzwiedz 1991, Scheel 1979).

Therefore, it is justifiable to install more gear control devices to be sure that the gear is working properly. Installation of symmetry sensors, bottom contact sensors, and a tension sensor in deepwater trawls are strongly recommended. For successful and efficient deepwater trawling high performance trawl and cable winches with higher drum capacity are needed. The otter boards need specific adjustment, and shooting and hauling of the trawl is more time consuming.

FIGURE 10
Details of a one warp system

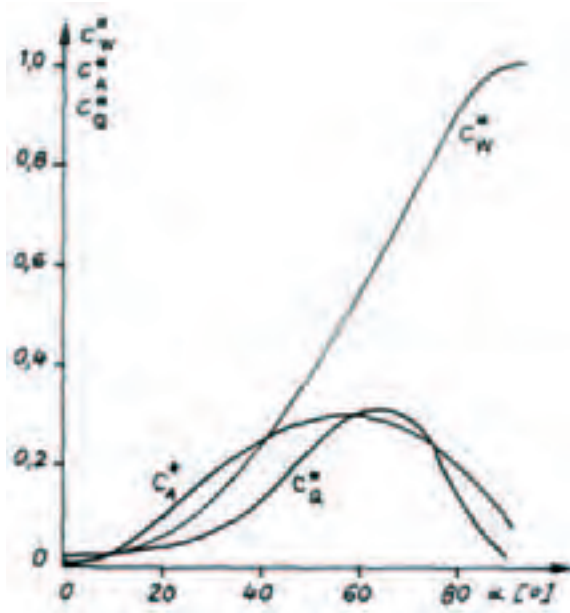


2.4 Estimation of gross forces in warps

The influence of the measurable hydrodynamic cross forces by using long warps are often underestimated. Such forces originate in overlying water currents due to horizontal movement of the rope through water with a circulating water layer, which is caused by the spiral like surface of the rope. A lot of systematic experimental investigations on that subject have been made to estimate the hydrodynamic coefficients for all kind of warp constructions. Figure 11 shows, as

FIGURE 11
Hydrodynamic coefficients of
steel warps (6 strands)

CW – coefficient on drag forces, CA – coefficient on lifting forces,
CQ – coefficient on cross forces



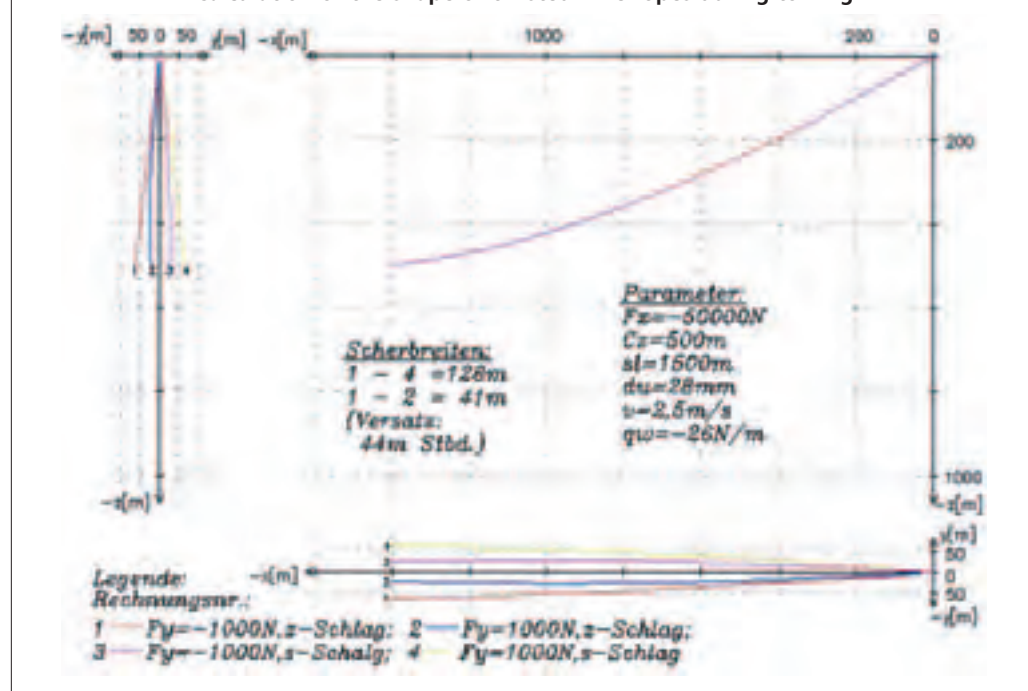
an example, coefficients for a six-strand rope. The size of the hydrodynamic gross forces can be estimated by using those coefficients.

The direction of the forces depends on the twist direction of the rope. By creating a right-lay (or Z-lay) rope, means the strands are twisted in a clockwise direction producing a force directed to the right. A left-lay (or S-lay) rope will create a force in the opposite direction. Such phenomenon can be used to support the efficiency of otter boards. The use of warps, twisted in the same direction on starboard and port side will also result in the gear being off center relative of the vessel (Niedzwiedz 1988, Paschen *et al.* 1995. The following graph (Figure 12) shows this effect.

The phenomenon demonstrated above makes it clear that the use of warps twisted in different directions (Z or S) will support the horizontal opening of the gear. It can be seen from the graph (C), that the distance of the otter boards will be 128 m; by using warps twisted in opposite directions and the trawl will run in line with the vessel

(No. 1–4). The use of equal twisted warps gives an horizontal opening of only 41 m and the trawl will tow 44 m off the course of the vessel (No. 1–2, 3–4) (See Figure 12).

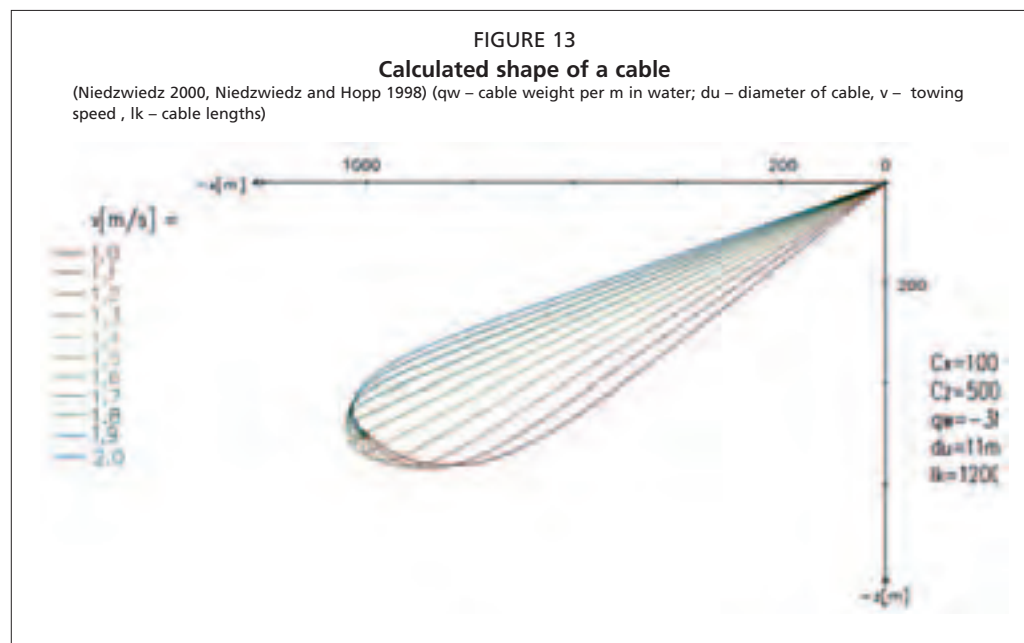
FIGURE 12
Calculation of the shape of twisted wire ropes during towing



Based on these calculations and practical experience it is recommended to use on the starboard side, Z-lay warps and on the port side S-lay warps in order to support the spreading forces of the trawl doors with the gross forces created by the warps. So there is a possibility to choose smaller doors of lower hydrodynamic resistance.

Torque from the warps may create another negative effect. As a twisted rope comes under strain, it tries to “unlay” and creates twisting forces, which may affect the tilt angles of the otter boards because this force attempts to rotate the otter boards. If both warps are right-lay, both otter boards will be tilted in the same direction relative to the boat, with the result that the trawl is running not in the same line as the vessel. But this force can be eliminated by the use of swivels and, or, use of warps twisted in different directions.

Trawls are often connected by cables for gear control and measurement instruments such as net sounders etc., which can also influence the symmetry of the gear. Therefore it is of advantage to know the shape and forces created by such equipment. An example that shows how the shape and the direction of forces can change is shown in Figure 13 where the shape of a cable fixed to a trawl is calculated at different towing speeds.



3. CONCLUSIONS

- The essential elements for deepwater trawling are the otter boards and warps.
- Otter boards must have a high static stability, which is influenced by the following main factors
 - hydrodynamic characteristics
 - length and tension of warps and
 - fixation coordinates of the doors.
- The reaction of trawl doors not exactly adjusted is sensitive to hydrodynamic forces created by the warps and this can led to an unstable run of the gear.
- The use of calculation and simulation programmes for the estimation of shape and tension of warps are useful tools to optimize deepwater fishing operations.
- Simplified rope calculations are not appropriate for deepwater trawling as more hydro-dynamic aspects arising from towing the gear must be taken into account.
- It is strongly recommended to use different twisted warps on star board and port side of the vessel.

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THEME 5

**Monitoring, compliance
and control**

Creating and implementing an effective deterrent

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1. INTRODUCTION

This paper deals with integrating compliance and fisheries management strategy, compliance theory and the New Zealand Ministry of Fisheries compliance strategy. In particular it focuses on the need to create and implement an effective deterrent against offending. It explains some of the innovative changes New Zealand has made over the past five years to support this strategy, principally by opting to move from real-time offence detection to retrospective offence detection, and aligning people and skills to achieve a cost effective deterrent against offending. Case studies are described to illustrate key concepts.

Briefly, and by way of background, New Zealand operates a rights-based quota management system (QMS) which is complemented by a legal framework that provides a strongly deterrent-based penalty and sanction scheme. The QMS is based on a documentary product flow system in which participants are required to submit and keep fishing returns and other documentation relating to fish movements and transactions.

2. COMPLIANCE AND FISHERIES MANAGEMENT

The starting point for the compliance strategy is that vessels and fishing companies do not commit offences, people do, i.e. achieving compliance is not just about catching the crooks, it is about creating incentives that influence people's behaviour to comply with the rules

Fisheries management is really about managing people. It is about influencing the behaviour of the participants in the fishery – be they quota holders, harvesters, licensed fish receivers or retailers of fish products – in a way that encourages them to comply with the rules and thereby achieving society's goals of sustainable fisheries. Even effective fisheries management frameworks will not, on their own, deliver sustainable fisheries unless those working within them agree with and comply with the rules that underpin them (Crothers 1999).

New Zealand has worked hard over the years to include stakeholders in the development and operation of the whole fisheries management system. People are far more likely to support a system when they have been included in its development. In so doing, the system gains legitimacy in the eyes of stakeholders in terms of process and outcomes. Building legitimacy translates into higher levels of voluntary compliance with the rules.

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The point is that the success – or otherwise – of a fisheries management regime depends on achieving optimal levels of compliance with the rules that underpin it. Our strategy over the years has been to forge strong relationships with stakeholders and encourage rights-holders to participate in all fisheries management processes, including the development of compliance strategy. We have found that this strategy has led to higher levels of voluntary compliance.

3. COMPLIANCE

3.1 The real world

Before one gets carried away with concepts of legitimacy, voluntary compliance and stakeholder participation, one ought to have a quick look at the real world of compliance. As we are all aware, achieving 100 percent compliance with rules is not likely, nor is it necessarily desirable. But what causes one person to obey the rules and another to break them? What are the driving forces behind the decisions people make to either comply or offend? In this regard fishers are no different to other segments of society.

In a typical situation about 80 percent of fishers will normally comply with the rules if the incentives and social influence they face are strong enough. A further 10 percent are so strongly influenced by moral and social obligations they will comply most, if not all of the time. Of most concern is a hard core of about 10 percent of fishers who set out to deliberately break the rules. These fishers have no respect for the legitimacy, or otherwise, of the rules and will tend to violate chronically and repeatedly. They may go to extraordinary lengths to avoid detection and apprehension. They are motivated by the reward of tangible short-term gains (usually financial) from illegal activity (Sutinen 1996).

The result is that most of the non-compliance and most of the risk to the sustainable management of the fishery is perpetrated by a relatively small group of hard-core non-complying fishers. Only by changing the economic incentives, reducing the potential illegal gains and increasing detection rates and penalties can we hope to control this segment of fishers. In other words, a “big stick” hard line enforcement approach and in so doing create a deterrent to others contemplating similar offending.

3.2 The theory

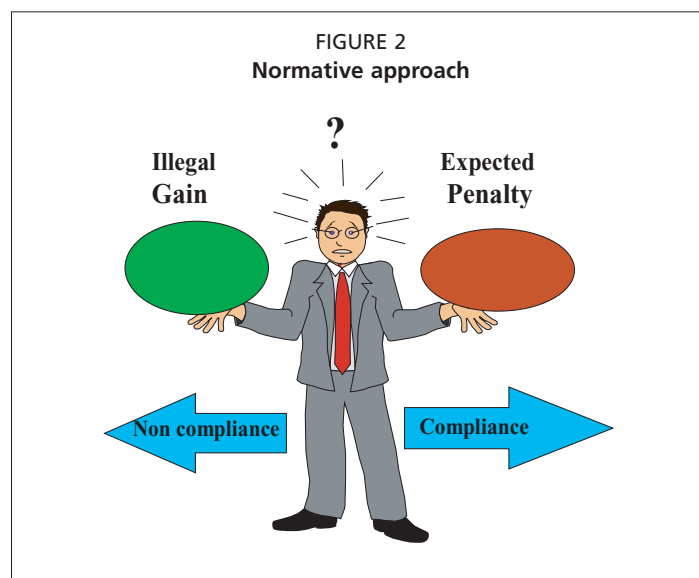
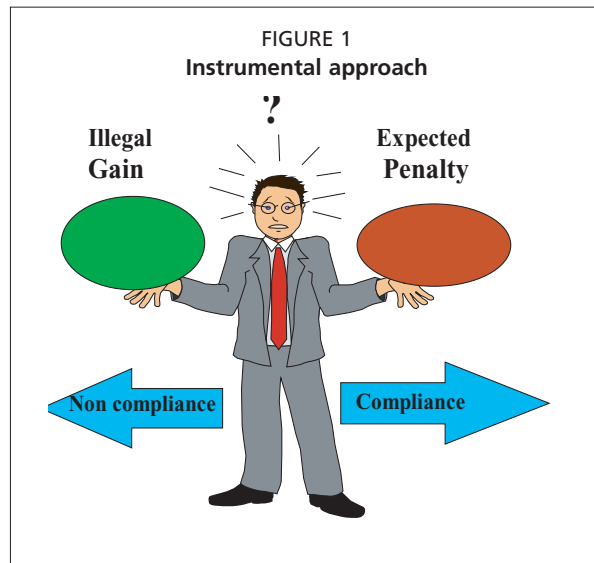
If achieving high levels of compliance is about influencing behaviour, how can this be achieved? In order to achieve high levels of compliance one must first understand four key sources of motivation that influence people’s decisions to either comply or not comply with regulations. These follow.

- i. The amount of illegal gain or benefit likely to be gained – this is the amount of cold hard cash that can be earned from breaking a rule.
- ii. The expected penalty if detected offending – harsh penalties seek to deter individuals from breaking a rule.
- iii. Moral obligation to comply – this is based on a person believing that complying with the rules is the “right thing to do”.
- iv. The fourth motivator – social influence – recognizes that most people’s behaviour is influenced by their peers and the people who matter to them.

Having understood the motivators that influence behaviour, the key is to apply them to compliance strategy development. The literature outlines two basic analytical frameworks that can influence behaviour to achieve high levels of compliance with the rules.

These are:

- instrumental and
- normative.



The first perspective – the instrumental – argues that people are driven by self-interest alone and that compliance is determined by the certainty and severity of sanction in the event of violation of the rules (Figure 1).

This is the “big stick” model, sometimes called the “deterrence approach”. It is a feature of most centralized government fish management regimes, especially those that are open-access systems. Policy-makers have long believed a big enough stick will offset the illegal gain and remove the incentive to break the rule. Experience tells us that this is rarely the case.

Regimes of this kind tend to be ineffective due to the low level of support by the regulated community, the high costs of enforcement and the reluctance of the judiciary to impose deterrence penalties. The normative perspective on the other hand stresses the morality and internalized social norms of individuals. It also includes a deterrent component but seeks to maximize voluntary compliance. It is founded on a belief that people will comply with rules they believe are fair and reasonable, and that are being administered in a fair and reasonable manner (Figure 2). In other words – and this is a key point – the moral obligation to comply is based on an individual’s perception of the fairness and appropriateness of the law and its institutions. This is a key factor to keep in mind when formulating and implementing a compliance regime.

4. COMPLIANCE STRATEGY DEVELOPMENT

4.1 Objectives

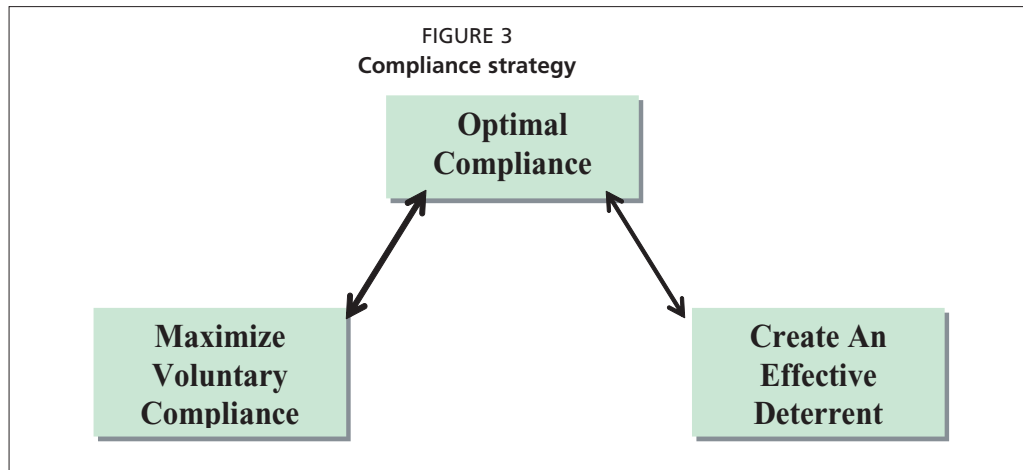
The Ministry of Fisheries’ strategic aim is “to achieve optimal levels of compliance”. This aim is achieved through two mutually supporting goals (Figure 3) of

- maximizing voluntary compliance and
- creating an effective deterrent.

This strategy can be likened to a “carrot and stick” approach, voluntarily comply with the rules or face hard line enforcement and prosecution action. Both arms of the strategy are necessary to achieve optimal compliance – but the main focus of this presentation is on creating an effective deterrent. However, to give context, it is useful to first understand the concept of maximizing voluntary compliance.

4.2 Maximizing voluntary compliance

For 90 percent of the fisher population it is possible to put down the big stick and design a system in which people willingly cooperate. That is a strategy of “maximizing voluntary compliance”. However, this involves the concept of legitimacy.



To be successful, a fisheries management system must be perceived to have legitimacy. Legitimacy operates on three levels.

- i. It starts with agreement on what a society wants to achieve from the use of its fisheries – that is, the vision and goals – and on the best management system to support this.
- ii. It extends to the strategies, rules and services that support the goal.
- iii. Finally, it extends to the integrity of the agencies that administer the system.

If stakeholders don't see that system as giving them a fair go, they may turn their backs on it. Building legitimacy might be more time consuming and costly up front but the payback comes later though lower costs of enforcement and higher rates of compliance.

4.3 Effective deterrence

Creating an effective deterrent has its origins in the Instrumental theory of compliance, which argues that compliance is determined by the certainty and severity of sanction when rules are violated. Thus, compliance is determined by a fisher's perception of the product of the probabilities of:

- chances of detection \times
- enforcement action being taken \times
- being successfully prosecuted and convicted and
- the penalty, with this being greater than potential illegal gains.

It has been argued that a strategy of creating an effective deterrent is expensive due to the high costs involved of enforcement. The reason an effective deterrent strategy can be costly is that many agencies rely on real-time offence detection. Given that offending may take place in the deep sea far from the prying eyes of enforcement officers, high levels of at-sea or aerial surveillance, at-sea inspections, observer coverage or dockside monitoring are required to create a credible detection capability that could influence fisher behaviour.

It is common knowledge within police circles that only about 3 percent of all offences are detected in real time. Not surprisingly patrolling police vehicles have proven to be an ineffective way of detecting offending. The same could be said for fisheries patrolling. The typical odds of being apprehended violating a fisheries regulation is below one percent and often close to zero (Sutinen 1996).

Simply put, in terms of real-time offence detection the strategy of creating an effective deterrent falls at the first hurdle due to the inability to create a perception in the minds of fishers that the probability of being detected is high. By not achieving this first and important threshold the remaining arms of the strategy also fail. The question is, how does one turn this perception around?

4.4 Moving to retrospective offence detection

The major obstacle to creating an effective deterrent is the inability to detect serious as distinct from minor or technical violations. The critical issue and the challenge for fishery enforcement agencies is moving from real-time offence detection to retrospective offence detection. This means that a fisher contemplating offending must not only be concerned with real-time apprehension by enforcement authorities, but with the fear and threat of being subsequently apprehended months, or even years, later hanging over their heads. Once this threat materializes against just a few fishers, the impact on the remaining fishers can be quite marked.

As an example, in New Zealand several vessels were recently prosecuted for area misreporting as a result of retrospective offence detection techniques. The fact that this type of offending had been detected spread quickly through Industry. Almost immediately a noticeable change in fisher behaviour occurred that suggested many other fishers may have also been previously offending.

It is this kind of approach that changes fisher behaviour, because the risks of being detected and prosecuted are now perceived to have increased to the point that the benefits of offending are outweighed by the risk of being caught and the imposition of deterrent penalties. The point here is that one needs to only retrospectively detect and successfully prosecute a small number of serious offences to have a significant deterrence impact.

4.5 The tools and techniques

The model of generalist enforcement officers able to cover a wide range of duties will not suffice in this environment. Generalist officers are still required for traditional enforcement and compliance work, but this model requires the development of specialist skills and expertise in quite specific areas.

To achieve retrospective offence detection, and thereby increase detection capability, investments must be made in three key areas of the organization:

- i. information systems and management
- ii. analytical skills and
- iii. specialist multi-disciplinary investigative teams.

Information systems and management

The need for good quality information from a variety of sources is critical to retrospective offence detection. Fortunately for New Zealand some of this work has been done by virtue of the QMS being a documentary-based product flow system where participants are required to submit and keep a range of documentation relating to fish movements and transactions. This provides a wealth of information about fishing, catching and landing practices as well as providing traceability of fish sales and movements.

The Ministry of Fisheries' Compliance Programme has invested heavily over the past five years in a range of information systems that provide valuable compliance-related information. These include:

- observer trip information where approximately 10–15 percent of deep-sea fisheries are covered annually
- vessel monitoring system (VMS) data – all vessels >28 metres must operate a VMS
- industry self-audit reports submitted annually for all medium to large licensed fish receivers
- Compliance Activity Monitoring System (CAMS) records the results of all inspections and fishing contacts undertaken by Fishery Officers
- Fisheries Intelligence Network (FIN) is an intelligence database used to record and store intelligence gained from a wide range of sources

- Offences Systems is a database that records prosecutions, warnings, inquiry or investigative files
- Threat Assessments which are a comprehensive analysis of all main fish stocks and details the major risks of offending for each fish stock and
- strategic alliances with other government organizations and overseas agencies that allow access to a wide range of fisheries-related information and intelligence.

The range of information available covers nearly all aspects of the fishing industry and provides invaluable source material able to be used for offence detection purposes. However, few traditional enforcement officers have the skill and aptitude to interrogate databases and make sense of wide-ranging and complex information.

Analytical skills

Once the organization is data and information “rich” then every effort must be made to build an analytical capacity to ensure that maximum value is being obtained from the information. Specialist skills and expertise are required to analyse, interpret and distil the information into meaningful reports that identify offences and direct enforcement activity.

The Ministry of Fisheries has invested in the development of its analytical capability and can now benefit from a range of specialist skills such as the following.

- Forensic Analysts, who spend much of their time delving through databases using techniques such as statistical, comparative and discrepancy analysis together with fisheries management, observer and scientific expertise to develop:
 - i. fishing trends and patterns
 - ii. fish stock and vessel profiles and
 - iii. company and fisher profiles.
- Computer Forensics – this small team of people are expert in capturing, to evidential standard, electronic information. Specialist tools and techniques are used to clone fishing company computers, laptops and databases, and electronic information stored on equipment such as fish plotters, communications equipment and navigational equipment. Having safely captured the information, specialist tools and software are used to investigate the information and detect offending.
- Forensic Accountants who are able to undertake fishing company audits, investigative audits, product flow analysis, and analysis of company and business documentation and fishing returns.

With a focus on offence detection, the collective results of these specialists is to identify such offences as dumping, fishing in closed areas, area misreporting, species misreporting and quota fraud. In nearly all cases traditional enforcement techniques that focus on real-time offence detection would not have detected the offending.

5. MULTI-DISCIPLINARY INVESTIGATIVE TEAMS

Having increased offence detection capability it is important to develop credible capacity to investigate and prosecute any offences that detected. This is best achieved through a highly specialized multi-disciplinary investigative teams comprising:

- forensic accountants
- forensic analysts
- computer forensics
- investigators/fishery officers and
- solicitors.

These teams have a sole responsibility to investigate and prosecute serious offences and might only achieve a few prosecutions per year. Scarce resources should be used in a cost-effective manner to target serious violations, as reductions in illegal fishing will be greatest when the chronic and flagrant violator is apprehended and fined.

Also, a positive multiplier effect of deterrence is expected when the chronic and flagrant violators are apprehended and penalized. On the other hand, severe enforcement actions taken against the marginal, inadvertent or infrequent violator may be counter-productive and possibly have a negative multiplier effect on deterrence.

While the process for retrospective offence detection, analysis and investigation is different, the reality is many of the skills are complementary and a single well-supported multi-disciplinary team can achieve both, all without necessarily having to leave land.

6. CASE STUDIES

6.1 Species misreporting

To demonstrate retrospective offence detection, the following case study provides some insight to the effectiveness of the approach.

Background

The hoki fishery is New Zealand's largest deepwater fishery by volume and as such is the backbone of the New Zealand fishing industry. A large number of vessels participate in the fishery each year with fishing activity being most intensive around the West Coast of the South Island (WCSI) between July–September each year. The fishery is a mixed fishery with a large number of quota and non-quota species typically being caught during each trip. Suspicions have long been held of large-scale offending occurring, particularly in the areas of dumping, high grading and misreporting.

Response

A specialist Serious Offences Unit commenced an analytical process to develop a fish stock profile of the WCSI hoki fishery. A large amount of data and information was analysed going back over seven years. The base data used were observer catch–effort logbook data, which is considered to have a high degree of reliability. Additional input was also sought from scientists and hoki fish stock experts. This information was subsequently compared against a large body of independent data from science and research observations and then against fisher returns (Figure 4).

A high-level hoki profile was developed with a large number of subprofiles. The task was to then compare all vessels in the fishery against the profile and identify those that fell outside the profile. The profile was able to identify that for each hoki trip, between 8 to 17 quota species and 13 to 26 non-quota species should be caught and landed. When this profile of a typical hoki trip was compared against the hoki fishing fleet some interesting trends emerged.

A number of vessels were identified that had catch profiles inconsistent with the fish stock profile including several vessels from one company. It became clear from the analysis that large scale intentional misreporting had been detected as these vessels were not reporting a number of quota and non-quota species as having been caught.

The hoki profile was expanded to compare the presence and absence of species between observed trips and non-observed trips in relation to the same vessels. This subprofile identified 12 species of fish that should be caught on every trip. The information was graphed and compared against actual reported catches by the suspect vessels. This revealed some interesting vessel profiles (Table 2).

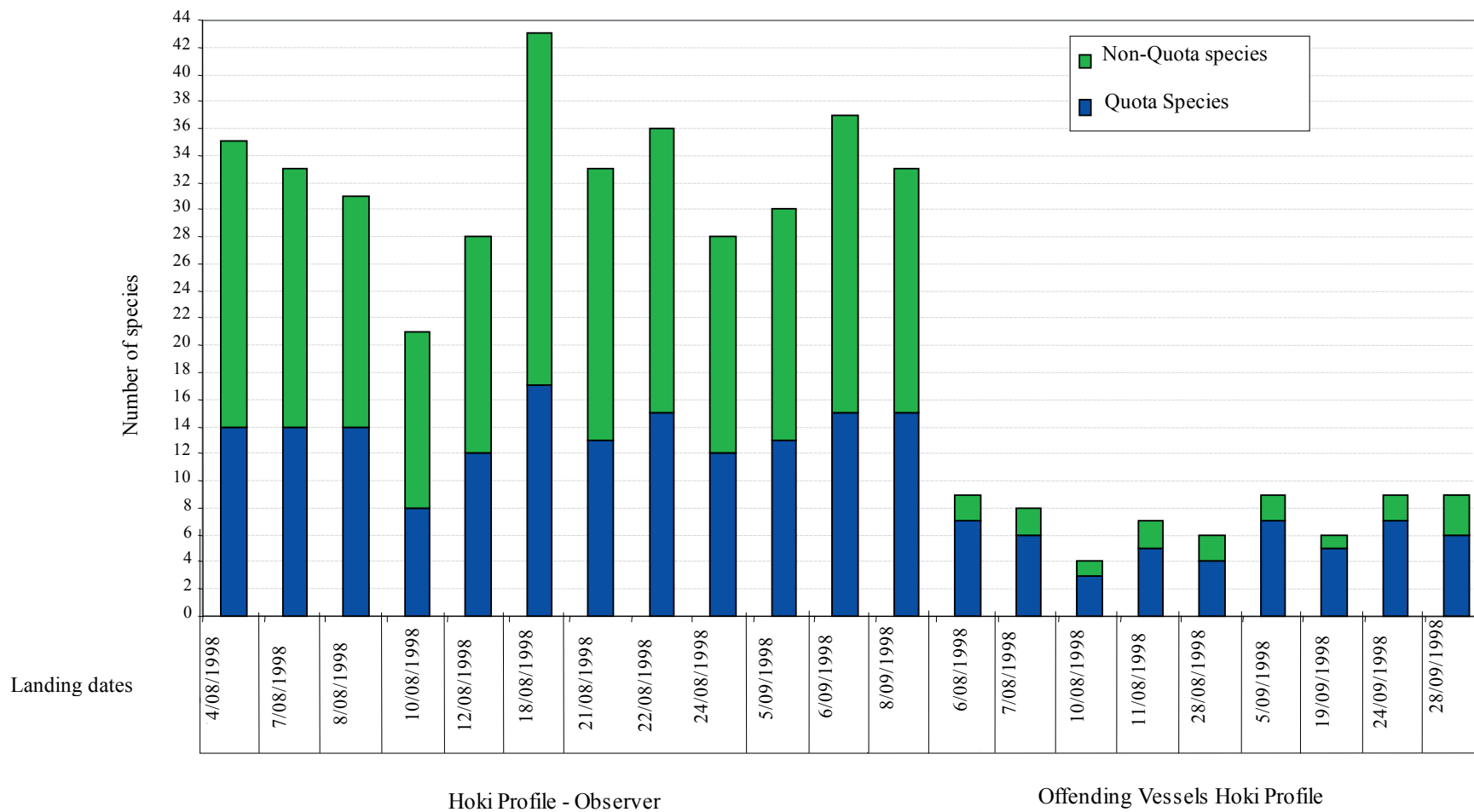
Every white or empty square in Table 1 represents a species of fish, which according to the profile, should have been caught but was not reported as having been taken by the vessels. It is clear from the analysis that the vessels were only reporting higher-value species with many species being either dumped or misreported.

Through this in-depth analysis, evidence of offending had been detected not only against these vessels but other vessels as well. The Serious Offences Unit investigated

FIGURE 4

Profile of a West Coast South Island Hoki (WCSI) fishery vessel

This was developed in response to suspicions of large scale dumping in a mixed fishery with a large number of quota and non-quota species.
A profile was identified for the WCSI Hoki fishery that between 8–17 quota species and 13–26 non-quota species should be caught on every trip.



- that no other vessels had caught those quantities of hake at that time of year on the Chatham Rise and
- that the catch rates were consistent with a spawning fishery, yet hake did not spawn until several months later.

The analytical profile was able to conclude that it was highly probable that hake reported as having been taken on the Chatham Rise must have been caught on the WCSI. The Serious Offences Unit investigated this case and a successful prosecution resulted. Again noticeable changes in reporting behaviour were noted as a result of this prosecution, not only in the hake fishery but other fisheries as well.

Why had fishers' behaviour changed? Fishers' perception of the risk of being detected and successfully prosecuted had changed to the extent that fishers had been influenced to comply with the rules. Simply put, the risks of being detected and prosecuted outweighed the benefits of illegal activity.

6.3 Conclusions

By adopting a retrospective approach to offence detection, those contemplating offending will need to balance the risks of

- the offence being detected **sometime in the future**
- enforcement action being taken by a highly specialized multi-disciplinary investigative team
- being successfully prosecuted and convicted due to the wide range of analytical, forensic and accounting skills being adopted and
- the penalty being greater than potential illegal gains due to the harsh penalty and forfeiture regime.

Result – A cost effective approach to creating an “effective deterrent”. The New Zealand experience is that it is not just about catching the crooks, it's about creating incentives that influence people's behaviour to comply with the rules

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Vessel Monitoring System (VMS) proves the case in court

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1. INTRODUCTION

Vessel Monitoring Systems (VMS) are proliferating around the globe and have emerged as one of the premiere tools for increasing efficiency in fisheries enforcement and management. More than 60 countries are currently running, or in the process of implementing, VMS systems, or are engaged in pilot projects to explore their feasibility.¹ While the utility of VMS systems may appear obvious, one crucial level of acceptance of this enforcement tool must occur in a court of law. VMS-based evidence that is used to prove a violation or offense has to be successfully subjected to courtroom scrutiny for the full benefit of this technology to be realized. This paper recounts the experiences of the United States in taking its first case to trial based exclusively on VMS evidence. It is believed this may be the first case of its kind to advance to a written decision from a judge, opining on the reliability and accuracy of a VMS system using geostationary satellites and a system of triangulation.

The particular case described in this paper involves a ninety-five foot scallop dredge vessel, the **F.V. Independence** and charges brought against it by the National Oceanic and Atmospheric Administration, (NOAA), a federal agency. The charges of illegal action against the vessel involved its presence in a closed area rather than fishing. This case was about establishing the accuracy of VMS regarding position verification; this was not a fishing vessel signature case. The activities giving rise to the violations which it was charged occurred on 8 and 11 December 1998 in an area closed by regulation and located in the northwestern Atlantic Ocean. More than four-dozen incursions of varying depths were made in the closed area by the **F.V. Independence** during its eight-day fishing trip, based on the vessel's VMS trackline. Severe penalties and sanctions were sought against both the corporate owner of the vessel and its master. The VMS system involved was a **BOATRACS/ QUALCOMM**.

2. BACKGROUND OF VMS IN THE UNITED STATES

VMS was initially tested by the United States in the late 1980s when a program was set up in the North Pacific involving the satellite monitoring of high-seas driftnet vessels. Some VMS units were also later placed on a small number of other foreign flag vessels as part of a court settlement agreement.

VMS was first used on a domestic fleet in the U.S. in the mid-1990s in the Hawaiian pelagic longline fleet in the Pacific, where a three-year pilot project was conducted. The Hawaiian fleet had a limited capacity of 166 vessels and about 100 vessels from this

¹ Side event on Vessel Monitoring Systems presented at the 26th COFI, FAO, Rome, February 2003.

fleet were likely to have been active at any one time. A number of useful lessons were learned from this pilot project experience.

Starting in May 1998, VMS was required on scallop vessels fishing along the eastern seaboard of the U.S. The case described in this paper occurred in this scallop fishery. VMS requirements have spread on a fishery-by-fishery basis in the same way that fishery management measures have traditionally been developed in the U.S. This has been under the aegis of the *Magnuson-Stevens Fishery Conservation and Management Act* (1990). The *Magnuson-Stevens Act* is the primary federal fisheries law (16 U. S. C. 1801 et seq.). The law sets up a system of eight regional fishery management councils, consisting of appointed representatives from industry and the states, as well as other experts. They have the responsibility for determining if a fishery is in need of management, and if so, how that fishery ought to be managed. Over 1 000 species are currently under federal management. These regional councils make the initial determination about whether a VMS should be required as a part of a fishery's management regime. Currently, approximately 1 600 vessels are required to use VMS in a number of different fisheries around the country. About 500 additional vessels will need to implement the system in January 2004. Different VMS systems are in use in different locations.

3. THE CASE

After initiating its fishing trip for scallops on 4 December 1998, the **F.V. Independence** was first detected inside the closed area through its VMS on 6 December. At the time, NOAA did not staff a "24/7" VMS watchstander in its regional office. In addition, although the system now sends vessels that are inside closed areas an automatic message alerting them to their position inside the closed area, the system did not do this at the time of the violations in December 1998.

NOAA's regional VMS technician followed the **F.V. Independence's** growing number of incursions from her office computer terminal and ultimately contacted the US Coast Guard and other NOAA law enforcement personnel to confer about the situation. The Coast Guard happened to have a cutter on fisheries enforcement patrol in the area and dispatched it to the vicinity of the closed area. Although coincidental, the ability of the Coast Guard to get on scene quickly was a key factor that added strength to the case as it set up verification of the illegal conduct using other methods besides VMS.

The evidence generated by the VMS system showed that the fishing vessel was identified inside the closed area dozens of times between 6 and 11 December 1998. While some of the vessel's positions were extremely close to or on the closed area's boundaries, many others were beyond a ½ nm distance inside and the deepest incursion was nearly 1.5 nm. Although the initial detection of the **F.V. Independence** inside the closed area had only VMS evidence to support it, the Coast Guard's arrival on the scene several days later while the fishing vessel was continuing to illegally fish inside the closed area boundary set up a strong factual case for the agency as more traditional radar and eyewitness based evidence could be used to support the later incursions.

When the Coast Guard cutter approached the closed area late in the evening on 10 December, it detected the **F.V. Independence** on its radar. The cutter took position fixes on the fishing vessel for nearly four hours before it contacted the vessel and then boarded it. Radar showed the **F.V. Independence** to be repeatedly inside the closed area.

The activity underlying an additional illegal action involving false statements occurred during the Coast Guard's boarding of the vessel. The master captain, Yacubian, lied about the quantity of scallops on deck and in the hold, understating the amounts by a wide margin. After the boarding, the unshucked scallops on board the vessel at the time, in total 91 bushels, were officially abandoned by the master and

returned to the sea before the vessel was escorted into port by the Coast Guard. The vessel's catch, worth nearly \$26 000, was also seized and sold upon return to shore.

The closed area violations committed by the **F.V. Independence** were serious. In the region where they occurred, closed area violations are considered to be some of the most serious types of violations that can be committed as many of the fisheries in this region have been overfished and consequently have been subjected to stringent limitations in an attempt to rebuild the stocks. In this particular closed area, located near the outer boundary of the US EEZ and near where Canadian and US waters abut (known as the Hague Line), fishing gear was required to be stowed. Vessel presence in the closed area was allowed only for emergencies or for compelling safety reasons. Neither justification applied in the case of the **F.V. Independence**. At the conclusion of the government's investigation and following a review by NOAA attorneys², the corporate owner of the vessel and the master of the vessel, Yacubian, were charged with three counts of illegal activity.

The respondents were charged with violating the following regulations: 50 CFR 648.14(a) 939, 648.81(b)(1) and 600.725(i), all of which implement *the Magnuson-Stevens Act*. The charges, which were brought through NOAA's administrative system³, included two counts of illegally being in a closed area, once on 8 December 2004 and again on 11 December and one false statement. In addition to the \$250 000 penalty, NOAA also sought revocation of the vessel and operator permits and forfeiture of the seized proceeds. The charges were brought jointly against the owner and master.

The case was "prosecuted". In the U.S. that term can also correctly describe an administrative case. To prove the violation, NOAA prosecutors had to show the vessel's position was inside a closed area. Here, vessel position had to be proved and fishing did not need to be established as an element of the violation. In the first closed area charge, on 8 December, the VMS data was the only evidence available to prove where the vessel was. This case presented the opportunity to legally "ground truth" (i.e. test the reliability and accuracy) the VMS System in front of a judge and with challenges from the fisherman.

In the system used by NOAA, it may seek penalties less than the statutory maximum for violations and typically does so. NOAA utilizes a published penalty schedule as guidance to try and achieve fair assessments for the different types of violations occurring around the nation. But due to the egregious nature of the behaviour, NOAA prosecutors determined they would seek the maximum penalty allowed by law for each closed area violation, i.e. \$110 000 per count. In NOAA's system, repeat violators can be treated more harshly. In the case involving the **F.V. Independence**, the violator had a convictions record of five federal fishing violations during the nine-year period immediately preceding this closed area violation. Considering all aspects of this

² The National Oceanic and Atmospheric Administration is a federal agency that is responsible for enforcing the provisions and regulatory requirements of the *Magnuson-Stevens Act*. Use of VMS in the scallop fishery and prohibiting entry into designated closed areas are regulatory requirements under the authority of the *Magnuson-Stevens Act*.

³ In the US, all federal agencies with administrative enforcement authority must adhere to the procedural principles laid out in the *Administrative Procedure Act*, 5 USC 501, et seq. (APA). The APA was enacted in 1946 and, was intended to bring consistency to the practices of federal agencies, both in promulgating regulations and in enforcing agency authorities. In the enforcement realm, the APA sets the parameters of the civil administrative enforcement system, providing for written charges against the accused; an opportunity for a hearing, which is like a trial, though without a jury, sworn witnesses or evidence. A written record is created. Due process must be afforded and specialized prosecutors and judges are used. The standard of proof in an administrative proceeding is "preponderance of the evidence", in contrast to "beyond a reasonable doubt" of a criminal process. The range of punishment that may be imposed in the civil administrative process cannot include incarceration but does encompass a variety of other sanctions, including monetary penalties, which can be substantial, and seizures and forfeitures of a vessel, catch and gear as well as revocation of a license or permit. In NOAA, on average, 400–600 new fisheries cases are charged administratively by agency attorneys each year.

case, including the gravity, extent, nature and circumstances of the violation, and the respondents' history of prior violations, and degree of culpability, NOAA determined that the maximum penalty under the statute was appropriate, as was revocation of the vessel and operator permits. These are the factors that "shall be taken into account" as enumerated in the *Magnuson-Stevens Act*, in addition to "other interests as justice may require".

Prior to charging the **F.V. Independence** case, all VMS-based cases that were pending in NOAA were carefully evaluated by a team of experienced prosecutors to determine which case seemed to present the most favorable situation. The importance of a successful outcome in the first case moving forward was well understood, given the significance that was attached to VMS systems everywhere. As the stakes were high for all parties, all subsequent decisions about the case were carefully considered.

The violations committed by the **F.V. Independence** were not the first VMS-based violations in the US, but they were the first to be contested before a judge. In the Hawaii longline fishery, no case based on VMS had advanced to a hearing stage, presumably because the fishermen believed that VMS evidence was controvertible and that a successful challenge could not be mounted. VMS had also been accepted by the industry there without significant resistance. In contrast, in the northeast region where the **F.V. Independence** case occurred, VMS requirements were not welcomed by the industry and the region has a history of invoking litigation more often than any other region in the country. VMS has had a positive effect in Hawaii, as shortly after VMS was introduced, the number of closed area violations went down dramatically.

4. THE HEARING

The multi-day hearing before the judge was conducted in two consecutive segments. In the first part, the judge took testimony and evidence about the reliability and accuracy of this VMS system in general, as required by U.S. law, as this technology was being used as evidence for the first time. This first portion of the hearing, known as a *Daubert*⁴ hearing, focused exclusively on expert testimony presented by the agency about the reliability and accuracy of the system. The Respondents, using cross-examination, their experts, and legal arguments, then attacked NOAA's case. At the conclusion of the *Daubert* segment, the judge ruled from the bench that he was, "[P]ersuaded ...that the *BOATRACS* system is a reliable system reporting positioning data accurately 95 percent of the time within 300 meters of the actual position"⁵.

During the second, more traditional, segment of the hearing, the judge began his fact finding by hearing all admissible evidence about whether VMS and all other types of evidence proved whether the specific violations were committed on those dates, as alleged by NOAA. As NOAA was the party seeking sanctions against the Respondents, the agency had the burden of proving that the VMS technology was reliable and accurate and that the VMS evidence the agency was relying on supported the charges in this case. To establish this, NOAA had to present evidence about the system and its operations and studies verifying its accuracy, in addition to the particular facts of this incident.

NOAA identified various witnesses to testify about the *BOATRACS* system, its operation and reliability. These witnesses included the chief operating officer of *BOATRACS* and several technical experts. These included both those employed by NOAA and external specialists. They explained studies of the *BOATRACS* system they themselves had conducted or evaluated.

⁴ Named for the United States Supreme Court case that first identified the necessary criteria that should be used to test the reliability of the evidence presented by experts. *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993) and subsequent related cases.

⁵ Transcript of hearing, vol., 2, p. 180.

NOAA also relied on an independent study of the *BOATRACS* system that had been done by the US Coast Guard. Its timing was fortuitous. The Coast Guard had been considering purchasing the *BOATRACS* systems for some of its own vessels in the Gulf of Mexico and as part of a pre-purchase evaluation by the Coast Guard, an independent study was carried out looking at a number of different technical and operational criteria, including reliability, position accuracy, error, rate of error and temporal spacing of error, coverage of the system, cost, availability of the system and latency (how long it takes messages to get through). The Coast Guard's study had begun several months prior to the **F.V. Independence** incident and was not linked to the eventual litigation. A Coast Guardsman who was an expert on satellite communications and navigational tracking systems presented this study. The Coast Guard study proved to be essential to the case, as the information proffered by the *BOATRACS* Chief Operating Officer (COO) could not provide anything beyond anecdotal information about the reliability of its system. No systematic study had been conducted by *BOATRACS* of the system's reliability.

The COO of *BOATRACS* testified that *BOATRACS* receives positioning data from the satellites, reformats it then sends it to NOAA. He testified extensively about the company, how it interacted with its customers, and especially how *BOATRACS* relied on customer contacts to inform them of problems with the system or its operation. He was offered as an expert on the reliability of the system, but the judge would not accept him as such, because the COO could produce no reports showing how, or if, the company had been tested for reliability. Instead, he said they relied on lack of complaints from customers to support this assumption. This was deemed insufficient for purposes of establishing reliability in a scientific and evidentiary sense. While the COO could not establish the system's reliability, he was able to establish that the VMS system was fully operational on the dates in question.

NOAA engaged another expert in the field of geo-positioning and satellite systems solely for the litigation. He was a recently retired physics instructor from the Coast Guard Academy and a graduate of Yale University and had impressive credentials. He was enlisted to evaluate the system and to conduct a limited literature review. He also reviewed the reports of the other government experts on position verification and reliability. He testified about the incident of 11 December where he compared the position reports of the radar to the VMS position reports from that date. He concluded that because there were so many data points inside the closed area, especially those in excess of $\frac{1}{2}$ nm, "It becomes a virtual mathematical impossibility that the **F.V. Independence** was not in the closed area". The $\frac{1}{2}$ nm was an important metric as it was a significantly greater distance than the error in both systems. Based on his work, and evaluation of nearly 3 000 data points from the studies he examined, he also testified that the system was accurate at least 95 percent of the time to within 300 metres, which ultimately became a key factual finding of the judge⁶. His testimony was useful not only for the expertise he brought to the process, but because he was able to convey highly technical information in such a way as to make it comprehensible to the judge and non-technical personnel.

In addition to the external experts, NOAA used several NOAA personnel as witnesses in its case, including a computer specialist who had developed the base station software to support the VMS reporting requirement. He had also done a small scale, in-house test using only five vessels where VMS position reports were compared to different GPS reports. NOAA also had fact-specific witnesses testify, including the VMS technician whose job it was to monitor the daily data reports provided by *BOATRACS* showing vessel positions.

⁶ This was also the degree of accuracy claimed by *BOATRACS* promotional materials.

The agency's evidence was presented in standard hard copy form but the critical VMS evidence was also loaded on a CD-Rom. The VMS tracklines and the various VMS based reports were then projected in the courtroom, enlarging their size, enhancing visual impact and graphically depicting the large number of incursions and depth of the incursions.

Some of the Respondents' primary defenses were based on the master's testimony but his version of what happened was not always consistent with the testimony of NOAA's witnesses. The judge determined the appropriate level of credibility to give this testimony. The Respondents also employed their own expert witness who attempted to discredit *BOATRACS* VMS.

The Respondents claimed that the evidence NOAA presented at the hearing did not support the agency's claims and charges. They claimed NOAA did not discharge its burden of proof. They maintained that NOAA had not proven that VMS was a reliable system in general, in spite of the judge's conclusion on this point. They also claimed that NOAA had not introduced reliable relevant evidence to specifically prove the violation of 8 December. They argued that there was no evidence showing that the system was working properly and accurately that day and it could not simply be assumed based on other generalized tests of the system. They also highlighted that NOAA did not call a QUALCOMM witness to establish the link between the two systems or the proper functioning of QUALCOMM on the date in question.

In spite of the judge's ruling that the VMS system was reliable at the end of the *Daubert* hearing, the Respondents continued to contest use of the system and argued over its unreliability. The Respondents criticized *BOATRACS* for failing to verify that the information it received from QUALCOMM was accurate and that there was no proof given that either system – *BOATRACS* or QUALCOMM – was working properly at any particular time. They also claimed that *BOATRACS* did not have redundancies set up in its system to evaluate possible error. They attacked the conclusion of 95 unshucked scallops accuracy by claiming that the data set used to draw these conclusions was too small and that it did not address the remaining 5 percent. The remaining, 5 percent they suggested was populated with erroneous readings that could cluster together in time and space and thus these errors provided the data points showing the **F.V. Independence** inside the closed area. However, as the *BOATRACS* data was insufficient, in their view, this too, was not able to be conclusively demonstrated.

The lack of quality control studies by the vendor, *BOATRACS*, resulted in repeated criticism by the Respondents. While the COO of *BOATRACS* provided lots of anecdotal reports of the system's reliability, the judge did not consider this adequate to legally establish the system's reliability. NOAA's paucity of similar controls, especially to determine proper functioning on the days in question, also drew fire from the Respondents.

They argued about the accuracy of the Coast Guard's radar and alleged calibration errors in Coast Guard navigational equipment. The degree of error, according to the Respondents, was great enough that it would properly place the **F.V. Independence** on the outer boundary of the closed area or outside the area altogether. On a variety of specific factual issues, they claimed that the **F.V. Independence** was not capable of going the speeds NOAA claimed (and VMS and radar supported) that it must have traveled. They also alleged that the various turning maneuvers shown on the tracklines were inconsistent with traditional scallop tows. The master also claimed that the vessel's lights remained on during the entire trip making it highly visible, in contrast to the testimony of the Coast Guard that the lights were extinguished when the cutter approached it during the early hours of 11 December.

At the conclusion of the hearing, both parties filed written briefs with the judge, arguing their position. Once the briefing was completed and the record closed, the judge took the case under advisement and issued his decision.

5. CURRENT STATUS

The judge's Initial Decision is attached (Appendix I), so that his conclusions about the case can be reviewed⁷. He found for NOAA and imposed the \$250 000 penalty and revoked the vessel and operator permits. The Respondents appealed the judge's decision to the Administrator of NOAA through administrative channels. The Administrator affirmed the judge's decision with a written decision of his own⁸. The case remains active, as the Respondents have now appealed further into the Federal District Court. At the District Court level⁹, they will get a review of the existing record of all of the proceedings held in NOAA. Further analysis by this author is not possible at this time, as the legal proceedings are ongoing.

Additional cases have been brought in several nations involving VMS, including Spain, the UK, Australia and New Zealand, as well as additional cases in the US. Some of these cases have involved the switching off of VMS units when they were required to be activated, as opposed to position violations.

⁷ Can be cited as 2001 NOAA LEXIS 8, December 5, 2001.

⁸ Can be found at 2003 LEXIS 15, July 2003.

⁹ The District Court case is Lobsters, Inc. and Lawrence Yacubian v. Evans, *et al.*, No. 03-11434DPW (D.Mass.).

APPENDIX I**United States of America Department of Commerce National Oceanic and Atmospheric Administration**

IN THE MATTER OF)	
	)	Docket No. NE 98 0310 FM/V
LOBSTERS, INC.)	
LAWRENCE M. YACUBIAN)	
)	
Respondents.)	
)	

INITIAL DECISION

The National Oceanic and Atmospheric Administration (the Agency) commenced this administrative proceeding with the filing of a Notice of Violation and Assessment (NOVA) on June 14, 2000.

The NOVA charged Respondents, jointly and severally, with three counts of violation of the Magnuson Fishery Conservation and Management Act (Magnuson Act) 16 USC § 1857(1)(A) and its implementing regulations found at 50 CFR §§ 648.14(a)(39), 648.81(b)(1), and 600.725(i). The Agency assessed a civil money penalty jointly and severally in the amount of \$250,000.00.

The Agency also issued a Notice of Permit Sanction (NOPS) asserting the same alleged violations set forth in the NOVA, which seeks to revoke the federal fishing vessel permit of the F/V Independence (Official Number 58581) owned by Respondent Lobsters, Inc. and the federal vessel operator permit of Respondent Lawrence M Yacubian (Number 10000756).

Count I of the NOVA alleged that at or about 23:21 hours, local time, on December 8, 1998 [which equates to 04:21 hours on December 9, 1998, Greenwich Mean Time (GMT)] at or near 41°17.1' North latitude / 66°27.6' West longitude, representatives, employees, or agents of Lobsters, Inc., the owner of the F/V Independence (official number 585811), including Lawrence M. Yacubian, the vessel's Master, unlawfully entered an area specified in 50 C.F.R. § 648.81(b)(1) during a period in which that area was closed to such entry in violation of 50 CFR § 648.14(a)(39). Specifically, the F/V Independence, a scallop dredge vessel, while operated by the named Respondents, was determined to be approximately 1.36 nautical miles inside Closed Area II on December 8, 1998.

Count II of the NOVA alleged that at or about 00:51 hours, local time, on December 11, 1998 [which equates to 05:51 hours on December 11, 1998, Greenwich Mean Time (GMT)] at or near 41°16.75' North latitude / 66°27.6' West longitude, representatives, employees, or agents of Lobsters, Inc., the owner of the F/V Independence (official number 585811), including Lawrence M. Yacubian, the vessel's Master, again unlawfully entered an area specified in 50 C.F.R. § 648.81(b)(1) during a period in which that area was closed to such entry in violation of 50 CFR §648.14(a)(39). Specifically, the F/V Independence, a scallop dredge vessel, while operated by the Respondents, was determined to be approximately .65 of a nautical mile inside Closed Area II on December 11, 1998.

Count III of the NOVA alleged that shortly after 02:07 hours, local time, on December 11, 1998, at or near 41°16.3' North latitude / 66°25.5' West longitude, Lawrence M. Yacubian, the Master of the F/V Independence (official number 585811) and an employee of Lobsters, Inc., unlawfully made a false oral statement to an authorized officer concerning the harvesting of fish in violation of 50 C.F.R. §600.725(i). Specifically, Captain Yacubian told LTJG Timothy Brown of the U.S. Coast Guard,

when asked him to state the amount of scallops on board the F/V Independence, Respondent Yacubian said there were approximately 4 or 5 bushels of scallops per side on the deck of the F/V Independence and approximately 2,500 pounds of scallops in the vessel's hold, when in fact there were approximately 17 bushels of scallops per side on deck (not counting what was in the shucking houses) and more than 4,300 pounds of scallops in the vessel's hold.

Both Respondents filed hearing requests in a timely fashion. During the pre-trial phase Respondents requested discovery from the Agency of information regarding their assessment of the civil money penalty. The Agency raised objections contending that the scope of the discovery request improperly intruded into the Agency's processes in assessing a penalty particularly the legal theories and thought processes of Agency counsel.

At that same time, another Agency matter (*In the Matter of AGA Fishing Corp.*) was pending before this judge which sought similar discovery. A discovery order was issued in that case which allowed for limited discovery of the Agency. Agency counsel there sought a reconsideration and interlocutory appeal. The reconsideration was granted and an order allowing for interlocutory appeal was also issued. Because the discovery issues in this case paralleled those in *AGA Fishing Corp.* an order staying this matter was issued on December 7, 2000 pending the decision of the Administrator of the Agency.

Subsequently, in *The Matter of AGA Fishing Corp.*, 2001 NOAA LEXIS 1 (March 17, 2001) the Administrator of the Agency resolved the discovery dispute and established a guideline for similar discovery in that and similar cases. An order lifting the stay in this matter was then issued on March 21, 2001 and the parties proceeded to discovery and preparation for trial.

The hearing was held in Boston, Massachusetts, commencing on June 19th and ending on June 22, 2001.

At the outset of the hearing on June 19th, a preliminary session was held to determine the reliability of the technology known as Boatracs. This was characterized to the parties as a *Daubert* hearing in conformity with the decision of the U.S. Supreme Court in *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993) and subsequent related cases.

Expert witnesses were qualified to present their opinion regarding that technology. A restatement of that decision follows prior to rendering a decision on the merits of the NOVA and NOPS.

RELIABILITY OF THE BOATRACS TECHNOLOGY

The parties offered expert evidence for the purpose of determining the reliability of certain satellite based geographic positioning technology and the data produced by that technology. The Agency contended that this technology provided through the Boatracs system was sufficiently reliable so that the data produced by that technology, which identifies the geographic position of respondents, was probative of the actual position. Respondents contend that the Boatracs system was not reliable and thus the data should not be used to determine the actual position of respondent.

This judge has wide discretion to determine whether to admit the testimony of an expert witness. See e.g., *United States v. Tocco*, 200 F.3d 401, 418 (6th Cir. 2000). Expert testimony need not be *necessary* to be admissible; rather, it must reasonably assist the administrative law judge as the trier of fact in understanding or determining a matter in issue. The task of the judge under this rule is to ensure that the expert's testimony rests on a reliable foundation and is relevant to the task at hand. *Daubert* supra. Since the Administrative Procedures Act and the Agency rule at 15 CFR § 904.251(b) [Evidence] essentially says that any and all evidence which is relevant is admissible in administrative proceedings that is, all evidence that is relevant, material, *reliable*, and

probative, and not unduly repetitious or cumulative, is admissible at the hearing. The formal rules of evidence do not *necessarily* apply to these proceedings.

From the *Daubert* decision and its progeny I discern the *Daubert* factors may be used, not to exclude evidence, but to determine the reliability of expert testimony.

Nevertheless, because the Agency procedural rules, in 15 CFR § 904.240(e)(3) only address the discovery of the substance of the facts and opinion to which an expert witness is expected to testify and provide a summary of the grounds for each opinion, I have been guided in this preliminary *Daubert* hearing by the Federal Rules of Evidence, particularly FRE 702, 703 and 704 and *Daubert* to determine the reliability of the evidence presented by each qualified expert.

FRE 702 states that a witness qualified as an expert by *knowledge, skill, experience, training or education* may testify in the form of an opinion or otherwise if it will assist the trier of fact to understand the evidence or to determine a fact in issue. In administrative proceedings the administrative law judge is also the trier of fact. Thus, I have considered the proffered evidence and testimony of the parties' respective experts in that light.

FRE 703 allows an expert's testimony to be based on facts or data perceived by the expert or made known to the expert at or before the hearing. In addition, if the facts relied upon by the expert are of a type reasonably relied upon by experts in the particular field when forming opinions, the facts need not be admissible in evidence.

Furthermore, FRE 704 allows an expert with an exception pertaining to criminal cases, to testify in the form of an opinion that embraces the ultimate issue to be decided by the trier of fact. I perceive the ultimate issue to be decided by me, as the trier of fact, is whether the Respondents, on the day(s) in question, were physically within the Closed Area II Closed Area. The issue leading to that is whether the Boatracs technology was sufficiently reliable to have accurately determined the geographical position of Respondents within the Closed Area II Closed Area.

This judge qualified Benjamin Peterson, PhD, Peter Dana, PhD, and LCDR Gregory W. Johnson as experts on the subject of the reliability of the Boatracs technology. This judge also admitted into evidence the reports of each of these experts. Also admitted was the report Eighth District BOATRACS Test and Evaluation Final Report, prepared for the United States Coast Guard Systems Directorate, and prepared by the United States Coast Guard, Research and Development Center, Advanced Communications Technology Project dated July 1998 (Coast Guard Boatracs Report) [A¹- 39]. Also admitted were A-40 (Position Error vs. Time) and Exhibit 41 (Figure 4-4 Scatter Plot of positions from the MCT located on roof of the ESD New Orleans).

Charles J. Drobny the Chief Operating Officer of Boatracs is qualified as an expert on the operation or workings of the Boatracs system which information system includes geographic positioning data collected for use by the National Marine Fisheries Service. He is capable of educating me how the system is structured, how the information is obtained, how is it processed and what is done with it in relation to the National Marine Fisheries Service. His expert testimony is thus limited to how the system operates. He is not qualified to offer an opinion on the reliability of the system.

A detailed description of the BOATRACS system is found in A 39. In summary, BOATRACS provides a two-way data transmission and position location (to within 300 meters using triangulation) within the Continental United States and 200 to 400 miles offshore. User mobile communication terminals (MCT) located on fishing vessels are in continuous contact with a geostationary satellite, which relays messages between the ship and the earth station. Messages are accessed from and sent to the earth station through a variety of terrestrial links. These links are QUALCOMM leased Ku-band transponders (seven at the time of the hearing) on existing satellites.

¹ A will be cited for Agency Exhibit as appropriate

The G-Star GE-1 satellite provides the communications service. A second satellite is used for the positioning service. Both satellites receive each transmission and a position is calculated at the earth station from the transmitted signal using a triangulation algorithm.

When BOATRACS receives the positioning data (in binary format) from the satellite it is then reformatted and sent to NMFS. Each morning a NMFS employee downloads the data and checks it for any incursions into closed areas. If some are found the Coast Guard is contacted who then follows up on that information.

Mr. Drobny related much anecdotal information with respect to the experience of his customers and the accuracy of the BOATRACS system. I have rejected the anecdotal evidence as insufficiently reliable because it had not been screened for confounding factors such as alternative uses than positioning information. However, I did recognize that such evidence could be the impetus for further study. I found that was the case with the Coast Guard study. The Coast Guard sought to corroborate or confirm the claims of BOATRACS that the system was reliable enough to report accurately geographic positions 95% of the time within 300 meters of the actual position.

I find the Coast Guard study to be an off the shelf study and was not prepared for the purposes of litigation. It was prepared prior to the time that might be in question in this case. Thus, I have concluded that the Coast Guard study which presented a statistically sound and reasonable conclusions regarding the reliability and the accuracy of the system's ability to identify the position of fishing vessels employing that system on board that vessel.

I conclude, that after hearing Dr. Dana, Dr. Peterson and LCDR Johnson I am persuaded based on the Coast Guard study alone that the BOATRACS system is a reliable system reporting positioning data accurately 95% of the time within 300 meters of the actual position. I also concluded that the system would reliably report positions 98 to 99 percent of the time within 400 to 450 meters of the actual position. See Transcript June 20, 2001 at pages 178-180. The Boatracs technology for determining a fishing vessel's geographic position is reliable and probative of its actual geographic position.

FINDINGS OF FACT²

Lobsters, Inc of New Bedford, Mass. Owns the F/V Independence bearing state registration number 585811 [A- 6, page 2]. Its Certificate of Documentation shows a mortgage lien as of April 1, 1987 in the amount of \$760,000.00 [A- 8, page 3]. It has a federal fisheries permit No. 410127 authorizing it in 1998 to fish for Northeast Multispecies limited sea scallops, non-regulated Multispecies, ocean quahog, summer flounder, American lobster, Squid/Butterfish, and Atlantic Mackerel [A-6, page 1].

Lobsters, Inc is a Massachusetts corporation with its principal office at 114 Macarthur Drive, New Bedford, MA 02740. Its principal officers are Lawrence M Yacubian, President, and Levon Yacubian, Treasurer/Clerk. Its board of directors consists of the officers and Susan A Yacubian.

Lawrence H Yacubian has been issued a federal vessel operator permit Number 10000756, which expires September 6, 2001 [A- 7].

On Sunday, December 6, 1998 Linda Galvin a NMFS employee observed the data produced by the NMFS Northeast Vessel Monitoring System (VMS) by running the daily VMS report. This VMS data is produced by the BOATRACS system. The daily

² Much of the factual findings are taken from the recitation of facts in the Agency's Initial Brief or Closing Argument. My review of those factual recitations and my corresponding examination of the transcript and exhibits, together with an examination of my trial notes and recollection of the testimony of the respective witnesses caused me to accept them as the most accurate statement of facts. Accordingly, I have adopted much of those as my finding of fact.

report disclosed five incursions into Closed Area II³ by the F/V Independence. All five incursions were calculated to be between 0.3 and 0.5 nautical miles inside the area according to data received by Boatracs from that vessel's on board MCT (A-28, p.1).

The next day's report, for December 7, 1998, indicated the F/V Independence had been inside closed area II 20 times, again from .3 to .5 nautical miles, (A-10, p.1).

The report for December 8th showed 2 more such incursions (A-10, p.1). The daily report for Wednesday, December 9, 1998, showed the F/V Independence to have been inside closed area II 17 times. These positions ranged from .3 to 1.4 nautical miles inside closed area II (A-10, p.1).

Ms. Galvin called the U.S. Coast Guard's District I headquarters in Boston, Massachusetts to inform them of the incursions. After briefing the Northeast VMS team by E-mail (A-10, p.2) Ms. Galvin continued to monitor position reports regarding the F/V Independence. Additional incursions inside closed area II were noted on December 10th and 11th 1998 (A-10, pp.2, 4). Ms. Galvin proceeded to prepare individual daily printouts for the entire fishing trip of the F/V Independence, which began on December 4th and ended on December 12th, 1998 (A-10, p.2). The deepest incursion into closed area II during the fishing trip by the F/V Independence occurred at 23:21 hours, local time, on December 8, 1998 (i.e., 04:21 hours on December 9, 1998, GMT) (A-10A) at or near 41°17.1' North latitude / 66°27.6' West longitude, a position 1.36 nautical miles⁴ inside closed area II (A-10, pp. 1-2, A-10C (1-5), A-29, T-Vol.2, pp.175-176, 285-311).

At 21:54 hours, local time, on December 10, 1998, the U.S. Coast Guard Cutter Wrangell (WRANGELL) while on a fisheries enforcement patrol in Closed Area II acquired a contact on the cutter's radar which Coast Guard personnel designated contact "alpha" (A-12, p.1). Coast Guard personnel from that point continuously monitored the radar contact until it was identified as the F/V Independence at 01:47 hours on December 11, 1998 (A-12, p.3). During the nearly 4 hours that the F/V Independence was tracked on radar by the WRANGELL a number of "fixes" of its position were taken. These fixes were made using the Wrangell's Differential Global Positioning System (DGPS) to determine the cutter's position combined with bearing and range information from the cutter to contact alpha taken from the Wrangell's radar and gyrocompass [A-12, T-Vol.3, p. 136, 140-147] and plotted on NOAA Chart 13204, 11th edition [A-12, p.1, A-20, T-Vol.3, pp. 157-159].

Prior to departure for this patrol, the Wrangell's DGPS unit, radar, and gyrocompass were determined to be functioning properly, as indicated by in-port checks of those systems [A-15, A-16, A-17, T-Vol. 3, pp. 249-270]. During the continuous tracking of contact alpha, the contact moved in and out of closed area II [A-11, pp.1-2, A-12, pp. 1-3, A-19, A-20, A-21]. Based on the experience of the Coast Guard members and their observations, F/V Independence was engaged in fishing [Exhibits A-10D, A-11, p. 2, A-12, p. 1, 3 ; T-Vol.3, pp. 136-137].

At 00:51 hours, local time, on December 11, 1998, from 10.7 nautical miles away, the Wrangell's personnel fixed F/V Independence's (Contact Alpha) position at or near 41°16.75' North latitude / 66°27.6' West longitude which, when compared to the boundary of closed area II placed the F/V Independence approximately .95 nautical miles inside closed area II, its furthest incursion into the area that evening [A-19 and A-21]. After a brief VHF radio discussion between the WRANGELL and the F/V Independence, a boarding party headed by LTJG Brown left the cutter in a rigid hull inflatable boat (RHIB) and were safely on board the F/V Independence at 02:07 hours (A-11, pp. 2-3). According to several boarding party members they observed an unusually large amount of scallops on the F/V Independence's deck and in the shucking houses (A-11, p. 3, A-13 and A-14). The scallops and fish lying on deck in the vicinity

³ The boundaries of Closed Area II are set out in 50 CFR § 648.81(b)(1).

⁴ This is equivalent to 2,518.6 meters.

of the dredges were still wet and alive (A-11, p. 3, A-13, p.1). LTJG Brown observed a dry erase board in the F/V Independence's wheelhouse listing the names and hull numbers of approximately 30 Coast Guard Cutters that perform northwest Atlantic fisheries patrols (A-11, p. 4). Brown also observed e-mail on the vessel's Boatracs VMS unit that appeared to have been sent by the F/V Edgartown and received by the F/V Independence at 06:25 hours on December 10, 1998. That e-mail read as follows; "Subj. aircraft (fixed and rotor) and cutters you are in the right place, no hassles, no questions. Tell Joe he is not missing anything." (A-11, p. 6). When questioned by LTJG Brown, Captain Yacubian stated that he was having no problems with his Boatracs VMS unit that he knew of, and in fact, both Yacubian and Brown observed together "he had a signal presence light and the screen indicated that the status was good" (A-11, p. 3). Respondent Yacubian indicated that he had experienced no mechanical problems that evening affecting his ability to maneuver his vessel (A-11, p. 3). When informed that the WRANGELL had plotted him approximately .9 nautical miles inside closed area II at 00:51 hours that evening, Yacubian denied that his vessel had entered the area and said that information concerning where he was fishing was maintained on his Boatracs and the Coast Guard should check with Boatracs to get that information. At that point LTJG Brown and Respondent Yacubian worked together to send e-mails to Boatracs requesting such information (A-11, p. 5). In response to questioning by LTJG Brown about whether the captain kept a personal fishing logbook, Respondent Yacubian replied that he kept a notebook (A-11, p.5). LTJG Brown recorded information from the top exposed page of this notebook, which was labeled "trip # 10." When asked by LTJG Brown what some of the writing in the notebook meant (T-Vol.4, pp. 320-321), Yacubian replied that he could not remember (A-11, p. 5).

The Coast Guard escorted the F/V Independence to New Bedford, Massachusetts in order to seize her catch. On the way to New Bedford, Respondent Yacubian signed an abandonment form relating to the unshucked scallops on his vessel and these scallops, totaling 91 bushels, were shoveled into bushel baskets and returned to the sea (A-11, p. 6, A-34). The WRANGELL followed the F/V Independence to New Bedford where its catch consisting of 4,325 pounds of Atlantic sea scallops, plus small amounts of monkfish, other fish and lobsters, was seized by NMFS Special Agent Louis Jachimczyk and sold to the highest bidder for \$25,972.26 (see A-5, p. 1, A-2 and A-4). The proceeds of the sale were put in an escrow account pending the resolution of this case (A-5, p. 4).

DETERMINATION OF VIOLATIONS

Count I

Count I alleges that respondents were found 1.36 nautical miles inside Closed Area II on December 8, 1998. The accuracy of this finding was based upon the Vessel Monitoring System employed by the Agency. That system utilized the Boatracs technology.

The record demonstrates respondents were within Closed Area II at the time and place shown by the Boatracs data. Moreover, the Boatracs data further demonstrate that this was not an incidental intrusion into the closed area, but between December 6 and December 8 there were numerous such intrusions.

The pattern of incursion further demonstrates that the purpose was to engage in fishing. Indeed, Respondents' fishing was quite successful. I have not seen any evidence that Respondent was merely transiting the area with all scallop dredges stowed and secured, and was doing so for a compelling safety reason. See 50 CFR § 648.81(b)(2)(i) and (ii).

I therefore conclude that Respondents unlawfully entered into closed area II as specified in 50 CFR § 648.81(b)(1) during the period of time in which that area was closed to entry and thus violated 50 CFR § 648.14(a)(39).

Count II

Count II alleges that on December 11, 1998 Respondents were determined by the U. S. Coast Guard cutter Wrangell personnel from their on board radar to have been within Closed Area II fishing for scallops. Additionally, the Boatracs data underlying the Agency's VMS also shows that respondents intruded into this closed area on that date. See Transcript, Vol. III, p. 243 (LT Brown) and A-10 (a)-(e).

Respondents have vigorously contested the accuracy of the Wrangell radar readings even contending that based on their expert's evidence that the Wrangell radar had such significant bearing error that the actual positions of the Respondents were outside of Closed Area II.

Respondents have presented a scenario in which the USCGC Wrangell's radar had an average bearing error of up to two degrees resulting from inaccurate calibration of the radar. Additionally, they claim the Wrangell's radar had a six-degree bearing error which is proven by various calculations between the Wrangell and the F/V Independence radar, and their respective Differential GPS (DGPS) and GPS systems when the F/V Independence was being escorted back to port. They say that this bearing error (4 to 6 degrees) actually locates the F/V Independence outside of Closed Area II eastern boundary during the time involved here. See Respondents' Post Trial Memorandum at page 13-14 citing Respondents' Exhibit 55, Transcript Vol. IV pp. 395-396 (Prof. Ouellette).

Much of this claim of bearing error is based on Professor Ouellette's expert testimony and report.⁵ At the trial I purposefully inquired of Prof. Ouellette how he arrived at the conclusion there was a 6-degree bearing error. He attempted for some time to demonstrate how he came to that result. He was given extra time to do so in an environment without undue pressure of the witness stand. He returned to the witness stand, recommenced this explanation, but it was so unintelligible I was still unable to understand what he was describing. To this day, I have no idea how he arrived at that figure. His testimony was not helpful to me as the fact finder. His opinion is therefore not reliable and has not been considered by me in rendering a decision on this count. See T Vol. IV at pp 390 ff. [examination by Judge]

Based on the evidentiary record before me, I must conclude that Respondents were in fact in Closed Area II on December 11, 1998. They were not there for mere transit but for fishing. Respondents thus violated 50 CFR §648.14(a)(39).

Count III – False Statement

Respondent Yacubian is alleged to have made false oral statements in violation of 50 CFR § 600.725(i) which provides as follows:

It is unlawful for any person to do any of the following:

- (i) Make any false statement, oral or written, to an authorized officer concerning the taking, catching, harvesting, landing, purchase, sale, offer of sale, possession, transport, import, export, or transfer of any fish, or attempts to do any of the above.

The Agency says that the false oral statements consist of answers to questions posed to Respondent Yacubian by LTJG Brown after having boarded the fishing vessel. The questions and answers were:

Q. "How much scallops he had on deck?"

A. "He stated that he thought he had four or five bushels per side."

(A 11, p. 4)

Q. "How much scallops he had in the hold?"

A. "He stated approximately 2500 lbs."

(A 11, p. 4)

⁵ See also Respondents' Exhibit 27 [Plots showing zero bias error, alleged 4° bias error, and 6° bias error], and Respondents' Exhibit 55 and 58 [Opinion 5 from expert report, and handwritten calculations prepared during trial by Prof. Ouellette].

The Agency says in fact there were approximately 17 bushels of scallops per side and more than 4,300 pounds of scallops in the vessel's hold. See A-11, pp. 5-7, A-13, p.2 and T Vol. III, p. 217 cited in Agency's Initial Brief at p. 10.

Respondent Yacubian says that his answers were not false because he only made estimates (apparently evidenced by his use of the words *thought* and *approximately*) and besides he had no intent to deceive LTJG Brown.

Neither the Agency's Initial Brief, nor its Reply Brief address the arguments raised by Respondent Yacubian that the statements were only estimates, and the regulation requires a showing of intent to deceive.

Two questions are raised by Respondent Yacubian's arguments. First, can an estimate be a false statement? Second, does 50 CFR § 600.725(i) require proof of intent to deceive?

An estimate is the expression of an opinion or value⁶. An expression is obviously a statement. It logically follows an estimate is a statement. See *United States v. Hartness*, 845 F.2d 158 (8th Cir. 1988) *cert. den.* 488 U.S. 925 (1988) [an over-estimate of annual income on an applicant's Farmer's Home Administration loan application is a false statement for purposes of 18 USC § 1001]. Thus, Respondent Yacubian's argument that his estimate of the number of bushels per side and the amount of scallops in the hold does not constitute a statement is rejected.

The word *false* means not *genuine* or *true*⁷. Here, the estimates were not objectively true. They weren't even close. In truth, the number of bushels of scallops on deck per side was 17. The hold held, in truth, 4300 pounds of scallops⁸.

Respondent's false oral estimates constituted false oral statements. *United States v. Hartness*, *supra*.

Regardless, Respondent says that an intent to deceive is a necessary element of the violation of 50 CFR § 600.725(i). He cites *In the Matter of Alba*, 1981 WL 37358 (NOAA 1981) and *In the Matter of Albert Adams and F/V Lillie Louise*, 2001 WL 128899 (NOAA 2001).

My review of *Alba* and *Albert Adams and F/V Lillie Louise* discloses that the Administrative Law Judge made no finding on the subject of intent to deceive as an element of the violation. Neither the decision in *Alba* nor the decision in *Albert Adams and F/V Lillie Louise* support Respondent Yacubian's argument.

I also reviewed other NOAA decisions involving false statements. Overall they tell me that *intent to deceive* is not an essential element of a false statement charge. Each of those cases involved a regulatory provision substantially identical to that here with the only significant difference being a particular fishery was involved.

However, the decision of the ALJ in *the Matter of William Train 3 O.R.W.* 140; 1983 NOAA LEXIS 47; (NOAA 1983) is instructive. There the ALJ said:

I recognize that the law and quotation from the regulation require something more than does the simple biblical abjuration "Thou shalt not lie." But not much. In situations such as this, where an authorized officer makes inquiries respecting margin fishery related activity he is presumptively entitled to a truthful response. [note omitted] Here the area of inquiry was a proper one, the Respondent was not entitled to "Lie a little bit" . . . (Emphasis supplied)

This tells me that the inquiry of an authorized officer must be a proper one. Here, a proper inquiry is one that concerns taking, catching, harvesting, landing, purchase, sale, offer of sale, possession, transport, import export or transfer of any fish. If the inquiry elicits a false statement then the maker of that false statement has violated the regulation. The maker may not "lie a little bit." The regulation does not include words,

⁶ Webster's New Collegiate Dictionary, 1974 Ed., page 391

⁷ Webster's New Collegiate Dictionary, 1974 Ed., page 413

⁸ One would expect an experienced scallop fisherman, like Respondent, would have been able to *truthfully estimate* how much he had on and below deck. After all this is his livelihood.

which would allow for a finding that Intent to deceive is an element of the regulatory violation. This is not a criminal statute where a *mens rea* may necessarily be implied. See *In re Northern Wind Seafood*, 1998 NOAA Lexis 1 (1998).

I find that LTJG Brown, a Coast Guard officer was an authorized officer.⁹ His inquiry of Respondent Yacubian concerned the taking, catching, harvesting, landing and possession of scallops. The inquiry was a proper one.

Respondent's answers were untrue. Respondent Yacubian violated 50 CFR § 600.725(i). Whether Respondent Yacubian intentionally sought to deceive LTJG Brown is, however, a factor to be considered in determination of the civil penalty as required by 16 USC § 1858(a). *In re Northern Wind Seafood*, 1998 NOAA Lexis 1 (1998).

AGENCY'S REQUEST FOR DISCOVERY SANCTIONS

The Agency has requested that I impose a sanction upon Respondents for failing to timely turn over Respondent Yacubian's notebook or logbook at his oral deposition.

The request is based on 15 CFR § 904.240(f). This rule states in relevant part:

(f) *Failure to comply*. If a party fails to comply with any *subpoena or order* concerning discovery, the Judge may in the interest of justice:

- (1) Infer that the admission, testimony, documents or other evidence would have been adverse to the party;
- (2) Rule that the matter or matters covered by the order or subpoena are established adversely to the party; (emphasis added)

The rule says there must be failure to comply with a *subpoena or order* concerning the discovery. I am unaware of any subpoena for Respondent's logbook or notebook. The only order of which I am aware regarding a discovery deposition is the order I issued on April 12, 2001, which provided in that respect as follows:

Discovery

Discovery in this matter is extended and will conclude by May 31, 2001. Response times to interrogatories or requests for production are shortened to 10 days. *Depositions may be noticed at the convenience of the parties, counsel and witnesses*. Agency's expert witness reports may be amended to conform to the requirements of Federal Rule of Civil Procedure 26(a)(2)(B) no later than the close of business 10 days from the date of this order. Respondents shall have 10 days from the filing date of the amended report, to file a rebuttal report. (Emphasis supplied)

My reading of the Agency's sanction request shows me the only order relied upon is the quoted order. This order neither addresses nor directs the production of any documentary material let alone any notebook or logbook. At most this amended discovery order merely authorizes the taking of depositions. Again, I did not order the production of any documentary material.

Consequently, when the Respondents failed to produce the notebook as requested in the deposition notice, the Agency had the right to file a motion, which requested that an order be issued directing its production¹⁰. No such request was ever made until trial and then only at the last did the Agency demand its production and that demand was in response to a partial production of the notebook by the Respondent in their defense. When that request was made at trial the logbook was produced to the Agency whose counsel claimed it was the first time they had seen the document. See Transcript, Vol. IV, p. 245, lines 16-17.

⁹ The terms Authorized *officer* are defined to include any commissioned, warrant, or petty officer of the United States Coast Guard. 50 CFR § 600.10 Definitions.

¹⁰ During the pre-trial phase of this case, the only agency motion to compel production of documentary material related to production of financial records of various types. That motion did not include a request to produce the logbook or notebook. See Agency motion and Judges order of June 7, 2001.

In sum, I read 15 CFR § 940(f) to require that an order first have been issued directing the production of the documentary material. The only order issued by me concerning discovery relevant to this request was one, which merely authorized the taking of depositions. That order did not direct the production of any documentary material. Since there is no order directing the production of any documentary material, which has not been complied with, I am not empowered by the regulation to make any adverse inference as a sanction for failure to comply¹¹.

Consequently, the Agency's request is denied.

DETERMINATION OF CIVIL PENALTY

The Magnuson Act and the applicable rule each require me to take into consideration when assessing a civil monetary penalty, the nature, circumstances, extent and gravity of the alleged violation, the respondent's degree of culpability, any history of prior offenses, ability to pay, and such other matters as justice may require. See 16 USC § 1858(a), 15 CFR § 904.108(a). Here the statute and regulation also require me to take into consideration the degree Respondents' culpability particularly the extent of their intent to violate the closed area II boundaries. See *In the matter of Northern Wind Seafood, Inc.*, 1998 NOAA Lexis 1 (1998).

The Agency has requested a civil money penalty be assessed against Respondents, jointly and severally, in the amount of \$250,000.00. It also seeks the revocation of Respondents respective permits.

The Agency says these penalties are justified because of three factors. First, Respondents have a history of violating the Magnuson Act and its rules citing Agency Exhibits 32 and 33. Second, the record evidence demonstrates that Respondents repeatedly entered closed Area II between December 4 and December 11, 1998. Third, the record shows Respondent Yacubian intended to enter Closed Area II and fish in spite of the prohibition.

Lastly, the Agency asserts, regardless of any claim to the contrary, Respondents have the ability to pay¹² the assessed money penalty, and because the violations were repeated and intentional a revocation of Respondents' permits is also justified.

Respondents say that NOAA has, without justification, imposed the most severe civil penalty and permit sanction available under the regulations. They say the Agency failed to produce evidence of any mitigating or aggravating factors it considered in assessing the penalties. They point to the failure to consider the biological impact of the violation, the willful or intentional nature of the violation, extent of cooperation, prior record, knowledge of the violation, and impact on viability of the regulatory scheme. See Respondents' Post Trial Memorandum, p. 40.

The Nature, Circumstances, Extent and Gravity of the Alleged Violation

Respondents entered into an area closed to fishing. The closure was for the purpose protecting against the depletion of Multispecies.¹³ It is to protect marine resources and allow for the recovery of fisheries stocks. Fishermen, who enter these closed areas to fish, unfairly compete with their fellow fishermen who obey the closure rules. Thus,

¹¹ The Agency's rule is similar to Federal Rule of Civil Procedure 37(b)(2). Sanctions under that rule are not available absent a prior valid order-compelling discovery under Rule 37(a). See *Shepherd v. American Broadcasting Cos., Inc.*, 62 F3d 11469, 1474 (DC Cir. 1995); *Schleper v. Ford Motor Co.*, 585 F2d 1367 (8th Cir. 1978).

¹² The Agency also argues that the Magnuson Act and implementing regulation does not *require* that I consider the Respondents ability to pay. Essentially, it is argued that such a consideration is permissive and I should not undertake such a consideration in light of the severity and extent of the Respondents' violations involved here and in the past. See Agency's Initial Brief at pp 9-10 citing 16 USC § 1858(a) where statute says ability to pay *may* be considered in assessing the penalty.

¹³ For a history of the closure of Area II see 63 Fed. Reg. No. 31 at pp 7727-7728.

entry into a closed area to fish is by its very nature a most serious undermining of the efforts to protect these precious resources.

The Respondents' entry into Closed Area II was not incidental, accidental or in the course of transit through the area. It was numerous and to fish for scallops. Respondents' fishing appeared quite successful with 17 bushels of scallops on deck and over two tons (4300 pounds) below. And this was only from a few days of activity.

Respondent contends the intrusions into Closed Area II had no discernible effect on the Multispecies stock preservation purpose of the closure. As a result, the purpose of the closure was not offended and thus they should not be assessed as severely as the Agency suggests¹⁴.

In my short time hearing NOAA cases this is the most serious intrusion into a closed area I have ever seen. Regardless of whether Respondent had harvested Multispecies they certainly harvested numerous sea scallops included within the closure restraints.

But I also must consider the deterrent effect any penalty is to have upon the individual involved and others within the industry. Certainly, knowledge that a significant penalty will be assessed against a person who intrudes into a closed area should be of some moment to others. If they believe that insignificant, cost of doing business, penalties would be assessed then potential wholesale violations of the closed areas would abound.

History of Prior Offenses

Respondents have a history of prior violations.

1. October 17, 1989 possessed on barrel of female American lobster. Penalty assessed -- \$1,000.00 Settled \$750.00. [A 33a]
2. September 4, 1991 landed 10,300 lbs of Atlantic Sea Scallops meats averaging 39.7 meats per lb exceeding 38.5 meats per lb standard. Seized proceeds of sale - \$9,141.36. Penalty assessed -- \$2,000.00 Settled \$1,000.00 and forfeiture of seized proceeds. [A 33b]
3. March 19, 1994 landing 7,585 lbs of Atlantic Sea Scallops without providing notification under the Days at Sea allocation program. Penalty - letter of warning. [A 33c]
4. April 10, 1994 failure to comply with scallop average meat count standard (10,931 lbs by sampling averaged 54.2 meats per lb rather than allowed 33 per lb) and smaller than permitted dredge gear (rings averaged 3.12 inches). Penalty assessed -- \$45,000. Settled \$15,000.00 penalty [A 32]
5. March 26, 1998 fishing with scallop dredge gear and harvesting 440 lbs of Multispecies when limited to 300 lbs of regulated Multispecies with such gear. Penalty assessed -- \$30,000.00. Settled \$1,000.00.[A 32].

Again, I must comment in the time I have served as a judge on these cases this is the most number of prior violations presented to me in any case I have heard. These five violations, over the past 12 years, together with the three count violations in this case suggest to me, a history of lack of respect for the law and regulations governing the fishing industry.

Respondents' Degree of Culpability

Section 308(a)[16 U.S.C. §1858(a)] of the Magnuson Act provides in civil penalty cases, the Secretary is to take into account the offender's degree of culpability in assessing the amount of the civil monetary penalty. Stated another way, the Secretary

¹⁴ During the pre-trial phase, Respondents urged that they be allowed to submit evidence regarding the biological impact of any incursion into Closed Area II. That request was granted. I have yet to see any evidence presented, which would arguably demonstrate any minimal, or absence of biological impact.

is to consider, *inter alia*, the *state of mind* of the alleged violator, such as knowledge, purposefulness, negligence or recklessness. *In re Northern Wind Seafood*, 1998 NOAA Lexis 1 (1998).

The Agency vigorously argues that Respondents *intended* to intrude into Closed Area II in order to fish for scallops, and succeeded skillfully and with stealth. Frankly, from the Boatracs evidence showing the locations of the Respondents in Closed Area II, I must agree. See A 10c 1-5, A 10d. A 10e. These plots show me Respondents skirted along the boundary darting in and out, staying as long as they believed they were not being spotted.

Respondents' claim they did not intentionally intrude into Closed Area II is incredible and is rejected. I find Respondents purposefully intruded into Closed Area II to fish for scallops. Not only did they intentionally intrude they did so with impunity.

Ability to Pay

Respondents plead poverty. I have examined the financial data provided by each party and the arguments of each in their closing briefs. I just don't believe Respondents are impoverished.

Moreover, Respondents argue the Agency assessment is out of proportion to the violation involved and reeks with punitive measure.

The Agency has summarized the assets available to Respondents to pay a civil money penalty. Agency Brief at p. 11-12. It is shown that Lobsters, Inc has a net worth of approximately \$250,000.00. Respondent Yacubian has an equitable value in real estate of approximately \$930,000.00 to \$1,830,000.00.

The Agency recommended assessment is \$250,000.00. Respondents have the ability to pay that assessment.

Permit Sanction

Often in these cases the Agency argues that a respondent can pay a penalty over time from the proceeds of their future fishing activity. Here the Agency points out that Respondent Yacubian has admitted that scalloping is better than its ever been. Agency Brief at p. 12.

But a penalty cannot be paid over time if there is no ability to earn the money to do so because the permits have been revoked. So frankly, I am puzzled by the Agency's argument regarding the Respondents' cash flow.

Nevertheless, permit revocation is what the Agency desires. Respondent, naturally, argues vigorously against liquidation of assets and removal from the applicable fisheries.

Removal of intentional and repeat violators does have a salutary appeal. Together with a significant monetary penalty, it would send a clear and loud message to the industry that repeated violations, especially purposeful and sustained incursions into closed areas will bring meaningful sanctions. Anyone hearing that message would be expected to heed its warning. And, of course, it has the effect of removing the repeated and intentional violator. Whether the Agency ever collects a single penny from Respondents is not the point.

I will revoke the Respondents' permits.

ORDER

The federal fishing vessel permit of the F/V Independence (Official Number 58581) owned by Respondent Lobsters, Inc. and the federal vessel operator permit of Respondent Lawrence M. Yacubian (Number 10000756) are hereby REVOKED.

Respondents are jointly and severally assessed a civil money penalty in the amount of \$250,000.00.

A failure to pay the above penalty to the Treasurer of the United States within thirty (30) days from the date on which this decision becomes the final Agency action will result in interest being charged at the rate specified by United States Treasury regulations and an assessment of charges to cover the cost of processing and handling the delinquent penalty and further, in the event the penalty or any portion thereof becomes more than ninety (90) days past due, the Respondent may be assessed an additional penalty charge not to exceed six (6) percent per annum.

Any petition for review of this decision must be filed within thirty (30) days of this date, with the Administrator of the National Oceanic and Atmospheric Administration as subject to the requirements of 15 CFR § 904.273.

Dated: December 5, 2001.

Edwin M Bladen
Administrative Law Judge

CERTIFICATE OF MAILING

I hereby certify that I have sent the attached pleading to the following persons as indicated:

Mitch McDonald
NOAA Office of General Counsel
One Blackburn Drive
Gloucester, MA 01930
Federal Express – Gov’t Overnight

Jeff Angley
Counsel for Respondents
One Bowdoin Square
Boston, MA 02114
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Pamela L. Lafreniere
Counsel for Respondents
404 County Street
New Bedford, MA 02740
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Dated: December 3, 2001.

Legal Assistant to Administrative
Law Judge

Technology solutions and international opportunities for improved maritime domain awareness

B. Botwin

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1. INTRODUCTION

The management and protection of deep-sea fisheries raises unique challenges to national navies, coast guards, and fishery ministries and organizations on a global basis. At the outer boundaries of national Exclusive Economic Zones, deep-sea fisheries are often beyond the range, loitering capacity and programmatic workload of responsible agencies. Further, most national agencies use aging and obsolete fleets of ships and aircraft, and limited budgets are focused on expensive operation and maintenance costs. New off-the-shelf technologies have not been identified or incorporated into current maritime assets. Competing requirements for deep-sea capable assets –search and rescue/maritime surveillance, illegal drug and migrant-interdiction, anti-piracy/maritime transportation, marine coastal environmental protection and counter-terrorism – and competing agency mission priorities, often relegate fishery-related requirements to a low priority.

The United States Government, working through the United States Coast Guard (USCG), has implemented a comprehensive programme to address these multifaceted challenges. The USCG has initiated through the Integrated Deepwater System Program or “Deepwater”:

- a performance based philosophy focused on capabilities not on numbers of assets
- a partnership with US industry as the system integrator and
- a required “Integrated System of Systems” design for surface, air, communications, sensors and logistics systems.

The overall goal of *Deepwater* is to maximize operational effectiveness while minimizing total ownership costs.

Deepwater will also allow for seamless interoperability within the US Coast Guard and with the US Navy and NATO assets. It will also enhance interoperability with other federal, state and local agencies. These same capabilities can be set up and used, in whole or in part, by international partners or purchasers of *Deepwater* assets. In

¹ <<http://www.bis.doc.gov/defenseindustrialbaseprograms/OSIES/DeepWaterProgram.html>>

addition, *Deepwater* participation provides the potential for an industrial base and economic benefits to any international partner through industrial participation, job creation and economic development. These industrial and economic factors may be critical selling points to ministries and organizations responsible for the management and control of continental shelf and deep-sea regions to order to justify financial and asset acquisition and support costs.

The US Department of Commerce, Bureau of Industry and Security is working closely with the US Coast Guard to develop deepwater-related international partnerships and joint ventures. In addition, the US Department of Commerce is ensuring that *Deepwater* participants also have access to financing, training and technology transfer opportunities. Regional arrangements involving multiple partners can also be supported by utilization of *Deepwater* assets. Opportunities for access to US Government fisheries protection and enhancement programmes as well as monitoring, control and surveillance systems are also potential benefits of participation in the *Deepwater* program. In sum, the Integrated Deepwater System Program provides the best value for governments and organizations responsible for the management and protection of deep-sea fisheries.

2. DEEPWATER PROGRAM OVERVIEW

Over the next 15–20 years, the USCG will modernize its aging fleet of ships, aircraft, helicopters and their sensors, and communications and logistics infrastructure through the \$17 billion *Deepwater* program. In June 2002, the USCG selected Integrated Coast Guard Systems (a joint venture between Lockheed Martin and Northrop Grumman) as the *Deepwater* systems integrator.

Deepwater missions typically require an extended, continuous presence at sea; the ability to operate in severe environments; long transits to reach the operating area; or a combination of these factors. They can be conducted in ports, coastal waters or many miles offshore. *Deepwater* assets can be used for a variety of missions, e.g. fisheries and environmental protection, drug and immigration interdiction, aids to navigation, anti-piracy, search and rescue, monitoring of Exclusive Economic Zones (EEZ), counter-terrorism and homeland security. International cooperation and coalition building are promoted through the export of *Deepwater* assets and sub-systems. Countries and organizations can enhance their own internal interoperability through the use of *Deepwater* systems.

When complete, *Deepwater* will include three classes of new cutters (national security, offshore patrol and fast response) and their associated small boats, a new fixed-wing manned aircraft fleet, a combination of new and upgraded helicopters, and both cutter-based and land-based unmanned air vehicles (UAVs). All of these assets are linked with state-of-the-art Command, Control, Communications and Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) systems and are supported by an integrated logistics regime.

These new assets, which possess common systems and technologies, common operational concepts, and a common logistics base, will give the US Coast Guard a significantly improved ability to detect and identify all activities in the maritime arena, a capability known as “maritime domain awareness”. Because these assets have been designed around the task sequence – Surveil, Detect, Classify, Identify and Prosecute – are used to perform all of the Coast Guard missions, the system components will have the flexibility to respond, not only to the full range of current Coast Guard responsibilities, but to emerging threats and missions as well.

Additional information about *Deepwater* is available at <<http://www.icgsdeepwater.com>> and <<http://www.uscg.mil/deepwater/international.htm>>.

3. FINANCING OPPORTUNITIES

A number of US Government agencies can provide financial and related assistance to facilitate the acquisition of *Deepwater* assets. These are as follows.

The US Export Import Bank (EXIM) supports short, medium and long-term financing to creditworthy international customers and working capital guarantees to US exporters. This is accomplished through a mix of direct loan, guarantees, export credit insurance and working capital guarantee programmes.

The US Department of Transportation, Maritime Administration (MARAD) provides loan guarantees to US and foreign ship-owners for financing US flag vessels or vessels for export constructed or reconditioned at US shipyards. The borrower and project must show an ‘income stream’ to participate in the MARAD programme.

The US Trade and Development Agency (USTDA) promotes US participation in developing and middle-income countries. USTDA assists through the funding of various forms of technical assistance, feasibility studies, orientation visits, specialized training grants, conferences and business workshops, in building mutually beneficial partnerships between US and overseas project sponsors. This can result in the completion of high quality, successful projects including maritime law enforcement, in host countries.

Additional information is available at <<http://www.exim.gov>> (EXIM); <<http://www.marad.dot.gov>> (MARAD) and <<http://www.tda.gov>> (USTDA).

4. TECHNOLOGY TRANSFER AND INDUSTRIAL PARTICIPATION OPPORTUNITIES

Countries have the opportunity to work with the US Department of Commerce’s National Oceanic and Atmospheric Administration (NOAA) on a number of projects related to fisheries management, protection and enhancement. NOAA programmes are compatible with the *Deepwater* program.

NOAA has developed an automated system for recording biological and oceanographic data during a trawl-based fishery resources survey. The Fisheries Scientific Computer System (FSCS) is replacing manual data recording and shaving months off the time required to make cruise data available for use. These data are essential to providing an accurate picture of marine fish stock abundance, condition and distribution over time - information that helps evaluate and support actions taken by fishery managers.

NOAA’s Monitoring, Control and Surveillance Network (MCSN) provides real-time information sharing among international fisheries enforcement officials to combat illegal and unreported fishing activities.

With regard to industrial participation, countries participating in the *Deepwater* program have the opportunity to work with the *Deepwater* US prime contractors to develop industrial relationships that can include job creation, manufacturing enhancement and exports. Successful acquisition and implementation of *Deepwater* related assets can also lead to host countries creating sustainable fisheries as well as marine eco-tourism industries. These types of projects can qualify for regional and global bank financing opportunities.

Additional information regarding FSCS and MCS is available at <<http://www.nmfs.noaa.gov>>. Additional information on *Deepwater* can be found at <<http://www.icgdeepwater.com>>.

5. CONCLUSION

The *Deepwater* program can provide a cost-effective solution to countries and organizations facing the unique challenges of deep-sea fisheries management and protection. The US Department of Commerce is pleased to be part of the *Deepwater* Team and looks forward to assisting interested parties better understand the maritime domain awareness benefits that can be derived from *Deepwater* assets and related opportunities for international partnerships, financing, technology transfer and industrial participation.

Prosecuting fishery law breaches – the roughy end of compliance

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1. INTRODUCTION

In August 2003 the Australian public was given a daily account via all news media of the discovery, pursuit, chase and seizure of an alleged illegal, unreported and unregulated (IUU) fishing vessel out of Uruguay – the **Viarsa**. (ABC - Australian Radio/TV/News Online; South African Press Association; Australian Press Association 2003) The vessel had been found fishing in the remote Australian Fishing Zone (AFZ) surrounding the sub-antarctic Heard and McDonald Islands (HIMI). It was subsequently chased for 3 900 nautical miles over 21 days, (the longest maritime chase in Australian history) before being captured in the south Atlantic Ocean on Thursday 21 August. (ABC News Online 2003) The **Viarsa**, carrying 85 tonnes of Patagonian toothfish, was subsequently escorted to Fremantle for trial. The crew of the **Viarsa** are foreign nationals and therefore entitled to the protection of the legal regime established by the 1982 United Nations Law of the Sea Convention (LOSC). This legal regime includes in Article 73 a provision against imprisonment. In contrast, Australian nationals who are found to be fishing illegally within the Australian Fishing Zone will be tried in their respective state court hierarchies and the penalties that they face include penal provisions.

This paper arose from a need to compare and contrast the judicial treatment of foreign and domestic nationals accused of fishing offences. The comparison is interesting from several legal perspectives. These include *inter alia*:

- lack of consistency by the Judiciary in taking environmental considerations into account when sentencing
- lack of consistency in the sentences that are imposed for fishery offences
- lack of any comprehensive data on the deterrence value of sentences that are imposed and
- significantly different treatment in Australian Courts for foreign nationals and Australian citizens who are accused of fishing illegally.

This paper has been presented within the Compliance theme of the Deep-Sea Conference for the simple reason that court proceedings may be seen as representing the ultimate or final chapter in compliance. That is, why should fishers comply with the law? Is it because it is morally or religiously or socially wrong to be greedy, or to destroy the environment or to break the law? From positivist jurisprudence this paper submits that most fishers comply with the law because they fear the penalties of being caught if they break the law. For this reason alone, it is important that the law is seen

as consistent, not a lottery dependent on factors such as where you get caught or which judge will hear the trial.

The paper is divided into two main parts that respectively contrast the prosecution of Australian nationals and foreign nationals accused of fishing offences within the Australian waters. It will be shown that there is widespread inconsistency in the judicial treatment of fishing offenders. To a certain extent, the differences are understandable. In common law jurisdictions, judicial discretion is sacred. Furthermore, in a federated state such as Australia there is a plethora of “hard” and “soft” State, Commonwealth, regional and international fishery laws. However, the paper submits that in sentencing fishery offenders, two core factors should be taken into consideration.

The first is some form of evaluation of the environmental impact of the offence. In the case of the orange roughy conspiracy, the offence occurred in a geographic region that has still not recovered from overfishing excesses in the 1990s. It will be submitted that if an offence occurs where there is a stock sustainability crisis, judicial discretion should err on the side of severity. In this way, the law can be a deterrent to overfishing. Further to this is consideration of precaution. The precautionary principle is now firmly embedded into State, Commonwealth and international law, in both conservation and fisheries disciplines. It is arguable that it is not only management that is required to give expression to this principle, but also that at the enforcement end of the process consideration must be paid to the environmental impact of an activity, and that taking into account the environmental impact of an action when handing down a sentence is the ultimate expression of this principle.

The second factor is that where fish stocks are confronting a resource sustainability crisis, there should be some form of consistency in sentencing fishery offenders. On this point, the paper critiques the work of the United Kingdom Sentencing Advisory Panel (See citation listing) which has acted to address the subject of inconsistency in sentencing for environmental offences. The paper also considers the application of domestic legal principles such as the financial circumstances of a defendant when determining a sentence in foreign illegal fishing cases (such as the IUU fishing vessels seized in the Southern Ocean.) It is suggested that the circumstances of sentencing foreign fishers differ in several critical ways from that of domestic offenders and that these differences need to be taken into account when sentencing foreign national fishing offenders.

2. A TALE OF TWO FISHERIES

This section compares two criminal cases heard by the Supreme Court of Tasmania concerning two different fisheries, that for deep-sea orange roughy and coastal fishery for abalone. The cases are *R. v Turner* [2002] TASSC 22 an orange roughy case and *R. v Georgiadis* (No.5) [2001] TASSC 88 an abalone case. Both cases dealt with vulnerable species that have a history of abuse through unregulated overfishing. Both cases involved several accused persons forming a conspiracy for the purpose of defrauding the Commonwealth Government Regulatory Body in the case of the orange roughy, and the Tasmanian Minister for Sea Fisheries in the case of the abalone. Finally, both cases were heard in the first instance by two of the six Supreme Court of Tasmania judges. The case of *Georgiadis* was later appealed to the Full Court of the Supreme Court, where a further three of the six judges sat on the bench. (*Georgiadis v R.* [2002] TASSC 58) For the purposes of the Deep-sea Conference, greater attention is given to the orange roughy case. However, reference is given to the abalone case in order to demonstrate how the orange roughy case might judicially have been handled differently. In this part of the paper, it will be argued that the *Turner* and *Georgiadis* cases show a lack of consistency in the value given to environmental factors. This may or may not have led to the lack of consistency in sentencing the offenders. It will be suggested that such inconsistencies, while preserving the common law's highly valued

notion of judicial discretion, nevertheless lead to a public perception that the law is a lottery. This is an important compliance issue. How can fisher compliance with fishery laws be obtained if the sanctions or penalties are viewed as a matter of luck rather than punishment?

Orange roughy live in waters approximately 500 to 1 500 m deep, predominantly around deep-ocean seamounts. These fish are slow growing and are believed to be one of the longest living marine species being able to live for over 100 years. They reach maturity at between 20 and 40 years of age and have low fecundity. The slow growth of the orange roughy makes it vulnerable to any factors (such as overfishing) that affect adult survival rates (CSIRO 2003). These biological facts are important to the arguments presented here as they reflect on the inability of orange roughy to quickly or effectively recover from an environmental devastation such as occurred in 1989. The facts of this incident are described as follows.

There are several major roughy fisheries around Australia but the South East Fishery which extends around south eastern Australia and surrounds Tasmania (AFMA 2003), will be considered for the purposes of this paper. The South East Trawl fishery has existed since 1915, but exploitation of orange roughy is a comparatively new phenomenon (AFMA 2003). It was discovered in commercial quantities off Western Tasmania in 1981 and commercial fishing practices commenced in 1982 (CSIRO 2003). During the 1980s, larger spawning aggregations of orange roughy were discovered off eastern Tasmania around the town of St. Helens (*Commonwealth DPP v Jansen and Others*). As the fish were found to withstand freezing well, orange roughy is ideal for export and a thriving market was established with the United States. In the words of Nicholls and Young orange roughy make excellent fish fingers (Nicholls and Young 2000, p. 273)!

The ease with which the spawning St Helens orange roughy could be caught in large quantities made it a profitable species to target. By 1989, the St Helens Hill fishery reached a peak with up to 67 vessels operating in this small region, such that the sea looked like a car park, with vessels waiting to scoop up their share. In 1989, 60 000 tonnes of orange roughy were taken. In those days (before management of the orange roughy), it was almost impossible for a trawl boat to return to shore without a full load (*Commonwealth DPP v Jansen and Others*). The fish being caught were all mature, being on average about 80 years of age. But, by 1990 the orange roughy fishery was in a state of collapse.

From 1991, the Commonwealth Government initiated an orange roughy fishery management plan pursuant to the *Commonwealth Fisheries Act* of 1952. This initial 1991 orange roughy management plan consisted of the Commonwealth regulatory authority setting catch limits and allocating individual transferable quotas (ITQs) to the competing fishers. For the South East Fishery (SEF) an industry quota was divided among the various operators in the industry. The amount of quota allocated to each operator was calculated using a formula that gave credit for the period in which each operator had been catching the species. Further, operators had an obligation to furnish returns to the management authority for every day the vessel operated within the SEF. The purpose of these returns was to enable the Commonwealth Government regulatory authority to monitor the amount of fish that had been caught by each operator during the licence term. During the same period the Commonwealth Government established the Australian Fisheries Management Authority (AFMA), which came into existence in early 1992.

This description of the Commonwealth intervention to save the orange roughy provides the background to the *R. v Turner* case in the Supreme Court of Tasmania. *R. v Turner* [2002] TASSC 22, also known as the Victrawl Case, involved five accused people: Lee, Turner, Coulston, Jansen and Tedesco being convicted of conspiring to defraud the Australian Fisheries Management Authority (AFMA) by dishonestly

agreeing to make returns to AFMA that falsely recorded their catches of orange roughy taken from the Southeast Fishery at St. Helens. The five accused pleaded guilty to a single count of conspiring to defraud AFMA, which is contrary to S.86A of the *Crimes Act 1914* (Cth). Their conspiracy continued from 1 December 1991 into 1993, but for the purposes of their criminal indictment the conspiracy was restricted to the period 1 December 1991 until 31 December 1992.

The facts of the case were as follows. Victrawl Pty. Ltd. was a fishing company affected by the 1991 management plan as it had fishing boats that landed catches of orange roughy in Tasmania. The accused, Turner was the manager of Victrawl. The accused Jansen and Tedesco were employees of Victrawl. The accused Coulston was the skipper of a fishing boat operated by Victrawl. The accused Lee was the manager of Trident Seafoods Pty. Ltd, which was a Hobart based fish processing company. The accused people agreed amongst themselves to stretch Victrawl's orange roughy quota by understating Victrawl's orange roughy catches by 15 percent. Accordingly, 49 of the 70 voyages made to the SEF by Victrawl vessels during the relevant period, made false returns to AFMA. Total catches on these voyages were understated by a total of 907 725 kg of orange roughy. The market value of orange roughy at the time was approximately \$A2.60 a kilogram. Therefore, the value of the undeclared orange roughy was about \$A2.36 million.

The conspiracy was complex. False figures were used in various documents in order to conceal the understated catches. Secret code letters were used to determine the percentage of understatement of each catch. All five of the accused were aware of the conspiracy and showed a flagrant disregard for both the AFMA management plan and the environmental consequences of their overfishing. The sentence of Justice Alan Blow is of particular interest for the purposes of this paper.

Throughout his judgment in *R. v Turner*, Justice Blow made a number of criticisms of the 1991 management plan. He noted that the formulas for orange roughy quotas were statistically flawed and produced results that were "unfair, unreasonable and absurd". These criticisms were well founded in law, but rendered immediately obsolete by a series of legal precedents from the 1990s. That is, the allocation of quotas to fishers under the 1991 management plan had already been subjected to litigation disputing its validity on several occasions in the 1990s. (*Minister for Primary Industries and Energy v Austral Fisheries Pty. Ltd* (1993) 40 FCR 381 (Full Court), *Coleman v Gray* (1994) 55 FCR 412, *La Macchia v Crean* (1992) 110 ALR 201). These earlier precedents had already declared the 1991 management plan to be void and as such all purported allocations of quotas that were made under the plan were legal nullities. (*Austral Fisheries Pty. Ltd. v Minister for Primary Industries and Energy* (1992) 37 FCR 363, *Minister for Primary Industries and Energy v Austral Fisheries* (1993) 40 FCR 381 per O'Loughlin J. (Full Court); *Coleman v Gray* (1994) 55 FCR 412 per Gummow J. at 431).

The legal effect of all this meant that if Victrawl had overfished quota in 1991 and declared their excessive catch they could not have been prosecuted. Alternatively, if they had overfished their quota and simply neglected to complete their catch returns, again they could not have been prosecuted. However, because the accused entered into a conspiratorial dishonest agreement to deflect AFMA from the performance of its public duty, the accused were guilty of the crime with which they were charged.

In sentencing the accused, Turner, Jansen, Coulston and Tedesco all received suspended sentences varying from four months to four years and were ordered to pay the Commonwealth a pecuniary penalty ranging from \$A2 000 to \$A25 000. Mr Lee received the most severe punishment and was sentenced to four years imprisonment, but to be released after serving seven months. This meant he was the only accused with a custodial or prison sentence.

In giving this sentence, a number of mitigating factors affected Justice Blow's reasoning. These were:

- the delay between the commission of the crime and the sentencing
- the fact that the accused had pleaded guilty and
- the declared void status of the 1991 management plan.

Some comment may be noted regarding these factors.

First, the delay between committing the offence and the matter coming to trial should only be a matter of significance if it is undue in the circumstances. (Warner 2003:113) Given the nature of the offences and the difficulties associated with detecting and investigating conspiracies, a delay in proceedings is arguably standard. At this point it is appropriate to introduce the second fishery case study, a conspiracy to defraud the quantity of abalone that was taken and processed, the case of *R. v Georgiadis* (No.5) [2001] TASSC 88. In this case, at paragraph 27, Justice Underwood held that the nature of the case was such that it would take a considerable time to investigate and prepare for trial. However, despite the delay, the sentence in the *Georgiadis* case was not mitigated by reason of delay.

Second, the weight given to a plea of guilty should depend on the relevant circumstances of each case (Warner 107). It is therefore a point of particular value in this case that the accused people who pleaded guilty to the conspiracy, did not demonstrate any remorse for their conspiracy and had only pleaded guilty due to an amendment of the indictment that was favourable to accused pleading guilty. Further, the fact that the accused chose to make a plea of guilty resulted in the Crown abandoning allegations of the conspiracy continuing throughout 1993 and accepting for the purposes of the trial the conduct of the accused just between December 1991 and December 1992.

Third, regarding the void status of the 1991 management plan, as it had already been suggested that as the management plan was no longer in operation, that aspect of the Justice Blow judgment was immediately obsolete. The initial Commonwealth management plan was bound to have teething difficulties in matters of administration. A new catch permit system was introduced by AFMA in 1993 and this was never the subject of a legal challenge.

Having commented on the factors that Justice Blow took into consideration in making his judgment, this paper submits that more glaring and surprising is the missing factor that we can only assume his honour deemed to be unimportant – the cost to the environment in general, and orange roughy stocks in particular.

There is clear scope for a judge who is passing sentence to take into account important policy considerations such as the environmental impact of a crime on the marine environment. In the abalone case of *R. v Georgiadis*, Justice Underwood gave particular consideration to the environment. At paragraph 22, His Honour held, "Unless properly respected, conserved and managed, exploitation will cause its [the abalone fishery] extinction. This resource belongs to the people of Tasmania." In paragraph 23, Justice Underwood went on to note that without careful management natural resources will be depleted and eventually lost forever. Further, those that are given the privilege by way of licence to take from the natural resource concurrently carry a heavy obligation to assist in the preservation of that resource. It should be noted that in contrast to the *Victrawl* case, the accused in the *Georgiadis* case ALL received custodial sentences, and only one of the four sentences contained a suspended sentence.

The differences in the cases of *R. v Turner* and *R. v Georgiadis* are difficult to reconcile. They both have similar facts, albeit involving different species – deep-sea orange roughy and coastal-water abalone. Yet the sentences imposed vary dramatically. It can only be assumed that the emphasis given by Justice Underwood, and not given by Justice Blow, to environmental considerations is the determinate factor in the difference between the cases.

This paper submits that if stocks are criminally overfished, and thereby threatened, any legal proceedings that result from the criminal activity, must incorporate environmental factors into the sentencing process. If this results in more severe sentences, the deterrence value of the sentence is arguably increased.

In view of the fact that contemporary environmental law only dates from the 1970s, the subject of how to weigh environmental considerations in sentencing is still relatively new. In the United Kingdom, a Sentencing Advisory Panel has produced a sentencing guideline on environmental offences "Environmental Offences: The Panel's Advice to the Court of Appeal". The report deals with specific environmental offences such as air and water pollution, illegal disposal of waste, illegal abstraction of water and failure to meet recycling obligations. While these subjects might appear to be superfluous to fishery offences, the Report does raise interesting considerations on measuring culpability of defendants accused of environmental offences. In paragraph 6, the Report notes that certain factors must be taken to enhance or aggravate culpability. It is submitted that three of the six factors apply to the accused persons in *R. v Turner*. They are

- the offence is shown to have been a deliberate or reckless breach of the law, rather than the result of carelessness
- the defendant acts from a financial motive, whether of profit or cost-saving ... and
- the defendant's attitude towards the relevant environmental authorities (AFMA) is dismissive or obstructive.

Interestingly, the UK Report was motivated by a public perception that the level of fines imposed by the courts in environmental damage cases, were too low.

The Sentencing Advisory Panel Report goes on to discuss sentencing. Their first recommendation is in support of the fine as the most appropriate sanction. This is based on the fact that environmental offences are "non-violent and carry no immediate physical threat to the person". Further, the level of fine should be fixed in accordance with the seriousness of the offence and the financial circumstances of the individual defendant (including the defendant's economic gain as a result of the offence).

The Report goes on to consider the value of community service and notes that "in cases of greater seriousness involving an individual offender, the court should consider whether there may be merit in imposing a community sentence rather than a fine." On the subject of custodial sentences, the report notes that these may be appropriate where the defendant is an individual as distinct from a company. The report provides, "To cross the custody threshold, a case would need to combine serious damage, or the risk of serious damage, with a very high degree of culpability on the part of the offender." (Paragraph 29 Sentencing Advisory Panel Report).

Today in Australia, the Victorian State Government alone is investigating the idea of establishing an equivalent body to the UK Sentencing Advisory Board. If such a body were established, consistency in sentencing environmental offences should again be a primary subject to address.

The cases of *Turner* and *Georgiadis* demonstrate how even in a small jurisdiction such as Tasmania, there can be inconsistency in how environmental damage is considered and in the sentences handed down by the courts. But, are the above mentioned evaluations by the UK Sentencing Advisory Panel good for advice in regard to sentencing in fishery offences? That is, what is the deterrence value of the sentences recommended in the Report? The writer cannot help but wonder how the individual delegates to the Deep-sea Conference would answer that question and how differently would fishermen vote from scientists, or diplomats from lawyers?

In the 2001 South Tote IUU fishing case heard by the District Court in Western Australia, (re: *Aviles* 11-10-01) Justice Jackson gave an interesting discussion on the subject of deterrence. Noting that many IUU offenders have Spanish Galician roots, Jackson J. held,

The deterrent effect that any sentence or order under consideration may have on the person is a matter to be taken into account. It is interesting that the Crimes Act does not refer to general deterrence. General deterrence is, however, an important part of sentencing. Notwithstanding its absence as a specific matter referred to in S. 16A, it is appropriate to be taken into account. As the prosecutor has pointed out, a number of recent offenders have all come from the same part of the north of Spain, and it is likely therefore that news of this penalty will become known to those who might be tempted in the future to offend in this way.

(Paragraph [j] *Sentencing Remarks for Leonardo Manuel Segade Aviles*, District Court of Western Australia, 11-10-01). It is submitted that the remarks of Justice Jackson can be applied to any fishing community where a person may contemplate fishing beyond quota, or in some other illegal, unregulated or unenforceable fishing manner. That is, the sentence must reflect the severity of environmental damage and be sufficiently severe that it will encourage compliance by acting as a deterrent on “those who might be tempted to offend” in the future. The extent to which the law does this with foreign nationals engaging in Southern Ocean IUU fishing is the subject of the second part of this paper.

3. DETERRING IUU FISHING IN THE SOUTHERN OCEAN – A TOOTHLESS TIGER?

This section of the paper considers the situation in international law and looks at several occurrences of illegal fishing in the Exclusive Economic Zone (EEZ) surrounding Australia’s Heard and McDonald Islands in the Southern Ocean.

The Law of the Sea Convention provides the primary legal framework for the regulation of fishing by foreign nationals and their vessels in the waters of coastal states. The right to fish in a state’s waters may be granted by an access agreement. Such vessels are required to comply with the conservation and other terms and conditions established in the laws and regulations of the coastal state (Article 62).

A coastal state has broad enforcement powers within its EEZ in relation to foreign fishing vessels. Article 73, subparagraph (1) provides that the coastal state may, “in the exercise of its sovereign rights to explore, exploit, conserve and manage the living resources in the exclusive economic zone, take such measures, including boarding, inspection, arrest and judicial proceedings, as may be necessary to ensure compliance with the laws and regulations adopted by it...”. Enforcement powers of the coastal state are subject to some limitations. States are required to

- promptly release arrested vessels and their crews upon the posting of a reasonable bond or other security (Article 73(2), 292)
- not imprison foreign nationals, in the absence of agreements to the contrary by the states concerned, or apply any other form of corporal punishment (Article 73(3)) and
- promptly notify the flag state of an arrested or detained foreign vessel as to the action taken and penalties imposed (Article 73(4)).

The LOSC also places a wide range of responsibilities on the flag state in regard to vessels flying its flag. A flag state must exercise effective jurisdiction and control over vessels flying its flag, though the manner in which such is exercised is subject to a state’s discretion.

The terminology “illegal, unreported and unregulated fishing” (IUU) is commonly used to refer to foreign vessels fishing without authorisation in the waters of a coastal state, or vessels fishing without authorisation in an area and for a species governed by a regional fisheries body. A substantial portion of the IUU industrial fishing fleet targets patagonian toothfish occurring in the Southern Ocean. In what has been described as a ‘white gold rush’, illegal fishing is believed to be taking between 60 and 90 per cent of all fish caught in the Southern Ocean (Greenpeace 1998).

There is no real way of knowing the quantity of the catch taken by IUU vessels. Estimates of the numbers of illegal fishing vessels operating in the Southern Ocean range from 40 to over 100 (Anon. 1997, Woolford 1998). Further estimates from 1997 and 1998 suggest that the illegal catch of Patagonian toothfish (*Dissostichus eleginoides*) was approximately 100 000 tonnes with a value of over \$A500 million, with the portion captured in Australia's island territories' EEZ in the multi-million dollar range (Anon. 1998). This trend has not abated and if anything IUU fishing in the Southern Ocean has increased. Unconfirmed reports state that when the **Lena** was arrested in February 2002 there were up to 12 vessels fishing illegally within, or just outside, the Heard and McDonald Islands AFZ. Based on the **Lena**'s catch of almost 80 tonnes this equates to almost 800 tonnes harvested illegally within a few short weeks, or 27 percent of the Total Allowable Catch as set by CCAMLR the responsible regional fisheries body.

Patagonian toothfish is a primarily demersal species, though it does spend some stages of its life in the pelagic environment. It is a large fish reaching more than two metres in length. The species is highly vulnerable to the impacts of overfishing due, by and large, to its late maturity of between ten and 12 years and its low fecundity as compared to most other fish species. Compounding this is that little is known about stock dispersal and other biological information relevant to management decisions, due primarily to the difficult conditions and remote locations of the fisheries involved. Hence, management needs to be precautionary and conservative in order to prevent economic collapse and ecological extinction of the species.

Heard and McDonald Islands¹, which are separated by only 40 km, are remote Australian external territories some 4 000 km south west of Perth. In 1953 the *Heard and McDonald Islands Act* (Cth) was passed, which effectively applied the laws of Australia to the Islands. In 1979, Australia declared a 200nm Australian Fisheries Zone offshore from the Heard and McDonald Islands followed in 1994 by the declaration of an Exclusive Economic Zone (Commonwealth of Australia Gazette No. S189, 26 September 1979; *The Maritime Legislation Amendment Act 1994* respectively). With the discovery and commencement of commercial exploitation of the Patagonian toothfish in the region, the last decade has seen a rapid rise of illegal fishing within the EEZ and in adjacent waters.

Fishing began in the mid-1990s and is tightly controlled under licences issued by AFMA who apply strict quotas reflecting the regional fisheries management regime in place under the CCAMLR. The AFMA has issued only two fishing permits with respect to the Heard and McDonald Islands Fishery. Moreover, as a matter of Australian domestic policy, CCAMLR Conservation Measures apply within the Australian Fisheries Zone (Part 2, Section 11, Heard Island and McDonald Islands Fishery Management Plan). The fishing quotas adopted by the CCAMLR Commission for Statistical area 58.5.2 have been adopted by Australia for the Heard and McDonald Islands Australian Fisheries Zone, as have many of the environmental measures (Bederman 2000).

In response to the threat posed by IUU fishing to both the valuable resources in the area and to Australian sovereignty over the region of the EEZ, Australia established a concerted enforcement programme. To date, Australian authorities have arrested seven foreign fishing vessels fishing illegally in this area of the Australian Fisheries Zone. The value of the combined catches on the seven vessels was in the vicinity of \$A6.8–7 million. The environmental cost of the illegal industry includes not only the target catch itself, but also the death of tens of thousands of albatross on the longlines. Table 1 outlines vessel seizures and the ultimate fate of the vessels and crews under Australian sentencing law.

¹ Often pronounced "He-me" or "Hi-me".

TABLE 1
Summary of IUU vessels apprehended in the Australian Fisheries Zone and penalties imposed

Vessel name	Flag state/ vessel owner	Date of arrest	Estimated value of catch	Bail and fines imposed	Fate of vessel, gear and catch
Salvora	Belize/Clayton Trading Co. Uruguay	16 October 1997	\$A178 571	Captain and Fishing Master fined \$A50 000 each (\$A25 000 for each offence).	Vessel, catch and gear forfeited (value \$A1 077 478). Vessel released on bond. Vessel not returned – bond \$A1.47 million forfeited.
Aliza Glacial	Panama/Norway	17 October 1997	\$A250 000 (21 t)	Captain and Fishing Master failed to appear to answer charges. Matters still outstanding.	Mortgagee action in Admiralty Law. Commonwealth legal costs paid from proceeds of sale. Vessel valued at \$A8 million.
Big Star	Seychelles/Big Star International Corp.	21 February 1998	\$A1.5 million (145 t)	Master fined \$A100 000. This was reduced on appeal to \$A24 000.	Vessel, catch and gear forfeited. Vessel released on bond. Vessel not returned – bond \$A1.5 million forfeited.
South Tomi	Togo/undisclosed	12 April 2001	\$A1.5 – 1.6 million (116 t)	Master fined \$A136 000.	Catch and gear forfeited. Bond not set as owner's identity not divulged by lawyers,. Vessel forfeited, to be disposed of at direction of Minister.
Lena	Russia/Alitas	6 February 2002	\$A900 000 (70–80 t)	Captain fined \$A50 000. First Officer and Officer fined a total \$A25 000 each.	Vessel, catch and gear forfeited. Bond not set as owner's identity not divulged by lawyers. Vessel forfeited, to be disposed of at direction of Minister.
Volga	Russia/Alitas	7 February 2002	\$A1.6 million (127–138 t)	Charges against Captain withdrawn subsequent to death shortly after arrest. Fishing Master, Fishing pilot and Chief Mate charged.	International determination such that bond may be set as equal to the value of the vessel.

In October 1997, 'Operation Dirk' saw the arrest and escort to the port of Fremantle of two boats apprehended in the Southern Ocean. The first of these was the **Salvora**. The Belize-flagged vessel was boarded some 174 nautical miles inside the Australian Fisheries Zone (*Queen v Paz and Santome*). Twenty boxes of frozen Patagonian toothfish and 43 boxes of unfrozen headed, tailed and gutted recently cut toothfish were found onboard. The Spanish Captain and Master were both charged with offences under Sections 100 and 101 of the *FMA*. Section 100 prohibits fishing by a foreign boat in the Australian Fisheries Zone unless so authorized under a foreign fishing licence. Section 101 prohibits a person from having in their possession or charge a foreign boat equipped with nets, traps or other equipment for fishing unless so authorized or if the boat's nets, traps or other equipment for fishing are stored and secured and the boat meets one of several requirements. These include: having AFMA approval; being on innocent passage on a direct route through the Australian Fisheries Zone; or being for use as a scientific research vessel and having an appropriate permit.

Both are strict liability offences and as such intention does not have to be proven. A 1999 Act addition does however require the prosecution to establish that the accused had knowledge of the vessel's position with the Australian Fisheries Zone (Sections 100A and 101A). Although defence counsel informed the District Court that the defendants were equally culpable and entered guilty pleas for all charges, they contended that the defendants were fishing in a location under explicit directions from the ship's owners. In other words they were unaware they were fishing within Australian waters and had they realized, they would have refused to do so. (*Queen v Paz and Santome*).

An additional argument submitted by the defence of both the **Salvora** and the **Big Star** cases was that the illegal fishing of Patagonian Toothfish was not a severe offence on environmental grounds. They argued that it was *not* the case "that the Patagonian Toothfish is a particularly endangered species" and as such the courts should be lenient. This statement runs in direct contradiction to all scientific data and substantial political recognition that "if illegal and unregulated fishing continues at the current level the population of Patagonian Toothfish will be so severely decimated that within the next two to three years the species will be commercially extinct" (press release, Parer and Downer, 1998a). And indeed, in the **Big Star** case Justice O'Sullivan expressed reservations in accepting some of these defence submissions.

In the case of the **Salvora**, on 14 October 1998 a fine of \$A50 000 was awarded to each defendant, to be apportioned equally for the two offences (*Queen v Paz and Santome*). The maximum fine open to the court was \$A275 000. The Court also made an order for the forfeiture of the vessel, fishing equipment and catch. The vessel had been released subject to a vessel monitoring system (VMS) bond of \$A100 000 and a total vessel bond of \$A1.47 million. Notwithstanding that the VMS had become inoperative shortly after the **Salvora** exited Australian waters, that bond was not automatically forfeited. The vessel did not return to Australia following the Captain and Master's conviction, and at that point the vessel bond was forfeited.

The second vessel was the Panamanian-flagged **Aliza Glacial**, arrested on 17 October 1997 having been sighted fishing illegally within the Heard and McDonald Islands Australian Fisheries Zone. The Captain and Fishing Master faced identical charges again under Section 101(1) of the *FMA*. The matters were adjourned with both defendants being granted bail 'without condition'. On 5 February 1998, both defendants entered a plea of not guilty to the charges and bail was extended. The matters were then adjourned to 6 July 1998. At this point, both defendants failed to appear on the first day of the trial and the warrants remain outstanding.

In relation to the vessel, notice of her seizure, and that of her gear, bait and catch was issued in late November 1997. The vessel's Norwegian mortgagee, Bergensbanken, made a successful application under the *Admiralty Act 1988* (Cth) for the sale of the vessel due the owner's default in loan repayments (*Bergensbanken v. Aliza Glacial*).

Thus the Australian Government's claim to forfeiture was defeated by an action for the recovery of the vessel by the boat's mortgagee. The Commonwealth's legal costs were however paid from the proceeds of the sale.

At the time federal fisheries law did not provide for the suspension of the sale of a vessel under admiralty law whilst a vessel is detained pursuant to the *FMA* (Section 84). This legislation has however, since been amended so that a foreign vessel, its equipment and fish is automatically forfeited to the Commonwealth if the vessel is used in an offence against certain sections of the *FMA*, including Sections 100 and 101.

In February 1998 a third vessel was apprehended in the Southern Ocean on suspicion of illegally fishing within the Heard and McDonald Islands Australian Fisheries Zone. The Seychelles-flagged, Honduras-registered **Big Star** was seized and brought into port for court proceedings (Bateman and Rothwell 1998). Apprehended 8 miles inside the Australian Fisheries Zone, the vessel's Spanish Master was charged under the *FMA Sections 100 and 101*. Evidence from the vessel's log books indicated that there had been three distinct periods of fishing within the Heard and McDonald Islands Australian Fisheries Zone. The vessel, fishing equipment, catch and crew were released on the posting of a security bond in May 1998 a few months after the arrest. The security bond totalled \$A1.35 million. When the vessel was not returned to Australia the court also made an order for the forfeiture of the vessel bond to the Commonwealth Government. Indeed, after departing Fremantle, the **Big Star** was renamed the **Praslin** and was arrested by French authorities, again released and later impounded attempting to land a catch in South Africa (ISOFISH 2002).

A guilty plea was entered by the Master to all six charges and fines totalling \$A100 000 were issued. In so doing the court took into consideration the monies made available by the vessel's owner in the event of the imposition of a fine. This fine was appealed and reduced to \$A24 000. The reduction was due to the Master's financial circumstances. Such consideration of the vessel owner's finances was a departure from the common law principle and is now codified in the *Crimes Act* (Section 16C(1)), i.e. a court is to take into account the financial circumstances of the accused when imposing a fine. Although the Court of Appeal held that the initial fine was "appropriate to reflect the gravity and criminality of the applicant's conduct", it was held that the trial judge failed to properly take into account the personal and financial circumstances of the defendant. Interestingly, the minority judge disagreed with this finding. He stated that such an interpretation would defeat the purpose and object of the Act as it would allow those outside the jurisdiction to hide behind the impoverished circumstances of their employees.

On 29 March 2001 once again a foreign fishing vessel was sighted fishing illegally within the Australian Fisheries Zone and was chased across the Indian Ocean by the **Southern Supporter**. This concluded with a successful arrest 14 days later of the **South Tomi**. The arrest occurred 8 500 km from Australia only after a show of firepower and with the aid of French and South African authorities (AFMA undated).

Unlike the case of the **Big Star**, in the instance of the **South Tomi** the defendant signed his own bail documents and hence technically the bail of \$A150 000 was considered to have been paid by the defendant himself. Consequently the financial means of the defendant were not an impediment to imposing a substantially larger fine than in the preceding case. It may however have been the situation that the \$A136 000 fine was actually paid by the owners of the vessel.

Due to the amendments of the *FMA*, the vessel, equipment and catch were automatically forfeited under Section 106A. This forfeiture was initially challenged, though the application was later withdrawn. In addition, Australia failed to set a reasonable bond under Article 73 of the LOSC. No protest, however, was lodged at this. As such, Article 292, which requires prompt release on the posting of a reasonable bond provisions, was never activated. There is no consideration under Article 73 of the

LOSC as to the logistics of a situation (not uncommon to IUU fishing) where a vessel owner cannot be identified. It follows however, that a bond cannot be set and paid without knowledge of the vessel owner's details.

The final two vessels to be seized before the most recent apprehension of the **Viarsa**, were the Russian vessels the **Lena** and the **Volga**. In February 2002 a Navy vessel arrested the **Lena**, subsequent to an unsuccessful pursuit by a civilian patrol vessel three month earlier. The vessel was arrested approximately 225 kilometres inside the Australian Fisheries Zone and with almost 80 tonnes of toothfish on board. The seizure of the **Volga** was an extra bonus, arrested on 7 February 2002 as it was exiting the Australian Fisheries Zone and escorted alongside the **Lena** to Fremantle.

The Captain pleaded guilty to a number of offences relating to fishing within the Australian Fisheries Zone without a licence. In a sentence handed down in June 2002, he faced fines totalling \$A50 000. Both the First Officer and Second Officer who, like the captain, were Spanish nationals, were also charged and pleaded guilty to offences under Sections 100 and 100A of the *FMA* and each were awarded fines of \$A25 000. In regard to the severity of the fines, a report in the Newcastle Herald on the hearings cites District Court Judge Kennedy as saying prior to sentencing that 'three Spaniards convicted of poaching protected fish from Australian waters may be treated more harshly than poorer Indonesian fishermen charged with similar offences.' To recall, in the case of the **South Tomi** the sentencing judge had commented on the Spanish Galician roots of many offenders and the need to take into account the deterrent effect of a sentence. Nonetheless, given the value of the vessel and catch these are not large fines.

The ship's captain of the **Volga** was initially charged, however following his death shortly after arrest, the charges were withdrawn. The Fishing Master, Pilot and Chief Mate were charged under Section 100(1) of the *FMA* for fishing within the Australian Fisheries Zone without a licence.

Following its arrival at the port of Fremantle the **Lena** was condemned as forfeited. A written claim for the release of the **Volga** under Section 106E of the *FMA* was submitted. This allowed a two-month period for the commencement of formal proceedings in accordance with *FMA Section 106F*. As with the **South Tomi**, the Australian Government maintained the position that the obligation lies with the vessel owners to pursue the issue of a reasonable bond under Article 73 of the LOSC. As the owners' details were provided for neither the **Lena** nor the **Volga**, and solicitors did not seek the posting of a bond, the vessels were subsequently to be disposed of at the direction of the Commonwealth Fisheries Minister. In the event a bond was set for the **Volga** and Spanish officials of \$A4.1 million.

The **Lena** and **Volga** are the first of the seized vessels to be flagged to a CCAMLR member state. Although flagged in Russian and owned by a company registered there, Russia failed to control the vessel's fishing activities, putting it in breach of its CCAMLR obligations. Their illegal catch undermined the efforts of the CCAMLR to set precaution catch limits via conservation measures.

4. CONCLUSION

The first theme raised at the opening of this paper was the need to take into consideration the environmentally deleterious impact that an illegal fishing action may have in sentencing.

In the evolution of natural resources law there is clearly a creeping inclusion of environmental considerations into more and more aspects of decision-making. Similar to the concept of the victim impact statement in a violent crime, there is no doubt that an increasing number of judges are examining the impact on the environment of an offence relating to natural resource over-exploitation. However, this environmental consideration is not consistent.

The second theme of the paper is that of consistency in sentencing fishery offenders. The application of domestic legal principles such as the financial circumstances of a defendant may become complicated in the case of foreign illegal fishing. Further, inconsistency in sentencing environmental offences is exacerbated when a host of other considerations are also taken into account. While on the face of it these may seem appropriate considerations, given the internationality of southern ocean management, the wisdom in applying principles designed more for domestic Australian law needs to be considered. That is, the wisdom and validity of taking into consideration a defendant's financial circumstances, when such defendants have been apprehended in the command of a multimillion dollar vessel with a multimillion dollar illegal fish harvest, is questionable. This is even more so when a state's ability to determine the real (beneficial) owners of the vessel is limited.

In addition, foreign nationals illegally fishing enjoy extra protection to that of Australian nationals convicted for a mirror offence by virtue of the 1982 United Nations Convention on the Law of the Sea whose Article 73 prohibits imprisonment of ships' crew. Accordingly, this paper recommends that when sustainability of stocks is an issue, stricter and consistent sentencing needs to be applied to domestic offences and commensurably larger fines to IUU offences so that the judicial treatment of fishery offenders acts as a meaningful deterrent and not a lottery.

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Purely high-seas fisheries – gearing for optimal compliance

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1. INTRODUCTION

Over the last decade, managing highly migratory and straddling fish stocks has been the primary focus for coastal and distant water fishing states (Franckx 2000). However attention is now turning to managing the deep-sea fish stocks found on the high seas. These stocks are considered the “last marine frontier”. While regional fisheries organizations have been identified as the “vehicle for good governance in the management of international fisheries” (FAO 1999), the design of these organizations has adapted over time to meet the changing needs of regional management.² Contemporary designs have focused on collective management of fisheries (regional fisheries management organizations), requiring member states to engage in active management of the fish stocks and to take measures ‘consistent with international law’ to deter the fishing activity of non-parties to the regional arrangements.³

The ‘regional fisheries management organization’ design recognizes that if regional management is to be successful the governance regime must be able to implement effective fisheries management measures that provide for sustainable utilisation of the fish stocks. It must also bind all states to an obligation to either comply with the regional conservation and management measures or refrain from fishing in that area (comply or refrain).⁴

Irrespective of whether the obligation to comply or refrain exists, members of three regional fisheries management organizations have agreed to impose punitive trade measures against non-parties to those arrangements in order to pressure non-parties to ‘comply or refrain’.⁵ While the legality of this approach, and its ability to achieve

¹ The views expressed in this paper are those of the author and are not necessarily those of the Ministry of Fisheries.

² Sydnes (2001) has identified three types of regional fisheries organizations – organizations focused on facilitating cooperation, organizations focused on developing regional policy, coordination and development and regional fisheries management organizations.

³ Art. 9 of the United Nations Agreement on Fish Stocks provided for the establishment of regional fisheries management organizations for straddling and highly migratory fish stocks. This model has been implemented in the recently concluded Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (concluded 2000) and the Convention on the Conservation and Management of Fishery Resources in the South-East Atlantic Ocean (concluded 2001). Art. 33.3 of UNFSA requires parties to take measures consistent with International Law to deter the activities of non-parties, which undermine the effective implementation of the Agreement.

⁴ Both of these concepts are contained in Art. 17 of UNFSA.

⁵ See the conservation and management measures of the Commission for the Conservation and Management of Antarctic Marine Living Resources, and the International Commission for the Conservation of Atlantic Tunas and the measures taken by Chile pursuant to the Galapagos Agreement.

compliance, is yet to be determined, the use of these measures is fast becoming a more widely accepted approach.⁶

This paper identifies three principles of compliance – the principle of state self-interest, the principle of perceived merit and the principle of capacity. It also reviews the governance architecture for purely high-seas fisheries, examines the lessons learned from regional management of other fish stocks and explores why the use of trade measures against non-parties is controversial. Finally within the paradigm of compliance theories this paper considers how to achieve compliance with an obligation to ‘comply or refrain’. This paper challenges those creating future governance architecture to design a regime that delivers compliance without being confined to refining yesterday’s solutions.

2. PRINCIPLES OF COMPLIANCE

In the domestic legal model there is a clear superior authority, the sovereign state, which makes the laws and has the ability to implement punitive measures to obtain compliance from its nationals (Scott and Carr 1996). When considering how to achieve compliance with international law, there is a temptation to assume that the international legal framework must match the domestic legal framework. However, international law involves the state as both “sovereign and subject” (Scott and Carr 1996), therefore, the traditional domestic enforcement model has limitations at international law.

In this context compliance has been defined as the “behaviour of a [State] when it conforms to internationally agreed obligations” (Joyner 1999). A number of international relations theories have been developed to explain and predict state compliance.

Managerial model theorists suggest that non-compliance results primarily from ambiguity of obligation and capacity of the state to comply (Chayes and Chayes 1995). Neo-liberal model theorists (invoking contemporary game theories) place state self-interest as the central driver of compliance and suggest that manipulation of positive and punitive incentives can alter state self-interest to achieve compliance (Parker 1999). Realists also focus on power and relative gains asserting, “States will always favour the outcome that maximizes its power and wealth relative to its rivals”, ultimately suggesting that these factors explain and predict state compliance. Cognitive theorists reject that states’ self-interest is “always unitary and egoistic” and suggests that perception of states’ self-interest can be influenced through persuasive techniques (Parker 1999). These theorists suggest that perception of states self-interest can be modified through international and domestic discourse. Legitimacy and fairness theorists suggest that “perceptions of legitimacy and fairness” have a significant impact on achieving compliance (Parker 1999).

While these theories each explain aspects of what drives compliance and non-compliance, they fail to provide a clearly articulated and succinct model for compliance.⁷ Although a comprehensive review of existing international relations theories and compliance is outside the scope of this paper, three compliance principles are readily distilled.

The first principle of compliance is state self-interest. This principle asserts that the likelihood of compliance increases when the cost–benefit analysis favours compliance. The likelihood of compliance increases when positive self-interest outcomes (rewards)

⁶See Articles 65 to 76 of the FAO International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU).

⁷Parker (1999) states: “However, there are two main weaknesses of IR theory: a proliferation of competing models; and the failure, so far, of IR theorists to address the special case of environmental trade leverage. The first weakness has impeded efforts to arrive at a single, comprehensive model of international behaviour; the second, regrettably, has marginalized IR theory as a guide to trade and the environment.”

result from compliance or where negative self-interest outcomes (penalties) result from non-compliance. State self-interest includes economic, reputational, and strategic gains or losses.

The second principle of compliance is perceived merit. This principle asserts that the likelihood of compliance increases when the rule making process and the outcome of compliance are perceived to have merit. Perceived merit occurs where rules have been developed through a legitimate and recognized process; and when rules are equitable, fair and right.

The third principle of compliance is capacity. This principle asserts that without the capacity to comply, irrespective of state self-interest and the perceived merit, states will be unable to comply. Capacity to comply includes access to expert knowledge, technology, resources and infrastructure.

Using these three interrelated principles as a compliance model provides a framework for examining how the contrasting international relations theories identify important elements of any comprehensive management regime that is geared for achieving compliance. This paper introduces these three interrelated principles of compliance as a model to explain and predict state compliance with an obligation to 'comply or refrain'.

2.1 Principle of State Self-interest

International community experience has shown that when the commons are subject to no management regime, states act to maximize their immediate interests (Ostrom *et al.* 1999, Hardin 1968).⁸ This phenomena is explained by the infamous 'prisoner dilemma' example of game theory that predicts that when players engage in a non-cooperative game they can adopt strategies that produce undesirable outcomes for both parties (Munro 2003).

The theory can be applied to explain the dynamics of cooperation in high-seas fishing. For example, if two states are fishing the same fish stocks, and State A decides to implement a conservation plan that involves restricting its nationals' fishing effort, this plan may result in the health of the stock temporarily increasing. However without cooperation from State B, State A can not achieve conservation, although State B can benefit from State A reducing its effort, at no cost to State B. In this scenario State B is a 'free-rider' on the conservation efforts of State A. State B's 'free-riding' means there is no incentive for State A to continue with conservation, and the conservation attempt will be abandoned (Munro 2003).

This theory predicts that non-cooperation is not in states long-term self-interest and that ultimately states will choose to cooperate (Parker 1999). However, the incentive to cooperate will be undermined by 'free-riding' by other states. Increased occurrence of 'free-riding' increases the likelihood that member states will be attracted to non-compliance (Munro 2003). To counter this consequence both positive and punitive incentives can be applied to modify states' self-interest. Traditionally the domestic legal framework has relied on punitive measures as the primary incentive to drive compliance with criminal sanctions providing both economic and reputational disincentives for the individual. In international relations states have also included punitive measures, including the withdrawal of diplomatic representation, trade measures and military force.

⁸Hardin suggested "The rational user of a commons makes demands on a resource until the expected benefit of his or her actions equal the expected costs. Because each user ignores costs imposed on others, individual decisions cumulate to a tragic overuse and potential destruction of an open-access commons." Those commentators go on to state "Although tragedies have undoubtedly occurred, it is also obvious that for thousands of years people have self-organized to manage common pool resources, and users often devise long-term, sustainable institutions for governing these resources."

Treaties are central to international environmental management and some have considered punitive measures to be essential for giving 'teeth' to these management agreements (Chayes and Chayes 1995) although a significant divergence of views exist on the appropriateness of using trade measures in this manner. Some commentators advocate trade measures as necessary to achieve the 'leverage' required to pressure states to engage in cooperation at a multilateral level (Parker 2001) while others advocate that trade measures should not be used to trump other states, that they are the "wrong solution to the wrong problem" (Kelly 2001) and that they are "largely a waste of time" (Chayes and Chayes 1995). Economic rewards for engaging in cooperation can just as easily be applied.

State self-interest is not a 'static' concept and can be influenced by positive and punitive incentives, and persuasion by international discourse and perception of self-interest can be altered by "research, knowledge infusion, normative discourse and change of players" (Parker 1999).

Key influences in shaping perceptions are multi-state expert working groups, sustained negotiations and contact between a stable set of officials and domestic politics. Media and non-governmental interest groups are having an increasing influence on the actions of state officials (Parker 1999). Developing a common understanding of the problem and the appropriate solutions can assist in states perceiving that compliance is in their self-interest.

The managerial theory suggests that international discourse is a fundamental instrument in achieving compliance. The diplomatic process of "explanation and justification, persuasion and dissuasion, approval and condemnation" is all part of the process to shape a state's perception of self-interest and generate support or "elicit cooperation" (Chayes and Chayes 1995). While persuasion and international discourse can influence perception of state self-interest, the principle of state self-interest predicts that the absence of self-interest based rewards and penalties will reduce the likelihood of compliance.

2.2 Principle of perceived merit

It has been suggested that the international legal framework is based on four fundamental principles:

- i. states are sovereign and equal
- ii. state sovereignty can be restricted by consent
- iii. consent binds (*pacta sunt servanda*) and
- iv. states, in joining the international community, are bound by these and other basic ground rules of community even if they do not formally consent to them (Parker 1999). At the foundation of this framework is an expectation of good faith and no trumping.

States make international rules through two recognized and legitimate processes involving either explicit or implicit consent. Explicit consent is expressed through positively adopting an international obligation, generally through ratifying a treaty. Implicit consent is expressed through state practice coupled with *opinio juris*, making customary international law (Bratspies 2001).⁹

As a rule, it is considered that states have a propensity to comply with treaty obligations, because the negotiation process generates an expectation of compliance.¹⁰ Although states can withdraw from treaty obligations, "they do not negotiate agreements with the idea that they can break them whenever the commitment becomes 'inconvenient'" (Chayes and Chayes 1995).

⁹ Bratspies (2001) notes that some rules of customary international law are considered so important they are classified as principles of *jus cogens* and take primacy over others.

¹⁰ See Chayes & Chayes (1995) *Pacta sunt servanda* is a fundamental norm of international law providing that treaty obligations are to be obeyed.

It is thought that rules that are considered fair, in both legitimacy and equity, are more likely to achieve compliance. Rules are considered legitimate when they are developed in accordance with the international legal framework, and involve no trumping (Parker 1999). The concept of equity requires the rule not to widen “the existing inequality of persons’ and/or States’ entitlements”.

Perception of merit can be influenced through clarity of the rule and developing understanding of purpose and objectives of the rule through the international discourse and domestic interest groups. The managerial model of compliance places a heavy emphasis on using dispute settlement mechanisms to clarify any ambiguity in treaty language. This model correctly recognizes that when treaties are negotiated the language deliberately adopted provides room for a range of reasonable interpretations (Chayes and Chayes 1995). Once again the use of international mechanisms for persuasion plays a key role in shaping states’ perception of merit. International discourse between a stable set of negotiators or a stable set of experts can “promote a convergence of beliefs and values, and a developing sense of community (a sense of ‘we’) among participants that further supports cooperation” (Parker 1999).

The principle of perceived merit predicts that the absence of a legitimate rule making process and outcomes reduces the likelihood of compliance.

2.3 Principle of capacity

Managerial theory concluded that “wilful flouting of legal obligations” infrequently caused non-compliance. This theory identified lack of capacity of states, and the necessary time lapse between agreeing to a new behaviour and developing the domestic framework to deliver on those obligations, as two of the three reasons for non-compliance (Chayes and Chayes 1995).¹¹ The decision to commit capacity is also influenced by the perceived importance and immediacy of issues.

This theory identified that the real objective of environmental treaties is not only to affect state behaviour but also to regulate the activities of its nationals. Fulfilling these obligations usually requires “detailed administrative regulations and vigorous enforcement efforts”. Irrespective of political will this involves technical capacity, appropriate bureaucracy and financial resources (Chayes and Chayes 1995).

The importance of ensuring all states have the capacity to comply has been recognized in contemporary multilateral fisheries agreements.¹² Under the United Nations Fish Stocks Agreement¹³ (UNFSA Art. 24), states are to “give full recognition to the special requirements of developing States” and to this end are to provide assistance. The forms of assistance particularized by this article include “financial assistance, assistance relating to human resource development, technical assistance, transfer of technology, including through joint venture arrangements, and advisory and consultative services”.

This assistance was to be directed at improving conservation and management of fish stocks through “collection, reporting, verification, exchange and analysis of fisheries data” (UNFSA Art. 25(3)(a)); “stock assessment and scientific research” (UNFSA Art. 25(3)(b)) and “monitoring, control, surveillance, compliance and enforcement, including training and capacity-building at the local level, development and funding of

¹¹ The other reason was ambiguity of the rule (addressed in this paper under perceived merits).

¹² See the UNFSA and the FAO Compliance Agreement, Art. VII “The parties shall cooperate, at a global, regional, subregional or bilateral level, and, as appropriate, with the support of the FAO and other international or regional organizations, to provide assistance, including technical assistance, to Parties that are developing countries in order to assist them in fulfilling their obligations under this Agreement.”

¹³ In full “The Agreement for the Implementation of Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks”.

national and regional observer programmes and access to technology and equipment” (UNFSA Art. 25(3)(c)).

The principle of capacity predicts that in the absence of the commitment by developed states to assist developing states, compliance with sophisticated regulatory regimes will be unattainable and therefore will reduce the likelihood of compliance.

3. REGIONAL MANAGEMENT

3.1 The United Nations Convention of the Law of the Sea Framework

The *mare liberum* doctrine has been an international norm since the seventeenth century¹⁴, recognized as a *jus cogen* “in the interests of all mankind” (Anand 2001). At a time when coastal states only exercised jurisdiction over a small territorial sea, usually 3 nm, this principle justified nationals of all states freely exploiting the resources of the high seas. This principle was premised on a belief that ocean resources were inexhaustible and “that one State’s right to exploit those resources would not interfere with the corresponding rights of other States” (Hewison 1999).

The concept of free or open access to exploit exhaustible resources frequently attracts the label “tragedy of the commons” and Garrett Hardin wrote in the late 1960s: “Ruin is the destination towards which all men rush, each pursuing his own interest in a society which believes in the freedom of the commons. Freedom in a common brings ruin to all.” (Ardia 1998)

After the Second World War fishing vessels of developed states commenced fishing areas of high seas bordering the territorial seas of developing states, and through significant technological advancements these vessels became more effective harvesters (Bratspies 2001, Sydnes 2002). By the 1950s coastal states were beginning to challenge the appropriateness of managing these common resources under an ‘open access regime’, asserting jurisdiction over varying areas of the high seas under the premise of “protecting their fisheries from depredations by outsiders” (Anand 2001).

Whether it was the inconsistency of state practice or the realisation that fisheries were not an inexhaustible resource (Anand 2001, Hewison 1999, Carr and Scheiber 2002), the United Nations was prompted to convene the 1958 conference on the law of the sea (UNCLOS I) in an attempt to settle and codify the rules. During that conference the Convention on Fishing and Conservation of the Living Resources of the High Seas was concluded (the 1958 Convention). Thirty-seven states ratified this convention and it remains in force to the extent it is not superseded by the 1982 United Nations Convention of the Law of the Sea (LOS). The language of the 1958 Convention purported to apply to all states, despite ratification by only 37 states. While the right of state parties’ nationals to fish on the high seas was confirmed, that right was made subject to treaty obligations, the interests and rights of coastal states, and the obligations concerning the conservation of high-seas resources (Art. 1(1)).

All state parties were obliged to adopt, or cooperate with others in adopting, measures necessary for the conservation of high-seas resources (Art. 1(2)). The LOSC also provided that where nationals from two or more parties fished the same stocks, and agreed to adopt conservation measures, new entrants to the fishery (who were parties to the 1958 Convention) were obliged to adopt the measures. Failure to comply with this obligation provided a basis for commencing binding dispute settlement procedures (Art. 5).

UNCLOS I addressed cooperation for the purposes of conservation of high-seas resources but it failed to resolve the area that could be subject to coastal state jurisdiction. In 1960 a second United Nations conference on the law of the sea was

¹⁴ Hugo Grotius propounded this doctrine. See Anand (2001).

convened to resolve this issue, however agreement was not reached. The third United Nations conference on the law of the sea commenced in 1973 and after ten years of negotiation the United Nations Convention on the Law of the Sea (LOSC) was concluded in December 1982 (Bratspies 2001, Sydnes 2002).

The negotiating States intended the LOSC to be a “complete package of rights and obligations to serve as the legal foundation for all activities and uses of the world’s oceans” (McLaughlin 1997, Rayfuse 1999). The 1982 Convention was to prevail over the 1958 Convention and future agreements were required to be compatible with “the effective execution of the object and purpose” (Art. 311(3)) and not to affect the application of the basic principles of the Convention, or the “enjoyment by other State Parties of their rights or the performance of their obligations under [the] Convention” (Art. 311(3)).

The 1982 Convention¹⁵ provides a framework for regulating fisheries, using the setting of a total allowable catch for maximum sustainable yield (Art. 119(1)) as the primary tool and required States to “ensure conservation measures and their implementation [did] not discriminate in fact or form against fishermen of any State” (Art. 119(3)). The binding dispute resolution mechanisms (Part XV) together with the duty on each state to “fulfil in good faith the obligations” (Art. 300) under the Convention and to “exercise the rights, jurisdiction and freedoms recognized in [the] Convention in a manner which would not constitute as abuse of rights” (Art. 300) provided a clear expectation between the parties that any conflicts arising under the LOSC would be resolved in accordance with its provisions, unless expressly excluded (McLaughlin 1997).

While the Convention delivered a detailed governance framework for fisheries resources within the exclusive economic zones and the territorial seas articulating state rights and obligations (McLaughlin 1997), little attention was given to governance arrangements for the high seas (Brownlie 1998). The foundation for legal order remained with the flag state, which retains basic exclusive jurisdiction over the activities of its vessels on the high seas (Shaw 1997). In effect the LOSC repeated the right of all states to fish on the high seas, subject to specified obligations and the duty of cooperation from the 1958 Convention (Edeson 2001) leaving a distinct tension between freedom to exploit and the need to conserve (Ardia 1998).

While the LOSC affirmed the concept of the “regional fisheries organization” (Art. 318) as the mechanism for state cooperation, the 1982 Convention did not repeat the 1958 Convention obligation on new entrants to comply with established conservation measures. This approach is understandable, given that at that time 99 percent of all fish harvested was taken within 200 nm of the coast. Therefore with the establishment of exclusive economic zones, States may have presumed that international high-seas fisheries were ‘nationalized’ (Sydnes 2001). But, fishing fleets have now developed high-seas fisheries beyond exclusive economic zones (Juda 1997) and the international community has once again been required to address management of the commons.

3.2 Modern regional fisheries management organizations

Governance architecture for regional fisheries organizations reflects two broad levels of cooperation, primary and secondary. Organizations of ‘primary level’ cooperation co-ordinate and facilitate for member states. Primary level organizations may “conduct and coordinate marine research” for the purposes of advising member states or alternatively, they coordinate regional fisheries policy and facilitate industry access to

¹⁵ There are currently 142 parties to the 1982 Convention and while the United States of America is yet to ratify the convention, the Convention is recognized as the living constitution of the oceans.

member's zones. Organizations at a 'secondary level' of cooperation "manage regional fisheries in the traditional sense by collecting and assessing scientific data, setting regulatory measures and establishing enforcement measures" (Sydnes 2001).

Contemporary fisheries management governance regimes are designed to achieve effective fisheries management, which requires constraining fishing activity to levels that achieve sustainable yield and requires two fundamental decisions, namely how much fish can be taken and by whom. These organizations are equipped with a decision-making body and a secretariat and states with a 'real interest' in the fishery are eligible to become members (Applebaum and Amos 1999). The decision-making body is responsible for agreeing on conservation and management measures necessary to achieve long-term sustainability and setting a total allowable catch or levels of fishing effort as required (UNFSA Art. 10(a)). The decision-making body is normally supported by advice from committees or working groups on scientific, compliance and other technical matters (Sydnes 2001).¹⁶ Funding for the secretariat and other functions are met through member contributions (e.g. WCPT Art. 18 as an example of how membership contributions are calculated).

These regional fisheries management arrangements authorize the decision-making body to adopt conservation and management measures that are relatively sophisticated from a regulatory perspective (Applebaum and Amos 1999). Measures involve: establishing a vessel register to record the vessels authorized to fish in the Convention Area (e.g. WCPT Art. 24(7) that requires the Commission to maintain a vessel register), requiring vessel to carry and operate a vessel monitoring system (e.g. WCPT Art. 24(8) that requires vessels to operate a "near real-time satellite position-fixing transmitter" and transmit the data to the Commission); observer coverage (e.g. WCPT Art. 28 that requires the Commission to establish a regional observer programme), fisheries data collection (e.g. WCPT Art. 23), high-seas boarding and inspection (e.g. UNFSA, Art. 21 and 22; and WCPT, Art. 26), port state inspections (e.g. UNFSA, Art. 23; and WCPT, Art. 27), enforcement of conservation and management measures (e.g. UNFSA, Art. 19; and WCPT, Art. 25), and vessel markings (e.g. UNFSA, Art. 18(3)(d); and WCPT, Annex III); measures to deter the fishing activity of non-parties, which undermine the effectiveness of the measures adopted (e.g. UNFSA Art. 33 and WCPT Art. 32.1).

The objective of these modern organizations is to effectively regulate the individual fishers harvesting the fisheries resources. Therefore, when ratifying fisheries agreements, states are undertaking to regulate the activities of their nationals, with "detailed administrative regulations and vigorous enforcement efforts" (Chayes and Chayes 1995).

3.3 Challenge of non-parties

Despite the creation of exclusive economic zones and the efforts of regional fisheries organizations, depletion of global fish stocks has continued (Vigneron 1998). The state of world fisheries has been labelled "one of the most urgent resource problems facing the international community today" (Carr and Scheiber 2002). It has been estimated that "two thirds of the fish stocks in the oceans are in urgent need of management" (FAO 1999). With this outcome the effectiveness of the current governance architecture is being challenged. Regional fisheries management organizations have been identified as the 'vehicles of good governance' but they have yet to deliver sustainable utilisation (Sydnes 2001). A key cause of this failure is the activity of non party states.

¹⁶ See also UNFSA, Art. 9(1)(d) and Art. 10(h). As an example, the Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific (WCPT) establishes a Commission; a scientific committee; and a technical and compliance committee.

For instance, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)¹⁷ has implemented a catch limit for Patagonian toothfish, but now estimates that more toothfish is taken each year by vessels engaging in illegal, unreported or unregulated activities (IUU fishing), than that taken by authorized vessels. Flags of convenience¹⁸ have been identified as primarily responsible for this IUU fishing¹⁹. Flags of convenience either run vessel registers that require no genuine link between the vessel owner and the flag state and consequently the flag state is unable to exercise effective control over the vessel, or the flag state does not have the legislative or administrative processes necessary to exercise effective control over its vessels (Polick 2001).

Greenpeace have identified the ‘top ten’ flags of convenience states²⁰ as Belize, Honduras, Panama, St Vincent & the Grenadines, Equatorial Guinea, Cyprus, Sierra Leone, Mauritius and Netherlands Antilles. All of these flag states are parties to the 1982 Convention and, therefore, have accepted the ‘duty to cooperate’ to manage and conserve high-seas fisheries. However, nine out of ten of these states are considered developing countries, with four being classified by the United Nations as ‘least developed countries’.

Regional fisheries management organizations have struggled with states that have failed to subscribe to the collective management model. Where conservation measures have been implemented to limit the fish harvested, fishing by non-parties has not only thwarted the efforts of those organizations, but has resulted in the non-party vessels benefitting from the reduction of fishing effort in the area (Franckx 2000). Non-parties fall into two categories, states who cannot become parties due to lack of capacity, and states that choose not to participate “because they seek to avoid the obligations” (Rayfuse 1999).

The UNFSA sought to address “problems of unregulated fishing, over-capitalization, excessive fleet size, vessel reflagging to escape controls, insufficiently reflective gear, unreliable databases and lack of sufficient co-operation between States” (Moran 1995). The agreement emphasizes collective management to deliver effective fisheries management. It also further particularized the LOSC rights, duties and obligations to the Parties, introducing a rule stipulating that where its parties were not prepared to comply with conservation and management measures adopted by a regional fisheries management organization, they were to refrain from fishing in that region/comply or refrain (UNFSA, Art. 17(1) and 17(2)).

While under international law states can consent in advance to the obligation to ‘comply or refrain’ (Franckx 2000), there has been significant debate as to whether the UNFSA obligation could be imposed on non-parties to UNFSA (Orebech, Sigurjonsson and McDorman 1998, Bratspies 2001). Despite the drafting language of the UNFSA purporting to create an obligation to ‘comply or refrain’ for all states, and the desire to create an international legal norm to stop “recalcitrant state[s] [being] a spoiler for the entire international community” (Charney 1993), commentators have finally concluded the *Pacta tertiis* rule prevails (Orebech *et al.* 1998, Franckx 2000).

¹⁷ CCAMLR contracting parties are – Argentina, Australia, Belgium, Brazil, Chile, European Community, France, Germany, India, Italy, Japan, Republic of Korea, Namibia, New Zealand, Norway, Poland, Russian Federation, South Africa, Spain, Sweden, UK, Ukraine, USA and Uruguay.

¹⁸ See <http://www.itf.org.uk/seafarers/foc/Body_foc.html>. The International Transport Workers Federation identifies the following countries as flags of convenience – Antigua and Barbuda Bahamas, Barbados, Belize, Bermuda, Bolivia, Burma/Myanmar, Cambodia, Cayman Islands, Comoros, Cyprus, Equatorial Guinea, Germany (second register), Gibraltar, Honduras, Jamaica, Lebanon, Liberia, Malta, Marshall Islands, Mauritius, Netherlands Antilles, Panama, Sao Tome and Principe, St. Vincent & The Grenadines, Sri Lanka, Tonga and Vanuatu. Of these 29 States, only 5 have not enter into a treaty ‘duty to cooperate’ in respect of high seas fishing.

¹⁹ See <<http://www.traffic.org/toothfish/tooth2.html>>.

²⁰ See <<http://archive.greenpeace.org/oceans/piratefishing/dodgingrules.html>>.

The *Pacta tertiis* rule provides that treaty obligations bind only those states that have consented to be bound.²¹ Without the express consent of states or the development of customary international law, the obligation to ‘comply or refrain’ would be limited in effect to UNFSA parties.

It has been suggested that theoretically the UNFSA obligations are unlikely to develop into customary international law, because the rules are too “technical and concrete” (Franckx 2000) to be appropriately developed as customary international law. Franckx (2000) contrasted the UNFSA to the LOSC, and concluded that because of the special nature of the 1982 Convention and the “quasi-universal adherence to it” the LOSC may have application beyond the parties, but that UNFSA did not. He further considered that where the UNFSA provisions “merely implemented” the LOSC but did not “go beyond its framework by incorporating rules, which cannot be reconciled with the content” of the LOSC then those rules would be binding on the parties to the LOSC. However, Franckx considered that the nature of the UNFSA Art. 8(4) obligation to ‘comply or refrain’ was of “novel character” and reflected “progressive development rather than codification of present day international law”. He concluded that “[a]s a consequence, even though the article in question only uses the term ‘States’, its application remains restricted to the parties to the 1995 Agreement”.

An alternative interpretation considers that the Article 8(4) obligation to ‘comply or refrain’ merely reflected a particularisation of the 1982 Convention’s “duty to cooperate” (Upton and Vangelis 2003). In the US Shrimp–Turtle case, the Appellate Body of the WTO considered that the generic term ‘natural resource’ was not “static in its content or reference, but rather by definition, evolutionary”. The Appellate Body interpreted the term in light of the acknowledgements made by the international community through bilateral and multilateral forums. It cited as authority for this approach the Namibia (Legal Consequences) Advisory Opinion (1971) ICJ Rep 31 where the Appellate Body had found

“The International Court of Justice states that where concepts embodied in a treaty are by ‘definition, evolutionary’, their ‘interpretation cannot remain unaffected by the subsequent development of law [...] Moreover, an international instrument has to be interpreted and applied within the framework of the entire legal system prevailing at the time of interpretation.”

Rayford (1999) has suggested that for the LOSC “to maintain its relevance and stature as the ‘constitution’ of the oceans, interpretation of its provisions today must account for alter[ing] realities and customary developments”.²² Multilateral forums have shaped contemporary international law (Charney 1993) and have played a significant role in particularising the elements of the LOSC duties and obligations that are necessary to meet current international expectations.

In the recently concluded International Plan of Action to prevent, deter and eliminate illegal, unreported and unregulated fishing (IPOA–IUU) (FAO 2001) it is recorded that states who are not members of regional fisheries management organizations “are not discharged from their obligation to cooperate” with those organizations. States are to “give effect to their duty to cooperate by agreeing to apply the conservation and management measures established by that regional fisheries management organization, or by adopting measures consistent with those conservation and management measures, and should ensure that vessels entitled to fly their flag do not undermine such measures” (Art. 79, FAO 2001).

²¹ The *Pacta tertiis* rule is both a rule of customary international law and codified in the Vienna Convention on the Law of Treaties.

²² Rayfuse (1999) cites the case concerning Gabcikovo–Nagymaros Project (Hungary/Slovakia) ICJ, 25 September 1997, para 140 “Such new norms have to be taken into consideration, and such new standards given proper weight, not only when States contemplate new activities but also when continuing activities of the past. This need to reconcile economic development with protection of the environment is aptly expressed in the concept of sustainable development”.

Interpreting the 1982 Convention's "duty to cooperate" as requiring parties to 'comply or refrain' is consistent with international development. Currently one hundred and forty-two states have agreed to 'cooperate in the conservation and management' of high-seas fish stocks and to use regional fisheries organizations as appropriate. Regional fisheries organizations cannot effectively conserve and manage these fisheries unless the duty to cooperate requires states to 'comply or refrain'. One hundred states involved in negotiating the text of the UNFSA mandated with considering "means of improving fisheries cooperation among states" articulated the obligation to 'comply or refrain' in an article entitled 'Cooperation for conservation and management measure' (FAO 2001). Non-party fishing was classified as 'unregulated' and deserving of punitive measures under the IPOA-IUU, adopted at the 24th session of the FAO Committee on Fisheries.

The LOSC 'duty to cooperate' is yet to be defined under the international dispute resolution procedures and to date only the 'duty to cooperate' matter has been referred to the International Tribunal for the Law of the Sea (ITLOS). That was in regard to the Chile-European Community case concerning the conservation and sustainable exploitation of swordfish stocks in the South-Eastern Pacific Ocean. The dispute was resolved prior to any determination by the Tribunal.

Despite the apparent limits under international law of the ability to bind non-parties, and without clarifying the duty through the LOSC mechanisms, members of regional fisheries management organizations have been tempted to consider fishing by non-parties as illegal (Chaves 2001)²³ rather than unregulated by the organization. As a consequence they have begun to develop compliance measures based upon this conviction.

The perceived failure of regional fisheries management organizations to deter 'free-riders' has led to members seeking compliance measures to give their agreement 'teeth'. To strengthen the effectiveness of regional fisheries management organizations, modern agreements include provisions requiring member states to take measures to deter non-compliant fishing activities by non-cooperating states.²⁴ At a global level, parties to UNFSA have agreed to "take measures consistent with [that] Agreement and international law to deter the activities of vessels flying the flag of non-parties which undermine the effective implementation of the Agreement".

At a regional level similar provisions are being adopted (WCPT, Art. 32(1); SEAFO, Art. 22(3)). The Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (WCPT) obliges all members to "take measures consistent with the Convention, the Agreement and international law to deter the activities of vessels flying the flags of non-parties to this Convention which undermine the effectiveness of conservation and management measures" (e.g. WCPT, Art. 32(1)). It is under the authority of these types of provisions that members of CCAMLR, ICCAT and Chile under the Galapagos Agreement have implemented trade measures against non-parties.

Fisheries-related state-imposed trade measures primarily include import prohibitions, flag state certification schemes, and port state landing prohibitions. Importation prohibitions are a blanket approach by which the importing state declares that specific fish from a specific country will not be imported. Flag state certification schemes have been adopted by a number of regional fisheries management organizations as a

²³Chaves suggested that regional fisheries management organizations should implement a trade certification scheme "whose goal is to allow commerce in only legally harvested fish", missing the point that non-party fishing is unregulated, not illegal according to the IPOA-IUU.

²⁴E.g. Art. 15(4) of the Convention for the Conservation of Southern Bluefin Tuna (concluded May 1993); Art. XII(3) of the Convention on the Conservation and Management of Pollock Resources Central Bering Sea (concluded June 1994); Art. 22(3) of the Convention on the Conservation and Management of Fishery Resources in the South East Atlantic Ocean (concluded November 2000).

means of establishing the total harvest; member states require the flag state to declare from where the fish has been taken prior to import. Port state landing prohibitions are implemented on a vessel-by-vessel basis; here port states exercise their exclusive jurisdiction to control vessel activities while in their internal waters. This assumption was challenged in the EC-Chile dispute, but was not resolved. Port state measures were introduced to fisheries management in 1989 with the adoption of the Convention for the Prohibition of Fishing with Long Drift-nets in the South Pacific. This Convention provided for member states to restrict access to ports and port facilities where vessels had been involved in drift-net fishing (Lobach 2001).

The UNFSA adopted the concept of port state measures when it had been established that catches were being taken in “a manner that undermines the effectiveness of” (UNFSA, Art. 23) regional or global conservation measures for the high seas but it did not address the inevitable interaction between these measures and international trade agreements. It is yet to be resolved whether port state measures and import bans are consistent with international law. However, there is a clear tension between achieving sustainable utilisation of the ‘commons’ and maintaining states’ obligations under international trade agreements. While Greenpeace has asked governments to stop the use of flags of convenience by closing their ports, closing their markets, and prohibiting their nationals from owning or operating flag of convenience vessels,²⁵ developing states claim these measures are discriminatory (Upton and Vitalis 2003).

3.4 Contemporary consideration of trade measures

International trade accounts for nearly 40 percent of all fishery products (Chaves 2001) so the significance of trade access has had a major impact on the thinking of states in determining how to leverage non-parties to ‘comply or refrain’ (Parker 1999). Trade sanctions that are ‘WTO consistent’ are “considered an essential strategy to enforce global norms because many international institutions suffer from an enforcement gap” (Kelly 2001). These measures have the potential to significantly affect developing states because the “flow of international fisheries trade is from developing countries to industrial countries” (McDorman 1999).

The World Trade Organization had 146 members as of April 2003. The majority of these members are also parties to the LOSC. The WTO obligations on members significantly limit the lawful actions that can be taken by states to encourage non-party compliance with regional fisheries management organizations (Upton and Vitalis 2003). Regional fisheries organizations are currently promoting trade sanctions to obtain compliance from non-parties but these measures are yet to receive scrutiny or endorsement from the WTO (Kelly 2001).

Signatories to the General Agreements on Tariffs and Trade (GATT) have adopted a multilateral trade system to “reduce and eliminate international trade barriers and [which] strives to provide equal access to foreign markets”. The WTO was established to implement the agreed trade policies and it is the WTO that provides the dispute resolution mechanisms to resolve conflict between members (Owen 2000).

The WTO does not ‘positively regulate’ trade, rather through adjudication it clarifies and expands the norms negotiated by the members. Historically, broad principles of customary international law have not been applied by the WTO to disputes. Recently commentators have suggested, “the broad principles of customary international law, such as human rights norms and the precautionary principle, are universal norms superior to negotiated trade norms and therefore should be applied by WTO dispute panels” (Kelly 2001). It has also been suggested that the customary international rule of sustainable development should be reflected in the WTO system. The object of sustainable development may be defined as to “consider the needs of

²⁵ See <http://achieve.greenpeace.org/oceans/pirate_fishing/troubleahead.html>.

present and future generations; accept limits on the use and exploitation of natural resources for environmental protection reasons; apply equity in the allocation of rights and obligations; and to integrate all aspects of environment and development” (Dailey 2001).

GATT contains three foundation principles: “most favoured nation treatment, national treatment and the prohibition of quantitative restrictions on trade”. Any restraint on trade by one member of the GATT against another provides a basis for commencing dispute resolution procedures available only to WTO (Owen (2000).

When considering trade measures employed by members of regional fisheries management organizations to deter fishing by non-parties, there are relevant GATT rules (GATT, Art. V).

- i. WTO members have agreed that there is to be freedom of transit through the territory of each member (GATT, Art. V).
- ii. No distinction is to be made on the basis of flag of vessel, place of origin, departure, entry, exit or destination, or on any circumstances relating to the ownership of goods, of vessels or of other means of transport (GATT, Art. V).
- iii. Goods are considered to be in transit when the passage across such territory is only a portion of a complete journey (GATT, Art. V). This transit obligation is relevant when considering the legitimacy of coastal states using port closures and landing prohibitions to deter the fishing activities of non-parties.
- iv. WTO members have also agreed to prohibit the use of quantitative restrictions on imports and exports (GATT, Art. XI), a relevant obligation when considering the use of import or export bans to support regional fisheries management organizations’ conservation measures.

GATT has made some provision for “green exceptions” (Polick 2001) to these rules. Article XX provides an exception where the trade measures are implemented in a manner that does not constitute a means of arbitrary or unjustifiable discrimination and are not disguised restrictions on international trade; and the measures are “necessary to protect human, animal or plant life or health” or where measures relate to the “conservation of exhaustible natural resources” and are “made effective in conjunction with restrictions on domestic production or consumption” (GATT, Art. XX (b) and (g)).

The use of import bans to support regional fisheries management organizations commenced with the endorsement of the imposition of measures in the International Commission for the Conservation of Atlantic Tunas (ICCAT).²⁶ In 1996 the Commission recommended that import prohibitions be implemented against Belize,²⁷ Honduras²⁵ and Panama²⁸ in respect of the imports of bluefin tuna. These measures were to have effect from 4 August 1997 against Belize and Honduras and from 1 January 1998 against Panama. These states were non-parties to ICCAT and classified as flags of convenience. This recommendation was implemented by the United States and Japan,

²⁶ See NOAA 96-76 press release “The import bans represent the first time multilateral measures have been authorized by an international fishery management organization to enforce compliance with conservation rules.” <<http://www.publicaffairs.noaa.gov/pr96/nov96/noaa96-76.html>>.

²⁷ Recommendation by ICCAT Regarding Belize and Honduras Pursuant to the 1994 Bluefin Tuna Action Plan Resolution (96-11). This recommendation entered into force on 4 August 1997 and the measures were to be effective from that date. In 1999 a import ban was recommended against Belize and Honduras in respect of swordfish, see Recommendation by ICCAT Regarding Belize and Honduras Pursuant to the 1995 Swordfish Action Plan Resolution (99-9), which entered into force on 15 June 2000. In 2000 a further import ban was imposed against Belize, Cambodia, Honduras, St. Vincent & Grenadines in respect of Atlantic bigeye tuna, see Recommendation by ICCAT Regarding Belize, Cambodia, Honduras, and St. Vincent & Grenadines Pursuant to the 1998 Resolution Concerning the Unreported and Unregulated Catches of Tuna by Large-Scale Longliner Vessels in the Convention Area.

²⁸ Recommendation by ICCAT Regarding Panama Pursuant to the 1994 ICCAT Bluefin Tuna Action Plan Resolution (96-12). This recommendation entered into force on 4 August 1997, but measures were not to take effect until 1 January 1998.

although the United States had never imported bluefin tuna from these states.²⁹ Japan also prohibited port calls by tuna longline fishing vessels registered in Panama, Belize and Honduras because those countries were designated by ICCAT as “diminishing the effectiveness of the management regime” (Komatsu 2001).

On 28 December 1998 Panama became a contracting party to ICCAT and at the 1999 Commission meeting it was recommended that member states lift the import prohibition on Panama in recognition of their new status. On 30 January 2000 Honduras became a member and as a result at the 2001 commission meeting it was recommended that the importation prohibition be lifted against Honduras. To date Belize still remains a non-party. The effective use of trade sanctions by the United States and Japan to encourage participation in ICCAT and the absence of WTO challenge appears to have encouraged other regional fisheries management organizations to implement these types of measures.

Subsequently, CCAMLR has been at the forefront of implementing trade sanctions. CCAMLR scientists have divided the convention area into a number of statistical areas for which management conservation measures have been adopted in respect of toothfish fisheries. These measures include: imposing catch limits for areas where access is subject to the jurisdiction of coastal states;³⁰ permitting exploratory fishing only,³¹ prohibiting fishing except for scientific research;³² and prohibiting fishing entirely.³³ To support these management measures compliance conservation measures have been imposed to deter the fishing activities of non-parties in the convention area.

CCAMLR now requires contracting parties to inspect all fishing vessels that enter their ports carrying toothfish,³⁴ to determine whether the fish was taken in the Convention Area and whether the fishing activity was in accordance with the conservation and management measures.³⁵ If vessel masters intend to land catch taken from the Convention area, the port state must confirm that all toothfish is accompanied by appropriate catch documentation.³⁶ Where there is evidence of fishing in the Convention area in contravention of the conservation and management measures, landing or transshipment is to be prohibited.³⁷

As every landing of toothfish must be accompanied by a completed catch documentation declaration, the Commission provides for cooperating non-contracting parties to issue catch documentation forms.³⁸ However, landing of fish taken in the

²⁹NOAA Press Release 97-R158 “US Bans Bluefin Tuna Imports From Three Nations Fishing in Violation of ICCAT” <<http://www.noaa.gov/public-affairs>> which stated “While no Atlantic bluefin tuna are currently imported into the United States from these countries, a formal prohibition against such imports was necessary to close the potential market and to support the anticipated actions of other ICCAT member countries such as Japan. Japan imports about 90 percent of the world’s bluefin tuna harvest.”

³⁰E.g., Conservation Measure 41-02 (2002) set a total allowable catch of 7 810 t for the *Dissostichus eleginoides* fishery in Statistical Sub-area 48.3 for vessels using longliners and pots only; Conservation Measure 41-03 (1999) setting a total allowable catch of 28 t for the *D. eleginoides* fishery in Statistical Sub-area 48.4. Access to these areas are regulated by coastal States.

³¹For example, Conservation Measure 41-04 (2002) limiting the toothfish fishery in Statistical Sub-area 48.6 to exploratory longline fishing by Japan, New Zealand and South Africa, and setting a precautionary catch limit at 455 t; Conservation Measure 41-05 (2002) limiting the toothfish fishery in Statistical Sub-area 58.4.2 to exploratory longline fishing by Australia, and setting a precautionary catch limit of 500 t.

³²For example, Conservation Measure 41-03 (1999) limiting the *Dissostichus mawsoni* fishery in statistical Sub-area 48.4 to scientific research only.

³³For example, Conservation Measure 32-09 (2002) “Prohibiting of Directed Fishing for *Dissostichus* spp. Except in accordance with Specific Conservation Measures in the 2002/03 Season”.

³⁴CCAMLR Conservation Measure 10-03 (2002) Port Inspections of Vessels Carrying Toothfish.

³⁵CCAMLR Conservation Measure 10-03, paragraph 1.

³⁶CCAMLR Conservation Measure 10-03, paragraph 1.

³⁷CCAMLR Conservation Measure 10-03, paragraph 3.

³⁸CCAMLR Measure 10-05 (2002) Catch Documentation Scheme for *Dissostichus* spp.

Convention area by non-contracting parties is prohibited. The catch documentation form requires masters to declare if toothfish was taken in a manner consistent with the CCAMLR conservation measures. If a non-contracting party has taken catch in the Convention area that catch will be presumed to have been taken in a manner that undermines “the effectiveness of CCAMLR conservation and management measures”³⁹ and on that basis landing is prohibited.

Recently Seychelles, Singapore, Mauritius and China have all implemented the catch documentation scheme for their ports as cooperating non-parties.⁴⁰ Namibia joined the Commission and implemented the catch documentation scheme in February 2001. CCAMLR has established a fund for enhancing the capacity of the Commission to improve the catch documentation scheme. The fund may be used to assist acceding states and non-contracting Parties that wish to cooperate with CCAMLR and implement a catch documentation scheme.

At each Commission meeting vessels that have engaged in illegal, unreported or unregulated fishing in the convention area are identified and entered on an ‘IUU Vessel List’.⁴¹ To the extent possible under their domestic legislation, all contracting parties are required, *inter alia*, to prohibit listed IUU vessels from fishing in their national jurisdiction, prohibit those vessels landing in their ports and prohibit importation of toothfish taken by those vessels.

The Commission has labelled the trade measures agreed by the contracting parties “multilateral trade-related measures”. These trade measures have yet to be challenged, however, similar measures were challenged in the Chile-European Community Swordfish dispute that arose from port state measures implemented under the Galapagos Agreement for the Conservation of Living Marine Resources on the High Seas of the South Pacific (the Galapagos Agreement).

The Galapagos Agreement was concluded by four coastal states – Chile, Colombia, Ecuador and Peru in August 2000. The Agreement was a purely high-seas arrangement with the exclusive economic zones of the coastal states expressly excluded from the area of application (Art. 3). Distant water fishing nations were able to accede to the agreement if they had “an established interest” (Art. 1(3)) in specific fishery resources in the agreement area. An ‘established interest’ was defined “interest demonstrated by a state whose nationals habitually fish for one or more fish populations within [the] Agreement’s area of application and whose participation may fall within the scope of this interest” (Art. 1(4)).

The Agreement required the Parties to prevent “disembarkation and ship-to-ship transfers when reasonable grounds exist to believe that captures of fish in the Agreement’s area of application have been carried out in the contravention of the rules and conservation measures adopted by the States Parties” (Art. 9(b)). It was agreed that the state parties in relation to non-parties would either “individually or collectively, adopt appropriate measures, compatible with international law, to dissuade fishing vessels flying the flags of non-party states from undertaking activities which undermine the effectiveness of the conservation measures adopted” (Art. 13).

Pursuant to these provisions Chile closed its ports to vessels flagged to states in the European Community that fished for swordfish in the high-seas area subject to the Agreement. In November 2000 the European Community requested a WTO dispute resolution panel be established to consider the port prohibition imposed by Chile. The

³⁹CCAMLR Conservation Measure 10-07 (2002) Scheme to Promote Compliance by Non-Contracting Party Vessels with CCAMLR Conservation Measures, par. 3.

⁴⁰Report of the Twentieth Meeting of the Commission, Hobart, Australia, 22 October–2 November 2001, CCAMLR XX, 132.

⁴¹CCAMLR Conservation Measure 10-07 (2002) Scheme to Promote Compliance by Non-Contracting Party Vessels with CCAMLR Conservation Measures.

European Community claimed that prohibiting the unloading of swordfish in Chilean ports rendered transit and importation impossible. (WTO WT/DS193/2, 7.11.2000). The European Community considered that the prohibition was “inconsistent with Art. V:1-3 and XI:1 of the GATT 1994 and, as a result nullif[ied] the benefits to the EC under that agreement”

In December 2000 Chile commenced proceedings in the ITLOS requesting that the dispute be submitted to a special chamber of the Tribunal.⁴² On 20 December 2000 the ITLOS unanimously agreed to form a special chamber of five judges to hear the dispute⁴³. The issues included: whether the European Community had complied with its obligations under Articles 116–119 to ensure conservation of swordfish; whether the European Community had complied its Article 64 obligation to cooperate with Chile as coastal state for the conservation of swordfish; whether the European Community had challenged the sovereign right and duty of Chile to prescribe conservation measures and implement port state measures, and whether such a challenge would be incompatible with the LOSC; whether the Articles 300 and 297(1)(b) obligations had been fulfilled by the European Community.

For the European Community the issues included: whether Chile’s domestic legislation imposing the ‘unilateral conservation measure’ was in breach of Articles 87, 89 and 116–119 of the LOSC; whether the Galapagos Agreement was negotiated in accordance with Art. 64 and 116–119 of the LOSC; whether Chile’s actions conformed with Article 300; and whether the special chamber had jurisdiction over the issue of the European Community challenge to Chile’s ‘sovereign right and duty’ by commencing the WTO dispute procedures.

Prior to either body considering these matters Chile and the European Community resolved their dispute. The European Community and Chile established a bilateral Scientific and Technical Commission to exchange information on swordfish stocks, fishing activities of the parties, environmentally safe and cost-effective fishing gear; to evaluate the state of the stocks; to identify research priorities and to draw-up necessary programmes; to advise on possible conservation measures; and consider further means of cooperation in scientific, technical or administrative fields. A research programme was also commenced allowing Chilean vessels and European Community vessels to each take 1 000 t of swordfish a year. They also agreed to commence a joint initiative to promote multilateral cooperation for the conservation of the stocks throughout their range (WTO WT/DS193/3, 06.04.2001).

3.5 ‘WTO Consistent’ Assessment

In the United States there have been an increasing number of statutes that authorize the imposition of unilateral trade measures as a method of pressuring other states on environmental issues (McLaughlin 1997). When challenged, these measures have failed to withstand the scrutiny of the WTO Appellate Body. Its decision in the United States – Import Prohibition of Certain Shrimp and Shrimp Products case (the US Shrimp–Turtle case) provided some direction to regulatory agencies on the framework required for trade measures to withstand WTO challenge (Owen 2000).

In the Shrimp–Turtle case the United States had enacted a law that prohibited the import of shrimp or shrimp products harvested by a method that “trap[ped] and suffocate[d] endangered sea turtles” (Dailey 2000). The legislation placed as a prerequisite for access to the United States market that the shrimp be certified as having been taken “under conditions that do not adversely affect sea turtles” or that the shrimps were harvested in “waters of a nation currently certified”. Certificates were to

⁴²Order of the ITLOS “Case Concerning the Conservation and Sustainable Exploitation of Swordfish Stocks in the South-Eastern Pacific Ocean” 20.12.2000.

⁴³Order of the ITLOS “Case Concerning the Conservation and Sustainable Exploitation of Swordfish Stocks in the South-Eastern Pacific Ocean” 20.12.2000.

be granted “to countries with a fishing environment which [did] not pose a threat of the incidental taking of sea turtles in the course of shrimp harvesting”. The United States Secretary of State was also called upon to “initiate negotiations as soon as possible for the development of bilateral or multilateral agreements with other nations for the protection and conservation of [...] sea turtles”.⁴⁴

The WTO dispute settlement panel found the legislation was not consistent with Article XI:1 of the GATT 1994, and “could not be justified under Article XX”. The United States did not appeal the finding, instead it appealed on whether the panel was correct in determining that the measure constituted unjustifiable discrimination between countries where the same conditions prevail. The Appellate Body considered that a balance must be struck between the rights and duties of members and suggested that parties achieve this equilibrium in agreements that contain “consensual undertakings”, and they implement environmental measures while giving ‘reaffirmation’ to WTO obligations. In considering whether the measure constituted ‘unjustifiable discrimination’ the Appellate Body commented that “[p]erhaps the most conspicuous flaw in this measure’s application relates to its intended and actual coercive effect on the specific policy decisions made by foreign governments which are members of the WTO”.⁴⁵

The Appellate Body found that the United States had failed to engage in “serious, across-the-board negotiation with the objective of concluding bilateral or multilateral agreements for the protection and conservation of sea turtles” and that the process for determining not to issue a certificate for a foreign state did not meet the “standards for transparency and procedural fairness in the administration of trade regulations.” In determining this, the Appellate Body considered first whether the measure could be characterized as a XX(g) exception, and then whether the measure breached the chapeau. They emphasized that the purpose and object of the chapeau was to prevent abuse of the exceptions and an expression of the “principle of good faith”.⁴⁶

The Appellate Body went through six steps before determining that the measure was unjustifiably and arbitrarily discriminating. It determined: whether sea turtles were an exhaustible natural resource; whether there was a jurisdiction nexus between the United States and the turtles; whether the measure related to the conservation of an exhaustible natural resource; whether the measures were imposed on domestic vessels; whether there was unjustifiable discrimination between countries where the same conditions prevail, questioning whether the measure was reasonable, fair and equitable; and whether there was arbitrary discrimination.

Comparing and contrasting New Zealand’s domestic implementation of the CCAMLR measures with the Appellate Body’s consideration of the issues in the US Shrimp–Turtle case provides a useful framework for examining whether the WTO dispute resolution process is likely to find these types of fisheries trade measure ‘WTO consistent’. A similar exercise has been undertaken, in respect of the United States’ implementation of the CCAMLR catch documentation scheme. Polick (2001) concluded that the measures were likely to survive scrutiny because the regulations “in reality should not prevent or limit the importation of toothfish” and determined that toothfish could be landed accompanied by catch documentation issued by non-contracting parties, without any assessment as to whether the catch had been taken consistent with the CCAMLR conservation measures.

New Zealand has domestic statutory authority under the *Fisheries Act 1996* (Section 113ZD) to implement port state measures to prohibit the landing of toothfish taken in a manner that undermines CCAMLR conservation measures (Section 113ZD, *Fisheries Act 1996*). The Chief Executive of the Ministry of Fisheries has the statutory

⁴⁴ US Shrimp–Turtle case (Appellate Body).

⁴⁵ US Shrimp–Turtle case (Appellate Body).

⁴⁶ US Shrimp–Turtle case (Appellate Body).

power to prohibit vessels coming into New Zealand's internal waters where he or she is satisfied that the vessel has been used to undermine international conservation and management measures. The Minister of Fisheries has also been empowered to prohibit vessels entering New Zealand's internal waters that have undermined international conservation and management measures.

New Zealand has implemented the CCAMLR catch documentation scheme and import and export prohibitions through a variety of domestic legislation.⁴⁷ The importation of Patagonian and Antarctic toothfish⁴⁸ is prohibited unless covered by a completed catch document "issued by a party to the Convention" By requiring the catch to be accompanied by a catch document issued by a party, New Zealand has prohibited importation of toothfish caught by nationals of cooperating non-contracting parties. Exportation of Patagonian and Antarctic toothfish is also prohibited unless accompanied by party issued catch documentation (*Customs Export Prohibition* (toothfish) *Order 2003*, Section 4).

Foreign-flagged vessels may only land Patagonian and Antarctic toothfish in New Zealand if the master of the vessel has completed catch documentation issued by a "party other than New Zealand". If fish is landed in contravention of this requirement the master commits an offence and is liable to a fine up to NZ\$100 000.⁴⁹

This domestic implementation does not allow for cooperating non-parties to issue the catch documentation. Further, because the CCAMLR measures and New Zealand's implementation has made no distinction between toothfish taken in the Convention area and toothfish taken outside the Convention,⁵⁰ New Zealand has prohibited the landing, import and export of all Patagonian and Antarctic toothfish by non-parties irrespective of whether it was taken inside the Convention area and irrespective of whether the non-party is a cooperating non-party.

4. EVALUATION OF TRADE MEASURES IN RELATION TO NEW ZEALAND

4.1 Exhaustible natural resource – comparison

In the US Shrimp–Turtle case the Appellate Body was satisfied "in the light of contemporary concerns of the international community about the protection and conservation of the environment", that sea turtles were indeed a "natural resource" (US Shrimp–Turtle case (Appellate Body)). In making this finding the Appellate Body was mindful of the members' commitment to sustainable development of the world's resources as provided in the preamble to the WTO Agreement. The Appellate Body also considered that it was beyond challenge that sea turtles were an exhaustible resource as recognized by their inclusion in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) as a species "threatened with extinction" [US Shrimp–Turtle case (Appellate Body) (Dailey 2000)].

At the 21st meeting of the CCAMLR Australia advised the Commission that "it had nominated toothfish for listing under Appendix II of the CITES". Most CCAMLR members expressed concern with Australia's proposal and urged Australia to withdraw its nomination. Members were mainly concerned that Australia's proposal was not based on CCAMLR scientific data; that CITES listing were 'species' based rather than 'stock' based and therefore toothfish could not meet the criteria for 'endangered'

⁴⁷ *Fisheries Act 1996*, *Antarctic Marine Living Resources Act 1981*, *Fisheries* (Toothfish Catch Documentation Scheme) *Regulations 2000*, *Customs Import Prohibition* (toothfish) *Order 2003*, and *Customs Export Prohibition* (toothfish) *Order 2003*.

⁴⁸ Section 2, *Customs Import Prohibition* (toothfish) *Order 2003*; Regulation 4, *Fisheries* (toothfish *Catch Documentation Scheme Regulations*) 2000; Section 4, *Customs Export Prohibition* (toothfish) *Order 2003*.

⁴⁹ *Fisheries* (Toothfish Catch Documentation Scheme) *Regulations 2000*, Regulations 8 and 9.

⁵⁰ Antarctic toothfish can only be taken in the convention area, however Patagonian toothfish can be taken beyond the convention area. See <<http://www.niwa.co.nz/ncfa/fau/2003-06/>>.

when the CCAMLR scientific committee were recommending increasing the TAC for a toothfish stock in Sub-area 48.3; and the proposal had not been discussed by CCAMLR members before making the nomination. The Commission did, however, agree to engage in further cooperation with CITES and to “urge all CITES Parties to require a CCAMLR CDS document on all toothfish imports”.

The absence of a CITES listing should not be fatal to establishing exhaustibility. The CCAMLR conservation measures restricting fishing effort have been agreed multilaterally on advice from a scientific committee for the purpose of conserving and managing the fisheries. With sustainable development accepted as a customary international norm (Dailey 2000), there should be no difficulty in establishing toothfish to be an ‘exhaustible natural resource’.

4.2 Jurisdictional Nexus – comparison

In the US Shrimp–Turtle case the WTO Appellate Body considered that there was a sufficient jurisdictional nexus between the United States as the ‘import banning state’ and the resource, for the purposes of XX(g). The Appellate Body found that because the species of sea turtles subject to the import ban were all found within the national jurisdiction of the United States, and information indicated that in certain circumstances those species migrated, there was “sufficient nexus between the migratory and endangered marine populations involved and the United States” (US Shrimp–Turtle case (Appellate Body)).

As Patagonian toothfish is found in the New Zealand EEZ and New Zealand participates in the regional organization responsible for conservation of Patagonian and Antarctic toothfish, there appears to be ample jurisdiction nexus between the species and New Zealand. CCAMLR was established to “conserve the marine living resources of the Antarctic marine ecosystem”⁵¹ and it also demonstrates the attributes of a regional fisheries management organization acting under the auspices of the United Nations.⁵²

4.3 Measure ‘related to’ conservation – comparison

In the US Shrimp–Turtle case the Appellate Body examined the trade measure to determine whether it was ‘related’ to the conservation of the exhaustible natural resource. The Appellate Body required a “substantial relationship” between the measure and the conservation goal defining such a relationship as a “close and genuine relationship of ends and means”.

The Appellate Body found that the exemptions from the import ban related “clearly and directly to the policy goal of conserving seas turtles” (Dailey 2000). The policy implementation of the import ban was designed not to be a blanket prohibition “without regard to the consequences (or lack thereof) of the mode of harvesting employed upon the incidental capture or mortality of sea turtles”. On that basis the Appellate Body concluded that the measure and policy guidelines were “not disproportionately wide in its scope and reach in relation to the policy objective of protecting and conservation of sea turtle species”, and therefore the means were “in principle, reasonably related to the ends”.

CCAMLR conservation measures restricting landing, import and export are designed to support the measures that restrict fishing effort in the Convention area. CCAMLR had carefully allowed for non-parties to certify the fish as being taken outside the Convention area and therefore as being consistent with the conservation measures for the Convention area. Had New Zealand faithfully implemented

⁵¹CCAMLR Resolution 18/XXI Harvesting of *Dissostichus eleginoides* in Areas Outside the Coastal State Jurisdiction adjacent to the CCAMLR Are in FAO Statistical Areas 51 and 57.

⁵²CCAMLR Resolution 18/XXI Harvesting of *Dissostichus eleginoides* in Areas Outside the Coastal State Jurisdiction adjacent to the CCAMLR Are in FAO Statistical Areas 51 and 57.

those measures into domestic legislation there would have been a tangible ‘means/ends’ relationship between the CCAMLR conservation measures and the domestic implementation. However a prohibition on all landing, import or export of toothfish by non-parties irrespective of cooperation or fishing area appears disproportionately wide for CCAMLR’s stated conservation purpose.

4.4 Domestic consistency – comparison

In the US Shrimp–Turtle case the Appellate Body was satisfied that there was ‘evenhandedness’ in the imposition of restrictions because the United States shrimp trawlers were required to comply with the United States regulatory regime (US Shrimp–Turtle case (Appellate Body), Dailey 2000).

New Zealand has imposed under its domestic legislation a requirement for all toothfish to be accompanied by catch documentation, therefore fish taken by domestic fishers is subject to the same requirements as fish taken by foreign fishers. However, New Zealand’s access to the CCAMLR fisheries could form the basis of an ‘unevenhandedness’ challenge.

While coastal states control access to CCAMLR fisheries inside exclusive economic zones, CCAMLR controls access to exploratory fisheries on the high seas areas in the Convention Area. Access is granted on an annual basis and there is no state allocation of quota. For the areas that are open for exploratory fishing all members are entitled to submit an exploratory fishing plan for consideration by the Commission. Therefore, new entrants have the same opportunity to gain access to those fisheries.

Over time New Zealand has negotiated access to three exploratory fisheries. For the 2002/2003 fishing year New Zealand was granted access for the purpose of exploratory fishing to Sub-areas 88.1, 88.2 which contains the Ross Sea and 48.6. In Sub-area 88.1 two vessels from Japan, six vessels from New Zealand, two vessels from Russia, two vessels from South Africa and one vessel from Spain were authorized by the Commission to fish. The total precautionary catch limit for those vessels was 3 780 t. In Sub-area 88.2 two vessels from Japan, five vessels from New Zealand and two vessels from Russia were authorized by the Commission to fish. The total precautionary catch limit for those vessels was 375 t. In Sub-area 48.6 one vessel from Japan, one vessel from New Zealand and one vessel from South Africa were authorized by the Commission to fish. The total precautionary catch limit for those vessels was 910 t.

While New Zealand has to date had greater access than other states, given access is negotiated each year, a determination that this access could amount to ‘unevenhandedness’ is unlikely. If every state is able to join CCAMLR, and every state is entitled to submit an exploratory fishing plan, as long as the process for determining access is fair it would be reasonable to conclude that there is no ‘unevenhandedness’.

4.5 Unjustifiably discriminatory – comparison

In the US Shrimp–Turtle case the Appellate body concluded that the legislation and guidelines were “provisionally justified under Article XX(g)” (Dailey 2000) and went on to consider whether there was a breach of the chapeau to that Article. The Appellate Body described the chapeau as providing the line of equilibrium:

“between the right of a member to invoke an exception [...] and the rights of the other members under varying substantive provisions [...], so that neither of the competing rights will cancel the other and thereby distort and nullify or impair the balance of rights and obligations.”

The Appellate Body considered that the line was “not fixed and unchanging; the line moves as the kind and the shape of the measures at stake vary and as the facts making up specific cases differ”. The Appellate Body found that the United States’ measure constituted unjustifiable discrimination because of its “intended and actual coercive effect” on the policy decisions of foreign governments. The measure was “rigid and

unbending”; the measure was “more concerned with effectively influencing WTO members to adopt the same comprehensive regulatory regime”; and the United States had failed to engage “in serious, across-the-board negotiations with the objective of concluding bilateral or multilateral agreements” (US Shrimp–Turtle case (Appellate Body), 149).

The Appellate Body was critical of the United States failure to give due consideration to the different positions and conditions of other WTO members (US Shrimp–Turtle case (Appellate Body), 155) and the practice of the United States of merely exchanging letters with the governments of some of the affected states.⁵³ They concluded that because the United States had negotiated seriously with some states, and not with others, the effect of the measure was “plainly discriminatory and, in our view, unjustifiable” (US Shrimp–Turtle case (Appellate Body), 168).

Arguably, in the absence of an international obligation being breached, impositions of trade measures are prohibited under international trade law on the basis of ‘unjustifiable discrimination’ (McDorman 1999). While the CCAMLR measures have been endorsed by a multilateral forum this does not negate the presence of coercion. These measures are attempting to convince other governments that they are under an obligation to ‘comply or refrain’.

Against the international legal history of the right of states to fish on the high seas, pressuring compliance with an established regional fisheries management regime has the potential to be classified as ‘unjustified discrimination’. New Zealand is currently in an unenviable position, with its domestic implementation of the CCAMLR measures failing to be a faithful implementation. Having cast the prohibition beyond that authorized by the CCAMLR, there is a likelihood that a claim of unjustifiable discrimination could be established.

Further, unlike the United States, New Zealand has LOSC obligations. The 1982 Convention requires that “conservation measures on the high seas must not “discriminate in form or fact against the fishermen of any State” (McLaughlin 1997). The LOSC provided binding dispute resolution procedures for clarifying the nature of rights and obligations under the Convention and bound parties to a duty of good faith. In those circumstances, without a clear obligation on non-parties to ‘comply or refrain’, New Zealand is in jeopardy of breaching its own international obligations (McLaughlin 1997).

4.6 Arbitrarily discriminatory – comparison

In the US Shrimp–Turtle case, the Appellate Body considered that the United States’ process for certifications allowed no opportunity for the affected states to be heard, therefore denying natural justice. The *ex parte* nature of the United States certification process resulted in the Appellate Body finding the measures also amounted to arbitrary discrimination (US Shrimp–Turtle case (Appellate Body) 177, 180).

When measures are developed in multilateral forums, after affected states are put on notice and given the opportunity to communicate with the Commission and Secretariat, they have a degree of transparency and due process. However, should New Zealand ever use its legislative prohibitions to actually stop a landing or import or export of toothfish from a non-party of CCAMLR, the process for refusing the fish would need to be transparent and fair. Currently, under the legislation all non-party toothfish would be prohibited without the non-party having the opportunity to prove that the

⁵³ Compare this to what occurred at the twenty-first meeting of the CCAMLR Commission, the Commission noted “the extensive work conducted by the Secretariat in cooperation with non-Contracting parties”, although, it did not elaborate on the nature and extent of this work. Spain advised that over the past two and a half years it had sent letters to IUU vessel flag States, calling on the States to “comply with their obligations under international law”. Spain recommended that other members also engage in that type of diplomatic action and offered to circulate their standard letter.

catch was taken outside the Convention area or in accordance with the conservation and management measures. The absence of this opportunity could result in a challenge on the basis of arbitrary discrimination.

4.7 Final comments by the Appellate Body

The Appellate Body concluded with a clear statement that WTO consistent measures could be used to protect the environment (US Shrimp–Turtle case (Appellate Body, 181)):

“We have not decided that the protection and preservation of the environment is of no significance to the members of WTO. Clearly, it is. We have not decided that the sovereign nations that are members of the WTO cannot adopt effective measures to protect endangered species, such as sea turtles. Clearly, they can and should. And we have not decided that sovereign states should not act bilaterally, plurilaterally or multilaterally, either within the WTO or in other international fora, to protect endangered species or to otherwise protect the environment. Clearly, they should and do.”

However, it emphasized that member states must fulfil their WTO obligations and respect the rights of other members (US Shrimp–Turtle case (Appellate Body), 182). There was a clear message from this decision: that measures could be ‘WTO consistent’, but that they must be grounded in consent and good faith.

It appears that until the Galapagos challenge it had been assumed by developed states that trade measures applied via a regional fisheries management organization were ‘WTO consistent’ (Upton and Vitalis 2003). However, developing states are now actively promoting the stance that trade measures against non-parties of environmental agreements risk “breaching the non-discrimination provision of GATT” (Upton and Vitalis 2003). Developed states can no longer assume that attempts to make unilateral measures multilateral by obtaining endorsement from a multilateral organization to which the exporting states is not a member will make the measure ‘WTO consistent’.

This divergence of view has resulted in the WTO members excluding consideration of the use of trade measures against non-parties from the Doha Ministerial Declaration (Adopted by WTO on 14 November 2001). Members have limited their negotiations to the relationship between WTO rules and ‘specific trade obligations’ set out in multilateral environment agreements, expressly confirming, “the negotiations shall not prejudice the WTO rights of any member that is not a party to the MEA in question” (Doha Ministerial Declaration, 14 November 2001, par. 31).

By not addressing the most pressing issue for fisheries management organizations, the long-term effectiveness of fisheries management governance hangs in the balance. If WTO members continue to exclude this issue from the international negotiating table, it will ultimately be resolved under an international dispute resolution mechanism. Should governance frameworks be based on the assumption that trade measures can legitimately be used to obtain compliance from non-parties, and that assumption later proves to be false, the international community will be powerless to address ‘free-riders’, and the foundation of the management regime may be irrevocably undermined.

5. GEARING FOR COMPLIANCE

5.1 Background

Achieving sustainable development and effective management of the high seas will require states to engage in the collective management of those stocks and comply with a global obligation to ‘comply or refrain’. Applying the compliance principles to non-party fishing activities assists in identifying why states are continuing to fish in a manner that undermines regional fisheries management organizations, despite members asserting that non-parties are under an obligation to ‘comply or refrain’. Although there are differing reasons for non-compliance depending on whether the state is a non-

party due to lack of capacity or because it is choosing to avoid obligations (Rayfuse 1999), these same principles can be used to design a governance regime that pulls towards compliance. The necessary elements of a new design are clear, there is a need for a global obligation to ‘comply or refrain’. If the obligation cannot be established under the dispute resolution processes of the LOSC, it needs to be negotiated.

5.2 Applying the principle of state self-interest

While ultimately it will be in all states’ self-interest to conserve fisheries for future generations, joining a regional fisheries management organization will not necessarily be in the immediate self-interest of all states. For developing states, if joining a regional fisheries management organization would result in a restriction on fishing effort and the requirement to implement a sophisticated domestic regulatory regime to actively manage the fishing activities of their nationals, the cost-benefit analysis will favour non-compliance (Rayfuse 1999).

A further disincentive for developing states is the risk that once they are members of the organization, punitive measures will still be imposed because they will not be able to meet the regulatory standards required. Equatorial Guinea joined ICCAT in 1987, however, at the 1999 meeting of the Commission, it was recommended that contracting parties prohibit the import of Atlantic bluefin tuna and its products from Equatorial Guinea⁵⁴, despite Equatorial Guinea being categorized by the United Nations as one of the ‘least developed countries’ (<<http://www.unisdr.org/unisdr/LDC.htm>>). In those circumstances a developing state’s self-interest would be best served by denying that there is an obligation to ‘comply or refrain’ rather than joining a regional fisheries management organization, only to receive further punitive measures.

For states that choose to avoid obligations, exercising control may result in the cost of compliance outweighing the benefits. Inevitably, exercising control would encourage vessel operators to use the state as a flag of convenience and to reflag their vessels. In circumstances where these states have no “indigenous fishing fleet of their own capable of participating in the fishery” there is no incentive in current regional fisheries management organizations for those state to comply (Balton 1999).

The principle of state self-interest implies that under the current regimes, for both developing and developed states acting as flags of convenience, the cost of complying outweighs the benefit of complying, therefore, reducing the likelihood of compliance. Positive incentives, rather than punitive, measures appear more likely to achieve compliance at a global level to an obligation to ‘comply or refrain’. Punitive measures may have a role in maintaining compliance with established rules but using these measures to pressure compliance undermines the principle of perceived merit and thus undermines achieving compliance.

Future designs will need to reshape the impacts upon state self-interest through incentives to favour compliance; one mechanism available is guaranteeing a share of high-seas fish stocks to each state. Potentially, the ability to lease a ‘State share’ would provide an incentive for developing states not to fish the high seas in the absence of the ability to control its nationals, receiving a benefit through leasing rather than fishing. However, the allocation model for shares would require careful consideration to ensure it satisfied the principle of perceived merit over time (Applebaum and Donohue 1999).

5.3 Applying the principle of perceived merit

The ambiguity in the 1982 Convention language fails to encourage compliance with an obligation to ‘comply or refrain’. Given that the LOSC failed to include the 1958

⁵⁴ Recommendation by ICCAT Regarding Equatorial Guinea Pursuant to the 1996 Recommendation Regarding Compliance in the Bluefin Tuna and North Atlantic Swordfish Fisheries (99–10).

Convention's requirement of the duty to cooperate, non-parties may believe that they are not breaching their treaty obligations when failing to 'comply or refrain'. The LOSC was carefully drafted to balance rights of coastal and distant water fishing states (McLaughlin 1997). Therefore, without clear articulation, of duties sufficient room is left for states to have a large range of interpretations (Chayes and Chayes 1995).

Failure to use the LOSC dispute resolution mechanisms serves to increase the legitimacy of a range of interpretations rather than increasing the perceived merit of the obligation to 'comply or refrain'. In 1974 the United States representative at the third United Nations Conference on the Law of the Sea made the following statement:

"[My] government believes that any law of the sea treaty is almost as easily susceptible to unreasonable unilateral interpretation as are the principles of customary international law. This is particularly true when we consider the essential balance of critical portions of the treaty, such as the economic zone, must rest upon impartial interpretation of treaty provisions. One primary motivation of my government in supporting the negotiation of a new law of the sea treaty is that of making an enduring contribution to a new structure for peaceful relations amongst States. Accordingly, we must reiterate our view that a system of peaceful and compulsory third-party settlement of disputes is in the end perhaps the most significant justification for the accommodations we are all being asked to make."

Yet despite the LOSC providing this clarification mechanism, parties to the 1982 Convention have preferred to use punitive measures rather than engage in determining the scope of the duty. In these circumstances all non-parties would be entitled to claim that LOSC parties have breached their obligation of good faith and have interfered with the flag state's rights under the LOSC (McLaughlin 1997). They could further claim that applying punitive measures to pressure compliance with an obligation to 'comply or refrain' without having first clarified the rule and assessing the capacity of the state to comply is fundamentally unfair (Parker 1999). In turn, this perceived unfairness may shape domestic pressure to cause the government to consider that non-compliance is preferable to the "political cost of compliance" (Joyner 1999).

While there is a valid relationship between trade and the environment, the process of implementing trade measures needs to be perceived to be legitimate. WTO members are free to consider the use of trade measures. This approach was endorsed in the US Shrimp-Turtle case. However, failure to clarify the relationship leaves states vulnerable to a WTO finding unjustifiable discrimination. If trade leverage rather than positive incentives is deemed essential for convincing non-members to join the negotiating table, states should be exploring this option (Parker 2001).

In the interim, any state that implements trade measures to deter fishing activities of non-parties will need to consider carefully whether that measure is justifiable. The definition of the 'duty of cooperation', the scientific basis for the total allowable catch, the degree of negotiations that have been engaged in, the extent of the offers to build capacity and the due process for the imposition of the measure will all be critical in this determination.

The principle of perceived merit implies that the likelihood of compliance is decreased where: a treaty obligation is ambiguous; where parties to the treaty have failed to clarify the obligation; or where punitive measures are imposed without proper consideration of the limited capacity of states.

While ambiguous treaty language assists the negotiation process, where obligations are critical to the integrity of the regime they need to be clearly articulated and particularized (Parker 2001). Failure to have a clear obligation undermines the legitimacy of imposing any punitive measures to encourage compliance. If the 'duty to cooperate' means something less than an obligation to 'comply or refrain', then the international community must design a governance arrangement that provides the necessary incentives for states to consensually adopt such an obligation.

It will also be necessary to design transparent processes for imposing punitive measures or delivering positive incentives. Ensuring that a decision-making body has the ability to impose measures that are contrary to some states' self-interest will be fundamental if punitive measures are to play a role in achieving compliance. For this to be achieved decision-making by consensus may be, of necessity, replaced by majority vote in this context. A forum for open discussion of compliance and non-compliance would also be essential in motivating state compliance. Compulsory dispute resolution mechanisms will continue to play a central role in resolving ambiguity and non-compliance issues (Parker 2001).

5.4 Applying the principle of capacity

Capacity to comply is a necessary ingredient of compliance where non-parties are developing states (Joyner 1999). When developed states have undertaken to build the capacity of developing states so that they can meet their obligations, failure to deliver on that obligation will decrease the likelihood of compliance.

Regulatory frameworks are designed to manage international issues over time. While fisheries arrangements should not be viewed as merely 'aspirational' there needs to be a recognition that all states are not equal in development and that compliance with the rules will be influenced by the social, political and economic situation of each state and, therefore, achieving compliance will take time (Chayes and Chayes 1995).

States may lack the technical ability to meet their obligations to participate in a sophisticated regulatory regime. Alternatively, states may not have the infrastructure or financial resources to establish a domestic fisheries compliance regime. When nine of the 'top ten' flags of convenience are classified as developing states, irrespective of the political will to comply, non-compliance is inevitable (Joyner 1995).

The principle of capacity implies that when the non-party is a developing state, the likelihood of compliance is decreased if compliance with the obligation to 'comply or refrain' requires a sophisticated domestic regulatory regime. The extent to which capacity of states needs to be developed depends upon the degree of responsibility that remains with the flag state under the management regime. Robust monitoring, surveillance and enforcement underpin effective fisheries management. With fishing activity being difficult to control and enforce, enforcement authorities have relied heavily on electronic data and verification (Parker 1999). Capacity building may involve building the individual capacity of each developing state or developing a multilateral regulatory and compliance capacity. If flag states were to retain exclusive jurisdiction over their vessels, capacity building through the transfer of expert knowledge and technical assistance would be as essential as financial assistance. There would need to be a long-term commitment to capacity building to ensure that all states have the ability to move with the times as the regulatory regime refines and develops (Parker 1999).

Before determining a future design the concept of flag states retaining exclusive jurisdiction should be examined and debated. Building international capacity rather than state capacity has economic advantages, but potentially challenges state sovereignty.

6. CONCLUSIONS

It is tempting to employ domestic solutions to fix international problems. However, it is essential officials understand international relations and the role of international dynamics in achieving compliance with management regimes and conservation measures. The principles of compliance outlined in this paper provide a framework for assessing the likelihood of compliance, and a mechanism to explain and predict compliance with international governance regimes.

Sustainable utilisation and effective management of high-seas fish stocks requires compliance with the obligation to 'comply or refrain' and states are more likely to engage in non-compliant activity when the regime fails to deliver on the principles of

compliance. Ambiguity of obligation, lack of effective punitive measures to discourage non-compliance, lack of positive incentives to encourage compliance, and lack of technical knowledge and resources all pull towards non-compliance.

The focus of the international community is now turning to managing purely high-seas fish stocks and states must take the opportunity to examine how they can gear high-seas fisheries management regimes to deliver compliance with the obligation to 'comply or refrain'. This paper has begun that examination. The challenge for officials is to design a structure fit for the purpose without being constrained by what have been considered appropriate solutions in the past.

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THEME 6

**Review of existing policies
and instruments**

Towards a high-seas fishery management regime: vision and reality

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1. IDEALISM AND REALISM IN FISHERY MANAGEMENT

Since the 1920s states have been trying to regulate ocean fishing outside territorial limits with a view to conserving commercially important stocks. The system of international fishery commissions established after the Second World War proved unable to achieve that goal in most cases. The global approach adopted at the First UN Conference on the Law of the Sea (UNCLOS I) in 1958 was no more successful. Bringing most of the world's major fisheries under coastal state jurisdiction at UNCLOS III in the 1970s introduced a higher order of equity into the international law of fisheries, at least from the coastal state's perspective, but not generally a much higher level of management effectiveness.

This history of frustrations should be uppermost in our minds as we try to come to grips with the prospect of a management regime for high-seas fisheries. Past efforts at international fishery management and conservation have not, of course, been totally unsuccessful, but the most accurate verdict is one of relative failure. The record of failure has been blamed on a wide variety of factors: overcapacity in the world fishing industry, the intensiveness of industrial fishing technology, the prevalence of national interest in a competitive domain, the unreliability of scientific data and predictions, the overambitiousness of fishery management goals, the inability or reluctance of national governments to control their fishing fleets, the difficulty of educating fishermen in conservation law and policy and so on.

Much of the present debate on world fishery management is heavily influenced by the idealism of ecologists and environmental ethicists. In the national sector, ecological and ethical concerns normally have to be balanced against industrial and communal interests. When the debate focuses on high-seas stocks, there may be less likelihood of the kind of balancing that is normally necessary for the formation of national fishery policy. So, on the one hand, there may be a better opportunity to place fishery management on an ideal, ecological and ethical, base than in national waters, but, on the other hand, there is a greater risk that relatively unfettered idealism will result in an unrealistic and unenforceable regime: another chapter in the history of frustrations. The challenge is to find a balance between idealistic and pragmatic expectations.

It has often been argued that the failure of international fishery management between the 1920s and 1970s was due in large part to the unrealistic language of international fishery management instruments: the language of biologically-defined goals and methods. It was discovered that the prescribed standards of evidence could not be met by most states, especially those with severely limited research and management

expertise. Bringing in ecological language in place of discredited biological language may be supported by a growing number of scientists, but many non-scientists have reason for skepticism that the new language will prove to have any great political or operational credibility.

Recent calls for ecosystem-based fishery management have included appeals for the use of large marine ecosystems (LMEs) as units of international fishery management and for the establishment of marine protected areas (MPAs) beyond, as well as inside, limits of national jurisdiction. Recently Australia hosted an important workshop on marine biodiversity conservation requirements.¹ Other significant initiatives are being taken to advocate a new, sophisticated, holistic approach to the management of high-seas fisheries. But, however attractive these ideas may be within the scientific and environmental communities, can they be “sold” to the negotiators of a new high-seas fishery management regime? If such a regime could be agreed to on paper, would it have a reasonable chance of becoming effective? What combination of “hard-law” and “soft-law” elements would be necessary to create realistic hopes of a reasonable degree of compliance with such a regime?

These are difficult questions; but perhaps a few preliminary observations may serve as a starting point in the *Queenstown 2003* discussions.

2. GAPS IN THE SYSTEM OF INTERNATIONAL INSTRUMENTS

The legal and institutional difficulties involved in the design of a high-seas fishery management regime begin, of course, with the overall governance of the regime of the high seas. In its 1982 formulation, this regime retains the ancient principle of the freedom of fishing in the high seas, subject to the provisions of the UN Convention on the Law of the Sea (LOS). Straddling stocks and highly migratory species were singled out for special attention and a major step in the direction was taken with the adoption of the United Nations Fish Stocks Agreement (UNFSA)² in 1995. However, states that choose not to become parties to UNFSA are free from the constraints created by that legally binding instrument, which is now in force but still collecting ratifications. Moreover, UNFSA does not apply to “discrete” high-seas stocks, such as fisheries associated with seamounts beyond the 200-mile limits of the exclusive economic zone (EEZ). There are, therefore, “gaps” in the international treaty system that would have to be filled in order to create a “complete” regime specifically designed for the protection of high-seas fisheries.

The closest the international community has come to dealing generically with the conservation and management of high-seas fisheries (and other living resources) is in the rather general provisions of Section 2 of Part VII of the LOS: Articles 116 to 120. Apart from the modest constraints of the Convention, states not bound by other treaty obligations, such as those of UNFSA and are free to fish on the high seas under Article 116. Articles 117 and 118 merely invoke a “duty to cooperate” in the conservation of high-seas living resources. Article 119 reproduces the general criteria set out for EEZ fishery conservation in Article 61. Article 120 makes the provisions of Article 65 applicable to marine mammals in the high seas.

There is not much here to build on. Ecologists will note the existence of ecological language on “associated or dependent species” in Article 119 (1)(b), which was added through the United States delegation’s proposal, suggested by the IUCN, at a late stage of negotiations at UNCLOS III. However, Section 2 of Part VII has very little mandatory force. It was not intended to. The challenge is how to design a regime that

¹ Workshop on the Governance of High Seas Biodiversity Conservation, 17–20 June 2003, Cairns, Australia. <<http://www.oceans.gov.au/pdf/EBM/Cairns%20EBM%20Report%20Oct03.pdf>>

² Agreement for the implementation of the provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the conservation and management of straddling fish stocks and highly migratory fish stocks, 1995

goes beyond Section 2, includes stronger and more modern provisions, and yet is likely to be accepted by most high-seas fishing states.

The orthodox approach would be to fill the “gap” with a single, legally binding instrument, but this may be the least likely way of capturing the consent of “culprit” states who could avoid conservation obligations by simply staying outside a consensual regime. The diplomatic alternative would be to design a regime in the form of a “package” consisting of two or more instruments, each an extension of existing instruments, containing both “hard law” and “soft law” in its elements.

The key norms that most would wish to incorporate into a high-seas fishery management regime already exist in a number of existing instruments. The LOSC, the UNFSA, Agenda 21, and the FAO Code of Conduct for Responsible Fisheries refer to such norms and goals as integrated ocean management, sustainability of ocean resources, the duty to cooperate, responsible fishing, the obligation to conserve, and the necessity for a precautionary approach to fishery development. Each of these instruments makes a distinctive contribution to the process of legal development. Each also has certain limitations. The package, ideally, would draw upon the strengths of each and reduce the importance of state consent given to any one legally binding instrument. The coexistence of two or more instruments that reflect the evolution of state practice, as far as *most* high-seas fishing states are concerned, would provide tangible evidence that the key responsibilities upon which effective high-seas fishery management will depend are becoming established in *customary* international law.

The 1982 United Nations Law of the Sea Convention, as we have seen, consists of general, “old-fashioned” provisions on high-seas fishery conservation and management. On the other hand, it is a legally binding, “hard law” instrument that is close to a “sacred text” of international law. By November 2004, it will become possible for any party to the LOSC to initiate the procedure of formal amendment under Article 312. Amendment to Section 2 of Part VII could be proposed thereafter by reference to other instruments in “soft law” form that could be negotiated within the next year or two. The purpose of the suggested package-making strategy would be to end up with amended high-seas fishery provisions of the LOSC that would be enforceable within the framework of Part XV on the settlement of disputes.

To circumvent the requirement for consent to a binding agreement, it may be useful for two kinds of non-binding instruments to be negotiated. One might be a Code of Conduct for Responsible High-seas Fisheries based on appropriate norms drawn from the existing FAO Code of Conduct for Responsible Fisheries, which is not presently applicable to the high seas. Language might also be taken from Agenda 21 and perhaps other sources. The second suggested new instrument might be a protocol to UNFSA, or an independent Statement of Principles Applicable to the Conservation and Management of High-seas Fisheries, whose purpose would be to extend some of the relevant norms and procedures of UNFSA now applicable to straddling stocks and highly migratory species to “discrete” high-seas fisheries.

3. THE QUESTION OF REGIME EFFECTIVENESS

Even if a high-seas fishery management regime could be assembled through a package-building strategy, as described above, what steps should be taken to reduce the risk of failure? What lessons have been learned from existing international regulatory regimes? The designers of the regime would have to concentrate on those aspects of regime-building that appear most likely to render such a package dysfunctional.

Scope: Care should be taken to avoid the trap of overextension. Because of the vastness of the high seas, encompassing more than half of ocean space by surface area, the enterprise might be rendered more credible if it were confined to straddling stocks, high migratory species and relatively shallow-water fish populations associated with seamounts. Most deepwater areas of the high seas are not sufficiently researched

to produce a reliable database for fishery management purposes. Too many efforts to conserve fish in familiar waters have failed – in part because of unreliable data. Overreaching the capacity of the scientific research community in unfamiliar waters would be the best way to guarantee failure.

The concept of large marine ecosystems (LMEs) has been suggested as appropriate for defining the scope of ocean management systems, ensuring an integrated approach to the assessment, conservation and management of all living resources within a large area. The operational credibility of this concept is obviously less questionable outside limits of national jurisdiction in regions of the high seas uncomplicated by maritime boundaries. Yet the larger the marine ecosystem invoked as the unit of management, the larger the problems of effective management are likely to become. In short, the LME concept does not strengthen the case for a high-seas fishery management regime. Indeed it is more likely to weaken the practicality or operational credibility of the whole enterprise.

Compliance: A good deal of attention has been given in recent years to the range of positive and negative sanctions available to induce compliance with international environmental regimes. The idea of freedom of use of the high seas has been established for hundreds of years. States cannot be browbeaten into cooperation with a new regime designed to restrict or constrain high-seas fishing. Distant fishing states have been driven out of the offshore areas of foreign states that now come under the EEZ regime subject to the sovereign rights of the coastal state. We need the food protein available in the high seas. The question is how to design incentives likely to persuade high-seas fishing states – and their fleets – to comply with reasonable and potentially effective international management controls.

This is not the time or place to review alternative incentive programmes. It might, however, be suggested that a study of the future economics of high-seas fishing should be commissioned by FAO with a view to identifying the realistic role that incentives might play in the operations of internationally regulated fisheries within the framework of a high-seas fishery management regime.

It is unlikely that an incentives programme, however sophisticated, would be sufficient on its own to deter cheaters. Surely it will be necessary also to resort occasionally to sticks as well as carrots. It is for this reason that it is argued above that the final stage in the design of the regime must involve formal amendment of the LOSC, so that virtually all nation-states, as parties to that “constitutional” text, can be brought within the dispute settlement procedures created at UNCLOS III for breach of the amended provisions of Section 2 of Part VII.

Enforcement: Some may fear that the kind of regime envisaged is more likely to be undermined by “rogue” fishing vessels rather than by flag states. By this reasoning, the effectiveness of the suggested regime depends as much on enforcement measures as on an incentives programme. Some alternative enforcement strategies for application to “discrete” high-seas fisheries might be developed through analogy with straddling stocks.

Enforcement measures applied to extensive ocean areas are expensive undertakings. Only the most highly motivated states – fishing nations with the most at stake economically – will be prepared to contribute substantially to the establishment and maintenance of observation, inspection and related enforcement programmes. How many high-seas fishing states are likely to fall into this category of affluent and willing fishing states? Do we have an appropriate coalition at hand?

It may be necessary to resort to more innovative, affordable, alternative strategies. For example, is it possible that the insurance and banking sectors could be persuaded to deny coverage and financial services to blacklisted fishing vessels that have been identified as “persistent offenders”? The target would be vessels used for “illicit” or “irresponsible” high-seas fishing in clear contravention of FAO-endorsed efforts

to regulate high-seas fishing in the global interest of marine resource conservation. Many states and international organizations would have to be willing to cooperate in the compilation of such blacklists. Since it is so easy to change vessel ownership and registration, it is important to understand that it is the vessels themselves that have to be blacklisted, so that new owners or states of registry cannot escape this system of financial sanctions.

Ethos: It may be that the approaches to the chronic problem of regime ineffectiveness are doomed to failure in the absence of a new ethos of sustainability applied to the high seas. As pressures on established commercial ocean fisheries continue to mount, and the threat of “fishery collapse” becomes more immediate, the appropriate global institutions will have to come together to launch a campaign to warn the world community of the imminence, or near-imminence, of ecocatastrophe in our ocean food production system.

Direful predictions of this kind are likely to be counterproductive unless backed up by strong scientific and economic evidence. Mere reference to the principle or rhetoric of precautionary avoidance is unlikely to carry the day, especially in the still-permissive domain of the high seas.

If a credible projection of present overexploitative trends were supported by the organized world community, then an ethos might evolve that would permit radical measures, such as unilateral intervention by a threatened coastal state, to deter culprit vessels from illicit misuse of the valuable living resources of the high seas.

4. AGENDA SETTING PRIORITIES

One thing is certain. Incrementalism cannot succeed. Only bold, innovative diplomacy supported by the most highly motivated high-seas fishing states can result in a potentially effective management system for high-seas fisheries, including the new category of discrete high-seas fisheries. Such an initiative should begin, perhaps, with the appointment of an international task force consisting of the most highly qualified and people respected in the field of fishery management. The task force would have to be mandated to review the complete range of approaches that might be taken to this regime-building challenge for high-seas fishery conservation and management.

One hopes that FAO and other global institutions such as UNEP and the Commission for Sustainable Development would be willing to work together in the call for such a task force. It might be the beneficiary of collective endorsement, with a cachet comparable to the UN Brundtland Commission in the 1980s and to the Stratton Commission of the United States of the 1960s. With the appointment of such a mechanism, the world community may be ready to assign priority to the problem of high-seas fishery conservation.

Global, regional and unilateral approaches to unregulated deep-sea fisheries

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1. INTRODUCTION

The Deep Sea 2003 Conference focuses on deep-sea fisheries, which are defined as those fisheries that take place on the continental slope and in deep-sea areas at depths greater than 200 m. The characteristics of deep-sea fisheries frequently distinguish them from other fisheries. First, they often target long-lived and slow-growing species with late maturity and low fecundity with consequential high risks of overexploitation and the collapse of stocks. As scientific understanding of the biological characteristics of many deep-sea species is still limited, this has serious implications for the adequacy of stock assessment models. This further increases the aforementioned risks. This brings along biodiversity concerns as they may lead not just to economic extinction but even local extinction. These concerns are even more acute for species or populations with small ranges of distribution, as often seems to be the case with species that aggregate around seamounts.

Second, as many of the target species are demersal, the use of certain fishing practices such as bottom trawling can have considerable ecosystem effects, for instance bycatch of other sedentary species and impacts on the sea-bed and subsoil (e.g. deepwater coral reefs). The ecosystem effects of these fishing practices may also lead to biodiversity concerns.

Third, and this leads to the core of this paper, due to their depth of operation, a considerable proportion of deep-sea fisheries takes place in areas where the current international law of the sea gives coastal states no jurisdiction to regulate fisheries unilaterally. In view of the fact that both coastal states and high-seas fishing states have rights and obligations with respect to straddling deep-sea fish stocks and discrete high-seas deep-sea fish stocks¹, their regulation must take place at the international level. As the effectiveness of international regulation is seriously constrained by its consensual nature, reflected in ‘lowest common denominator’, ‘free rider’ and ‘prisoner’s dilemma’ problems, this makes deep-sea fisheries even more problematical. This does not mean, as is by now widely recognized, that unilateral coastal state authority is a sufficient guarantee of sustainable fisheries.

¹ Straddling stocks are generally accepted to be the stocks mentioned in Art. 63(2) of the LOS Convention (United Nations Convention on the Law of the Sea (LOSC), Montego Bay, 10 December 1982. In force 16 November 1994, 1833 *United Nations Treaty Series* 396; <www.un.org/Depts/los>). Even though they may not always be easier to regulate, shared deep-sea fish stocks within the meaning of Art. 63(1) of the LOSC – thus involving exclusively coastal States – are left beyond the scope of discussion.

The last decade especially has witnessed a strong growth in deep-sea fishing activity, as a consequence of the continued worldwide over-capacity in fleet sizes, increasing overexploitation of traditional fish species, increasing global demand for fish products and technological innovations among other factors. In recent years the international community has become more and more aware of, and concerned by, the threats to sustainability of deep-sea fisheries and the threats to marine biodiversity. Such concern was *inter alia* expressed by the focus on protecting vulnerable marine ecosystems at the Fourth Meeting of the UN's Open-ended Informal Consultative Process on Oceans and the Law of the Sea², by the latest United Nations General Assembly (UNGA) Resolution on Oceans and the law of the sea³, and by the 7th Meeting of Parties (CoP7)⁴ to the Biodiversity Convention⁵ in February 2004. Moreover, various non-governmental organizations with environmental objectives and several states have been actively addressing these concerns at the national and international level.⁶

The main objective of this paper is to examine whether, in view of the special characteristics of deep-sea fisheries, the present international legal regime and state practice, there is a need to develop new international law and, or, a more widespread, consistent or pro-active application of existing international law. Section 2 gives a succinct analysis of the present international legal regime and state practice on the basis of which Section 3 proposes regulatory approaches to enhance the sustainability of deep-sea fisheries and to lessen the threats to marine biodiversity. Section 4 ends with some conclusions and observations.

2. THE PRESENT INTERNATIONAL LEGAL REGIME AND STATE PRACTICE

The present international legal regime applying to deep-sea fisheries that target straddling and discrete high-seas deep-sea stocks is not laid down in a single treaty. Rather, it consists of a multitude of global, regional and bilateral treaties with diverging objectives as well as legally binding acts from various global and regional inter-governmental organizations (IOs). Particularly relevant IOs at the regional level are regional fisheries management organizations (RFMOs).⁷ In addition, many non-legally binding international instruments and acts of IOs have relevance as well.

The basic international legal framework for deep-sea fisheries is provided by the 1982 United Nations Law of the Sea Convention (LOSC). Most importantly, this

² UN Doc. A/58/95, of 26 June 2003. See *inter alia* paras 1, 13, 20, 21(d) and 22 on pp. 1, 6 and 8 and paras 80–81, 87–89, 94, 98–100. See also the 2002 Report of the UN Secretary-General on 'Oceans and the law of the sea' (UN Doc. A/58/65, of 3 March 2003), at pp. 52–70 and especially paras 183–184, 191–192, 197–205, 222–223, 228–231.

³ Paras 8 and 56 of UNGA Resolution 57/141 (Doc. A/RES/57/141, of 21 February 2003); paras 51–52, 57 and 68 of draft UNGA Resolution 58/14 (Doc. A.58/L.19, of 18 November 2003 (adopted on 23 December 2003 but not yet issued at the time of writing); and para. 46 of UNGA Resolution 58/14, of 24 November 2003.

⁴ *Inter alia* paras 30 and 57–62 of the Draft Decision on Marine and Coastal Biological Diversity (Doc. UNEP/CBD.COP/7/L.31, as approved on 21 February 2004).

⁵ Convention on Biological Diversity, Nairobi, 22 May 1992. In force 29 December 1993, 31 *International Legal Materials* 822 (1992); <www.biodiv.org>.

⁶ For example, *Towards a Strategy for High-seas Marine Protected Areas*, Proceedings of the IUCN, WCPA and WWF Experts Workshop on High-seas Marine Protected Areas, 15–17 January 2003, Malaga, Spain, K.M. Gjerde and C. Breide (eds) (IUCN: 2003) and the Workshop on the Governance of High-seas Biodiversity Conservation, 16–19 June 2003, Cairns, Australia (for the *Meeting Record* and the *Draft Summary Record of Discussion and Suggestions for a Way Forward* see <www.oceans.gov.au/highseas.jsp>). See Lack, Short and Willock (2003), <www.wwf.org.au>, <www.traffic.org>, and the info and initiatives at <europe.oceana.org>.

⁷ For this paper, unless specified otherwise the acronym RFMO applies to 'arrangements' in the sense of Art. 1(d) of the Fish Stocks Agreement (Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, New York, 4 August 1995. In force 11 December 2001, 34 *International Legal Materials* 1542 (1995); <www.un.org/Depts/los>).

convention recognizes the sovereignty, sovereign rights and jurisdiction of coastal states with respect to marine living resources within their maritime zones (Arts 2(1), 49(1), 56(1)(a), 56(3) and 77 of LOSC) and the right for all states for their nationals to engage in fishing on the high-seas (Art. 116. See also Art. 92(1)). These rights are qualified by obligations owed to each other (e.g. Arts. 63(2) and 116(b)) and to the international community. The latter obligations are aimed at safeguarding such international community interests as conservation and optimum utilisation of marine living resources and the protection and preservation of the marine environment, including rare or fragile ecosystems and habitats of depleted, threatened or endangered species and other forms of life.⁸

Among the large number of relevant treaties, two global treaties are particularly relevant. These are the Fish Stocks Agreement and the Biodiversity Convention. The Fish Stocks Agreement applies exclusively to straddling fish stocks and highly migratory fish stocks and therefore not to discrete high-seas fish stocks.⁹ In view of the characteristics of deep-sea fisheries this has important implications. Both treaties contain provisions that ensure that the jurisdictional framework of the LOSC is left unaffected.¹⁰ The reality is, however, that while the basic fishing entitlements of the LOSC remain unaltered, international legal developments since the adoption of the LOSC have made the exercise of these entitlements increasingly qualified. The widening and deepening of relevant obligations is also evident in these two treaties, for instance their basic obligations to conserve biological diversity and to apply the precautionary approach.¹¹ In addition, the key role accorded to RMFOs under Article 8 of the Fish Stocks Agreement is intended to eventually lead to a situation where (high seas) fishing can only be engaged in by vessels flying the flag of states that are members of RFMOs or that cooperate with them (Art. 8(4) of the Fish Stocks Agreement). Opportunities for a high level of compliance are offered by the compulsory dispute settlement procedures of the LOSC and the Fish Stocks Agreement.¹²

In spite of these positive developments, the effectiveness of the regulation of international fisheries is constrained by the principle of *pacta tertiis*. This fundamental principle of international law provides that states cannot be bound by rules of international law unless they have in one way or another consented to them¹³. This not only imposes considerable restraints on law formation but also tempts states to ignore commitments made by others and enjoy 'free-rider' benefits. As these benefits can in principle be enjoyed by all nationals of a state, both natural and juridical persons, obtaining the nationality of a free rider state is attractive. General international law and the LOSC moreover give states a wide discretion in deciding on the conditions that vessels must meet to register with it (fly its flag or obtain its nationality). The requirement of a 'genuine link'¹⁴ between a state and its vessels is broadly accepted as meaning 'no more' than that flag states must exercise effective jurisdiction and control

⁸ E.g. Arts 61(2), 62(1), 117–119, 192 and 194(5) of the LOSC.

⁹ This is evident from the full title of the Agreement (see footnote 7 and Arts 2 and 3).

¹⁰ Art. 4 of the Fish Stocks Agreement and Art. 22 of the Biodiversity Convention.

¹¹ Arts 1 and 6 of the Biodiversity Convention and Arts 5(c) and 6 and Annex II to the Fish Stocks Agreement. It is worth emphasizing, however, that, in areas beyond national jurisdiction, the general obligations under the Biodiversity Convention do not apply to components of biodiversity but only to processes and activities that have adverse effects on biodiversity (cf. Arts 4, 7(c) and 8(l); see also UN Doc. A/AC.259/8, of 22 May 2003, at pp. 4–5).

¹² Part XV of LOSC and Part VIII of the Fish Stocks Agreement.

¹³ *Inter alia* Art. 34 of the Vienna Convention on the Law of Treaties (Vienna, 23 May 1969. In force 27 January 1980, 1155 *United Nations Treaty Series* 331).

¹⁴ Art. 91(1) of LOSC.

over them.¹⁵ Sadly, there is no multilateral agreement on a minimum level of effectiveness or what the consequences should be if effectiveness falls below that level.

To an important extent, these international law constraints lie at the heart of the problems that illegal, unreported and unregulated (IUU) fishing currently pose to marine capture fisheries worldwide. This is particularly true for unregulated fishing within the meaning of Paragraph 3.3.1 of the IPOA on IUU Fishing.¹⁶ There, unregulated fishing essentially refers to fishing activity under the flag of non-(cooperating) members of RFMOs. Until the Fish Stocks Agreement enjoys (quasi-) universal participation by states that fully comply with its obligations, in particularly those in Article 8 in relation to RFMOs, this is expected to remain a considerable problem in the foreseeable future due to the *pacta tertiis* principle. This troublesome prospect was a major factor in the call for an IPOA on IUU Fishing, whose overarching objective is to ensure that states and IOs do whatever possible to combat IUU fishing, provided they remain within the limits of international law.

It is submitted that unregulated fishing within the meaning of Para. 3.3.2 of the IPOA on IUU Fishing – that is: fishing in the absence of (international) regulation – is at the moment actually a more serious problem for deep-sea fisheries. Clearly, in the absence of regulation by RFMOs, fishing cannot be inconsistent with, or contravene any, measures and thereby amount to unregulated fishing within the meaning of Para. 3.3.1. Although such fishing activities may amount to state responsibility, this seems less likely to lead to unilateral or multilateral action by other states than if fishing activity would have been contrary to an RFMO's measures. In the latter case, action would benefit from more legitimacy and could be taken pursuant to established compliance procedures.

The absence of international regulation can in part be explained by the fact that deep-sea fishing is a relatively new type of fishing. So far, the only example of international regulation with an exclusive focus on deep-sea fisheries seems to be the bilateral arrangement of 2000 between Australia and New Zealand for the South Tasman Rise orange roughy (*Hoplostethus atlanticus*) fishery.¹⁷ As a consequence of new population size estimates, both states agreed in July 2003 to considerably lower the total allowable catch (TAC) with immediate effect and to further lower the TAC in coming years unless the fish return in large quantities.¹⁸

¹⁵ This was *inter alia* confirmed by the International Tribunal for the Law of the Sea (ITLOS) in the M/V Saiga case (The M/V Saiga Case (No. 2) (Saint Vincent and the Grenadines v. Guinea), Judgment of 1 July 1999; text at <www.itlos.org>) at par. 83. See also Art. 92(1) of the LOSC which confirms the primacy of flag State jurisdiction on the high seas. Note that the draft (November 2003) of the 2003 UNGA Resolution on 'Oceans and the Law of the Sea' calls for efforts to study, examine and clarify the role of the genuine link (para. 28).

¹⁶ International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing. Adopted by consensus by FAO's Committee on Fisheries on 2 March 2001 and endorsed by the FAO Council on 23 June 2001; text available at <www.fao.org/fi>.

¹⁷ Arrangement between the Government of Australia and the Government of New Zealand for the Conservation and Management of Orange Roughy on the South Tasman Rise. Signed for New Zealand on 17 February 2000 and for Australia on 25 February 2000. In effect on 1 March 2000; reproduced in 16 *International Journal for Marine and Coastal Law* 119–123 (2001). For a discussion see E.J. Molenaar (2001).

¹⁸ As based on information contained in the letter sent in August 2003 by G. Hurry, AFFA, to B. Satia, FAO (on file with author). See also Serdy (2005).

Only a few of the RFMOs that are currently operating would in principle have competence to deal with straddling and discrete high-seas deep-sea fish stocks.¹⁹ Of these, only the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR),²⁰ the Northwest Atlantic Fisheries Organization (NAFO)²¹ and the North-East Atlantic Fisheries Commission (NEAFC)²² seem to have actually exercised that competence so far. This does not mean that a need to regulate deep-sea fisheries will arise or has already arisen within the regulatory area of all or most existing RFMOs. However, in areas where such a need *does* arise and a competent RFMO is not in place, the characteristics of deep-sea fisheries are such that they may no longer exist once the international institutions are operational. An example is the negotiation of the establishment of a South West Indian Ocean Commission (SWIOFC), where progress has so far been slow.²³ The lucrative orange roughly fishing grounds which triggered one of the two SWIOFC negotiating tracks have by now been exhausted.²⁴ It is admitted, however, that the nature and history of these negotiations, especially that the two tracks were initially operating in isolation from, and ignorance of, each other and the difficulty of integrating the fundamentally different objectives of these two tracks, contributed greatly to this lack of progress.

¹⁹ In addition to CCAMLR, NAFO and NEAFC (mentioned in the main text below), this would seem to include the GFCM (Agreement for the establishment of a General Fisheries Council for the Mediterranean, Rome, 24 September 1949. In force 20 February 1952, 126 *United Nations Treaty Series* 239; amended version available at <www.fao.org/fi/body/rfb/GFCM/gfcm_basic.htm>). The new GFCM Agreement that was adopted by the FAO Council at its 113th Session in November 1997 is not yet in force (text at <www.oceanlaw.net>); the SEAFO (established by the Convention on the Conservation and Management of the Fishery Resources in the South East Atlantic Ocean, Windhoek, 20 April 2001. In force 13 April 2003, 41 *International Legal Materials* 257 (2002); <faolex.fao.org>; see Arts 1(l) and 2; not yet operational); and the Commission to be established under the Framework Agreement for the Conservation of the Living Marine Resources on the High Seas of the Southeast Pacific ('Galapagos Agreement; Santiago, 14 August 2000. Not in force, *Law of the Sea Bulletin*, 70–78, No. 45 (2001); <www.oceanlaw.net/texts/index.htm>; Art. 4). As the International Pacific Halibut Commission (IPHC) manages what is essentially a shared stock, it is beyond the discussion here.

²⁰ Established by the Convention on the Conservation of Antarctic Marine Living Resources (Canberra, 20 May 1980. In force 7 April 1982, 19 *International Legal Materials* 837 (1980); <www.ccamlr.org>). For CCAMLR's competence see Arts I and II.

²¹ Established by the Convention on Future Multilateral Cooperation in the Northwest Atlantic Fisheries, Ottawa, 24 October 1978. In force 1 January 1979, 1135 *United Nations Treaty Series* 369; <www.nafo.ca>; see Art. I(4)). At the 25th Annual NAFO Meeting (2003), the TAC for Greenland halibut was substantially reduced (see press release at <www.nafo.ca>).

²² Established by the Convention on Future Multilateral Cooperation in the North-East Atlantic Fisheries (London, 18 November 1980. In force 17 March 1982, 1285 *United Nations Treaty Series* 129; <www.neafc.org>). For NEAFC's competence see Art. 1(2). See also the "NEAFC ad hoc and temporary conservation and management measures for deep-sea species in the NEAFC Regulatory Area in 2003", by which NEAFC finally responded to the calls for regulation that environmental NGOs had been making at least since 2000, but probably for more than a decade). Prior to 2003, the EU had passed some modest regulation unilaterally (for the current regulation see Council Regulation (EC) No. 2340/2002, of 16 December 2002, *fixing for 2003 and 2004 the fishing opportunities for deep-sea fish stocks* (OJ 2002, L 356/1)). See also Lack, Short and Willock 2003, note 6, at pp. 31–36; and § 12 of the 'Bremen Statement', issued at the June 2003 Ministerial meeting of the OSPAR Commission (text at <www.ospar.org>).

²³ The third inter-governmental consultation took place between 27–30 January 2004, more than two years later than envisaged by the second consultation in September 2001 (cf. FAO Fisheries Report No. 664, para. 20, p.26). Nevertheless, the third consultation was a breakthrough that it was decided to once again split the negotiation process into two tracks. One track will aim at establishing an advisory body under Art. VI of the FAO Constitution with an area of competence that will exclusively encompass coastal State maritime zones. The other track will aim at establishing a non-FAO RFMO or legally-binding arrangement whose regulatory area will exclusively encompass high seas. Linkages will be made to ensure compatibility in the management of straddling stocks (cf. *Report of the Third Intergovernmental Consultation on the Establishment of a Southwest Indian Ocean Fisheries Commission*, Nairobi, Kenya, 27–30 January 2004; draft as approved on 30 January 2004. On file with author).

²⁴ For a discussion of the initial stages of the negotiations see Molenaar (2001), note 17, at pp. 109–115. See also Lack, Short and Willock (2003), note 6, at pp. 37–40.

Space here does not allow for a comprehensive examination of global state practice on the regulation of deep-sea fisheries. But, the overall impression is nevertheless that, so far, both national and international regulation of deep-sea fisheries has often been too little, too late and insufficiently cautious to ensure sustainable fisheries and to avert serious ecosystem effects and biodiversity threats.²⁵ Whereas the need for (more) national and international regulation of deep-sea fisheries is not challenged, diverging views abound as to the level at which regulation should take place and which form it should take.

3. SOME REGULATORY APPROACHES

3.1 Regulatory options

The future national and international regulation of deep-sea fisheries can take many forms due to the wide choice of potentially effective technical measures and more generally oriented regulatory approaches. Which measures are appropriate for regulating deep-sea fisheries depends on many factors, most importantly on their spatial dimension and the level (national or international) at which they are adopted. Examples of possible measures are strict ‘no-take zones’, area-closures for certain fishing practices and areas with vertical zoning. The next three subsections address possible global, regional and unilateral regulatory approaches. The emphasis is specifically on deep-sea fisheries rather than on current problems of high-seas fishing in general. Generic regulatory approaches are therefore only mentioned.

3.2 Global regulatory approaches

At present there is no single ‘purpose-built’ global treaty or IO for high-seas fishing in general or for discrete high-seas fish stocks in particular. As the Fish Stocks Agreement does not apply to discrete high-seas fish stocks, the international legal framework for these fisheries proceeds from rather general provisions of the LOSC, without the benefits of the progressive development of the law that has been achieved by means of the Fish Stocks Agreement. The question is therefore whether negotiations should be started to create such a global treaty²⁶ and, if so, whether that global treaty should at the same time function as the constituent instrument for a single global fisheries management organization (GFMIO). It is submitted that in view of the urgent need for regulation of deep-sea fisheries and the considerable time that is likely to be involved in negotiating such a treaty, these approaches should not have the international community’s priority. They should only be pursued after, or in tandem with, agreement on other global, regional or unilateral approaches that are likely to have more beneficial short-term impact on the regulation of deep-sea fisheries.

The negotiation process for the UNCLOS III had little support for the establishment of a single GFMIO.²⁷ To some extent this may have been motivated by a traditional, common and widespread resistance against ambitious and comprehensive institutional reform, especially where the role and competence of existing institutions established pursuant to the then predominant piecemeal approach, would be under threat. Such sentiments are likely to be widespread today as well. A lack of support then and now can further be explained by a recognition that the regulation of marine fisheries will always require a strong regional component. In contrast, there was widespread recognition

²⁵ The conclusions by Lack, Short and Willock (2003), note 6, at pp. iv and 57 are consistent with this view.

²⁶ There are various processes that can be used to establish such a treaty, for instance amendment of the LOSC (cf. Art. 312), amendment of the Fish Stocks Agreement (cf. Art. 45), ‘implementation agreements’ under the LOSC or the Fish Stocks Agreement or a single-standing instrument.

²⁷ See, for instance, the proposals made by Lebanon (UN Doc. A/AC.138/SC.1/SR.17, of 9 August 1971 and by Mexico (UN Doc. A/AC.138/SC.II/SR.30, of 29 March 1972) in regard of an IO for high seas fisheries.

that the need for uniformity in international merchant shipping required regulation at the global level. For this reason, the LOSC enhances the role of the International Maritime Organization (IMO) as the “competent international organization”.²⁸ It is therefore agreed with Hayashi (2005) that the most appropriate way forward would be to gradually strengthen the respective roles of the UNGA and FAO’s Committee on Fisheries (COFI).²⁹

The negotiation of a global treaty for high-seas fisheries would, similar to the Fish Stocks Agreement, require implementation at the regional level by means of (the establishment of) RFMOs. That the treaty may also take considerable time to enter into force may perhaps be less problematic. Even prior to its entry into force, the Fish Stocks Agreement already had a large impact on the negotiation-processes of the SEAFO Convention³⁰ and the WCPFC Convention³¹ and the treaties that were eventually adopted. More problematic is the fact that the Fish Stocks Agreement has been adopted only relatively recently and its status of participation, and thereby its support, does not yet come near that of the LOSC.³² Presumably, therefore, the most that the negotiation of a global treaty could at the moment hope for is essentially a *mutatis mutandis* application of some of the main provisions of the Fish Stocks Agreement.³³ It could even be argued that some years are needed to consolidate the advances in international law laid down in the Fish Stocks Agreement and to secure its wider participation and support. Starting a related global negotiation-process too early could even lead to a regression of the law.³⁴ If the *mutatis mutandis* approach is accepted as the best that can be hoped for, the UNGA could in one way or another be involved in achieving this result.

It is also questionable whether such a global treaty would really be necessary before action can be taken at the regional level. The negotiation and adoption of the Fish Stocks Agreement has not triggered a general overhaul of the constituent instruments of RFMOs that were already in existence prior to the negotiations.³⁵ Instead of constitutional reform, most RFMOs seem nevertheless to have adjusted their practice to many aspects of the Fish Stocks Agreement. Furthermore, it seems reasonable to assume that those RFMOs with competence to deal with discrete high-seas (deep-sea) fish stocks³⁶ will manage these stocks on relevant aspects essentially similar to

²⁸ See *inter alia* Art. 211(1) of the LOSC, which refers to “competent international organization” in the singular, in contrast with *inter alia* Arts 207(4) and 210(4).

²⁹ See Hayashi (2005) in these proceedings.

³⁰ See note 19.

³¹ Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean, Honolulu, 5 September 2000. In force 19 June 2004, 40 *International Legal Materials* 277 (2001); <www.ocean-affairs.com>; not yet operational.

³² Whereas the LOSC had by 16 January 2004 attracted 144 contracting parties, the Fish Stocks Agreement by that time only 51.

³³ Particular relevant would seem to be Arts 5, 6 and 8 and Annex II.

³⁴ There are many indications of the lack of support for the Fish Stocks Agreement. See, for instance, the Chilean observations in UN Doc. A/55/PV.44, of 30 October 2000, at p. 10 and the recently adopted Preamble to the Antigua Convention (note 35), which refers to the Fish Stocks Agreement in a separate preambular paragraph that merely starts with “Taking note”. See in this respect Edeson (2003).

³⁵ Exceptions are the complete revision of the IATTC Convention (Convention for the establishment of an Inter-American Tropical Tuna Commission, Washington D.C., 31 May 1949. In force 3 March 1950, 80 *United Nations Treaty Series* 4; <www.iattc.org>) by means of the Antigua Convention (Convention for the Strengthening of the Inter-American Tropical Tuna Commission Established by the 1949 Convention Between the United States of America and the Republic of Costa Rica, Washington D.C., 14 November 2003. Not in force, <www.iattc.org>) and the partial revision of the NEAFC Convention (see note 22 and the agenda for the 22nd Annual NEAFC Meeting (2003) at <www.neafc.org>). Note that the negotiation-process of the CCSBT Convention (Convention for the Conservation of Southern Bluefin Tuna, Canberra, 10 May 1993. In force 20 May 1994, 1819 *United Nations Treaty Series* 360; <www.ccsbt.org>) overlapped partly with that of the Fish Stocks Agreement but the latter seemed to have little actual impact on the former.

³⁶ See notes 19-22 and accompanying text.

straddling fish stocks. It is noted that in relation to discrete high-seas stocks, RFMOs could not rely on provisions of the Fish Stocks Agreement, which are unable to become customary international law or are unlikely to do so in the near future. Examples are the dispute settlement provisions and the technical intricacies of the provisions on non-flag state high-seas enforcement. But, it is also submitted, existing RFMOs and negotiation-processes to establish new RFMOs can by now quite safely rely on customary international law in applying concepts like the precautionary approach.

It is finally argued that the legitimacy of RFMOs in managing marine capture fisheries is not, or is no longer, fundamentally challenged. The challenges that do arise relate to the consistency of their establishment with international law³⁷ or the consistency of the adoption and application of their conservation and management measures with international law. In fact, challenges based on these grounds implicitly confirm the legitimacy of RFMOs and their competence to take, or call for, measures against (non-cooperating) non-members.³⁸ This also suggests that the strengthened duty to cooperate with RFMOs pursuant to paragraph (3) of Article 8 of the Fish Stocks Agreement has already evolved into customary international law.³⁹ However, an authoritative confirmation of the correctness of this assertion may not be available until such time that RFMOs accept the need for bolder measures against non-cooperating non-members, for instance through trade-related measures. As such measures could lead to the institution of proceedings under international trade law, RFMOs need to be aware of the consequences of discrimination between (cooperating non-) members and (non-cooperating) non-members.⁴⁰ But as argued here, those RFMOs that do not have to fear such consequences, would be acting in accordance with international law when combating unregulated fishing of discrete high-seas (deep-sea) fish stocks.

3.3 Global regulatory approaches involving existing global bodies

There are several global bodies that could assist in averting some of the threats to the sustainability and biodiversity of deep-sea fisheries. This is a consequence of the decentralized nature of international law. No hierarchy exists between the various forms or manifestations of international law (e.g. treaties, custom, international judgments and acts of IOs). Even the notion that the doctrine of the consensual nature of international law does not apply to peremptory norms of international law (*jus cogens*)⁴¹ is merely accepted as a principle, whereas no agreement exists on which norms would be covered. All that is available is a handful of general principles such as that more specific rules take precedence over general rules (*lex specialis derogat legi generali*)⁴² or that newer rules take precedence over older rules (*lex posterior derogat lex priori*).⁴³ Hierarchy is also absent in relation to international law-making processes (e.g. IOs, international dispute settlement bodies and diplomatic conferences).

The competence or mandate of many international bodies, including dispute settlement bodies, often overlap with each other. Overlaps in competence can take many forms. An overlap in a geographical sense is usually not a problem in the absence of a substantive overlap (e.g. of species). Where a substantive overlap does exist, different types of regulation (e.g. management, conservation or trade regulation)

³⁷ See note 83.

³⁸ Cf. the reasoning of the International Court of Justice in the *Case Concerning Military and Paramilitary Activities In And Against Nicaragua* (Nicaragua v. United States of America), Judgment (Merits) of 27 June 1986, *ICJ Reports* 1986, at p. 98, para. 186.

³⁹ See Rayfuse (2003) pp. 320–321 who comes to the same conclusion (see also pp. 66–81). The duty for States to take account of “generally recommended international minimum standards” pursuant to Art. 119(1)(a) of LOSC may have contributed to this evolution.

⁴⁰ See the *chapeau* to Art. XX of the General Agreement on Tariffs and Trade (1947; <www.wto.org>).

⁴¹ See Arts 53 and 64 of the 1969 Vienna Convention, note 13.

⁴² See *inter alia* Art. 41(1) of the 1969 Vienna Convention, note 13.

⁴³ Cf. Art. 30 of the 1969 Vienna Convention, note 13. See also Art. 103 of the UN Charter.

may still lead to incompatible results. To minimize incompatibility, many international bodies have formal or informal coordination or primacy arrangements.⁴⁴ These arrangements as well as the competence of international bodies are in a constant state of flux as a consequence of new developments and the changing needs and interests of the international community. The decision of a particular international body, including dispute settlement bodies, to pursue a particular issue, is often determined by considerations of international policy, politics and ‘forum-shopping’.⁴⁵ This also shows that international bodies are not independent actors as such, but groupings of states in diverging compositions subjected to diverging rules of procedure and decision-making.

In view of their objective of averting some of the sustainability and biodiversity threats of deep-sea fisheries, the usefulness of three global bodies is discussed: CITES⁴⁶, CMS⁴⁷ and the UNGA. With respect to the use of the ‘machinery’ of the Biodiversity Convention, it is merely noted that this may be an attractive option for some states, but not for others.⁴⁸

The usefulness of CITES in regulating trade in deep-sea fish species has been the subject of heated debate in recent years. The suitability of the criteria used by CITES to determine the need for trade regulation for commercially exploited aquatic species has been questioned.⁴⁹ One of the main problems is that where one or more stocks of such a species is or are healthy, this would make listing the species too general a tool. But, there may be situations where the interests of biodiversity outweigh those of exploitation. Many states also regard a resort to CITES as a move that would undermine the authority and legitimacy of RFMOs and the FAO.⁵⁰ This played a considerable role during the 12th Meeting of the Conference of the Parties (CoP12) to CITES, 2002 when Australia proposed to list Patagonian and Antarctic toothfish (*Dissostichus* spp.) on Appendix II of CITES, but, faced by lack of support, eventually withdrew the proposal.⁵¹ A month or so prior to CoP12, this Australian proposal had received practically no support at the XXIst Annual CCAMLR Meeting (2002).⁵² In the background, the sensitive sovereignty situation in the Antarctic Treaty System (ATS), of which CCAMLR is part, also explains the reluctance to ‘external interference’. Whereas the 25th Meeting of COFI in 2003 saw the ‘in principle’ confirmation of the primacy of the FAO and RFMOs in fisheries conservation and management, it also recognized that a role for CITES is not excluded “in exceptional circumstances”.⁵³

⁴⁴ E.g. Art. VI of the CCAMLR Convention, which acknowledges the primacy of the IWC; and IOTC (Indian Ocean Tuna Commission) Resolution 98/03 ‘on southern bluefin tuna’, which acknowledges the primacy of the CCSBT. See also notes 83 and 84 and accompanying text.

⁴⁵ E.g. the efforts by Japan within the IOTC to establish a Working Party on Temperate Tunas, which would *inter alia* deal with southern bluefin tuna, even though that would lead to overlapping competence with the CCSBT (see IOTC Resolution 98/03). Another example is the dispute between the EC and Chile on the unloading of (Pacific) swordfish in Chilean ports, which led the EC to institute dispute settlement procedures within WTO (WTO case WT/DS193) and, as a consequence, Chile instituted proceedings under the LOSC (ITLOS case No. 7).

⁴⁶ Convention on International Trade in Endangered Species of Wild Fauna and Flora, Washington, D.C., 3 March 1973. In force 1 July 1975, 993 *United Nations Treaty Series* 243; <www.cites.org>.

⁴⁷ Convention on the Conservation of Migratory Species of Wild Animals, Bonn, 23 June 1979. In force 1 November 1983, 1651 *United Nations Treaty Series* 355; <www.wcmc.org.uk/cms/>.

⁴⁸ See UN Doc. A/58/95, note 2, at para. 98, p. 28. But see also note 4.

⁴⁹ See in this respect the slow progress within FAO (Report of the 25th Session of COFI (2003; Doc. CL 124/7), paras 46–50 and Appendixes E, F and G and Doc. CL 124/7–Add.1).

⁵⁰ Similar issues of overlapping competence exist between CITES and the International Whaling Commission.

⁵¹ See listing proposal 39 (withdrawn). Some of the pro-whaling States that are members of CCAMLR also have other reasons for not using CITES.

⁵² For the discussion see Doc. CCAMLR–XXI, paras 10.1–10.75 and the observations in paras 10.11 and 10.19 on the increased TAC for some stocks of *Dissostichus* spp.

⁵³ See FAO Docs CL 124/7, para. 47 and Appendix G and CL 124/7–Add.1 (note 49).

Whether or not parallel regulation by CITES has more advantages than disadvantages cannot be adequately discussed here. However, it is to be hoped that the possibility of full involvement by CITES will eventually be beneficial to the sustainability of (deep-sea) fisheries, including the minimization of ecosystem effects. At least for the moment the focus is on strengthening cooperation between CITES and FAO on the one hand and CITES and RFMOs like CCAMLR on the other.⁵⁴ Unfortunately, at the XXIInd Annual CCAMLR Meeting in 2003 no progress was made in this respect.⁵⁵ If progress on the enhancement of the conservation and management of toothfish continues to be minimal, this inaction is expected to bolster the determination of those in favour of using CITES⁵⁶ to enhance conservation measures. This is particularly relevant for deep-sea fisheries, where regulation is currently often absent. While this would, therefore, avoid actual overlaps in competence between CITES and a concrete RFMO or arrangement, the more fundamental concerns about the roles of the FAO and RFMOs would still exist. At least in the immediate future the role of CITES may therefore be limited to that of the ‘bogeyman’ for RFMOs.

The reasons for the limited usefulness of CITES for tackling unregulated deep-sea fisheries are partly similar to those of the CMS. The scope of the CMS would certainly allow states to list commercially exploited fish species occurring within coastal state maritime zones as well as the high-seas under its Appendix I.⁵⁷ Listing means that state parties must prohibit intentional capture and also protect relevant habitats. Species could also be listed on Appendix II and be covered by agreements aimed not merely at conservation but also management, thus encompassing utilization.⁵⁸ Such agreements could also be developed without listing on Appendix II, pursuant to Article IV(4) of the CMS. It is worth noting that none of the agreements that have been established under Article IV so far have a utilization component. However, as is similar to the situation with CITES, even if this would not lead to actual overlaps in competence, it would raise fundamental concerns about the roles of the FAO and RFMOs.⁵⁹ Resort to the CMS in the near future is therefore not only unlikely but is also insufficiently plausible to exert a bogeyman effect.

A potentially more successful approach to addressing the urgent situation in deep-sea fisheries would involve the UNGA. Based on the UNGA’s instrumental role in establishing a global moratorium on large-scale pelagic drift-net fishing on the

⁵⁴ See the proposals for cooperation between CITES and CCAMLR (Doc. CoP12 16.1; adopted (Doc. CoP12 Plen.7); Conference Resolution 12.4) and between CITES and FAO (Docs. CoP12 16.2.1 and 16.2.2; adopted (Doc. CoP12 Plen.7); CoP Decisions 12.7) at the CoP12 of CITES; see also CoP Decisions 12.57–12.59.

⁵⁵ See Doc. CCAMLR–XXII (Preliminary Version of 12 November 2003), paras 14.1–14.19. However, the CITES Observer noted the possibility for States parties to CITES to unilaterally list species on Appendix III to CITES. Such action would, unlike Appendices I and II listing proposals, not require a two-third majority decision (see Arts XV and XVI of CITES). However, in para. 4.16 Norway observed that “no Member [of CCAMLR] should bring about any decision on toothfish without a decision taken by [CCAMLR] by consensus”, thereby emphasizing the primacy of CCAMLR and rejecting the unilateral discretion of States that are parties to both CCAMLR and CITES.

⁵⁶ See the discussion at the 21st Annual NEAFC Meeting (2002) (Report, pp. 37–38) on the Appendix II listing proposal by the United Kingdom (on behalf of all EU Member States) of basking shark (*Cetorhinus maximus*) at CoP12. For a variety of reasons this proposal was, unlike the toothfish proposal, successful.

⁵⁷ See Art. III and the definitions in Art. I(1)(a), (f), (h) and (i), which establish a low threshold for including transboundary fish species. So far, only one fish species (pangasid catfish (*Pangasianodon gigas*)) is listed under both Appendices I and II of the CMS (as well as Appendix I of the CITES).

⁵⁸ See Arts. IV and V of the CMS. Note that Art. V shows similarities with certain provisions of the Fish Stocks Agreement (e.g. para. (2) need to include non-Parties to the CMS and para. (5)(k) in relation to “illegal taking”).

⁵⁹ See <www.wcmc.org.uk/cms/> for an overview of these agreements. See also Art. V(4)(f) in relation to the IWC.

high seas⁶⁰, the UNGA could adopt a (non-legally binding) resolution calling for a moratorium on certain types of deep-sea fishing, for instance for bottom trawling on seamounts, deepwater coral reefs and other biodiversity hotspots.⁶¹ Although such a moratorium would certainly be welcome, it seems that whereas the non-sustainability and wastefulness of large-scale pelagic drift-net fishing was widely recognized, such a general and unqualified view probably does not exist *vis-à-vis* deep-sea fishing, or even more specifically, deep-sea bottom trawling. Proposed resolutions may therefore not be adopted without a vote and may even attract a significant number of votes. Whereas such resolutions would still be passed in accordance with the decision-making procedures (Art. 18 of the UN Charter), they may eventually be unable to attract the necessary universal support, and thereby authority, to lead to universal implementation. While this may be true, even an UNGA resolution that lacks universal support can make a contribution to enhancing awareness and to creating stimulus and legitimacy for further action at the regional and national level.

3.4 Regional regulatory approaches

A regional approach to addressing the absence of regulation of deep-sea fisheries appears both logical and suitable, whether or not pursued in tandem with a global approach through, for instance, the UNGA. As was argued in Section 1, action at the regional level does not have to await the adoption or entry into force of a global treaty modelled on the Fish Stocks Agreement. Those RFMOs that already have competence to regulate discrete high-seas deep-sea fish stocks should therefore immediately use this competence to assess the need for regulation and, if this need has been ascertained, to commence regulation consistent with the Fish Stocks Agreement. More problematic are situations where no existing RFMOs have competence spatially or substantively (species) owing to the range of distribution and the type of deep-sea fish stocks will have greater difficulties. As the negotiation-process for SWIOFC to some extent illustrates, the urgent need for regulation may render the negotiation of a classic-style RFMO an inadequate solution. An alternative would be an ‘arrangement’ within the meaning of Article 1(1)(d) of the Fish Stocks Agreement. This provision defines an arrangement as

“a cooperative mechanism established in accordance with the [LOS] Convention and this Agreement by two or more states for the purpose, inter alia, of establishing conservation and management measures in a subregion or region for one or more straddling fish stocks or highly migratory fish stocks”.

This clearly allows for a wide range of different types of arrangements, provided the general condition of consistency with international law is met and the arrangement’s purpose falls within the scope of the Fish Stocks Agreement. This does not prevent states from establishing arrangements with a purpose that falls beyond the scope of the Fish Stocks Agreement, e.g. because they deal with discrete high-seas stocks. Such arrangements must nevertheless comply with other rules of international law, including the LOSC and customary international law. Moreover, as the 2000 South Tasman Rise Orange Roughy Arrangement illustrates, an arrangement does not necessarily have to be laid down in a treaty.⁶² Compared with RFMOs, establishing arrangements may often have more benefits in relation to expeditiousness, flexibility and cost.

One possible regional approach is to use the cooperative framework of an existing RFMO to establish such an arrangement. Here again, many different approaches are

⁶⁰ See *inter alia* UNGA Resolutions 44/125, 45/197 and 46/215.

⁶¹ See M. Gianni, *High Seas Bottom Fisheries and Their Impact on Vulnerable Deep-Sea Ecosystems: Preliminary Findings*, paper submitted to the 58th Meeting of the UNGA (2003), UN Doc. A/58/95, note 2, at para. 87, p. 25 and UN Doc. A/58/65, note 2, at paras 183 and 230, pp. 56 and 67–68.

⁶² This is *inter alia* supported by the systematic use of “will” instead of “shall” throughout the text of the Arrangement.

possible. An interesting case is that of the regulation of toothfish under the CCAMLR Convention. The regulatory scope of the CCAMLR Convention, and thereby the competence of CCAMLR, is set out spatially and substantively in Articles I and II. The basis of its spatial competence is an approximation of the Antarctic Convergence (Art. I), which delimits the warmer northern waters from the cooler southern waters. The CCAMLR Convention Area is therefore regarded as one of the few RFMOs whose regulatory area largely coincides with that of a large marine ecosystem (LME),⁶³ with all the consequential advantages that should bring for ecosystem-based management. In reality, however, several species managed by CCAMLR also occur outside the Convention Area, either as transboundary or discrete stocks. In the latter case, stocks may be discrete to the high seas (outside the Convention Area) or to coastal state maritime zones or they may be straddling stocks between these areas.⁶⁴ Its occurrence beyond the Convention Area is particularly relevant for Patagonian toothfish. Article XI of the CCAMLR Convention addresses a part of this problem by requiring CCAMLR to cooperate with coastal states with a view to harmonizing conservation for transboundary stocks between the Convention Area and coastal states maritime zones beyond the Convention Area.⁶⁵

Faced with serious IUU fishing problems, CCAMLR was compelled to act not only under Article XI but to also address the high-seas dimension of the problem. In addition to adopting four (non-legally binding) CCAMLR Resolutions,⁶⁶ the main measure so far has been the regulation of trade in toothfish through the ‘Catch Documentation Scheme for *Dissostichus* spp.’ (CDS).⁶⁷ The main objective of the CDS is to determine whether toothfish are caught in a manner consistent with CCAMLR’s Conservation Measures. All toothfish transhipped, landed in ports, imported, exported or re-exported must be accompanied by a completed and validated *Dissostichus* catch document (DCD).

Whereas contracting parties to the CCAMLR Convention are legally bound to these specific obligations under the CDS,⁶⁸ if non-contracting parties or their vessels want to engage in some of these activities, in particular fish export, they are effectively forced to participate in the CDS. Several non-contracting parties therefore currently participate on a voluntary basis in the CDS.⁶⁹ Obviously, however, if toothfish are caught in contravention of CCAMLR’s Conservation Measures, in particular inside

⁶³ See LME #61, ‘Antarctic’ at <www.edc.uri.edu/lme>.

⁶⁴ See the discussion at the XXIInd Annual CCAMLR Meeting (2003) as to whether or not Patagonian toothfish in the Indian Ocean should be treated as a metapopulation and, consequently, as a straddling stock (Doc. CCAMLR–XXII, note 55, paras 11.2–11.3). See note 1 on the use of the term ‘straddling stock’. The CCAMLR Commission may eventually embrace this metapopulation theory by concluding that the transboundary effects caused by the exchange of individuals between the various populations is such that they should no longer be exclusively managed as discrete stocks. Embracing this approach may have important consequences for coastal States with relevant maritime zones inside and outside the Convention Area and for the evolution of the competence of CCAMLR, both substantially and geographically.

⁶⁵ Whether or not as straddling stocks pursuant to Art. 63(2) of the LOSC. See also note 64.

⁶⁶ Resolution 10/XII on ‘Harvesting of Stocks Occurring Both Within and Outside the Convention Area’, Resolution 16/XXII ‘Application of VMS outside the Convention Area in the Catch Documentation Scheme’, Resolution 17/XX ‘Use of VMS and other Measures for the Verification of CDS Catch Data for Areas Outside the Convention Area, in particular, in FAO Statistical Area 51’ and Resolution 18/XXI on ‘Harvesting of *Dissostichus eleginoides* in Areas Outside of Coastal State Jurisdiction adjacent to the CCAMLR Area in FAO Statistical Areas 51 and 57’.

⁶⁷ Currently laid down in Conservation Measure 10–05 (2003).

⁶⁸ Although the CDS is explicitly directed towards contracting parties, only Members of the Commission are formally and legally bound by Conservation Measures. See in this regard Art. XXII of the CCAMLR Convention and CCAMLR Resolution 14/XIX ‘Catch Documentation Scheme: Implementation by Acceding States and Non-Contracting Parties’.

⁶⁹ Doc. CCAMLR–XXII/BG/18 Rev. 1, of 21 October 2003, ‘Implementation and Operation of the Catch Documentation Scheme in 2002/03 (Secretariat)’.

the Convention Area by an unlicensed vessel,⁷⁰ the DCD will not be accepted. If, on the other hand, the DCD indicates that the catches were made outside the Convention Area, whether on the high seas or within coastal state maritime zones, the DCD must in principle be accepted in view of the sovereignty, sovereign rights and high-seas freedoms related to fishing under international law. As a consequence, however, CCAMLR had implicitly started to regulate fishing activities outside the Convention Area.⁷¹ The experience in the operation of the CDS so far has demonstrated a serious suspicion that much of the toothfish reported in DCDs as caught on the high seas outside the Convention Area, is in reality caught inside the Convention Area.⁷² Whereas the CDS⁷³ and CCAMLR Resolutions 16/XXII and 17/XX⁷⁴ recognize the discretion of states, in particular in their capacity as port state, to require additional verification of DCDs for catches on the high seas outside the Convention Area, *inter alia* by means of satellite-based vessel monitoring system (VMS) data, there is no legally-binding obligation to do so. Attempts to address these problems at the XXIst and XXIInd Annual CCAMLR Meetings in 2002 and 2003 by means of more explicit regulation beyond the Convention Area were largely unsuccessful.

At the XXIst Meeting, Australia proposed that the spatial scope of the CCAMLR Convention be amended to include certain areas of the Indian Ocean. In addition, or alternatively, it was proposed that CCAMLR adopt the necessary Conservation Measures to regulate fishing in the high-seas parts of these areas.⁷⁵ The first proposal attracted no support whatsoever and the alternative proposal was not discussed.⁷⁶ Some delegations noted that the process of amending the CCAMLR Convention pursuant to its Article XXX would be lengthy and possibly unsuccessful as it requires formal adherence by all Commission Members. Other delegations noted that this would affect the competence of other RFMOs.

At the XXIInd Meeting, Australia, New Zealand and the United States submitted a proposal for a centralized VMS (CVMS) which would also apply to fishing for toothfish outside the Convention Area.⁷⁷ Rather than amending the CCAMLR Convention, this proposal envisaged a Conservation Measure that would either apply explicitly outside the Convention Area or implicitly by means of a linkage with the CDS.⁷⁸ This time the objections not only related to other RFMOs with competence but also alluded to CCAMLR's lack of (spatial) competence.⁷⁹ In the end, even a watered-down proposal whose scope was limited to the Convention Area was unable to attract a consensus.⁸⁰

The lack of consensus on these 2002 and 2003 proposals seems to indicate that whereas CCAMLR Members were prepared to accept the implicit approach pursued by the CDS in 1999, the explicit approach pursued by these recent proposals would

⁷⁰ Vessels of non-contracting parties will always be regarded as unlicensed.

⁷¹ This was not seen as a major obstacle at the XVIIIth Annual CCAMLR Meeting (1999), when the CDS was adopted. (see the Report, paras 5.10–5.43, in particular paras 5.36 and 5.38–5.41).

⁷² See *inter alia* CCAMLR Resolution XXI, note 66; Doc. CCAMLR–XX (2001), paras 5.12–5.18; and Doc. CCAMLR–XXI (2002), paras 8.2–8.8.

⁷³ See paras 14 and A3.

⁷⁴ See note 66.

⁷⁵ Doc. CCAMLR–XXI/24, of 18 October 2002, 'Achieving Sustainable Fisheries for *Dissostichus* spp.: Managing the Harvesting of Stocks Outside the CCAMLR Area' (Delegation of Australia). This proposal built on discussions at the XXth Annual CCAMLR Meeting (2001) (see Doc. CCAMLR–XX, paras 7.18–7.20).

⁷⁶ See the discussion in Doc. CCAMLR–XXI (2002), paras 8.74–8.84.

⁷⁷ Docs CCAMLR–XXII/54 and CCAMLR–XXII/BG/21.

⁷⁸ Draft Conservation Measure 10–04, of 29 October 2003 (Australia, New Zealand, USA) (on file with author).

⁷⁹ Doc. CCAMLR–XXII/59, of 3 November 2003, 'Report of the Standing Committee on Implementation and Compliance (SCIC)', paras 3.27–3.54, in particular paras 3.32–3.33.

⁸⁰ Doc. CCAMLR–XXII, note 55, at paras 10.12–10.23. Argentina proved to be the main, if not only, bar to consensus, probably largely because it saw the proposal as affecting its sovereignty in the context of the sovereignty dispute between Argentina and the United Kingdom over South Georgia, the South Sandwich Islands and Shag Rocks (para. 10.21).

secure no consensus. It is submitted that some of the objections that were raised are more convincing than others. As regards conflicting, or overlapping competence with other RFMOs it should be recognized that the establishment of SWIOFC may not just still take considerable time but may not even happen at all. Also, even if the Galapagos Agreement⁸¹ enters into force and becomes fully operational, some CCAMLR Members may not regard it as a ‘competent’ organization in view of the substance of the Agreement as well its negotiation-process.⁸² Last, while the SEAFO Convention has recently entered into force, it will take some time for it to become fully operational. And even when that happens, its membership may decide to recognize the primacy of CCAMLR in regulating toothfish.⁸³ Finally, if CCAMLR would adopt Conservation Measures whose spatial scope would overlap with the proposed regulatory area of another RFMO, it could specifically indicate that these are to be withdrawn when that RFMO, once established, so wishes. It is to be hoped that such an RFMO does not request such a withdrawal until it is capable of managing the fish stocks with comparable effectiveness and that the two RFMOs establish cooperative arrangements to ensure compatibility in their management.⁸⁴

As regards the formal competence of CCAMLR, it has to be admitted that the relevant provisions of the CCAMLR Convention leave little room for an extensive, purposive or ‘implied powers’ interpretation. Even though Article I(1) and (2) of the CCAMLR Convention provide that it applies to ‘Antarctic marine living resources’, this is firmly linked to the spatial scope of the Convention. Moreover, the Convention’s objective of “the conservation of Antarctic marine living resources” in Article II(1) must be interpreted in light of Article I(1) and (2). The function or mandate of CCAMLR laid down in Article IX(1) is to give effect to the Convention’s objective and is thereby also linked to Article I(1) and (2). The residual tasks and types of Conservation Measures under Article IX(1)(h) and (2)(i) and CCAMLR’s obligations to cooperate with coastal states under Article XI and with relevant IOs (including RFMOs) under Article XXIII(3) and (4), do not warrant a different conclusion either.

It seems also likely that some CCAMLR Members were concerned about potential implications beyond CCAMLR if a strict treaty interpretation would not be followed. The many competence issues that have arisen under the IWC Convention⁸⁵ in recent years are just one example.⁸⁶ Having said that, one fundamental difference between the IWC Convention and the CCAMLR Convention is that decision-making in the former occurs by simple or qualified majority. Consensus decision-making within the CCAMLR Convention at least guarantees the widest possible support. One possible solution to the lack of formal competence would be, as suggested in the beginning of this subsection, to use the cooperative framework of CCAMLR to establish an arrangement. Whereas CCAMLR would function as a forum to negotiate such an

⁸¹ See note 19.

⁸² Molenaar (2001), pp. 102–103. Note that the Japanese statement in para. 3.32 of Doc. CCAMLR–XXII/59, note 79, refers to SEAFO and SWIOFC but not to the Galapagos Agreement.

⁸³ A. Serdy (2004) at footnote 24 and accompanying text on the original ICCAT (International Commission for the Conservation of Atlantic Tunas) statistical document and its application to southern bluefin tuna beyond ICCAT’s regulatory area.

⁸⁴ Note in this regard the cooperation between NAFO and NEAFC with regard to the management and conservation of oceanic redfish (see e.g. the Report of the 20th Annual NEAFC Meeting (2001), at p. 6; and NAFO’s 2001 Annual Report, at pp. 51–60).

⁸⁵ International Convention for the Regulation of Whaling, Washington D.C., 2 December 1946. In force 10 November 1948, 161 *United Nations Treaty Series* 72; <www.iwcoffice.org>.

⁸⁶ For instance, the ‘Berlin Initiative on Strengthening the Conservation Agenda of the International Whaling Commission’ (as adopted by IWC Resolution 2003–1); the competence of the International Whaling Commission to decide on requests for adherence to the IWC Convention (see Chair’s Report of the 53rd Meeting, pp. 12–15 and the info related to the Icelandic adherence at <www.iwcoffice.org>); and the objective of special permit scientific whaling under Art. VIII of the IWC Convention (see section 6.2 and Appendixes 2 and 3 to Annex O of the 2002 Report of the IWC Scientific Committee).

arrangement, its adoption would take place according to independent procedures. As already noted, such an arrangement must be consistent with international law, including the LOSC and customary international law. Most importantly, it should be non-discriminatory, open to new participants and based on an equitable distribution of fishing opportunities. The adoption of such an arrangement would attest to the CCAMLR Members' willingness to provide flexible and expeditious solutions to pressing problems. Such action would also allow CCAMLR to reassert its position as a pioneering and leading RFMO; a position that has been under increasing pressure in recent years. While the specifics of CCAMLR's lack of competence are probably unique to CCAMLR, the proposed solution is relevant for many different lack-of-competence scenarios. The envisaged action by CCAMLR may therefore also inspire others to adopt the flexible and expeditious solutions that the regulation of deep-sea fisheries so desperately needs.

3.5 Unilateral regulatory approaches

States can choose from a wide range of unilateral regulatory approaches that can benefit the sustainability of deep-sea fisheries and the safeguarding of biodiversity. However, where these are based on a state's jurisdiction under the nationality principle (including flag state jurisdiction), there are of course economic implications. The domestic fishing industry is likely to regard stringent unilateral regulation or a prohibition of (certain) deep-sea fisheries as unfair in view of the competitive advantages for states regulating less stringently or not at all. The effectiveness of such unilateral regulation may also be less than satisfactory. However, a lack of effective national or international regulation cannot serve as an excuse for continuing to engage in fishing activity that is inconsistent with obligations under international law both for being unsustainable and for the threat it poses to biodiversity. Action at the global level, e.g. through a resolution by the UNGA, would be helpful as it would remind states of their obligations and, one hopes, contribute towards creating a level playing field.

One approach to regulating or prohibiting high-seas bottom trawling that would not be affected by open access and 'free rider' problems relies on a coastal state's sovereign rights over its continental shelf. This option would be available to states that have not yet established an EEZ or exclusive fishing zone (EFZ), e.g. many coastal states in the Mediterranean Sea. It would also be available to states with a so-called outer continental shelf: i.e. the legal continental shelf extending beyond 200 nm from the baseline in accordance with Article 76 of the LOSC.⁸⁷

A coastal state has sovereign rights over its continental shelf "for the purpose of exploring it and exploiting its natural resources" (Art. 77(1) of the LOSC). These natural resources consist of the non-living resources of the sea-bed and subsoil together with living organisms belonging to sedentary species (Art. 77(4) of the LOSC). The latter are defined as:

"organisms which, at the harvestable stage, either are immobile on or under the sea-bed or are unable to move except in constant physical contact with the sea-bed or the subsoil" (Art. 77(4) of the LOSC).

While it is generally accepted that this would include species like clams and abalone, for other species this is not so clear.⁸⁸ This notion of 'sovereign rights' falls short of full

⁸⁷The implications of taking such action before the coastal State has established the outer limits of the outer continental shelf on the basis of the recommendations of the Commission on the Limits of the Continental Shelf (CLCS) pursuant to Art. 76(8) of the LOSC are complex issues that cannot be discussed here. It is nevertheless submitted that in many circumstances this requirement does not prevent the coastal State from the types of action envisaged in this subsection.

⁸⁸E.g. in 1962–63, disagreement over the categorisation of lobster led to the so-called lobster-war between Brazil and France (cf. J.A. de Yturriaga, *The International Regime of Fisheries. From UNCLOS 1982 to the Presential Sea* (Martinus Nijhoff Publishers: 1997), p. 109) and in 1994 Canada and the United States disagreed on the categorisation of scallops (see 10 *International Journal of Marine and Coastal Law* 221–222 (1995)).

sovereignty, but comprises comprehensive jurisdiction with a scope that is identical to the scope of the sovereign rights.⁸⁹ Article 78(2) of the LOSC stipulates that coastal states are not to exercise their sovereign rights in a way that would infringe or result in unjustifiable interference with the rights and freedoms of other states.

As mentioned before, it is submitted that these sovereign rights can also be used to regulate or prohibit deep-sea fisheries that use bottom-trawling, for instance to protect deepwater coral reefs (e.g. *Lophelia pertusa*) or benthic communities.⁹⁰ To protect these, such fishing practices have occasionally been prohibited within EEZs or EFZs. For instance, in 1999 Norway commenced mapping deepwater coral reefs within its EEZ and subsequently protected them by prohibiting the use of fishing gear that is dragged along the bottom. At the time of writing, the protected reefs include the Sula ridge, the Iver ridge and the Røst reef, the world's largest coldwater reef.⁹¹ In May 1999 Australia proclaimed the Tasmanian Seamounts Marine Reserve in which all trawling deeper than 500 m was prohibited to protect benthic coral- and urchin dominated communities as from August 1999.⁹² And, the EU banned bottom trawling in the area of the Darwin Mounds, northwest of Scotland in 2003⁹³ and proposed a similar ban in areas around the Azores, Madeira and the Canary Islands in 2004.⁹⁴

So far, however, there does not seem to have been an exercise of sovereign rights over the continental shelf or on the outer continental shelf in the circumstances envisaged in this subsection; that is, in the absence of an EEZ or EFZ. It is nevertheless submitted that international law, including the LOSC, would not only allow an exercise of these sovereign rights for this purpose but would at times require this. As regards the scope of the sovereign rights, the purpose of “exploring it and exploiting its natural resources” would by implication allow a coastal state to prohibit any exploring or exploitation whatsoever and thereby preserve the natural resources (Art. 77(2) of the LOSC). However, whereas the definition of natural resources in Paragraph (4) of Article 77 includes all non-living resources, the only living organisms explicitly included are those belonging to sedentary species. The rationale for the inclusion of sedentary species can partly be explained by their limited mobility at the harvestable stage. As their exploitation would have only minimal transboundary impacts, there was no need for internationalisation. It was generally accepted that demersal fish species would not fall within this category.⁹⁵

It can be argued that coral reefs fall within the definition of natural resources for the reason that they consist of both living and non-living components. It is submitted, however, that the words “at the harvestable stage” should not be interpreted in a way that would exclude benthic organisms that are not (yet) intended for exploitation. Such an interpretation would not be consistent with the above-mentioned rationale. Consequently, it is submitted that the sovereign rights under Article 77 can also be used to preserve such organisms and protect them from interference. States wishing to prohibit bottom trawling or other fishing practices that have adverse impacts on the

⁸⁹ Cf. the Commentary by the International Law Commission (ILC) (*Yearbook of the International Law Commission*, 1956, Vol. II, p. 297) on what would become Art. 2(1) of the Convention on the Continental Shelf (Geneva, 29 April 1958. In force 10 June 1964, 499 *United Nations Treaty Series* 311; <www.un.org/law/ilc>). Art. 2 was reproduced almost verbatim in Art. 77 of LOSC.

⁹⁰ See in general Long and Grehan (2002).

⁹¹ Pers. Comm. T. Løbach, IMR, Bergen, Norway, September 2003. See also *Seabed News*, No. 1 (July 2000), at p. 1 (available at <www.eu-seased.net>).

⁹² *Commonwealth of Australia Gazette*, No. GN 20, of 19 May 1999.

See info at <www.ea.gov.au/coasts/mpa/seamounts>.

⁹³ Commission Regulation (EC) No. 1475/2003, of 20 August 2003, on the protection of deepwater coral reefs from the effects of trawling in an area north west of Scotland.

⁹⁴ See COM (2004) 58 final, of 3.02.2004, ‘Proposal for a Council Regulation amending Regulation (EC) No 850/98 as regards the protection of deepwater coral reefs from the effects of trawling in certain areas of the Atlantic Ocean’.

⁹⁵ *ILC Yearbook*, Vol. II, p. 297. See also the discussion in De Yturriaga, note 88, at pp. 106–110.

natural resources of their continental shelf, including sedentary species, should also point to their obligations under international law and emphasize that such action would respond to the growing concern of the international community on these issues.⁹⁶ Here too, action at the global level, *inter alia* through a resolution of the UNGA, would help to support states that contemplate such action.

Finally, it should be emphasized that Articles 78(2) and 300 of the LOSC require coastal states to ensure non-discrimination in the exercise of their sovereign rights. This is necessary in two distinct situations. In the first, coastal state regulations on the (outer) continental shelf must apply equally to foreign and nation vessels. In the second, the stringency of coastal state regulation must be consistently uniform in all its maritime zones. An unjustifiable or arbitrary higher level of stringency in regulation on the (outer) continental shelf in comparison with maritime zones where foreign vessels have no fishing access, would give national vessels a competitive advantage and thereby discriminate against high-seas fishing states.

4. CONCLUSIONS AND OBSERVATIONS

If the gradual worsening of the current worldwide crisis in marine capture fisheries is to be reversed, states have to be progressive, pro-active and precautionary, whether at the national, regional or global level. If ever there were a need for such a course of action it would be for the regulation of deep-sea fisheries now. In view of the special characteristics of deep-sea fisheries, the current international legal regime and relevant state practice, regulatory action needs to be taken with the utmost urgency. As there may not be enough time for conceptually sound and holistic but incremental processes for regime-building, the focus should first of all be on flexible and expeditious action in the short term.

The approach advocated in this paper would be one where complementary action is taken simultaneously at the global, regional and national level. Efforts at the global level should first be directed through the UNGA to enhance awareness and to create the necessary stimulus and legitimacy for further action at the regional and national level. In view of the urgency of the matter priority should not be given to starting a negotiation-process for a global treaty modelled on the Fish Stocks Agreement. Under the current circumstances, the outcomes of such a process are expected to be modest at best. Moreover, even without such a global treaty, the regulation of discrete high-seas (deep-sea) fish stocks would still be possible on the basis of customary international law. This basis can be relied on not only for such concepts as the precautionary approach but also for the fundamental role and authority of RFMOs in fisheries management and their ability to call for, or take, action against (non-cooperating) non-members.

At the regional level, the need for urgency requires that efforts should not initially be aimed at establishing new RFMOs but instead at more flexible and expeditious options, for instance concluding arrangements, treaty or non-treaty, and within or outside the cooperative framework of existing RFMOs. It is to be hoped that CCAMLR can play a leading and guiding role in this regard.

One option for unilateral action discussed in this paper would be available for coastal states that have yet to declare an EEZ or an EFZ or that have a continental shelf beyond 200 nm from their baselines. Such states should exercise, in a non-discriminatory manner, their sovereign rights to regulate or prohibit bottom trawling and other fishing practices that have adverse impacts on the natural resources of their continental shelf.

⁹⁶ These obligations are set out in Section 400. Note that Part XII of LOSC does not provide coastal states with more comprehensive rights over a wider range of natural resources than pursuant to Parts V and VI. The fact that Part XII imposes many obligations with respect to the marine environment (a term not defined by the LOSC) on (coastal) States, cannot alter that. Consequently, even if certain fishing practices could be classified as 'pollution of the marine environment' (see Art. 1(1)(4) of LOSC), which is a tenuous claim at best, provisions like Art. 208 would still not give coastal States broader jurisdiction than under Arts 56 or 77.

5. ACKNOWLEDGMENTS

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CCAMLR's approach to managing Antarctic marine living resources¹

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1. INTRODUCTION

The “ecosystem and precautionary” principles of the 1980 Convention on the Conservation of Antarctic Marine Living Resources’ (CAMLRL Convention)(CCAMLR 2002a) are encapsulated in its Article II (Box 1). These principles are often cited as the Convention’s most innovative feature compared to other fisheries and management instruments adopted both before, and after, the Convention’s entry into force in 1982 (Butterworth 1986, Constable *et al.* 2000, Molenaar 2001).

The Commission (CCAMLR) established under Article VII of the Convention has a number of important functions. The most notable of these are outlined in paragraphs 1 and 2 of Article IX and focus on the formulation, adoption and revision

BOX 1

CCAMLR Convention Article II [from CCAMLR (2002a)]

1. The objective of this Convention is the conservation of Antarctic marine living resources.
2. For the purposes of this Convention, the term ‘conservation’ includes rational use.
3. Any harvesting and associated activities in the area to which this Convention applies shall be conducted in accordance with the provisions of this Convention and with the following principles of conservation:
 - (a) prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment. For this purpose its size should not be allowed to fall below a level close to that which ensures the greatest net annual increment
 - (b) maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations to the levels defined in sub-paragraph (a) above and
 - (c) prevention of changes or minimization of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades, taking into account the state of available knowledge of the direct and indirect impact of harvesting, the effect of the introduction of alien species, the effects of associated activities on the marine ecosystem and of the effects of environmental changes, with the aim of making possible the sustained conservation of Antarctic marine living resources.

¹ The opinions expressed in this paper are those of the authors and do not reflect the collective, or official, views or decisions of CCAMLR.

of Conservation Measures² based on the best scientific evidence available [Article VII, paragraph 1.(f)]. Such measures include, *inter alia*, setting of catch limits, effort controls, closed areas and seasons, etc.

At its first two meetings in 1982 and 1983, CCAMLR was preoccupied with procedural issues and with setting up terms of reference for its advisory Scientific Committee (the functions of which are set in Convention Article XV) and other subsidiary bodies. At that time, there was a growing and urgent sense of concern over the status of fish stocks around South Georgia and the Kerguelen Islands (Kock 1992). With CCAMLR's "newness" there was also insufficient data with which to make scientific assessments of stocks in either area.

Consequently, the first two conservation measures adopted in 1984 established mesh size regulations for pelagic and bottom trawl fisheries around South Georgia while setting up a 12 nautical mile closed area offshore (CCAMLR 1984). In keeping with the Chairman's Statement (CCAMLR 2002a) setting conditions for the application of jurisdiction in waters under sovereign control within the Convention Area³, CCAMLR accepted that the fish stocks within the French Exclusive Economic Zone (EEZ) around Kerguelen Island were subject to national regulatory measures.

Additional concern surrounded the impending likelihood that a potentially large fishery would develop for one of the Southern Ocean's keystone species – Antarctic krill (*Euphausia superba*) in the foreseeable future (Miller 1991, Agnew and Nicol 1996). Given the historic precedents associated with exploitation of a number of top predators (both whales and seals) in the region, there was also a growing fear that exploitation of krill, an important food item, could compromise predators' statuses as well as their recovery from past unsustainable levels of exploitation. Despite the relative success of the international Biological Investigations of Marine Antarctic Systems and Stocks (BIOMASS) Programme, particularly the First International BIOMASS Experiment (FIBEX), knowledge of krill potential yield and sustainability continued to be severely limited (Fogg 1994). These concerns resulted in the unique formulation of paragraph 3 of Article II and the Convention being termed the "krill ecosystem convention" (Mitchell and Sandbrook 1980, Edwards and Heap 1981).

Following its rather modest start, CCAMLR soon launched a comprehensive programme of scientific work. This included the evolving development of procedures to analyse historical fishery data as well as the collection of data necessary for monitoring fisheries, stock assessment, and improving the understanding of fishery stock dynamics, biology and productivity. A most important initiative set up the CCAMLR Ecosystem Monitoring Programme (CEMP) [Paragraph 7.2 in SC-CAMLR (1985)]:

"To detect and record significant changes in critical components of the ecosystem to serve as a basis for the conservation of Antarctic marine living resources".

This objective was qualified as follows:

"The monitoring system should be designed to distinguish between changes due to harvesting of commercial species and changes due to environmental variability, both physical and biological."

Institutionally, CCAMLR recognized that adequate enforcement posed a serious challenge to ensuring effective implementation of its Conservation Measures envisioned under Article IX. The problem is compounded by the Convention Area's size,

² CCAMLR Conservation Measures are binding on all Commission Members (CCAMLR 2002a).

While there is a body of opinion which does not accept that conservation measures are binding on all CCAMLR Contracting Parties, Convention Article XXI.(1) mandates each Contracting Party to take "appropriate measures within its competence to ensure compliance with the Convention's provisions and with conservation measures adopted by the Commission to which the Party is bound under Article IX". In contrast to Conservation Measures, CCAMLR Resolutions are not binding. The numbering system for CCAMLR Conservation Measures, but not Resolutions, was changed in 2002.

³For further information on, and discussion of the Statement's legal implications, see Molenaar (2001).

remoteness and relative ease of access, particularly its high-seas areas (Molenaar 2001). An ambitious work programme to develop a CCAMLR compliance regime culminated in the setting up of the CCAMLR System of Inspection and Scheme of International Scientific Observation (see Section 5.2.3)(Rayfuse 2000) to improve at-sea, as well as in port, monitoring and enforcement.

In subsequent years, CCAMLR developed a comprehensive suite of Conservation Measures based on both traditional fishery management approaches as well as some to address precautionary and ecosystem concerns (e.g. CCAMLR 2002b). Currently, CCAMLR's Conservation Measures comprise an integrated set of individual measures dealing with all aspects of modern fisheries management. The Measures are kept under constant review to evaluate performance and, if necessary, provide for revision or the adoption of new measures. This approach has resulted in CCAMLR being viewed as a pioneer in developing novel and innovative measures to address both precautionary and ecosystem principles (Everson 2002). It has also served to improve management of some important CCAMLR stocks on a global basis; an approach which required implementing both compliance and trade-related measures (Sabourenkov and Miller 2004).

With growing recognition of its achievements, CCAMLR is viewed as a useful model for fisheries management in other areas, particularly on the global high seas. Through applying its precautionary and ecosystem approach, CCAMLR has addressed the concerns that:

- All data that can be collected are. The extent and effect of uncertainties and gaps in such data are taken into account before management decisions are made. This process minimizes the risk of long-term adverse effects rather than delaying decisions until all necessary data are available.
- Account is taken of all potential relationships between harvested species, including those related thereto, and physical components (such as currents, sea temperature) constituting the Antarctic marine ecosystem.

In this paper, we document some of CCAMLR's experiences in developing and implementing a feedback (i.e. modifiable) system of contemporary fisheries conservation and management measures for the resources for which it is responsible. The first part of the paper details three examples of CCAMLR's efforts to implement some of Article II's provisions. These examples have been chosen to highlight the development and evolution of attached measures dealing with: (a) uncertainty attached to new and exploratory fisheries (Section 2), (b) reduction and elimination (i.e. minimization) of seabird bycatch in longline fisheries in the *Convention Area*, including mitigation measures (Section 3), and (c) trade related measures to combat unregulated fishing both in the *Convention Area* from a global perspective (Section 4). The second part of the paper focuses on assessing CCAMLR's achievements. It also identifies some potential threats to its future effectiveness and suggests possible solutions to counteract them.

2. REGULATION OF NEW AND EXPLORATORY FISHERIES

2.1 Introduction

In an ideal world, all the information required for sustainable and scientifically-defensible exploitation of new fishery stocks should be in place before commercial fishing is permitted (Butterworth 1986, 1999). Comparisons can then be made of stock status before and after exploitation begins, with management action being adjusted accordingly to ensure maintenance of some desirable, or pre-ordained stock level. Reality may differ and new fisheries are often exploited – even overexploited – well before the necessary management information is available or even collected (Butterworth 1999). The precautionary approach envisioned under CCAMLR Article II attempts to

TABLE 1

Modifications and, or additions to CCAMLR Conservation Measure 112/XV providing general rules for new/exploratory toothfish (*Dissostichus* spp.) fisheries

Modification/addition	Revised measure	Reference
<ul style="list-style-type: none"> • Extended to include exploratory fisheries • Addition of Data Collection Plan 	133/XVI	CCAMLR 1997a
<ul style="list-style-type: none"> • Elaboration of Macrourus and other bycatch provision • Addition of Research Plan 	182/XVIII	CCAMLR 1999a
<ul style="list-style-type: none"> • Addition & identification of small-scale research units as part of Research Plan • Designation of/requirement for 20 “research hauls” 	200/XIX	CCAMLR 2000b
<ul style="list-style-type: none"> • More precise definition of haul location 	41–01	CCAMLR 2002b

balance these two somewhat contradictory elements in a way that strives to minimize risk of irreversible changes in target, or dependent, stocks (Table 1).

2.2 History of CCAMLR's approach to new and exploratory fisheries

Following advice from its Working Group for the Development of Approaches to Conservation of Antarctic Marine Living Resources (WG-DAC) in 1989 [Annex E in CCAMLR (1989)] and from the Scientific Committee a year later [Paragraph 9.2 SC-CAMLR (1990)], CCAMLR set up a process to address the management of new⁴ fisheries in the Convention Area [Paragraph 9.3 in CCAMLR (1990)]. It was recognized that the development of such fisheries “should be directly linked with the process of elaborating scientific advice and management” measures to ensure that fisheries development does not outpace CCAMLR's ability to meet the objectives of Article II [Paragraph 9.3 in CCAMLR (1990)].

CCAMLR accepted the Scientific Committee's advice (Paragraph 289 in Annex 5 of SC-CAMLR (1990)) that certain information is vital for assessing the potential yield of a new fishery and that such information should be considered before a new fishery develops further [Paragraph 9.4 in CCAMLR (1990)]. Finally, it was emphasized that development of measures directed at informing the Commission of intentions to conduct any fishery in the Convention Area was crucial to ensuring effective implementation of CAMLR Articles II and IX [Paragraph 9.5 in CCAMLR (1990)].

The following year, CCAMLR adopted Conservation Measure 31/X [Paragraph 10.3 in CCAMLR (1991)] setting out provisions requiring notification of any new fishery and attached conditions for implementation. This particular Measure has remained unchanged since its inception, now standing as Conservation Measure 21-01 (CCAMLR 2002b).

Through promulgation of Measure 31/X, CCAMLR expressly recognized that fisheries should be managed from the time they commence. Prenotification of new fisheries is thus an essential component in preparing for their management, particularly when fishing is targeting species, and, or, a fishing ground that has not previously been fished. Similar considerations apply if there is an intention for the fishery to use a new fishing technique. Thus the objective of Measure 31/X is to collect information on target, as well as dependent, species and to limit catch, effort or both.

In 1993, CCAMLR developed Conservation Measure 65/XII [now Measure 21–02 – CCAMLR (2002b)] to deal with fisheries that were no longer new but for which critical management information on topics such as those outlined in Box 2

⁴Under Conservation Measure 21-01, a “new” fishery is defined as a fishery on a species using a particular fishing method in a Statistical Sub-area for which: (a) information on distribution, abundance, demography, potential yield and stock identity from comprehensive research/surveys or exploratory fishing have not been submitted to CCAMLR; or (b) catch and effort data have never been submitted to CCAMLR; or (c) catch and effort data from the two most recent seasons in which fishing occurred have not been submitted to CCAMLR (CCAMLR 2002b).

BOX 2

Key considerations associated with the continuing classification of a fishery as exploratory

[from Paragraph (1).(ii) of CCAMLR Conservation Measure 21-02 – CCAMLR (2002b)].

An exploratory fishery shall continue to be classified as such until sufficient information is available:

- (a) to evaluate the distribution, abundance, and demography of the target species, leading to an estimate of the fishery's potential yield
- (b) to review the fishery's potential impacts on dependent and related species and
- (c) to allow the Scientific Committee to formulate and provide advice to the Commission on appropriate harvest catch levels, as well as effort levels and fishing gear, where appropriate.

remained lacking [Paragraph 8.39 in CCAMLR (1993)]. Following a year of fishing as a new fishery, the fishery becomes an “exploratory” fishery⁵. Conservation Measure 21-02 allows for application of both CCAMLR's precautionary approach and the collection of data necessary to move towards full assessment of the fishery and stock(s) concerned, while attempting to reduce the potential for “irreversible change(s)”. An attached, and essential element defines a Data Collection Plan as well as the need to produce Research and Fishery Operational Plans (CCAMLR 2002b). The Scientific Committee annually reviews these plans and provides advice on prosecution of the attached fishery.

2.3 History of CCAMLR's approach to new and exploratory fisheries

CCAMLR's initial experience with new and exploratory fisheries dealt with a new fishery for crabs (*Paralomis spinosissima* and *P. formosa*) around South Georgia (Sub-area 48.3), notified by the United States in 1990. The approach adopted was consistent with that outlined in Conservation Measure 31/X [Paragraphs 6.7 to 6.12 in CCAMLR (1991)] and aimed at setting conservative catch limits while requiring full reporting of information on the fishery's prosecution to the Scientific Committee. The initial Conservation Measure adopted in 1992 (Measure 60/XI) dealt with these aspects. In the ensuing years, additional refinements provided more detail on data reporting requirements culminating in a final version of the *Measure* (52-01) for the 2002/03 season (CCAMLR 2002b).

Following a CCAMLR-sponsored Workshop on the Longterm Management of the Antarctic Crab Fishery in early 1993, the Commission [Paragraph 4.25 in CCAMLR (1993)] accepted the Scientific Committee's advice that an experimentally-based approach should be applied to this fishery [Paragraph 4.14 in SC-CAMLR (1993)]. This approach was geared towards answering specific questions concerning the population dynamics of *Paralomis* stocks in Sub-area 48.3 in general, and of *P. spinosissima* in particular. It initially comprised three experimental phases to be conducted over two

⁵ Conservation Measure 21-02 defines an “exploratory” fishery as one previously defined as a “new” fishery under Conservation Measure 21-01 and one which continues to be defined as “new” until such time that certain conditions (e.g. key data on which to base estimates of yield etc.) have been met (CCAMLR 2002b). Both “new” and “exploratory” fisheries are subject to a rigid notification and review procedure before CCAMLR authorises fishing. All other fisheries are seen either as “closed” (i.e. not specifically open to fishing as new or exploratory fisheries, or as closed by specific CCAMLR Conservation Measures) or are classed as no longer being exploratory (i.e. since essential management and catch/effort information have become available).

fishing seasons. These consisted of a survey of crab distribution, a series of depletion experiments and redirecting fishing effort into areas depleted during the second phase [Paragraph 4.14 in SC-CAMLR (1993)]. The latter requirement was subsequently modified in later revisions of the Measure (Measure 75/XII) and culminated in the provisions of Paragraph 5 of Measure 52-02 (CCAMLR 2002b), which stipulate that: “vessels completing the experimental harvest regime are not required to conduct experimental fishing in future seasons”.

With the emergence of interest in new and exploratory fisheries for toothfish (*Dissostichus* spp.) in various parts of the Convention Area, the latter part of the 1990s and recent years, have been characterized by a large number of notifications for such fisheries (Agnew 2000, Sabourenkov and Miller 2004). In addition to regulatory measures setting catch limits and other restrictions (e.g. fishing season and effort limitations) on an areal basis, CCAMLR developed a single general measure (Conservation Measure 112/XV) [Paragraph 8.33 CCAMLR (1996a)] to outline requirements for new Toothfish fisheries in the 1996/97 season. This Measure contained a number of important elements that included, *inter alia*, procedures to spread fishing effort, both temporally and spatially, defining data reporting requirements, bycatch limits for other fish species, mandatory deployment of CCAMLR International Scientific Observers, and by implication, longline fisheries were linked to a need for seabird incidental mortality mitigation measures (see Section 3).

Measure 112/XV went through a series of significant modifications in the ensuing years. The most notable have been mentioned in the previous subsection and are presented in Table 1. The introduction of small-scale research units in 2000 required those prosecuting a Toothfish exploratory fishery to collect data in a more scientifically rigorous way and to spread catch and effort over a number of fine-scale rectangles [Figure 1 on page 57 of CCAMLR (2002b)]. Building on similar principles to those underpinning the exploratory crab fishery outlined above, and using experience gained from an exploratory trawl fishery in Division 58.4.3 [Conservation Measure 144/XVI – CCAMLR [1997a)], the small-scale research unit approach aims at improving data on *Dissostichus* spp. distribution and abundance from areas where information is limited or absent. Put simply, the approach strives to maximize the data collection potential of fishing vessels while ensuring that unacceptable damage is not inflicted on stocks for which essential management data are missing.

Following the introduction of its new and exploratory fisheries measures, CCAMLR was faced with the need to better define when fisheries are no longer exploratory (i.e. when data for management purposes become sufficient to allow a regulated fishery) [Paragraph in 5.28 SC-CAMLR (1998)] as well as the principles to be applied when fishing is resumed on opening a fishery which was previously defined as “closed” or “lapsed” [Paragraph 8.35 in CCAMLR (1996a)]. The Commission’s subsequent debate focused on the need to review the interrelationship of fisheries development stages, including for new and exploratory fisheries, to ensure that there is a coherent progression from the exploitation of an unexploited resource, through various fishery phases, to a fully- commercial fishery [Paragraph 104 in CCAMLR (1997b)]. After several iterative steps, the first major breakthrough in this process introduced a Unified Regulatory Framework (URF) for CCAMLR fisheries [Section 7 in SC-CAMLR (2000)].

This URF had three key objectives [Paragraph 10.3 in CCAMLR (2000a)] whose objectives are:

- provide clear guidance on the data and information requirements from all fisheries in the Convention Area to support development of management advice by the Scientific Committee in accordance with the precautionary and the ecosystem approaches to fisheries management

- support design of control mechanisms that will enable the collection of data and information for scientific analysis, and aim to ensure that fisheries in the Convention Area do not expand faster than the acquisition of information necessary for the development of management advice and
- streamline annual review and assessment of fisheries by the Scientific Committee and its working groups, in the face of a mounting workload created by the increasing number of fisheries in the Convention Area.

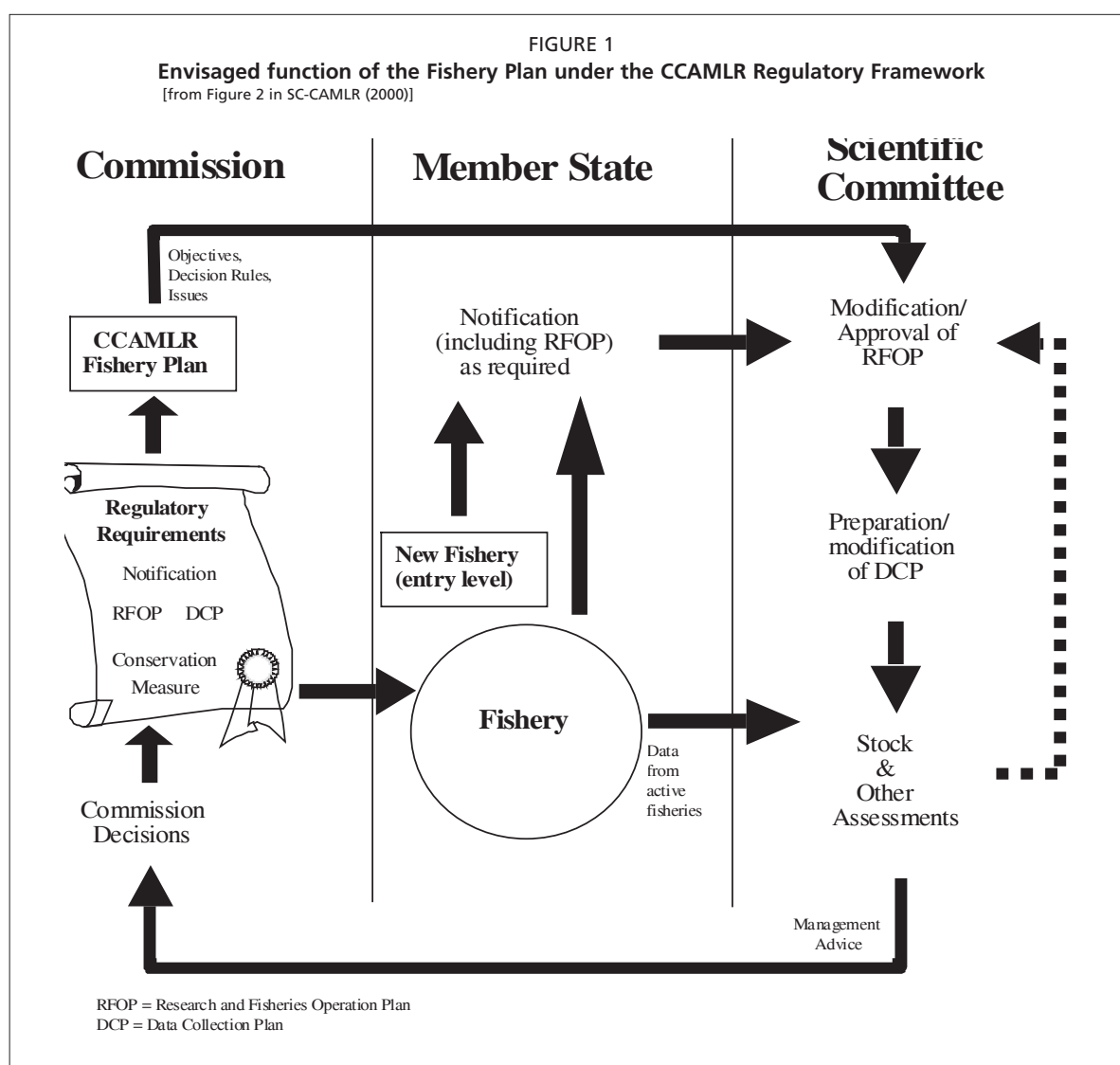
The Framework also fell within the existing regulatory requirements of the relevant Conservation Measures (Measures 31/X and 65/XII), most notably by including prior notification and establishment of Research and Fishery Operational and Data Collection Plans. This approach was then extended to all fisheries, not just those classified as “new” or “exploratory”, and no longer relied on defining the stage(s) of fishery development.

The generalized URF requires preparation of a new reference document to be maintained by the CCAMLR Secretariat for each fishery in the Convention Area. Known as the Fishery Plan, this provides a comprehensive summary of information on each fishery, including a list of all attached regulatory requirements. An outline of the Plan’s envisaged functions is provided in Figure 1. It also provides a summary of fishing activity and a summary list of data lodged in the CCAMLR database for the most recent fishing season. Consolidating all this information in one place facilitates the ability of the Scientific Committee and its working groups to plan future work based on data submitted from the fishery and, or, any notifications received [Paragraph 10.5 in CCAMLR (2000a)].

The Commission agreed that in order to provide comprehensive coverage of all CCAMLR fisheries under the URF, a Fishery Plan should be maintained for all fisheries currently active, or which have been active, in the Convention Area. This would simplify the structure of two fishery types to those with, and those without, fishery plans [Paragraph 7.9 in SC-CAMLR (2000)]. In respect of the former, the regulatory and scientific requirements would be specified in the Plan. For the latter, the Commission would be required to establish entry-level conditions; an issue that has already been addressed in the context of new and exploratory fisheries.

Fishery Plans enable the Scientific Committee to develop advice on whether a new assessment of a particular fishery is required and, or, possible. It also allows the Commission to formulate Conservation Measures based on all appropriate information from the fishery. Fishery Plans have been developed for the krill fishery in Area 48 [Appendix D in Annex. 4 of SC-CAMLR (2001)] and the Icefish (*Champsocephalus gunnari*) fishery in Sub-area 48.3 [Appendix E in Annex. 5 of SC-CAMLR (2001)]. The Commission has subsequently agreed [Paragraph 10.2 in CCAMLR (2001)] that the next step should be to prepare Fishery Plans for other fisheries in the Convention Area. The fisheries given highest priority are those for *D. eleginoides* in Sub-area 48.3 and Division 58.5.2, *Dissostichus* spp. in Sub-area 88.1 and *C. gunnari* in Division 58.5.2.

One important objective of the URF is to streamline the Scientific Committee’s annual review of fisheries. In this regard, the Working Group on Fish Stock Assessment, (WG-FSA) developed a summary table for new and exploratory fisheries notifications [Table 19 in Annex 5 of SC-CAMLR (2001)], which incorporates recent information from all fisheries in the Convention Area. The table includes information on most recently reported catches, notifications of intentions to take part in the fishery and advice about the currency of the most recent assessment for each fishery. Consequently, notification becomes an essential URF component. Further, the WG-FSA fishery summary is a useful complement to the Fishery Plans and its development continues to be a key element in providing guidance to the Working Group itself, as well as to the Scientific Committee, on priorities for future assessment work.



2.4 Evaluation of CCAMLR's approach to new and exploratory fisheries

A precautionary and positive adjunct to the assessment of new and exploratory longline fisheries has been the Scientific Committee's efforts to objectively assess the risks attached to the prosecution of such fisheries in certain areas and, or, times in relation to potential incidental seabird mortality [e.g. Paragraph 4.67 in SC-CAMLR (1997)]. This is discussed in Section 3.3.

Sabourenkov and Miller (2004) have noted that "despite the large number of new and exploratory fisheries authorized by CCAMLR, only a relatively small number have been prosecuted" (Figure 2). In this context, the Scientific Committee has agreed that a 'prospecting default arrangement' should be put in place in the absence of fishing on, or a formal assessment of, such fisheries [Paragraph 7.6 in SC-CAMLR (2001)]. The management advice provided then has to be qualified as being "multi-year in the absence of surveys or fishery-based research information". For previously notified fisheries, for which notifications continue to be received, the absence of new information means that no new assessments are possible. The Commission has agreed that until new information is received, no further advice on notified, but un-prosecuted, fisheries should be developed [Paragraph 10.3 in CCAMLR (2001)]. Hence, the "prospecting default arrangement" remains the current and only advice. It should be reiterated that not only does non-prosecution of notified fisheries commit administrative resources to the processing of notifications, it serves to erode application of precaution due to

growing uncertainty associated with a lack of information on the intended fishery and, or, stock(s) concerned.

3. MINIMIZATION OF SEABIRD BYCATCH IN LONGLINE FISHERIES

3.1 Introduction

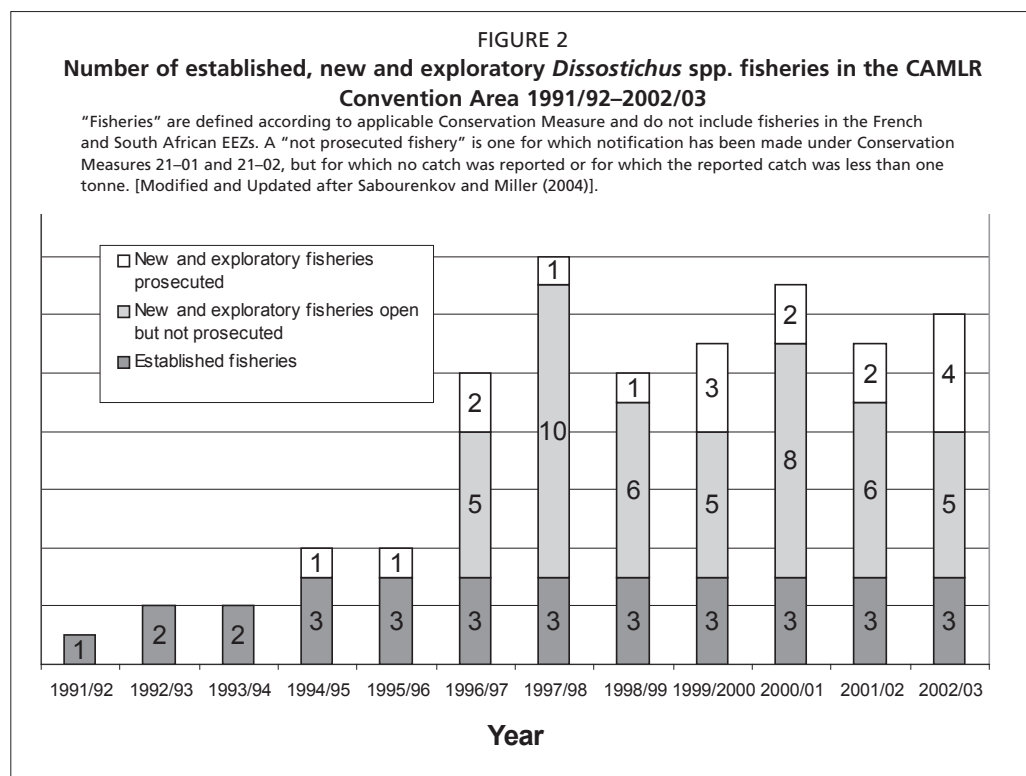
The 1999 FAO International Plan of Action for Reduction of Incidental Catch of Seabirds in Longline Fisheries (IPOA-Seabirds) (FAO 1999) clearly highlights concerns associated with the number of seabirds being incidentally caught and killed by commercial longline fisheries worldwide. The salient aspects of such concerns are: (a) fears over possible negative consequences of mortality levels on threatened seabird stocks, and (b) the possible impact on fishing productivity and profitability. Internationally, governments, non-governmental organizations and commercial fisher associations have all begun petitioning measures to reduce the incidental take of seabirds in such fisheries.

For CCAMLR, seabird bycatch associated with longlining has two important implications. First, many species breeding in the Convention Area, most notably Albatrosses and Petrels, have been affected by longline fisheries during winter months to the north of the Area [Paragraphs 6.7 and 7.3 in SC-CAMLR (1989) and SC-CAMLR (1990) respectively]. Second, the emergence of longline fisheries in the Area, often close to seabird breeding sites, has provided additional impetus to CCAMLR's efforts to address the problem.

In 1989, CCAMLR became the first international organization to institute seabird incidental mortality mitigation measures. Most of these measures, and CCAMLR's experiences therewith, provided a background to, or were incorporated into, the IPOA-Seabirds.

3.2 Rationale for CCAMLR seabird incidental mortality mitigation measures

The assessment and avoidance of incidental mortality of Antarctic marine living resources due to fishing has long been an important issue for CCAMLR in the context



of the potential “direct impacts” provisions of Article II.(3).(c) (Table 1). As long ago as 1984 the Commission requested Members⁶ to document and report the number, species and, where appropriate, the age, size, sex and reproductive status of any birds or marine mammals taken incidentally during fishing operations [Paragraph 21 in CCAMLR (1984)].

In 1989, demersal longlining was introduced to the Convention Area for the first time. The fishery targeted *D. eleginoides* (Patagonian toothfish) around South Georgia in the South Atlantic (CCAMLR Statistical Area 48.3). CCAMLR noted with concern that experience elsewhere indicated considerable levels of risk attached to this type of fishery given its attendant potential to cause substantial seabird mortality during fishing operations; a factor compounded by the relative proximity of the fishery to land-based, seabird breeding sites on the Island [Paragraph 24 in CCAMLR (1989)].

Initial and conservative CCAMLR estimates put the number of albatrosses (most Sub-Antarctic species) being killed annually at 44 000 in tuna longline (i.e. pelagic) fisheries alone outside the Convention Area. This estimate was sufficiently high to substantiate claims that observed and serious declines in Albatross populations within the Convention Area could be attributed to this type of fishing activity [Paragraphs 6.7 and 7.3 in SC-CAMLR (1989) and SC-CAMLR (1990) respectively].

CCAMLR went on to note that Australia and Japan had experienced some success in reducing seabird bycatch in tuna longline fisheries. This success was largely attributed to deployment of streamer lines, or ‘tori [bird]’ poles, to deter birds from taking baited hooks close to the surface, particularly when lines were set during daylight. The streamer lines were situated to trail in the water aft of the setting vessel and directly over the fishing line being set. CCAMLR noted that the attendant seabird catch was significantly reduced when tori poles were deployed. In addition, there appeared to be an added benefit in that bait loss was reduced during line setting [Paragraph 7.5 in SC-CAMLR (1990)].

It was therefore agreed that all CCAMLR-sanctioned longline fisheries should be regulated to minimize incidental seabird mortality [Paragraph 5.3 in CCAMLR (1989)]. The initial step was taken in 1989 when CCAMLR adopted Resolution 5/VIII (“Protection of Seabirds from Incidental Mortality Arising From Longline Fisheries”). This Resolution urged all CCAMLR Contracting Parties to investigate and, as soon as possible, introduce measures to minimize incidental seabird mortality associated with longlining in the Convention Area.

The following year, the first CCAMLR Conservation Measure was adopted to prevent, or minimize, seabird incidental mortality associated with longline fisheries in the Convention Area. This *Measure* (Conservation Measure 29/X), in a substantially revised form, continues to be applied (i.e. Conservation Measure 25–02 (2002)(CCAMLR 2002b). The Measure’s provisions are outlined in Box 3.

3.3 Development of CCAMLR seabird incidental mortality mitigation measures

Since 1991, CCAMLR has continued to develop and, as necessary, revise its seabird bycatch mitigating measures. These measures have been augmented by establishing closed seasons to prohibit fishing within traditional foraging areas at times when the birds are most at risk (e.g. during land-based breeding)[see CCAMLR Conservation Measure 41–02 – CCAMLR (2002b)]. Other regulations prohibit setting longlines during daylight (Conservation Measure 25–02). A complimentary measure (Conservation Measure 25–01) was adopted in 1993 to regulate the use and disposal

⁶ Under CCAMLR Convention Article XII only CAMLR Commission Members are able to take part in decisions subject to the conditions for membership set out in Article VII and budgetary provisions in Article XIX (CCAMLR 2002a). This means that States may become a party to the Convention, but may not necessarily be Members of the Commission.

in the Convention Area of plastic packaging bands used to secure bait boxes in an effort to avoid entanglement by birds and marine mammals in such bands (CCAMLR 2002b).

The key elements of Conservation Measure 25–02 set out requirements for:

- a line weighting regime
- mandatory use of streamer lines
- streamer line specifications
- mandatory night setting of lines
- minimal ship lighting
- rapid sinking of bait
- mandatory use of thawed bait only
- regulation of dumping of trash and offal and
- procedures for handling seabirds caught on longlines.

Both the line weighting regime and streamer line specification possess a number of unique components. These include weight size and spacing on the fishing line, the position and height of the streamer line above the water, a minimum streamer line length and stipulation of streamer line spacing.

Implementation of provisions as complex as those in Conservation Measure 25–02 was never going to be easy. Evaluating the Measure's performance has also proved difficult. In particular, traditional methods to boost compliance (i.e. imposition of licensing requirements, application of special permit conditions, in-port and at-sea inspection of vessels) have not been sufficient to fully evaluate the performance of individual vessels under the Measure. Nevertheless, port inspections of vessels provide some indication that vessels are able to implement Measure 25–02. For example, a number of vessels have been shown to meet the design specifications ensuring that

BOX 3

CCAMLR Conservation Measure 25–02 [from CCAMLR (2002a ^{1,2})]

The Commission,

Noting the need to reduce the incidental mortality of seabirds during longline fishing by minimising their attraction to fishing vessels and by preventing them from attempting to seize baited hooks, particularly during the period when the lines are set,

Adopts the following measures to reduce the possibility of incidental mortality of seabirds during longline fishing.

1. Fishing operations shall be conducted in such a way that the baited hooks sink as soon as possible after they are put in the water. Only thawed bait shall be used.
2. For vessels using the Spanish method of longline fishing, weights should be released before line tension occurs; weights of at least 8.5 kg mass shall be used, spaced at intervals of no more than 40 m, or 6 kg mass shall be used, spaced at intervals of no more than 20 m.
3. Longlines shall be set at night only (i.e. during the hours of darkness between the times of nautical twilight³)⁴. During longline fishing at night, only the minimum ship's lights necessary for safety shall be used.
4. The dumping of offal is prohibited while longlines are being set. The dumping of offal during the haul shall be avoided. Any such discharge shall take place only on the opposite side of the vessel to that where longlines are hauled. For vessels or fisheries where there is not a requirement to retain offal on board the vessel, fish hooks should be removed from offal and fish heads prior to discharge.
5. Vessels which are so configured that they lack on-board processing facilities or adequate capacity to retain offal on board, or the ability to discharge offal on the opposite side of the vessel to that where longlines are hauled, shall not be authorized to fish in the Convention Area.

6. A streamer line designed to discourage birds from settling on baits during deployment of longlines shall be towed. Specification of the streamer line and its method of deployment is given in the appendix to this measure. Details of the construction relating to the number and placement of swivels may be varied so long as the effective sea surface covered by the streamers is no less than that covered by the currently specified design. Details of the device dragged in the water in order to create tension in the line may also be varied.
7. Other variations in the design of streamer lines may be tested on vessels carrying two observers, at least one appointed in accordance with the CCAMLR Scheme of International Scientific Observation, providing that all other elements of this conservation measure are complied with⁵.
8. Every effort should be made to ensure that birds captured alive during longlining are released alive and that wherever possible hooks are removed without jeopardising the life of the bird concerned.

¹ Except for waters adjacent to the Kerguelen and Crozet Islands

² Except for waters adjacent to the Prince Edward Islands

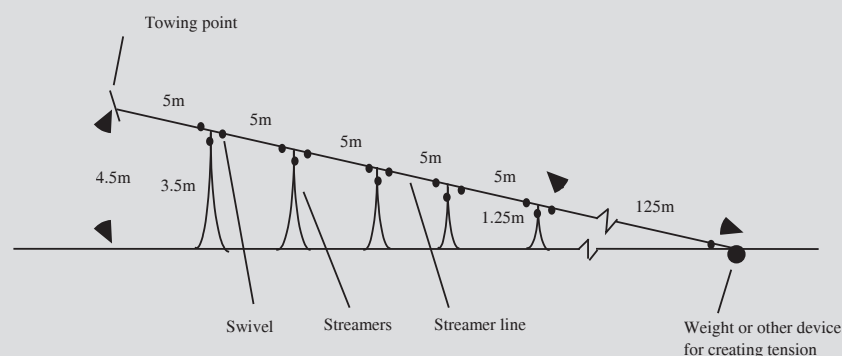
³ The exact times of nautical twilight are set forth in the Nautical Almanac tables for the relevant latitude, local time and date. All times, whether for ship operations or observer reporting, shall be referenced to GMT.

⁴ Wherever possible, setting of lines should be completed at least three hours before sunrise (to reduce loss of bait to/catches of white-chinned petrels).

⁵ The streamer lines under test should be constructed and operated taking full account of the principles set out in WG-IMALF-94/19 (available from the CCAMLR Secretariat); testing should be carried out independently of actual commercial fishing and in a manner consistent with the spirit of Conservation Measure 21-02.

Appendix to Conservation Measure 25-02

1. The streamer line is to be suspended at the stern from a point approximately 4.5 m above the water and such that the line is directly above the point where the baits hit the water.
2. The streamer line is to be approximately 3 mm diameter, have a minimum length of 150 m and have a device at the end to create tension so that the main line streams directly behind the ship even in cross winds.
3. At 5 m intervals commencing from the point of attachment to the ship five branch streamers each comprising two strands of approximately 3 mm diameter cord should be attached. The length of the streamer should range between approximately 3.5 m nearest the ship to approximately 1.25 m for the fifth streamer. When the streamer line is deployed the branch streamers should reach the sea surface and periodically dip into it as the ship heaves. Swivels should be placed in the streamer line at the towing point, before and after the point of attachment of each branch streamer and immediately before any weight placed on the end of the streamer line. Each branch streamer should also have a swivel at its attachment to the streamer line.



offal is only dumped over the vessel side opposite to that where longlines are set and hauled [e.g. Paragraph 7.53 in Annex 5 of SC-CAMLR (2000)]. Similarly, most vessels carry streamer lines on board and their designs usually meet stipulated specifications. However, meeting all these conditions in port does not necessarily mean that they will be effectively applied during fishing.

At-sea inspections are similarly limited since they provide only an instantaneous picture of compliance at the time of inspection (Kock 2001). This is an obvious shortcoming when fishing voyages may last two months. An additional limitation is that at-sea inspections are usually carried out when a vessel is not fishing. Therefore, it is difficult to envisage how they will be able to evaluate the efficacy of the seabird mitigations measures being applied or whether in fact bird bycatch is minimized.

Such shortcomings motivated CCAMLR to ask dedicated scientific observers aboard longline vessels to collect the information necessary to evaluate the application of Measure 25–02. On introduction of the CCAMLR Scheme of International Scientific Observation in the 1992/93 season (Section 5.2.3), it became possible to gather such information during “normal” fishing operations. The observation of incidental marine mammal and seabird mortality associated with fishing has thus become a priority task under the Scheme (CCAMLR 2002a). It entails scientific observers collecting data on vessel operations, particularly the setting of fishing lines, deployment of streamer lines, dumping of offal, etc. The deployment of international scientific observers under the CCAMLR Scheme is now mandatory for all longline as well as trawl vessels engaged in *Dissostichus* and *C. gunnari* fisheries in the Convention Area. National observers operate in most of the maritime zones under coastal state jurisdiction within the Area.

In 1992 CCAMLR established an *Ad Hoc* Working Group on Incidental Mortality Arising from Longline Fishing (WG-IMALF) to deal with incidental mortality of animals during fishing operations on a more formal basis. In 2001, this Group’s name was changed to the *Ad Hoc* Working Group on Incidental Mortality Associated with Fishing (WG-IMAF). The group’s terms of reference include reviewing data collected by scientific observers on seabird bycatch as well as implementation and monitoring of the performance of CCAMLR seabird incidental mortality mitigation measures.

Since 1992 CCAMLR has undertaken annual assessments of seabird-related measures and of the potential impact of longline fisheries in the Convention Area on seabird populations. Results from these assessments have been used to review and amend Measure 25–02 and its predecessors (Table 2). Further CCAMLR has used scientific observer data on seabird bycatch for compliance-related purposes. In 2002 CCAMLR established a special Joint Assessment Group (JAG) with membership that comprised both enforcement (from the CCAMLR Standing Committee on Implementation and Compliance) and scientific specialists (Scientific Committee) [Paragraph 8.12 in CCAMLR (2002c)]. One of JAG’s major tasks is to develop methods to evaluate the compliance of individual vessels with complex Conservation Measures such as 25–02.

Illustrated in Table 2 is Measure 25–02, which has been revised a number of times since its inception in 1991. The first revision in 1995 elaborated on the general provision for baited hooks “to sink as soon as possible” after entering the water during line setting. Weight specifications were developed for the “Spanish” longline system, which stipulated that weights should be a minimum of 6 kg and be spaced on the line at intervals of no more than 20 m [Paragraph 3.49 in SC-CAMLR (1995) and Conservation Measure 29/XIV in CCAMLR (1995a)]. The modification was based on results from limited experiments on, and modelling of, line-sinking rates. Subsequent analyses indicated low levels of compliance with this particular provision [Paragraph 7.58 in Annex 5 of SC-CCAMLR (2000)]. A key practical consideration was the time taken to place multiple weights at short intervals on the line. In addition, 20 m spacings do not adequately allow for undulations in bottom topography, and there is an increased tendency for lines to become tangled during both setting and hauling. Such limitations

TABLE 2

Development of CCAMLR Conservation Measures (CM) to mitigate incidental seabird catch during longline fishing in the Convention Area

(from pages (xxiv) to (xxix) in CCAMLR (2002b))									
Measure component	CM 29/X (1991)	CM 29/XI (1992)	CM 29/XII (1993)	CM 29/XIII (1994)	CM 29/XIV (1995)	CM 29/XV (1996)	CM 29/XV1 (1997)	CM 29/XIX (2000)	CM 25-02 (2002)
Line weighting	General provision for quick sinking	No change	No change	No change	Specify weight for Spanish system (6 kg at no more than 20 m spacing). Weight release before line tenses	No change	No change	Revise Spanish line weighting (option for 8.5 kg at no more than 40 m spacing)	No change
Bait	-	-	Only thawed	No change	No change	No change	No change	No change	No change
Night setting	Mandatory with minimum ship lighting	No change	No change	Night qualified as darkness between nautical twilight	Line setting at least 3 hrs before dawn to minimize White Chinned Petrel mortality	Reference to exact time of nautical twilight. Term “sunrise” replaced with “dawn”	Reference to <i>Nautical Almanac</i> to get time of nautical twilight	Exemption to allow daylight setting subject minimum sink rate of 3m/s determined according to CM 216/XX	No change. Cross-reference to CM 25-01 as CM 216/XX in 2000
Trash/Offal dumping	Prohibition during longlining	No change	No change	Unavoidable dumping only on side farthest from line set/haul area	Clarification. Unavoidable dumping only on “opposite side” of vessel to where lines set/hailed	No change	Revision prohibiting dumping during setting. Unavoidable dumping now only during hauling	Fishing only authorized if vessels able to process offal or discharge it on opposite side of vessel to line set/haul area	Request to remove hooks from fish heads and offal prior to discarding
Handling caught birds	-	-	-	Request every effort to release birds alive and remove hooks	No change	No change	No change	No change	No change
Streamer line use	Request streamer line use during daylight setting	Streamer deployed during longline deployment	Slightly more flexibility allowed for swivel placement	Details of devices to create streamer line tension – may vary	More flexibility in streamer line tension device	No change	No change	No change	No change
Streamer line specification	Specifications of streamer line and deployment	No change	No change	Conditions for testing streamer lines	Further clarification of conditions for testing streamer lined	No change	No change	No change	No change

necessitate slower setting speeds and mother lines need to be heavier [Paragraph 7.143 in Annex. 5 of SC-CAMLR 2000). Consequently, the weight requirements and interval settings were modified to 8.5 kg and no more than 40 m intervals in 2000 (CCAMLR 2000b). The levels of compliance immediately increased [Paragraphs 7.77–7.80 in Annex. 5 of SC-CAMLR (2001)].

The requirement to set lines only at night has been reiterated and clarified since CCAMLR first initiated its seabird bycatch mitigation measures. This is a relatively simple provision aimed at avoiding the setting of lines at times when the bait is clearly discernible (i.e. during daylight) or when many species, particularly White-Chinned Petrels, are active (i.e. during twilight). Initially, uncertainty over the exact “local” time associated with ambient light levels at nautical twilight resulted in some non-compliance. The problem was resolved by incorporating a cross-reference to nautical almanac tables in Conservation Measure 25–02 to define local twilight times as a function of latitude and time of the year (Box 3). This arose out of earlier, and unsuccessful, efforts to provide simple tables in the Measure itself stipulating twilight times throughout the Convention Area by selected degrees of latitude [Conservation Measure 29/XV in CCAMLR (1996b)].

Conservation Measure 25–02’s line weighting and night fishing requirements were further refined in 2002. As a result, Conservation Measure 24–02 set out experimental protocols to evaluate line sink rates as a function of line weighting [Conservation Measure 24–02 in CCAMLR (2002b)]. Fulfilling these requirements sets the precondition for granting exemption from night setting in specific areas (Sub-areas 48.6 [south of 60°S], 88.1 and 88.2, and Division 58.4.2) under paragraph 3 of Measure 25–02. Scientific observers are responsible for implementing, and reporting on, such evaluations.

The provisions addressing offal dumping were modified a number of times (Table 2). Initially (1991), dumping of offal was prohibited during fishing. This requirement was later modified to ensure that dumping, if unavoidable, was done on the opposite side of the vessel to where lines were being set (CCAMLR 1994) and to ensure that dumping was confined to periods of line hauling only (CCAMLR 1997a). In 2000 (CCAMLR 2000b), CCAMLR finally decided that vessels unable to process offal on board, or discharge it as required, should not be authorized to fish in the Convention Area.

The requirement to use streamer lines during longline deployment was introduced in 1992 after Conservation Measure 29/X (a predecessor to Measure 25–02) had been in force for a year. This requirement has remained essentially unchanged since that time with some allowance for more flexibility in streamer line design in 1995 (CCAMLR 1995a).

As already noted, CCAMLR seabird bycatch measures have been augmented by defining periods of the year (i.e. seasons) during which longlining is permitted. In 1997, WG-IMALF carried out a comprehensive analysis of relationships between time of year and the attached risks for enhanced Albatross and Petrel mortality resulting from longline fishing in the Convention Area. Results indicated that moving the opening of the Toothfish longline fishing season from 1 March to 1 May lead to substantial benefits (particularly until such time that all vessels comply with night-time setting and streamer line requirements) [Paragraph 4.61 in SC-CAMLR (1997)]. CCAMLR agreed to delay the commencement of longline fishing until 1 April in 1998 with a compromise date of 15 April being subsequently agreed to for the following season. Since 1999 the stipulated opening date has been 1 May for most longline fisheries in the Atlantic and Indian Ocean with the season closing on 31 August (Kock 2001).

Longline fishing seasons in the Pacific Ocean Sector (CCAMLR Statistical Area 88) (e.g. high-latitude fisheries in Ross Sea) have been defined taking into account seabird distribution and periods of darkness available in which to set gear. For example, the fishing season in the Ross Sea south of 65°S was moved from 15 to 1 December for the

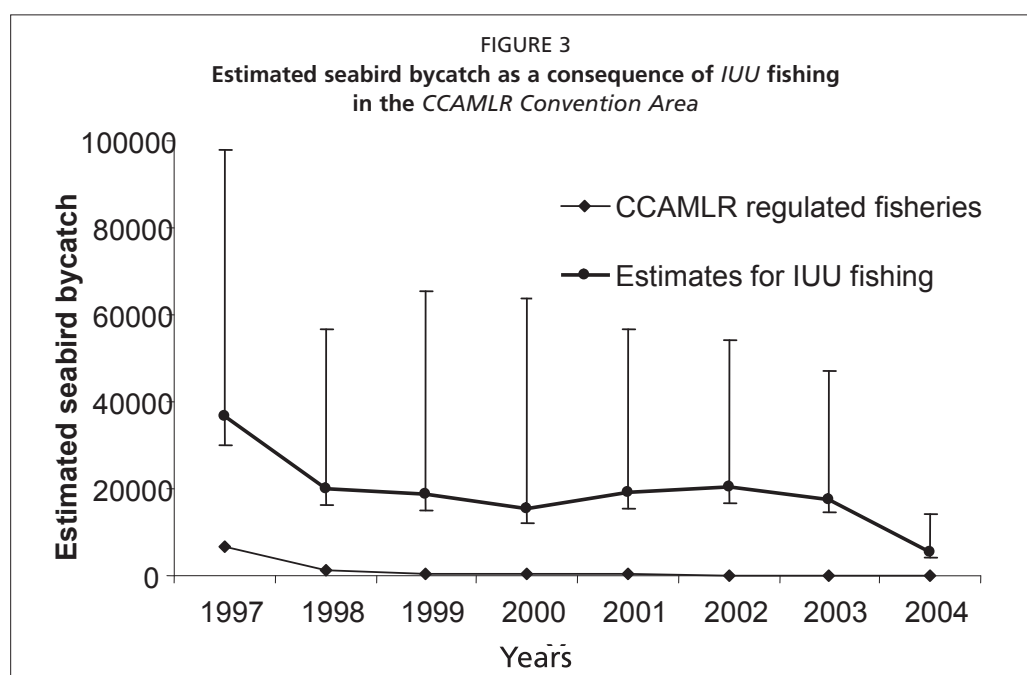
1999/2000 season (CCAMLR 1999a). Daylight setting has been made subject to the results of line-weighting trials to demonstrate that vessels are able to comply with a line sink rate of ≥ 0.3 m/sec (see discussion above in respect to Conservation Measure 24-02). Any vessel catching a total of three or more birds during a single fishing season is required to revert immediately to night setting in accordance with paragraph 3 of Measure 25-02 (CCAMLR 2002b). As noted, the carrying of onboard international scientific observers remains mandatory for all vessels.

3.4 Evaluation of CCAMLR seabird incidental mortality mitigation measures

Over the past five years the seabird bycatch and bycatch rate in regulated fisheries in the Convention Area has been significantly reduced. This is attributed to a combination of improved compliance with seabird bycatch measures and by delaying commencement of fishing until the end of the breeding season of most Albatross and Petrel species (Kock 2001). By 2001, regulated longline fisheries in the Convention Area exhibited negligible levels and rates of seabird bycatch in Sub-area 48.3, low levels in the South African EEZ in Sub-areas 58.6 and 58.7 and no incidental mortality in Sub-areas 88.1 and 88.2 for four successive years. In 2002, the Scientific Committee noted that, based on reported data, levels of seabird bycatch in the Convention Area had been the lowest ever recorded [Paragraph 5.3 in SC-CAMLR (2002)] (Figure 3).

In addition to implementing measures to minimize seabird bycatch in regulated fisheries, CCAMLR also considers WG-IMAF's advice on seabird bycatch associated with proposed new and exploratory fisheries. Each year, WG-IMAF reviews proposals from such fisheries and, taking into account the potential risk of seabird bycatch in each area concerned, recommends an appropriate application of mitigation measures. A particular consideration specifically addresses fishing season restrictions and, or, night setting requirements.

CCAMLR, in keeping with its growing concern (Sabourenkov and Miller 2004), recently endorsed the Scientific Committee's and WG-IMAF's view that IUU fishing in the Convention Area, combined with seabird bycatch in fisheries adjacent to the Convention Area, constitute the main threats to many seabird populations in the Southern Ocean [e.g. Paragraph 6.8 in CCAMLR (2002c)]. Estimates of potential bycatch levels associated with IUU fishing in each of the past seven years are presented in Figure 3. CCAMLR concluded that such mortality levels remain unsustainable for



populations of albatrosses, giant petrels and white-chinned petrels breeding in the Convention Area with many of these species declining at rates such that extinction is possible [Paragraph 6.98 in Annex 5 SC-CAMLR (2002)]. CCAMLR remains gravely concerned with the present situation – a compelling incentive for stricter measures to combat IUU fishing (Kock 2001).

3.5 Future development of CCAMLR seabird incidental mortality mitigation measures

CCAMLR Conservation Measure 25–02 comprises a few essential elements. The most pervasive strive to reduce the probability that foraging seabirds encounter bait on the surface during the setting of fishing lines. However, no single mitigating measure is likely to eliminate all seabird mortality during longline operations. An important factor remains the setting of bait that avoids visual detection. Underwater setting of lines offers one way to achieve this. The bait would be unlikely to be detected and seized, even by birds with highly developed visual acuity. Other topics for investigation include internal weighting of fishing lines to promote rapid sinking and deployment of “stealth” (dyed) bait to reduce detection.

In 2000, the Scientific Committee advised CCAMLR that once full compliance with seabird bycatch measure is attained, together with negligible levels of seabird bycatch, relaxation of the extent of closed season provisions could be introduced in a stepwise fashion, provided that any consequences were carefully monitored and reported [Paragraph 4.42 in SC-CAMLR (2000)]. CCAMLR would need to ensure that fishers comply fully with the other seabird bycatch measures, such as offal discharge, streamer line deployment and night setting. Refining and enhancing compliance with the line-weighting regime for the Spanish longline system remains a priority [Paragraph 6.11.(i) of CCAMLR (2002c)]. The development of a line-weighting regime for autoline systems also requires additional encouragement [Paragraph 6.16.(iii) in CCAMLR (2000c)].

The search for new and effective measures to enhance avoidance of seabird bycatch continues (IFF 2002). Underwater setting and hauling of lines, more effective line weighting and deployment of “stealth” bait are avenues for future research and development. In particular, the need for vessel design modification has prompted CCAMLR to draw the attention to a requirement that designs of new or replacement vessels should take account of the following to ensure, or facilitate, reduced levels of incidental seabird mortality during longline fishing [From Paragraph 6.84 in Annex 5 of SC-CAMLR (2000)]:

- deploying longlines from an optimal position relative to the location and rotation direction of the vessel’s propeller
- equipping vessels with fish meal plants to process fish offal on board
- incorporating special attachment points for streamer lines into the design of vessels
- adopting a through-the hull line setting and hauling capability in vessel design and
- locating deck lights to minimize illumination astern as well as to meet safety requirements.

CCAMLR continues to review its seabird bycatch measures on an annual basis and these measures constitute a significant component of the IPOA-Seabirds (FAO 1999).

4. TRADE RELATED MEASURES TO COMBAT UNREGULATED FISHING

4.1 Introduction

Until the mid 1990s, CCAMLR’s monitoring, control and surveillance (MCS) measures were based on conventional approaches as used by many other fisheries management

authorities, both national and international (Rayfuse 2000). Such approaches largely relied on the application of flag state jurisdiction and the fulfillment of port state responsibilities. The CCAMLR MCS measures therefore included prohibiting fishing without due authorization, monitoring fishing location using vessel monitoring systems (VMS) and notification of vessel movements. Also included were port inspections, the development of an at-sea inspection scheme (Sections 3.3 and 5.2.3) and comprehensive fisheries data reporting (Miller, Sabourenkov and Slicer 2004).

At-sea inspections in the Convention Area have essentially been confined to areas of intensive fishing, mainly around Sub-Antarctic islands and inside 200-nautical-mile Exclusive Economic, or Fishing, Zones (EEZ or FZ) established under coastal state jurisdiction. VMSs are deployed and monitored by flag states. Reports to CCAMLR are thus usually confined to instances when fishing vessels enter the Convention Area and, or, cross the boundaries of CCAMLR Statistical Sub-areas and Divisions.

With the circum-Antarctic expansion of deepwater longline fisheries for toothfish in the early to mid-1990s (Figure 4), CCAMLR soon realized that the traditional MSC approaches would likely prove to be inadequate, especially in combating a persistent and expanding IUU fishery (Agnew 2000). The problem was compounded by the size of the Convention Area and by the mix of jurisdictional conditions represented therein (Section 5.2.2).

Many authors (e.g. Lutgen 1997, Dodds 2000, Green and Agnew 2002, Kirkwood and Agnew 2004, Sabourenkov and Miller 2004, Miller, Sabourenkov and Slicer 2004) have documented the emergence and development of IUU fishing for *Dissostichus* spp. in the Southern Ocean in general and in the Convention Area in particular. CCAMLR was faced with a situation in which the stricter regulatory measures became in some areas, such as around South Georgia, the more IUU fishing moved eastward (Figure 4). Attendant restrictions in both diplomatic and legal efforts to address issues such as fishing by Non-Contracting Parties (NCPs) and the use of Flags of Convenience⁷ greatly compounded CCAMLR's difficulties in effectively combating IUU fishing (Agnew 2000, Green and Agnew 2002).

The situation remains further complicated in that the origin of toothfish catches is hard, if not impossible, to verify in the absence of regular and accurate reporting procedures when catches may be taken both within and outside the Convention Area. For example, a number of countries such as Chile, Argentina and Uruguay have developed toothfish fisheries within their domestic EEZs outside the Area. Others, (France South Africa and Australia), have toothfish fisheries in their EEZs and FZs within the CCAMLR Area. Toothfish also occur on the high seas adjacent to the Convention Area, particularly in the Indian Ocean.

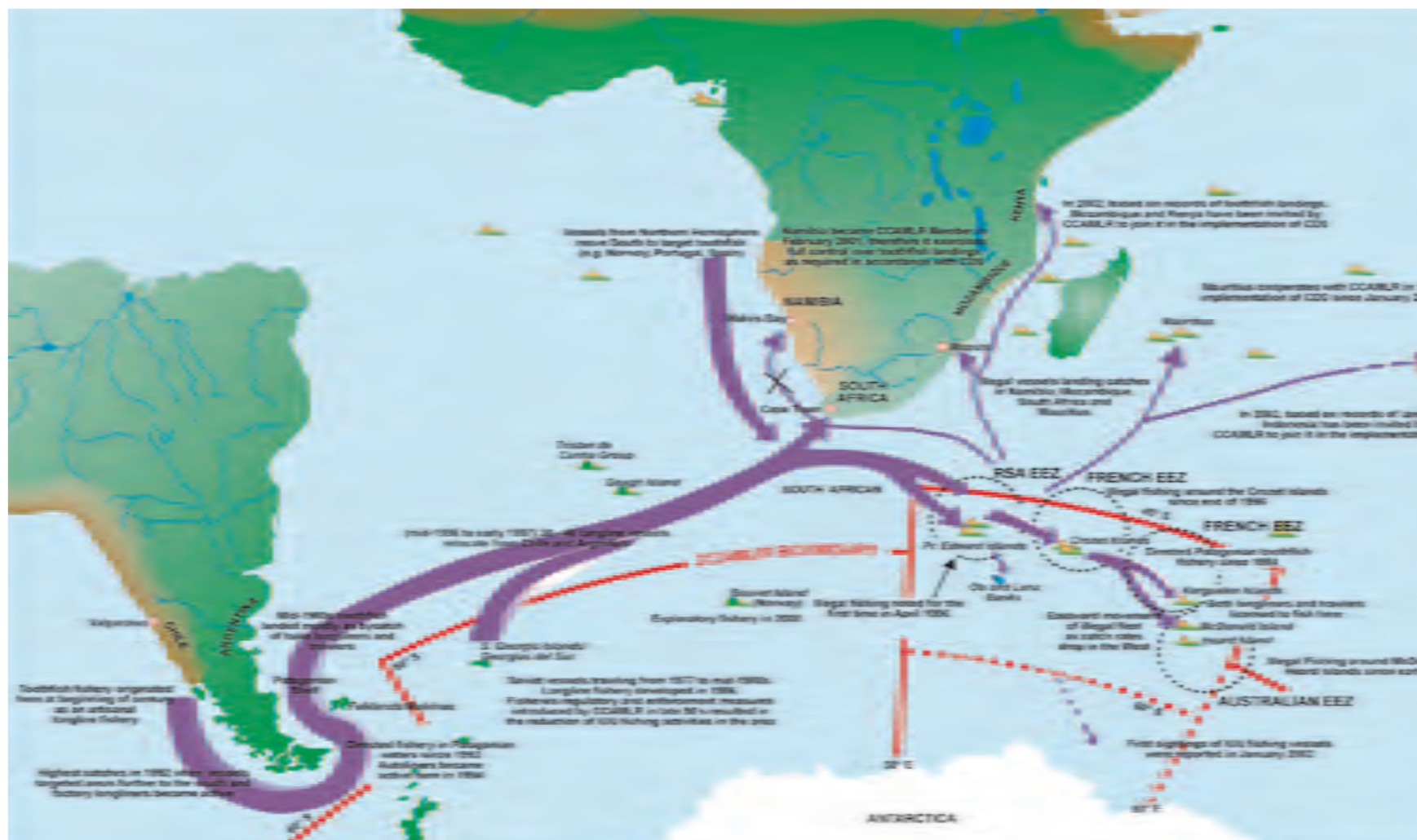
Finally, a growing demand for toothfish has meant that catches continue to attract high prices – an added incentive for IUU operators to continue fishing and, if necessary, go to substantial lengths to conceal the origin of IUU-caught fish (Agnew 2000, Green and Agnew 2002). As CCAMLR's efforts to regulate IUU fishing became more effective, IUU operators have been seeking new ways of “laundering” the origin of toothfish catches and other steps to enhance their market share or increase the supply of toothfish. As a consequence, CCAMLR was moved to develop additional and innovative measures to combat IUU fishing (Agnew 2000). These have the dual objective of controlling and, or, monitoring, IUU fisheries in the Convention Area and preventing the sale of IUU-caught fish on world markets.

4.2 History of CCAMLR trade-related measures

In 1998 CCAMLR began to pursue additional measures to monitor landings and the access to international markets of toothfish caught in the Convention Area by its

⁷ For a detailed discussion of issues surrounding the use of flags of convenience in general and some examples of activities in the CCAMLR Area, see Vukas and Vida (2001).

FIGURE 4
Development of IUU fishing in the CCAMLR Convention Area [from Sabourenkov and Miller (2004)]



Members, as well as in waters under their jurisdiction (Agnew 2000, Green and Agnew 2002). At the time, various other initiatives to monitor international trade in specific fish species had been negotiated or were in the process of being negotiated internationally. The most prominent of these was the Bluefin Tuna Statistical Document (BTSD) introduced by the International Commission for the Conservation of Atlantic Tuna (ICCAT) in 1992 (ICCAT 1966, 1993). The BTSD monitors trade in fresh and frozen tuna. A subsequent measure requires that ICCAT Members prohibit landings in their ports of tuna caught outside ICCAT measures or in the absence of a BTSD (ICCAT 1993).

Unlike the ICCAT and BTSD, CCAMLR toothfish trade-related measures introduced a number of new and important elements. For example, the BTSD only applies to catches entering international trade and so it represents a “trade documentation system”. It is not as encompassing as the CCAMLR Catch Documentation Scheme (CDS) that targets all harvested, landed, transhipped and traded toothfish catches. In considering the development of the CDS in some detail, Agnew and others (Agnew 2000, Larson 2000, Green and Agnew 2002, Sabourenkov and Miller 2004) have stressed that the design, adoption and implementation of the Scheme by far constitutes CCAMLR’s most significant attempt to combat IUU fishing both in the Convention Area and on a global basis.

The key principles underpinning the CDS (Box 4) were never intended to provide stand-alone measures, but should rather be viewed as an integral component in a suite of CCAMLR measures aimed at combating IUU fishing. Bearing this in mind, the CDS’s two main objectives are best summarized as

- tracking landings of, and the world trade in, toothfish caught both within and outside the Convention Area and
- restricting access of IUU-caught toothfish from the Convention Area to international markets.

BOX 4

Key principles underpinning the applicability of the CCAMLR Toothfish CDS

Based on information presented by Agnew (2000), Larson (2000), Kirkwood and Agnew (2004) and Sabourenkov and Miller (2004).

- Applies to IUU fishing by both CCAMLR contracting and non-contracting parties
- Non-discriminatory, fair and transparent
- Practical with easy/rapid implementation
- Applies to fishing within, and outside, Convention Area (e.g. recognition given to “transboundary” nature of Toothfish distribution)
- Conducive to CCAMLR non-contracting party participation
- Includes sufficient validation & verification procedures to raise confidence in information produced
- Indicates responsibilities and/or obligation of all participants

Since its adoption, and entry into force on 7 May 2000, the CDS has been refined through versions of the CCAMLR Conservation Measure 10–05 (CCAMLR 2002b), (Box 5). Tracking toothfish landings via the CDS requires both identification and verification of catch origin. This enables CCAMLR through landing or transshipment records to identify the origin of toothfish entering the markets of all participants in the CDS. It also facilitates determination of whether toothfish in the Convention Area have been caught in a manner consistent with the CCAMLR Conservation Measures.

The data collected by the CDS are vital for estimating “total” toothfish removals, an essential factor in improving stock assessment and for providing more precise information on global catch levels (Sabourenkov and Miller 2004).

BOX 5

Key features of the CCAMLR Catch Documentation Scheme (CDS) for toothfish (*Dissostichus* spp.)

[from Agnew (2000) and Sabourenkov and Miller (2004)]

- Ascertain catch origin for transhipped/landed, imported/exported toothfish
- Trade-related elements with worldwide application (i.e. not limited to the Convention Area)
- Prohibit entry of toothfish into world markets in absence of properly issued & verified catch documents
- Determine whether toothfish caught in Convention Area harvested in manner consistent with CCAMLR Conservation Measures
- Vessels to possess flag state authorization to fish for toothfish in areas within & outside Convention Area
- Every toothfish landing/transshipment to be accompanied by valid catch document
- Every toothfish import or export to be accompanied by valid, export-validated or reexport validated document
- Submission of catch (export and reexport validated) documents to, and communication with, CCAMLR, including details of national authorities responsible for issuing/validating documents
- Opens participation to CCAMLR Non-Contracting Parties under same conditions as Contracting Parties
- Examination of toothfish shipments & catch documents by appropriate authorities in port, export and import states
- Encourages cooperation between flag state, port state & importing state on CDS operation
- Encourages CDS Parties to request additional verification of catch documents by flag states, including use of VMS, for High seas catches of toothfish outside Convention Area
- Conditions for sale of Toothfish seized or confiscated through enforcement action

The CDS creates a precondition limiting market access only to those fishing operators complying with the Scheme’s provisions (Agnew 2000). To do so, the CDS relies on participation by all CCAMLR Members engaged in toothfish fishing within, and outside, the Convention Area. It also encourages other CCAMLR Contracting Parties as well as NCPs (Section 5.2.4 provides further discussion on the obligations of NCPs) who conduct fishing within and outside the Convention Area to participate in the world toothfish trade. A notable demonstration of the CDS’s positive effect in this context has been reflected in product price levels on the major international markets particularly in the United States and Japan. Toothfish sold in conformity with the CDS fetch a much higher price than fish sold outside the Scheme (Sabourenkov and Miller 2004).

A notable CDS innovation [Paragraph 14 of Conservation Measure 10–05 – CCAMLR (2002b))] provides participants in the Scheme with an opportunity to require additional verification of catch documents from a vessel’s flag state. In particular, VMS information can be sought for catches taken on the high seas outside the Convention Area when landed in, imported into, or exported from the territory of

a CDS Party. Under certain conditions, non-compliance with CDS requirements may result in confiscation of toothfish catches or imports; a provision to be implemented nationally [Paragraphs 2.101 in Annex 5 of CCAMLR (2001)] and internationally (CCAMLR 2002b).

The CDS is open to both CCAMLR Parties and NCPs and draws non-participating states into the Scheme in such a way that their catches can be monitored (Green and Agnew 2002). This ensures that cooperation with NCPs is encouraged without discriminating between their obligations under the Scheme and those of CCAMLR Contracting Parties. This requirement essentially mirrors Articles 117–118 of the *1982 United Nations Law of the Sea Convention* (LOSC) (Anon. 1983) and Article 8 of the *1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks* (UNFSA) (Anon. 1998a).

We should emphasize that CCAMLR went to considerable lengths to ensure that the CDS is consistent with the provisions of the World Trade Organization (WTO) and the General Agreement on Tariffs and Trade (GATT) (Agnew 2000). As Larson (2000) has indicated, the CDS employs measures similar to those for other marine species and which have been found to be inconsistent with WTO–GATT obligations. However, unlike such measures, the CDS strikes a careful balance allowing CDS Parties to meet CCAMLR conservation needs without violating the legal rights of fellow WTO-Members. In particular, it ensures that any discrimination on the basis of national origin is minimized (Larson 2000). Consequently the CDS expressly addresses three of the WTO's key concerns – non-discrimination, transparency in multilateral resolution and a demonstrable linkage to a policy aimed at conserving the resource(s) in question.

Despite this, the CDS continues to attract widespread interest within the WTO, particularly by its Committee on Trade and Environment (CTE). The WTO Secretariat has indicated that: “The CDS, along with the ICCAT BTSD, can be considered to provide an example of appropriate and WTO-consistent (i.e. non-discriminatory) use of trade measures in multilateral environmental agreements” (WTO 2000a). Nevertheless, the CTE as a whole has yet to reach formal consensus on the matter and how RFMOs such as CCAMLR may take part in its business (WTO 2000b).

Finally the CDS serves to define more precisely the role of port (i.e. where toothfish are landed) as opposed to “market” (i.e. into which toothfish are imported for sale following export from elsewhere) states. This distinction aims at discouraging trade in IUU-caught toothfish without diminishing any flag state responsibility. Recent experience in application of the CDS has focused on the need for CCAMLR NCPs to assume heightened responsibility for combating trade of toothfish taken in a manner that expressly undermines the CCAMLR Conservation Measures (Green and Agnew 2002). Not only does this improve the CCAMLR's ability to combat IUU fishing directly, it is at the centre of ensuring that obligations under UNFSA Articles 20, 21 and 23 (Anon. 1998a) are as effectively and widely met as possible (see Section 5.2.6).

4.3 Development of CCAMLR trade-related measures

The CDS has been in operation for a little over three and a half years. It has provided much information and enabled CCAMLR to act expeditiously to address certain IUU activities, particularly falsified or fraudulent DCDs. However, despite the CDS' obvious merits, CCAMLR remains concerned at the continued persistence of IUU fishing in the Convention Area [Paragraph 8.3 in CCAMLR (2002c)]. It has therefore embarked on various initiatives to enhance the CDS's performance. The more prominent of these aim to address the:

- use of flags of convenience resulting in reduced flag state participation and responsibility

- use of ports of CCAMLR NCPs to land toothfish without a valid DCD
- insufficient monitoring of transshipments at sea – a difficult task given the geographic extent of the convention area
- misreporting of catch origin – either deliberate or accidental
- “laundering” of fish either through using false DCDs or by issuing documents that are not carefully monitored by the flag and/or port state and
- inconsistent verification of catch position, either by “patchy” flag state monitoring and/or verification of VMS data, or by non-deployment of VMS, or by at-sea tampering with VMS units.

To date, revisions of the CDS have aimed at clarifying the Scheme’s provisions, particularly the deadlines attached to exchange of CDS information between participating parties at any stage of the trade cycle ranging from the landing of toothfish catches through to actions taken by the flag, port, export or market states and culminating in final import and product sale. Such work continues and is currently being conducted by a specially convened CDS Inter-session Task Group [Paragraph 7.12 in CCAMLR (2002c)]. This Group includes personnel from CDS parties with fishery, trade, enforcement, legal and information management expertise.

4.4 Evaluation of CDS performance

CCAMLR has established a centralized and secure CDS database at its Secretariat in Hobart. The database has a web-based interface to provide accredited national CDS operators access to DCD information. The system constitutes an effective network for information exchange between CDS Parties on landing, export and import certification and verification.

The CDS is clearly an important component in a suite of CCAMLR measures aimed at eliminating IUU fishing in the Convention Area. Table 3 shows how the CDS, in the time since it became operational, has combined with other measures to detect and address potential violations of CCAMLR Conservation Measures. It is clear that all CDS Parties have increased their efforts to support the Scheme, especially through conducting in-port inspections of both CCAMLR Contracting and Non-Contracting Party vessels (Sabourenkov and Miller 2004). This trend continued in 2003.

TABLE 3
CCAMLR Conservation Measures (CM) or Resolutions aimed at supporting application of the CDS under Conservation Measure 10–05 (CCAMLR 2000b)

Measure	Provisions supporting CDS
CM 10–02 (2001)	<ul style="list-style-type: none"> • Requires CPs license all vessels fishing in Convention Area • Sets out CP obligations to inspect licensed vessels
CM 10–03 (2002)	<ul style="list-style-type: none"> • Mandates Contracting Party (CP) inspections of CP & Non- Contracting Party (NCP) vessels intending to land or tranship Toothfish. Inspections aim to determine (a) whether catch is accompanied by a catch document required by the CDS (b) that catch agrees with information reported in the document, & (c) that fishing in Convention Area in accordance with CCAMLR CMs • Prohibits transshipments/landings from vessel where evidence of fishing in contravention of CCAMLR CMs
CM 10–04 (2002)	<ul style="list-style-type: none"> • Establishes compulsory requirement for use of automated satellite-linked VMS on all CCAMLR Member vessels licensed to fish in Convention Area (krill fishery currently excluded)
CM 10–06	<ul style="list-style-type: none"> • Scheme to promote compliance by CP vessels with CCAMLR CMs similar to those of NCPs (CM 10–07 below) • Directly cross-referenced to CM 10–03 for NCP vessels denied landings/transshipments under that measure as well as to “failures” to comply with CDS requirements (CM 10–05) • Sets up process to identify and list CP vessels “undermining” CCAMLR CMs • Outlines various measures to avoid licensing, reflagging etc. of listed vessels • Outlines measures to prohibit landings, transshipments, import and export of catches from listed CP vessels

CM 10–07 (2002)	<ul style="list-style-type: none"> • Requests full cooperation from NCPs • Directly cross-referenced to CM 10–03 in respect of NCP vessels denied landings/transshipments under that measure • Sets up process to identify and list NCP vessels “undermining” CCAMLR CMs • Outlines various measures to be taken by CPs to avoid licensing, reflagging, etc. of listed NCP vessels • Also outlines measures to prohibit landings, transshipments, import and export of catches from listed NCP vessels
Various resolutions	<ul style="list-style-type: none"> • See Table 6

CDS-derived statistics show that Japan, the United States, the European Community and the People’s Republic of China are the main importers of toothfish (Sabourenkov and Miller 2004). Based on trade statistics provided for 2000, Canada should also be included in the list of main toothfish importers [e.g. as implied by Paragraph 5.42 in CCAMLR (2001a)]. While these states, except Canada, are CDS Parties, recent reports prepared by TRAFFIC (Trade Records Analysis of Flora and Fauna in Commerce) International (Lack 2001, Lack and Sant 2001, Willock 2002) show the global market share of these countries in the toothfish market to be of the order of 90 percent. Over 90 percent of traded toothfish are, in turn, supplied by Argentina, Australia, Chile, France, New Zealand, South Africa and the United Kingdom – all CCAMLR Members. CCAMLR continues to work actively to involve NCPs responsible for the remaining 10 percent of toothfish traded and caught under the CDS [Paragraph 7.3 in CCAMLR (2002c)]. Finally, it should be noted that the CDS now covers a large portion of the world’s surface and a high proportion of the global population (Figure 5).

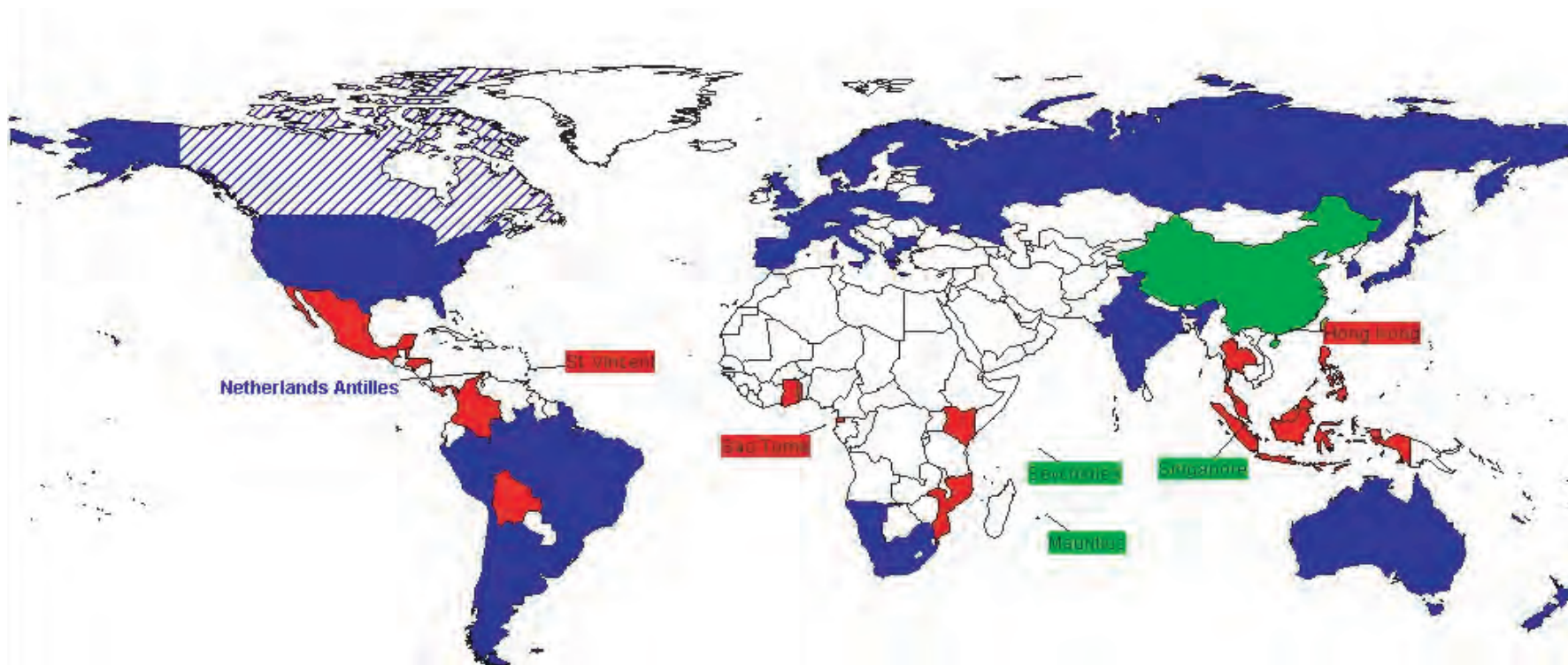
4.5 Further CDS development

With the UNFSA’s recent entry into force (Section 5.2.5), it is anticipated that implementation of the CDS will be strengthened, particularly in terms of more global application of the provisions on cooperation in fisheries management set out in UNFSA Articles 8 and 17 (Lutgen 2000, Dodds 2000). As a consequence, CCAMLR’s standing as a regional fisheries management organization (RFMO) will be boosted in terms of emerging international practice so placing pressure on NCPs to meet their obligations under the UNFSA to cooperate in the conservation and management of “transboundary” stocks such as toothfish (Lutgen 2000). While CCAMLR may be unlike other RFMOs, UNFSA Article 1.(1).(d) does not preclude any RFMO having purposes other than fisheries conservation or management alone (Molenaar 2001). Even though not essential, the unique sovereignty situation and other characteristics attached to the CAMLR Convention could be used to justify use of non-flag state powers in accordance with UNFSA Articles 21 and 22 (Anon. 1998a) to enhance international efforts aimed at ensuring sustainability of certain exploited fish stocks.

The CDS is also likely to benefit from global standardization of catch certification and trade documentation systems initiated by the FAO in collaboration with various regional fisheries organizations, including CCAMLR (FAO 2002, Miyake 2002). The FAO consultations, while still at a relatively early stage, are likely to address cooperation with both WTO and the World Customs Organization (WCO). As the CDS combines features of both catch certification and trade documentation, and since it is consistent with the provisions of current international fisheries arrangements such as UNFSA, it constitutes a useful prototype on which future standardization could be based.

Finally, over the past year CCAMLR has established and tested an “online” facility to augment timely submission and processing of CDS documents using a central, secure database at the CCAMLR Secretariat [Paragraph 7.16 in CCAMLR (2002c)]. The system, or “Electronic CDS” (E-CDS), will enable all CDS Parties to issue and process DCDs online thereby creating a “real-time” network for exchanging information on certification and verification of landings, exports, re-exports and imports. The key features and benefits of the E-CDS are outlined in Box 6.

FIGURE 5
The CDS' geographic area of application
[from Miller, Sabourenkov and Slicer 2004]



BOX 6

Key features and benefits of the CCAMLR Electronic CDS (E-CDS)

[From Paragraphs 7.15, and 2.29 of Annex 5, in CCAMLR (2002c)]

- All web access to E-DCDs is password-protected. Passwords are allocated on an individual basis and each individual's access is limited to the level that they require;
- The communications technology and software needs of E-CDS users are no more than those already regulating access to the internet;
- Information from flag, port export and import states can be monitored and cross-checked by CDS management authorities in close to real-time, allowing problem documents to be identified immediately;
- Data reporting and validation are substantially improved compared with the paper-based CDS; the latter which experiences considerable missing or incorrect information
- The possibility of issuing fraudulent catch and export documents is eliminated;
- The scope for fraudulent trade via misuse of valid export and re-export documentation is significantly reduced, and
- Problems associated with poor quality facsimile copies are solved and the number of errors in data reporting are reduced as a result of checking procedures built into the data-entry interface.

5. FURTHER DEVELOPMENT OF THE CCAMLR FISHERIES MANAGEMENT AND CONSERVATION REGIME

5.1 Introduction

The first part of this paper documented three examples of CCAMLR's efforts to implement some of Article II's general provisions (summarized in Box 1). These illustrate attempts to: (a) ensure that harvesting does not compromise sustainability of harvested stocks during periods of maximum uncertainty, i.e. "precaution" is applied during periods of fishery development (Section 2), (b) minimize direct effects of fishing on species affected by such operations, i.e. negative affects on certain ecosystem (Figure 5,) components are minimized (Section 3) and (c), promote a more holistic approach to management by dealing with complete stocks of harvested species both within and outside the Convention Area (Section 4).

It remains to be shown how such initiatives can be developed further to improve the effectiveness of CCAMLR's management approach. In recent years, a considerable body of literature has addressed this particular issue (e.g. Agnew 1997, Constable *et al.* 2000, Miller and Agnew 2000, Constable 2002, Everson 2002, Miller 2002). Rather than repeating, or trying to summarize, such information we will focus on some key areas of concern. We then evaluate the information presented here as a means of assessing CCAMLR's achievements (Section 5.2) as well as possible future challenges to its effectiveness (Section 5.3).

5.2 CCAMLR's achievements

5.2.1 Introduction

As a "new generation" (i.e. post-LOSC) agreement, CCAMLR's evolving management practices have resulted in the several noteworthy achievements considered below. Each achievement may be viewed as "strategically important" since it addresses principle likely to influence CCAMLR future actions and, or, policies.

5.2.2 Precautionary and ecosystem approach to management

CCAMLR's efforts to develop a management approach that is both precautionary and ecosystem-based stand out as the organization's preeminent achievement (Everson 2002, Miller 2002). As demonstrated for new and exploratory fisheries in Section 2, the foundation for the development of such an approach was laid by WG-DAC (Miller 2002). As such, the Commission and Scientific Committee were able to pursue more operationally-effective interpretations of Article II based on the coherent and pre-agreed principles set out in Box 7.

Nevertheless, as Constable (2002) has highlighted, CCAMLR's development of an integrated precautionary approach has been largely confined to a single species – *Euphausia superba* (Antarctic krill). In this case, CCAMLR's exercise of precaution became based on a rudimentary management procedure that includes pre-agreed decision rules to guide adjustment of catch limits. Such controls are, in turn, subject to scientific assessment of stock(s) status (Miller 1991, Nicol and de la Mare 1993, de la Mare 1996, 1998, Constable *et al.* 2000, Miller and Agnew 2000). The procedure also implicitly accounts for predator needs to provide an element of precaution when calculating krill catch levels (Miller and Agnew 2000).

The application of the decision rules approach for krill has been generalized to other CCAMLR species, such as *D. eleginoides* (Constable and de la Mare 1996) and *C. gunnari* (de la Mare, Williams and Constable 1998). In this respect, decision rules are reviewed for the species concerned with subsequent assessments being contingent on available knowledge and the inherent limitations of the applied methodologies. By using a generalized approach to assess long-term annual yields, provision is made for incorporating uncertainties into a single assessment to provide further precaution (Constable *et al.* 2000).

Despite advances in refining its ecosystem and precautionary approach, CCAMLR has some way to go in developing explicit management procedures to account for ecosystem considerations. As Constable (2002) and de la Mare (1996) have emphasized, it still has to develop a management procedure that improves the probability of maintaining ecological relationships and that also ensures predator needs are met by allowing for a sufficient "surplus" from harvested stocks to meet such needs. How such a procedure could be applied is illustrated in Figure 6 and its key features are summarized in Box 8.

A *post-hoc* summary of the management approach developed by CCAMLR for the krill fishery has been provided by Miller (2002) and Figure 7 illustrates the systematic manner of CCAMLR's management approach. Further, CCAMLR has recognized its limitations in its efforts to manage the krill fishery from both a precautionary and ecosystem-based perspective. As a result, it has attempted to further develop a decision-making process aimed at incorporating dependent (i.e. ecosystem) considerations more explicitly into developing management advice for the krill fishery (Figure 8).

In addition to the steps outlined in Figure 6, other considerations (after Constable 2002) to be addressed, or currently being developed, include:

- ensuring that correct and timely decisions are facilitated so that the conservation (including rational use) provisions of Article II are better met
- undertaking sufficient monitoring to ensure that harvest controls do not affect dependent predators in some unacceptable way
- allowing sufficient time to detect and rectify any harvest-induced changes in the ecosystem within the two or three decades recovery period set out in Article II
- refining assessments of harvested stock yield by taking into account new estimates of demographic parameters and by dividing precautionary yield into small-scale management units of appropriate scale (Murphy *et al.* 1988, Murphy 1995) to improve predictive power and spread the risk of irreversible ecosystem changes and

BOX 7

Philosophical considerations underpinning CCAMLR's approach to ecosystem and precautionary management in relation to the provisions of Article II as outlined by WG-DAC

[From Miller (2002) and Paragraphs 65 to 75 in CCAMLR (1989), 8.1 to 8.14 in CCAMLR (1990) and 6.13 to 6.23 in CCAMLR (1991)].

1. The term “conservation” includes rational use. “Rational use” is subject to different interpretations, inter alia:
 - (a) Harvesting of resources is on a sustainable basis
 - (b) Harvesting on a sustainable basis means harvesting activities are conducted to ensure that the highest possible long-term yield can be taken from a resource, subject to the general principles of conservation to be met, and
 - (c) The cost–efficiency of harvesting activities and their management should be given due weight.
2. Harvesting and, or, associated activities should be conducted according to accepted conservation principles.
3. As a general principle, the ecosystem(s) should be maintained in a state where:
 - (a) Present and future options are preserved. Requires prevention of decrease in size of any harvested population to levels below which stable recruitment and maintenance of ecological relationships between harvested, dependent and related populations are ensured
 - (b) Risk(s) of irreversible change or long-term adverse effects of harvesting and, or, associated activities should be minimised, and
 - (c) Wherever applicable, both consumptive & non-consumptive resource use should be given due weight and should be maximized on a continuing basis.
4. Management decisions should take account of uncertainty associated with imperfect knowledge and should be “precautionary” (i.e. conservative) in the absence of complete knowledge
5. Measures conserving resources should be formulated and applied to avoid wasteful use of other resources
6. Planned and actual use of resources should be preceded, and accompanied, by surveys to assess resource potential, the monitoring of resource status and associated analysis of ancillary data

- developing operational objectives for non-harvested species (Beddington and de la Mare 1985, Butterworth 1986, de la Mare 1996) to account for uncertainties associated with ecosystem function, the dynamic relationships amongst predators, and those between predators and their prey (Constable 2002).

Finally, CCAMLR's attempts to develop its precautionary approach, pre-empted by some years similar efforts by the international community (e.g. as documented in FAO 1995, 1996).

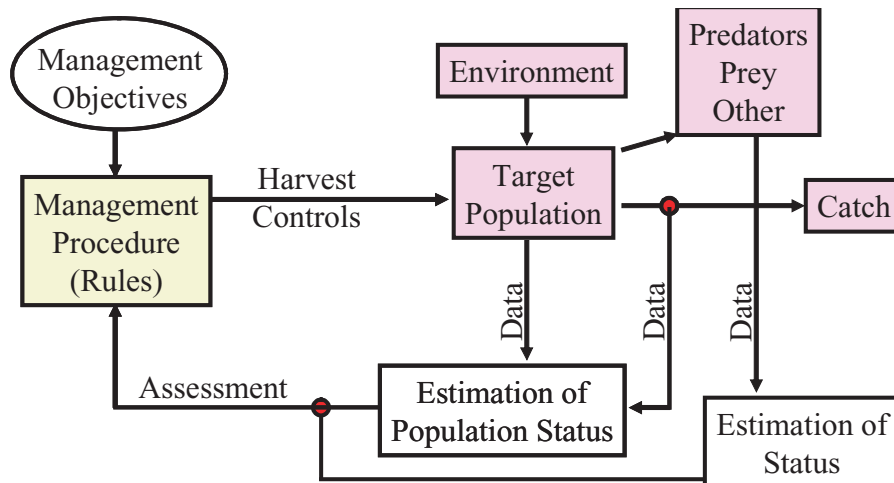
5.2.3 The jurisdictional imperative

The biogeographic limits of species harvested in the CCAMLR area are generally confined to the Convention Area (i.e. south of the Antarctic Convergence) and to depths between 500m and 2500m in shelf waters, or on shallow seamounts in the northern parts of the Area [Fischer and Hureau 1985, Shust 1998 and pages 387–413 of Annex 5, Appendix E in SC-CAMLR (1995)]. Stocks of species such as *D. eleginoides* are also found in areas just north of the Convention's northern boundary, particularly in the Indian Ocean (Kock 1992).

FIGURE 6

An ecosystem-based management approach addressing effects of fishing on dependent and related species [from Constable (2002) after de la Mare (1996)].

The "Management Procedure" comprises a set of rules on which adjustments to harvest levels are based in response to assessments so that "Management Objectives" exhibit a high probability of being met. The "Physical World" (shaded boxes) represents the actual state of the system observed through monitoring [i.e. via the CCAMLR Ecosystem Monitoring Programme – Constable (2002)]. Assessments take account of uncertainty associated with physical world functioning as well as the relationship between the monitoring programme and that world.



BOX 8

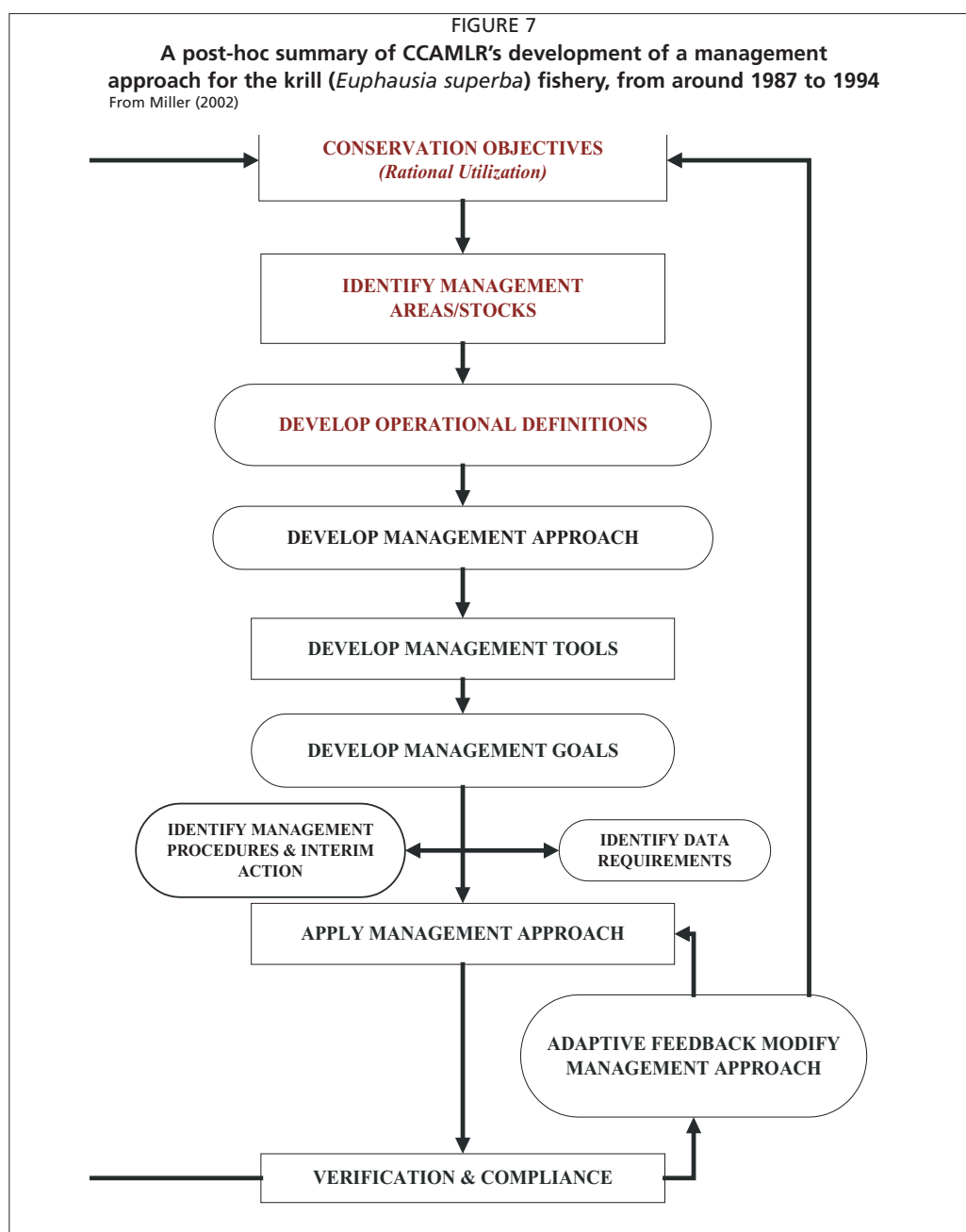
Pro Forma Process for a CCAMLR ecosystem management practice

(from Constable 2002)

- Operational objectives articulating the target status for relevant ecosystem aspects
- Methods to assess ecosystem status
- Decision rules for how harvest controls to be adjusted accounting for differences between assessments & agreed objectives
- Methods dealing with uncertainty [including ecosystem functional ("physical world") uncertainty] to facilitate scientific consensus

Initially, fishing grounds for *D. eleginoides* were confined to areas close to a few oceanic islands within the Convention Area, most notably, CCAMLR Statistical Sub-area 48.3, the Prince Edward Islands (Sub-areas 58.6 and 58.7), the Crozet Islands (Sub-area 58.6), the Kerguelen Islands (Statistical Division 58.5.1), and Heard and McDonald Islands (Division 58.5.2). The unique provisions of the CCAMLR Chairman's statement (CCAMLR 2002a) allowed the states involved (Australia, France, South Africa and, in practice, the United Kingdom) to exercise jurisdiction over most of the productive fishing grounds in accordance with CCAMLR Conservation Measures and, or, through more stringent national measures.

This arrangement provided for coastal state enforcement in conformity with CCAMLR's requirements – a situation that provided an incentive for the United Kingdom in 1993 to define fishing waters (including a Maritime Zone of roughly equivalent area) outwards to 200 nautical miles offshore around South Georgia and the South Sandwich Islands (Clover 1991, Anon. 1993). The United Kingdom justified this action in response to growing IUU fishing for *D. eleginoides* in the area concerned, despite Argentine concerns over sovereignty. Since then, the United Kingdom has



applied CCAMLR Conservation Measures and maintained control over authorizations to fish in this zone.

It is interesting to note how France and South Africa, in contrast to the United Kingdom practice, have reconciled application of CCAMLR Conservation Measures and national measures under the Chairman's statement. France has formally lodged reservations to any Measure that may impact on both its territorial, jurisdictional and administrative procedures in its sovereign waters within the Convention Area. South Africa initially only recorded reservations in respect of Conservation Measures that may affect its sovereign rights, particularly in terms of affecting attached permit conditions. However, it began to record reservations to more administrative measures (such as to Measures 23-04 and 23-05 on data reporting) in 1997. This may give the impression that South Africa only began to expand its reservations after the country's political changes in 1994 and in response to the development of a fishery for *D. eleginoides* in its EEZ around the Prince Edward Islands. However, examination of all Measures

Maritime Legislation Amendment Act 1994) is viewed as a “good faith” attempt to regulate the fishing activities of Australian flagged vessels adjacent to the Territories rather than an attempt to augment any sovereignty claim contrary to the spirit of Article IV of the CAMLR Convention (Joyner 1995).

TABLE 4

Number and types of reservations lodged by South Africa and France on application of CCAMLR conservation measures

See Section 5.2.2 for detailed discussion. Measures are identified following numbering in CCAMLR (1997a, 2002b)

Country	Administrative		Sovereign (permit conditions)	
France	10-01	10-03	10-02	21-01
	22-03	23-04	21-02	141/XVI
	23-05	24-01	142XVI	
	25-03	32-11		
	32-12	33-03		
	41-01			
South Africa	23-04	23-05	10-02	21-01
	24-01	24-01	21-02	141/XVI
	32-11	32-12	142XVI	
	41-01			

A further point is whether reservations for any particular Conservation Measure have lead to any significant impact in the effective application of the Chairman’s statement. This is hard to judge. However, if the full intent of the statement’s paragraph 3.(a) (CCAMLR 2002a) is applied then it could be anticipated that both South Africa and France in applying their sovereign powers would have promulgated national measures at least comparable to, or more stringent than, those of CCAMLR. This does not appear to be case, particularly in light of South Africa’s repeated assertion of a need to continue year-round fishing to combat IUU fishing in the Prince Edward islands’ EEZ (Brandão *et al.* 2002). Such an assertion could be interpreted as the reason for a reservation being recorded in respect of closed season requirements set out in measures such as Conservation Measures 141/XVI and 142/XVI (CCAMLR 1997a) aimed at protecting breeding seabird populations from incidentally mortality during longline fishing in the region.

Finally, both France and South Africa have not recorded reservations to a number of significant Measures aimed at combating IUU fishing. These include Conservation Measures 10-04 mandating deployment of VMS, 10-05 describing the CDS, 10-06 promoting compliance by Contracting Party vessels and 10-07 promoting compliance by NCP vessels.

Taken as a whole, the above situation does not imply that IUU fishing is no longer a challenge to coastal state sovereignty in the Convention Area. Possibly, with the exception of South Africa, because of their lack of enforcement capability (Brandão *et al.* 2002), the countries most affected (France and Australia) have devoted considerable effort to protect their waters from such fishing. Despite these efforts, IUU fishing has seriously affected specific toothfish stocks⁸. Around the Prince Edward Islands, such fishing has severely threatened the future sustainability of *D. eleginoides* in the region (Brandão *et al.* 2002).

An ancillary consideration is the extent to which the Convention’s provisions (particularly Conservation Measures) can be effectively applied on the high seas within the Convention Area (Joyner 1995, Levy 1997). The situation is exacerbated by the Convention’s Area’s geographic extent (*ca.* 35 x 10⁶. km²) which tends to favour

⁸ See paragraph 5.4 of CCAMLR (1999b) which states - “The Scientific Committee drew the attention of the Commission to the potential similarities between the implications for future sustainability of *Dissostichus* spp. stocks as a consequence of IUU fishing and the collapse of *Nototothenia rossii* stocks due to overfishing in the late 1970s”.

fishing outside CCAMLR's regulatory control, particularly by vessels flying the flags of CCAMLR NCPs (Agnew 2000). While the list of specific Conservation Measures dealing with CCAMLR NCPs systematically grows, there is still a need to balance the implied regulatory provisions of such Measures with the rights of all states, CCAMLR Contracting and Non-Contracting Parties alike, to fish the high seas under LOSC Article 116 (Anon. 1983).

It should be recognized that when LOSC Article 116 is read in conjunction with Articles 117 to 119 (Anon. 1983), there is a clear obligation on all states to cooperate in the conservation and management of marine living resources on the high seas and to take appropriate measures to ensure this occurs. The FAO Compliance Agreement (Anon. 1998b) and UNFSA Articles 8, 19 to 23 (Anon. 1998a) provisions oblige states fishing on the high seas in the CCAMLR Convention Area to do so consistent with measures aimed at ensuring stock sustainability and in a manner which does not discharge them from cooperating with CCAMLR in the conservation and management of relevant fisheries resources.

Despite these obligations, there is still scope to explore how effectively the LOSC provisions, and especially those of UNFSA, could be aligned with CCAMLR's efforts to combat issues such as IUU toothfish fishing (Dodds 2000) within the Convention Area, as well as in closely adjacent zones. The expression of CCAMLR's institutional support to the FAO International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU)(FAO 2001) is a step to address this problem [Paragraph 8.15 in CCAMLR (2002c)].

5.2.4 Enforcement issues

It has been suggested that CCAMLR's potential actions are severely limited in apprehending vessels fishing in defiance of its Conservation Measures on the high seas compared to those of coastal state in areas under national jurisdiction within the Convention Area (Lutgen 1997, Kirkwood and Agnew 2004). Nevertheless, the management processes and ancillary enforcement measures essentially remain the same (Joyner 1998). These are best summarized in a common "enforcement paradigm" for both jurisdictional regimes (Figure 9).

An initial concern in addressing the enforcement paradigm is that, like most RFMOs, CCAMLR's high seas regime is based on flag state enforcement. Rayfuse (1998) has suggested that such regimes exhibit a few inherent, serious, flaws. These tend to arise from insufficient, or inaccurate, data reporting, lack of enforcement capability and intransigence amongst others; considerations all compounded by the Convention Area's size. To an unquantifiable extent, such failings may be ameliorated by the "moral imperative" implicit in the inclusive nature of CCAMLR's consensus-based decision-making⁹. Having agreed to be bound by a specific Conservation Measure, it is likely to be morally difficult for any individual CCAMLR Member to then intentionally undermine such a measure.

A second concern is the perceived threat posed to the effective implementation of CCAMLR Conservation Measures by NCPs activities such as IUU fishing (Molenaar 2001). This allows Measures to be circumvented, or "undermined" while also providing an incentive to flag, or reflag, vessels to Non-CCAMLR flag states. This concern appears well justified given the number of CCAMLR NCPs involved either as flag states in fishing for, or as port states in the trade of, IUU-caught toothfish (Table 5).

⁹ Consensus-based decision making is mandated for all CCAMLR decisions on "matters of substance" under Convention Article XII (Anon. 2002a).

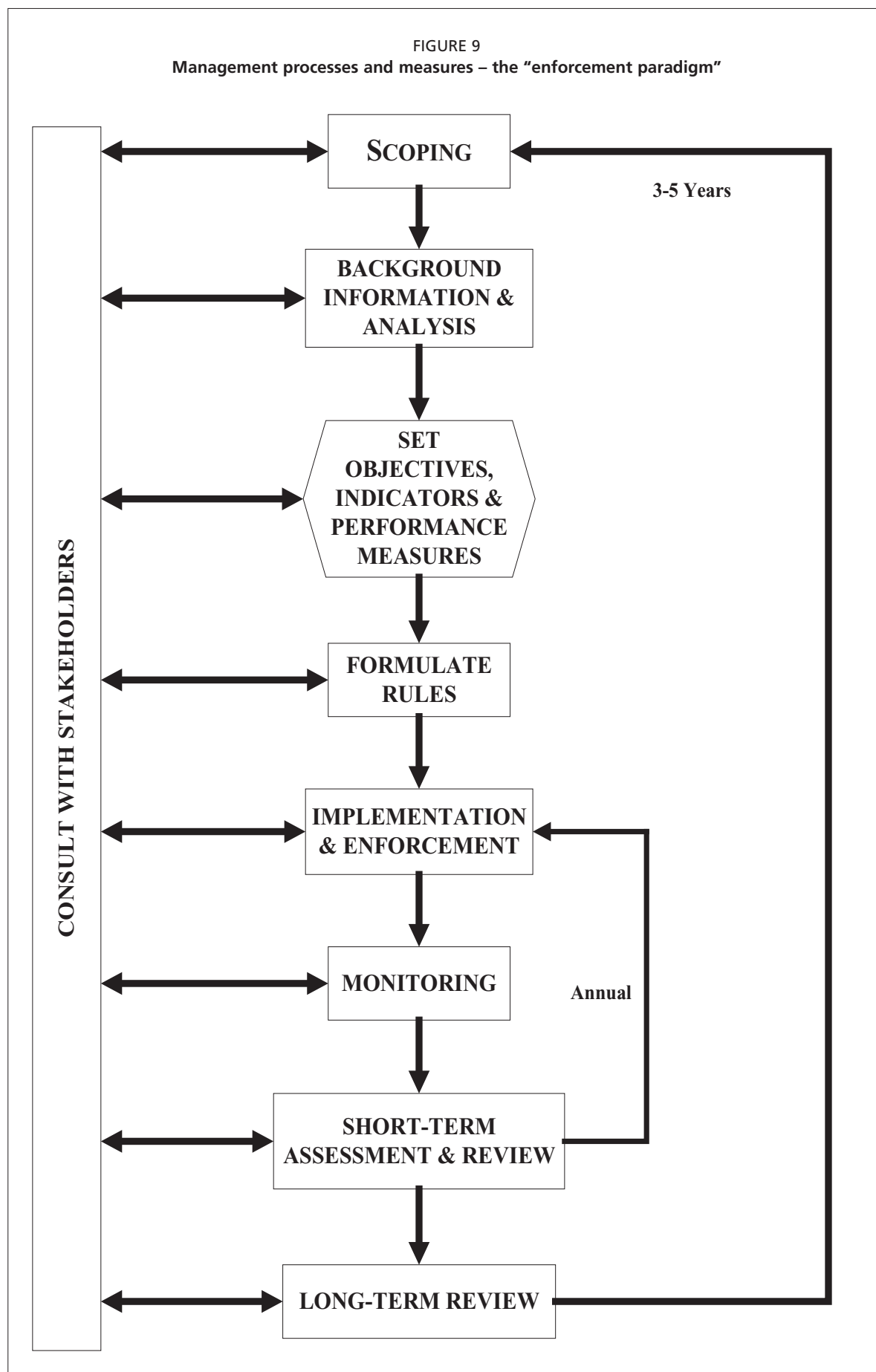


TABLE 5
Non-CCAMLR Members involved in IUU fishing for, or trade of, Toothfish166

"Flag State" Vessels flying such flags have been reported engaged in toothfish operations; "market state" – state known to have engaged in toothfish trade; "port state" – state where toothfish have been landed; "owner/operator state" – state where vessel operators known to have based activities. [adapted from Molenaar (2001) using additional information from CCAMLR (2000b), Lack and Sant (2001), and Willcock (2002)].

State	Flag State	Market State	Port State	Owner/Operator State
Belize	✓	–	✓	?
Bolivia	–	✓	–	✓
Canada ^a	–	✓	–	–
China ^b	–	✓	✓	–
Denmark ^c	–	✓	✓	–
Honduras	✓	–	✓	–
Indonesia ^b	–	✓	✓	–
Kenya	–	–	✓	–
Malta	✓	–	✓	–
Mauritius ^b	✓	✓	✓	✓
Mozambique	–	–	✓	–
Netherland Antilles ^d	✓	–	✓	✓
Panama	✓	–	✓	✓
Portugal ^c	✓	–	✓	–
Sao Tome & Principe	✓	–	–	✓
Seychelles ^b	✓	–	✓	✓
Singapore	–	✓	✓	–
Vanuatu ^{a, b}	✓	–	✓	–

a. CCAMLR contracting parties but not commission members

b. Voluntary participants in the CDS

c. Subject to control under European Union's Common Fisheries Policy

d. Falls under Netherlands responsibility as a CCAMLR contracting party

The potential absence of effective enforcement on the high seas within the Convention Area has forced CCAMLR to develop alternative methods to augment flag state enforcement, apart from unilateral extension of coastal state jurisdiction (Molenaar 2001). Three complementary approaches have been pursued. The first is clearly illustrated by the suite of CCAMLR measures aimed at eliminating IUU fishing. The second is CCAMLR's development of inspection and observation provisions. The third is illustrated by development of the CDS (Section 4).

5.2.5 CCAMLR System of inspection

CCAMLR's progressive development of fishery control measures has required collection of fisheries data and information on fish biology, ecology, demography and productivity. Such information is crucial to monitoring fishing activity and in assessing stock status. In 1989, CCAMLR introduced its own System of Inspection to provide at-sea control of Contracting Party vessels fishing in the Convention Area by inspectors specifically designated by CCAMLR member states. Details of the Inspection System are provided in CCAMLR Basic Documents (CCAMLR 2002a).

The CCAMLR Inspection System operates nationally with inspectors being appointed by their national authorities and reporting to CCAMLR via the member state which designated them. CCAMLR inspectors usually operate from designated Member vessels on the high seas within the Convention Area. However, inspections may be carried out from any vessel [Article III of the CCAMLR System of Inspection in CCAMLR (2002a)]. The scheduling of inspections is a matter for the flag and designating state. Inspectors are permitted to board fishing, or fisheries research vessels, on the high seas in the CCAMLR Convention Area at will with the understanding that

such vessels are flagged to CCAMLR Contracting Parties.¹⁰ Finally, the Inspection System provides for reporting sightings of NCP-flagged fishing vessels.

While the total number of at-sea CCAMLR inspections undertaken annually remains small, inspection efforts have tended to concentrate on areas of most intensive fishing activity. The outcomes of these efforts have been summarized in other publications (Agnew 2000, Sabourenkov and Miller 2004). Many of the perceived failings of the CCAMLR System of Inspection highlighted by Rayfuse (1998) have been rectified. For example, both the number and extent of inspections have increased while Members have greatly improved the submission of information on their vessels intending to fish in the Convention Area during any particular season as well as on sanctions imposed for transgressions (Sabourenkov and Miller 2004).

The prevailing and positive perception of the CCAMLR's System of Inspection's effectiveness has prompted at least one other "new generation" fisheries arrangement, the Convention on the Conservation and Management of Fishery Resources in the South East Atlantic (SEAFC) (Anon. 2001a, Miller 2005), to build on the System. Combined with the application of some of the provisions of UNFSA Article 22 (Anon. 1998a), the interim SEAFC interim inspection procedures are not too dissimilar to those applied by CCAMLR.¹¹

Nevertheless, a number of distinct and interrelated factors still impede the CCAMLR Inspection System's efficacy. Rayfuse (1998) attributes these to the system's physical and practical limitations, its inherent design deficiencies, and legal and political considerations associated with flag state enforcement being implemented nationally. However, at-sea inspection is only one, albeit vital, tool in a range of CCAMLR measures aimed at combating IUU fishing. Consequently, many of the recent measures presented in Table 14 greatly contribute to enhancing CCAMLR's enforcement efforts within the Convention Area when compared with requirements stipulated in the FAO IPOA-IUU (FAO 2001). The mandatory deployment of VMS on toothfish vessels, the strengthening of both port and flag state controls and development of the CDS in particular have achieved much in this regard (e.g. Tables 3 and 6).

TABLE 6

CCAMLR conservation measures (CMs) aimed at eliminating IUU fishing in the Convention Area

These measures have been developed since 1996/97 and are referenced to Conservation Measures currently in force [From CCAMLR (2002b), Sabourenkov and Miller (2004)].

Type of measure	CCAMLR conservation measure
Fishery regulatory measures	
Prohibit directed toothfish fishing in convention area except in accordance with CMs	CM 32–09
Advance notification of new fisheries.	CM 21–01
Advance notification and conduct of exploratory toothfish fisheries, including data collection and research plans	CMs 21–02 & 41–01
Reporting catch, effort and biological data, including reporting of fine-scale data	CMs 23–01, 23–02, 23–03, 23–04 & 23–05
Placing international scientific observers on vessels targeting toothfish	CM 41–01 Various area-specific measures
Reducing seabird mortality during longline and trawl fishing	CMs 25–02 & 25–03

¹⁰ Paragraph 7.25 of CCAMLR (1995b), in conjunction with paragraph 7.26, allows for addition of a new Article (Article IX) to be added to the System of Inspection to provide a definition of activities assumed to comprise "scientific research on", or "harvesting of," marine living resources in the Convention Area.

¹¹ SEAFC Article 16 (Anon 2001a), following UNFSA Articles 21 and 22 (Anon. 1998a), provides guidelines for sub-regional/regional cooperation in enforcement and for the boarding and inspection of vessels. SEAFC has expanded on these guidelines in its Annex 1and, but leaves finalization of its monitoring, control and surveillance system to the first meeting of the SEAFC Commission. See also discussion in Miller (2005).

Flag state measures

Contracting Party licensing & inspection obligations for fishing vessels under their flag in the convention area	CM 10–02
At-sea inspections of contracting party fishing vessels	System of inspection
Marking of fishing vessels & fishing gear	CM 10–01
Compulsory deployment of satellite-based VMS on all vessels (except krill fishery) licensed by CCAMLR members to fish in convention area	CM 10–04
Toothfish catch documentation scheme	CM 10–05

Port state measures

Port inspections of vessels intending to land Toothfish to ensure compliance with CCAMLR CMs	CM 10–03
Scheme to promote compliance by contracting party vessels with CCAMLR CMs	CM 10–06
Scheme to promote compliance by non-contracting party vessels with CCAMLR CMs	CM 10–07

Resolutions

Harvesting stocks occurring both within, and outside, Convention Area, paying due respect to CCAMLR CMs	Resolution 10/XII
Implementation of catch documentation scheme by acceding states and non-contracting parties	Resolution 14/XIX
Use of ports not implementing the toothfish catch documentation scheme	Resolution 15/XIX
Application of VMS in catch documentation scheme	Resolution 16/XIX
Use of VMS and other measures to verify CDS catch data outside Convention Area, especially in FAO Statistical Area 51	Resolution 17/XX
Harvesting of Patagonian toothfish outside areas of coastal state jurisdiction adjacent to Convention Area in FAO Statistical Areas 51 & 57	Resolution 18/XXI
Flags of non-compliance	Resolution 19/XXI

Policy

Policy to enhance cooperation between CCAMLR & non-contracting parties	-
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5.2.6 CCAMLR Scheme of International Scientific Observation

In 1992, the CCAMLR Scheme of International Scientific Observation (CCAMLR 2002a) was introduced and did much to augment the System of Inspection. Under the Scheme, international scientific observers are deployed on vessels undertaking fisheries research or commercial fishing in the Convention Area. The designation of international scientific observers under the Scheme is arranged bilaterally between the Member wishing to place an observer aboard a vessel and the flag state of the vessel concerned [Section B of the CCAMLR Scheme of International Scientific Observation (CCAMLR 2002a)].

A scientific observer's primary task under the CCAMLR Scheme is to collect essential scientific data and to promote the Convention's objectives. To ensure scientific impartiality, observers designated under the Scheme are confined to nationals of CCAMLR Members other than the flag state of the vessel on which they are assigned. Deployment of observers under the Scheme is a mandatory requirement for all CCAMLR-sanctioned toothfish and icefish fisheries, particularly in areas outside national jurisdiction. A recent requirement has also directed observers to provide factual data on sightings of activities by vessels other than those on which they are deployed [Paragraphs 4.10–4.11 of Annex 5 in CCAMLR (1998)]. To date, observers have provided much needed scientific data, especially for “new” and “exploratory” fisheries (Section 2).

Despite the above, the most effective deterrent of toothfish IUU fishing in the Convention Area probably remains coastal state action (Kirkwood and Agnew 2004). A key factor appears attributable to the punitive fines that coastal states have imposed (in some cases in excess of US\$1 million), coupled with their seizure of vessels, and, or, catch, and an increased risk of apprehension. An example of effective coastal state action is apparent from the recent ruling by the International Tribunal of the Law of the Sea's on Australia's prosecution of the Russian flagged *Volga* for fishing in the Australian FZ around Heard and McDonald Islands.¹² Further examples of effective action are evident from the levels of international cooperation exhibited by a number of CCAMLR Members. These resulted in apprehension of the *South Tomi* in 2001 [Paragraph 2.15 in CCAMLR (2001)] and the *Viarsa* in August 2003. In both cases, Australia exercised its right under LOSC Article 111.(2) (Anon. 1983) to chase vessels illegally fishing in its waters around the above Islands. With the assistance of South Africa, it was able to intercept the *South Tomi* south of the Cape of Good Hope, and with the assistance of South Africa and the United Kingdom the *Viarsa* was intercepted in the midsouth Atlantic.

Kirkwood and Agnew (2004) have acknowledged that effective deterrence depends largely on the extent to which any imposed sanctions are comparable from one jurisdiction to another. This is a complex consideration that depends on factors such as the equivalence of judicial, or regulatory, procedures between states (Joyner 1998). In its broadest terms, CAMLR Convention Article XI may be interpreted as implying that any harmonization of conservation measures for species occurring in both the Convention Area and in adjacent areas under national jurisdiction may necessitate consideration of equivalence in any imposed sanctions. However, CCAMLR has never specifically discussed the matter, and it is suggested that there may be merit in pursuing a similar course of action to that outlined in Article 4.(b) of the South African Development Community Protocol on Fisheries (SADC) (Anon. 2001b) which urges cooperation in the: "establishment of region-wide comparable levels of penalties imposed for illegal fishing by non-SADC vessels and with respect to illegal fishing by SADC vessels in the waters of other State Parties". It is easy to visualize the potential benefits of such an approach being consistently applied by all CCAMLR Contracting Parties.

Furthermore, it has to be recognized that any significant reduction in unacceptable fishing practices by CCAMLR constitutes an essential element in improving and assessing its enforcement capabilities (Kirkwood and Agnew 2004). For example, an FAO report (FAO 1981) has stated that: "There will always be a relationship between the probability of detection and the level of compliance with a regulation. The more severe the penalty faced, the greater the likelihood of compliance, provided that a reasonable probability of detection exists." It follows especially in CCAMLR's case that the absence of severe penalties combined with limited enforcement capability could result in the potential lucrative rewards of IUU fishing outweighing the penalties. Such fishing thus becomes more cost-effective than legitimate practices (Levy 1997). Consequently, effective enforcement should take account of where, and by whom, the benefits of IUU fishing are being enjoyed. In these terms, and like Rayfuse (1998), we acknowledge the potential shortcomings inherent in flag state enforcement.

While it may be argued that references to "nationals" in the LOSC¹³ are perfunctory rather than obligatory, it would appear that there is a growing awareness that some

¹² The International Tribunal for the Law of the Sea ruled on 23 December 2002 that Australia should release the *Lena* on the posting of a bond of A\$1,920,000, see Website - <<http://www.itlos.org>>.

¹³ Various LOSC (Anon. 1983) articles make reference to the obligations of "nationals" to comply with, or cooperate in, the implementation of conservation measures governing marine living resource utilization. The most prescriptive of these include Articles 62.(4) and 117.

¹⁴ UNFSA Article 11.(l) (Anon. 1998a) also states - "ensure the full cooperation of their relevant national agencies and industries on implementing the recommendations and decisions of the organization of

control is necessary over natural and legal persons to allow states to fulfil their obligations to cooperate effectively through RFMOs (Rayfuse 2000). Clear evidence of this intent is found in UNFSA Article 10.(l) (Anon. 1998a)¹⁴ and in various initiatives by states to exert direct control over the activities of their nationals as a means of ensuring compliance with both third party and international fisheries management measures.¹⁵ The control of “nationals” is therefore obviously a question worth exploring as an important element of CCAMLR’s efforts to combat IUU fishing.

5.2.7 Control measures

The initial expansion of Toothfish IUU fishing in the Convention Area during the mid-1990s coincided with expansion of legitimate fishing activity approved by either CCAMLR or by coastal states in the Indian Ocean (Sabourenkov and Miller 2004). The levels of IUU fishing at that time were unprecedented with more than 40 fishing vessels being sighted within the South African EEZ at the Prince Edward Islands alone during 1997/98 (Agnew 2000). Since then, CCAMLR has been constantly revising its Conservation Measures [Pages (xxiv) to (xxix) in CCAMLR (2002b)] in an effort to eliminate IUU fishing (see Footnote 2) (Table 6). These efforts promote cooperation between CCAMLR Contracting Parties to improve compliance, implement at-sea inspections of Contracting Party vessels, ensure marking of all vessels and fishing gear, and introduction of VMS, to verify catch location. Additional measures address mandatory port state inspections by Contracting Parties of their vessels licensed to fish in the Convention Area and developing ties with NCPs involved in toothfish fishing or trade. Most recently, CCAMLR has established a vessel database to facilitate information exchange between Members on vessels known to have fished in contravention of its Conservation Measures [*Conservation Measure* 10–06 in CCAMLR (2002b) Sabourenkov and Miller (2004)].

As highlighted in Section 4, IUU fishing for toothfish clearly undermines CCAMLR’s Conservation Measures. It also violates the principles in UNFSA Articles (Anon. 1998a) addressing flag state duties (Article 18), the obligations of Non-Members, or Non-Participants, in regional fisheries arrangements (Article 17) and LOSC Articles 116–119 (Anon. 1983). Given its economic value, toothfish remains in high demand and continues to attract high prices internationally (Section 4.1). With fishable stocks straddling the Convention Area’s boundaries, it has been difficult to trace IUU-caught fish through global trade avenues on account of uncertainties attached to the exact origin of catches. As a result, undetermined quantities of toothfish have enjoyed non-restricted access to international markets to the benefit of IUU fishing operators (Agnew 2000, Sabourenkov and Miller 2004).

arrangement”. This principle is further elaborated in SEAFRC (SEAFRC 2001) Article 13.6.(a) which states - “Without prejudice to the primacy of the responsibility of the flag State, each Contracting party shall, to the greatest extent possible, take measures, or cooperate, to ensure that its nationals fishing the Convention Area and its industries comply with the provisions of this Convention. Each Contracting Party shall, on a regular basis, inform the Commission of such measures taken”. In terms of SEAFRC’s area of application this relates to both straddling and migratory stocks, as well as discrete stocks on the high seas (see SEAFRC Articles 2, 4 and 19.1) - a point emphasized by Jackson (2002).

¹⁵ A number of States have introduced regulatory provisions that require that their nationals comply with international conservation and management measures inside or outside their national waters. Notable examples include the Australian *Fisheries Management Act, 1991* (Act No. 162 of 1991), Part 6A of the New Zealand *Fisheries Act*, application of Article 6 of the Norwegian 1977 Regulations Relating to Fishing and Hunting Operations by Foreign Nationals in the Economic Zone of, application of the South African *Marine Living Resources Act, 1998* (Act. No. 18 of 1988 – *South African Government Gazette Notice No. 189630 of 27 May 1998*) [Particularly provision 70.(1)(b)] and Spanish *Directive 1134/2001 of 31 October 2002*. A recent and interesting development has been the indictment by United States authorities of a number of South African citizens and joint South African-United States nationals under the United States *Lacey Act*. The indictment concerns perceived offences under, and alleged illegal harvesting of South Coast Rock Lobster and Patagonian Toothfish, in defiance of, South African statutes and CCAMLR Conservation Measures (Anon. 2003).

By developing the CDS, CCAMLR has clearly indicated its resolve to adopt innovative, contemporary and legitimate measures to avoid undermining its conservation efforts by IUU fishing. We should emphasize that all the measures highlighted in this paper are fully consistent with the provisions of LOSC Articles 116 to 119 (Anon. 1983), UNFSA Articles 21 to 23 (Anon. 1998a) and Articles III to VIII of the Compliance Agreement (Anon. 1998b). In reaction to UNFSA Articles 8 (particularly paragraphs 3 and 4) and 17, CCAMLR has encouraged its Members to accept and promote the Agreement's entry into force¹⁶, along with the Compliance Agreement (Anon. 1998b), and to accept the *FAO Code of Conduct* (Anon. 1998c) [Paragraph 6.32 in CCAMLR (1998)].

5.2.8 International cooperation

International cooperation is one of the Antarctic Treaty's most enduring features (Vicuna 1986). Like many other aspects of the Treaty this has been carried over to the CAMLR Convention.¹⁷ From a practical perspective, CCAMLR has done much to advance such cooperation. For example, a number of the CCAMLR Conservation Measures identified in this paper are obviously dependent on institutionalizing international cooperation (Lutgen 1999) as a means to combat IUU fishing in the Convention Area. Together with UNFSA's recent entry into force¹⁸, there is every expectation that CCAMLR will benefit from enhanced international cooperation to the extent that its capacity to meet the Convention's objectives will be improved (Dodds 2000).

CCAMLR has frequently acknowledged that the entry into force of both the UNFSA and the FAO Compliance Agreement (Anon. 1998b) are likely to contribute significantly to the Commission's work in reducing and eliminating IUU fishing in the Convention Area. In particular, [e.g. Paragraphs 5.11 and 5.32 in CCAMLR (1997)] CCAMLR Members have actively contributed to the FAO's work on implementing the above agreements – most notably the development of their IPOA-Seabirds (FAO 1999) and the IPOA-IUU (FAO 2001). Institutionally, CCAMLR actively participates as an observer at the meetings of the FAO Committee on Fisheries (COFI) and its sub-committees, especially the biennial meetings of Regional Fisheries Management Bodies that the CCAMLR Executive Secretary currently chairs.

CCAMLR actively cooperates with various regional fisheries organizations, particularly those managing fisheries in waters adjacent to the Convention Area such as ICCAT, the Indian Ocean Tuna Commission (IOTC) and the Commission for the Conservation of Southern Bluefin Tuna (CCSBT).¹⁹ This cooperation includes, *inter alia*, the exchange of information on IUU fishing on the high seas and efforts to combat its effects and consideration of incidental seabird mortality arising from longline fishing.

As emphasized in Section 4, the CDS is a serious effort by CCAMLR to promote multilateral cooperation in combating toothfish IUU fishing. In contrast to other

¹⁶ UNFSA entered into force on 11 December 2001 when the necessary 30 ratifications had been deposited.

¹⁷ Article XXII of the CAMLR Convention (CCAMLR 2002a) specifically strives to build cooperative relationships between CCAMLR and relevant inter-governmental and non-governmental organizations. Article XXIII specifically mandates cooperation with other elements of the Antarctic Treaty System and the Scientific Committee for Antarctic Research (SCAR).

¹⁸ UNFSA Part III (Articles 8 to 16) (Anon. 1998a) outlines various mechanisms for international cooperation in the management of the resources concerned. These complement similar sentiments implicit in LOSC (Anon. 1983) Articles 61, 63, 64 and 117-119.

¹⁹ The annual CCAMLR meeting considers its cooperation with other international organizations as a standing agenda item. It also considers such cooperation under other agenda items where appropriate, including during various discussions by the *Commission's* subsidiary bodies, the Scientific Committee in particular.

Conservation Measures that are limited to the Convention Area and to CCAMLR Members, the CDS is global in application. Further, its implementation is consistent with provisions of UNFSA Articles 7, 8 and 17 (Anon. 1998a).

A final point concerns the CDS' performance and its legitimacy. As the CDS is aimed at minimizing any potential for national bias (Larson 2000), its effectiveness should benefit as a consequence of enhanced international cooperation. In this respect, and following an Australian proposal to list toothfish under Appendix II of the Convention on Trade of Endangered Species (CITES), the recent decisions by CCAMLR and the Twelfth Conference of CITES Parties (COP-12)²⁰ [Paragraphs 10.72 to 10.75 in CCAMLR (2002c)] to improve cooperation and the exchange of information aims at broadening the CDS' global application. As highlighted in Section 4.2, this could reduce any possible WTO scrutiny arising from a perception that relatively few parties participate in the Scheme. Consequently, the CDS would more effectively qualify as a "multilateral solution based on international cooperation and consensus" to combat an environmental problem of a transboundary or global nature.

5.2.9 Balancing flag, port and export/import state duties and responsibilities

Table 6 outlines some of the significant measures that CCAMLR has developed to ensure that the duties, responsibilities and obligations of flag and port states are fulfilled in support of the obligations that its Contracting Parties have assumed under the Convention, particularly Articles II, VIII, IX, XXI and XXII (CCAMLR 2002a). Under these Articles, CCAMLR Contracting Parties are mandated to:

- support the Convention's objectives (Article II)
- underwrite the Commission's legal personality (Article (VIII))
- contribute to the Commission's functions, including formulation of Conservation Measures (Article IX)
- take measures to ensure compliance with appropriate measures (Article XXI) and
- exert appropriate effort to counteract and discourage, activities contrary to the Convention's objectives (Article XXII).

The impact of both the Measures outlined in Table 6 and Contracting Party obligations under the Convention has been augmented through the introduction of the CDS. Table 6 also illustrates how recent measures have promoted the synergy of CCAMLR's efforts to promote compliance and improve enforcement with its Conservation Measures. The introduction of the CDS for enforcement efforts extends responsibility to exporting and importing states participating in the Scheme (Table 3).

CCAMLR has taken care to ensure that its measures are consistent with international law in the development of the CDS (Larson 2000). However, evolution of CCAMLR's enforcement regime has been more reactive than prescriptive and has not followed a predesignated process. By contrast, UNFSA and SEAFC are more prerogative in nature and explicitly set out flag state duties and port state measures. As the complexity of the legal, sovereign and political issues addressed by CCAMLR continue to grow, there may be considerable benefit from revisiting the duties, rights and obligations of various categories of states under the Convention and from developing explanatory provisions to better define their different requirements following the various UNFSA and SEAFC articles²¹. We are not suggesting that the CAMLR Convention be renegotiated, rather

²⁰ The need for cooperation between CCAMLR and CITES has been addressed in paragraphs 10.72 to 10.75 of CCAMLR (2002c) and by CITES COP-12 Conference Resolution 12.4 with Decisions 12.57 to 12.59 (CITES 2002).

²¹ Specific UNFSA Articles elaborate Flag State Duties (Article 18), Flag State Compliance and Enforcement Obligations (Article 19) and Port State Measures (Article 23)(Anon. 1998a). Due recognition is also given to the special requirements of Developing States (UNFSA Articles 24 to 26). SEAFC outlines definite Contracting Party Obligations (Article 10) as well as both Flag (Articles 18 and 19) and Port Duties (Article 23)(Miller 2005).

it may be helpful to develop some interpretative policies to guide the Commission's interaction with different categories of the states involved in the implementation of Conservation Measures.

5.2.10 CAMLR non-contracting parties (NCPs)

The status of NCPs (Sections 5.2.3 and 5.2.4) under the CAMLR Convention remain an issue for many RFMOs, including CCAMLR in particular (Rayfuse 2000, Molenaar 2001). This is illustrated by CDS-derived data that clearly show considerable NCP and CCAMLR Non-Member involvement in toothfish fishing and trade (Table 5). Molenaar (2001) has indicated that NCP involvement in activities such as IUU fishing has implications for RFMOs such as CCAMLR and is often “constrained by the consensual nature of international law as reflected in the principle of *pacta tertiis*”. He suggests that at a global level every effort should be made to enhance flag state performance and responsibility. These were major objectives of the Compliance Agreement (Anon. 1998b), UNFSA (Anon. 1998a) and the 1995 *FAO Code of Conduct for Responsible Fisheries* (Anon. 1998c). At the regional level, CCAMLR has found several ways to overcome the restrictions imposed by *pacta tertiis*. These have been outlined by Molenaar (2001) and include institutional, organizational and political initiatives, most notably the 1999 adoption of a comprehensive Policy to Enhance Cooperation between CCAMLR and NCPs [Annex. 8 in CCAMLR (1999b)]. This Policy provides the basis for many of the measures outlined in Tables 3 and 6.

Molenaar (2001) suggests that the above Policy, and the CDS, treat NCPs in a way that is consistent with international law. In particular, the key element of port state control is in harmony with UNFSA Article 23 by virtue of the fact that it is agreed multilaterally and is not subject to the crucial issues of participation and allocation (Molenaar 2001). Although CCAMLR has not indicated any intention to avail itself of the non-flag state powers envisaged under UNFSA Articles 21 and 22 and, as suggested for the various categories of states in Section 5.2.5, there be some utility in considering whether these specific Articles could facilitate CCAMLR's management of transboundary stocks such as toothfish. The groundwork for such consideration was outlined ten years ago in CCAMLR Resolution 10/XII (Box 9). Nevertheless, characterization of the CAMLR Convention along the lines suggested by Molenaar (2001) may still be necessary.

6. CONCLUSIONS

6.1 CCAMLR's achievements

Table 7 summarizes some of CCAMLR's more noteworthy achievements in respect of the various topics discussed here. First, we emphasize that CCAMLR's achievements may be favourably viewed as those of a successful “new generation” i.e. post-LOSC, agreement, a point supported by the consistency between CCAMLR, LOSC and UNFSA provisions. Second, CCAMLR continues to make progress in developing its adaptable and decision-based management approach (Section 5.2.1). In this respect, the development of management measures that take account of krill as a target resources, as well as its status as an important ecosystem component is revolutionary (Constable *et al.* 2000, Constable 2002, Miller 2002). Third, CCAMLR has remained responsive to international developments, such as improving cooperation between Parties and NCPs. Internationally, CCAMLR has served as a trend-setting organization through its development of seabird incidental mortality mitigation measures and the CDS.

BOX 9

**The text of CCAMLR Resolution 10/XII (CCAMLR 2002b)
Resolution on harvesting of stocks occurring both within and outside the
convention area**

The Commission,

Recalling the principle of conservation in Article II of the Convention and in particular that of maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources,

Recalling the requirement under Article IX of the Convention for the Commission to seek to cooperate with Contracting Parties which may exercise jurisdiction in marine areas adjacent to the area to which the Convention applies in respect of the conservation of any stock or stocks of associated species which occur both within those areas and the area to which the Convention applies, with a view to harmonizing the conservation measures adopted in respect of such stocks,

Emphasizing the importance of further research on any stock or stocks of species which occur both within the area of the Convention and within adjacent areas,

Noting the concerns expressed by the Scientific Committee on the substantial exploitation of such stocks inside and outside the Convention Area,

reaffirmed that Members should ensure that their flag vessels conduct harvesting of such stocks in areas adjacent to the Convention Area responsibly and with due respect for the conservation measures it has adopted under the Convention.

TABLE 7
Summary of CCAMLR “strategic” achievements “CM” – Conservation measure

ACHIEVEMENTS AS A NEW GENERATION AGREEMENT

Precautionary and ecosystem approach
Inspection system & observer scheme
Relationship to LOSC (Articles 116–118)
Relationship to UNFSA (Articles 8, 17 and 19–21)
Increased global transparency with CDS introduction
Cooperation, transparency and consensus

CONTROL MEASURES

Flag State

CM 10–1 (Marking of vessels and fishing gear)
CM 10–02 (License to fish)
CM 10–05 (CDS)
CM 10–04 (VMS)
Resolution 15/XIX (flags of non-compliance)
Resolution 16/XIX (VMS in CDS)

Port State

CM 10–03 (port inspections of toothfish vessels)
CM10–06 (compliance & CP cooperation)
Resolution 15/XIX (closure non-CDS ports)

Cooperation

CM 10–07 (compliance & NCP compliance)
CM 10–06 (compliance & CP cooperation)
Resolution 14/XIX (acceding/NCP application of CDS)
Resolution 17/XX (VMS in Area 51)
Policy to enhance cooperation between CCAMLR & non-contracting parties
development of CCAMLR POA-IUU

Finally, in dealing with the problem of IUU fishing CCAMLR has addressed the practical and jurisdictional issues encountered in preserving the balance between the “right to fish” and the attendant responsibilities described by LOSC Articles 116–119. In this regard, both CCAMLR’s Policy to Enhance Cooperation between CCAMLR and NCPs and its elaboration of an interconnected suite of control measures (Table 5) are noteworthy.

6.2 Future challenges

In an ever-changing world, it is reasonable to assume that like many other RFMOs, CCAMLR will continue to face a variety of challenges, and threats, in addressing its objectives whilst it must remain responsive and flexible to changing circumstances. Table 8 provides some examples as well as some suggested solutions for their resolution. (Lutgen 1999).

TABLE 8
Some challenges to CCAMLR’s future and suggested solutions

Challenges	Solutions
INSTITUTIONAL	
Loss of interest/complacency/priority erosion (post “war on terror”)	High service delivery standards promotion of public/political awareness education
Threats to status/competence erosion (Relationships RFMOs/UNFSA/CITES)	Informed decision-making, self-promotion and participation
Internal friction (especially over IUU fishing)	Moral persuasion Sanction
Relationship with CEP (Reconciling philosophical differences)	Dialogue informed participation
Shortage of “new blood”	Education and outreach Information dissemination
Perceived lack of transparency	Education and outreach Self-promotion Information dissemination (Policy of communication)
Financial	Promote cost-efficiency source additional funds (Special projects/prosecution proceeds)
PRACTICAL	
Inadequate Enforcement	Improve cooperation (São Tome and Viarsa)
“Too Little Too Late”	Fallacy (Perceived delays of consensus) Current achievements (CDS/Precautionary/Ecosystem Management)

As Table 8 shows, a common theme running through the threats that CCAMLR faces is the political uncertainty and shifting priorities of a world characterized by changes and shifts in the balance of power, both economic and social. Taking such uncertainty into account, we suggest that its impacts on CCAMLR’s operational integrity may be ameliorated through improving cooperation and enhanced education on CCAMLR matters. Similarly, care needs to be given to nurturing CCAMLR’s successes and promoting its operational efficiency. This will allow CCAMLR to set an example for other regional and sub-regional fisheries organizations to follow (Rayfuse 1998).

The CAMLR Convention has been described as “a model of the ecological approach (Freestone 1996). On this basis CCAMLR has notably performed in both promoting and advancing such an approach. Time and history will reveal how successful it has ultimately been.

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Deep-sea fisheries management: the approach taken by the European Union

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1. INTRODUCTION

The European Union (EU) consists of 15 member states: Italy, France, the Netherlands, Belgium, Luxembourg, Germany, United Kingdom, Denmark, Ireland, Greece, Spain, Portugal, Sweden, Finland and Austria. In 2004, this number will grow as seven more countries join. In order to understand the European Union's approach to fisheries management, it is necessary to highlight the three main political institutions.

- i. **The European Commission** consists of commissioners appointed by member states governments, subject to the approval of the European Parliament. The Commission is the only institution that can propose EU legislation. It is also responsible for implementation and enforcement of EU legislation and it represents the EU at international organisations in areas defined by the European Treaties. The Commission has a permanent civil service of about 18 000 officials.
- ii. **The Council of the European Union** is the main decision making body. It represents member states and its composition is variable according to the subject being treated. Normally, one minister from each member state deals with sectoral issues such as fisheries. The Council deals directly with issues such as setting annual total allowable catches.
- iii. **The European Parliament** is composed of members directly elected by the electorates of the member states. It has the power, along with the Council to pass legislation and control the EU budget. The Parliament has a role in supervising the Commission.

The EU has a Common Fisheries Policy (CFP) that applies to all member states. There are four areas in the CFP, summarized as follows:

- i. **Conservation** – management of fisheries, control and enforcement of regulations
- ii. **Structures** – aids to the fishing and aquaculture
- iii. **Markets** – common organisation of markets and
- iv. **Relations with third countries** – fisheries agreements at international level with countries outside the EU (third countries) within regional and international fisheries organisations.

Management of deepwater fisheries before 2002, was ineffective. European deepwater fisheries developed from the 1970s onwards. Two pieces of legislation, *Council Regulations 685/95* and *2027/95* imposed upper levels on the effort that could be expended on four deepwater species, roundnose grenadier (*Coryphaenoides rupestris*),

black scabbardfish (*Aphanopus carbo*), orange roughy (*Hoplostethus atlanticus*) and Portuguese dogfish (*Centroscyrnus coelolepis*). However, this legislation was mainly aimed at the regulation of fishing for shelf-dwelling species and was not an effective measure for deepwater fisheries. In addition, the European Union imposed minimum landing sizes for ling (*Molva molva*) (63 cm) and blue ling (*Molva dypterygia*) (70 cm) as part of *Council Regulation 850/98*, the legislation dealing with technical conservation measures (TCMs) for EU fisheries.

Annual negotiations with regard to relations with third countries (i.e. outside the EU) are undertaken to deal with the management of straddling stocks. Under such negotiations, quotas for deepwater fish are allocated to Norway and the Faroe Islands, while affording in exchange fishing opportunities to EU vessels to fish in the waters of these states. In the northeast Atlantic, the body that coordinates regulatory measures for fisheries in international waters is NEAFC, the Northeast Atlantic Fisheries Commission. The EU is a contracting party to NEAFC, along with Russia, Norway, Denmark (representing the Faroe Islands and Greenland), Iceland, Poland and Estonia. Some management issues relating to deepwater fisheries have been discussed at NEAFC in recent years.

At present, the EU management regime covers the fisheries in the northeast Atlantic. In the Mediterranean, fisheries management within the CFP is less developed and there is no special management system for deepwater fisheries. This paper presents the EU deepwater fisheries management regime in the northeast Atlantic and points to future directions in the management of international waters fisheries.

2. THE FISHERIES

2.1 Fisheries in the ICES area

The International Council for Exploration of the Sea (ICES) defines deepwater fisheries as those in waters deeper than 400–500 m. This definition does not distinguish what are commonly known as deep-sea fish from more traditionally targeted shelf species. For example, demersal species such as monk and megrim are often caught in depths below 400 m and could be included. Conversely, ling is found on the continental shelf and in inshore waters, but the main international fisheries are in deep waters. Blue whiting, a species normally fished in depths of around 400 m, is not usually considered as a deepwater species.

Deepwater fisheries have developed rapidly in recent years. This rapid expansion has been in response to the decline (or indeed collapse) of some traditional stocks. Some of these deepwater fisheries are long established, for example the Norwegian longline fishery for ling and tusk (*Brosme brosme*) (Connolly, Kelly and Clark 1999) while others are by now well established, for example the pelagic trawl fisheries for blue whiting (*Micromesistius poutassou*) and greater argentine (*Argentina silus*) (Gordon 2001). Others have developed in the last 10 years, such as the French mixed-species trawl fishery (Charuau, Du Pouy and Lorange 1995) and the Spanish deepwater longline fisheries for sharks, forkbeard (*Phycis blennoides*) and mora (*Mora moro*) (Pineiro, Casas and Banon 2001). In most recent years further expansions of fishing to grounds such as Hatton Bank for Greenland halibut (*Reinhardtius hippoglossoides*), blue ling (*Molva dypterygia*) and sharks (Langedal and Hareide 2000, Pineiro, Casas and Banon 2001) have taken place. In southern parts of the ICES area, deepwater fisheries are mainly artisanal in nature. In Portugal longline fisheries for black scabbardfish and sharks have been in operation since the 1980s and in the Azores there has been an artisanal fishery for kitefin shark since the 1970s (Gordon *et al.* 2003). Detailed reviews of deepwater fisheries in Atlantic European waters are presented by Gordon *et al.* (2003) and Large and Bergstad (2005).

2.2 Fisheries in other areas

There are extensive EU deepwater fisheries in other areas, both in European waters and elsewhere. A review of current knowledge of Mediterranean deepwater fisheries is presented in STECF (2001). The longest established deepwater fishery in the world is the Madeira (Portugal) artisanal fishery for black scabbardfish that has been in operation for several centuries (Merrett and Haedrich 1997). Elsewhere, there are fisheries for deepwater species off Mauritania (Fernandez, Salmeron and Ramos 2002). In the northwest Atlantic (NAFO area), vessels from the EU are involved in fisheries for Greenland halibut and redfish (*Sebastes* spp.), with a bycatch of other deepwater species. There are EU fisheries for Patagonian toothfish (*Dissostichus eleginoides*) in the Southern Ocean. Little information exists on new developing fisheries outside the northeast Atlantic; this paper deals with the northeast Atlantic fisheries, because it is these that are subject to the new management regime, introduced in 2003. The scope of this paper does not extend to management of Greenland halibut and redfish because these have been managed by TAC for many years and are generally caught in different fisheries.

3. SCIENTIFIC ADVICE AND THE PROCESS OF FRAMING MANAGEMENT MEASURES

In 2000, ICES produced a document discussing possible management options for deepwater fisheries. Advice for individual species was provided based on assessments carried out by ICES SGDEEP. ICES provided advice for reductions in effort for ling, tusk, black scabbard and roundnose grenadier. The ICES advice for other species was that fisheries should only be permitted when they “expand very slowly, and are accompanied by programmes to collect data for evaluation of stock status” (ICES 2001a).

In 2001, ICES ranked the deepwater species according to their vulnerability to exploitation, based on life-history characteristics. In addition two categories of species were defined, those that were “fully or overexploited” and those that were taken in “developing, new fisheries”. In 2001, ICES revised the precautionary reference points, based on fishing mortality F , spawning stock biomass (B) and total exploitable biomass (U). ICES also gave information on improvements that should be made in data collection (ICES 2001b). In 2001, the Scientific, Technical and Economic Committee for Fisheries of the European Commission (STECF) convened a subgroup to deal with management options for deepwater species in the Atlantic and Mediterranean. This group defined management areas and stated that effort control offered a better means of regulating these fisheries than catch control (STECF 2001).

In 2002, ICES (2002) advice was to reduce effort by specified percentages on ling, tusk, roundnose grenadier and black scabbard that were classified as overexploited in 2001. ICES advice for orange roughy and blue ling, in areas where they were considered to be overexploited, was that there be no directed fishing. For the remaining species, taken in “developing, new fisheries”, the ICES advice was similar to that provided in 2000, that “fishing should not be allowed to expand faster than the acquisition of information necessary to provide a basis for sustainable exploitation”. In the absence of updated assessments, the ICES advice was in general, a reiteration of previous advice.

In response to the scientific advice that many stocks were overexploited, the EU set about framing a management regime for deepwater fisheries. There were a number of consultations on the issue. There was an open hearing on the issue held by NEAFC in 1999 at which scientists and managers participated. In 2001, the European Commission hosted an open hearing for EU member states. Later in 2001, the European Commission announced its intention to propose a management regime.

The Commission highlighted a number of difficulties that it had in implementing the scientific advice directly identified with this advice:

- First, although ICES recommended some specific effort reductions, information was not available on the corresponding baseline effort from which effort should be reduced. Managers did not have available information adequate to regulate for any particular amount of fishing effort, deployed with any stated fishing gear, measured in any particular units, nor deployed in any particular area. The scientific advice was therefore not directly implementable without gathering a substantial amount of further information.
- Second, some sections of the fishing industry stated that there was an allocation problem. In the EU, fisheries resources are conventionally allocated using fixed percentages of overall TACs. Applying an effort-based management system did not provide the resource allocation model that many parts of the sector were used to.
- Third, the scientific advice referred to some potentially sensitive areas requiring greater protection, such as seamounts for orange roughy and areas of spawning aggregations of blue ling. However, the scientific agencies were not able to provide precise locations where special conservation measures should be put in place.
- Last, the great spatial distribution of the fishery and its relatively low catch value did not justify, in the opinion of the Commission, extensive survey-based resource monitoring nor widespread vessel- or aircraft-based control and inspection systems.

Because of these issues, the Commission proposed a two-stage strategy to develop a management system. TACs were to be introduced in order to establish a resource allocation model and to assist conservation in the short term. Then a programme of actions aimed at developing a management system better tailored to the characteristics of deepwater fisheries was to be introduced. This would be developed in consultation with scientific experts, but the following elements were identified at the outset.

- A limit on fleet capacity to recent levels in order to halt the expansion of a deep-sea fleet and diversion of effort from shelf species to deep-sea species while more detailed information was being collected.
- Improved monitoring, so that vessels would be prohibited from transshipping and be permitted only to disembark deep-sea species at a number of designated ports.
- Improved scientific data collection, implemented by a scientific work programme based on log-book reports and observer information. Due to the high cost of surveying extensive areas, the best use should be made of information gathered during commercial fishing activities.

The Commission explained that these obligations would be attached as conditions to a specific type of fishing vessel licence. The overall fleet capacity to which licences could be granted would be limited. Only vessels holding such licences would be allowed to land significant quantities of deep-sea species. Based on the information gained, it would then be possible to develop more effective conservation measures based on effort limitation. Vulnerable areas would then be candidates for local closures or possibly effort limitations. Vessel monitoring systems (VMS) were envisaged as the principal monitoring tool.

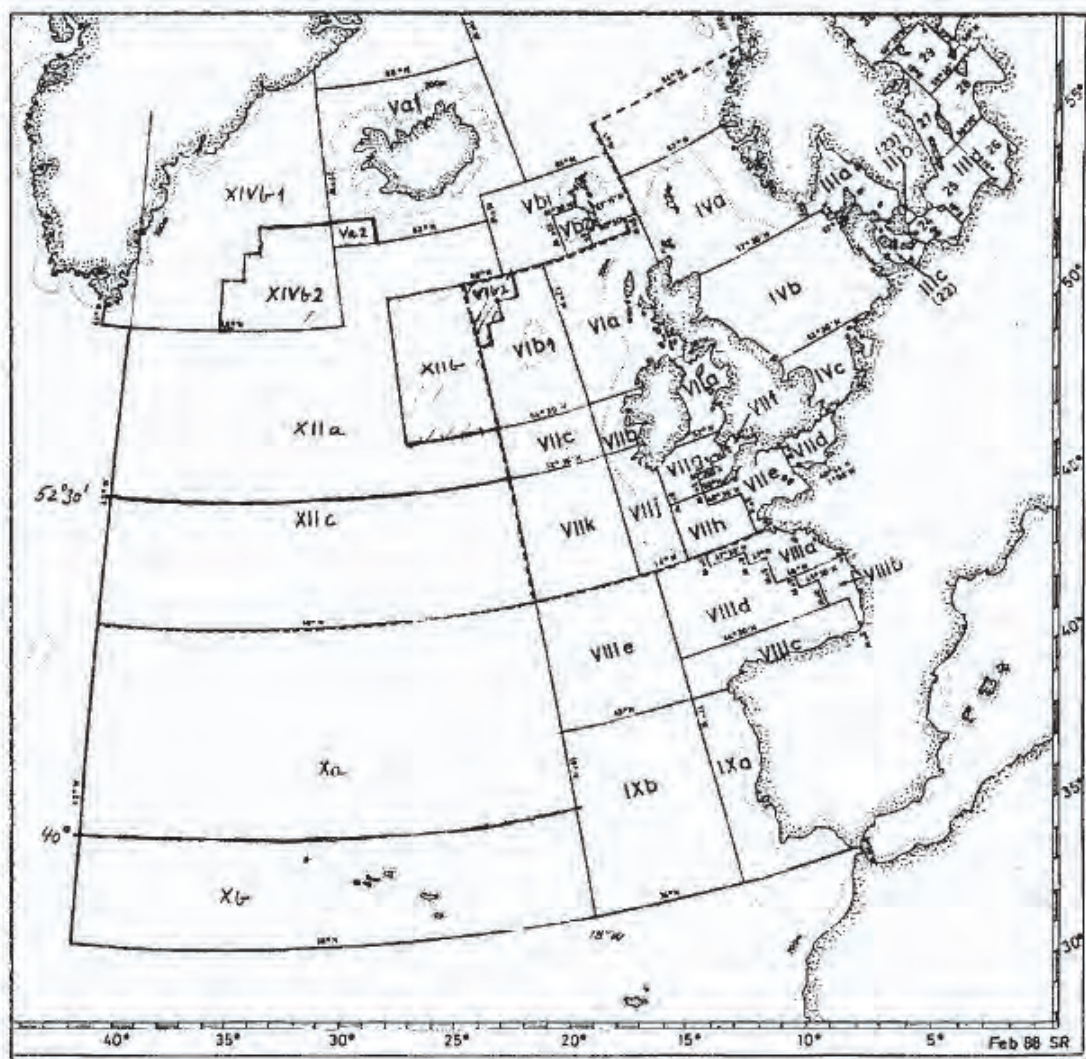
4. MANAGEMENT MEASURES

Extensive consultations took place before the legislation was finally adopted in 2002. Two new pieces of legislation apply to European deepwater fisheries. *Council Regulation 2340/2002* sets TACs and quotas for member states' vessels for a number of deepwater species in certain areas. These catch restrictions are binding in EU waters and waters not under the jurisdiction or sovereignty of third countries. The species and ICES areas (Figure 1) covered are:

• Black scabbard	<i>Aphanopus carbo</i>	I, II, III, IV, V, VI, VII, IX, X, XII
• Argentine	<i>Argentina silus</i>	III, IV, V, VI, VII
• Tusk	<i>Brosme brosme</i>	I, II, III, IV, V, VI, VII, XIV
• Roundnose grenadier	<i>Coryphaenoides rupestris</i>	I, II, III, IV, Va, Vb, VI, VII
• Orange roughy	<i>Hoplostethus atlanticus</i>	VI, VII
• Blue ling	<i>Molva dypterygia</i>	II, III, IV, V, VI, VII
• Ling	<i>Molva molva</i>	I, II, III, IV, V, VI, VII, VIII, IX, X, XII, XIV
• Red seabream	<i>Pagellus bogaraveo</i>	VI, VII, VIII, IX, X

FIGURE 1

ICES Subareas and Divisions, including the new Divisions and Subdivisions created in 2003 to deal with deepwater fisheries related issues



This legislation provides for the allocation of fishing opportunities to member states, by way of quota shares of the TAC for the above species. Details of these TACs for EU vessels, along with the allocations by member states are given in Table 1. However, the TACs do not cover all deepwater species in the ICES area. These TACs are binding in EU waters and on EU vessels in international waters.

The second piece of legislation, *Council Regulation 2347/2002*, establishes a capacity and effort control system for deepwater fisheries. The definition of what constitutes a deepwater species is based on a list of “true” deepwater species: as far as possible those species that are found exclusively in deep water (see Table 2). Most relevant species are covered by this regulation but ling is excluded because it is extensively caught in shallow water fisheries too. A special deepwater permit allows access to catches and to land certain deepwater species. Any vessel landing more than 10 t of these species in a calendar year must carry a licence. Vessels landing less than 100 kg per trip and less than 10 t a year of the deep-sea species are exempt from having a deepwater permit.

FIGURE 2
ICES areas and Exclusive Economic Zones of coastal states in the northeast Atlantic

TABLE 1

TAC's and quota allocations, by member state, for deepwater fish as established under the new EU deepwater fisheries management legislation (Council Regulation 2340/02)

	TAC	BEL	DEN	FRA	GER	IRE	NETH	POR	SPA	SWE	UK	Others
BLACK SCABBARD FISH												
I, II, III, IV ⁽¹⁾	30			10	10						10	
V, VI, VII, XII ⁽¹⁾	3110			2,600	37	93			185		185	10 ⁽²⁾
IX, X ⁽¹⁾	4000							4,000				
GREATER SILVER SMELT												
III, IV ⁽¹⁾	1566		1,388	10	14	10	65			54	25	
V, VI, VII ⁽¹⁾	6247			10	476	441	4,971				349	
TUSK												
I, II, XIV ⁽¹⁾	35			10	10						10	
III ⁽¹⁾	40		20		10					10		
IV ⁽¹⁾	370		100	70	30					10.00	150	10 ⁽²⁾
V, VI, VII ⁽¹⁾	710			415	10	40			35		200	10 ⁽²⁾
ROUNDNOSE GRENADIER												
I, II, IV, Va ⁽¹⁾	20		2	14	2						2	
III ⁽¹⁾	1870		1,769		10					91		
V, VI, VII ⁽¹⁾	5106			4,396	10	346			86		258	10 ⁽²⁾
ORANGE ROUGHY												
VI ⁽¹⁾	88			58		10			10		10	
VII ⁽¹⁾	1349			1,019		300			10		10	10 ⁽²⁾
BLUE LING												
II, IV, V ⁽¹⁾	138		10	61	10	10					37	10 ⁽²⁾
III ⁽¹⁾	25		10		5					10		
VI, VII ⁽¹⁾	3678			2,788	39	10			122		709	10 ⁽²⁾
LING												
I, II ⁽¹⁾	45		10	10	10						10	5 ⁽²⁾
III ⁽¹⁾	136	10	76		10					30	10	
IV ⁽¹⁾	4666	30	467	260	289		10			20	3590	
V ⁽¹⁾	54	14	10	10	10						10	
⁽¹⁾	14966	56	10	4,397	204	1,102		10	4,124		5063	
RED SEABREAM												
VI, VII, VIII ⁽¹⁾	350			14		10			281		35	10 ⁽²⁾
IX ⁽¹⁾	1271							271	1,000			
X ⁽¹⁾	1136							1,116	10		10	
Total	51,006	110	3,872	16,152	1,196	2,372	5,046	5,397	5,863	225	10,683	85

⁽¹⁾ Community waters and waters not under the sovereignty or jurisdiction of third countries

⁽²⁾ May be taken in NAFO Divisions IF and 3K but shall be counted against the quota for V, XII, XIV within a total quota of 25 000 tonnes.

⁽³⁾ Community waters and areas beyond fisheries jurisdiction of other coastal States.

TABLE 2

List of defined deepwater species and additional species for which data must be collected under deepwater fisheries management legislation (Council Regulation 2347/2002)

List of species as defined in regulation		Additional species	
<i>Aphanopus carbo</i>	black scabbardfish	<i>Pagellus bogaraveo</i>	red seabream
<i>Apristurus</i> spp.	Iceland catshark	<i>Chimaera monstrosa</i>	Rabbitfish
<i>Argentina silus</i>	greater argentine	<i>Macrourus berglax</i>	roughhead grenadier
<i>Beryx</i> spp.	Alfinsino	<i>Mora moro</i>	Mora
<i>Centrophorus granulosus</i>	gulper shark	<i>Antimora rostrata</i>	Antimora
<i>Centrophorus squamosus</i>	leafscale gulper shark	<i>Epigonus telescopus</i>	Cardinalfish
<i>Centrosyllium fabricii</i>	black dogfish	<i>Helicolenus dactylopterus</i>	Bluemouth
<i>Centroscyrnus coelolepis</i>	Portuguese dogfish	<i>Conger conger</i>	conger eel
<i>Coryphaenoides rupestris</i>	roundnose grenadier	<i>Lepidopus caudatus</i>	Silver scabbardfish
<i>Dalatias licha</i>	kitefin shark	<i>Alepocephalus bairdii</i>	Baird's smoothhead
<i>Deania calceus</i>	birdbeak dogfish	<i>Lycodes esmarkii</i>	Esmark's eelpout
<i>Etmopterus spinax</i>	velvet belly	<i>Raja hyperborea</i>	Arctic skate
<i>Galeus melastomus</i>	blackmouth catshark	<i>Sebastes viviparus</i>	small redfish
<i>Galeus murinus</i>	mouse catshark	<i>Hoplostethus mediterraneus</i>	Mediterranean roughy
<i>Hoplostethus atlanticus</i>	orange roughy	<i>Trachyscorpia cristulata</i>	spiny scorpionfish
<i>Molva dypterygia</i>	blue ling	<i>Raja nidarosiensis</i>	Norwegian skate
<i>Phycis blennoides</i>	greater forkbeard	<i>Geryon affinis</i>	deepwater red crab
<i>Centroscyrnus crepidater</i>	longnose velvet dogfish	<i>Raja fyllae</i>	round skate
<i>Scymnidon ringens</i>	knifetooth shark	<i>Hydrolagus mirabilis</i>	large eye rabbitfish
<i>Hexanchus griseus</i>	sixgill shark	<i>Rhinochimaera atlantica</i>	straightnose rabbitfish
<i>Chlamydoselachus anguineus</i>	frilled shark	<i>Alepocephalus rostratus</i>	Risso's smoothhead
<i>Oxynotus paradoxus</i>	sailfin roughshark	<i>Polyprion americanus</i>	Wreckfish
<i>Somniosus microcephalus</i>	Greenland shark		

The capacity of this deepwater fleet (i.e. vessels holding deep-sea licences) is restricted to the highest aggregate engine power and gross tonnage of vessels that had caught more than 10 t of fish on the deep-sea vessel list in any one of the years 1998 1999 or 2000. In addition, there is a requirement for member states to nominate designated ports, outside of which deepwater species may not be landed. There is also provision for the use of VMS. The regulation also requires that member states deploy observers to ensure that scientific data are collected. Borges *et al.* (2005) describe one approach to implementing this aspect of the regulation.

In addition to these regulations there is further legislation dealing with deepwater fisheries management. Under bilateral agreements quotas are decided for EU vessels in Norwegian and Faroese waters, and also for Norwegian and Faroese vessels in EU waters. The Council of the European Union sets out these allocations in the annual fisheries management legislation agreed each year after negotiations within the EU, between the "Coastal States" (Norway and the Faroe Islands) and the EU and also within NEAFC. The current quotas are set out in *Council Regulation 2341/02* (Table 3).

TABLE 3

Quotas for deepwater species as agreed by the “Coastal States” agreements, as set out in *Council Regulation 2341/02*

Species	Areas	Total	FRA	GER	UK	NOR	FAR IS	Notes
1 Ling, blue ling	Vb (Faroeese waters)	3,240	950	2,106	184			See 2
2 Roundnose grenadier, black scabbardfish	Vb (Faroeese waters)	1,080						Maximum allowed bycatch in 1 above
3 Deepwater sharks*	IV, VI, VII (EU waters)	NA				200		Longline only
4 Blue ling, roundnose grenadier, black scabbardfish	VIa north (EU waters), VIb	NA					940	Trawl only
5 Ling	IIa, IV, Vb, VI, VII (EU waters)	NA				9,500		Interchangeable between ling and tuskup to 2,000, longline only. Provides for a bycatch of other species up to 3,000 t
6 Tusk	IIa, IV, Vb, VI, VII (EU waters)	NA				5,000		
7 Ling, blue ling, tusk	VIa N, VIb (EU waters)	NA					800	Longline only. Provides for a bycatch of other species up to 75 t.
8 Greater argentine	V, VIa N, VII (west of 12° W) (EU waters)	NA				500		Permitted bycatch in blue whiting fishery
9 Greater argentine	V, VIa N, VII (west of 12° W) (EU waters)	NA					see note	Unavoidable catches permitted against blue whiting quota (45,000 t)
Total		3,240	950	2,106	184	15,200	1,740 ^(see9)	

* grey shark (sic)
black shark
birdbeak dogfish
leafscale gulper shark
greater lanternshark
smooth lanternshark (sic)
Portuguese dogfish
spurdog (catches also permitted in EU waters of IIa, IV and Vb)

The capacity of this deepwater fleet (i.e. vessels holding deep-sea licences) is restricted to the highest aggregate engine power and gross tonnage of vessels that had caught more than 10 t of fish on the deep-sea vessel list in any one of the years 1998 1999 or 2000. In addition, there is a requirement for member states to nominate designated ports, outside of which deepwater species may not be landed. There is also provision for the use of VMS. The regulation also requires that member states deploy observers to ensure that scientific data are collected. Borges *et al.* (2005) describe one approach to implementing this aspect of the regulation.

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5. FUTURE DIRECTIONS

In 2002 and 2003, a series of meetings were held to discuss possible management measures for these species in the NEAFC regulatory area, i.e. the area beyond EEZ waters in the North Atlantic. The EU made a proposal in the NEAFC to put in place a similar management régime to that described above for all the waters covered by NEAFC. This has been under discussion in NEAFC. So far, it has been agreed in NEAFC to recommend a temporary freeze on the effort that can be expended in fishing for deepwater species in international waters of the ICES area in 2002 and 2003 (the NEAFC Regulatory Area), as defined in Table 4. Effort must not exceed the highest level in previous years for each contracting party. Fishing effort was variously defined by contracting parties as aggregate power, aggregate tonnage, fishing days at sea or number of vessels that fished for these species.

TABLE 4
List of species to be considered for management in the NEAFC regulatory area

Scientific name	Common name
<i>Aphanopus carbo</i>	Black scabbardfish
<i>Apristuris</i> spp.	Iceland catshark
<i>Argentina silus</i>	Greater silver smelt
<i>Beryx</i> spp.	Alfonsinos
<i>Brosme brosme</i>	Tusk
<i>Centrophorus granulosus</i>	Gulper shark
<i>Centrophorus squamosus</i>	Leafscale gulper shark
<i>Centroscyllium fabricii</i>	Black dogfish
<i>Centroscymnus coelolepis</i>	Portuguese dogfish
<i>Coryphaenoides rupestris</i>	Roundnose grenadier
<i>Dalatias licha</i>	Kitefin shark
<i>Deania calceus</i>	Birdbeak dogfish
<i>Etmopterus princeps</i>	Greater lanternshark
<i>Etmopterus spinax</i>	Velvet belly
<i>Galeus melastomus</i>	Blackmouth dogfish
<i>Galeus murinus</i>	Mouse catshark
<i>Hoplostethus atlanticus</i>	Orange roughy
<i>Molva dypterygia</i>	Blue ling

<i>Molva molva</i>	Ling
<i>Pagellus bogaraveo</i>	Red Seabream
<i>Phycis</i> spp.	Forkbeards
<i>Reinhardtius hippoglossoides</i>	Greenland halibut

There is a need for an agreed definition of deep-sea fishing activity to be restricted, an agreed measure of effort and standard baseline for the effort freeze. Further work to develop this policy is planned for 2004.

In 2003, NEAFC began the process of collating the effort data required to calibrate a management regime in international waters. This process was difficult due in part to the lack of agreed data definitions and structures. The issues were discussed at an Extraordinary Meeting of the NEAFC in May 2003. Among the proposals for the management of the regime that the EU put forward was the deployment of scientific observers to collect biological and fisheries data in support of scientific stock assessments. The EU also proposed a standard format for the exchange of data concerning catch and effort directed at deep-sea fishing. However the Contracting Parties have not yet been able to reach an agreement on such a format.

The process of agreeing to management measures for EEZs and international waters will be a challenge for deepwater fisheries managers in the near future. It is still too early to evaluate whether the management regime that has been applied within the EU is successful.

In 2003, ICES has stated that most deepwater fish stocks were already severely depleted by 1998, and ICES suggested the use of the effort data for this year as a reference level for reductions for such stocks (ICES, in prep.). Given the urgency of the situation, it will be necessary to achieve a harmonized management system for deepwater fisheries in the northeast Atlantic as quickly as possible.

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Schrödinger's TAC – superposition of alternative catch limits from 2003 to 2006 under the South Tasman Rise orange roughy arrangement between Australia and New Zealand

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1. INTRODUCTION

Quantum mechanics normally has little to do with either the science, the management or the law of fisheries, although measurement of the size of a stock by fishing could be seen as a partial application on the macroscopic scale of Heisenberg's Uncertainty Principle, in which measurement is impossible because the very act of observation changes the quantity being observed. The decision on the future total allowable catch (TAC) for the South Tasman Rise orange roughy fishery made by Australia and New Zealand in 2003 does however call to mind Schrödinger's famous thought experiment illustrating the probabilistic nature of the subject. A cat is sealed in a box with a radioactive substance whose decay may or may not kill it. As long as the box remains sealed, the cat is said to be simultaneously in two superposed states of being alive and dead, until its state is "resolved" to one or the other by opening the box to see whether it has survived.

It is just such a superposition that has been achieved by the 2003 TAC decision (Appendix I), serving simultaneously the ends of conservation and rational exploitation of the South Tasman Rise orange roughy stock by in effect having two alternative catch limit pathways, one leading downwards to a TAC of 200 t, sufficient only for a bycatch or at most a one-trip fishery, and the other maintaining catch limits at up to 1 300 t should the stock in fact still be in a relatively healthy state. The embedded decision rules, taking as their input empirical evidence in the form of success or failure of fishing operations early in the season, gradually resolve the superposition in favour of one of the possible TAC "states". Before explaining how this came about, however, a brief recapitulation of the history of the regulation of this fishery is in order.

* The standard disclaimer is made. The author records here in addition his gratitude to Erik Jaap Molenaar and Richard Tilzey for helpful comments on earlier drafts; any remaining errors of fact, law or judgement, however, are solely his own.

2. THE POSITION BEFORE THE DECISION

It is not necessary to go far into the history of the South Tasman Rise orange roughy fishery and its regulation, because the Australia–New Zealand 2000 Arrangement for this fisheries regulation¹, together with matters surrounding its management, have been expertly analysed by Molenaar (2001).

The South Tasman Rise is a large, submerged plateau forming part of Australia's continental shelf – the significance of which will become clear below – rising to less than 1 000 m from the surface. It lies partly within and partly beyond the outer limit of the Australian Fishing Zone (AFZ)². Its general shape can be inferred from the bathymetric contours in Figure 1.

In September 1997, significant aggregations of orange roughy were discovered on this feature and a fishery rapidly developed, with Australian vessels landing over 1 500 t by the end of the year. As the bulk of these fish were taken outside the AFZ, the fishery also attracted vessels from the New Zealand deepwater trawl fleet. During 1997, the two fleets made a total catch of over 2 000 t. Mindful of the earlier rapid depletion of the nearby Lord Howe Rise orange roughy stock, the two countries negotiated a formal Arrangement³ to take effect from 1 March 1998 to establish what was thought to be a precautionary TAC of 2 100 t for orange roughy within a defined area of high seas encompassing the known fishery, based and apportioned on the verified 1997 catch of the two countries (1 669 t Australia, 431 t New Zealand). The defined area adjoins the AFZ lying south of Tasmania between 146 ° 30 'E and 150 °E and is bounded to the south by the parallel of latitude 48 ° 30 'S, as illustrated in Figure 1 above.

For a number of reasons that essentially boil down to the usual problems of allocation and which therefore need not detain us further⁴, it proved more difficult than expected to reach accord on a TAC and national shares for 1999, but the two Governments reached an informal understanding so as to allow their fleets to resume fishing from 1 March 1999. Officials subsequently settled on an increased TAC of 2 400 t, shared 75 percent (1 800 t) to Australia and 25 percent (600 t) to New Zealand,

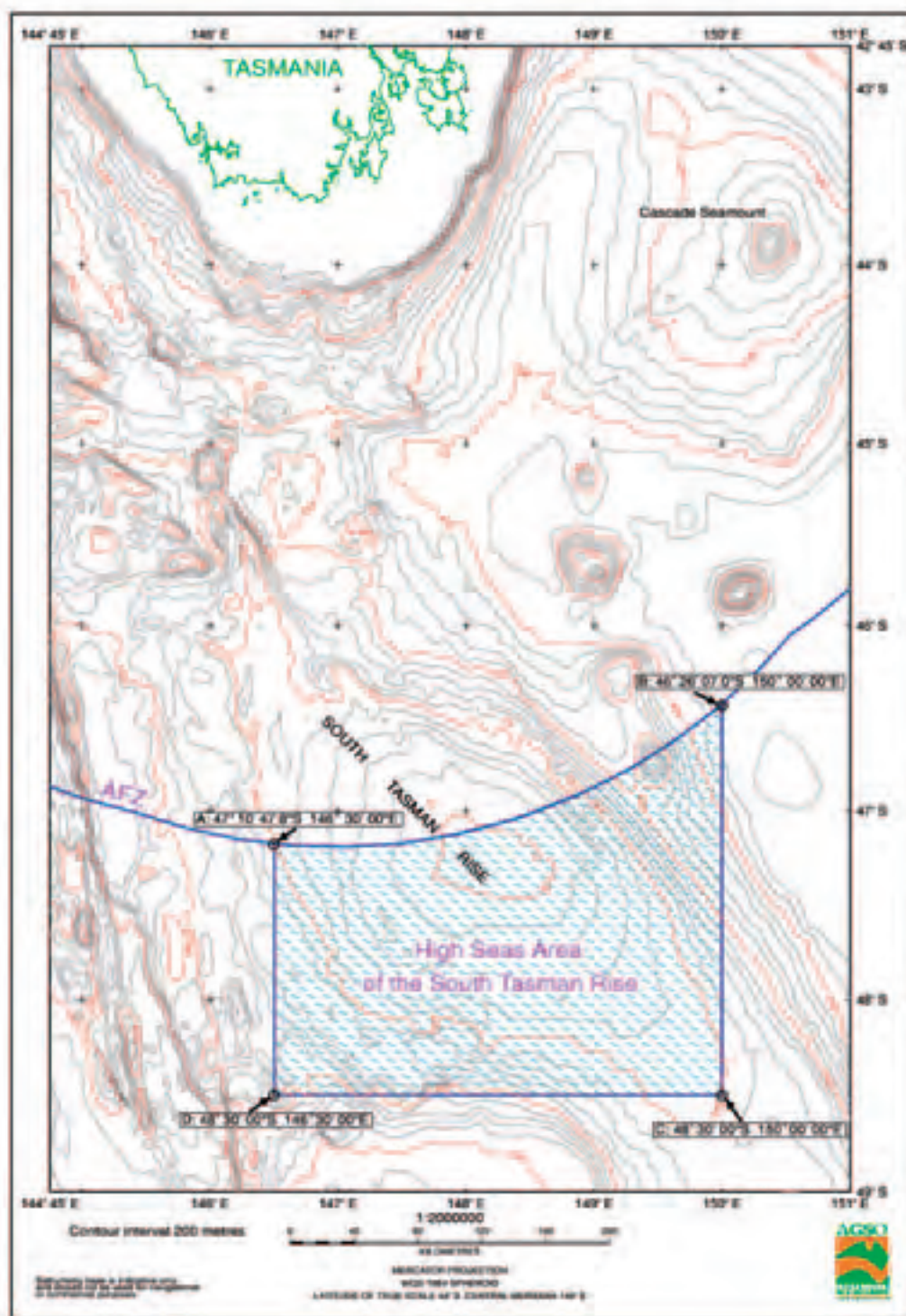
¹ Confusingly bearing the same title as its 1998 predecessor cited in Note 3, this Arrangement is reproduced as an appendix in Molenaar 2001.

² Although they are not completely identical, for present purposes the term “Australian Fishing Zone” may be used interchangeably with the Australian Exclusive Economic Zone (EEZ); for the precise definition see s.4(1) of the *Fisheries Management Act 1991* (Cth).

³ Arrangement between the Government of Australia and the Government of New Zealand for the Conservation and Management of Orange Roughy on the South Tasman Rise, obtainable from the website of the Australian Department of Foreign Affairs and Trade: <www.dfat.gov.au/geo/new_zealand/roughy.pdf>.

⁴ See the slightly conflicting accounts from each side of the Tasman in two papers presented at the Norway-FAO Expert Consultation on the Management of Shared Fish Stocks (Staples 2002; Willing 2002). Some of the views attributed to Australia in the latter, however, appear to mistake the Australian industry's wishes for Government policy. In particular, Australia did not claim “exclusive rights to catch and manage the orange roughy fishery on the high-seas area of the South Tasman Rise” (Willing 2002, page. 3). Rather, Australia pointed out that, in line with its (since vindicated) view that the stock did straddle its EEZ boundary, by Article 116(b) of the United Nations Convention on the Law of the Sea fishing of the stock in the adjacent high-seas area is subject to the rights, duties and interests of Australia as the coastal State, as provided in Article 63(2). The primary obligation of States concerned under the latter provision is to seek to agree on measures necessary for the conservation of the straddling stock. Should such agreement not be possible despite their best efforts, it may be surmised that Australia – or indeed any coastal State – would find attractive the view of Professor Burke that the coastal State may proceed to regulate the entire fishery, though not enforce its laws beyond 200 miles (Burke 1984). Now that the UN Fish Stocks Agreement is in force, however, there is room for argument over whether, as among its parties, this would be supplanted by the compulsory availability of provisional measures through the dispute settlement procedures in Article 7(5). It is in this sense that the passage “Australia claims the right...to manage the orange roughy fishery as a straddling stock” (Staples 2002, p. 4; note that the claim is not described as “exclusive”) should be understood. Note also that Willing's Figure 2, distinguishing diagrammatically among straddling stocks depending on whether their biomass is mostly inside the EEZ, mostly outside the EEZ or approximately evenly distributed across the boundary, has no basis in law: all are equally captured by Article 63(2). This

FIGURE 1
The South Tasman Rise, showing bathymetric contours and the defined High Seas Area



but before it could be reduced to writing for the two countries' Fisheries Ministers to approve, the New Zealand fleet's catch grew to more than 1 600 t for lack of legal capacity to limit the catch until the instrument was concluded⁵.

As an interim measure the two Ministers, by an exchange of letters, closed the fishery for the remainder of the season, though Australian operators, who had retained a small portion (60 t) of their allocation to allow for orange roughy bycatch when targeting oreos, were permitted to target oreos until the orange roughy quota was filled.

In 2000 Australia and New Zealand entered into a new Arrangement (the 2000 Arrangement) for the 2000–2001 fishing year and beyond – which has continued in effect to the present day – with the TAC again being set at 2 400 t and apportioned 75 percent to Australia and 25 percent to New Zealand⁶. For the first six years, however, New Zealand also agreed to repay 640 t of its notional overcatch by reducing its actual catch limits over seven years – 100 t a year for six years and 40 t in the seventh year⁷.

Despite considerable searching and fishing effort on the South Tasman Rise during the 2000 season, only 830 t (790 t Australia, 40 t New Zealand) of orange roughy were landed. Subsequent catches have been even lower (Caton (Ed.) 2003): 188 t in 2001,

is not to say that the distinction lacks practical significance; in the extreme case, if the coastal State does not actually fish the stock within its EEZ, because its vessels find the catch rates on the high seas better, and has no, or insufficiently specific, measures in place to benefit from the non-undermining rule of UN Fish Stocks Agreement Article 7(2), this could render hollow the legal advantage of Article 116(b).

⁵ States' differing domestic legislative capacities to regulate unilaterally their own fishing on the high seas can produce an anti-precautionary effect on bargaining power. The position at the time was that Australia did, but New Zealand did not, have power at domestic law to regulate the fishing activities of its nationals on the high seas in the absence of an agreement or understanding with another country: *Fisheries Management Act 1991* (Cth), s.8; *Fisheries Act 1996* (NZ), s.297(1)(o) – see now however s.297(3) of the latter, as amended by the *Fisheries Act 1996 Amendment Act No 2 1999* (NZ). Thus, Australia was able to hold its catch to its 1800-tonne quota in 1999 even in the absence of a renewal of the 1998 Arrangement, while the New Zealand authorities could do nothing to prevent the overcatch despite strong entreaties to the industry at Ministerial level. Had New Zealand sought to exploit this imbalance, it would have put Australia in the difficult position of having to seriously contemplate taking an anti-precautionary step of its own in order to restore the bargaining equilibrium. Where two countries are less closely attuned in terms of culture and fisheries management philosophy, it is easy to see how this can lead to undesirable outcomes.

⁶ Paragraph. 3 of the 2000 Arrangement.

⁷ Although this represents little more than half of the notional New Zealand overcatch had the negotiated limit been in effect, it is more than a year's worth of quota. As far as the author is aware, this proportion is unsurpassed in international fisheries practice by way of settlement of a disagreement about overfishing. The repayment entailed displacement of the default rule in Paragraph. 7 of the 2000 Arrangement, which sets up a system resembling the board game Monopoly. The stock itself acts as the bank, from which Australia and New Zealand collect their respective equivalents of \$200 (Australia 75 percent of the TAC, New Zealand 25 percent) every time they "pass Go" (1 March), with their actual catch limit for the season adjusted to reflect overcatch or undercatch in the previous season unless the Parties jointly decide otherwise: see Paragraphs 7 and 8. They did so decide in the case of the 640 t, recording it in a further exchange of letters. The stringent standard set by Australia and New Zealand in Paragraph 7, whereby a party's "annual catch limit" takes account of any overcatch in the previous season by debiting against its quota one tonne for each of the first hundred tonnes of excess catch, and two tonnes for each tonne of excess catch thereafter, is decidedly more demanding than, say, the practice that has developed in the International Commission for the Conservation of Atlantic Tunas (ICCAT), starting with the "Recommendations (made in 1991) for Enhancement of the Current Management for Western Atlantic Bluefin Tuna" (Annex 7 to Proceedings of the Twelfth Regular Meeting of the Commission, Madrid, November 11–15 1991), where overcatch is repaid not in the following year but the subsequent one, initially with no penalty rate and subsequently for some stocks with a 25 percent penalty: "if the catch of [a relevant State] exceeds its annual or biannual scientific monitoring quota, then in the biannual period or year *following reporting of that catch* to [the Commission], that [State] will reduce its catch to compensate in total for that overage" (ICCAT 1992, page 67; emphasis added); for the 25 percent penalty, which is not automatic and applies only if quota is exceeded during two consecutive management periods, see the "Recommendation by

though fishing effort (expressed in terms of number of tows) was down by roughly the same proportion, and 103 t in 2002⁸. While environmental factors cannot be excluded as a cause, the precautionary approach to fisheries set out in Annex II to the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (hereinafter the UN Fish Stocks Agreement)⁹ dictates that it should be presumed to reflect a decline in resource size. The low catches in recent years suggest that even though the two Governments thought they were being precautionary when they set their TAC at 2 400 t, the maximum sustainable yield (MSY) may well be appreciably smaller than that, and the remaining catch available for the fishdown phase¹⁰ may also be quite limited. The TAC was therefore reduced to 1 800 t in 2002. In addition, consequent on New Zealand's acceptance that there was in fact one stock straddling the AFZ boundary, Australia's domestic management zone for the fishery was extended to include the area of the South Tasman Rise lying within the AFZ.

3. SUBSEQUENT REDUCTIONS IN QUOTA

The further fall in catch in 2002 prompted the Governments to reduce the TAC again more sharply in 2003. The Australian industry had funded surveys of orange roughy aggregations during the winter-spawning seasons in 2000 and 2001. Scientific advice obtained by the industry suggested that the data could be interpreted as showing that the stock retained a fish-down capacity for some years at 900 t *per annum*, with MSY around 300 t. There is a belief in some sections of the industry that the movements of the stock are not necessarily governed by a yearly cycle; the large aggregations found in 1997–1999 could, on this view, be expected to return at some point in a few years, none the worse for the fishing that had already taken place. While this hypothesis is considered in most quarters to be improbable, there is potential for wastage of the resource should it actually be correct¹¹, and the two Governments thought it reasonable to make some provision for that contingency, as described below.

Ministers agreed in 2002 that the current annual management cycle should be reviewed with the aim of establishing a three-year cycle. Their 2003 decision implementing such a cycle is formally an adjustment of the TAC in accordance with

ICCAT Regarding Compliance in the Bluefin Tuna and North Atlantic Swordfish Fisheries" (Annex 5-14 to Tenth Special Meeting of the Commission, San Sebastian, November 22-29, November 1996) (ICCAT 1997, page. 95). Paragraph 8 in effect provides that if the overcatch formula yields a negative annual catch limit, the party concerned must refrain from fishing for as long as necessary to work off its "debt" to the stock. This too bespeaks a more serious determination to prevent overcatch than any other fisheries instrument known to the author.

⁸ The entire catch was taken in both years by Australian vessels, the New Zealand fleet apparently deterred by the small quota remaining for them after factoring in the annual 100-tonne repayment to the stock.

⁹ 2167 United Nations Treaty Series 3.

¹⁰ The fishdown phase is described in the following terms on the Orange Roughy Management Company's website <www.orangeroughynz.com/stockstatus.html> (visited on 7 October 2003): "Once a new fishery has been located and assessed, catch limits are set at a level that will reduce the biomass size down to the B_{MSY} level [i.e. that yielding the MSY]. This involves reducing each stock down to around 30 percent to 44 percent of B_0 [virgin biomass] through the setting of catch levels that are above sustainable levels during the fishing down transition. Once the stock size is estimated to have reached B_{MSY} , the [catch limit] is set at a lower level to maintain catches at long-term sustainable levels." In theory the rate at which a stock is reduced from B_0 to a biomass approaching B_{MSY} should not affect the stock, though if the annual catch in this phase significantly exceeds the MSY, then the necessary subsequent reduction to a sustainable level may be politically difficult for managers to achieve, particularly if a level of fishing capacity for the fishdown phase has been permitted to emerge that represents overcapacity once this phase is over.

¹¹ The concept of waste has been called into question on the basis that the nutrient value of fish that die of old age is returned to the ecosystems as they decompose (Holt 1979, page. 81). It may be surmised that this recycling would be faster in shallower waters.

Paragraph 4 of the 2000 Arrangement, though such is its significance that it is all too easy to slip into the error of describing it as an “amendment”.

The contingent nature of the TAC under this adjustment operates in two ways – one within a season and the other between seasons. Viewed in one way, the decision starts with a TAC for 2003 of 800 t and maps out a path for reducing it in equal steps to 200 t in 2006. Viewed another way, the decision offers a means for keeping the TAC at 1 300 t for this and the next three seasons. There is also a fixed number of possible intermediate TAC outcomes.

In the first season there are only the two states of 800 t and 1 300 t – and the parallel with Schrödinger’s cat holds. It holds in future seasons too, even though the number of possible TAC levels grows to four in 2004, six in 2005 and seven in 2006. This is because, by the time each season starts, enough information will be known to reduce the number to two.

How is this done? The base case is that, starting from 800 t in 2003, the TAC falls in 2004 and each subsequent season by 200 t, until in 2006 it reaches 200 t. This reduction is however postponed for a year, if in the season just ended the trigger mechanism has been activated and the catch exceeds the original TAC by at least 100 t¹². It is this which explains the proliferation of possible TAC levels. That is, seen from 2003, in 2004 the initial TAC will be either 800 t or 600 t, and the triggering of a further 500 t from either starting point will generate another two possibilities (1300 t and 1100 t respectively). Similarly, in 2005 there are again these four possibilities plus (if the initial 2004 TAC was 600 t) 400 t and 900 t, making six. A seventh is then added in 2006 (200 t, if the initial 2005 TAC was 400 t).

The extra 500 t is an adjustment made to the TAC mid-season if a large aggregation of orange roughy is demonstrated to have returned to the South Tasman Rise in any of the next three seasons, by three eighths of the TAC (i.e. 300 t, 225 t or 150 t, depending on whether the TAC at the start of the season is 800 t, 600 t or 400 t) being taken in a number of consecutive observer-verified tows (including tows with nil catch) small enough to yield a mean catch per tow of 2 t or more. If this condition is met, the additional tonnage can become available for that season, but this is neither automatic nor immediate. Rather, the increase takes effect only once 75 percent of the original TAC (600 t, 450 t or 300 t respectively) has been or appears likely to be caught. This ensures that the additional tonnage does not become available unless it is likely to be needed, which may not be the case if the catch rate subsequently falls. (It would also call into question the higher abundance it initially suggested.¹³) The mechanism is deactivated for the 2006 season if the operation of the decision as a whole results in a 200 t TAC in that season, so that there are seven possibilities for that season’s TAC, not eight.

Finally, the 2003 decision provides for review of the TAC in 2006. Under the 2000 Arrangement, the default position if the parties are unable to reach accord on a TAC is that the previous season’s TAC applies again, i.e. the TAC for the 2007 season would be the same as that of 2006 determined under the 2003 decision.¹⁴

¹² The intertwining of the decision rules may mislead hurried readers of the decision who go no further than this to form the impression that the parties are inviting and rewarding overcatch. This is assuredly not the case. For postponement of the reduction, the TAC must first have been increased by 500 t under the trigger rule, so that the true threshold is undercatch of less than 400 t – the rationale being that greater undercatch would be evidence that the abundance may not after all be as high as the fulfillment of the trigger rule would have suggested.

¹³ This is consistent with the rationale outlined in the previous footnote.

¹⁴ Paragraph 4 provides a mechanism to “vary” the TAC, with the necessary implication that it continues unvaried from year to year unless the mechanism is activated. It will not have escaped the parties’ notice in drafting this clause that, had they included a similar provision in their 1998 Arrangement, the problems that beset them in 1999 could have been avoided.

The contingent TAC appears to be without precedent, although there are examples of contingent national allocations depending on the size of future TACs. One such is a 1996 ICCAT Recommendation on bluefin tuna in the Western Atlantic¹⁵ (ICCAT 1997, p. 82), which fixed quotas in absolute terms for the relevant years, but went on to set out two alternative quota-sharing ratios among Canada, Japan and the United States depending on whether the quota for 1999 was between 2 350 t and 2 660 t, or above 2 660 t.

4. STRADDLING STOCKS AND THE ONUS OF PROOF

Another possible service that the South Tasman Rise orange roughy fishery has done the international fisheries law community lies in raising, though not really answering, the question of the burden of proof as to whether a stock is a straddling stock, a matter on which both the United Nations Convention on the Law of the Sea¹⁶ (LOSC) and the UN Fish Stocks Agreement are silent.

Though not incontrovertible, all available scientific evidence indicates that the South Tasman Rise orange roughy fishery is based on a single discrete stock that straddles the AFZ boundary. A joint Australian/New Zealand study during 1998 examined stock structure through fish samples from summer commercial catches and from three winter (spawning season) research cruises. Genetic analyses carried out by the National Institute of Water and Atmospheric Research (New Zealand), and otolith microchemistry studies by the Commonwealth Scientific and Industrial Research Organisation (Australia) found no differences between South Tasman Rise fish inside and outside the AFZ, indicating a common straddling stock. The principal recommendation of a joint scientific workshop to discuss research findings held in Wellington in December 1998 was that the South Tasman Rise fishery for orange roughy should be managed as a single discrete stock.

But what if New Zealand had continued to deny that the fish of the same species taken on either side of the AFZ boundary belonged to the same stock?¹⁷ The 1998 Arrangement took an indirect approach to the onus of proof, contemplating (Paragraph 23) that a wider negotiation would follow “if as a result of the collaborative scientific work undertaken under [the 1998 Arrangement] the preponderance of the evidence indicates that the orange roughy stock on the South Tasman Rise is a straddling stock occurring both within the AFZ and in the adjacent high seas area”. This peculiar formulation both assumes through the use of the singular that there is a single stock and yet hints that the onus lies on the state asserting that the stock in question straddles the outer limit of its exclusive economic zone (EEZ) to prove this.

¹⁵ “Recommendation by ICCAT to Establish a Scientific Monitoring Quota for Bluefin Tuna in the Western Atlantic for 1997–1998” (Annex 5-4 to Tenth Special Meeting of the Commission, San Sebastian, November 22–29, 1996).

¹⁶ 1833 United Nations Treaty Series 3.

¹⁷ One short-term consequence of New Zealand’s initial denial was that Australia felt no obligation to advise New Zealand of its management arrangements for the orange roughy fishery within the AFZ. This was because New Zealand would have a legitimate interest in knowing these, as set out in Article 7(7) of the UN Fish Stocks Agreement (“Coastal States shall regularly inform States fishing on the high seas in the subregion or region...of the measures they have adopted for straddling fish stocks and highly migratory fish stocks within areas under their national jurisdiction.”), only if it accepted that the stock did indeed straddle the boundary. In the abstract, a coastal State in this position will also need to take into account the risk that adhering too rigidly to this stance might suggest a lack of confidence in its scientific case. As noted above (text following note 10), however, in this instance Australia’s measures applying in the high-seas area of the South Tasman Rise were extended to the AFZ in 2001.

If the matter were ever litigated under the dispute settlement provisions of the LOSC or the UN Fish Stocks Agreement, it would seem that the state asserting that there is a single stock straddling its EEZ boundary must either prove that element of its case or argue as a preliminary point that the onus of disproving it should fall on the denying state.¹⁸

A possible argument that the asserting state might use in this situation is that once fish of the same species are found on both sides of an EEZ boundary in its vicinity, a presumption that they belong to the same stock straddling the boundary is more in keeping with the precautionary approach to fisheries management mandated by Article 6 and Annex II to the UN Fish Stocks Agreement. The actual text of these provisions is, however, not of much assistance here. On the one hand it may be precautionary to presume that fishing on one side of a line will have some effect on what is possibly the same stock on the other side of the line. On the other hand, two smaller stocks will each be more vulnerable to overfishing than a single larger stock that is an amalgam of the two, so that precautionary managers should presume that a stock which may straddle a boundary is in fact two separate stocks until the evidence suggests otherwise. What little literature there is on the question appears to prefer the latter approach (Molenaar 2001).

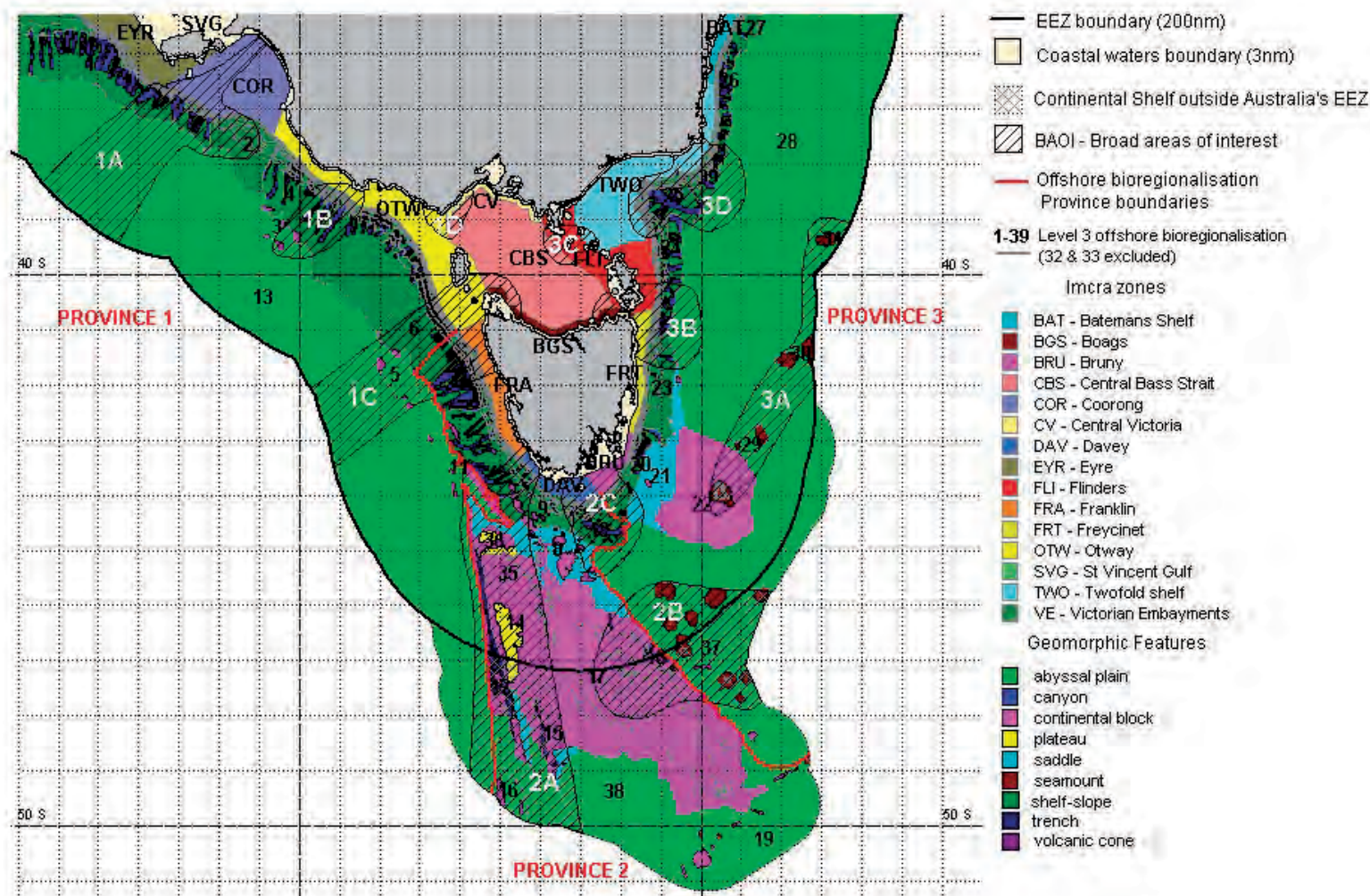
There is relatively little state practice on the question. The best examples, though not cast in terms of the onus of proof as such, may be the opportunistic stances taken in this regard by the states that subsequently became parties to the 1994 Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea.¹⁹ Before this Convention was negotiated, the United States took the view that the pollock found throughout the Bering Sea constituted a single stock, while Japan maintained that there were three separate stocks, the range of one of them corresponding with the high-seas area in the middle of that Sea to which the Convention relates. If correct, the Japanese view would mean that LOSC Article 63(2) would be inapplicable, leaving the United States with no automatic right to participate as a coastal state in the negotiation of the Convention, and none under Article 118 either, as its vessels had not fished in the high-seas area. Though there were practical and political reasons for not seeking to exclude it from the negotiation, the fact that the United States did so participate, and subsequently became party to the Convention, would support the contention that the onus of proof was on the party denying that a stock straddles an EEZ boundary. One factor pointing the other way is that under the Convention the assessment of the biomass of pollock in the high-seas area may in some circumstances be done by reference to a specific area in the vicinity of Bogoslof Island lying within the United States EEZ, clearly implying that the stock moves between the high-seas part of the Bering Sea and that area, to which the United States had extended domestically the moratorium on high-seas fishing.²⁰

¹⁸ Note that there is no comparable problem with highly migratory species, because Article 64 of the LOSC creates (in Annex I) a closed list of these species, although there may be some uncertainty at the margins (described in Serdy 2004).

¹⁹ For the text of this Convention see (1995) 34 *International Legal Materials* 67. The remainder of this paragraph draws on Kaye's recent analysis of the negotiations (Kaye 2001, at 323ff).

²⁰ Japan's view (shared by China) that, while the moratorium continued, the coastal states should take appropriate conservation measures in their EEZs (Kaye 2001, at 350n) must either have rested on the assumption that there was but one stock – inconsistently with its former position – or been an attempt to call the United States' bluff. The fact that the United States did not do so until urged does not, however, necessarily undermine its own one-stock stance; it is explicable as an application of coastal State priority as reflected in the UNCLOS Article 116(b).

FIGURE 2
Approximate extent of South Tasman Rise extending beyond Australia's EEZ



A truly precautionary test could be formulated as “Which assumption when used as a basis for conservation measures, should its falsity later become evident, will be less likely to have damaged the stock(s)?”, but this is a question that may be best answered by scientists on a case-by-case basis, and does not lend itself readily to distillation into a legal rule.

5. THE SOUTH TASMAN RISE AS PART OF AUSTRALIA’S EXTENDED CONTINENTAL SHELF

During the 1999 moratorium four vessels flagged to third states caught significant amounts of orange roughy just outside the AFZ, desisting only as a result of diplomatic pressure by Australia on the flag states, citing the duty of cooperation in Article 63, Paragraph 2 and Articles 117 and 118 of the LOSC (Molenaar 2001, Staples 2002). Although this fishing was prompted by knowledge that orange roughy were there for the taking, recent catch statistics provide much less of an incentive for third-state vessels to make the long journey to the South Tasman Rise purely on speculation.²¹ What if a similar incident were now to recur, however?

It does not seem open to serious question that the 2000 Arrangement is a subregional arrangement within the meaning of Article 8, Paragraph 3 of the UN Fish Stocks Agreement. The third-party provisions of the 2000 Arrangement indeed speak of admitting new participants on the basis of a “real interest”, although what realistic expectation they can have of gaining a share of the TAC is open to question, particularly if it ultimately falls under the 2003 decision to 200 t, which as noted above could be tantamount to a ban on targeting orange roughy. At any rate, it would seem reasonable to assume that Australia and New Zealand would both prefer third states not to enter the fishery, at least until such time, if ever, as there is strong evidence that the MSY is a great deal more than 300 t a year. New Zealand could be expected to have the additional concern that, to the extent that any of Australia’s catch is taken within the AFZ, Australia would have a cogent argument based on LOSC Article 116(b) that any reallocation in favour of third states should come out of the high-seas share, disproportionately affecting New Zealand.

The proposition advanced in this section is that a ban on fishing altogether for demersal species could be enforced unilaterally by Australia by virtue of the South Tasman Rise being part of Australia’s continental shelf. Since 1994 the outer limit of Australia’s continental shelf has been defined by reference to Article 76 of the LOSC²², which makes the depiction of that limit on a map difficult, given that Australia has yet to make its submission in this regard to the Commission on the Limits of the Continental Shelf – though by November 2004 Australia will have done so if it adheres to the original 10-year rule in Article 4 of Annex II to the LOSC²³. A rough idea of the shelf’s extent can, however, be gained from material prepared by Australia’s National Oceans Office in relation to the draft South-East Regional Marine Plan (Figure 2), which shows that it encompasses the whole of the area covered by the 2000 Arrangement with a great deal to spare.

²¹ If the tonnage taken by these vessels was at the higher end of the range in the anecdotal reports (Staples 2002) and the subsequent low catches reflect depletion of the stock, then there may in fact be a cause-and-effect relationship between them.

²² *Seas and Submerged Lands Act 1973* (Cth), ss 3(1) and 12 (as amended by the *Maritime Legislation Amendment Act 1994* (Cth)).

²³ The Eleventh Meeting of States Parties to the UNCLOS decided in May 2001 to extend the deadline to May 2009 for all States that would otherwise have faced an earlier deadline: Decision regarding the date of commencement of the ten-year period for making submissions to the Commission on the Limits of the Continental Shelf set out in Article 4 of Annex II to the United Nations Convention on the Law of the Sea, UN doc SPLOS/72 (29 May 2001).

Part XII of the LOSC allows coastal states to take measures to prevent damage to fragile ecosystems found on their continental shelves.²⁴ Orange roughly aggregations tend to occur on seamounts and are typically exploited by methods which involve nets coming into contact with – and damaging – the bottom. Seamounts are features of great biological diversity, which has led to calls for a moratorium on trawling on such elevations.²⁵ It is submitted that it would be open to a state to prohibit activities that cause, or could reasonably be expected to cause, damage to the environment of the seabed of its continental shelf. As the coastal state's jurisdiction over fisheries does not extend beyond the EEZ, however, it will be severely constrained in the design of its measures. In particular, it would be dangerous for the prohibition to be directed solely against fishing vessels. Still less would it be possible for the prohibition to extend only to foreign vessels or activities. Such a measure would in effect be claiming an exclusive right for the coastal state to damage the marine environment, which would be a perversion of the purpose of Part XII of the LOSC and contrary to Article 227.²⁶ In a practical sense, the blunt instrument of a total ban may be all that Part XII allows.

Accordingly, a coastal state wishing to impose less restrictive measures tailored to the operation of fishing vessels, particularly those intended to place its own vessels at an advantage, would need to find justification for these, if it can, in the fisheries provisions of the LOSC or in the UN Fish Stocks Agreement. The exclusive jurisdiction that the coastal state has over sedentary species on its continental shelf under the LOSC Article 77, Paragraph 4 may not be sufficient. A ban only on foreign fishing, which would entail a claim by the coastal state to the exclusive right to damage its own sedentary species fisheries, seems not as obviously contrary to principle as the same claim in respect of the seabed environment, but only the brave would predict with confidence that it would withstand a challenge based on the abuse of rights limb of the LOSC Article 300. For one thing, its practical effect would be to reopen the controversial question of whether demersal fish species are included within sedentary species, clearly settled in the negative by the 1958 Convention on the Continental Shelf²⁷, whose Article 2, Paragraph 4 is in almost identical terms. Banning demersal fishing in a well defined location on the continental shelf outside the EEZ may be defensible where it threatens a known sedentary species fishery, but would be much less so in respect of a wide area on the off-chance that it may contain sedentary living resources.

6. CONCLUSIONS

It is perhaps one of the ironies of international fisheries law and management that, although developed to settle a disagreement about fish that may well no longer be there, the Australia-New Zealand South Tasman Rise orange roughly arrangement of 2000, together with aspects of the decisions taken under it, can nonetheless serve as a model for other straddling stocks. The superposed alternative catch limits in the 2003 decision on TAC in particular can be seen as one of the first attempts to manage a fishery in accordance with Annex II to the UN Fish Stocks Agreement. Although not expressed

²⁴ Although the focus of Part XII is pollution, and the general provision (Article 208(1)) is expressed in terms of coastal states "adopt[ing] laws and regulations to prevent, reduce and control pollution of the marine environment arising from or in connection with sea-bed activities subject to their jurisdiction...", Article 194(5) provides that measures taken in accordance with this Part "shall include those necessary to protect and preserve rare or fragile ecosystems as well as the habitat of depleted, threatened or endangered species and other forms of marine life."

²⁵ This was for example a theme common to the conclusions presented by many of the working groups formed at the recent Workshop on High-Seas Biological Diversity, Cairns, 16-20 June 2003, and is the first short-term option listed in the Summary Record of Discussion and Suggestion for a Way Forward, available online at <www.oceans.gov.au/pdf/draft_summary_record_of_outcomes.doc>.

²⁶ This Article provides that "In exercising their rights and performing their duties under this Part, States shall not discriminate in form or in fact against vessels of any other State."

²⁷ 499 United Nations Treaty Series 312.

in terms of target and limit reference points – too little is known about the stock for managers to be able to set these with any confidence – the decision is replete with reference points for “trigger[ing] pre-agreed conservation and management action” for which Paragraph 4 of that Annex calls. This innovative “resolve-as-you-go-through-feedback” approach could become a standard way of accommodating opposing views on abundance and desirable catch outcomes dependent on these. It also serves as a neat illustration of the fact that, while the precautionary approach to fisheries cannot completely eclipse the coastal state’s obligation under LOSC Article 62, paragraph 1 to promote the optimum utilisation of its EEZ resources, it does now cement utilisation into a rung in the hierarchy of norms that is subordinate to the one occupied by conservation.

Where the fishery takes place in waters superjacent to an extended continental shelf, Part XII of the LOSC may provide the coastal state with a blunt instrument to close the fishery altogether in order to protect the seabed environment, but does not extend the ordinary regulatory powers available to it in its EEZ to the entire fishery, at least unless all reasonable efforts to cooperate with other states have failed.

If nothing else, the events on the South Tasman Rise during the 1999 catch limit hiatus show that, however imperfect management measures may be, they are far better than not having any. While it would be tempting to conclude that no management decision rule should henceforth be regarded as complete unless it includes a deadlock-breaking formula for deriving one season’s TAC and national allocations from the previous season in the absence of a decision to the contrary, it may be futile to insist on this in circumstances where to do so would prevent the adoption of such a rule in the first place.

Finally, a lesson from the *ad hoc* moratorium that followed the hiatus is that, irrespective of the legal opposability of such a measure to third states, it is of no practical value unless they know of it. Because the moratorium was not widely publicised, the flag states of the vessels that fished the South Tasman Rise during its currency could reasonably say that they did not know the area was closed to fishing (and one did so: see Willing 2002, page 6)²⁸. Although owing a duty of cooperation to states already managing a straddling stock under Articles 63, 117 and 118 of the LOSC and now also Article 7, paragraph 1 of the UN Fish Stocks Agreement, as a practical matter the only way for them to prevent fishing by their vessels, which is surely preferable to having to rein them under pressure once fishing has begun, is if the measures with which they are expected to cooperate are brought to their attention in good time.

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²⁸ Constructive notice can be achieved for measures contained in a treaty by prompt registration of the treaty under Article 102 of the Charter of the United Nations, but no equivalent procedure is available for instruments of less than treaty status. The 2000 Arrangement therefore provides for the Parties to lodge it with the FAO for circulation to all the latter’s Members (see Paragraph 35), as does the 2003 TAC decision.

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APPENDIX I

The 2003 TAC decision

Extract from letter dated 25 June 2003 from the Hon Pete Hodgson MP, New Zealand Minister of Fisheries, to Senator the Hon Ian Macdonald, Australian Minister for Fisheries, Forestry and Conservation

[The Minister begins by rehearsing the recent history of the management of the South Tasman Rise (abbreviated in the letter to STR) since the conclusion of the 2000 Arrangement. He continues:]

The limited catches taken on the STR over the last two seasons and previous scientific advice suggest a declining orange roughy stock and has [*sic*] given cause for concern. In order to responsibly manage the stock based on scientific advice while creating some flexibility should the fish return in large quantities, we have provided a two-tiered approach for the next three years. I propose that the following arrangements apply.

The TAC for the 2003/04 fishing season will be set on 14 July 2003 at 800 tonnes, an overall reduction of 1000 tonnes. If the fish do not return in large quantities the TAC will be incrementally decreased annually to 200 tonnes in 2006-07. If the fish return in large quantities there will be an additional 500 tonnes of Trigger TAC available to industry. A detailed description of the TAC reduction and Trigger TAC mechanism is presented in Appendix II. The TAC will still be divided between Australia (75%) and New Zealand (25%) as stated in the 2000 [Arrangement].

These management arrangements will apply unless we mutually decide that a review of these arrangements is appropriate in accordance with paragraph 4 of the 2000 Arrangement. In addition, I propose that officials ensure information is exchanged as frequently as is necessary to achieve the above in a timely way. Both countries shall also prepare and exchange, by 1 March each year, a consolidated annual report detailing fishing information and scientific research from the previous fishing season.

In any event, I propose that officials from both our countries meet during the 2006-07 season, to decide on management arrangements for the next three-year cycle. In accordance with our mutual objective to retain flexibility, a future arrangement should take account of best science.

[The Minister goes on to suggest measures that a future arrangement might include, before concluding:]

I look forward to receiving confirmation from you that this proposal is acceptable to the Australian Government and that this letter, together with your reply to that effect, will constitute an understanding between the Governments of New Zealand and Australia. In that case, I ask that Australian officials notify the Fisheries Division of the United Nations Food and Agricultural Organisation on behalf of both countries of the management arrangements contained in this understanding.

Yours sincerely

(signed)

Hon Pete Hodgson
Minister of Fisheries

Extract from reply dated 14 July 2003 from Senator the Hon Ian Macdonald, Australian Minister for Fisheries, Forestry and Conservation to the Hon Pete Hodgson MP, New Zealand Minister of Fisheries

[The Minister refers to his New Zealand counterpart's letter and continues:]

I am particularly pleased that the proposal put forward by officials recognises the special circumstances of this orange roughy fishery. I know that from the perspective of the Australian industry, the proposal for a longer-term arrangement is appreciated as it allows industry some certainty in managing their fishing operations in a fishery where the ecology of the target species is not clearly understood.

[...] I support the introduction of these arrangements from Monday 14 July 2003. I also note that that these arrangements will apply unless we mutually agree to review them and that officials from both countries will, in any event, meet during the 2006-07 season to decide upon management arrangements for a further three years.

I therefore confirm that the arrangements as detailed in your letter and its two enclosures are acceptable to the Australian Government and that your letter, together with this response, constitute an understanding between the Governments of Australia and New Zealand.

[a paragraph is omitted on the arrangements to apply beyond 2006-07, the Minister suggesting that they be negotiated in view of the state of the fishery at that time]

As requested, I will arrange for Australian officials to notify the United Nations Food and Agricultural Organization of the management arrangements contained in this understanding.

Yours sincerely

(signed)

Ian Macdonald

APPENDIX II

Proposal for the Total Allowable Catch of Orange Roughy on the South Tasman Rise

2003-04 Total allowable catch (TAC) will be set at 800 tonnes (represents a reduction of 1000 tonnes)¹. An additional 500 tonnes of catch will be available in the form of a Trigger TAC if the trigger conditions are met².

2004-05 TAC will be set at either 800 tonnes or 600 tonnes depending on the level of catch in the previous season¹. An additional 500 tonnes of catch will be available in the form of a Trigger TAC if the trigger conditions are met².

2005-06 TAC will be set at 800 tonnes, 600 tonnes or 400 tonnes depending on the level of catch in the previous seasons¹. An additional 500 tonnes of catch will be available in the form of a Trigger TAC if the trigger conditions are met².

2006-07 TAC will be set at 800 tonnes, 600 tonnes, 400 tonnes or 200 tonnes depending on the level of catch in the previous seasons¹. An additional 500 tonnes of catch will be available in the form of a Trigger TAC if the trigger conditions are met². Parties will meet during 2006 to develop [an] arrangement for the next three years.

¹ TAC Rules

The total allowable catch (TAC) will initially be set at 800 tonnes in 2003-04. The TAC in following seasons will be reduced by 200 tonnes each season until reaching 200 tonnes in 2006-07 at the end of this Arrangement.

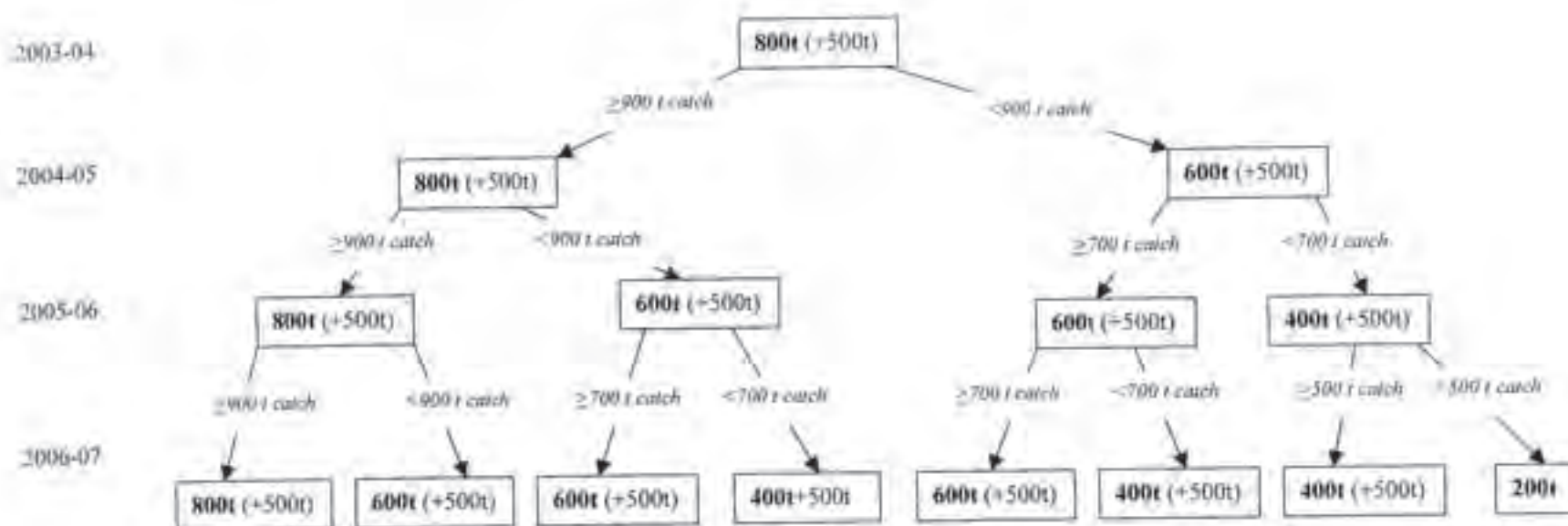
The preceding paragraph will apply, unless the total catch taken from the entire area of the STR by vessels authorised by either country to operate on the STR ('combined total catch') by 1 February is greater than or equal to 100 tonnes above the TAC, in which case the TAC will not be decreased in the following fishing season.

² Trigger TAC Rules

A Trigger TAC of 500 tonnes will be available if the *average catch rate* has reached two tonnes per tow. The *average catch rate* will be calculated from a sample of three eighths of the original TAC for the season taken from consecutive, observer-verified tows, including any tow that produces zero tonnes of catch. Only observed tows undertaken by vessels authorised by either country to operate on the STR will be taken into account.

The Trigger TAC will be made available from the date on which the combined total catch reaches, or is likely to reach, 75% of the original TAC for the season. A Trigger TAC will not be available for the 2006 season if the TAC is set at 200 tonnes

Total Allowable Catch (TAC) of Orange Roughy on the South Tasman Rise



(+500t) is triggered if at:

- 800t TAC (300t of observer verified catch with an average of 2t/shot)
- 600t TAC (225t of observer verified catch with an average of 2t/shot)
- 400t TAC (150t of observer verified catch with an average of 2t/shot)

The devil and the deep sea – economics, institutions and incentives: the theory and the New Zealand quota management experience in the deep sea

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1. INTRODUCTION

This paper will look at three key questions in fisheries management.

- i. Does theory suggest a property rights regime can be relied on to protect fish stocks and the environment of the deep sea?
- ii. Has the New Zealand property rights based Quota Management System (QMS) been a success in terms of its management of fish stocks and the environment in the deep sea?
- iii. What lessons can be learned for the deep sea from the New Zealand experience?

To address these questions, this paper canvasses basic economic theory including harvesting theory predictions and draws on theory of property rights, institutions and incentives and commonly expressed expectations about property rights. The paper briefly outlines the salient elements of the evolution of New Zealand's QMS. It examines the empirical record to determine what has happened in management of deep-sea fisheries in New Zealand. In the light of both the theory and the New Zealand experience, it then addresses how this informs choices for the deep sea.

2. FISHERIES IN ECONOMIC THEORY

2.1 Economic nature of fisheries

Diagnosis of the “tragedy of the commons” (Hardin 1968) as instead a “tragedy of open access” (Bromley 1991) has led to much attention to institutional forms and property rights approaches to fisheries management. But there is more to fisheries economics than the “tragedy of open access”. Fisheries theory notes that relative rates of growth of fish themselves is a significant element in the determination of harvest rates, even for a single owner. The of costs and benefits of the fishers may well differ from that of society. There are strong incentives to externalise costs. The marine environment yields a range of valued services, goods and ecological functions over a time path that stretches to infinity.

Fisheries are non-rival for ecosystem functions and for viewing and existing so everyone shares the benefits when they are in the sea. Fish are rival when extracted. Some of this value may be translated into market values if the fish are sold on markets rather than being used for subsistence. We can assume that there is little subsistence deepwater fishing and that most of the harvesting of deep-water species is for sale.

Fishing impacts not only the target fish stocks but bycatch, incidental mortality and damage to the host environment. Some methods such as trawling do considerable damage. Some ecosystem functions and benefits from the impacted environment are lost to all, possibly irrevocably, when the environment is affected. These adverse effects of fishing are known as “external costs”.

Fishing is a joint product of human effort, capital and entrepreneurship and the environment so for fishers their investment decisions may take into account fishing capital and fish stocks. Harvesting may affect the environment and its attributes, thus diminishing the natural capital (Prugh 1995) and the capacity of the environment (Randall 1987).

2.2 Value of fish, market and non-market – Total Economic Value

Economists use the “Total Economic Value” concept to capture both market and non-market values (Pearce and Turner 1990). The value of fish and seafood that is sold on the market is only one small part of the value that people attach to fish. Non-market economic values include:

- the values of ecosystem functions and non-extractive uses and values (e.g. for observation or scientific inquiry) of fish
- the values of retaining the marine environment and fish stocks and ecosystems intact for their own sake (existence value)
- the value put on handing the resource and environment to the future in good shape (bequest value) and
- the value of retaining options for all uses in the future (option value).

“Total Economic Value” does not include, but may reflect aspects of cultural values. In public policy, ethical concerns, such as the sense of the obligation to not cause extinctions and to retain ecosystems intact may set limits to extraction or after other uses or abuses of the environment. Efficiency then becomes an optimisation problem – often subject to constraints such as not causing ethically unacceptable harms.

2.3 Core economic harvesting theory – market values

Although environmental economic analyses are now well established, it is not necessary to rely on this theory to analyse what are the incentives that drive harvesting decisions. We could elaborate the theory and introduce many complex modelling elements, including the effect of harvesting and processing capital, but for the purposes of this paper we reduce the analysis to the core standard dynamic economic harvesting theory. This harvesting theory¹ suggests that the decision as to how much fish stock should be retained and how much effort should be deployed by a single owner only concerned about the financial flows of harvest depends on:

- the physical productivity of the fish stock
- the impact on productivity rates of current (and past) harvesting
- the rate of change of costs as a result of harvesting and other elements
- the future expected revenues and
- the discount rate (i.e. the rate of preference for an immediate rather than future return).

Economic theory suggests that for fish stocks with low productivity, the net rate of growth of the capital value of the fish stock in the sea may be less than the rate

¹ For an introduction to the fisheries economics dynamic theory, see Pearce and Turner 1990, Chapter 16.

of return from harvesting the fish and investing the revenues in the best alternative (Conrad 1995). Under these conditions the dominant incentive will be to “mine” the fish stock and to invest funds in the next best alternative as the proceeds of the sale of the fish stock can then be expected to grow faster than the net capital value of the fish stock in the sea.

2.4 Property rights

Suggestions that the solution to over-fishing is the creation of property rights rely on the idea that those with ownership in an asset are more likely to conserve it than those without them (Clark 1976). But the basic theory above shows that even a sole owner of a stock is, under the conditions described, likely to want to harvest the whole stock that can be taken and invest the proceeds (Clark 1976, Conrad 1995). The optimism that a share in ownership will cause the stock to be maintained overlooks that basic theory.

2.5 Harvest quantity limits

In general the setting of catch quotas as done in New Zealand with the imposition of a total allowable catch (TAC) or total allowable commercial catch (TACC)² or both (*Fisheries Act 1996*), provides a limit to the amount of fish that may be caught (though more may be killed during harvest than are landed). This provides more certainty than “effort” controls, which use input controls such as gear, seasonal or other controls as a proxy for harvest controls.

The purpose of allocating sub-sets of the total quota, as community or individual quota, is to alleviate the “race to fish” and to diminish “capital stuffing”. Capital stuffing is where vessels are filled with expensive gear designed to give them an advantage over competitors during some limited period or other controlled fishing conditions.

A major reason economic theorists (Clark 1976, 1985, Anderson 1979, Crutchfield 1961, Gordon 1954, Stokes 1979) advocate limited entry, quantity limits and shares of catch limits rather than relying on rationing access to fish via effort controls, is that quantity limits provide for more efficient fishing. There is less dissipation of potential rents than occurs when fishers have to comply with “imposed” inefficiencies such as seasonal closures and effort-reducing “input” measures (Christy 1996, Conrad 1995, Crutchfield 1973, Gordon 1954, Scott 1988, Turvey 1964). Catch quantity limits and property rights do not remove the incentives to “mine” a resource and to use the proceeds elsewhere for the reasons outlined in Section 2.2. They rather promote more efficient harvesting and a lowering of costs compared to restrictions using effort controls. Transferable property rights allow for efficiencies from economies of scale and reduction of total fishing capital and capacity.

2.6 Quota owner associations

In general the idea of quota owner associations relies on theories of government failure, co-management, compliance, clubs, and institutional theory (Wilson *et al.* 1994, Jentoft and McCay 1995, Jentoft, McCay and Wilson 1998, Hannesson 1988, Sandler and Tschirhart 1997). Quota owner associations are founded on the idea that compliance with rules including catch limits will be promoted if quota owners form mutually binding contracts and rules to diminish competitive fishing and cheating. There is more incentive for restraint if each fisher can be confident that all other fishers will be restrained. There are fewer enforcement costs if members of the group have the incentive to police each other. In the absence of incentives for mutual forbearance, the forbearance of one fisher will simply benefit others rather than leaving more fish in the sea for tomorrow, in which case incentives to forbearance are eroded. Such fisher

² TAC includes TACC plus allowance for recreational and customary Maori catch and all other mortality to that stock caused by fishing (Section 21, *Fisheries Act 1996*).

‘clubs’ are posited as a means for limiting competitive fishing (Jentoft and McCay 1995). Harvesting will be less competitive and more cooperative: but incentives to harvest a stock completely may remain.

2.7 Externalisation of costs

Since many deepwater benthic species are also slow growing and of no market value, there is little or no incentive to look after the host deepwater environment. Ordinary incentives to externalise the effects on the environment prevail. There will be no incentive to consider these in private decision making. As with any profit-driven enterprise, as long as the costs of environmental damage by fishing do not enter into the fishers’ private equations, or into preferences of consumers, and hence into market choices and prices, then there is no incentive to avoid environmental damage. Property rights regimes do not provide incentives to protect the environment unless there is a rapid impact of the environmental damage on harvests. In the case of the deep sea, with its long-lived and slow-growing invertebrates and fish, property rights do little to reduce damage to the host environment. There remain strong incentives to externalise costs.

2.8 Predictions from theory – a summary

The establishment of TACs, of individual transferable quota (ITQs) and quota owner associations does not remove the incentives to “mine” stocks. The outcome of transferable property rights and quota owner associations is that harvesting a stock will be done more co-operatively and more efficiently from a private fishers’ financial point of view than if there are input controls, but this does not take account of externalized environmental costs or the costs of lost non-extractive values.

3. DEEPWATER FISHERIES IN NEW ZEALAND

3.1 Background

Along with other jurisdictions, New Zealand has adopted institutional and property rights approaches that focuss on achieving an approximation to the incentives facing a “club” as a proxy for a single owner. How adequate has this approach been in protecting fish stocks in the deep sea? What about the ecosystem? What about other values?

There have been many reports that the New Zealand fisheries management QMS has been a success (Annala 1996, Shallard 1998, Clark, Major and Mollett 1988) and this view has been asserted by officials (MoF 1997a, 2004; Tuck 2001), Ministers (Minister of Fisheries 1998a), and fishing industry representatives (Treaty of Waitangi Fisheries Commission 1999).

Internationally, deepwater fisheries have been defined as fisheries that occur beyond the continental shelf break. DEEP SEA 2003³ defined the deep sea as 200 m and deeper. At the International Council for the Exploration of the Seas (ICES) 400m and deeper has been used to define deepwater fisheries (ICES 2003).

In New Zealand, deepwater fisheries have been defined for stock assessment purposes as those deeper than around 700 m (Annala *et al.* 2003). The New Zealand fisheries covered here, following this definition, include orange roughy (*Hoplostethus atlanticus*), smooth and black oreos (*Neocyttus rhomboidalis* and *Alloctytus niger*), black cardinal fish (*Epigonus telescopus*) and ribaldo (*Mora moro*). Ribaldo is a bycatch species in trawling for hoki (*Macruronus novaezelandiae*), for orange roughy and for ling (*Genypterus blacodes*) and in longlining for ling. There is a range of other species that would meet the ICES or Deep Sea 2003 definitions, which are not considered here

³ DEEP SEA 2003 Conference, Queenstown, New Zealand, 1–5 December 2003.

but are listed in Table 1. These species represent about 45 percent of New Zealand wild fisheries exports (NZ Seafood Industry Council 2002a).

The main deepwater target fisheries managed under the QMS include orange roughy, two of the three species of oreos (only smooth and black oreos are caught in large numbers), black cardinal fish and ribaldo. Orange roughy and the oreos have been managed in the QMS since 1986. Black cardinal fish was added in 1998 for Quota Area 2 to 8 and in 1999 for Areas 1 and 9. Ribaldo entered the QMS in 1998 for all areas. Black, smooth and spiky oreos are managed as a combined species group with a single catch limit per quota management area (QMA) (Figure 2). Spiky oreos (*Pseudocyttus maculatus*) are a minor part of the catch and are not targeted.

This paper primarily examines the orange roughy fisheries for evidence as to whether the property rights regimes protected fish stocks. This is because orange roughy has been the dominant deepwater species over the 20 years of quota system management by ITQs, both in terms of volume and in terms of price and value. A time line of important events in the development of deepwater fisheries in New Zealand is given in the Appendix.

3.2 Evolution of the New Zealand QMS

New Zealand declared a 200 nm EEZ on 1 April 1978 that covers 1.2 million nm². Until this time there had been little New Zealand deepwater fishing – such fishing had been done, if at all, by distant water fleets (Insall 1978, NZ Fishing Industry Board Annual Reports 1975–1989, Struik 1980, MAF 1973–1995, MAF 1982, Belgrave 1984). New Zealand's inshore fisheries were under stress and the government encouraged New Zealanders to “think big” and expand into the deepwater (MAF 1979). After the declaration of the EEZ, initially most deepwater fishing was done under government-to-government licensing but this was rapidly replaced by foreign vessels on charter to

TABLE 1
Main deepwater and middle depth species in New Zealand fisheries

Species	New Zealand category	Depth of fishery (m)	Target or bycatch species	Year into QMS	Catch in 2001–2002 fishing year (t)
Orange roughy (<i>Hoplostethus atlanticus</i>)	Deepwater	700 – 1200+	Target	1986	14 381
Black oreos (<i>Allocyttus niger</i>)	Deepwater	600 – 1200+	Bycatch	1986 oreo combined	4 565
Smooth oreos (<i>Neocyttus rhomboidalis</i>)	Deepwater	650 – 1200+	Target	1986 oreo combined	13 003
Black cardinal fish (<i>Epigonus telescopus</i>)	Deepwater	600 – 900	Target	1998–99	2 349
Ribaldo (<i>Mora moro</i>)	Deepwater	500 – 1000	Bycatch	1998	1 311
Frostfish (<i>Lepidopus caudatus</i>)	Middle-depth	50 – 600	Bycatch	1998	2 913
Gemfish (<i>Rexea solandri</i>)	Middle-depth	50 – 550	Target	1986	664
Hoki (<i>Macruronus novaezelandiae</i>)	Middle-depth	300 – 800	Target	1986	196 000
Dark ghost shark (<i>Hydrolagus novaezelandiae</i>)	Middle-depth	150 – 700	Bycatch	1998	2 063
Pale ghost shark (<i>Hydrolagus</i> sp. B2)	Middle-depth	400 – 1000	Bycatch	1999	1 649
Hake (<i>Merluccius australis</i>)	Middle-depth	250 – 800	Target/ bycatch	1986	11 826
Ling (<i>Genypterus blacodes</i>)	Middle-depth	200 – 800	Target/ bycatch	1986	19 561
Scampi (<i>Metanephrops challengeri</i>)	Middle-depth	300 – 500	Target	No	979
Silver warehou (<i>Seriotelella punctata</i>)	Middle-depth	200 – 800	Bycatch	1986	8 551
Southern blue whiting (<i>Micromesistius australis</i>)	Middle-depth	250 – 600	Target	1999–2000	32 500
White warehou (<i>Seriotelella caerulea</i>)	Middle-depth	150 – 800	Bycatch	1998	1 941

New Zealand companies (MAF 1982). Often the arrangement was not much more than a tolling arrangement with the fee going to the company rather than to the government. These were initially described as “joint ventures” (MAF 1982) but became charter arrangements (Wallace 1998a, Batstone and Sharp 1999, MAF 1987c). The orange roughy fishery first developed on the Chatham Rise in 1979 (Belgrave 1984), with other grounds subsequently being found.

The evolution of the New Zealand QMS began in 1983 with a trial in the deepwater fisheries of a quota management regime called the Deepwater Enterprise Allocation System comprising a small number of companies with deepwater fishing arrangements (MAF 1982, Sissenwine and Mace 1992). Thus, New Zealand experience of the QMS in the deepwater fisheries spans over 20 years.

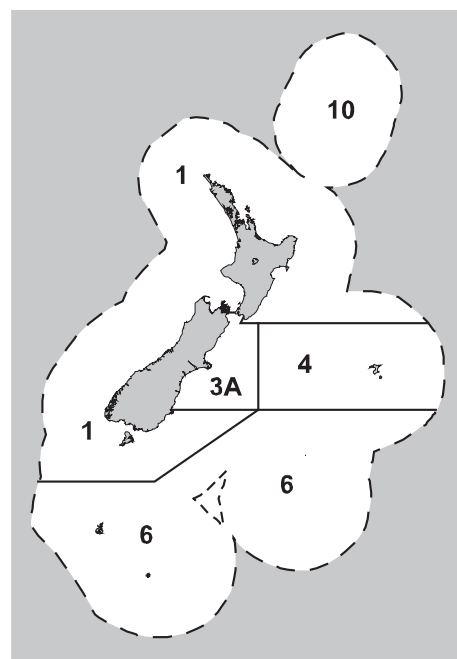
About this time – 1983, 1 500 to 1 800 inshore fishers were removed without compensation from the fisheries if they earned less than 80 percent of their income, or less than \$NZ10 000 from fishing, or were disqualified in other ways (Waitangi Tribunal 1988). This was an attempt to reduce pressure on inshore stocks and to simplify and cut down the costs of fisheries management and was done prior to the 1986 introduction of the QMS to the inshore fisheries. This exclusion of part-timers, many of whom were Maori, was one issue that led to later Maori claims to quota (Waitangi Tribunal 1988, 1992).

In 1986 inshore species were introduced into the QMS. The system involved the setting of TACs, from 1990 also TACCs and the issue of ITQs. In the deepwater, there was no recreational or customary catch. All of the catch, beyond that taken for scientific purposes, is commercial. ITQs were allocated after considerable debate on “grand parented” catch history. Allocations were of quota in perpetuity on an absolute tonnage basis to those with a catch history in the fishery. This allowed people to nominate their quota surrender prices and leave the fishery voluntarily (Wallace 1999). Quota constitutes not a right of ownership of the fish but a perpetual right of access to harvest a certain amount of fish under the conditions imposed by the authorities. In the inshore fisheries, initial “over-allocations” of quota were removed from the fisheries by a system of competitive tenders to “buy back” and retire quota.

FIGURE 1
Orange roughy QMAs Annala *et al.* 2003



FIGURE 2
Oreo QMAs Annala *et al.* 2003



Prior to the operation of the QMS, allocations and fishing operations were subject to sustainability constraints and other laws including a variety of regulations and input controls for biological reasons. Quota was issued for each of the ten QMAs (Figures 1 and 2) with few biologically determined restrictions on the location of fishing within each one. Sustainability constraints remain, but there is, to date, no environmental management planning in place though there has been discussion of the need for these since 1991 (Fisheries Task Force 1991) and these are being developed. The *Fisheries Act 1996* has environmental principles, which have never been matched with any systematic environmental impact assessment or other systematic environmental effects management beyond catch limits and control of bycatch of marine mammals and birds.

The expectation under the QMS was that the government would buy and sell quota, buying if fish stocks were such that quota needed to be retired for sustainability and other reasons, selling if more fish could be harvested (Clark and Duncan 1986). As it turned out, there was considerable overestimation of the sustainable yield of some stocks and hence over allocation of catch, often under industry pressure. For instance in the mid 1980s New Zealand fisheries managers were persuaded by experts brought in by the fishing industry to accept a figure for natural mortality of 0.2 rather than 0.1 for the important Challenger Plateau orange roughy stock, as the scientists had originally suggested and as was applied to other orange roughy stocks (Robertson and Grimes 1983, Robertson 1985).

This change in the assumption of natural mortality allowed the catch limit to be doubled from 6 000 t to 12 000 t. Despite clear warnings from the scientists of high probability of catch collapse if high TACC levels persisted (Robertson, Mace and Doonan 1988), fishery managers, under pressure from fishers and their advisors, allowed continued high catch rates or did not reduce the catch rates sufficiently (Zwartz 1986, Weeber 1986). Subsequently, as the scientists had predicted, the Challenger Plateau stock collapsed to 3 percent of the unfished biomass (Annala *et al.* 2000). Industry submissions to officials and ministers frequently lobbied for higher catch limits than those suggested by stock assessments prepared by scientists (e.g. MAF 1991, 1992, 1993, 1994a, MoF 1995, 1996, 1997b, 1998, 1999a, 2000a, 2001a, 2002a, 2003a).

When the need for catch reductions for orange roughy and later hoki became glaring the government baulked at the fiscal implications of spending large sums on a buy-back of quota. On 9 October 1989, after extensive bargaining with the industry and with more bargaining in prospect, the government agreed to convert the ITQs from absolute tonnage allocations to percentage shares of the TACC. The Cabinet also agreed in 1989 to freeze resource rentals rates and to compensate fishers for reduced catch limits to the value of the uncollected resource rentals (MAF Cabinet papers 1989a)⁴.

In the subsequent "Accord" reached in 1989 between the government and the industry, all resource rentals plus \$NZ5 million were put into a fund over six years to compensate fishers for downward adjustments in the TACCs for orange roughy and hoki. This came to a total of \$NZ128.5 million plus interest of \$NZ 5 million (MoF 1997c).

The change to ITQs as a proportional share of TACCs (*Fisheries Amendment Act 1990*) altered incentives. Whereas before the government had faced most of the risk of total catch limit adjustments and the expense of buying quota and selling to lower or raise the catch limit, now quota owners had *pro rata* reductions in tonnage allocated as catch limits fell (as they mostly did, reflecting too optimistic initial catch limits) or

⁴ This includes unpublished memo 13 October 1989 and supporting Cabinet papers including Dev (89) M14/8; Dev (89) 102; Papers to the Chairman of the Cabinet Economic Committee 19 May 1989, 23 June 1989 from MAFFish; Dev (89) 80 (MAF1989b, NZ Cabinet Economic Development and Employment Committee 1989).

in some cases, benefited from *pro rata* increases. As indicated, industry argued for, and got, compensation for catch reductions in 1989 in orange roughy and hoki. The *Fisheries Act 1996* does not provide any requirement for compensation and is specific that TAC or TACC adjustments for sustainability reasons are not subject to such claims (Section 308(2)).

One effect of the change to percentage shares is that changes in TACC affect the balance sheets of quota owners. Thus, there is usually considerable resistance to catch reductions and pressure to maintain, or to increase, catch limits. The main exception to this has been outside the realm of the subject of this paper – from either small coastal communities with a big stake in the local shellfish or rock lobster or from one group of hoki fishers who were selling into a market with a price elasticity of demand such that increases in catch depressed total revenues.

In some cases industry has proposed to “shelve” quota (i.e. not fish it) rather than face TACC reductions. Examples include the paua (abalone) fishery and the East Coast North Island orange roughy fishery (Paua Fisheries Management Company 1999, MoF 1999a, MoF 2000a). A reduction would reduce the quantity of quota they owned and list on their balance sheets, so affecting their ability to borrowing. This arrangement leaves balance sheets unchanged even though there are in fact no fish to match the “shelved” portion of TACC, i.e. “ghost” ITQ on the balance sheets⁵.

The *Fisheries Amendment Act 1990* also allowed for consultation on setting TACs and TACCs. This process (Section 28D) allowed, for the first time, consultation with a range of parties in addition to the NZ Fishing Industry Board. Commercial fishers, recreational fishers, Maori fishing interests and environmental groups are consulted under this provision, which was reinforced by the provisions in *Part III (Sustainability Measures)* of the *Fisheries Act 1996* that replaced most of the 1983 Act.

During the 1990s and the early 2000s, there have been on-going changes and evolution to the QMS. The ITQ which contained both a catching rights and the property right was divided to create a further right, an Annual Catching Entitlement (ACE). ACE is generated at the start of the fishing year in proportion to the quota owned and ceases at the end of each fishing year. It can be sold or leased. The ACE system started on 1 October 2001.

Quota owner associations were formed in the mid-1990s, e.g. of the Orange Roughy Management Company in 1991 and the Hoki Fishery Management Company in 1997. From 1983 as the New Zealand fishing industry expanded with its own or charter vessels into the 200 nm zone, fishing companies hired vessels to find new seamounts within the zone and beyond. There has been a process of serial depletion of seamounts as new ones were found (Clark 1999, Francis 2001).

Over the years as information was gained about the fish and fisheries some of the original QMAs were subdivided under agreement between the Minister of Fisheries and the industry – but for the most part the QMAs remain large. Fisheries management processes have evolved and are further described in Starr, Annala and Hilborn (1998).

3.3 Other institutional developments

The quota management system is not the only institutional development in fisheries management in New Zealand. The 1980s and 1990s were times of major public sector restructuring and the application of new norms and processes of public management and finance (Boston 1995): fisheries were no exception. When the deepwater fishery QMS trial began in 1983, there was a Ministry of Agriculture and Fisheries (MAF). The MAF Fisheries Research Division was parceled off in 1995 and became part of the National Institute of Water and Atmospheric Research (NIWA), a government research agency in a corporate institution. The fisheries management section of MAF

⁵ Such an arrangement has uncanny similarities with the dead serfs accumulated by the would-be landowner, Chichikov, at the centre of Gogol’s 1842 novel *Dead souls* (Gogol 1842).

was subsequently set up as a stand-alone Ministry of Fisheries (MoF) in 1995 with policy, management, legal, compliance, monitoring, enforcement, and catch effort and quota registry functions. At the behest of the fishing industry (NZ Fishing Industry Association 1997, Pfahlert 1999) the business of tracking and managing the fisheries quota registry was handed to an industry run company in 2001. The government retains ownership of the information.

3.4 Maori share and resource rentals

At the beginning of the QMS, the government instituted a modest resource rental charge. When Maori in 1987 (Grieg 1987) intervened with legal and political challenges to the quota allocations on the grounds that the Treaty of Waitangi 1840 between the British Crown and Maori guaranteed possession of fisheries to Maori, negotiations ensued. Maori were partially successful in this challenge and emerged with 10 percent of the quota allocation of the time, (*Maori Fisheries Act 1989*), a promise of 20 percent of future allocations and a half share in a large quota-owning fishing company, Sealords (*Treaty of Waitangi (Fisheries Claims) Settlement Act 1992*).

3.5 Cost recovery and influence

The fishing industry seized the moment of Maori intervention to challenge resource rentals and emerged with an agreement for a cost recovery scheme instead. This provided for the fishing industry to pay fisheries management and research costs attributable to the industry. The total to be paid has been whittled down under intense pressure from the industry, shrinking below what the government expected (Wallace 1998b).

The cost recovery scheme was introduced in 1994. Costs are recovered for research, management, and observers undertaken by, or for, the MoF and a smaller conservation services programme managed by the Department of Conservation (DoC). Industry has often disputed government fisheries management services, in particular policy and research (Primary Production Committee 1998; NZ Fishing Industry Association 1997; Fishing Industry 1995a, 1995b, 1996, 1997). For example: "We wish to make it clear that many of the projects and activities outlined in the policy area are not regarded as required services by the fishing industry... It is very difficult for the industry ... to understand the need for 12 policy analysts/advisors based in Auckland, eight based in Nelson and nine based in Dunedin" (NZ Fishing Industry 1995b).

One effect of the cost recovery system has been to enhance the industry's ability to influence and control the activities and priorities of the MoF (NZ Fishing Industry Association 1997). This demand was encapsulated in the slogan "user pays, user says", which was used frequently by industry representatives in meetings with the MoF to press home their desire that the Ministry not do activities that they did not care for (e.g. NZ Fishing Industry 1995a, NZ Fishing Industry Association 1997).

Fishing industry representatives have used the processes of consultation with the MoF over its business plans and cost recovery intentions to exercise considerable influence on the fisheries management and research services undertaken or commissioned by the Ministry⁶. For example, in the 1996–97 financial year the MoF proposed a research budget of \$NZ18m, the fishing industry proposed \$NZ7.5 m (NZ Fishing Industry 1996) and the Minister agreed to cut research to under \$NZ14.5m (Minister of Fisheries 1996a). For the next three years research budgets stayed under \$NZ14.5m. This was the lowest fisheries research budget funded since the late 1980s and is well below the \$NZ 22.4m funded in the 1991–92 fishing year prior to the cost recovery regime being implemented (MAF 1992 Annual Report). By the 2003–04 financial year the research budget had recovered to about \$NZ21.6m. The MoF's costs recovered from the fishing

⁶ The authors observed this directly at meetings. There is evidence of this in the many documents that show the records of industry meetings with the Ministry, industry submissions and Ministry responses.

industry fell from \$NZ35.3m in 1995/96 financial year to \$NZ31.4m in 2002–03. At the same time the total proportion of the cost of the Ministry's operation recovered from the fishing industry fell from 72 percent in 1995–96 to less than 40 percent in 2002–03 (MoF 2003b, c).

3.6 QMS “success”: catch exports expansion

The original intention of the QMS was to relieve over-fishing, to restore profitability and to conserve inshore stocks while expanding effort into deepwater fisheries (NZ Fishing Industry Board 1985, and MAF 1987 c). Sometimes “success” is portrayed as the rising export revenues from fish (Clark, Major and Mollett 1988, Major and Wallis 1995c). These rose from \$NZ50.4m in 1978 to about \$NZ1.5 billion in 2002, of which \$NZ1.3 billion is from capture fisheries (NZ Fishing Industry Board 1986, NZ Seafood Industry Council 2004). About 88 percent by value of the total New Zealand fish catch is exported (MoF 2004). About 40 percent of the total catch is caught by chartered vessels (NZ Seafood Industry Council 2003), a figure that has declined as New Zealand companies gradually picked up both fishing and marketing. Several companies now deploy their vessels outside the New Zealand EEZ in the Southern Ocean, in the Indian Ocean, around the Pacific and around Southern Africa. Deepwater species make up about 13 percent of capture fish exports in 2002 by value. This rise in total export earnings has been due partly to catch increases that exceeded long-term sustainable harvest rates (so-called “fishing down” to, and often below, B_{MSY} ⁷) and the replacement of foreign licensed vessels with chartered and new domestic vessels (MAF 1987c, Batstone and Sharp 1999).

“Success” of the QMS is less evident if it is judged on the state fish stocks. There has been a rapid decline in deepwater fish stocks since 1983 when quota management started in the deepwater. As noted by Clark (2001), there have been significant catch reductions from annual catches of 40–50 000 t in the orange roughy fisheries during the 1980s, which peaked in 1989/90. In the major established orange roughy fisheries, catches were supplemented with harvests from newly developed fisheries. These were often from newly-found seamounts, sometimes found by the New Zealand government's research vessel **R.V. Tangaroa** on charter to the deepwater fishing industry. Catch reductions have been closely fought by the industry (Fishing Industry Board 1989, submissions by industry bodies to the Minister and MoF and its predecessor (Starr, Annala and Hilborn 1998).

3.7 Ownership concentration and capacity

The New Zealand experience with the QMS and ITQs is that quota ownership has concentrated ownership of vessels, reduced over-capacity and enhanced financial benefits to fishers (Falloon 1993, Major and Wallis 1995c, Connor 2001, Newell, Sanchirico and Kerr 2002). Those in the first round of allocations of ITQs received windfall gains as the beneficiaries of first-round grand parented allocations. Vessel numbers fell by 22 percent between 1983/4 and 1986/7, then by a further 53 percent by 1994/5 (Major and Wallis 1995c), primarily in the inshore fishery.

3.8 Legislative and policy environmental requirements

The 1996 *Fisheries Act* introduced new objectives for the management of fisheries in New Zealand. The provisions require decision-makers to “provide for utilisation while ensuring sustainability” (Section 8). “Utilisation” is defined as “conserving, using, enhancing, and developing fisheries resources...”. “Ensuring sustainability” is defined as “maintaining the potential of fisheries resource to meet the reasonably foreseeable

⁷ B_{MSY} is the biomass that will support the maximum sustainable yield.

needs of future generations” and “avoiding, remedying, or mitigating any adverse effects of fishing on the aquatic environment” (Section 8).

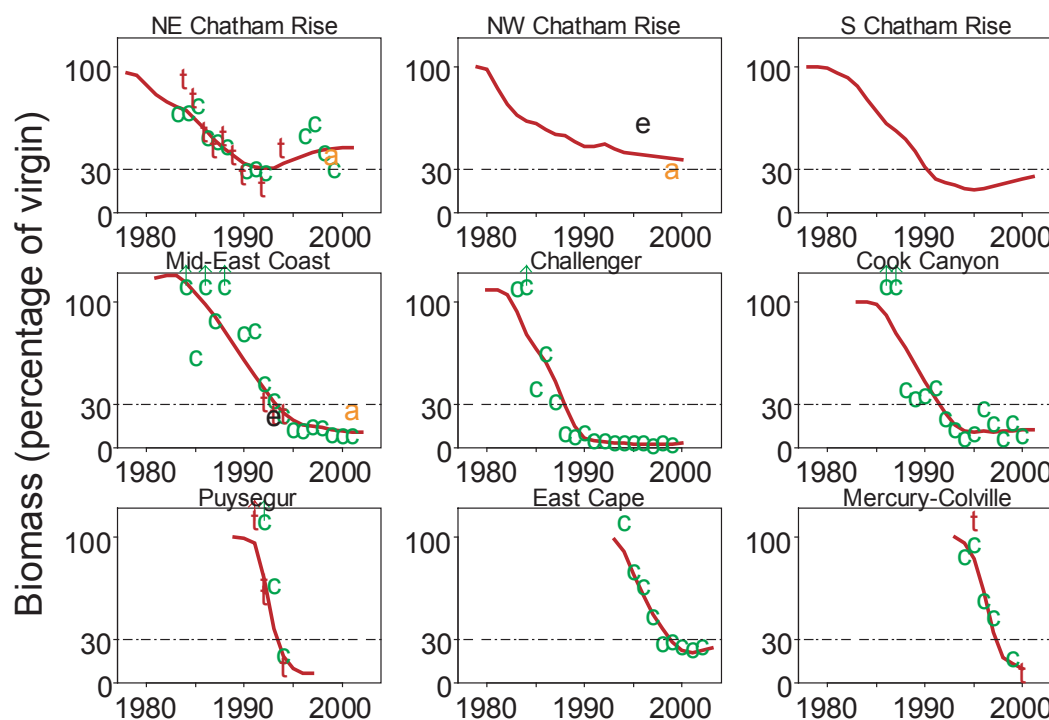
The environmental principles (Section 9) include requirements to maintain biodiversity, maintain associated and dependent species and protect habitats of particular significance to fisheries management. There has been some progress in identifying “associated and dependent species” but little in identifying habitats of significance to fisheries management. Pressure from environmental groups has resulted in a range of research contracts to look at impacts on the aquatic environment.

Section 13 of the *Fisheries Act 1996* requires the Minister to set the TAC at a level that “maintains the stock at or above the level that can produce the maximum sustainable yield...” but the evidence below shows that for the most part stocks in the deepwater fisheries have been allowed to drop below biomasses that will support the MSY (B_{MSY}), or its proxies, the biomass that will support the maximum average yield (B_{MAY}) or the biomass that will support the maximum constant yield (B_{MCY}) (see Tables 4, 5 and Figure 3).

The Controller and Auditor General (1999) criticized the MoF for the small budget for research on the aquatic environment. It considered that the “Ministry is not able to make informed recommendations to the Minister on issues such as the effects of fishing on the environment and the inter-relationship of fish species” (p54). It noted that “little work on this subject has been contracted for in 1999-2000” (Controller and Auditor General 1999). Since then funding on the effects of fishing has changed little. This repeated a finding ten years earlier that the “system [was] struggling to provide the necessary information for management decisions which can control fishing at

FIGURE 3
Orange roughy stock declines

The dotted line represents 30 percent of the unfished biomass, the biomass calculated to provide the MSY. This is the legal minimum for target fish stocks, which the Fisheries Act 1996 requires to be fished to “at or above” the level that would give MSY.



Note: Letters on the graphs refer to the type of stock assessment: c= catch per unit effort; a= acoustic survey; t=trawl survey; e=egg survey.
Source: M. Clark, NIWA, New Zealand.

sustainable levels and ensure sustainability of the fishery resource” (Controller and Auditor-General and Parliamentary Commission for the Environment 1990).

3.9 Environmental impacts controls

It is sometimes argued that ownership of quota will cause fishers to be more ready to protect the environment as well as the stocks (NZ Seafood Industry Council 2001, Sanford 2003, Harte 2000). There has been little evidence of this in New Zealand. Under heavy pressure from industry, and conditioned by habit and inertia, the New Zealand MoF has been slow to develop any form of environmental impact assessment or integrated environmental management, despite the environmental principles (Section 9) in the *Fisheries Act 1996*, and the purpose of Act (Section 8) including the “avoiding, remedying and mitigating the adverse effects of fishing on the aquatic environment”.

The annual “sustainability round” administered by the MoF, at which catch levels may be changed, and other controls imposed, modified or lifted has approached environmental issues in a largely *ad hoc* way to the extent that they have been considered at all. To date, environmental administrative processes remain largely notional though a process for developing policy for environmental standards finally started in 2000. By April 2004 these had not yet come into existence. There is virtually no spatially based environmental planning though there are some area fisheries closures and vessel limits. There are many *ad hoc* regulations relating to gear restrictions for biological protection purposes and in some cases to season and area restrictions. There is a well-embedded but much challenged set of processes for considering marine mammal and seabird impacts (e.g. MoF 2003d, Minister of Fisheries 2003b)⁸. Driven by public opinion, measures have been put in place to protect marine mammals and seabirds – though large mortalities of fur seals, sea lions and seabirds have been tolerated for years in the mid-water hoki fishery, the squid trawl fishery, domestic tuna fishery and various others (Baird 2001, Manly, Seyb and Fletcher 2002a, b, c).

Fishing impacts on marine invertebrates, ecosystems, non-target fish, the effects of fishing on invertebrates and fish removal received little attention despite environmental organizations’ pressure until the late 1990s. In late 1999 environmental organizations finally persuaded a new Minister of Fisheries to pressure the industry and Ministry into developing administrative processes for environmental assessment. These are still in development, are largely not operative and may be sidelined. To the concern of environmental organizations⁹, such measures will be administered within a framework of industry-written fisheries plans with many fisheries management and research functions devolved to the industry. The Ministry intends to develop environmental standards for such management (MoF 2002b and 2003e), but other stakeholders are to make their submissions to the fishing firms or quota owner associations and not to the government. The Minister, it is planned, will then approve or disallow fisheries plans but may not change these (MoF 2002c, 2003b).

Environmental organization pressure has also resulted in funding for research on marine biodiversity since 2000 and to some extent on the impacts of fishing – but this effort is small compared to the range and scale of impacts, particularly of trawling on the benthic invertebrates. Such pressure has rarely if ever been welcomed by significant

⁸ For example, the MoF has run consultation processes with stakeholders since 1992 to set limits on the number of endemic New Zealand sea lions (*Phocartos hookeri*) that can be drowned in the squid fishery around the Auckland Islands. This process involves annual consultation with the DoC and a range of interest groups and finally an annual plan is signed off between the Minister of Fisheries and the Minister of Conservation.

⁹ Expressed by the Environment and Conservation Organizations of NZ (ECO) and the Royal Forest and Bird Protection Society (Forest and Bird) in submissions to the Minister of Fisheries and MoF from 1998 onwards.

players in the fishing industry: it is not apparent that there is any deepwater industry pressure for environmental protection.

Research carried out in the early 1990s showed a decline in genetic diversity of orange roughy stock on the Chatham Rise, Challenger Plateau and East Coast of the North Island that was attributed to fishing pressure (Smith, Francis and McVeagh 1991). Later Smith and Benson (1997) found a smaller but non-significant effect over a longer time period. Managers have yet to consider how they would respond to a decline given the obligations under the *Fisheries Act 1996* to maintain biodiversity including genetic diversity, and international obligations under the Convention on Biodiversity and the 1982 United Nations Convention on the Law of the Sea (Section 5 of the *Fisheries Act 1996*).

Trawl surveys undertaken between 1984 and 1994 to monitor orange roughy stocks on the Chatham rise also showed a significant decline in biomass of most of the main bycatch species that were monitored (Clark *et al.* 2000). In the principal bycatch species they found levels of decline of 85 percent for basketwork eel (*Diastobranchus atlanticus*) and nearly 80 percent for white rattail (*Trachyrincus aphyodes*). Of current quota species, ribaldo fell by 60 percent and black cardinalfish by over 90 percent. Managers have not responded to the decline in bycatch species.

3.10 Seamounts

All fisheries targeting deepwater species are undertaken by bottom trawl. Initially deepwater fisheries targeted flatter areas but there has been an increasing trend towards targeting seamounts or hill features.¹⁰ According to Clark and O'Driscoll (2003) between 1980 and 1984 less than 30 percent of tows were associated with seamounts or hill features. By the 1990s this had risen to 60–70 percent.

There has been concern over the impact of deepwater bottom trawls on seamount biodiversity (including hill features) since the mid-1990s (Probert, McKnight and Grove 1997, Koslow and Gowlett-Holmes 1998, MoF 1998). In 1998 the Minister of Fisheries directed the Ministry to prepare a strategy on the impacts of trawling on deepwater seamounts and to prepare advice on closing four representative seamounts to fishing in 1999. The same year the MoF produced a draft strategy to address the impacts of fishing on seamounts but the four areas were not progressed that year. A final strategy has never been produced. In 2000 a new Minister consulted on a proposal to close 19 “seamount” areas to trawling. Submissions from the fishing industry in general opposed closing “large areas of seamounts” as “totally unreasonable and unacceptable” (Orange Roughy Management Company 2000). Many in the industry saw the proposed closures as “the thin edge of wedge” with regards to the erosion of property rights” (NZ Seafood Industry Council 2000). In 2001 the Minister of Fisheries decided, after consultation, to close 19 seamount features to all trawling. These features represent about 2 percent of the 800 seamounts identified in the New Zealand region. This decision is under challenge by the Orange Roughy Management Company in the New Zealand High Court.

The impact of trawling on “flat” areas has also been highlighted in a 2002 review of the impact of bottom trawling for scampi, tarakihi and gemfish in depths of 200–600 m in the Bay of Plenty by Cryer, Hartill and O'Shea (2002). They found a significant impact on a range of benthic biodiversity based on research trawls undertaken over three years. They considered the impact to be indicative of the effects of trawling occurring throughout the fisheries management area. There has been no management action in response to these results nor advocacy from the fishing industry for protection

¹⁰ In New Zealand seamounts have been defined as “identifiable geological/topographical feature that rise greater than 100 m above the surrounding seafloor in any depth of water, whether they are stand-alone features or part of a range” (MoF 1999b).

of seamounts. The MoF in 2001 refused to consider the impacts of trawling, but has foreshadowed future attention to this issue (MoF 2001b).

3.11 ITQs and perceptions of legitimacy

One subtle but powerful influence of the QMS and ITQs in New Zealand has been the effect on perceptions of the legitimacy of various claims to the marine environment and fish. The question of who, if anyone, actually owns the fish remains unresolved¹¹ but it is clear from the *Fisheries Acts 1983* and *1996* that the Crown, on behalf of society, allocates access to fish. These allocations are to customary, scientific, recreational and commercial fishers. Environmental obligations are recognized in the *Purpose (s8) and Environmental Principles (s9)* of the *Fisheries Act 1996* but are not systematically implemented. There are obligations to consult with environmental and harvesting interests (s12) when catch limits and setting of controls are to be decided.

The articulation of rights under the QMS in the form of ITQs has led some to believe that these commercial property rights trump other harvesting rights or those of the rest of society to an intact environment. This has led to the intensification of the power of the fishing industry and, for many years, to the neglect by the Ministry of its environmental responsibilities. For instance, after the passage of the *Fisheries Act 1996*, both industry and Ministry staff frequently referred in meetings to the environmental and future-regarding aspects of the *Fisheries Act 1996* as “the religious bits”. The Ministry treated these aspects as discretionary and did little to implement them. The Ministry has also allowed fish stocks to drop well below the legal target of “at or above a level that can produce the maximum sustainable yield..”(s13(2)a), and continues to allow fishing despite catches exceeding these limits, often for several years in a row.

The lack of resources on the part of the environmental movement in New Zealand, which lacks the infrastructure of grant making foundations found in most developed countries, has left the environmental organizations unable to challenge the deficiencies of the Ministry in court. In contrast, industry interests have been quick to challenge the Ministry in Court. Since the *Fisheries Act 1996* environmental and recreational groups have yet to challenge the decisions of Minister of Fisheries or the MoF. In contrast the fishing industry has taken the Minister of Fisheries to the High Court (and the Court of Appeal) on a wide range of issues including the:

- decision to prohibit trawling on 19 seamounts
- decision to prohibit trawling for squid around the Auckland Islands after a limit on the number of New Zealand sea lions that can be drowned in that fishery is exceeded (Young 2003)
- decision to prohibit the use of set nets of part of the West Coast of the North Island to protect the critically endangered North Island Hector’s dolphin (Young 2002)
- decision to reduce the catch limit for northern snapper (Tipping 1997) and
- concurrence on a marine reserve proposal near Gisborne, North Island (Thomas, Ellis and Doogue 2001).

Industry opposition to the inclusion of other parties in discussions on fisheries management is indicated by the advice from the MAF to the Minister of Fisheries (2 August 1990, MAF 1990). This records industry opposition to the addition

¹¹ In New Zealand there is no clear articulation over who, if anyone, actually owns fish. It is no one, the Crown or Maori. The Treaty of Waitangi acknowledges the rights of Maori to the “full exclusive and undisturbed possession of the Lands, Estates Forests Fisheries and other properties so long as it is their wish and desire to retain the same in their possession” (Art 2, part 1, English version). In the English version, Article 1 has Maori ceding sovereignty to the British Crown. When Maori challenged the Crown over the establishment of the Quota Management System, Maori settled for 10 percent of the quota, a half share of the Sealords company and 20 percent of future fisheries allocations. For discussion of the politics of the debate in New Zealand over the Treaty, see Sharp (1990).

of recreational fishers, Maori and environmental groups to the TACC Advisory Council.

3.12 Spatial management and spatial property rights

Fisheries quota is issued by QMA, which are large areas and are not ecosystem or ecologically coherent areas. Neither does such right of access to harvest provide any exclusive rights over either space or fish. Access to fish using quota specified by area was never intended to convey a priority right for commercial fishers over recreational or customary harvesters. Over time however, some in the fishing industry have come to see their quota based rights as having priority over other fishers and providing more exclusivity than its specification provides. Industry attempts to challenge the right of the Minister of Fisheries to allocate greater proportionate shares of snapper to recreational fishers failed in the Court of Appeal (Tipping 1997) who found that the Minister could vary the proportion of the TAC between commercial and recreational interests.

The power to create marine reserves was established by the *Marine Reserves Act 1971* and the protection of marine mammals was instituted by the *Marine Mammals Protection Act 1978*, both pre-dating the QMS and not repealed by the *Fisheries Acts 1983 or 1996*. Commercial fishing interests have argued that they should be compensated for the creation of marine reserve, marine mammal sanctuaries, and other protective measures (NZ Seafood Industry Council 2002b, 2003).

As commercial fishing has come into conflict with both recreational fishing and aquaculture, commercial fishers have also attempted to portray their rights as prior to other activities and have again demanded compensation for others' use of fish and marine space (Harte and Bess 2000, Froude 2001). Fishers have also proposed that their rights are spatially defined or that they should be (McClurg 2002). This would give fishers greater powers to object to other interests and gain "compensation" if their rights are infringed.

4. STATE OF THE NEW ZEALAND DEEPWATER STOCKS

4.1 Overview

Many deepwater species can be categorized as long-lived and of low-productivity. The main deepwater commercial species are slow to mature and long lived in the absence of fishing with values for natural mortality below 0.1. The biology of ribaldo is not well described, with no estimates of age or natural mortality (Table 2). Hoki is added to the table just for comparison as a species that is faster growing and has moderate natural mortality. All four deepwater species are long-lived. Orange roughy, black oreos and black cardinal fish have estimated maximum ages greater than 100 years. All deepwater species are estimated to mature at ages greater than 20 years and to have low levels of natural mortality. The values of von Bertalanffy K^{12} are similar to the slowest growing galeoid sharks (Musick 1999). This makes the main deepwater species targeted by commercial fishers vulnerable to over-exploitation and is further reason why precautionary catch limits should be set when considering the uncertainty in assessments of stock status or yields.

The ranges of parameter estimates for orange roughy and oreos shown in Table 2 represent the range of estimates derived from assessments of these species in different quota areas. There is much uncertainty about recruitment variability in both orange roughy and oreo stocks.

¹² Von Bertalanffy "K" is the parameter in the von Bertalanffy growth model that describes how a fish grows towards a theoretical maximum length or weight. K describes the speed at which a fish reaches that maximum.

Table 3 provides times series of catch history. Orange roughy, discussed in Section 4.6, shows a decline from the peak catches in the 1980s to levels less than a third of these catches.

TABLE 2
Estimates of biological parameters for key deepwater species Annala *et al.* (2003)

	Orange roughy	Smooth oreos	Black oreos	Black cardinal fish	Hoki*
Natural mortality (M)	0.045	0.063	0.044	0.034	0.25–0.3
Age at recruitment (yr)	23–29	21	Unknown	45	1–7
Age at maturity (yr)	23–29	31	27	45	4–5
Max age (yr)	120–130	86	153	100+	20–25
Von Bertalanffy k:					
Female	0.061	0.047	0.043	0.034	0.161–0.213
Male	0.070	0.067	0.056	0.034	0.232–0.261
MCY ¹³ (%B ₀)	1.47–1.51	1.6	Unknown	Unknown	Unknown
B _{MAY} ¹⁴ (%B ₀)	30	21–25	27–29	Unknown	Unknown

* Hoki is included for comparison. MCY is the maximum constant yield, a proxy for MSY (maximum sustainable yield). B_{MAY} is the biomass the biomass that will support the maximum average yield. The von Bertalanffy k figure shows that the main deepwater species have growth rates a third to a quarter that of hoki.

TABLE 3
Summary catch history of deepwater species Annala *et al.* 2003

Year	Orange roughy (t)	Smooth oreos (t)	Black oreos (t)	Black cardinalfish (t)	Ribaldo (t)
1982-83	48 207	5 022	8 237	79	225
1986-87	52 332	9 182	5 349	1 816	126
1991-92	37 013	11 903	7 277	1 839	675
1996-97	16 645	13 148	8 607	4 567	1 824
2001-02	14 381	13 003	4 565	2 840	1 312

4.2 Oreos

Soviet Union vessels dominated the early oreos catches targeting black oreos, but there has been a switch to domestic vessels targeting smooth oreos. In later years in Southland and on the Southern Plateau there was some fishing by chartered Korean and Norwegian vessels (McMillan *et al.* 2002). There has also been an increase in oreo catches since 1992 associated with greater targeting of orange roughy in areas south of the Chatham Rise (MOF 1996, Coburn, Doonan and McMillan 2002). These are areas with relatively higher oreo bycatches.

The catch trends for oreos have risen, though not evenly. The QMAs do not fit with stock boundaries (see Figure 2). The OEO1 QMA is made up of four main fisheries:

¹³ MCY - maximum constant yield - The maximum constant catch that is estimated to be sustainable, with an acceptable level of risk, at all probable future levels of biomass. See <<http://www.fish.govt.nz/sustainability/research/stock/guide.htm>>.

¹⁴ The MAY is the long-term average annual catch when the catch each year is the CAY. With perfect knowledge it would be possible to do better by varying the fishing mortality from year to year. Without perfect knowledge, adjusting catch levels by a Current Annual Yield (CAY) strategy as stock size varies is probably the best practical method of maximizing average yield. The CAY - the one-year catch calculated by applying a reference fishing mortality, F_{ref} , to an estimate of the fishable biomass present during the next fishing year. F_{ref} is the level of instantaneous fishing mortality that, if applied every year, would, within an acceptable level of risk, maximise the average catch from the fishery (same source as for footnote 13).

Southland, Puysegur, Snares and Wairarapa. The Wairarapa fishery is 500 km north of the Southland fishery. The OEO3A stock and the shallower waters of the Chatham Rise lie in between. The Southland fishery also covers part of OEO3A. This creates problems in establishing sustainable catch limits for these fisheries.

Stocks Assessments have so far been undertaken for OEO3A smooth and black oreos and OEO4 smooth oreos (Annala *et al.* 2003) and a 2003 stock assessment for smooth oreos in Southland fishery (OEO1) (Table 4) (Coburn, Doonan and McMillan 2003). The OEO3A assessments resulted in a staged reduction in the OEO3A catch by over 60 percent from 1996 to 2001. The industry opposed initial reductions (MoF 1996). The TAC for OEO6 (sub-Antarctic) was increased by the Minister of Fisheries in 1996 from 3 000 t to 6 000 t after advocacy from the fishing industry (MOF 1996). This increase occurred against the advice of the MoF and without any stock assessment advice or a proposal for an adaptive management programme (MOF 1996). Since the 1983 deepwater allocation, oreos have been managed as one species group despite being in fact three distinct species. Since the 1983 decision to manage these as one-stock fishery, scientists have argued for their separation into separate quota stocks and species (McMillan 1985). This advice has been repeated in subsequent stock assessment plenary reports (e.g. Annala *et al.* 2002, 2003) but managers have been slow to act on this recommendation.

The then Minister of Fisheries in 1996 recommended that work be undertaken to split the oreo species and to manage these separately from 1998 (Minister of Fisheries

TABLE 4
State of oreo stocks by area and species as a percent of the unfished biomass and the current catch limits and estimated yields in 2003

Fishery	Current stock as % of unfished biomass	TACC or sub-area limits for 2003/2004 (t)	Estimated current annual yield ¹⁵ (t)	Estimated long-term maximum constant yield (t)
OEO1 Southland				
black oreos	Unknown	5 033	Unknown	Unknown
smooth oreos	30		440	310
Other areas				
smooth oreos	Unknown	2 500	Unknown	Unknown
black oreos	Unknown		Unknown	Unknown
OEO3A				
black oreos	20-24*	2 500	1 400 – 2 100	1 200 – 1 600
smooth oreos	21		880	1 400
OEO 4				
black oreos	Unknown	7 000	Unknown	Unknown
smooth oreos	55*		7 700	4 200
OEO6				
black oreos	Unknown	6 000	Unknown	Unknown
smooth oreos	Unknown		Unknown	Unknown

B_{MSY} is interpreted as B_{MAY} which is 21-25% B_0 for smooth oreos and 27-29% black oreos and B_{MCY} ¹⁶ which is 34-48 percent B_0 for smooth oreos and 27-29 percent black oreos (Annala *et al.* 2003).

* Mature biomass. (Annala *et al.* 2003; Coburn, Doonan and McMillan 2003).

¹⁵ CAY – current annual yield – this is the estimate of the maximum sustainable catch for one-year catch in reference to a reference level of fishing mortality that if applied every year and within an acceptable level of risk would maximise the average catch of the fishery.

¹⁶ B_{MSY} is the biomass that would support fishing at the maximum sustainable yield. B_{MCY} is the biomass that would support fishing at the long-term maximum constant yield (MCY).

1996a). This was not done by the Ministers of Fisheries apart from the establishment of a voluntary catch limit applied to smooth oreos in the South-West Chatham Rise (OEO3A) from 1998. No other sub-area or species limits apply for oreos. A proposal to limit black oreos catches in the South-East Chatham Rise (OEO4) was rejected by the Minister of Fisheries and the fishing industry in 2003 (MoFs 2003a, Minister of Fisheries 2003b). There is little evidence that precaution has motivated stock management of this species, shown vividly by the lack of industry pressure to manage the stocks separately and managers' refusals to set separate catch limits despite scientific recommendations.

4.3 Cardinal fish

The increase in black cardinal fish catch since 1982 is due to the targeting of this species in QMA2 and the bycatch associated with increased orange roughy catches in Area 1 in the 1990s. Catches of cardinal fish peaked in the 1996–97 fishing year. A stock assessment was completed in 2001 for cardinal fish in QMA2 (Field and Clark 2001) but was not accepted by the Stock Assessment Plenary (Annala *et al.* 2001). Catch rates (t/tow) have dropped by three-quarters since the peak rates of 1990–91. The fishing industry has not proposed catch reductions despite these dropping catch rates.

4.4 Ribaldo

Ribaldo was first reported to have been caught in significant numbers (up to 4 920 t) in the mid-1970s by Japanese and Korean longliners (Annala *et al.* 2003). In the 1980s most of the catch was taken as bycatch in the hoki, orange roughy and ling fisheries. Since the 1990s catch as bycatch in domestic longline fisheries has increased. Ribaldo reported catch history is likely to be an under-estimate of the total catch prior to 1998 due to possible discarding (Annala *et al.* 2003).

4.5 Orange roughy

Orange roughy serves as a further test of the thesis that property rights in the form of ITQs have provided an incentive to maintain stocks. As outlined in Section 2.2 economic theory suggests discount rates drive incentives to harvest. Property rights do not cancel such incentives. The evidence is largely supportive of this contention. As noted by Starr, Annala and Hilborn (1998) the fishing industry has vigorously contested proposed catch limit reductions (see also MAF 1990). It has required pressure from environmental organizations and at times strong-minded officials and, or, ministers to achieve TACC reductions. Stock assessment working group rules that prevent these bodies from making recommendations of catch limit changes have prevented scientific peer review of proposed TACs and TACCs. Over several years, at the request of industry, industry scientists and others who were attached to “stakeholders” were allowed to attend the meetings to recommend catch limits, but not the government stock assessment scientists who alone were deemed to have a vested interest.

As shown in Table 5 there have been rapid declines in orange roughy catches – as theory would predict. Graphs by Francis and Clark (2005) (Figure 3) show there has been a rapid and severe decline of most orange roughy stocks. The dotted line shows the target management reference point, defined in the Fisheries Act as B_{MSY} and established for management purposes as 30 percent of virgin (unfished) biomass. B_{MSY} is interpreted as B_{MAY} which is 30 percent B_0 or 51 percent B_0 for B_{MCY}^{11} for orange roughy). More detail is available in stock assessment papers – Annala *et al.* (2003), Clark (2001), Francis and Clark (2005), and Table 5.

Data in Table 5 are based on stock assessment information in the 2003 stock assessment plenary report (Annala *et al.* 2003). Clark's graphs (Figure 3 and his 2005 paper) summarize the estimated change in stock size over time. The estimates use the results from base case model runs unless there was no base case. In this event a range

TABLE 5

State of the orange roughy stocks by area as a percent of the unfished biomass (B_o), current catch limit and estimated yields at 2003

Fishery and QMA	Current stock as a % of unfished biomass (B_o)	TACC or sub-area limits for 2003/2004 (t)	Estimated current yield (t)
ORH 1 – Mercury-Colville – Ohena Box	10 – 15	30	16 to 29
Other areas	Unknown	1 370	Unknown
ORH 2A – North/East Cape	24	200	370
ORH2A (South), 3A and 2B – East Coast North Island	11	800	750
ORH3B – NW Chatham's Rise	21 – 44	2 000	930 – 2600
NE & E Chatham's Rise	34 – 54	7 000	7 800 – 11 800
South Chatham Rise	24	1 400	1 540
Puysegur	7	Closed	90 – 340
Southern areas	Unknown	1 300	Unknown
ORH 7A – Challenger	3	Closed	220
ORH 7B – West Coast South Island	12	120	120

* B_{MSY} is interpreted as B_{MAY} which is 30% B_o or 51% B_o for B_{MCY} ¹¹ for orange roughy.
Source: Annala *et al.* 2003.

of the model run results is presented. The stock assessment results indicate that for all but two areas the stocks have been reduced below B_{MAY} (30 percent B_o). In one case (Challenger ORH7A) the stock was fished to three percent of its unfished size. Fishing was not closed before this despite protests from environmental organizations. The Challenger fishery was closed by the (then new) Minister of Fisheries in 2000. The fishing industry finally agreed to close the Puysegur fishery (part of ORH3B) in 1997 when that stock reached an estimated seven percent of its unfished size. This overfishing continued despite protests from environmental organizations.

With the exception of ORH1, these fisheries have gone through a series of catch reductions. Most of these reductions have been opposed by the fishing industry (MAF 1991, 1992, 1993, 1994b and MoF 1995, 1996, 1997b, 1998, 2000a, 2001a, 2002a, 2003a). The Chatham Rise orange roughy fishery started in the early 1980s and provided over 90 percent of the orange roughy catch in 1981–82. This fell to just over 40 percent of the catch in 1991–92 and made up nearly 70 percent in the 2001–02 fishing year. These changes reflect the discovery of new orange roughy fishing grounds and then their subsequent over-fishing as fisheries declined throughout the New Zealand EEZ in the 1990s.

On the South Chatham Rise there appears to have been a sequential depletion of hill aggregations as the fishery moved further east and catch rates on hills fished in earlier years declined (Clark 1999, Francis 2001). Declines have occurred in the face of successive warnings from scientists. Frequently managers have moderated recommendations by scientists for TACC cuts (e.g. MAF 1990) and have largely resisted calls by environmental organizations for cuts¹⁷.

4.6 “Hard” vs “soft” landings

Management of the orange roughy fisheries have been characterized by an absence of precaution. The fishing industry has on numerous occasions over the last 15 years been

¹⁷For example, ECO 31/8/90 letter to Minister of Fisheries; p. 9 re: Challenger; Forest and Bird 1990, 27 Sept. 1990. Media Release.

asked by the Minister of Fisheries to choose between large decreases in catch (“hard” landings) or small sequential decreases in catch (“soft” landings). The fishing industry has preferred to take higher catches and accept large catch reductions in future years. For example, in 1996 the fishing industry indicated in submissions that they would prefer a hard landing for the management of the 2A North fishery (MoF 1996, 2000b). As Table 5 indicates, the fishery was estimated in 2003 to be reduced to 24 percent of its unfished size and below the minimum target of 30 percent.

Legal requirements for management at, or above, B_{MSY} (Section 13, *Fisheries Act 1996*) have often been ignored despite environmental group protests and scientists recommendations. The MoF regards the requirements in the *Fisheries Act 1996* as a “target” and not a limit. Environmental organizations have been unable to afford legal action apart from a case taken by Greenpeace in 1995 on Chatham Rise orange roughy catch limits (Gallen 1995).

4.7 Case study: East Coast North Island

In 1996 the MoF proposed a review of the 2A North fishery. The industry proposed maintaining the 3 000 t catch limit but the Minister cut the catch limit by 500 t to 2 500 t (MoF 1996, 1996b). In 1998 the Minister reviewed the catch limit for 2A North again. The industry advocated again retaining the catch limit. The Minister, under pressure from environmental advocates, agreed to cut it by another 500 t to 2 000 t (Minister of Fisheries 1998b).

In 2000 the Minister of Fisheries proposed a phased reduction of the East Coast North Island fishery TACC (ORH2A South, 2B and 3A) (Minister of Fisheries 2000a, 2000b), which the fishing industry opposed. Instead they suggested “shelving” 1 500 t of quota, which they would not fish against, but which would remain on their balance sheets. The industry advocated retaining the 2A North catch limit of 500 t (MoF 2000). The Minister agreed to a phased reduction and reduced the combined TACC for ORH2A, 2B and 3A from 4 600 t to 1 700 t, including a cut to 200 t for the ORH2A North fishery (Minister of Fisheries 2000b).

In 2001 the MoF proposed a further reduction in the fishery TACC on the East Coast of the North Island. The 2001 stock assessment estimated the stock could be around 11 percent of its unfished size (base case). Catch reductions were opposed by the fishing industry (MoF 2001a, 2002a). The Minister retained the TACC for a year, but in 2002 reduced the TACC to 800 t (Minister of Fisheries 2002) but did not close the fishery despite the requirements of the *Fisheries Act 1996* that stocks be maintained at, or above, B_{MSY} . This is set at 30 percent for orange roughy, yet stocks had already fallen to 11 percent of B_0 .

4.8 The Challenger orange roughy fishery

The Challenger fishery has had two major reviews. The first occurred between 1989 and 1990 and second occurred in the late 1990s as it became evident that the stock was not rebuilding and further catch reductions were required.

In 1998 the MoF proposed a review of the Challenger fishery (ORH7A) after declining catch rates and the biomass was estimated as 15–19 percent B_0 (mid-season 1997–98) (Annala *et al.* 1998). The fishing industry opposed any changes to catch limits (MoF 1998). The Minister cut the TACC from 1 900 t to 1 425 t and indicated that he would impose a further reduction in 1999 unless contrary assessment information became available (Minister of Fisheries 1998b). In 1999 the Minister decided on a much reduced fisheries sustainability review process. The Challenger fishery was not reviewed and no cuts were made.

In 2000 the Minister of Fisheries reviewed the fishery on the basis of new stock assessment advice which indicated the fish stock was around three percent of its unfished size (Annala *et al.* 2000). Fishing industry submissions supported catch

reductions to a TACC of either 500 t or 750 t but opposed the closure of the fishery (MoF 2000a). The Minister of Fisheries agreed to set a TACC of one tonne effectively closing the fishery (Minister of Fisheries 2000b).

4.9 Small deepwater stocks

The sustainable yields for small deepwater stocks and those taken by bycatch are notoriously hard to assess and are easy to overfish. There has been an absence of precaution in managing these stocks. Two examples are the Southern ORH3B and the ORH1 Bay of Plenty stocks.

4.10 Southern orange roughy (ORH3B) stocks

The potential yields of the orange roughy fisheries in QMA ORH3B south of the Chatham Rise, except for the Puysegur stock, have not been estimated. The catch limit for the area south of the Chatham Rise is 1300 t. In the 1996–97 fishing year it was 5000 t. As reported in Annala *et al.* (2003), the unfished biomass required to support a catch limit of 1300 t at the long term MCY level would require an exploitation rate of 1.51 percent of the unfished biomass based on estimates from the Chatham Rise. The unfished population size to support this would be around 86 000 t (Table 6). This implies an unfished stock size equivalent to the estimated Challenger (ORH7A) (91 000 t) or the South Chatham Rise (95 000 t) orange roughy stocks. This size of unfished orange roughy biomass is unlikely given recent catch history, which, except for the closed Puysegur fishery, has seen relatively small catches. The fishery that developed west of the Antipodes Islands rapidly declined from 3 400 t in 1995–96 to just one tonne in 2000–2001 (Clark, Anderson and Dunn 2003).

TABLE 6
Unassessed orange roughy fisheries

Fishery and QMA	Current catch limit	Implied B ₀ * (MCY)	Implied B ₀ * (MAY)
Sub Antarctic (ORH3B)	1 300	86 000	65 000
Northern (ORH1)	1 370	93 000	71 000

* B₀ required to support this level of MCY or MAY.

4.11 Adaptive management

New Zealand started an adaptive fisheries management programme (AMP) in 1992. Fishers were allowed to fish against higher catch limits for stocks where the sustainable yields were unknown in exchange of the quota holders paying for extra research. The AMP has had a patchy history for deepwater species. Only two deepwater stocks have been covered – oreos in Area 1 and orange roughy in Area 1.

The Oreo Area 1 (OEO1) TACC was increased by 20 percent in 1992 on the basis that extra research and monitoring would be carried out by the industry to help assess the stock and potential yields. In 1996 the Minister of Fisheries noted that “with the withdrawal of the Puysegur trawl survey there is now little current monitoring of the OEO1 adaptive management increase” (Minister of Fisheries 1996b). In 1997 the MoF recommended that OEO1 be removed from the AMP because the “agreed monitoring programme is not in place for this stock” (MoF 1997b). The Minister decided, after receiving submissions, to permit the Orange Roughy Management Company to retain the increased TACC for another year to allow the industry to propose a new monitoring programme (Minister of Fisheries 1997). In 1998 the Orange Roughy Management Company agreed that an AMP for OEO1 was not possible and proposed an exploratory fishing programme (MoF 1998). The Minister decided instead to cut the TACC back to the level prior to the increase in 1992 and deferred the exploratory

fishing proposal (Minister of Fisheries 1998a, b). Overall, no new stock assessment research information resulted from the AMP between 1992 and 1998.

Orange roughy 1 (ORH1) has been through two AMPs. The first started in 1995 and ended in 2000 with an assessment that estimated that the Mercury-Colville-Ohena box orange roughy stock size had been reduced to between 10 and 25 percent ($\infty = 0.05$) of the unfished population (see Table 5). If a decision rule had been used as originally proposed, then the TACC could have been cut in 1998 after a low stock estimate from the trawl survey. This was not done. In a further risky move a third industry-run trawl survey was delayed a year in 1999 after an industry request to the Minister and Ministry and was not undertaken until 2000. This third trawl survey confirmed the 1998 decline. Through the *Fisheries Act 1996* requires stocks to be managed at, or above, B_{MSY} there has been no closure of this fishery despite the stock now standing at about 10–15 percent B_o (Annala *et al.* 2003).

The second five-year AMP started in 2001 with a total catch limit set at 1 400 t and a range of area and feature sub-limits. A catch limit of 30 t was set for the Mercury Colville “Box” (Minister of Fisheries 2001). The implementation of this AMP has been of concern to the Minister (Minister of Fisheries 2003b) who stated that he was “particularly concerned that the catch limit for the Mercury-Colville box was significantly exceeded in the 2001–02 fishing year, despite assurances that this would not occur.” The 30 t catch limit for this box was exceeded in the 2001–02 fishing year with a reported catch of 116 t and it was exceeded by 14 t in the 2002–03 fishing year. The Minister agreed to review this AMP and whether it should continue in 2004. On the basis of this history we conclude that the AMPs for deepwater fisheries have not been a great success.

4.12 Overall review of state of deepwater stocks

The process of fisheries stock management, on paper, appears to have been diligent. Between 1990 and 2003 there were over 55 reviews of orange roughy stocks and 15 reviews of oreo stocks. But responses to the evidence of stock declines were sluggish and catch limit cuts were too slow. Interest groups were only allowed to make submissions on TACC changes from 1990 though the QMS began in 1986. Five changes in catch limits in oreos and orange roughy involved an increase in catch limit and all but two of these were due to the Minister of Fisheries agreeing to an adaptive management programme.

After fishing in the deepwater for 20 years, most of which was regulated under the quota management system, all but two of New Zealand’s assessed orange roughy stocks are below the size that would support the B_{MSY} . In one case Challenger (ORH7A) the stock has been reduced to three percent of its estimated unfished size. The two Chatham Rise stocks are currently estimated to be in a more healthy state. In the two areas, to the north of North Island (ORH1) and the fishery south of the Chatham Rise, the current catch limits are unlikely to be sustainable and do not indicate a precautionary approach is being taken by the MoF or the Minister. An overall assessment of oreos, rubyfish and cardinal fish suffers from the absence of a current stock assessment in all or most QMAs.

4.13 The effects of the QMS in New Zealand’s deepwater fisheries

In summary, the effects of the QMS in New Zealand’s deepwater fisheries include the following.

- i. As predicted by economic theory, and contrary to much optimism at the time that an ownership stake in ITQs imparts strong incentives to maintain stocks, (Environmental Defence Fund 2002), the QMS in New Zealand has not been a sufficient or even an apparent incentive to protect deepwater stocks. The stocks have declined, been “mined” or serially depleted, and fisheries managers have

- come under strong pressure to set catch limits that are too high even when stocks are well below the legal limit of B_{MSY} . In addition it has not protected the environment. The evidence presented here contradicts the claims of “success” of the QMS in protecting deepwater stocks.
- ii. In the QMS and industry-driven adaptive management programmes, fish stocks in all deepwater QMAs have declined. Even for the two stocks which are currently estimated to be above B_{MSY} on the Chatham Rise, in the space of two decades large declines have occurred and stocks are now estimated to be rebuilding.
 - iii. Other scholars have shown that the quota markets have operated with increased profitability and increased concentration of ownership.
 - iv. The dangerous practice of managing as one stock several stocks or mixed species has persisted (e.g. oreo mixes or ORH3B, which consists of several stocks) with little industry pressure to avoid this practice. The legislative means to split stocks has been included in fisheries legislation since 1996 and to split species since 1999 (all in Sections 25 to 26). To date there has been no formal proposal by the Minister of Fisheries to either split stocks or species groups.
 - v. The change to ITQs as a percentage share of TACC in 1990 removed the fiscal burden on the Government but altered the source of resistance to TACC adjustments to quota holders.
 - vi. The dubious practice of “shelving” has continued unchecked and with official sanction. This allows firms to retain “ghost” fish quota on their books while promising the Minister of Fisheries to not fish this notional quota.
 - vii. Fishing by trawling has done considerable damage (Clark *et al.* 2000, Probert, McNight and Grove 1997, Koslow and Gowlett-Holmes 1998) to the environment. Attempts to reduce environmental damage have been met by considerable resistance from fishers.
 - viii. Cost recovery has enhanced industry ‘capture’ of the MoF. ITQs in combination with “cost recovery”, have further distorted perceptions in the minds of many officials, industry and, at times, politicians of the legitimacy of quota owners compared to the environment, the other non-extractive values and uses of the environment. This has led to the use of language such as harvesters being “rights holders” while others are referred to as “other interests”.
 - ix. Windfall gains were held by first round recipients of ITQs from the initial allocation of ITQs. Inadequate society capture of resource rents followed by the lack of resource rentals has allowed quota owners to invest uncaptured resource rentals into influencing officials and politicians and so have a disproportionate voice in fisheries management¹⁸.
 - x. The MoF has yet to establish an environmental management strategy though work is underway to establish a system of environmental standards for judging harvester-written fisheries plans that are subject to ministerial approval.
 - xi. Fisheries management is being further disintegrated by stock-focused “fisheries management plans” to be done by industry.
 - xii. There is a myth of environmental commitment by the New Zealand fishing industry. The reality has been vociferous and ferocious opposition to environmental protection.
 - xiii. There has been no governmental support to non-extractive users or equal voice for others.

¹⁸ Records of attendance at consultation meetings shows that there is regularly a considerable majority of industry representatives at stakeholders meetings, with few customary Maori, recreational or environmental representatives. Industry delegations, however, frequently are not only numerous but are accompanied by lawyers, scientists and others. There are, of course, many other meetings where industry and MoF staff or the Minister meet.

- xiv. Pressure by environmentalists for ecosystem-based management with spatial dimensions is being used by fishers as a basis to extend ITQ rights into spatial property rights (McClurg 2002).
- xv. Resource rentals were replaced with cost recovery but these are conceptually different from resource rentals, which are a payment to an owner for scarce resource use while cost recovery is for management and research. In 1995–96 about 70 percent of the total MoF budget was recovered from the fishing industry. Cost recovery has been a potent instrument of industry influence on the MoF and DoC.
- xvi. The New Zealand adaptive management has failed in its promise to sustainably manage deepwater stocks.

5. CONCLUSIONS

Does theory suggest a property rights regime can be relied on to protect fish stocks and the environment of the deep sea? The short answer to this is no economic theory is clear if discount rates are higher than the net rate of growth of the capital value of the fish stock then there will be a dominant incentive to harvest the resource and to use the proceeds elsewhere. Quantity limits are important: it is vital for society that those with high discount rates are resisted. Quantity limits, if properly set and enforced, would help contain over-fishing but only if limits as such protect and are observed and enforced. Incentives to avoid damage to the environment are not provided by ITQs: harms continue to be externalized. Discounting applies as much to the slow-growing host environment as it does to fish stocks.

New Zealand's deep water fisheries have been managed by ITQs from 19983, initially as a trial, then under the QMS from 1986. Evidence from official stock assessment reports was used to examine the state of stocks including deep-sea species such as orange roughy, smooth and black oreos and cardinal fish. We asked the question, how stocks in the deep sea have fared under New Zealand's property rights based fisheries management? What protection has the marine environment had from the impacts of fishing? The evolution of some of the relevant institutions was tracked and the environmental policy and performance assessed.

The report card on stocks is mixed with assessed orange roughy stocks ranging from 3% to near 40% of the original biomass. Most orange roughy stocks and other deep water species had significant and risky declines. The environment fared little better with moves to protect it slow and reactive, not proactive. Although by 2003 2.5% of seamounts were closed to trawling, some after having been fished, there is still no systematic environmental management process. Despite quota owner companies, these stock declines and other outcomes would be expected in the light of dynamic economic theory of harvesting where discount rates are high and stock productivity low.

Fishing has continued to be allowed on stocks suffering major declines to well below B_{MSY} . Many of the stocks have effectively been "mined". New Zealand has experienced continuing pressure by fishers for catch limits that reduce stocks below B_{MSY} and officials and ministers have been reluctant to stand up to this pressure, particularly to industry litigation.

The highly defined property rights of commercial interests through ITQs, combined with the cost recovery mechanism, have resulted in considerable capture of fisheries management by these commercial interests, the evolution of institutions to benefit quota owners, marginalization of other interests and strong resistance to even basic environmental assessment or protection measures. Fishing industry representatives have successfully advocated for a reduction in fisheries research contracted by the MoF.

What lessons can be learned for the deep sea from the NZ experience? Property rights can distort the perceptions of officials, industry and politicians as to who is

the principal for whom officials and politicians becoming the agents. Officials and others lose sight that the principal is society and with the future, not the industry. Incentives for fishers to invest in lobbying and other measures to capture control of fisheries management, to contest environmental protection and to “capture” fisheries management and research remain strong.

The ITQ system, the industry capture of fisheries management and the cost recovery system have together substantially marginalized other interests in fisheries management, particularly those who want to retain higher fish stocks for non-extractive and ecosystem purposes. Institutional forms and who makes decisions on catch limits, how payment is made, and the levers of influence open to, and on, players are crucial to the management process.

Authorities should charge resource rentals and management costs and make provision for support for the expression, and defence, of policy discussions of non-extractive values of fish. This is important since these, and other non-commercial voices are likely to be swamped and marginalized by the resource rent-rich quota owning voices. Independence of research and management from pressure and influence is crucial. It is important to decouple cost recovery payments from control, or expected control, of the commissioning of research or management. Strong environmental controls continue to be needed. Property regimes do not provide effective environmental protection. Neither the theory nor the evidence of the New Zealand experience support the notion that property rights will protect the environment or slow-growing low-productivity deepwater fish stocks.

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APPENDIX

TIME LINE OF DEEPWATER FISHERIES

- 1972 Soviet fishing starts for black oreos on South Chatham Rise/Sub-Antarctic.
- 1978 200 nm Exclusive Economic Zone declared.
- 1978 Chatham Rise orange roughy fishing starts.
- 1980 Challenger orange roughy fishery starts.
- 1981 East Coast North Island orange roughy fishery starts.
- 1981 First catch limit for Chatham Rise orange roughy (3B) of 23 000 t.
- 1983 Deepwater fishing ITQs introduced.
First catch limits for oreos – Chatham Rise 3A and 4 of 10 000 t and 6 750 t respectively.
- 1984 West Coast South Island orange roughy fishery starts.
- 1986 Oreos and orange roughy move to Quota Management System and catch limits for all areas.
- 1987 Indications that catches on Chatham Rise are unsustainable.
- 1988 Orange roughy catch reported on Chatham Rise peaks at 32 700 t.
- 1989 Reported orange roughy catch peaks at over 54 000 t with the peak TAC of over 62 000 t.
Non-Chatham Rise ORH3B fishery starts at Puysegur.
Challenger ORH fishery TAC cut from 12 000 to 2 500 t.
- 1990 ORH 3B TAC cut from 32 787 to 23 787 t.
Challenger ORH fishery TAC cut twice: first from 12 000 to 2500 t and then again to 1 900 t.
- 1992–1995 Chatham Rise ORH spawning box “closed”; Puysegur ORH fishery reported catch peaks at 6 950 t.
- 1992 Start of OEO1 Adaptive Management Programme (TAC increased from 5 033 t to 6 044 t).
- 1994 East Cape ORH fishery takes off with reported catch of 3 400 t.
Mid-East Coast ORH (ORH 2A South, 2B and 3A) TAC reduced from 6 660 t to 2 100 t
ORH3B TAC cut from 21 300 to 14 000 t.
- 1995 ORH1 first Adaptive management programme starts with TAC increase from 190 t to 1 190 t.
Auckland Islands ORH fishery peaks at 1 250 t.
Chatham Rise makes up just under 36 percent of catch.
OEO3A TAC reduced to 6600 from 10 106 t.
- 1996 Antipodes ORH fishery starts with a reported catch of 3 400 t.
OEO6 TAC increased from 3 000 to 6 000 t with no stock assessment.
OEO reported catch peaks at over 24 700 t and OEO3A TACC cut for the first time to 6 600 t.
- 1997 Puysegur ORH fishery “closed”.
- 1998 OEO 1 removed from the Adaptive Management Programme.
Puysegur OEO fishery “closed”
Voluntary limit on smooth oreo catch in OEO3A introduced at 1 400 t.

- 1999 Antipodes ORH fishery ends. OEO3A reduced further to 5 900 t.
- 2000 Challenger ORH fishery “closed” with 1 tonnes TACC.
First ORH1 AMP Ends with Mercury Colville stock down to 10–15 percent of B_0 .
TAC reduced to 800 t.
East Cape (2A North) catch limit cut from 2 000 to 200 t and the Mid-east coast limit cut to 1 700 t.
- 2001 Second ORH1 AMP starts with TAC at 1 400 t.
Chatham Rise OEO catch falls below 50 percent of total oreos catch of over 18 700 t.
OEO3A TACC reduced to 3 900 t and OEO4 to 5 200 t.
- 2002 Chatham Rise ORH catch limits adjusted to increase East Rise from under 5 000 t to 7000 t – sub-antarctic catches reduced from 4 000 to 1 300 t. Chatham Rise makes up nearly 70 percent of reported orange roughy catch. Mid-East coast catch limit reduced to 800 t.
- 2003 ORH3B makes up 84 percent of orange roughy reported catch.

Management of New Zealand orange roughy fisheries – a deep learning curve

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1. INTRODUCTION

This paper presents two case studies of the management of orange roughy fisheries in New Zealand. When management measures were first introduced for orange roughy in the early 1980s, decisions had to be based on little or no information on the biology of the species or its abundance. New Zealand's orange roughy fisheries are currently divided into a number of separate fishery management units governed by both Government regulations and industry management agreements. The paper concludes with the fisheries management lessons learned from the New Zealand experience and offers suggestions on how these lessons could be applied to the management of new fisheries for orange roughy and other deepwater, slow-growing fish species.

2. HISTORY OF THE FISHERY

Orange roughy were first taken commercially in New Zealand in 1979. They are caught primarily between 700 m and 1500 m depth. They have been taken in a mix of fisheries on both hills and over flat bottom. Over ten separate orange roughy fisheries have been developed within the New Zealand EEZ since the fishery first began (Figure 1, from Clark *et al.* 2000). Numerous papers have been published describing the New Zealand orange roughy fisheries (see Clark *et al.* 2000, Francis 2001, Clark 2001 and references therein).

The early years of most fisheries were characterized by high catch rates (over 50 t a tow in some fisheries) and saturation fishing. These high catch rates lasted only a few years in most fisheries and were followed by sharp declines in CPUE. As the fisheries continued the fisheries on flat bottom areas contracted in both the total area of the fishery and the high catch rate area. Catch rates also declined on hills and serial depletion of hills was observed in some fisheries. This behaviour was observed during the fish-down phase in most orange roughy fisheries when the accumulated, unfished biomass is reduced by fishing.

Quotas were first introduced in 1983 and set at a level of about 23 000 t for all orange roughy fisheries combined. As new fisheries were discovered, the total quota

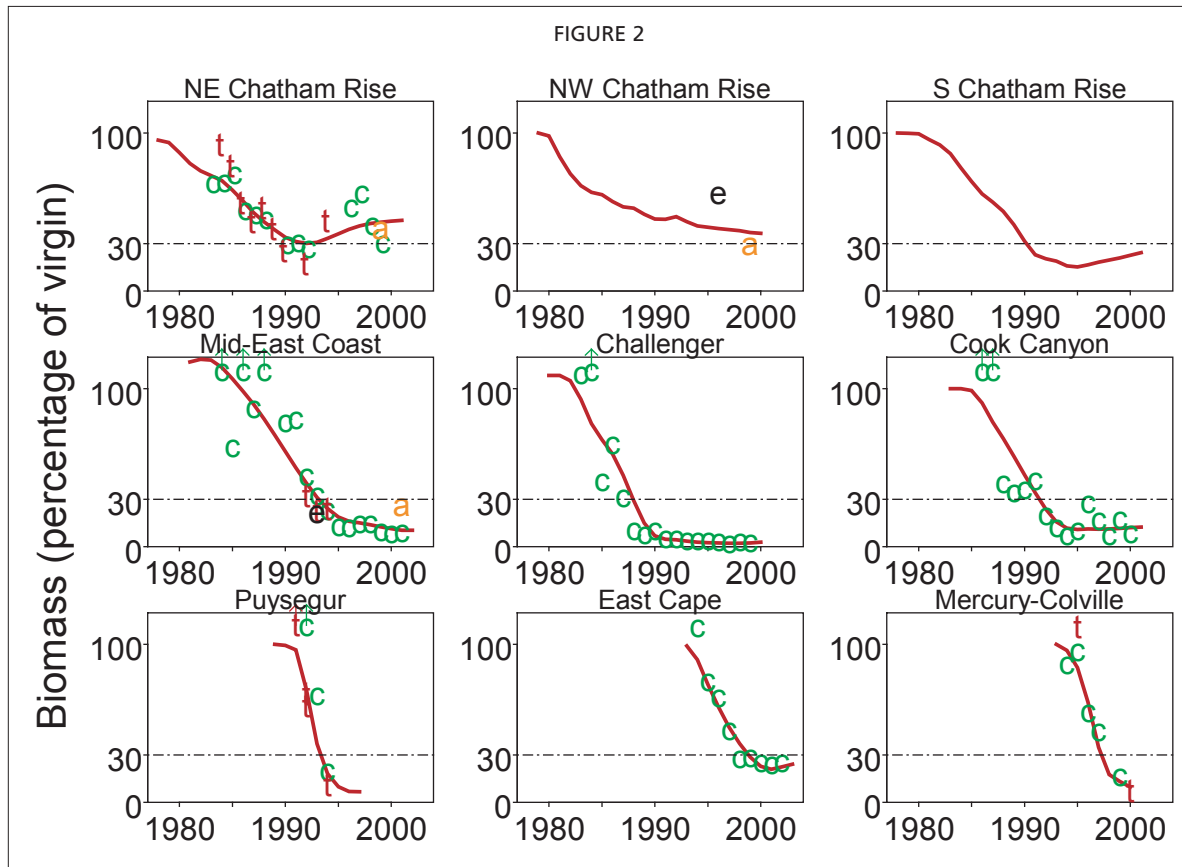
was increased, eventually peaking at about 63 000 t in 1989. Total catches from all areas combined increased rapidly, reaching about 45 000 t by 1985 and eventually peaking at about 57 000 t in 1989. Since the late 1980s total quotas have been steadily reduced as new information has been obtained on orange roughy biological parameters and abundance indices and their stock assessment methods have been refined.



New Zealand legislation requires that stocks be maintained at or above the size that will support the maximum sustainable yield (B_{MSY}), or be rebuilt to that level if they fall below them. For the nine fisheries for which quantitative stock assessments have been conducted, stock size has fallen below that target level in seven stocks (Figure 2, from Francis and Clark 2005). For all of these seven fisheries, management strategies with reduced catch limits have been implemented to promote stock rebuilding.

3. BIOLOGY

Orange roughy are estimated to be long-lived and slow growing and a number of studies indicate maximum ages are greater than 100 years (e.g. Smith *et al.* 1995, Tracey and Horn 1999). Estimates of natural mortality (M) are low, 0.04–0.05 (Francis *et al.* 1992, Doonan 1994). Estimates of age at first maturity are high, at about 30 years (Francis and Horn 1997, Horn, Tracey and Clark 1998). Fecundity is relatively low with the average female producing about 50 000 eggs per spawning (Pankhurst 1988). In addition, recruitment could be low and highly variable (Francis *et al.* 1992).



The combination of the above characteristics makes orange roughly a relatively unproductive species. Sustainable yields are low at an annual rate of 1 to 2 percent of the virgin biomass and 4 to 6 percent of the biomass that supports the maximum sustainable yield. Their predictable aggregation behaviour in time and space for both spawning and feeding makes localized populations vulnerable to overexploitation.

4. BIOMASS ESTIMATES

Four different biomass estimation methods have been used over time. The initial biomass estimates for many fisheries came from random trawl surveys. Commercial CPUE was not used during the early stock assessments because it seemed obvious that it would not be proportional to biomass. Many early fisheries were based on aggregations and it was thought that fishers would be able to maintain high catch rates while the aggregations shrunk and abundance declined. Thus, CPUE was expected to decline more slowly than biomass. However, the opposite may also be true because fishing may disperse aggregations.

Beginning in the early 1980s, egg production surveys were used in three fisheries to estimate absolute abundance (Francis, Clark and Grimes 1997, Zeldis *et al.* 1997). However, they are no longer used because of the difficulty of estimating the mortality of eggs. While acoustic surveys of orange roughy have been undertaken since the mid-1980s, the technique has only been well-developed enough to estimate absolute abundance since the late 1990s. Acoustic surveys appear promising for fisheries in which most of the stock is in mono-specific aggregations. However, they are of less value for depleted stocks where abundance is low, and for stocks widely distributed over flat bottom as opposed to being in aggregations. Target identification and target strengths of other species become difficult issues to successfully address in these latter situations. In these situations, the large number of other species found in association with orange roughy, most of which have greater target strengths than orange roughy, tend to dominate the echoes from roughy.

5. CASE STUDIES

5.1 Development of fisheries

Two case studies are presented that cover the range of New Zealand's orange roughy fisheries both in terms of their size and longevity. The fishery on the northeast Chatham Rise is both New Zealand's largest and longest running orange roughy fishery, beginning in 1979. The fishery on East Cape is one of the smallest and newest of the fisheries, first developing in 1994.

5.2 Northeast Chatham Rise

A retrospective analysis has been carried out for the fishery on the northeast Chatham Rise in ORH 3B (Francis 2001). Table A1 from Francis (2001) with the addition of information on the method of biomass estimation; the stock assessment model used; and the relevant yield estimates, catch limits, and catches are shown here as Table 1. A number of large changes have been made to the data used for the stock assessment and the assessment modelling approach during the history of the northeast Chatham Rise fishery, which have resulted in changes to estimates of biomass and yield. These were as follows.

- *Changes to the biomass estimation technique and the way the estimates were incorporated in the stock assessment model* – Trawl survey biomass estimates were the only indices used for the northeast Chatham Rise fishery before the 2001 assessment. Before 1989 they were treated as absolute estimates and since 1989 as relative indices. Acoustic biomass estimates (treated as absolute estimates of abundance) and standardized analyses of commercial CPUE were first incorporated in the stock assessment in 2001.
- *Changes to biological parameter estimates* – Probably the most important changes to biological parameters were the estimates for natural mortality (M), the average age at maturity (A_r) and the age at maturity ogive (S_r). M was assumed equal to 0.10 in the early years of the fishery before any ageing studies of orange roughy had been conducted. This was thought to be conservative given the common value of 0.2 applied to many shelf species. It was reduced to 0.04 to 0.05 in the late 1980s – early 1990s as the results of early aging studies became known. A_r was initially set to five years in 1987 and subsequently increased to 33–34 years in 1994 and then reduced to 30 years in 1997. S_r was initially set to three years in 1991, increased to 9–8 years in 1994 and later reduced to three years in 1999.
- *Changes to the stock assessment methods used* – Initially, stock assessments were based on treating the random stratified trawl survey biomass estimates as absolute, back calculating the results to obtain an estimate of virgin biomass (B_0), and using $MSY = 0.5 MB_0$ “relation of Gulland (1971) to calculate the sustainable yield. Since 1989 trawl survey biomass estimates have been treated as relative and stock assessment models have become increasingly more sophisticated. The first “model-based” stock assessment was for the Chatham Rise using a modified de Lury method (Sissenwine 1988). This was followed by deterministic stock reduction models in 1990 (Francis 1990). In 1992 this method was extended to the enhanced stock reduction analysis technique (Francis *et al.* 1992) that uses stochastic recruitment and allows the fitting of mean length data. The next major step was the development of a Bayesian stock assessment approach for the northeast Chatham Rise in 2001 (Smith *et al.* 2002). The Bayesian approach was also adopted in a model called CASAL (Bull *et al.* 2002) that was used for the first time for orange roughy in the 2003 assessment for the East Cape stock (Anderson 2003).
- *Changes to model assumptions* – There have been a number of changes to model assumptions and model structure through time, which are summarized by Francis

TABLE 1
Chatham Rise Management Data

Biological parameter estimates of natural mortality (M), average age at maturity (A_y), age at maturity ogive (S_y), biomass indices, and models used in the stock assessments; estimates of virgin (B₀) and current (B_{current}) biomass and yield estimated from the assessment models; and catch limits and catches. Year is the last year of the fishing year which runs from 1 October to 30 September, e.g. 1999 = 1 October 1998–30 September 1999. The areas that apply to the stock assessments for various years are: 1986–1990, all of ORH 3B; 1991–1995, all of the Chatham Rise; 1996–2000, Northeast and South combined; 2001, Northeast only. Catch limit and catch are only for the area of the stock assessment and take effect the year after the assessment.

Year	M	A _y	S _y	Biomass indices*	Model** MSY=	B ₀ (kt) (B _{current} as a % of B ₀)	Yield estimate***(t)	Catch limit (t)	Catch (t)
1985	0.1	-	-	T(A)	0.5MB ₀	609	MSY – 30 450	30 000	29 340
1986	0.1	-	-	T(A)	0.5MB ₀	935	MSY – 46 750	29 865	30 075
1987	0.1	5	-	T(A)	0.5MB ₀	935	MSY – 46 750	38 065	30 689
1988	0.1	6	-	T(A)	0.5MB ₀	407(24)	MSY – 20 350	38 065	24 214
1989	0.05	20	-	T(R)	dSRA	389(33)	C – 8 000	38 300	32 785
1990	0.05	23	-	T(R)	dSRA	411(19)	C – 5 500	32 787	31 669
1991	0.05	23	3	T(R)	dSRA	383(10)	C – 2 200	23 787	20 621
1992	0.04	23	3	T(R)	sSRA	473(17)	C – 3 200	23 787	15 469
1993	0.04	22.2	6	T(R)	sSRA	411(21)	C – 3 300	14 300	14 000
1994	0.045	33/34	9/8	T(R)	sSRA	416(14)	C – 3 700	14 300	13 500
1995	0.045	33/34	9/8	T(R)	sSRA	416(14)	C – 3 700	8 000	8 100
1996								4 950	5 100
1997	0.045	30	4	T(R)	SSRA	289(17)	C – 3 400	4 950	5 000
1998								4 950	6 300
1999	0.045	29	3	T(R)	sSRA	300(17)	C – 3 400	4 950	4 800
2000								4 950	5 700
2001	0.045	29	3	T(R), A(A), CPUE	sSRA BAY	373(45) 325(44)	C – 10 400 C – 9 200	4 950	5 200
2002								7 000	6 700
2003								7 000	

* T(A) = trawl survey indices used as absolute biomass estimates, T(R) = trawl survey indices used as relative abundance indices, A(A) = acoustic survey indices used as absolute abundance indices, CPUE = standardised CPUE analysis relative abundance indices.

** dSRA = deterministic stock reduction analysis, sSRA = stochastic stock reduction analysis, BAY = Bayesian stock assessment model. See text for details.

*** MSY = Maximum Sustainable Yield, Y = Yield, C = Current Annual Yield.

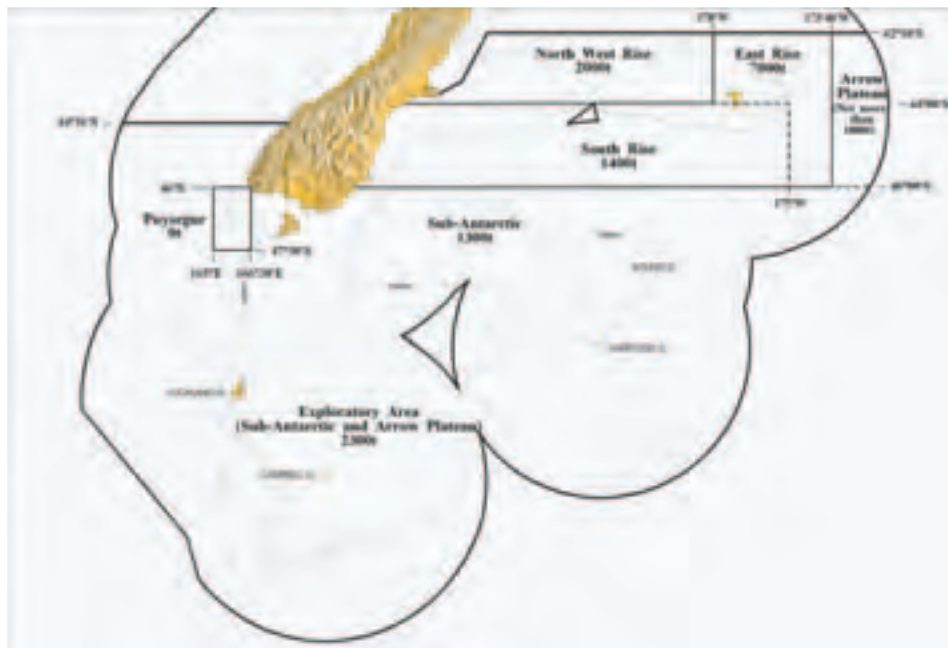
(2001). There have also been changes to the areas on the northeast Chatham Rise to which the stock assessment has been applied. From 1986 to 1990 the stock assessments were for the entire ORH 3B management area; however, because most fishing occurred on the Chatham Rise, the stock assessments effectively applied only to that area. Between 1991 and 1995 the assessments were for the entire Chatham Rise, including the Northwest, Northeast and South Rise (Figure 3). From 1996 to 2000 the assessments applied to the Northeast and South Rise combined. In 2001 the assessment applied to the Northeast Rise only. Separate assessments were carried out for the Northwest and South Rise areas, as the Chatham Rise is now assumed to have three separate stocks for management purposes.

Discussion

Stock assessments have been carried out for the northeast Chatham Rise fishery since 1985. However, as described above, there have been many changes to the models used and the data inputs over time as more knowledge has been gained about the species and the fishery. What have been the impacts of all these changes?

The retrospective analysis of Francis (2001) shows a consistent reduction in the estimates of virgin biomass through 1989, which he attributed to the short time series of data in the earlier years (Table 1). However, since 1990 there has been no consistent trend that can be attributed to the longer time series of data available for the assessment.

FIGURE 3
Southern New Zealand Orange Roughy Management Areas



Inspection of the changes to the model used and the data inputs and assumptions does not reveal any single change that lead to the reduction in the estimates during the earlier years. It is most likely that these reductions were due to a combination of factors acting in complex ways.

Between 1987 and 1988 the estimates of B_0 more than halved because of a change in how biomass was calculated from the trawl surveys (no school height adjustment was applied). In 1989 the trawl survey biomass estimates were changed from relative to absolute, the M estimate halved from 0.1 to 0.05, and A_r increased from 6 to 20 years. All these changes made little difference to the estimates of B_0 . However, the change from the use of Maximum Sustainable Yield (MSY) as the reference yield, where $MSY = 0.5 MB_0$, to the use of Current Annual Yield (CAY)¹ resulted in a substantial reduction in the yield estimate, from 20 350 t in 1988 to 8 000 t in 1989, while the estimates of virgin and current biomass changed little between those years. Between 1989 and 1991 the estimates of $B_{current}$ decreased from 33 percent of B_0 to 10 percent of B_0 . This appears to have been mainly caused first by catch levels being substantially greater than the production from the stock and second, by the effect of sampling error in the trawl survey estimates. The change from a deterministic to stochastic stock reduction analysis in 1992 made little difference to the estimates of biomass and yield.

The biggest change to the yield estimates resulted from a reduction in the estimate of B_0 from over 900 000 t in 1987 to about 400 000 t in 1988, coupled with a change to the yield estimation technique from the use of $MSY = 0.5 MB_0$ to the estimation of CAY from the deterministic stock reduction analysis and a reduction in the estimate of $B_{current}$ from 33 percent of B_0 in 1989 to 10 percent of B_0 in 1991. This reduced the estimate of sustainable yield from 46 750 t in 1987 to 2 200 t in 1991. As a result of the reduction in biomass and yield estimates in successive stock assessments during the late

¹ CAY is defined as the one-year catch calculated by applying a reference fishing mortality, F_{ref} , to an estimate of the fishable biomass present during the next fishing year. F_{ref} is the level of (instantaneous) fishing mortality that, if applied every year, would, within an acceptable level of risk, maximize the average catch from the fishery.

1980s and early 1990s, the catch limit was reduced from 38 300 t to 8 000 t over the six year period from 1988–89 to 1994–95. Since 1997 the area for the stock assessment has been reduced to the northeast Chatham Rise only, so biomass and yield estimates and catches and catch limits are not comparable to those for earlier years.

In the 2001 assessment the estimate of B_{current} increased to 44–45 percent of B_0 due mainly to the inclusion of the acoustic biomass estimates and CPUE indices in the models. The model estimates indicate that the stock is currently above the B_{MSY} target and some model trajectories suggest that it may never have been below B_{MSY} .

In summary, for the Chatham Rise fishery, as more and better information was obtained a number of positive steps were taken in the management of the fishery.

- The fishery was progressively subdivided into a number of management units that better reflected what is known about the biological stocks in the area.
- Catch limits and catches were progressively reduced during the fishing down phase of the fishery.
- It appears that the stock size has been maintained at a level near or above the target level of B_{MSY} .

5.3 East Cape

Several hill complexes in the East Cape area (Figure 1) of ORH 2A (North) were first fished commercially in 1994. The fishery has occurred mainly during the June winter spawning period. Over time a number of critical changes have been made to the data used in the stock assessment and the assessment modelling approach that resulted in changes to estimates of biomass and yield (Table 2). These are described as follows.

- *Changes to the biomass estimation technique and the way the estimates were incorporated in the stock assessment model* – Before 2000 the only biomass estimate used in the stock assessment was an absolute estimate of abundance from an egg production survey carried out in 1995 and incorporated into the assessment for the 1996–97 fishing year. This estimate was reviewed the following year and revised downwards. Relative biomass indices from a standardized analysis of commercial CPUE were first incorporated into the assessment in 2000. The base

TABLE 2

East Cape. Biological parameter estimates

Natural mortality (M), average age at maturity (A_v), age at maturity ogive (S_v), biomass indices and models used in the stock assessments; estimates of virgin (B_0) and current (B_{current}) biomass and yield estimated from the assessment models; and catch limits and catches. Year is the last year of the fishing year which runs from 1 October to 30 September, e.g. 1999 = 1 October 1998–30 September 1999. Catch limit and catch are only for the area of the stock assessment.

Year	M	A_v (y)	S_v (y)	Biomass indices*	Model**	B_0 (kt) (B_{current} as a % of B_0)	Yield estimate*** (t)	Catch limit (t)	Catch (t)
1994								6 666 ²	3 437
1995								3 000	2 921
1996	0.045	33–34	9–8	Egg, A(A) ¹	dSRA	47 (81%)	C – 2 400	3 000	3 235
1997	0.045	30	4	Egg	dSRA	36 (68%)	C – 1 400	2 500	2 491
1998								2 500	2 411
1999								2 000	1 901
2000	0.045	26	3	Egg, CPUE	dSRA	18.6 (14%)	C – 130	2 000	1 456
2001								200	302
2002								200	186
2003	0.045	26	3	CPUE	CASAL	21.1 (24%)	C – 370	200	

* Egg = egg production survey used as an absolute abundance estimate, A(A) = acoustic survey indices used as absolute abundance indices, CPUE = standardised CPUE analysis relative abundance indices.

** dSRA = deterministic stock reduction analysis, CASAL = CASAL model. See text for details.

*** C = Current Annual Yield.

¹ Biomass estimate from acoustic survey not accepted for stock assessment.

² A separate catch limit for the East Cape hills did not exist in 1993–94 and it was included in overall TAC of 6 666 t for ORH 2A.

case assessments for 2000 and 2003 used the CPUE analysis only and did not incorporate the egg production biomass estimate.

- *Changes to biological parameter estimates* – Probably the most important changes to biological parameters were those for the average age at maturity (A_r) and the age at maturity ogive (S_r). (M has always been set equal to 0.045 for the stock assessments for this fishery.) A_r was initially set to 33–34 years in 1996 and subsequently reduced to 30 years in 1997 and then 26 years in 2000. S_r was initially set to 9–8 years in 1996, and later reduced to 4 years in 1997 and then 3 years in 2000.
- *Changes to the stock assessment methods used* – The deterministic stock reduction model of Francis (1990) was used for all assessments through 2000. The CASAL model (Bull *et al.* 2002) was used for the 2003 assessment.

5.4 Discussion

The absolute abundance estimate from the 1995 egg survey was revised from 40 000 t in 1996 to 29 000 t in 1997 and was the main reason for the decrease in the estimates of biomass and yield from the stock assessments for those two years. In 2000 relative abundance indices from a standardized CPUE analysis were incorporated into the stock assessment for the first time. The base case assessment used only the CPUE indices and provided substantially reduced estimates of biomass and yield compared with the previous assessment in 1997. The alternative case used both the revised egg survey estimate and the CPUE indices. However, the six years of CPUE data dominated the single absolute biomass estimate from the egg survey in the alternative case, and the estimates of biomass and yield were similar between the two cases. Changes to the biological parameter estimates appear to have had little impact on the model estimates of biomass and yield.

The only major change in 2003 was the use of the CASAL model for the first time. The base case again used the CPUE data only. The estimate of current biomass increased from 14 percent B_0 for the 2000 assessment to 24 percent B_0 for the 2003 assessment and the CAY increased from 130 t to 370 t. The 2003 model results suggested that the stock size had been rebuilding over the previous few years.

As more and better information was obtained for this fishery, and the early catch limits and catches were determined not to be sustainable, positive management interventions were made with the catch limit being reduced from 2 500 t in 1998 to 200 t in 2001.

6. SEAMOUNTS META-ANALYSIS

A meta-analysis of data from orange roughy fisheries on seamounts and hills in the New Zealand region was carried out to determine if information from fishing on these features can be informative in predicting possible population size for new fisheries on these features (Clark, Bull and Tracey 2001). Physical attributes and catch data for orange roughy fisheries for 77 hills and seamounts were analysed as independent variables against the minimum orange roughy population size estimated from the historical level of catch taken from these features. These data were evaluated to determine if they were useful predictors of the likely safe catch level from newly developed hills and seamounts. It was concluded that data on the physical features of hills and seamounts can be informative in predicting approximate possible stock size of orange roughy on previously unfished features and can provide useful guidelines for the management of these fisheries.

7. MANAGEMENT OF DEEPWATER FISHERIES IN NEW ZEALAND

What are the main features of New Zealand's Quota Management System (QMS) that have provided the framework for managing New Zealand's deepwater fisheries?

- A fundamental, underlying feature of New Zealand's QMS is the expectation that a rights-based fisheries management system provides the proper incentives to quota holders to maintain their asset value through long-term sustainable management
- The main management objective is to maintain stocks at or above the level that will support the Maximum Sustainable Yield (B_{MSY}). Where stocks are below that target level, they must be rebuilt to at least the target level.
- A flexible management approach has developed within the framework of the QMS. The major examples of this flexibility in the deepwater fisheries have been (a) the establishment of area catch limits, often around specific features such as hill fisheries, within the Total Allowable Catch (TAC) to allow for fine-scale management and (b), the implementation of an adaptive management programme in new fisheries (e.g. ORH 1) that allows catch limits to be set at experimental levels, followed by a monitoring programme, to "test" what catch levels may be sustainable in the long-term
- TACs and sub-area catch limits are set to attain the target biomass level. During the fishing down phase TACs and catch limits may be set at levels higher than the long-term sustainable yield until the target biomass is reached. For stocks that have been reduced below the target biomass level, TACs and sub-area catch limits are set at levels below long-term sustainable yield levels to promote stock rebuilding.
- Fisheries management is supported by sound, high-quality scientific research and stock assessment, and a comprehensive enforcement programme that for the deepwater fisheries are largely paid for by the fishing industry.
- Fisheries management, research and stock assessment is largely supported by the fishing industry through purchase of additional research (e.g. acoustic surveys and at-sea biological data collection), stock assessments and assistance with Ministry contracted research (e.g. provision of catchers vessels for biomass surveys).

8. DISCUSSION

8.1 Approaches to stock assessment

Francis (2001) suggested three possible approaches to stock assessment (and the subsequent implications for provision of management advice) in data limited situations with a short time series of biomass estimates. These were

- say that we don't know where we are and that we need to wait for more data before providing stock assessment advice
- use the mode of the distribution of B_0 (rather than the mean or median) in the provision of assessment advice and
- constrain recruitment to be deterministic, which underestimates the true uncertainty but allows the early provision of advice. This was Francis' (2001) preferred alternative.

From a fisheries manager's perspective, the first alternative of doing nothing is not acceptable. We have to use the best information that is available, even when it is incomplete, and make decisions based on that information. If that information is subsequently proved incorrect, then we have to be prepared to change our decisions.

8.2 Lessons learned

What lessons have been learnt from the past 20 years of research, stock assessment and management of New Zealand's orange roughy fisheries?

- Because of their low productivity, sustainable yields from orange roughy fisheries are estimated to be low, at an annual rate of 1 to 2 percent of the virgin biomass, B_0 , and 4–6 percent of B_{MSY} .

- ii. Because of the aggregating behaviour of orange roughy, particularly on hill features and during the spawning season, it is easy to overestimate the unfished biomass.
- iii. The major scientific challenges have been to obtain reliable estimates of orange roughy life history parameters and stock size in order to estimate the yields required to move the stocks from B_0 to B_{MSY} and maintain them at that level. These challenges have required the development of innovative scientific and technological solutions to obtain estimates of biomass and productivity of these fish, which live at 800 m to 1 500 m depth, are seasonally mobile and are difficult to survey. Significant advances in biomass estimation and modelling techniques have been made in the late 1990s for the larger fisheries. Moreover, using the results of quantitative analyses such as the seamounts meta-analysis and qualitative comparisons with similar existing orange roughy fisheries, it is possible to make approximate estimates of likely unfished stock size for new fisheries. The challenge remains for managers and scientists to continue to refine these methods and to apply them to the smaller fisheries.
- iv. Given the combination of low long-term sustainable yields and difficulties in accurately estimating initial stock size, it is difficult to accurately specify a time stream of future catches and catch limits that will result in an orderly fishing down phase to achieve the target biomass. In New Zealand this has resulted in the B_{MSY} target being exceeded in many fisheries and the subsequent need to rebuild stocks back to B_{MSY} . However, it is possible to set appropriate catch limits to prevent stocks from being reduced below target levels, at least for large stocks such as the northeast Chatham Rise, given a good scientific basis for research and stock assessment and a management framework that supports sustainable management decision-making.
- v. The major fisheries management challenge is to use information on possible stock size and our knowledge about the low productivity of the species to devise an orderly fish-down strategy that satisfies both the desire for high initial catch levels and the need to ensure that the target biomass level is not exceeded. The use of fine-scale catch limits and the adaptive management programme, as is done in New Zealand, provides fisheries managers with two mechanisms that support this approach.

These lessons learnt from orange roughy can be applied to fisheries for other deepwater, slow-growing fish species. Such species would include black oreo, smooth oreo and black cardinalfish. These three species all form aggregations in New Zealand waters and elsewhere for spawning and feeding, often over seamounts and hill features and are often caught in large quantities by bottom trawling. Given that the longevity and productivity for all three species are similar to that for orange roughy, the same management approach as that proposed for orange roughy for setting catch limits for new fisheries of these species can be applied.

9. ACKNOWLEDGEMENTS

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The Namibian orange roughy fishery: lessons learned for future management

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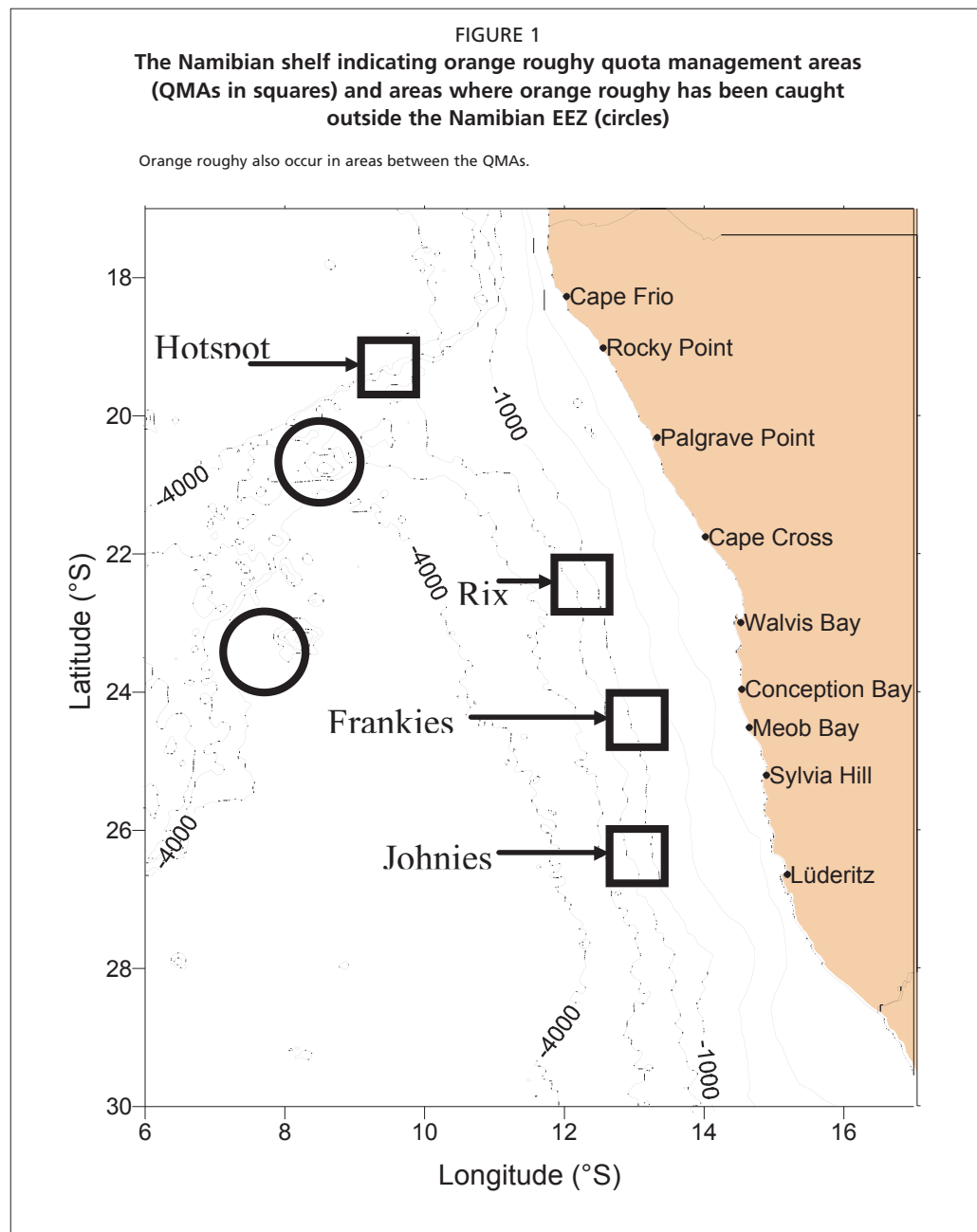
1. HISTORY OF THE NAMIBIAN ORANGE ROUGHY FISHERY

During the pre-independence period of Namibia the South East Atlantic Fisheries Commission (ICSEAF), to which 17 states were party, managed the waters off the coast of Namibia. During this period distant water vessels did most of the fishing and there was a fairly clear-cut specialization by vessels from different countries or groupings of countries in targeting certain species. It so happened that the east block (former Soviet Union) countries concentrated mainly on horse mackerel while the Iberian countries targeted hake using bottom trawls. Having used powerful, large freezer vessels and thus been able to fish at fairly great depths (500 metres plus) their vessels, from time to time landed alfonso and orange roughy as bycatch. The fact that the larger, more valuable, hake size classes tend to occur in deeper waters naturally enticed these vessels to fish at greater depths increasing the probability of landing orange roughy.

The development of orange roughy, e.g. off New Zealand and Australia and in the north Atlantic, and high-price niche it found in the market, naturally led to an interest in investigating the potential of the orange roughy resource off Namibia. As a result a large Spanish group made a search for orange roughy off Namibia, but with discouraging results. It turned out that this particular search did cover some of the grounds that later on, yielded orange roughy. It is therefore puzzling that the first attempt to establish the presence of an orange roughy resource was unsuccessful.

Soon after independence in 1992 a Namibian-based company approached the Ministry of Fisheries and Marine Resources for permission to fish experimentally for orange roughy. After an agreement was reached the company was given the approval to start fishing. One of the interesting conditions of the agreement was that should the company succeed in finding a resource it would be allocated 50 percent of any future TAC in compensation for putting at risk its capital and for its effort to find the resource. The company, Gendor, did find a viable orange roughy resource and up to now the Ministry has honoured the undertaking by allocating 50 percent of the TAC to them to reward their pioneering work.

The Ministry got involved in the research of the resource in 1995 with the formation of the Deep Water Fisheries Working Group. By mid-1996, four spawning areas had been discovered (Figure 1). The first swept-area and acoustic biomass surveys of three of these four areas were done in 1997. The Ministry, recognizing that the fishery had



the potential to become a viable commercial fishery, announced that the experimental phase of the fishery would be terminated. At the same time the then Minister of Fisheries, the Hon. H. Pohamba, invited the public to apply for rights in the orange roughy fishery.

In adjudicating the applications, emphasis was placed on the access to expertise and access to, or possession of, suitable vessels and gear to ensure that the successful applicants would be able to successfully participate in the fishery. Not surprising, therefore, that of the five successful companies, two had ties with companies active in the New Zealand and one with a French company experienced in orange roughy fisheries. This illustrates the importance the Ministry attached to having companies that would have access to the necessary expertise in orange roughy fishing. As it turned out, three companies were granted quotas while two companies were not. The granting of rights to five companies, however, bears testimony of the high expectations that existed in Namibia of the orange roughy fishery becoming a major fishery and money earner.

In 1995 an orange roughly working group was formed with participation by Namibian Resource Management staff and the three companies that received catch quotas. This working group decided to solicit inputs from the stock assessment group of the University of Cape Town in South Africa led by Professor D. Butterworth, and Dr. M. McAllister from the Imperial College of London, because the fisheries research institute in Namibia lacked personnel with sufficient numerical skills to develop suitable stock assessment models. The three orange roughly quota holders created a trust account to which they each contributed on a *pro rata* basis to the size of their quotas to fund the involvement of the Butterworth group. The Ministry also contributed to the costs and the co-funding removed the potential perception that advice by the Butterworth group could be influenced by the “he who pays the piper” principle. In the working group, management advice to the Ministry was generated that aimed at:

- establishing a proper management regime for the individual fishing grounds and
- putting in place sufficient incentives for the five companies to keep up with exploratory fishing outside the known areas. The known areas were referred to as QMAs (quota management areas).

The TAC that was announced was subdivided and allocated to be fished on the individual grounds. Any fish landed outside the QMAs were not regarded as part of the quotas (and therefore were outside the TAC). Trigger levels were set at 100 t of fish landed from an area outside a QMA after which a company could request the area to be declared an exclusive zone, which would reserve the area exclusively for the finder. After 500 t had been landed the area would be declared a QMA and the finder would be treated preferentially in regard to any quotas allocated for such an area in future. It is therefore clear that ample rewards were put in place to entice companies to spend time on exploratory fishing outside the QMAS. This was done in particular because Monte Carlo simulations indicated there to be up to ten possible fishing grounds worthy of QMA status. To date, however, only four spawning grounds have been found (Figure 1), and the likelihood of more grounds to be discovered in future is slim.

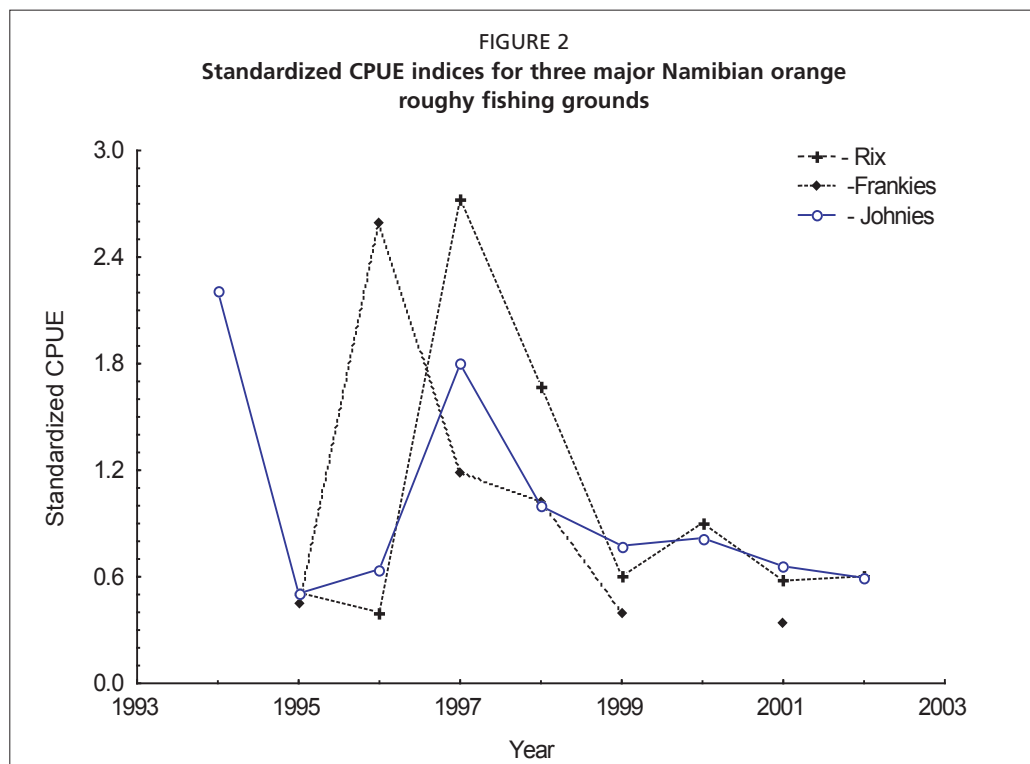
Despite the seemingly excellent incentives that were put in place, the two companies that were not granted quotas made no effort to get involved in the exploratory fishing arguing that “the best grounds would have been found first”. For the companies with quotas, to land their quotas during the winter spawning period when the CPUE is high and landing cost per ton is at its lowest, was more important than searching for new grounds. As a result not as much effort as was hoped for was directed to further exploratory fishing.

2. THE HISTORY OF CHANGES IN THE RESOURCE ABUNDANCE

When the first stock assessment was done in 1997 the biomass calculated for the QMAs was close to 300 000 t and had an associated high CPUE. In the following year there was already a reduction in the biomass estimate as indicated by the survey and the CPUEs were starting to fall (Figure 2). This downward trend continued despite the very conservative approach in management aiming at not fishing the biomass down to less than 50 percent of pristine biomass. The fishing down was planned to occur over 14 years with a “soft landing at the end when the sustainable level was to be reached.

The much reduced biomass estimates obtained by subsequent surveys caused some parties to doubt the accuracy of the 1997 biomass estimate for it was clear that the volume of fish taken out of the estimated 1997 biomass by fishing mortality could not account for the reduction in subsequent biomasses determined by survey.

If however the 1997 biomass estimate was correct and fishing mortality alone could not account for the drop in biomass, alternative hypotheses had to be formulated to explain the phenomenon. The three competing hypotheses were proposed that attempted to explain the observed drop in biomass were:



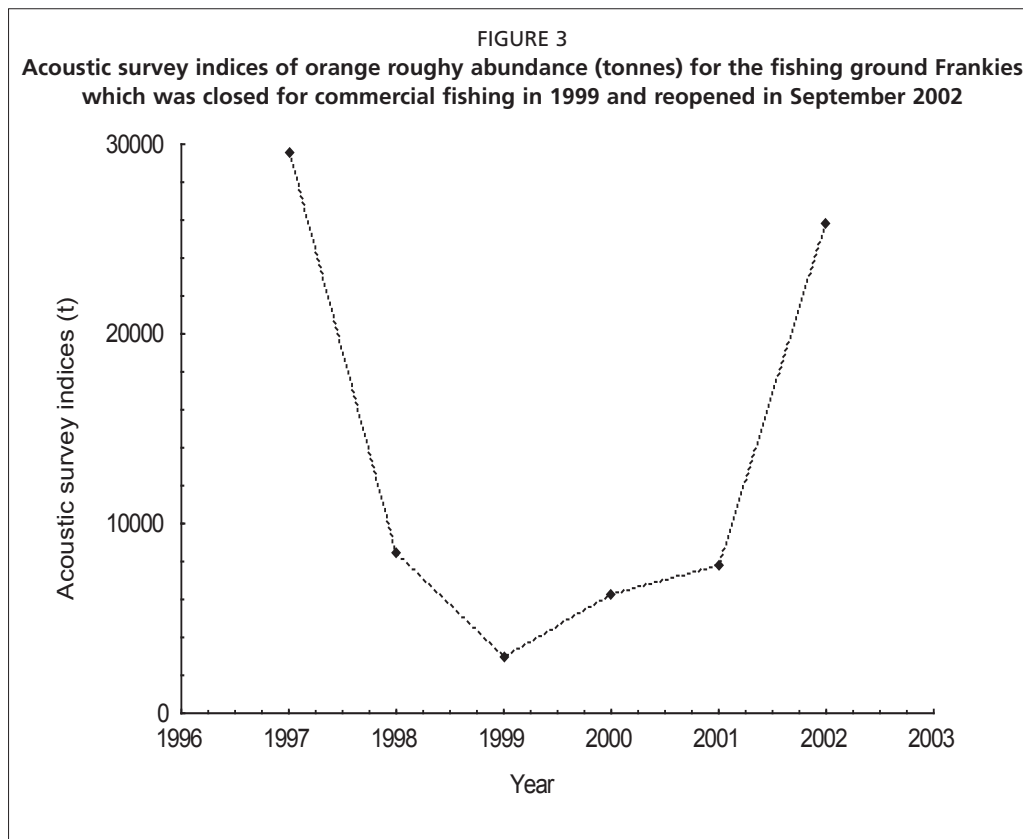
- i. fishing down
- ii. disturbance of the fish aggregations and
- iii. intermittent spawning behaviour, i.e. fish would congregate intermittently during environmentally favourable years to spawn.

To test the competing hypotheses the decision was made to close one of the grounds (Frankies) to fishing in 1999 and to monitor the abundance of fish at that location. As can be seen from Figure 3 in 2002 the biomass resurged and was back almost to the level it was at during the 1997 survey. This result almost definitely ruled out overfishing as the single cause of stock biomass reduction. These grounds are about 120 nm apart and are treated as separate populations although this could not yet be verified by detecting sufficient genetic differences between the populations.

Differentiating between the remaining two hypotheses is not easy. The fact that the 1990 search by the Spanish company did not find orange roughy may be taken as circumstantial evidence that the fish were not aggregated on the spawning grounds during that year. The return of the fish to Frankies after three years of “rest” however rather strongly points to disturbance as being the major causative factor in the much lower biomass estimates before 2002. If the return of the fish to the Frankies was mainly the result of attractive spawning conditions it should also have been evident in higher than the normal presence of fish on the other grounds. A swept area survey of the most southern ground, Johnies showed a two to three times higher biomass estimate than in previous years.

3. BEST MANAGEMENT OPTIONS

Retrospectively, it seems clear that orange roughy protects itself rather effectively from being fished out by either aggregating infrequently or by moving away from frequently trawled grounds. Inevitably, therefore, the CPUE will drop on new grounds after a few seasons. This should therefore not cause alarm. It also renders such grounds difficult to manage from the point of view of ensuring that landings are consistent, and



profitable. If it turns out that spawning is intermittent and is the major factor causing fluctuations in fish abundance the problem will become more difficult.

In such a scenario a single vessel may monitor the grounds and, if aggregating fish are found, the “make hay whilst the sun shines” principle may be the way to go. This is not a scenario that will be desired by industry for markets will be supplied with fish sporadically and fishing fleets and processing capacity will be idle for years unless it can be used for other fisheries in the meantime. This strategy, for obvious reasons, is therefore not to be seriously considered.

If disturbance, or a mixture of disturbance and intermittent spawning, turns out to be the major cause of biomass reduction, management may be based on the closure of the grounds to allow the fish to re-aggregate. Assuming a rest period of three years, at least four grounds need to be available so that a single ground can be fished each year and rest for three years. In this way relatively high CPUEs can, one hopes, be maintained and a steady, albeit small volume of fish will flow to the markets. An added advantage will be that a small number of vessels or even a single vessel will be sufficient to fish and thus the fishing can be cost effective.

This approach will be possible only once the potential of fishing grounds is known and stock assessment is sufficiently sophisticated to enable the setting of individual TAC's for the grounds. There is also an additional cost saving advantage in that once a fairly extensive data series on the grounds has been compiled a survey only needs to be done on the ground before it is opened the following season. This assessment approach may be considered, e.g. in the south Indian Ocean once a Regional Fisheries Management Organization has been established for that region. The orange roughy grounds of Namibia and the grounds presently being developed off Chile may also benefit from such an approach.

Marine protected areas (MPAs) as management tools to conserve seamount ecosystems

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1. INTRODUCTION

Understanding of the diversity and complexity of deep-sea ecosystems has developed rather slowly, principally because of the substantial difficulties in conducting research in such an extreme and inaccessible environment. Nevertheless, what was for a long time assumed to be a somewhat uniform, sparsely populated and constant environment is now increasingly recognized as a dynamic, biologically diverse and integral component of the biosphere. Initial reports of higher than expected species richness from the late 1960s have been confirmed only relatively recently by more extensive and quantitative surveys of deep-sea communities (Soetart, Haip and Vincx.1991, Etter and Grassle 1992, Grassle and Maciolek 1992, Rex *et al.* 1993).

Coupled with this general realization has come an understanding of the importance of the physical heterogeneity of the deep sea in contributing to overall diversity and species distributions. Of particular importance has been recognition of the significance of seamounts as foci for aggregation and/or higher productivity of diverse assemblages of deep-sea fauna (Wilson and Kaufmann 1987). Seamounts, rather loosely defined as geological structures rising at least 1 000 m above the seabed, have been variously described as reservoirs or “hotspots” of biodiversity, aggregation and productivity. What is clear, however, is that they represent, individually, and in combination, a vital component of the structure and processes of deep-sea ecosystems and their interactions with other biosphere compartments (Koslow *et al.* 2000, Roberts 2002).

Sadly, while our knowledge of deep-sea ecology has grown significantly over the past few decades, the technologies allowing commercial exploitation of these same environments, particularly for living resources, have developed much more rapidly (Clark and O’Driscoll 2003). This trend has been driven by a combination of increased pressure on fish stocks in shallower waters and the high prices commanded by some deepwater species. To date, most exploitation of seamount-associated fish stocks, especially of benthopelagic species such as orange roughy (*Hoplostethus atlanticus*), has been characterized by remarkably rapid development and subsequent depletion of newly discovered fishing grounds (Clark 1999, Roberts 2002, Smith 2003). This, in turn, has led to serial depletion of stocks in adjacent areas as effort has shifted in attempts to sustain catch. The task of quantifying the scale of impacts on non-target species, especially from intensive bottom trawling, has only recently begun (Koslow *et al.* 2000, Anderson and Clark 2003).

Few could argue that exploitation of benthopelagic fish over seamounts has been conducted in a sustainable manner so far. In the vast majority of cases, the diversity and vulnerability of seamount ecosystems have become apparent only after substantial, and

possibly irreversible, damage has been done. We are faced with the prospect of having lost innumerable species before they are even discovered, both from waters under national jurisdiction and from the global commons. At the same time, seamount assemblages face a diversity of other threats or potential threats, including coral collection, seabed mineral mining, waste disposal and the unpredictable impacts of global climate change (Key 2002, Glover and Smith 2003, Johnston and Santillo 2004).

Together, these various threats raise the question as to whether, and if so how, seamounts may be exploited in a sustainable manner in the future. Can we preserve the integrity and diversity of these fragile geological and biological features while allowing continued commercial exploitation, for example through further refinements of stock assessments, fishing gear and fishery management plans? Or should the case now be made that the only sustainable option is the more precautionary one of closing seamounts to most, if not all, human activities? The answer depends largely on one's judgement of the values of ecosystems and one's perception of what constitutes sustainability.

2. SEAMOUNTS AS DIVERSE AND FRAGILE ECOSYSTEMS

Because of the manner in which seamounts interact with and modify oceanic currents, their presence is commonly associated with an increase in productivity and, or, biomass, both directly over the seamount and in the surrounding waters. Higher biomass may result from enhanced primary productivity through, e.g. upwelling and entrapment of nutrient rich waters (Mouriño *et al.* 2001) or from trapping of diurnally migrating planktonic organisms as they are advected across a seamount (Rogers 1994). It seems inevitable that the precise manner in which individual seamounts enhance productivity and production will be determined by a complexity of interacting factors influencing different seamounts to different degrees (Roff and Evans 2002, Trasvina-Castro *et al.* 2003). Likewise, the extent and mechanisms by which different components of deep-sea food webs are affected by, or even depend on, the physical presence of the seamount are also likely to be highly specific to location and local environmental conditions (Dower and Mackas 1996).

It has long been recognized that many fish species are often more abundant over seamounts than in the waters surrounding them. Seamounts are known to act as aggregation zones for commercially important species such as pelagic armourhead (*Pseudopentaceros wheeleri*), orange roughy (*Hoplostethus atlanticus*), rockfish (*Sebastes* spp.) and oreos (especially *Allocyttus niger* and *Pseudocyttus maculatus*) (Clark and O'Driscoll 2003), a factor which has contributed substantially to the rapid expansion of seamount-associated deepwater fisheries. However, it is increasingly apparent that these commercially exploited species represent only a fraction of the total biomass and faunal diversity associated with seamounts.

Although research into community structure of seamount ecosystems remains limited, with most information arising from relatively few locations around the world, it is increasingly clear that even deepwater seamounts can support complex, biologically diverse and highly productive faunal communities. Because hard, rocky substrates characterize seamounts, they commonly support benthic communities dominated by suspension feeders such as corals, sea fans and sponges and so are markedly different from the fauna present in and on the surrounding soft sediments.

As Probert, McKnight and Grove (1997) note, much of the existing knowledge on the composition of seamount benthic communities to date is based on observations of bycatch in trawls for benthopelagic fish. Although such information has given an indication of the diversity of these faunal assemblages, it must be remembered that those species recovered unintentionally in commercial trawls may represent only a fraction of those present on the seafloor (Anderson and Clark 2003). The relatively few scientific surveys that have been conducted on deepwater seamounts have generally revealed

hundreds of species of benthic and benthopelagic fauna with an especially diverse invertebrate community. For example, surveys of 14 of the Tasmanian seamounts, located 170 km south of Hobart, reported a total of 279 species, 242 of which were invertebrate species and the remaining 37 fish species (Commonwealth of Australia 2002a). Similarly, a survey of just four seamounts on the Lord Howe Rise east of the Australian mainland revealed more than 100 species (Commonwealth of Australia 2002b). At the same time, there is increasing evidence that seamounts along with other distinctive geological features of the ocean floor can act as important aggregation zones for pelagic top predators, including tuna and sharks (Worm, Lotze and Myers 2003), although the efficiency of energy transfer from the benthic to the pelagic community over seamounts remains largely unknown (Commonwealth of Australia 2002a).

A characteristic of many deep-sea benthic and benthopelagic organisms is their relatively long life-histories, including lengthy times to maturity. These highly “K-selected” life histories are perhaps best described for some of the commonly exploited fish species. For example, the orange roughy is able to live well in excess of 100 years, reaching sexual maturity only after 20–30 years (Tracey and Horn 1999). Oreos, another important component of total deepwater catches in New Zealand (especially over the southern Chatham Rise), are also long-lived, with maximum ages varying from 86 years for *P. maculatus* to 150 years for *A. nigra* (Smith 2003). Some rockfish (*Sebastes* spp.) have been estimated to be approximately 200 years old (Roberts 2002). Periodic, or even sporadic, recruitment may also be a common feature (Koslow *et al.* 2000), further reducing resilience to fishing mortality or other major disturbances.

Little is known about the life histories and population age structures of most of the other benthopelagic fish which aggregate over seamounts, although it is reasonable to expect that slow growth, late maturity and relatively long life are characteristics common to many deepwater fish species. In terms of invertebrates, the hard corals and sponges, which typify many of the Pacific seamounts studied to date are likely also to be long-lived and therefore, highly sensitive to disturbance. Although few empirical data are available concerning age structures and growth rates of deepwater black and gorgonian corals, it is thought that the larger colonies on relatively undisturbed seamounts may be several hundreds of years old (Smith 2003).

Seamount communities as well as representing local “hotspots” of biodiversity also appear to demonstrate a remarkably high degree of endemism, especially among their invertebrate fauna. In one of the earliest reviews encompassing 92 seamounts, Wilson and Kaufmann (1987) estimated that an average of around 15 percent of species may be restricted to individual seamounts. More recent studies have suggested even higher proportions of endemic species. For example, Richer de Forges, Koslow and Poore (2000) reported that between 29 and 34 percent of a total of 850 macro- and megafaunal species found on seamounts in the Tasman Sea and southeast Coral Sea (including the Norfolk Ridge and Lord Howe Rise seamounts) were “new to science” and possibly, endemic to individual seamounts or ridges.

Of the 242 invertebrate forms found on the Tasmanian seamounts, only around one third have so far been identified to species level, of which as many as 20 have not previously been found in Australian waters. Of the remaining 168 species, 139 have since been identified to genus level and, of these, it is thought that more than 50 may be species previously unrecorded anywhere in the world (including representatives of seven entirely new genera). Even for the fish species recorded, as many as one third of all species, and around half of all those occupying the deeper zones of the Tasmanian seamounts, are new to Australia or previously undescribed (Commonwealth of Australia 2002a). On the Lord Howe Rise, an area well noted for its high marine biodiversity at shallower depths, approximately 30 percent of species from deepwater seamount habitats appear to have been recorded for the first time (Commonwealth of Australia 2002b). Diversity and endemism on the seamounts of the Norfolk Ridge

system further east from the Lord Howe Rise may be even higher, with as many as 17 new genera being recorded (Richer de Forges, Koslow and Poore 2000).

Moreover, in contrast to the significant overlap in species composition associated with deepwater soft sediment substrates over the Tasman and Southeast Coral Sea region, comparison of faunal assemblages from the Tasmanian and Lord Howe Rise seamounts indicates that there are no species common to both systems (Richer de Forges, Koslow and Poore 2000). Such findings suggest strongly that the geographical separation of these isolated and distinctive habitats can also result in a high degree of ecological and genetic isolation. This is undoubtedly most pronounced among those invertebrate species with relatively limited ranges of larval dispersal. For example, within the Azores seamounts system, distances of between 100 and 200 km appear sufficient to prevent the spread of larvae and egg capsules for some gastropod molluscs (Gofas 2002). Nevertheless, some localised genetic differentiation is also apparent in certain deep-sea benthopelagic fish species, even those apparently showing worldwide distribution. Hence, whereas genetic homogeneity appears characteristic for species such as pelagic armourhead (*P. wheeleri*) and smooth and black oreos (*P. maculatus* and *A. niger* respectively) (Smith 2003), genetic differentiation has been detected in some geographically isolated populations of the orange roughy (Smolenski, Ovenden and White 1993).

In summary, available evidence indicates that seamounts show high levels of biodiversity, are characterized by numerous characteristic species that are long-lived and slow to mature and may well support faunal assemblages with degrees of endemism unprecedented to science for the marine environment. Taken together, these characteristics imply that seamount ecosystems are likely to be particularly sensitive to, and slow to recover from, disturbances of any kind. Coupled to this is the important caveat that, despite recent advances in research, we still understand remarkably little even of the structure of seamount ecosystems, less still their dynamics and interactions with surrounding waters. Irrespective then of whether the high rate of identification of “new” species is a reflection of true endemism or an artefact of the small proportion of global seamount habitat so far surveyed, the sheer number of such new species, and even genera, that have come to light in recent years must surely highlight the intrinsic value in preserving these ecosystems.

3. THREATS TO SEAMOUNT ECOSYSTEMS

3.1 Seamounts effects

Because of the combined attributes of high biodiversity and sensitivity to adverse impacts, there is growing recognition of the need for protective measures for seamount ecosystems. At the same time, emerging evidence of the speed at which long-established seamount ecosystems are being profoundly impacted by human exploitation is serving to highlight the urgency with which such measures must be imposed. It is likely that seamounts and other such geologically and ecologically distinct deep-sea features will respond differently, perhaps uniquely, to the diversity of anthropogenic activities facing deepwater ecosystems now and in the future compared to the soft sediment communities typifying the majority of the deep-ocean area (Glover and Smith 2003).

3.2 Fishing

Among the various threats facing seamounts, undoubtedly the most immediate and by far the most extensively damaging to date has been deep-sea fishing, especially bottom trawling.

In contrast to coastal and shelf fisheries, deepwater fisheries over seamounts are a relatively recent development, made possible by advances in vessel design, trawl gear and equipment enabling more accurate mapping of the seafloor and location of

fish aggregations. During the last few decades, interest in exploitation of seamount-associated species has grown markedly. Ironically, the characteristic of such populations that yields the high catches per unit effort necessary to make deep-sea fishing economically viable, namely the dense aggregations of the most important commercial species, inevitably results in overexploitation of these populations within remarkably short time scales. For example, intensive fishing of stocks of pelagic armourhead over the Pacific seamounts northwest of Hawaii led to their commercial extinction in less than 20 years (Roberts 2002).

Developments in the New Zealand orange roughy fisheries illustrate a typical pattern of rapid development leading to overexploitation and the serial depletion and collapse of stocks (Clark *et al.* 2000, Clark 2001, Smith 2003). These fisheries, target orange roughy but also take a valuable bycatch of oreos (especially *P. maculatus*) and have been established for 20–30 years. During this time, fishing effort and total catch of orange roughy has focused increasingly on populations aggregating over seamounts such that by 2000 approximately 80 percent of such structures within the appropriate depth range for orange roughy had been fished to some extent (Clark and O'Driscoll 2003). Total catch for seamount fisheries in New Zealand waters stands at approximately 40 000–45 000 t a year, a high proportion of which is sustained by the orange roughy fisheries.

In the late 1970s, only one seamount in New Zealand waters had been documented to have been affected by more than 10 tows (within 10 km of its centre point); by 1999–2000 this had increased to 248 (217 of which were fished for orange roughy), with more than 100 seamounts fished in a typical year. Much of this increase occurred in the early 1990s and resulted from a combination of improved technology and declining catches on other seamounts (Clark and O'Driscoll 2003).

Typically, newly discovered stocks have been fished down to around 15–30 percent of the estimated virgin biomass within only 5–10 years of the start of exploitation (Koslow *et al.* 2000). Despite drastic reductions in total allowable catches (TACs) in many regions of Australia and New Zealand, these have all too often been incapable of preventing rapid stock decline. Although there is some evidence that orange roughy catches over certain seamounts are “relatively stable” (Clark 2001), or even that populations are beginning to increase, the periods over which observations are available are much shorter than the life-histories of the fish themselves, such that any trends must be interpreted with a high degree of caution. Moreover, even if some increases in catch have been reported, the possibility remains that such increases have resulted not from a genuine “recovery” of orange roughy populations but merely from juveniles, which previously escaped trawls, reaching sizes that render them vulnerable to capture. The irony is that in the many years, if not decades, it will take for the underlying population dynamics to be confirmed, depletion of mature individuals to levels below those necessary to sustain a population could easily occur.

Of course, the effects of deep-sea fishing are not restricted to the target species themselves, nor even to those species commonly landed as bycatch, although it is these impacts which have in the past been most visible and, because of their commercial consequences, subject to most management interest. As noted above, damage to non-target organisms in the benthic and benthopelagic zones from the passage of bottom trawls is of particular concern, especially given the high diversity, low growth rates and fragility of many sessile deepwater species.

The trawl gear typically employed in orange roughy fisheries is large and heavy and is designed to withstand being towed across the rough terrain characteristic of seamounts. Its deployment directly on the seafloor, close to which orange roughy commonly aggregate, inevitably leads not only to bycatch of other demersal species but also to extensive damage to sessile invertebrates, including corals, within the trawled areas (Anderson and Clark 2003). In addition, secondary but more widespread impacts

may be expected from resuspension of areas of softer substrate by the passage of the trawl gear (Collie, Escanero and Valentine 1997) though the significance of any such impacts on seamounts have not yet been assessed.

Anderson and Clark (2003) provide the first comprehensive overview of the scale and diversity of bycatch in seamount fisheries based on observer data collected from New Zealand vessels fishing orange roughy on the South Tasman Rise between November 1998 and September 2000. Although oreo species make up the majority of the bycatch (and a total of 29 percent of the total catch), various corals, at around 150 t over the period, accounted for around 22 percent of bycatch and more than 8 percent of the total weight of material captured in the trawls. Observer reports indicate that for a single trawl to bring up between 1 and 15 t of coral is not uncommon. There is some evidence that similar or even higher quantities of coral per trawl have been recorded by other operators in this region (Anderson and Clark 2003). Although data are almost absent from other such fisheries, there is every reason to expect that high levels of coral bycatch, and the resultant long-term damage to the benthic community, are inevitable consequences of bottom trawling on seamounts throughout the world.

Studies of trawl damage on the Tasmanian seamounts recorded much higher proportions of bare rock in heavily trawled areas (up to 95 percent) than in comparable "unimpacted" areas of seamount (10 percent bare rock) (Koslow *et al.* 2000, 2001). Dredge samples from fished areas recovered 59 percent fewer species and little over half the biomass recovered from equivalent samples collected in unfished areas.

More recent observations on Ritchie seamount, a structure located off the east coast of New Zealand's North Island and heavily fished for orange roughy, revealed prominent "gouges" associated with the passage of trawl doors and associated equipment (Clark and O'Driscoll 2003) with approximately 50 percent of the total seamount area impacted to some degree.

Other surveys of heavily and less heavily fished seamounts in New Zealand waters reveal marked differences in the quality and integrity of the benthos. On the heavily fished "Graveyard" and "Morgue" seamounts, as many as 29 and 17 percent of survey photographs respectively indicated significant fishery-related impacts, compared to only 1 to 5 percent on the less intensively fished "Gothic" and "Diabolical" seamounts respectively. Moreover, whereas frequent patches of 100 percent standing coral cover were recorded on these latter two seamounts, occurrence of coral on the heavily fished seamounts did not exceed 2–3 percent cover in any of the locations surveyed (Clark and O'Driscoll 2003).

Based on the relatively slow growth rates observed for deep-sea corals and other sedentary organisms, recovery of severely damaged areas may be expected to take decades or even centuries (Jones 1992). Moreover, deepwater corals provide a complex and diverse array of refugia for other seamount-dwelling organisms (Smith 2003), which can therefore also suffer both immediate direct damage and suffer the longer-term impacts of habitat loss as a result of the passage of the heavy trawl gear. Although there is evidence that some profound changes in deep-sea community structure can occur over long timescales as a result of natural events and processes (Steele 1998), the rapidity and severity of changes resulting from human activities such as intensive bottom trawling are likely to far surpass any such natural fluctuations and trends. Their ultimate effects and, indeed, the ability of complex and fragile benthic communities to recover fully even over long periods of time remains to be seen.

3.3 Other human activities

Without doubt, the most direct and immediate human affects on seamount ecosystems – overfishing and destructive fishing techniques – are by no means the only anthropogenic activities and changes which threaten seamounts in the medium to longer term. Aside from deep-sea fishing, Glover and Smith (2003) list the principle threats facing the deep sea in general as

- disposal of wastes (structures, radioactive wastes, munitions and carbon dioxide)
- oil and gas extraction
- marine mineral extraction and
- climate change.

Particular attention is drawn to growing pressure for deep-sea carbon dioxide disposal, which could have profound and unpredictable impacts on biogeochemical cycles. Another is mineral extraction, particularly manganese nodule mining, highlighted as “one of the most significant conservation challenges in the deep sea” on the basis of the total areal extent ultimately likely to be impacted (Glover and Smith 2003). Other authors have noted a similar array of threats with more specific reference to their potential impacts on seamount ecosystems (Key 2002, Johnston and Santillo 2004).

Proposals to recover mineral resources such as polymetallic nodules and crusts from the deep sea are likely to be a commercial reality only some time into the future but are already under active consideration by the International Seabed Authority (ISA 2002), the body to which jurisdiction over the deep-sea bed of the global commons was assigned under the United Nations Convention on Law of the Sea (LOSC 1982). So far, work within the ISA has focused primarily on the development of regulations concerning the exploitation of polymetallic nodules. Of greater significance to seamount ecosystems, however, may be the potential exploitation of ferromanganese crusts, features which are not uncommonly located adjacent to, or even on the slopes of, seamounts (Hein *et al.* 2000). At this early stage, prediction of the nature and scale of impacts is inevitably a highly uncertain exercise, although significant near and far field effects may be anticipated. These may include physical damage in the immediate vicinity of the mining operation (Thiel 2001), secondary impacts from resuspended sediment on the benthic and pelagic communities down-current from these operations (Koslow 2002) and, even further afield, settlement of fine particulates and other wastes arising from surface processing operations (Rolinski, Segschneider and Sündermann 2001). As Halfar and Fujita (2002) stress, the implementation of management programmes incorporating a high degree of precaution will be essential from the outset of deep-sea mineral exploitation.

The scale of threats presented to seamount ecosystems by these and other potential human activities in the deep sea (oil and gas exploration and exploitation, CO₂ disposal, etc.) will depend critically on the proximity of the activities to seamounts and the direction and strength of ocean currents. Nevertheless, prediction and assessment of impacts are destined to remain highly uncertain, not least because of the lack of knowledge regarding, and difficulties in researching, deep-sea ecosystems and their responses to perturbation. While there is now widespread acceptance that the deep-sea, pelagic and atmospheric components of the biosphere are closely interlinked over intermediate and long-term timescales, predicting even the direction of possible impacts of human intervention, let alone their magnitude, remains a speculative activity.

Further, the extent to which the pressures of fishing mortality and disturbance contribute to increased vulnerability of target species to other environmental stresses, both natural and anthropogenic (Lauck *et al.* 1998), is not known, although once again such indirect impacts are likely to be more pronounced in low-fecundity, slow-growing deepwater species. The likelihood of adverse impacts arising from global climate change, even that to which we are already committed through historic emissions, only increases the necessity to minimize as far as possible the magnitude of other stresses within our control.

4. APPROACHES TO THE CONSERVATION OF SEAMOUNT ECOSYSTEMS

4.1 Extent of the challenge

It is evident then that deep-sea ecosystems, far from being isolated from local and global environmental changes and human pressures, are likely to be highly sensitive to stresses in ways that will be difficult to predict and which may result in serious or irreversible loss of habitat and biodiversity. Seamount communities, while representing just one component of the deep-sea environment, nevertheless deserve special consideration because of their particularly high ecological value, vulnerability and the ongoing nature of widespread and intensive human exploitation.

The extensive damage already caused to many seamount ecosystems through overfishing and destructive fishing practices has rightly attracted a high level of concern from the scientific community and, increasingly, from policy-makers. The recent opening statement on protecting deep-sea coral and sponge ecosystems, initiated by the Marine Conservation Biology Institute and so far signed by more than 1 000 scientists is a clear illustration of this level of concern (MCBI 2004). This statement draws attention to the “unprecedented damage” being done to benthic communities on continental plateaus, slopes and seamounts, and, noting the overwhelming contribution of bottom trawling to this damage, calls upon all states to introduce prohibitions on this activity in the vicinity of coral stands and similar structures within their EEZs. Further, the statement urges the United Nations to establish a moratorium on bottom trawling throughout the high seas.

Given the history of bottom-trawl impacts on seamounts, this radical approach has considerable merit and substantial conservation benefits over more traditional fishery management responses. For example, reductions in TAC or gear restrictions may provide some level of enhanced protection for target and some non-target species, but it will remain almost impossible, especially in deepwater environments, to determine whether these measures are really “conservative” enough, or even whether they are effective at all in conserving the integrity of seamount ecosystems. As Lauck *et al.* (1998) noted in a more general context, “coastal state fishery management programmes have proven in far too many instances, to be seriously deficient”. For target species themselves, lack of good data on levels and patterns of recruitment is a major source of uncertainty in current stock assessments (Clark 1999). The success of any management strategy that allows continued exploitation of living resources over seamounts will, therefore, inevitably be subject to the undeterminable errors and biases that are inherent in management models, as well as to the substantial uncertainties in effort and catch estimates. This alone is a major limitation to achieving sustainability, even from the limited perspective of single species conservation. Add in the collateral damage to the benthos, which seems an unavoidable consequence of bottom trawling over seamounts, and any hope of achieving sustainability by any reasonable definition disappears.

Even the precautionary approach to fishing developed by Myers and Mertz (1998), in particular the assurance that fish should be permitted to spawn at least once before they are subject to fishing pressure, may have limited applicability to conservation of seamount biodiversity, not least because it relies heavily on the effective selectivity of fishing gear. Given the markedly long life-histories and late maturity of many deepwater demersal fish species, it seems unlikely that any gear could be sufficiently selective to ensure that this management principle was not violated in the case of, for example, orange roughy fisheries. Bottom trawling on seamounts is by no means a highly-controlled process and, given that knowledge of the population structure and ecology of most deepwater organisms remains limited, it is difficult to see how such a “spawn-at-least-once” policy could ever be reliably applied to seamount-associated species. Moreover, while potentially introducing an element of precaution in relation to the target species of a fishery, the approach of Myers and Mertz (1998), taken in

isolation, once again fails to address the collateral impacts of bycatch and damage to sedentary benthic organisms.

The complete closure of selected seamounts to bottom trawling (or, indeed, all forms of fishing) may appear as a radical and, perhaps, somewhat blunt approach but it is neither an unprecedented measure nor one which is unjustified in both scientific and management terms. For example, formal measures closing 19 seamounts to bottom trawling and dredging within New Zealand waters were introduced by the New Zealand Ministry of Fisheries in 2000 and came into effect in May 2001 (Clark and O'Driscoll 2003). Although they represent only a fraction of the total number (and area) of seamounts in the region, the sites were selected to give as broad a biogeographic range as possible with the objective to confer at least some protection upon an equally wide representation of fauna. All but one of the seamounts covered by the closure had not been previously fished; Morgue Seamount was included to allow monitoring of long-term recolonization of an area heavily affected by previous bottom trawling operations. As Smith (2003) notes, the immense difficulties anticipated in monitoring gear restrictions and policing partial closures of seamounts contributed to the decision of the Ministry to opt for closure of the 19 representative seamounts to all forms of fishing activity.

Although significant, both in terms of the level of protection conferred and the precautionary basis on which closures were assigned, it must be remembered that the 19 seamounts covered by this order represent only a small fraction of the total number of such features even within New Zealand's EEZ. Therefore, while these closed areas will undoubtedly contribute something to the conservation of deep-sea biodiversity in the region, exploration and exploitation of fisheries over the majority of New Zealand's seamounts looks set to continue. The same concerns relate to the rather limited extent of fully closed seamount areas incorporated within conservation management systems in operation in other coastal states (see below), though it must be recognized that the mere existence of Australia's National Representative System of Marine Protected Areas (NRSMPA) is a substantial asset given the near absence of any effective measures or strategies in the waters of most coastal states (ANZECC 1998).

In short, what is currently missing is a much more comprehensive international or even global approach to the protection of deep-sea ecosystems, including seamounts, from the full spectrum of human activities and impacts. Whereas a moratorium on the most damaging fishing practices would clearly be a welcome and highly progressive step, this in itself is unlikely to provide the level of security or breadth of coverage required to protect deep-sea biodiversity in perpetuity. As such, a moratorium can be seen as a "necessary but not sufficient" management response to the totality of threats facing deep-sea biodiversity. It is vital that, alongside such immediate measures, much greater attention is given to the development of effective and integrated systems of marine protected areas (MPAs) which encompass *inter alia* sufficient representation of seamounts from all distinct biogeographic zones.

4.2 Application of the Marine Protected Area concept to seamounts

Marine protected areas are increasingly seen as valuable, or even essential, components of strategies aimed at the conservation and sustainable management of the marine environment. Lauck *et al.* (1998) point to the "irreducible scientific uncertainty pertaining to marine ecosystems", which, coupled with the problems of controlling catches and minimising bycatches, provides substantial justification for the emplacement of large-scale MPAs as a key component of future management regimes. In addition to the obvious protection conferred on biodiversity, MPAs can provide for a simple management regime within the protected areas as well as acting as a buffer against the impacts of possible failures of fishery management measures outside these areas.

Although there are a diversity of definitions emphasising different aspects of the concept, most capture the same essential elements as the widely recognized IUCN definition of a protected area:

“an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means” (IUCN 1994).

In outlining the mechanisms for the establishment of Australia’s National Representative System of MPAs, the ANZECC MPA Task Force provided a more specific goal:

“to establish and manage a comprehensive, adequate and representative system of MPAs to contribute to the long-term viability of marine and estuarine systems, to maintain ecological processes and systems, and to protect Australia’s biological diversity at all levels” (ANZECC 1998).

Of particular importance are the facts that MPAs established under the NRSMPA programme are established with the conservation of biodiversity as their primary goal and that their status is protected under law. Furthermore, the requirements for comprehensiveness, representivity and adequacy when establishing individual MPAs are vital to the success of the system in meeting their primary objective.

It is clear that MPAs are more a management concept than a sharply defined and universally applicable tool; clearly they need to be defined, protected and monitored in a manner that is appropriate and effective in relation to the specific environments in which they are located and should aim at optimization over time as their effectiveness is assessed. In recognition of the differing levels of human intervention that can be tolerated by various biogeographic zones and components of the marine environment, IUCN Guidelines (1994) provide for six categories of protected area, ranging from Category I (including Ia – “strict nature reserve”, and Ib – “wilderness area”), representing areas fully protected from all activities, to Category VI (“managed resource protected areas”), which allow for “sustainable flow of natural products and services to meet community needs”. In practice, the degree of actual protection conferred will depend heavily on the commitment to, and effectiveness of, management of the MPA as well as the suitability of the Category designation to the management goal. Moreover, the areas need to be large, integrated and representative enough to provide effective refuge to threatened species (Parrish 1999, Mangel 2000).

It is estimated that there are currently about 1 300 MPAs designated worldwide (Boersma and Parrish 1999), albeit representing a wide diversity of management goals and permitted activities. Their effectiveness varies, as may be expected, though most can be seen to have provided some significant positive benefits in terms of diversity and biomass of both commercially important and non-commercial species at least within the boundaries of the reserves (e.g. Jennings, Marshall and Polunin 1996, Kelly *et al.* 2000, Halpern and Warner 2002). Application of the concept to migratory species has also delivered some tangible improvements in conservation (Guenette, Lauck and Clark 1998). Halpern (2003) provides a useful review based on studies of 76 MPAs.

Despite the increasing rate of designating MPAs across the globe, the total area of the marine environment covered by at least some degree of protection remains woefully small and inadequate to protect representatives of even the most sensitive marine ecosystems across all biogeographic zones. Moreover, it is specifically the severe lack of marine protected areas that are effectively closed to all damaging or potentially damaging human activities (so-called “wilderness”, “fully protected” or “sanctuary” areas) that gives the greatest cause for concern (Dayton *et al.* 2000).

The UK Government’s Environment, Food and Rural Affairs Committee recently concluded (House of Commons 2004) that *“The current patchwork of national, European and international laws, Directives and agreements is not fully capable of providing proper protection for the marine environment in the 21st century, subject*

as it is to increasing commercial exploitation”. Similar concerns have led to a number of political initiatives at national and international levels in recent years aimed at greatly extending and integrating systems of MPAs. At the global level, one significant outcome of the World Summit on Sustainable Development (UN 2002) was a common commitment to develop by 2012 “representative networks” of MPAs to begin to address the rapid depletion of marine biodiversity. At a regional level, the 2003 Joint Ministerial Meeting of the OSPAR and Helsinki Commissions (protecting the North East Atlantic and the Baltic regions respectively) agreed to develop “by 2010 a joint network of well-managed marine protected areas” (OSPAR/HELCOM 2003).

On the basis of the special concerns for seamounts outlined in previous sections of this paper, it seems reasonable to argue strongly that any coordinated development of MPAs must incorporate a substantial number of seamounts and seamounts types. Indeed, this is a necessary condition for the effectiveness of these developments to meet their conservation goals. This point is also strongly made in the joint scientific statement referred to earlier

“...we urge [individual nations and states] to establish effective, representative networks of marine protected areas that include deep-sea coral and sponge communities” (MCBI 2004).

Further, given the particular sensitivity of such communities to long-term, potentially irreversible damage from all forms of human exploitation, it seems reasonable that these structures should also receive the most protective status (equivalent to IUCN Category I) within MPA designations. Once again, there is some precedent for this within the few examples of existing MPAs that encompass seamounts.

4.3 MPAs incorporating seamounts

4.3.1 Existing practices

Those seamounts currently afforded protection under national jurisdiction represent only a fraction of the many thousands known to exist worldwide. Nevertheless, the significance of these isolated examples, concentrated particularly in the waters around Australia and New Zealand, must not be underestimated, from the perspective of both the degree of local protection they provide and the example they can set for similar initiatives worldwide.

Important examples of MPAs incorporating seamounts can be found in US waters (e.g. Cordell Bank, a relatively shallow structure of the Californian coast), the Caribbean (Saba Marine Park in the Netherlands Antilles, incorporating two seamounts) and even in Antarctica (Port Foster Site of Special Scientific Interest, which includes a sub-sea volcanic caldera) (Roberts 2002). However, among the most widely known are those in Australian waters, including the Tasmanian Seamounts Marine Reserve and the Lord Howe Island Marine Park and the much discussed Bowie Seamount in Canadian national waters.

4.3.2 The Tasmanian Seamounts Marine Reserve

The Tasmanian Seamounts consist of approximately 70 structures located 170 km south of Hobart and rising to between 1940 and 660 m of the sea surface. As noted in Section 2, those seamounts studied indicate remarkably high diversity and endemism, with benthic fauna dominated by stands of the coral *Sollenosmilla variabilis* or, in deep areas, by sea urchins.

Following initial reports of high benthic biodiversity in the mid 1990s, an interim closure of an area of 370 km² to fishing was agreed to. This was followed in 1999 by the designation of the marine reserve, encompassing 15 of the seamounts (primarily the deeper structures) and representing approximately 20 percent of the total area of the Tasmanian Seamounts region. This selection was considered a representative sample of

seamount diversity in the area (Commonwealth of Australia 2002a), although it must be noted that this decision was necessarily taken in the face of high uncertainty.

The primary objective of the reserve is “to protect the unique and vulnerable benthic communities of the seamounts” (Commonwealth of Australia 2002a). The Tasmanian Seamounts reserve is divided into two zones based for management purposes exclusively on depth. On the basis of an assessment that pelagic fisheries over the seamounts were not the primary concern with respect to conserving biodiversity, and that the area did not represent a spawning ground for key migratory species, the waters down to a depth of 500 m are administered as a “managed resource protected area” (equivalent to IUCN Category IV). Below 500 m, the seamounts are managed as a strict nature reserve (IUCN Category Ia) and all fishing and other forms of human exploitation are prohibited. Importantly, the exclusion zone extends to 100 m beneath the seabed to guard against any future interests in mineral extraction.

4.3.3 Lord Howe Island Marine Park

The seabed ridge structure which breaks the surface at Lord Howe Island and Ball's Pyramid runs roughly parallel to the coast of Australia, 700 km northeast of Sydney. The Park incorporates all elements of the marine environment from the shallows down to a depth of approximately 1800 m, including a number of seamounts and similar structures. Once again this area is recognized as an area of immense diversity and high conservation value (Commonwealth of Australia 2002b).

The existing 12 nm exclusion zone for pelagic fishing (for tuna, billfish and squid) and 25 nm exclusion zone for bottom trawling date from 1993. In practice, bottom trawling over the steep and rugged slopes of much of the rise has been limited by lack of technical feasibility, although there have been some exploratory deepwater fisheries in the past, particularly for orange roughy. There are not thought to be any significant mineral or oil reserves in the immediate vicinity of the rise.

The primary objective of the reserve is “to protect the seamount system and its conservation values associated with marine biodiversity, habitats and ecological processes” though secondary goals of supporting tourism and certain traditions of the local community are also defined. The majority of the Park is assigned IUCN Category IV, such that some commercial activities other than mining may be permitted, subject to conditions including that these activities do not undermine the primary conservation objective. To this end, both trawling and long-lining are prohibited. In addition, two areas are set aside as Category Ia Sanctuary Zones, designed to protect a representative proportion of the shelf, slope and deepwater environment from all human activities and, in turn, to provide a baseline for research and monitoring.

4.3.4 The Bowie Seamount

The Bowie Seamount forms part of the Canadian Government's commitment to develop an MPA system for Pacific coastal waters (Governments of Canada and British Columbia 1998). The seamount is located 180 km west of the Queen Charlotte Islands and rises from the seafloor at 3 100 m to within 25 m of the sea surface. It is recognized as a site of high biological diversity and productivity and, since the 1980s, has supported commercial fisheries for sablefish (*Anoplopoma fimbria*) and rockfish (*Sebastes* spp.) (Fisheries and Oceans Canada 2001).

MPA status was assigned to the Bowie Seamount at the end of 1998 and the area of interest has subsequently expanded to incorporate the Hodgkins and Davidson seamounts to the northwest. However, since 1998 progress towards development and emplacement of the associated management plan has been relatively slow. The Bowie Seamount MPA differs significantly from those in Australian waters in its explicit recognition of “the conservation and protection of commercial and non-commercial fisheries of the area” as one of the three main management objectives. It may well be,

therefore, that some considerable degree of human intervention and, inevitably, damage will ultimately be tolerated by the terms of the MPA. The extent to which this may compromise the other primary objectives of conservation and protection of habitats and biodiversity remains to be seen. At present, three options are under consideration for designation of parts of the MPA as no-take “harvest refugia”, ranging from an area covering only the Bowie Seamount itself to full protection for all three seamounts in the immediate vicinity (WWF 2003).

4.3.5 New Zealand seamount closures

These have been discussed in Section 4.1. It should be noted that the New Zealand closures are a specific and free-standing measure, rather than forming part of a broader programme of MPA designation. Nevertheless, the significance of the closures is in their regulatory simplicity and the immediacy in affording protection from the damaging effects of fishing. Their establishment in this manner does not preclude a subsequent incorporation into such a programme in the future. Indeed, it is to be hoped that such measures can swiftly be extended to encompass a much larger proportion of seamounts in New Zealand waters, whether pristine or previously fished. Otherwise there is a danger that these 19 closures will provide little more than token protection for seamount biodiversity in the region.

5. MEETING THE CHALLENGES: PROTECTING SEAMOUNT BIODIVERSITY

It is easy to point to the deep-sea, and to seamount ecosystems specifically, and conclude either that the MPA concept simply cannot be applied to such systems in any meaningful way or, at least, that any such designation will need to await much more detailed description and understanding of ecosystem structure and dynamics. It is hoped that the positive examples of seamount MPAs already in operation will increasingly serve to dispel the first criticism. The dilemma regarding the second assertion is that at current rates of human exploitation, biodiversity is undoubtedly being lost at a far greater rate than it is being discovered.

The ability to define specific objectives with respect to MPAs at the time of their establishment is seen as an important guiding principle for the development of MPA systems (see e.g. Fogarty, Bohnsack and Dayton 2000). Inevitably, however, such ambition has to be tempered with the limitations to understanding of the system which the MPA is being designed to protect. Delaying the designation until such time as the size, depth range and management regime can be fully optimized is unlikely to be an option.

In such cases, which may be encountered frequently in the case of seamounts, it may be necessary to accept in the first instance a relatively broad management objective, such as those set for the Tasmanian and Lord Howe Seamounts, in order to apply precautionary measures in advance of obtaining detailed descriptions of community structure and dynamics. It is worthy to note that relatively little was known about the fauna of most of the 19 seamounts closed to fishing by the New Zealand government in 2001; rather it was hoped that the habitats and specific fauna captured by these measures would be representative of the biogeographic diversity of New Zealand seamounts (Clark and O’Driscoll 2003). Therefore, although described by some as a “stab in the dark”, acting to protect these communities in advance of a full description of what would be protected could clearly be justified given the rapid development of the fishery.

As Lauck *et al.* (1998) stress, an “optimal” location, size and set of ecological objectives for a marine protected area may be beyond realistic definition. Indeed, it seems inevitable that optimization may need to be an iterative and adaptive process; verification of optimal design and management is unlikely ever to be a definitive goal. Nevertheless, the existence of such uncertainties and indeterminacies should

not be used to argue against the closure of marine areas to all human activities as one component strategy to conserve biodiversity. On the contrary, these characteristics emphasize further the fundamental importance of the more precautionary management elements that come from a protected area approach.

Allison, Lubchenco and Carr (1998), while noting the limitations to conservation effectiveness conferred by marine reserves (principally in that they clearly cannot provide a physical barrier to the impacts of some changes occurring at broader spatial scales), nevertheless view them as an essential component of future marine management programmes. These authors advocate substantial increases in the number and size of such designated areas, while noting that such developments must go hand-in-hand with a diversity of other measures aimed at protecting habitat and biodiversity even beyond the boundaries of reserves. In short, they see marine reserves as “necessary, but not sufficient” to guarantee a high probability of effective marine conservation.

6. SEAMOUNT EXPLOITATION AND SUSTAINABILITY

The view expressed by Richer de Forges, Koslow and Poore (2000) that “the highly localized distribution of many seamount species has profound implications for their conservation” is now almost beyond disagreement. The question of what this means in terms of the management of human activities on, and over, seamounts remains the subject of intense debate. A central guiding principle in future decisions regarding their conservation should be that any permitted activities must be compatible with the overarching goal of sustainability.

One relevant question is “can seamounts ever be fished sustainably?”. In answer, it is fair to say that there is little, if any, evidence that they have been to date, especially in relation to the exploitation of benthopelagic fish using bottom trawls. Even in pure fisheries management terms of stock assessments and fishery management plans, the picture is bleak. If one considers impacts at a broader ecosystem level, it is difficult to see how experience to date could fit with any reasonable definition of sustainability.

As an example, the six “principles for sustainable governance of the oceans” proposed by Costanza *et al.* (1998) provide valuable guidance for the development of future marine management regimes capable of addressing current patterns of overexploitation and loss of biodiversity. Of these principles, those of precaution and of responsibility to ensure that any use is sustainable have particular relevance to the protection of seamount ecosystems. We have already noted the enormous uncertainties associated with the structure and dynamics of seamount ecosystems and their response to human disturbance. At the same time, it is difficult to see how exploitation of seamount fisheries to date could ever be described as “sustainable”, even in the strictly limited terms of basic fisheries management.

Costanza *et al.* (1998) also propose that all existing or proposed activities should be subject to “full cost allocation”, including all internal and external costs and benefits. The fundamental difficulty here is that whereas it is relatively simple to assign a value to the economic benefits of exploitation (e.g. total export value of a given fishery), the costs in terms of ecological damage are almost impossible to quantify fully, let alone express in equivalent monetary terms. What does seem to be clear, however, is that the benefits of fisheries such as those targeting orange roughy in New Zealand and Australian waters are almost exclusively economic. Given the high costs inherent in catching such species, their consequent high value per tonne and the relatively limited contribution they make to the global availability of seafood and food security in general, it is difficult to see how seamount fisheries substantially contribute to social equity.

Comparison against other recognized definitions of sustainability lead to similar conclusions. For example, two of the four “first order principles” proposed by Cairns (1997) are:

“(3) the physical basis for productivity and diversity of nature must not be systematically diminished and (4) fair and efficient use of resources with respect to meeting human needs.”

Both could be seen to be violated by the practice of bottom trawling alone. Nor is it conceivable that other potentially damaging human activities, such as seabed mining, oil or gas extraction or waste disposal, could ever be conducted in the vicinity of seamounts in a manner consistent with these broad principles of sustainability.

7. CONCLUSIONS

The deep sea is a reservoir of biodiversity and as such must be recognized as a priority for the development of suitably protective measures, both in waters of coastal states and on the high seas. Seamounts are an important part of the deep-sea environment, given their propensity to support particularly rich and abundant faunal communities. Moreover, it is these structures that are already among the most exploited and threatened features of the deep sea. To date, destructive fishing practices, especially bottom trawling, are undoubtedly responsible for the greater part of adverse impacts, although many other ongoing or potential future human activities also pose substantial threats.

In this context, an immediate moratorium on the use of bottom trawls and other destructive fishing gear on seamounts would be an invaluable and entirely justified response. In the longer term, such an action must form part of a more concerted effort to greatly increase the number of seamounts around the globe conferred protection from the full spectrum of damaging human activities through designation as MPAs.

These two approaches, the universal application of fishing gear restrictions and the establishment and management of MPAs are by no means incompatible. Rather they could prove complementary, not least because an immediate decline in the rate of seamount exploitation would ensure a much greater availability of unaffected, or only partially affected, regions that could then form vital components of representative networks of well managed MPAs.

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Sea and sky: Patagonian large marine ecosystem programme integrating continental shelf realities with deep-sea potentialities

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1. INTRODUCTION

Our core message in this paper is one of precaution: given the precedents, historical perspectives and current geopolitical contexts, the exploitation of fisheries resources in the southwest Atlantic should be contingent on the development of frameworks and models that incorporate precautionary, risk-assessment approaches to sustainable management, together with explicit attention to the needs of dependent and related species and to the minimization of risks to non target species, ecological processes and habitat. We believe that this approach, developed in a transparent fashion with reference to all stakeholders, is particularly vital to a region where conservation, management and politics are inextricably interlinked. In this paper, we develop these ideas, recollecting that the SW Atlantic Ocean, was, at least in the early 1990s and according to FAO, the only part of the Atlantic Ocean that had not yet been overfished.

2. THE SEA & SKY PROGRAMME

2.1 Background

Sea & Sky (S&S) is our vision for the future of the Patagonian Large Marine Ecosystem (PLME) in the SW Atlantic. It aims at Large Marine Ecosystem management in a context of international cooperation between stakeholders. Our priority is to see the need for sustainable management of economic resources balanced by giving appropriate levels of protection to the wildlife, biodiversity and other conservation values of this rather little known – and increasingly imperiled – part of the global ocean.

2.2 Aims, rationale and geography (scale and boundaries)

We propose an environmentally sensitive management system be applied to a dynamic open-ocean area comprising the oceanographic regimes under the influence of the Falkland-Malvinas (F-M) Current. The implementation of priority-use zones and sectors under particularly precautionary management will reflect the variability in the productivity, according to the season and location of ocean fronts for an area 2 000 000 km² (70 percent the size of Argentina). Its specific focus is the pelagic waters of the Patagonian shelf and slope connected to coastal and sub-Antarctic habitats by the Falkland-Malvinas current. This broad oceanscape is an epicenter of biological productivity that sustains just for coastal Patagonian breeders alone, more than 1 000 000 pairs of Magellanic penguins, 100 000 South American fur seals (*Arctocephalus australis*), 70 000 South American sea lions (*Otaria flavescens (byronia)*) and 50 000 elephant seals. Unless the resources on which these species depend are managed in sustainable fisheries using ecosystem approaches, the habitats of this system may become rapidly impoverished.

The rationale of the project is supported on the following assumptions:

- i. The Patagonian seascape is a large threatened ecosystem not yet depleted past the point of no return.
 - A vast majority of ocean productivity occurs on the continental shelves, the dominant habitat of the Patagonian Large Marine Ecosystem.
 - The shallow (< 100 m) shelf is truly a unique habitat; the largest in the hemisphere (1 000 000 km²).
 - The Falkland-Malvinas and Brazil currents generate oceanographic regimes that sustain productivity and a large biomass and species diversity at all trophic levels; this includes a variety of 'charismatic' top predators: Southern right whales (*Eubalaena australis*), wandering albatrosses (*Diomedea exulans*), Black-browed albatrosses (*Diomedea melanophrys*), royal albatrosses (*Diomedea sanfordi*), southern elephant seals (*Mirotunga leonina*), Magellanic penguins (*Spheniscus magellanicus*), rockhopper penguins (*Eudyptes chrysocome*), gentoo penguins (*Pygoscelis papua*), macaroni penguins (*Eudyptes chrysolophus*) and king penguins (*Aptenodytes patagonicus*).
 - The relevance of the system extends beyond coastal Patagonia, Tierra del Fuego and the Falkland (Malvinas) Archipelago¹ to sustain species from South Georgia, Gough, Tristan da Cunha, Diego Ramirez and New Zealand. Several Antarctic species winter in the region.
- ii. Nevertheless there are already serious signs of degradation and over-exploitation. Thus:
 - collapse of Argentine hake (*Merluccius hubbsi*) fisheries is posing real challenges for stock restoration management;
 - squid fisheries are threatened by hundreds of vessels operating just outside the EEZs, as revealed by nocturnal satellite imagery detecting the lights used to attract squid (Waluda *et al.* 2002), and
 - coastal oil pollution is estimated to kill thousands of Magellanic penguins annually. The localized winter ranges of this and rockhopper penguin makes them especially vulnerable both to oil spills, chronic oil pollution and pesticides brought to the ocean by river systems.
- iii. There is a remarkable opportunity to improve the fate of this system of global significance.

¹ This report complies with UN formal designation of the Archipelago in public documents written in English as *Falkland Islands (Malvinas)*. See A/AC. 109/2002/16 <<http://www.un.org/Depts/dpi/decolonization/main.htm>>.

- Conservation efforts worldwide are focusing on the ocean. There is no more time to lose. Unsustainable management policies and practices must be replaced with modern approaches and mechanisms.
- Scientific information based on remote-recording technologies is widely available for the area. *Sea & Sky* has already created the most complete database on top-predator biology available for the Patagonian Large Marine Ecosystem.
- The coast-ocean co-evolving system, in the UNDP/GEF-funded *Patagonian Coastal Zone Management Plan* has already taken major steps towards sustainable management and policies. iv. Challenges ahead demand international collaboration involving participation of all stakeholders in developing systems for managing shared resources.
- The Patagonian Large Marine Ecosystem is under a wide range of jurisdictional regimes, including international waters.
- Jurisdictional conflicts have limited the scope and nature of fisheries management. This is compounded by the traditional difficulties associated with managing high-seas fisheries.
- Paucity of data and shortage of funding for technical support will favour uninformed decision-making leading to further habitat degradation.

2.3 Scope and early achievements

Sea and Sky is a multiple-phase, ‘umbrella’ programme that seeks to integrate scientific, technical, jurisdictional and socio-economic data and perspectives. Ecosystem approaches to sustainable management lie at the core of the programme. Zoning strategies are intended to delimit areas of precautionary management and use that reflect seasonal variation of the oceanography regimes that influence productivity.

In its technical aspects, the project so far reflects the collaboration of an international group of scientists that have contributed information, time and expertise to create the most comprehensive database available for the Patagonian Large Marine Ecosystem: 173 integrated datasets for 45 species of marine birds, 17 for marine mammals, 14 for fishes and four for squids, plus oceanographic and utilization information for the entire SW Atlantic. The data base contains more than 50 000 high-quality satellite locations for 11 marine bird and mammal species. The Landscape Ecology and Geographic Analysis Programme of the Wildlife Conservation Society processed and acts as curator for the information. Data are already leading to new awareness of interrelationships, such as a template based on robust physical regimes, as a basis for zoning exercises.

2.4 Future steps

The next steps for the *Sea & Sky* programme are to: (a) strengthen and expand the scientific foundations, (b) begin collaboration with critical stakeholders (Government and fisheries) and (c), ensure programme institutional sustainability by creating an international alliance.

Strengthening scientific groundwork. The objective is to maintain an updated, comprehensive database with centralized management and geographical information systems (GIS) outputs available to stakeholders. Data will give technical support to zoning plans and facilitate the development of theoretical and practical tools to tackle conflicting positions.

Strategic planning to approach and recruit support from stakeholders. Pragmatically, the fate of the Patagonian Large Marine Ecosystem is in the hands of resource managers, especially of commercial fisheries. Additional but less urgent issues are related to oil and tourism industries. Coastal development with effects on the open ocean may also threaten ecosystem conservation. The complexity of the fishing industry, ranging from coastal artisanal to international commercial, demands a coherent strategic approach.

Ensuring programme sustainability. Sea & Sky will attempt to bring together national, international, government, inter-governmental and non-governmental organizations together with specialists in the various disciplines. Its intention is to provide a scientifically based forum for developing and evaluating ecosystem approaches to management and for synthesising the results in operational terms. These mechanisms might range with the design and implementation of Marine Protected Areas and Fish Stock Assessment models incorporating temporal and spatial variability with extinction risk probabilities.

3. TRENDS IN FISHERIES MANAGEMENT

3.1 Future requirements

The future of the Patagonian Large Marine Ecosystem is partially dependent on the present administration of its economic resources, particularly those targeted by international fisheries. The perspectives are gloomy considering the collapse of most major world fisheries. The management crises that resulted from the failure of dominant paradigms has promoted the development of new tools, such as the concept of sustainability and the use of property rights in management of natural resources. But the need still remains to reformulate management and move from a traditional towards a more inclusive conservation paradigm. This section explores the origin of the prevailing views and reflects on future action.

3.2 The past: building up a plethora of institutions and organizations

The development of the current fisheries management paradigm (FMP) occurred during the twentieth century (Sinclair 1988). Its inception resulted from the merging interest in explaining catch variability with the development of models to interpret it (Kurlansky 1997). The basis of this conceptual development was an attempt to avoid fisheries collapses, while its most ambitious goal was to regulate fishing activity to optimize catch efficiency. A main reason that guided the onset of the paradigm was the demonstration that fishing could negatively affect resource availability and chances of recovery (Smith 1994). Once the first quantitative models that attempted to describe, explain and predict population dynamics and interaction were developed, the ecological perspective emerged as a competent and relevant approach to establish a theoretical framework for rational exploitation and management (Kingsland 1985).

The foundation of the current fisheries management paradigm (Hamilton, Duncan and Flanders 1998) resulted from the interaction among four endogenous variables: (a) *Fish catch* – the actual quantity of fish caught, both that landed and discarded; (b) *Fish stock* – the actual, but unknown size of the fish population of commercial interest; (c) *Stock estimate* – what assessment scientists or decision makers perceived about the size of the fish population; (d) *Restrictions on catch* – formal or informal controls intended to limit the catch. Both the estimates of the fish stock and the restrictions on catch shaped the “rules of the game”, i.e. the institutions, and the creation of endless research and management organizations whose main task was to implement and run the system.

Implementation of the current fisheries management paradigm has involved the search for optimal solutions and along with this the development of the maximum sustainable yield (MSY) concept (Clark 1981). The estimate of MSY turned into the focal objective in natural resource management for many following years. A practical correlate of MSY in fisheries management was the determination of Total Allowable Catch (TAC), the level of catch intended to ensure the correct use of resources. The TAC-oriented approach is conventionally supported by the establishment of regulations and procedures, and monitoring, surveillance and control protocols. The MSY was the fundamental criterion that managers used in the decision making process, although the concept has suffered a progressive loss of theoretical and practical support

for the concept (Larkin 1977) that eventually undermined its dominant role in the current fisheries management paradigm. A new discourse appeared in the fisheries management scene, which flowed from two main conceptual streams: (a) sustainable development (as the outstanding expression of policy goal); and (b) fisheries management based on property rights (as the competent instrument to reach that goal).

The emergence of sustainable development and quota management systems (QMS) allowed an evolution of the current fisheries management paradigm (Scott 1989). Nevertheless, and in spite of some achievements, criticism regarding the current fisheries management paradigm occurred from three perspectives: (a) *judicial*, given the common good character of fish resources, a conceptual difference is made between the right and privilege to fish (Connor 2000); (b) *social anthropology*, given the unintended effects of quota management systems (QMS), there is a concern about the uneven distribution of the profits and the threats to the permanence of fishing-dependent communities (McCay 2000); and finally (c), *policy analysis*, Government failures are assessed in terms of institutional limitations related to governance styles and management procedures (Symes 2000).

Scientists also voiced their concerns, pointing out the need to design ecology-based approaches, offering three main strategies to improve the limitations of the previous current fisheries management paradigm: (a) adaptive management (Walters and Hilborn 1976, Hilborn 1979, Smith and Walters 1981, Walters 1986, Fournier and Warburton 1989, Ludwig and Walters 1989), (b) fisheries administration based on ecological principles; and (c) management procedures (Donovan 1989, Magnusson and Stefánsson 1989, Kirkwood 1993, de la Mare 1996).

In spite of the efforts to improve the current fisheries management paradigm, an integration of fisheries and environment management objectives cannot be achieved until it is recognized that both essentially have the same objective, i.e. sustainable fisheries management goals are a subset of those regarding sustainable environmental management (Richardson 2000).

3.3 Present: rebuilding fisheries or reinventing management

The crisis affecting fish stocks mirrors the institutional crisis centred on the limitation and failures of fisheries management. The discourse that arose to overcome the traditional constraints and reinvention of fisheries management (Pitcher, Hart and Pauly 2001) was in response to two different and complementary frameworks: (a) sustainability and (b) property rights.

Sustainability

The ideological and institutional framework in which the concept of “sustainable development” is articulated, just as it is conceived and enacted in relation to the marine capture fisheries, comes from the United Nations Convention on Environmental Development, the Agreement on Biodiversity, and the adoption, in 1982, of the Convention on the Law of the Sea. The United Nations Commission on Human Environment elaborated the first guidelines towards sustainable development in Stockholm in 1972. The concept was a consequence of a development style based on unrestrained economic growth. In 1987, the Brundtland Report titled *Our Common Future* pointed out that sustainable development must “... *meet the needs of the present without compromising the ability of future generations to meet their own needs.*”

As overexploitation of fish stocks and impact on ecosystems contrasted with the goal of sustainable fisheries, in 1991 the Food and Agriculture Organization (FAO) recommended developing new management approaches that took into account environmental, social and economic goals. The process led to the International Conference for Responsible Fishing (Cancun, Mexico, May 1992). Based on the Declaration of Cancun, and as a part of Agenda 21, the United Nations Conference of

Environment and Development (Rio de Janeiro, June 1992). FAO (1996) promoted a Code of Conduct for Responsible Fisheries that was adopted on 31 October 1995. Since then, the precautionary approach and the design of procedures for better management have become key aspects of a sustainable development reference system.

Scientists have also attempted to analyse the impact of fishing on the ecosystem and promoted the adoption of ecological principles on the design of management models. Two outcomes of these concerns were the International Council for the Exploration of the Sea (ICES) Marine Science Symposium on the Effects of Fishing on the Ecosystem (Montpellier, March 1999), and the Conference on Responsible Fishing in Marine Ecosystems (Reykjavik, October 2001). The aims of the Montpellier meeting were to develop a synthesis of the effects of fishing on the marine ecosystem, to develop new methodologies to quantify these effects and to provide a forum for discussion about the integration of conservation goals within the fisheries management. The objective of the Reykjavik Conference was to articulate the necessary ecological principles in a scheme of fisheries management, identifying challenges and strategies for the future. It is noteworthy in this context that the 4th World Fishing Conference (Vancouver 2004) aims to reconcile fishing and conservation, as the main challenge for the management of the aquatic ecosystems.

Property rights

The establishment at the end of the 1970s of fisheries management systems based on property rights has been one of the most revolutionary events in the history of fisheries (Neher, Arnason and Mollett 1989). Since the beginning, quota management systems (QMS), based on individual transferable quotas (ITQ) have elicited support and criticism. Support came from economic frameworks, whereas criticism was mainly derived from social perspectives (Apostle *et al.* 1998, National Research Council 1999).

Successful application of QMSs assumes the occurrence of several essential conditions that are often absent. A heterogeneous group of scientists with diverse positions on this subject, including anthropologists, sociologists, lawyers, biologists, economists and fisheries managers, met in Fremantle (Australia, November 1999, see Shotton 2000). They concluded that the use of a QMS includes both the chances to reach intended goals, such as the reduction of fishing capacity and the appearance of unintended consequences, such as the increase of marginality caused by capital concentration.

Thus far, Iceland and New Zealand are the only two countries to make a significant comprehensive move from traditional fisheries management models to a QMS. In both cases the experience seems to have been successful, nonetheless some criticism persists. Implementations have been carried out in other places (e.g. Australia, Canada, The United States, Estonia, Holland and Chile) and a transitions toward quota regimes is occurring. However, most countries and management organisations persist with the old paradigm.

3.4 Future: rhetoric stagnation

Although it seems that an appropriate conceptual framework is available to guide actions towards responsible fishing, there is a chronic incapability (lack of political will or means) to effectively address the major problems of massive or selective bycatch, excess fishing capacity, irreversible degradation of habitats and steady loss of populations and species.

The policy support to overcome the fisheries crises is readily available, as stated by Gislason *et al.* (2000):

“Within the UN Convention on the Law of the Sea, nations accepted an obligation to consider the impacts of their policies on marine ecosystems [...]. This obligation has

been restated by the 1995 FAO Code of Conduct for Responsible Fisheries and by many recent policy documents worldwide. It no longer suffices to focus on the sustainable yield of the target species itself; the impacts of fishing on the structure and functioning of the ecosystem have to be considered as well [...] We assume that such objectives will include the maintenance of biodiversity and of habitat productivity. The challenge to science is to reach consensus on indicators and reference points that will support decision making on ocean-use activities that threaten biodiversity and habitat productivity [...] There is a need to enhance the conservation objectives of fisheries-management plans to include explicitly ecosystem considerations.”

Likewise, Sainsbury, Punt and Smith (2000) noted that:

“Fisheries management has historically focused on achieving objectives that relate to the well-being of commercially harvested species and the associated fishing industry, but there is now an increasing trend to consider broader, ecosystem-orientated objectives as well [...] including] recovery of endangered species, effects of fishing on species and habitats impacted incidentally by fishing or as bycatch, preserving the food supply for other marine predators, maintaining biodiversity at all biological levels (e.g., genetic, species, habitat, community), and maintaining ecosystem integrity and resilience.”

Despite the fact that the above statements leave no doubts as to what must be done, changes in management of the oceans that take into account biodiversity conservation are modest. The current fisheries management paradigm rationale is such that conservation initiatives are placed in a disadvantageous position to exert their influence. From a conservation perspective, *fide* Agardy (2000)

“...the solution is not to shut down fisheries but rather to modify the type of management, and use public awareness to help raise political will for taking responsibility for the conservation of marine systems [...] Without decision-makers taking more responsibility for fisheries management and habitat protection, fisheries and marine biodiversity will be permanently compromised.”

But even conservation intentions constrained to simple common sense often have to struggle with minor principles and goals in an attempt to balance the priorities of major interests and find avenues through which to advance partial limitations of fishing activity. This scenario maintains the *status quo* in fisheries management, which leads to the inability to overcome recurrent crises on the traditional fishing grounds.

FAO (1999) endorsement of a sustainable development reference system, integrating environmental, social and economic indicators reflects a tendency that will lead towards strengthening government plans and fisheries management strategies. The policy for the implementation of ecologically sustainable development for fisheries and aquaculture in Western Australia is an example of a framework compatible with the guidelines noted above.

The underlying problem, however, continues to be that a perfect market supposes the existence of a perfect Government (Weimer and Vining 1992). In practice, solutions to market or Government failures, including those related to fisheries capture, depend on the formulation of corrective public policies. As an alternative, the balance should be shifted from favouring exploitation goals to favouring conservation processes (e.g. fishing simply as a part of ecosystem function and tolerated within limits appropriate to the multiple goals inherent in maintaining healthy systems).

3.5 Lessons to be learned

Implementation of an ocean conservation paradigm must address the fact that any attempt to come up with a sustainable administration of nature must be founded in the best traditions of ecology. Precedents in this field show that to deal with ecological complexity and uncertainty one needs appropriate models and tools. The built-in uncertainty of complex systems demand an alternative standpoint in hypothesis testing, raising the need to have robust models oriented towards minimizing Type II, instead of minimizing Type I, statistical errors (Hall 1999).

Management should promote sustainability through the preservation of resilience as an intrinsic ecosystem feature to guarantee the maintenance of a stable topology compatible with system structure and function. The precautionary principle within this approach would involve preserving those characteristics that strengthen biodiversity and ecosystem integrity rather than establishing a precise maximum catch or a reference value above which the biomass of a target species should be kept (Peterson, Allen and Holling 1998). It would be a sensible move to shift from a management model biased towards commercial fishing, with the prevalence of concepts of efficiency and income (the current fisheries management paradigm), towards one that recognizes broader potential values of the ocean under ecological principles (OCP).

4. NEW CONJECTURES: SEARCHING FOR THE RIGHT ERROR

4.1 Conceptual background

Better management decisions would result by changing the emphasis from models that minimize Type I errors, to those that build “robustness” i.e. that associated with minimizing Type II errors (Steel and Torrie 1980). Robust models seem to be a sounder basis for predictions than those focused on statistical power (Wimsatt 1980). The *Sea & Sky* programme may represent an opportunity to apply this rationale to a valuable and still relatively well-preserve oceanscape.

4.2 Power versus robustness – Strategies in model building

In ecology, the interface between theory and reality has always been controversial. Thus, the strategy of adopting models to deal with ecosystem complexity and uncertainty has been much debated. Doubts were specifically centred on the extent results depended on essential properties of the models or on the simplifying assumptions introduced when they were created. Just as epistemologists recommend working with more than one alternative hypothesis, ecologists propose reducing the range of doubts by applying diverse, alternative models to deal with the same problem. Differences between models could then be the results of simplification in the context of maintaining supporting biological assumptions. The quality of the models then remains indissolubly linked to the convergence of the obtained results, because this convergence is an assurance of model “robustness” (Levins 1966).

These statements lead to an essential property relevant to the construction of ecology models: robustness is a characteristic linked to the consequences of the models but not to their intrinsic nature. Acknowledging that no model can reflect all the complexity of an ecological system, the state of the art in ecosystem modelling has developed in three main directions: (a) generality, (b) realism and (c) precision. Since no model can maximize all its objective functions simultaneously, it is necessary to relinquish some features to improve the rest. Thus, by sacrificing generality, bio-economic models would gain precision and realism. Otherwise, as it occurs with, e.g. predator-prey models, sacrificing realism improves generality and precision. For example, MacArthur and Levins being less concerned with precision, improved the realism and generality of their models, which gave them a notable flexibility compared with the limitations in the Volterra-Lotka models, but which came from the lack of realism in their assumptions (Kingsland 1985).

4.3 The rationale behind the paradigms

Management of the SW Atlantic poses a challenge to sustainable initiatives. The lack of strong coherent fisheries management throughout the SW Atlantic enhances opportunities for fleets of distant countries to undertake illegal, unreported and unregulated fishing. The need to improve this situation is complicated by the underlying jurisdictional conflict between Argentina and the United Kingdom, which hampers the development of new solutions. Against this background, the *Sea & Sky* programme

advances the precautionary scheme of considering the Patagonian Large Marine Ecosystem within the conceptual umbrella of environmentally sensitive or marine protected areas and management principles and practices evaluated and proposed by an alliance of organizations representing relevant stakeholders.

One of the most sensitive and difficult questions to agree upon has been the shared vision of success beyond the ambit of coalitions and the prevalence of their internal interests (Bryson 1995). *Sea & Sky* proposes an Alliance for the Conservation of the SW Atlantic Ocean in which management occurs at the level of large marine ecosystems. Such a central framework will promote the integration of economic, social and environmental principles of the sustainability with the values that arise when ethical and aesthetic perspectives are taken into consideration.

4.4 Synthesis and reflective remarks

- i. We gathered to consider an expansion of our frontiers of development in a context of uncertainty. The advance may take place despite the fact that some problems of present development do not have apparent solutions, and the technical tools available may not suffice to cope with the consequences of ecosystem degradation. To minimize the “tragedy of unavoidable consequences” we should limit the extent of the potential damage. This common sense claim may have a weak voice but it has many merits.
- ii. A potential starting point to discuss new expansions in the frontiers of use should be the revision of the conceptual models that have so far been underlying strategic decisions. We must recognize that by introducing paradigm biases, observers do not enrich the reality but their subjective image of it, further conditioning their thoughts and decision-making and interpretative behaviour.
- iii. Fisheries worldwide are going through a crisis partially due to the criteria that dominated use and management of resources in the ocean. If the sector hesitates to replace those models responsible for the crises, the opportunities to move forward will be few and the repertoire of potential solutions are constrained.
- iv. The above global concerns underlie the ecosystemic approach to management of the SW Atlantic that is the *Sea & Sky* programme.

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THEME 7

Governance and management

Governing deep-sea fisheries: future options and challenges

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1. INTRODUCTION

The papers and discussions presented at the Conference make it clear that despite great advances in the global regime on fisheries the existing legal instruments are not adequate in dealing effectively with the current challenges to the management of deep-sea fisheries. The main task of this paper is to explore the ways to address the gaps in the existing regime with a view to establishing a better global governance system.

At the outset, it should be stressed that given the universal acceptance of the 1982 UN Convention on the Law of the Sea (LOSC) and its character as the “constitution for the oceans”, the global governance of deep-sea fisheries in the foreseeable future must be built on the basis of the Convention. Some new steps can be taken under existing provisions to strengthen the management of deep-sea fisheries. This does not mean, however, that they are perfect and sufficiently detailed to meet the current and future challenges effectively.

One of the options available for filling any gaps or improving existing provisions of the LOSC is the amendment procedure under Article 312, as Dr Johnston has pointed out (Johnston 2004). It has also been widely felt that the Convention, which lays down essentially the general principles and framework, particularly in the field of fisheries, should be supplemented by additional legal instruments as the international community perceives such needs or finds new gaps in its provisions. Indeed, this is what was already done in the form of the UN Agreement¹ in 1995 with respect to the conservation and management of straddling stocks and highly migratory stocks. These two approaches are not incompatible with each other, and in any future discussions both options should be kept open, so that depending on the substantive contents, either of the two, or both, approaches may be used.

In this paper, I shall focus on the latter approach since I believe that a supplementary instrument could provide a vehicle for formulating more specific, detailed and flexible rules. It is also a procedurally easier one to employ than the amendment approach.

In discussing future legal options for the more effective management of deep-sea fisheries, four situations should be clearly distinguished according to the location where the targeted stocks occur: first, stocks occurring solely within the exclusive economic zone (EEZ) of a coastal state; second, those straddling the borderline of two or more EEZs; third, those that straddle an EEZ and adjacent high sea areas; and fourth, the discrete stocks occurring only in the high seas. The first three situations do not require any new binding instrument supplementing the LOSC. However, in my view, the last situation would benefit from a supplementary agreement.

¹ The 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (United Nations Fish Stocks Agreement – UNFSA).

I shall discuss these four situations in turn. But the main focus will be on the last, dealing with the high seas.

2. STOCKS OCCURRING WITHIN AN EEZ

Where a deep-sea stock is found solely within the EEZ of a coastal state, the coastal state has the exclusive jurisdiction and a duty to conserve and manage them in accordance with Articles 61 and 62 of the Convention. In addition, the relevant provisions of Part XII (Protection and preservation of the marine environment), in particular Article 194 (5), apply. That article requires states to take measures “necessary to protect and preserve rare or fragile ecosystems as well as the habitat of depleted, threatened or endangered species”. It should also be noted that in taking any regulatory measure related to fishing, the coastal state must have due regard to the rights and duties of other states within the EEZ. This last point is particularly relevant when the coastal state establishes highly restricted marine areas, such as marine protected areas (MPAs), which could affect the freedom of normal navigation and other lawful uses.

One may argue that these provisions are not sufficient for the effective management of deep-sea stocks. However, since such stocks are located within areas under exclusive national jurisdiction, it would be unrealistic to expect that a more detailed agreement be concluded at the global level. A more practical approach would be the preparation of a set of guidelines by the FAO on the basis of the LOSC and the various existing soft-law instruments, particularly the FAO Code of Conduct for Responsible Fisheries and the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem. Incidentally, this suggestion for FAO guidelines is made not only with respect to those stocks within EEZs, but also all types of deep-sea stocks. The guidelines thus should be a comprehensive document containing specific measures to be taken by all stakeholders involved in deep-sea fisheries. It should be a code of conduct relating specifically to deep-sea fisheries in the various jurisdictional waters.

3. STOCKS STRADDLING TWO OR MORE EEZS

With respect to the shared or transboundary deep-sea stocks straddling two or more EEZs, there is only one general provision of Article 63(1) in the LOSC. The provision requires the coastal states concerned to “seek, ... to agree upon the measures necessary to coordinate and ensure the conservation and development of such stocks”. Several bilateral or regional arrangements or agreements have been concluded dealing with some of such stocks.

However, no agreement dealing specifically with shared deep-sea stocks has apparently been concluded. Since the coastal states are duty bound to make efforts in good faith, under Article 63(1) and also under Article 300 of the Convention, to reach agreement on necessary measures, it would be useful if the suggested FAO guidelines could develop some model arrangements.

4. STRADDLING STOCKS

Turning now to straddling stocks, a great deal of international attention has been paid since the early 1990s and the comprehensive agreement that was adopted on the basis of Article 63(2) of the LOSC, for the effective conservation and better management of such stocks, as well as highly migratory stocks. That agreement, the UN Fish Stocks Agreement, is applicable to straddling deep-sea stocks between the parties. It applies, presumably, to orange roughy on the Challenger Plateau and the South Tasman Rise, since New Zealand and Australia respectively regard them as such stocks.

Under the Fish Stocks Agreement, states fishing for the straddling stock and relevant coastal states are obliged to become members of the regional fishery management organization or arrangement (RFMO), or, if no RFMO exists, to cooperate to establish one (Article 8(3) and (5)). Only those states that are members of such an RFMO, or

which agree to apply the conservation and management measures established by such RFMO, are given access to the resources concerned (Article 8(4)). The Agreement provides for the precautionary approach and contains detailed rules in order to ensure effective conservation and management of the stocks. It further gives teeth to its provisions by empowering states parties that are members of the RFMO to board and inspect fishing vessels of another party in the high-seas regulatory area of the RFMO concerned, whether or not such a state party is a member of the RFMO.

The Agreement, thus, would go a long way toward achieving an effective regime for the conservation and management of straddling deep-sea stocks. A major challenge, however, is how to make it universally applicable. Until that objective is achieved, there are always some free-rider vessels that keep engaging in fishing in regulatory areas without being bound by the Agreement nor by conservation and management measures adopted by the RFMOs concerned. Thus, for example, even if a RFMO adopts a moratorium on fishing or establishes an MPA within its competence, it cannot be enforced against those states which are party to neither the RFMO nor the Fish Stocks Agreement.

Currently there are three groups of states that are not parties to the Fish Stocks Agreement. The first group consists mainly of some distant water fishing states, which are in favour of its general thrust but are reluctant to become parties because some of the provisions are considered as contrary to their important interests. The second group consists of those which want to stay out of the Agreement to keep their fishing activities as free as possible under freedom of high-seas fishing, thus maximizing their short-term profit. These are mainly flag-of-convenience states whose vessels are mostly owned in fact by nationals of other states. The third group of state are those that pay little attention to the Agreement because they have virtually no stake in the subject. The problem is how to bring the first two groups of states into accepting the regime established by the Fish Stocks Agreement. It is clear that unless, and until, these fishing states become parties or otherwise accept the regime the Agreement would never become effective.

In my view, two different strategies should be adopted to make the Fish Stocks Agreement regime more effective. One addresses the first group of states and another the second group. The latter states would never be willing to accept the regime as long as they have the first group on their side. The only way to bring the second group of states into the regime would be to isolate them and bring concerted pressures upon them. Such pressures may include economic and trade measures. Several RFOs, particularly regional tuna management organizations such as the ICCAT and the IOTC, have actually adopted such measures. On the other hand, the first group of states are fully aware of the biological as well as economic risks that they themselves would eventually have to face unless they cooperate with other fishing states and the coastal states. Unlike the second group of states, these distant water fishing states do have a strong motivation to establish effective regional management regimes.

It is therefore desirable that the current parties to the Fish Stocks Agreement consider practical ways and means for removing the obstacles that non-party distant-water fishing states are facing. To this end, dialogues should be started between the two. This does not necessarily mean that the Agreement should be amended; all possible means for adjusting those provisions causing problems in their implementation should be explored. The review conference, which is to be convened shortly after December 2005, would be a timely occasion for that purpose.

5. DISCRETE HIGH-SEAS STOCKS

On the high seas, all states have freedom of fishing, including for deep-sea species, subject to Articles 117-119 of the LOSC and any obligations under other treaties to which they are parties. Article 117 requires of all states that their nationals take

conservation measures. Article 118 provides for the duty of all states to cooperate in the conservation and management of fishery resources, including in establishing RFMOs as appropriate. And Article 119 lays down certain standards in taking conservation measures. In addition, within the context of their duty to protect and preserve the marine environment in all areas, states are required to take the measures necessary to protect and preserve rare or fragile ecosystems as well as the habitat of depleted, threatened or endangered species and other forms of marine life (Article 194(5)). It should also be stressed that in exercising the freedom of fishing, states are obliged to pay due regard to the interests of other states (Article 87(2)).

These are, however, all generally-formulated duties in the form of framework provisions. Several regional agreements have been adopted for the conservation and management of certain stocks, and some attempts have been made specifically to regulate the orange roughy fishery on the high seas in the southeastern part of the Indian Ocean. However, no agreement exists that would serve as a linkage between the LOSC and regional agreements or arrangements. All states are certainly under a *general duty to cooperate* in the conservation and management of high-seas stocks and to set up RFMOs if necessary. But these provisions alone do not provide a sufficient legal basis to compel unwilling fishing states to join in specific collaborative efforts. Without a global agreement that facilitates the implementation of the general duties contained in the LOSC and provides for enforcement scheme, there would always be some states which choose not to join RFMOs and continue their unregulated fishing under freedom of high-seas fishing.

It is therefore suggested that a new global agreement be adopted with a view to bridging the gap between the LOSC and RFMOs, and where no RFMOs exist to facilitating the establishment of such an RFO. Although the immediate candidate species to be covered by such a global agreement are the deep-sea stocks, it would be desirable that the new agreement be formulated in such a way as to cover all existing and potentially harvestable fishery resources in the high seas. The specific species to be regulated deep-sea or otherwise, should be grouped according to appropriate criteria and placed in a separate annex to the agreement, together with a set of conservation and management measures that are specifically required for each group. Some of the measures may be in an obligatory form, while others could be in the form of guidelines, which could subsequently be adopted as binding measures by RFMOs. The meeting of states parties should be given the power to adopt new annexes as new species are discovered or new needs arise. The conservation and management measures accompanying each annex should also be subject to review and modification through simplified procedures, as new scientific knowledge and techniques become available.

The main parts of such new high-seas fish stocks agreement could be modelled on the UN Fish Stocks Agreement. A number of the latter's substantive provisions can be used mostly with minor adjustment. These are, in particular, Articles 5 (general principles) and 6 (the precautionary approach) in Part II, as well as most of the provisions in Parts III (mechanisms for international cooperation), Part IV (non-members of RFOs), Part V (duties of the flag state), Part VI (compliance and enforcement) and Part VII (requirements of developing states). Similarly, Annexes I (data collection and sharing) and II (the application of precautionary reference points) could also be adjusted and updated. Naturally, any developments in the review conference under Article 36 of the Agreement, if any, must be taken into account. In addition, the future agreement should incorporate one new element, under which FAO's Committee on Fisheries (COFI) would be given a coordinating role for all RFMOs dealing with the high seas as well as straddling fish stocks. I return to this point below.

In the negotiations for a new high-seas stocks agreement, it is of utmost importance to ensure that the new agreement command widespread support. Otherwise, it would not serve as an effective link between the LOSC and RFMOs. So, here again, the major

challenge to be overcome is the drafting of a global agreement capable of attracting universal or near-universal adherence.

6. GLOBAL FISHERIES GOVERNANCE STRUCTURE

Once the UN Fish Stocks Agreement and the proposed global high-seas stocks agreement achieve *de facto* universal acceptance, and main high-seas fisheries are regulated by relevant RFMOs, one can expect that the global governance of high-seas fisheries will be improved considerably and be better structured than what we have today. This governance system would actually not be limited to the high seas, but it would serve generally for all fisheries including, to a certain degree, the areas under national jurisdiction.

The basic global governance structure consists of the UN General Assembly, the FAO's COFI and the various RFMOs. As the world's highest political body, the UN General Assembly continues to lay down most important policy recommendations within the overall context of ocean governance addressed to states as well as global and regional organizations. At the same time, as an organ with oversight role in the implementation of the LOSC, the Assembly may initiate the process of negotiating new instruments, particularly those intended to promote the implementation of some of its provisions. Since the time for the Assembly's annual debate on ocean affairs and the law of the sea is quite limited, it should continue to be assisted by the more detailed informal discussions (e.g. by the UNICPO) on some of the priority topics, which are open also for participation by international organizations and civil society representatives.

The COFI receives specific requests from time to time from the General Assembly. It is, however, in its own right the highest global body in fishery matters, competent at the direction of FAO member states to deal with all questions relating to fisheries, including the drafting of new conventions and non-binding instruments such as the codes of conduct and international plans of action. In many cases, such conventions and instruments are addressed not only to states but also to RFMOs.

The COFI has some degrees of supervisory or coordinating power over RFMOs that have been created on the basis of the FAO Constitution. It has, however, currently no such power with respect to those RFMOs which are set up outside the FAO framework. With the increase in the number of non-FAO RFMOs, it is highly desirable for FAO to be given the role to coordinate the activities of not only FAO bodies but also of non-FAO RFMOs. The Meeting of Regional Fishery Bodies, which has been institutionalized recently to meet in conjunction with COFI is an encouraging step in this direction. Existing RFMOs should be urged to establish closer ties to COFI through this arrangement. With regard to future RFMOs in charge of high-seas stocks, the proposed new global agreement on discrete high-seas stocks should provide for such linkage.

Coordination and cooperation among RFMOs is increasingly becoming important for variety of purposes, including sharing of experience and information, settling problems of overlapping jurisdiction, cooperation in enforcement against IUU fishing vessels and avoiding duplication of efforts.

7. CONCLUSIONS

I have tried to paint a somewhat ideal picture for the conservation and management of deep-sea stocks. It is of course easy to draw the picture; the actual work to achieve it would face a number of obstacles and require a great deal of time.

In order to facilitate that long-term goal, however, the FAO, through the COFI, should be given the immediate task of preparing four sets of guidelines for deep-sea fisheries, i.e. for those stocks found solely within EEZs, those shared by two or more EEZs, those that straddle an EEZ and the high seas, and those occurring solely in the

high seas. The guidelines should contain specific measures to be recommended to states and RFMOs, as appropriate, for the conservation and management of such stocks. They should not be intended to be comprehensive and rigid from the beginning; rather they should take a step-by-step approach, to be expanded as the new discoveries are made and scientific information and data become sufficiently available. Such guidelines would no doubt be of great value for the future works, discussed above, in improving the regime of the UN Fish Stocks Agreement, as well as the development of a new regime covering high-seas stocks.

Management and governance conventions and protocols – SEAFC¹, WCPFC and SADC²

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1. INTRODUCTION

The 1995 *Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks* (United Nations Fish Stocks Agreement – UNFSA) (Anon. 1998a) aims to consolidate relevant provisions (particularly Articles 63, 64 and 116 to 120) of the 1982 *United Nations Convention on the Law of the Sea* (Law of the Sea Convention – LOSC) (Anon. 1983), which addresses conservation of such stocks. Together with the 1995 *FAO Code of Conduct for Responsible Fisheries* (Code of Conduct) (Anon. 1998b), UNFSA provides a framework for practical implementation of effective fisheries conservation and management measures. One of its main objectives is to progressively facilitate rational and long-term sustainable utilization of fisheries resources on both the high seas and in waters under national jurisdiction. It therefore places high priority on ensuring effective co-operation between coastal states and distant-water fishing states on a range of fundamental and technical issues pursuant to LOSC Articles 63 and 64.

This paper reviews two international fisheries agreements negotiated immediately prior to the entry into force of the UNFSA on 11 December 2001. These agreements seek to apply UNFSA provisions specifically to straddling fish stocks in the South-East Atlantic Ocean (Anon. 2001a) and to highly migratory fish stocks in the Western and Central Pacific Ocean (WCPFC) (Anon. 2000). More detailed emphasis is given to the former with the latter being included for comparative purposes. In conformity with the statement made by the UNFSA negotiation's Chairman (Nandan 1995), the paper also illustrates how a regional economic and political alliance – the South African Development Community (SADC) – has recognized (through a specifically developed Protocol on Fisheries – Anon. 2001b) the importance of regional co-operation to ensuring consistent application of the UNFSA's provisions in general, and of specific fisheries arrangements such as the South East Atlantic Fisheries Commission (SEAFC) in particular.

¹ For the purposes of this paper, the acronym SEAFC refers to the Convention on the Conservation and Management of Fishery Resources in the South-East Atlantic and the acronym SEAFO refers to the institutional arrangements set up under SEAFC Articles 5, 6, 9, 10 and 11 (the “Organization”).

² See SADC 1993.

³ The opinions expressed in this paper are those of the author do not represent the collective, or official, views or decisions of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR).

2. SOUTH EAST ATLANTIC FISHERIES COMMISSION

2.1 Background

The regional fisheries management organization (RFMO) established under SEAFRC Article 5 succeeds the International Commission for the Conservation of the Living Resources of the Southeast Atlantic (ICSEAF), established under the Convention of the same name, which entered into force on 23 October 1971 (ICSEAF 1969).

The evolution of SEAFRC is closely associated with post-independence re-structuring of Namibia's fishing industry. Prior to independence in 1990, ICSEAF strived to implement sustainable management of fisheries in the Southeast Atlantic in general, and in Namibian waters in particular. However, in practice, many of the 17 member states used ICSEAF as a way of legitimizing unsustainable exploitation of many target stocks concerned, despite South Africa's attempt to regulate fishing off the Namibian coast through promulgation of a 200-mile Exclusive Economic Zone (EEZ) on 1 April 1981. This situation was largely attributable to the refusal of nations, whose flagged vessels were operating in Namibian waters, to recognize South Africa's administrative powers granted under the League of Nations' C-Class Mandate for the governance of South-West Africa in 1920. This Mandate was formally overturned by the *United Nations General Assembly Resolution 2145* in 1961.

On independence, Namibia declined to become an ICSEAF Member and subsequently declared a 200-mile EEZ under the Territorial Sea and Exclusive Economic Zone of *Namibia Act 1990*. In combination with the *1992 Sea Fisheries Act*, this legislation was directed at improving the management of targeted stocks and at developing Namibia's own domestic fishing capacity. These actions were vindicated by a dramatic recovery of a large number of depleted resources within the Namibian EEZ, but necessitated terminating ICSEAF through a Protocol of Termination adopted in Madrid on 19 July 1990. Although the Protocol has not been ratified, it effectively ended ICSEAF.

During the 1990s, Namibia continued to consolidate its fisheries by implementing far-sighted management policies and through systematic commitment to both its national interests and its obligations under various international fisheries agreements. Clear demonstration of such commitment is apparent by the country's signature and subsequent ratification (8 April 1998) of the UNFSA and its acceptance of the International Convention for the Conservation of Atlantic Tunas (ICCAT)(ICCAT 1966) in 1999. However, despite these developments, Namibia continued to express concern that certain and commercially valuable straddling stocks such as orange roughy (*Hoplostethus atlanticus*) required better protection to avoid compromising their domestic potential as a result of unsustainable fishing practises on the adjacent high seas. Such concern was aggravated by prevailing uncertainty concerning the status of such stocks and about the actual levels of fishing targeting them⁴.

Namibia taking advantage of impetus provided by the UNFSA negotiations approached three neighbouring coastal states (Angola, South Africa and the United Kingdom, on behalf of its Dependencies of Ascension, St Helena and Tristan da Cunha) to establish a RFMO closely aligned with the UNFSA to manage fisheries resources on the high seas adjacent to their respective EEZs. During three meetings in 1997 (Table 1), the coastal states developed a draft convention which was presented to five other parties [the European Community (EC), Japan, Norway, Russian Federation and the United States], identified as having distant water fishing interests in the region. Other parties joining the negotiations included the Republic of Korea, Iceland, Poland and Ukraine. Negotiations continued over seven additional meetings and one technical consultation between 1997 and 2001 prior to the Convention's signature on

⁴ Jackson (2000, 2002) provides a detailed history of the *SEAFRC* negotiations.

20 April 2001 by the four coastal states and by the EC, Iceland, the Republic of Korea, Norway, and the United States. Japan did not sign the Convention but indicated its support for it.

The various SEAFDC drafts drew on a number of existing instruments to provide for the highest possible standards of fisheries management. Particular cognisance was taken of relevant provisions of the LOSC, UNFSA, Code of Conduct and the 1982 *Convention on the Conservation of Antarctic Marine Living Resources* (CCAMLR) (CCAMLR 2002). Although, the initial draft text was extensively modified during the various meetings, the core principles remain distinct in the final Convention text (see Section 2.2). However, it should be emphasized that the UNFSA constituted the basis for most of the discussions on the SEAFDC text.

SEAFDC was ratified by Namibia on 7 June 2002, approved by the EC on 8 August 2002 and ratified by Norway on 12 February 2003. The conditions for the Convention's entry into force (three signatories, one being a coastal state) under Article 27 were therefore met on 13 April 2003, 60 days after the Norwegian ratification.

TABLE 1
SEAFDC negotiating meetings

MEETING	LOCATION	DATE
Coastal States	Cape Town, South Africa	24-26 February 1997
	Otjiwarongo, Namibia	30 June – 4 July 1997
	Cape Town, South Africa	9-10 September 1997
	Windhoek, Namibia	2 December 1997
First	Windhoek, Namibia	3-4 December 1997
Second	Cape Town, South Africa	19-22 May 1998
Third	Swakopmund, Namibia	22-25 September 1998
Fourth	Oxford, United Kingdom	8-11 March 1999
Fifth	Cape Town, South Africa	27 September – 1 October 1999
Sixth	Midgard, Namibia	8-12 May 2000
Seventh	Windhoek, Namibia	9-11 November 2000
Eighth	Windhoek, Namibia	19 April 2001
Technical Consultation	Windhoek, Namibia	1-4 March 2000
Final Conference	Windhoek, Namibia	20 April 2001

2.2 The Convention

2.2.1 Background

SEAFDC's primary objective (Article 2) is to “ensure long-term conservation and sustainable use of the fishery resources in the Convention Area”. There was considerable debate as to whether the term “fishery resources” should be applied rather than the broader term “marine living resources”. Partly in deference to the EC's undisputed competency for fisheries matters, the current formulation was accepted. It therefore became necessary to clearly define “fishery resources” (see Section 2.2.2) as opposed to “marine living resources” in Article 1 to limit the Convention's primary application to exploited species, unless otherwise indicated [e.g. in Article 10.(2).(c)] or expressly qualified by some direct effect of fishing activities on non-target species such as seabirds.

2.2.2 Area of application

The SEAFDC Area roughly corresponds to FAO Statistical Area 47. It applies to waters beyond areas of national jurisdiction (SEAFDC Article 4) and is bounded in the south, i.e. at 50°S, by the northern CCAMLR boundary. The Area extends south-east of

South Africa to 30°E in the Indian Ocean in an attempt to account for hydrological and ecological commonalities between the Benguela and Agulhas Currents in the Atlantic and Indian Oceans respectively, particularly in the vicinity of the Agulhas Bank. In definitive terms (Figure 1), the SEAFC Area comprises all waters in an area bounded by a line joining the following points of latitude and meridians of longitude “beginning at the outer limit of waters under national jurisdiction at a point 6° South, thence due west along the 6° South parallel to the meridian 10° West, thence due north along the 10° West meridian to the equator, thence due west along the equator to the meridian 20° West, thence due south along the 20° West meridian to a parallel 50° South, thence due east along the 50° South parallel to the meridian 30° East, thence due north along the 30° East meridian to the coast of the African continent”. There is a small deviation from Statistical Area 47 in the vicinity of Ascension Island so as to include the entire zone around the Island as well as the adjacent high seas (Jackson 2002).

In the Final Minute⁵, and at Angola’s insistence, a resolution was attached to allow possible application of the SEAFC Area to include the small enclave known as Cabinda, which adjoins the Congo River on the borders of Angola and the Democratic Republic of the Congo (DRC). The result is a small discontinuous region in the Convention Area’s northern boundary. Given the prevailing uncertainty at the time concerning the legitimacy of the DRC government, this may have been aimed at underpinning the international legitimacy of Angola’s claim to oil-rich Cabinda rather than an expression of any particular fisheries interests. It remains to be seen how the boundary in the Cabinda region will be applied in practice. The resolution clearly indicates that the issue will be considered at the first full meeting of the SEAFO Commission.

It should also be noted that Japan in particular expressed reservation on whether the application of SEAFC to areas outside those under national jurisdiction alone was

FIGURE 1
The SEAFC Area and SADC Member States



⁵ Final Minute of the Conference on the South East Atlantic Fisheries Organization and of the Meeting of Coastal States and Other Interested Parties on a Regional Fisheries Management Organization for the South East Atlantic held in Windhoek, Namibia 20–21 April 2001.

consistent with other agreements. While the reasons for this position are not clear, it may have been an attempt to enhance historic fishing performance under ICSEAF as a precedent for gaining access to Namibia and Angola's comparatively rich fisheries resources. Alternatively, it could also have been in response to developments elsewhere, especially the parallel WCPFC negotiation process (Section 3).

2.2.3 Stocks covered

SEAFRC Article 1.(l) identifies the fishery resources to be covered by the Convention as all resources of fish, molluscs, crustaceans and other sedentary species within the Convention Area, excluding:

- sedentary species subject to the fishery jurisdiction of coastal states pursuant to Article 77.(4) of the LOSC and
- highly migratory species listed in LOSC Annex I.

In excluding highly migratory species, SEAFRC recognizes the competence of ICCAT. In this context, Article 18.(4) ensures that in applying SEAFRC's objectives (Article 2) and general principles (Article 3), co-operation is encouraged with other relevant fisheries management organizations, such as ICCAT and account is taken of their conservation and management measures for the region.

TABLE 2
Species covered by SEAFRC listed in Section 5 of the Annex to the Convention

Species	Scientific name
Alfonsino	Berycidae
Horse mackerel	<i>Trachurus</i> spp.
Mackerel	<i>Scomber</i> spp.
Orange roughy	<i>Hoplostethus</i> spp.
Skates	Rajidae
Sharks	Order Selachimorpha
Armorhead	<i>Pseudopentaceros</i> spp.
Cardinalfish	<i>Epigonus</i> spp.
Deepsea red crab	<i>Chaecon maritae</i>
Octopus and squid	Octopodidae/Loliginidae
Patagonian toothfish	<i>Dissostichus eleginoides</i>
Hake	<i>Merluccius</i> spp.
Wreckfish	<i>Polyprion americanus</i>
Oreodories	Oreosomatidae

The stocks covered by SEAFRC (Table 2) include those that straddle the Convention Area and adjacent waters under national jurisdiction as well as discrete high-seas stocks that do not occur during any part of their life cycle in waters under national jurisdiction. Jackson (2002) has indicated that this distinction is a legal one and does not necessarily conform to the biological distribution of individual stocks. This is an important distinction since the SEAFRC negotiating process recognized that conservation and management of discrete stocks, notwithstanding their distribution exclusively in the high seas, would incorporate such stocks under the general obligation to co-operate in the development of suitable conservation measures outlined in LOSC Article 117. Equally, they would not be subject

to specific requirements for regional co-operation contained in LOSC Articles 63 and 64 or throughout UNFSA.

Despite being limited to the high seas, SEAFRC Article 19 provides for co-operation between coastal states and other SEAFRC Parties to ensure compatibility between conservation and management measures for straddling stocks both in the Convention Area and in adjacent coastal waters under state jurisdiction.

2.2.4 Openness and transparency

Both the SEAFRC negotiations and provisions covering ratification, approval (Article 25) and accession (Article 26) render the Convention open to all parties (including states and regional economic organizations) in accordance with their rights and obligations under LOSC Article 116 in particular. In addition, Article 22.(4) provides for the co-operation of fishing entities in meeting the Convention's objectives. Such reference clearly draws on similar consideration outlined in UNFSA Article 1.(3). This particular provision anticipates that such entities, as well as other non-contracting parties, will enjoy benefits from participation commensurate with their commitment to SEAFRC's conservation and management measures. How such participation could be assessed was

not addressed and remains moot. Nevertheless, the encouragement of openness assists in avoiding complicated assessments of the rights of new participants in terms of some of the considerations identified in UNFSA Article 11. Some of these, however, have taken into account in the procedures attached to the allocation of fishing opportunities (UNFSA Article 20 and Section 2.2.6) and the need to account for the special needs of developing states (SEAFC Article 21).

Another issue that remains unresolved is that of “real interest”. After much debate, the SEAFC negotiators were not able to define this term in relation to the fisheries covered by the Convention⁶ despite an obvious desire to further the real interest eligibility provisions of UNFSA Article 8.3. Despite their failure, the Convention’s Preamble clearly indicates that the question of “real interest” remained in the minds of the negotiators as an important consideration for participation in meeting SEAFC’s objectives.

The Convention complements its attempts to promote openness by expressly recognizing the need to provide for transparency in its activities. Based on similar sentiments in UNFSA Article 12, SEAFC Article 8.(9) clearly urges the Commission to adopt rules of procedure, as a matter of urgency, to allow for transparency in its activities. It further emphasizes that these rules should not be unduly restrictive and should provide for timely access to SEAFO records and reports subject to any subsequent agreement on procedural rules.

2.2.5 Institutional aspects

SEAFC Article 5 establishes the “Organization” (i.e. SEAFO) responsible for carrying out the institutional functions underpinning the Convention’s successful implementation. This comprises the Commission, the Scientific and Compliance Committees as subsidiary bodies and the Secretariat. The Commission is also empowered to establish subsidiary bodies as necessary. The functions of the Commission and its subsidiary bodies are detailed in Articles 6 (Commission), 9 (Compliance Committee), 10 (Scientific Committee) and 11 (Secretariat). In particular, the language of Articles 6, 10 and 11 draws heavily on similar CCAMLR Articles - namely IX, XV and XVII respectively (CCAMLR 2002).

Budgetary considerations are outlined in SEAFC Article 12 with Article 12.1 and clearly stress that the Organization be cost-effective. As a matter of principle, each contracting party is required to contribute to the budget [Article 12.(2)] an equal basic fee and a fee determined from the total catch of species covered by the Convention. Parties agreed during negotiations that every effort should be made to activate SEAFO in order to anticipate, and ameliorate, any potential problems likely to arise should fishing in the Convention Area suddenly increase. However, in budgetary terms, considerable uncertainty surrounds the economic value of both the current and future fishery in the Area. The Parties thus anticipated that SEAFO’s tasks would increase at a rate commensurate with the work required by the development of the fisheries concerned.

To assess both the urgency for SEAFO conservation measures and to provide some basis for budget estimates, the negotiating Parties attempted to share available catch data from the Convention Area. Initially, information was compiled by the South African Government until 1999, when the Parties agreed at the Fifth Meeting (Table 1) that, to ensure the veracity and consistency of data, future attempts to monitor fishing in the Convention Area should await SEAFC’s entry into force when obligations to that

⁶ The issue of “real interest” was discussed at length, particularly at the Second *SEAFC* Negotiating Meeting (Table 1). Considerable thought was given to the concept as it may relate to each of the negotiating parties and how it might be assessed. Discussions focussed on a range of activities such as scientific interest, historic fishing performance, desire to fish, commitment to conservation and related matters in respect of both current and potential future participants. For example, SEAFC Article 1.(h).(ii) linked scientific research directly to “fishing”. However, later agreement in Article 25 removed the need for any eligibility criteria for participants. For a full discussion of the concept of “real interest” refer to Molenaar (2000).

effect could be created. Therefore, the Technical Consultation held in February 2000 (Table 1) drafted interim measures to ensure collection of relevant data by contracting party flag states immediately upon the Convention's entry into force. These measures were annexed to the SEAFRC.

Following a similar approach invoked by CCAMLR Article XIX.(3) and its attached financial regulations (CCAMLR 2002), SEAFRC Article 12.(4) requires an equal contribution from each contracting party for the first three years after the Convention's entry into force, or any shorter period as decided by the Commission. This was seen as a way to cover SEAFRC's initial establishment costs. Thereafter, it was agreed that the assessed proportionate contributions alluded to in Article 12.(2) would be applied in a manner that considered the economic status of each contracting party. The basis of how this status could be assessed has not been made clear although the final sentence of Article 12.(3) indicates that it should be the economic status of any territory which adjoins the Convention Area as opposed to that of the contracting party governing such territory. This provision was inserted at the request of the United Kingdom to account for the overseas territories (Ascension, St Helena and Tristan da Cunha) on whose behalf it was negotiating.

2.2.6 Decision-making

Contrary to many other RFMOs, the SEAFRC negotiators recognized that there was merit in ensuring that once a decision is reached on any matter of substance (e.g. conservation measure) then every effort should be made to ensure that it is implemented by all contracting parties in a manner that does not require that it be revisited for any reason other than some "exceptional circumstance". Therefore, SEAFRC Article 17 indicates that any SEAFRC decisions on matters of substances will be by consensus. The wording of this particular article is similar to CCAMLR Article XII (CCAMLR 2002), which also provides for consensus-based decision-making.

SEAFRC Article 23 sets out how decisions will be implemented. As emphasized by Jackson (2002), and notwithstanding any compromises attached to the achievement of consensus, Article 17 provides for a contracting party to register its non-acceptance of such decisions and therefore not be bound by them. This is similar to the non-acceptance procedures outlined in CCAMLR Article IX.(6) (CCAMLR 2002) and in Article XII of the Convention on Future Multilateral Cooperation in Northwest Atlantic Fisheries (NAFO) (NAFO 1979).

Despite perceptions to the contrary, Article 23 attempts to make clear the exceptional nature of any application of SEAFRC's "non-acceptance" provisions. Consequently, this particular Article introduces a number of procedural checks to preserve the right of any SEAFRC contracting party not to comply with a SEAFRC decision. These checks include written detail of any alternative measures to be implemented by the party concerned, a clear explanation of why the party is unable to be bound by the decision, the opportunity for all Contracting Parties to review the matter at a special meeting and, on request, the establishment of an *ad hoc* expert panel to make recommendations on the matter.⁷ It is unclear how these provisions will work, however, it should be stressed that in CCAMLR's some twenty-two year existence, its "non-acceptance" provisions have been activated once and then only for technical reason relating to data reporting requirements contained in CCAMLR Conservation Measure 37/X (CCAMLR 1991). The adoption of a new conservation measure (CCAMLR Conservation Measure 56/XI) the following year appeared to rectify the problem.

⁷ The establishment of an *ad hoc* panel may be viewed as part of SEAFRC's dispute resolution mechanism detailed in Article 24 [particularly paragraph (3)], which is to be elaborated by the Commission's first meeting.

Finally, SEAFRC does not provide a mechanism for specifically resolving potential deadlocks in decision-making. Consequently, it is implied that failure to resolve any deadlock would automatically result in a “dispute” being declared and the matter would become subject to the procedures of Article 24 (Section 2.2.8).

2.2.7 Fishing opportunities

The SEAFRC article (Article 20) dealing with allocation of fishing opportunities was one of the last and most difficult to negotiate. Not only had equitable access to economic benefits to be addressed, consideration also had to be given to providing for a balance between the interests of distant-water fishing nations and those of developing coastal states eager to build their fishing industries. A key consideration was how historical fishing performance in the Convention Area should be weighted in providing access to resources for new entrants and in terms of providing equity of access to previously unregulated, or unexploited, resources. A clear illustration of the inherent complexity and difficulty of such debate was also manifest during ICCAT’s deliberations on quota allocation over the past few years.⁸

In the first instance, all the SEAFRC negotiating Parties agreed that the LOSC Article 116 should prevail and consequently all states have a legitimate right to engage in fishing subject to their LOSC obligations and the rights and duties of coastal states provided for, *inter alia*, in LOSC Article 63.(2) and Articles 64 to 67. While SEAFRC does not provide a precise recipe for fisheries or quota allocations, Article 20 provides extensive guidance. In this context, it is worthwhile noting that the term “fishing opportunities” was developed at the Third Meeting of the Coastal States (Table 1) in an attempt to detract from negative connotations attached to the use of such phraseology as “quota allocation” and “fishing rights”.⁹ Further, an original coastal states’ proposal to reserve a pre-determined, but unspecified, quota percentage for their use had fallen away by the Third Meeting (Table 1).

As noted, SEAFRC Article 20 (Table 3) takes account of all the criteria set out in UNFSA Article 11. Noteworthy additions include the stage of fishery development

TABLE 3

Factors to be taken into account by the SEAFRC Commission in determining nature and extent of participatory rights in fishing opportunities under Article 20 (1)

a) The state of fishery resources including other marine living resources and existing levels of fishing effort, taking into account the advice and recommendations of the Scientific Committee
b) Respective interests, past and present fishing patterns, including catches and practices in the Convention Area
c) The stage of development of a fishery
d) The interests of developing states in whose areas of national jurisdiction the stocks also occur
e) Contributions to conservation and management of fishery resources in the Convention Area, including the provision of information, the conduct of research and steps taken to establish co-operative mechanisms for effective monitoring, control, surveillance and enforcement
f) Contributions to new and exploratory fisheries, taking account of the principles set out in Article 6.6 of the 1995 UNFSA
g) The needs of coastal fishing communities which are dependent mainly on fishing for the stocks in the South-East Atlantic and
h) The needs of coastal states whose economies are overwhelmingly dependent on the exploitation of fishery resources.

⁸ See various ICCAT efforts to address, and subsequently agree on, quota allocations: Website: <<http://www.iccat.es>>.

⁹ The reports of early SEAFRC negotiating meeting provide details of this discussion.

[Article 20.(1).(c)] and contributions to new and exploratory fisheries subject to UNFSA Article 6.6 [SEAFC Article 20.(1).(f)]. Application of the various criteria in SEAFC Article 21.(1) is qualified for allocation of fishing opportunities insofar that the Commission takes into account information, advice and recommendations on the implementation of, and compliance with, conservation and management measures by the contracting party concerned.

Article 20 affords no priority weighting to any particular criteria nor does it indicate how they should be applied. It does attempt to recognize the diverse interests of SEAFO Parties in such a way that transparency is introduced to the way that decisions on allocation of fishing opportunities are taken. Also, while providing some guidance on allocation, possibly more than other regional Conventions that pre-date UNFSA (Jackson 2002), specific details have been left to the Commission to develop at a later stage.

2.2.8 Control measures

Considerable focus was given during the SEAFC negotiations to development of a robust SEAFO monitoring, control and surveillance (MCS) system. As emphasized by Jackson (2002), this system came to be based largely on flag state responsibilities and complementary measures.

Flag state measures

SEAFC Article 14 sets out the flag state responsibilities of SEAFC parties. These include the taking of necessary measures to ensure that the Convention is not undermined [Article 14.(1), 14.(2) and 14.(4)]. The type of measures envisaged are outlined in Article 14.(3)(Table 4) and it is apparent that some of these (e.g. dealing with bilateral exchange of observers and deployment of vessel monitoring systems) are cognisant of similar measures used by other RFMOs and by CCAMLR in particular. In addition, Article 14.(4) requires that SEAFO flag states ensure that their vessels operating in waters adjacent to the SEAFC Area do not fish in a way that undermines the Organization's agreed measures. As a whole, SEAFC Article 14 draws heavily on UNFSA Articles 18 and 19.

The generalities outlined in SEAFC Article 14 are developed further in Article 16 in respect of observation, inspection, compliance and enforcement – the 'MCS' System. In particular, Article 16 establishes principles to underpin the System [Article 16.(2)] and introduces elements comprising control measures linked to flag state duties under Article 14 as well as at-sea and in-port inspection, at-sea observer programmes and procedures to follow-up on infringements [Article 16.(2)]. There was considerable debate on whether the System constituted an alternative mechanism for regional co-operation in enforcement, as in the UNFSA Article 21.(15), or not. The EC in particular believed that it did and therefore the detailed development of SEAFC MCS procedures should await the Convention's entry into force, particularly in respect of reciprocal arrangements for boarding and inspection as outlined in the UNFSA Article 22.

Consequently, Article 16 leaves it to the SEAFO Commission to establish its own observation, inspection, compliance and enforcement system [Article 16.(1)]. However, it also emphasizes that the "major purpose" of such a system is "to ensure that contracting parties effectively discharge their obligations under this Convention and, where applicable under the 1995 Agreement [i.e. UNFSA], in order to ensure compliance with the conservation and management measures agreed by the Commission". Article 16.6 provides the additional caveat that after two years a special meeting may be convened at the request of any contracting party should the Commission not establish a satisfactory MCS system and to strengthen the effective discharge of contracting party obligations under both SEAFC and UNFSA. This compromise contrasts markedly with the mandatory institution of the procedures outlined in UNFSA Article 21 and 22 in the

TABLE 4

Measures to be taken by SEAFIC Parties under Article 14.(3) to ensure flagged vessels give effect to measures agreed by the Commission

a) Measures to ensure that a flag state investigates immediately and reports fully on actions taken in response to an alleged violation by a vessel flying its flag of measures adopted by the Commission
b) Control of such vessels in the Convention Area by means of fishing authorization
c) Establishment of a national record of fishing vessels authorized to fish in the Convention Area and provisions for sharing this information with the Commission on a regular basis
d) Requirements for marking of fishing vessels and fishing gear for identification
e) Requirements for recording and timely reporting of vessel position, catch of target and non-target species, catch landed, catch transhipped, fishing effort and other relevant fisheries data
f) Measures to permit access by observers from other Contracting Parties to carry out functions as agreed by the Commission and
g) Measures to require the use of a vessel monitoring system as agreed by the Commission.

event that consensus cannot be reached on a suitable MCS system within the first two years after SEAFIC's entry into force (see Section 3.2.7). It also illustrates the difficulties faced by the SEAFIC negotiators in developing the Convention before UNFSA's entry into force, particularly when extending the former's mandate to include discrete stocks on the high seas in the absence of a clear international precedent.

Article 16 anticipates that there is probably little point in applying specific MCS procedures in the absence of information on the form, extent or direction of, as yet undeveloped, management measures. For this reason, Article 16.(5) anticipates the setting up of the Convention's Annex (developed at the Technical Consultation in April 2000 – Table 1) to provide interim arrangements for flag state reporting as a precursor to the MCS system. These interim arrangements will remain in force until the system is adopted or until the Commission decides otherwise.

Other measures

Other major measures aimed at ensuring compliance in the absence of effective flag state control include attempts to outline port state controls and to target individuals (i.e. "nationals") or national industries (i.e. "beneficial owners") as sources of non-compliance with SEAFO measures.

The SEAFIC port state controls are relatively straightforward. Article 15 provides for in-port inspections and, where appropriate, prohibition of landings and transshipments. While the language of this particular Article is essentially similar to UNFSA Article 23, a major difference is that it mandates port state action.

In respect of nationals or national industries, the SEAFIC negotiations again encountered difficulties in the absence of any clear international precedent. For this reason, the wording of SEAFIC Article 13.(6).(a) is complex, convoluted and highly qualified:

"Without prejudice to the primacy of the responsibility of the flag state, each Contracting Party shall, to the greatest extent possible, take measures, or co-operate, to ensure that its nationals fishing in the Convention area and its industries comply with the provisions of the Convention. Each Contracting Party shall, on a regular basis, inform the Commission of such measures taken".

The difficulties appeared to diverge on a matter of principle. Essentially, this depended on whether the negotiating parties saw reference to nationals in LOSC Articles 116 to 118 as being perfunctory and, or, salutary as opposed to mandatory.

Furthermore, the EC expressed some interpretational difficulties associated with the term “nationals”, presumably based on complimentary status of people in respect of their sovereign birthright and their right to citizenship under the 1992 Maastricht Treaty (Anon. 1992).

In light of such divergence of opinion, and as for other parts of SEAFRC, the compromise reached attempts to balance prevailing views. Therefore, as Jackson (2002) has emphasized, by according primacy to the flag state, along with recognition of exclusive jurisdiction of such states over their flagged vessels on the high seas¹⁰, the scope of Article 13.(6).(a) is limited to preventative measures before, or corrective measures after, nationals have fished in defiance of SEAFRC measures. As a consequence, there is no suggestion that flag state jurisdiction aboard the vessel(s) concerned has been compromised in any way. Second, while the precise measures or type of co-operation are not spelt out, the obligation to act “to the greatest extent possible” is not insignificant.¹¹

Also, despite their complexity, the SEAFRC provisions addressing control of nationals may be viewed as unique. While building on presumptive wording in UNFSA Article 10.(l), there is little doubt that they were also developed because of growing international concern over eliminating Illegal, Unreported and Unregulated (IUU)¹² fishing, as well as a growing national practice aimed at addressing the problem¹³ by denying vessel operators the economic benefits of unregulated fishing.

While it should be recognized that effective action under SEAFRC Article 13.(6).(a) may prove difficult for legal reasons (e.g. collection of evidence or attribution of responsibility), its inclusion does indicate recognition that action against nationals and, or, national industries may be required. Obviously, such action would only be taken in response to violation of SEAFRC measures.

Finally, Article 13.(6).(b) attempts to require SEAFRC Contracting Parties to exercise their fishing responsibilities subject to the vessels concerned flying their flags. As emphasized by Jackson (2002), this attempts to deal with the chartering of vessels and is different from the situation of NAFO (NAFO 1979) where one contracting party may charter a vessel from another without a change of flag.

¹⁰ Following LOSC Article 92, SEAFRC Article 30, clearly indicates that nothing in the latter will affect the rights and obligations of States under LOSC – a sentiment also implied in UNFSA Article 44. In addition, SEAFRC Article 1.(m) clearly indicates that a regional economic integration organization (i.e. such as the EC) is considered as a flag state in respect of any vessel flying the flag of one of its member states.

¹¹ Jackson (2002) has indicated that this expression is open to interpretation and in practice may not exclude a situation where no measures are actually taken or co-operation is not forthcoming.

¹² Paragraph 18 of the FAO *International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing* (FAO 2001) clearly duplicates the wording of SEAFRC Article 13 (6) (a) and indicates that: “In the light of the provisions of the 1982 Convention, and without prejudice to the primary responsibility of the flag State on the high seas, each State should, to the greatest extent possible, take measures or co-operate to ensure that nationals subject to their jurisdiction do not support or engage in IUU fishing. All States should co-operate to identify these nationals who are operators or beneficial owners of vessels involved in IUU fishing”.

¹³ A number of states have introduced regulatory provisions aimed at ensuring that their nationals comply with international conservation and management measures inside or outside national waters. Notable examples include Australia in application of the *Fisheries Management Act*, 1991 (Act No. 162 of 1991) [Section 8 of the Act applies the Act’s provisions to specified areas outside the Australian Fishing Zone (AFZ) to Australian citizens, bodies corporate, vessels and persons aboard such vessels. When a provision of the Act is applied to any such area, references in that provision to the AFZ are read as reference to that area. Section 8 as a whole also does not limit extra-territorial operation of the Act], New Zealand subject to Part 6A of the *New Zealand Fisheries Act 1996* [Part 6A came into force on 1 May 2002 and prohibits New Zealand nationals (as defined in Section 2 of the Act) from using vessels not registered under the *Ship Registration Act 1992* to fish on the high seas unless specific authorization is provided in conformity with specified criteria]. Norway applies Article 6 of the 1977 Regulations Relating to Fishing and Hunting Operations by Foreign Nationals in its EEZ. In particular, this Article sets out conditions for the issuing of fishing licenses, or their withdrawal, in respect of: (a) fisheries

2.2.9 Other provisions

General principles

Initially, the SEAFRC's Objective and attached General Principles formed part of a single article. However, by the Sixth Meeting, Article 2 had been agreed to in an attempt to provide the Convention with a more sharply focused objective. Nevertheless, there was general agreement that there would be efficacy in listing some key general principles associated with the SEAFRC's effective implementation in Article 3. In particular, two of the original objectives proposed by the coastal states were retained and these focused on the need to take account of the best scientific information available when adopting measures [Article 3.(a)] and to ensure minimal impacts by fishing practices and management measures on the marine ecosystem as a whole [Article 3.(e) and 3(f)]. The retention of these elements was an attempt to counter the rather narrow definition of the "target" resources contained in the Convention mentioned in Section 2.2. It was also deemed necessary in the light of similar attempts to manage fisheries from an ecosystem perspective as referenced in UNFSA Article 5 and practiced by other regional RFMOs such as CCAMLR.

Application of the precautionary approach

In respect of applying the precautionary approach, SEAFRC Article 7 went through a series of major modifications. In the initial coastal state draft, extensive cross-reference was made to UNFSA Article 6, even to the point of producing two annexes detailing the approach's general implications [based on Section 7.5 of the 1995 FAO Code of Conduct for Responsible Fisheries and particularly Section 1.6 of the attached Technical Guidelines –FAO (1996)] and attempting to provide some guidelines for the application of precautionary reference points (UNFSA Annex. II). The abbreviated, and somewhat diluted, final version of Article 7 was thus probably a consequence of two factors. First, certain of the SEAFRC negotiators (particularly Japan and the EC) were reluctant to agree to wording similar to that in UNFSA, in absence of their ratification and acceptance (see also Section 2.3). Second, the EC also appeared to have difficulty in addressing application of the precautionary approach, along with ecosystem concerns, most probably as a consequence of perceived limitations in its mandate to deal with such matters.

within the Norwegian EEZ where a vessel owner or vessel has contravened national law; (b) where a vessel, or its owner, has taken part in fishing outside national quotas in international waters on stocks which are subject to Norwegian fisheries jurisdiction and (c), where the vessel or vessel owner have taken part in fishing operations which contravene regulatory measures of regional or sub-regional fisheries management organizations or arrangements. The legislation was used in 2000 to comply a vessel "blacklist" for which the Norwegian authorities would not issue fishing licenses. South Africa applies its *Marine Living Resources Act 1998* (Act. No. 18 of 1988 – South Government Gazette Notice No. 189630 of 27 May 1998)[Particularly provision 70.(1)(b), which applies the jurisdiction of the courts under the Act to outside South African waters for citizens of the Republic or any person ordinarily resident in the Republic subject to the definition of a South African person contained in Section 1.(lii), which includes trusts or close corporations]. Spain applies Directive 1134/2001 of 31 October 2002. This aims at establishing a mechanism to deal with contraventions by legal and natural persons of Spanish fisheries regulations aboard vessels of other flags. It also establishes criteria to identify such flags and to provide for "aggravating circumstances" for non-compliance by Spanish nationals. A an interesting development in this regard has been the indictment by United States authorities of a number of South African citizens and joint South African-United States nationals under the *United States Lacey Act*. The indictment relates to perceived offences and alleged illegal harvesting of South Coast Rock Lobster and Patagonian Toothfish, in defiance of South African statutes and CCAMLR measures (Anon. 2003).

Co-operation and compatibility of management measures

SEAFC Articles 18 and 19 respectively deal with co-operation between SEAFO and other relevant organizations (principally the FAO) and with ensuring harmonization of measures for straddling stocks in the Convention Area and in areas under national jurisdiction. The negotiation of both Articles was relatively uncontroversial. However, it should be noted that Article 19 calls for compatibility of measures in a manner consistent with their establishment under LOSC Articles 61 and 119.

Special requirements of developing states

Much of the impetus to negotiate SEAFC was provided by developing states. This was clearly reflected in various provisions, particularly the Articles dealing with fishing opportunities (Article 20) and the budget (Article 12). In fact, the balance of interests between distant water fishing states and coastal developing states set out in Article 20 paved the way for Article 21 that explicitly recognizes the special needs of developing states in the SEAFC region. As such, SEAFC Article 20 draws heavily on UNFSA Articles 24 and 25. Emphasis is given to meeting the financial, technical and other needs of both present and future developing states in the region to provide for their improved conservation of, and sustainable access to, the resources covered by the Convention. Not only is recognition given to the general intent of LOSC Article 63.(2), the SEAFC drafters clearly strived to reflect the intention that SEAFO is open to all states in the region, as well as other distant-water fishing states, while bearing in mind a common benefit to the region as a whole.

Non-Parties

As for UNFSA Article 33, SEAFC Article 22 calls on Non-Parties to co-operate fully with SEAFO to ensure that its measures are not undermined [Article 22.(1)] and that appropriate steps are taken by contracting parties [Article 22.(3)] to deter inappropriate fishing activities by non-contracting parties which undermine SEAFO conservation measures. However, SEAFC Article 22 goes further than the UNFSA in specifically providing for the exchange of information on non-party fishing activities [Article 22.(2)] and in addressing the aspirations of fishing entities [Article 22.(4)] (See Section 2.2.3).

Dispute settlement

SEAFC Article 24 outlines procedures for settling disputes. To address issues likely to arise from both straddling and discrete stocks, the Article quite cleverly uses the dispute settlement procedure for the former contained in UNFSA Part VIII and for the latter in LOSC Part XV. As already emphasized in Section 2.2.5, provision is also made for the establishment of an ad hoc expert panel to address technical disputes similar to that established under UNFSA Article 29. Finally, the SEAFC procedures apply to all contracting parties whether or not they are parties to UNFSA and, or the LOSC.

Relation to other agreements

As already emphasized, SEAFC Article 30 does not release any contracting party from its obligations under the LOSC, or any other compatible agreement, nor does it erode its rights under any such agreement. Obviously, the question of compatibility of any agreement with the LOSC is open to some interpretation, but given the precedents of international law, this is unlikely to be a major shortcoming in the effective application of the Article.

Maritime claims

In light of the Angolan resolution attached to the final minute (see Section 2.2.1), a disclaimer on recognition, or otherwise, of claims, or positions, on the extent of waters

or zones claimed by any contracting party was deemed necessary to avoid potential disputes in the future. Therefore, Article 31 specifically elaborated the attendant provisions necessary to protect SEAFO's position and those of all contracting parties.

Finally, it should be emphasized that all the SEAFRC negotiating parties felt that it was not necessary to develop specific provisions, such as those contained in UNFSA Articles 34 and 35, to address good faith and abuse of rights along with responsibility and liability respectively. In the case of the former, the sentiment was strongly expressed that finalization of SEAFRC was in itself a clear indication of "good faith", but a reference to the need for each contracting party to fulfil its SEAFRC obligations in good faith was made in Article 13.(8).

2.3 Relationship with the UNFSA and other instruments

Discussion thus far has identified various links between SEAFRC and UNFSA. However, some of these are worth re-emphasizing together with other considerations. In the first instance, it is notable that the FAO was only an observer during the SEAFRC negotiation process and that no non-governmental organizations (NGOs) attended any of the sessions. This situation prevailed despite the negotiators obvious acceptance that SEAFO should ultimately be an "open" organization (see Section 2.2.3). Non-participation by such organizations was seen by many of the negotiating parties, particularly the coastal states, as a way of ensuring that the interests of these parties were not compromised by any extraneous influences. A similar situation prevailed in the MHLC negotiations [Section 3.1]. Nevertheless, and despite limited involvement, FAO provided useful technical input into the SEAFRC negotiations.

Second, the use of the UNFSA as a basis for much of the SEAFRC negotiations resulted in some uncertainty as the UNFSA was not in force. This was complicated by the fact that some SEAFO negotiating parties (e.g. South Africa) were not yet UNFSA signatories and it was unclear whether all future SEAFRC Parties would be bound by the Agreement. Japan, in particular, appeared wary of legitimizing the UNFSA through "inappropriate" or "subversive" cross-referencing (Jackson 2000).

However, together with SEAFRC's application to discrete high-seas stocks, such considerations raise various questions on the extent of the relationship between SEAFRC and UNFSA. One obvious question is whether SEAFRC's application to discrete stocks implies any extension of UNFSA's mandate to all fishing on the high seas.

Prior to negotiating SEAFRC, only LOSC Article 117 provided the general international legal framework whereby states are obliged to co-operate to ensure conservation of living resources on the high seas (Jackson 2002). With the exception of the dispute settlement procedures in SEAFRC's Article 24, that Convention's provisions apply equally to both straddling stocks and high-seas stocks. It would therefore be reasonable to assume that at least the SEAFO Parties have indicated their willingness to apply UNFSA provisions to discrete high-seas stocks. Whether this will set a legal precedent remains to be seen. Pursuant to this, in considering control measures, there was no general unanimity among the SEAFRC negotiators as to how far UNFSA provisions could be transposed into the Convention text. This consideration was put off until such time as the Commission can agree on the MCS system it wishes to support.

Apart from consideration of discrete stocks, the extensive use of UNFSA by the SEAFRC negotiators illustrates some of the Agreement's strengths. The SEAFRC experience shows that much of UNFSA's language can be tailored to fit a more focused regional agreement. Contrary to Jackson's (2002) suggestion, this may not mean that UNFSA offers a rigid framework on which to base the drafting of such agreements, but it will facilitate negotiation. To emphasize the point further, the SEAFRC and WCPFC (see Section 3.3) processes clearly illustrate how easily UNFSA lends itself to different regional contexts.

It was always intended that SEAFO should have a strong regional character. This was catered for in the SEAFRC articles dealing with the budget (Article 12), MCS (Articles 14-16) and the special needs of developing states (Article 21). Cost-efficiency is emphasized with particular allowance made for the Commission to develop its own MCS System [Article 16.(5) and the Convention Annex].

The UNFSA also remains flexible enough to provide for parties that may not be parties to the Agreement. However, this may give rise to apprehension that selective use of UNFSA language may directly, and possibly prejudicially, affect the obligations to which particular SEAFRC Contracting Parties become bound in a regional sense and this could prejudice the interest(s) of such parties elsewhere. However, as Rayfuse (2000) has emphasized, reiterating a quotation in reference to the Antarctic Treaty, the UNFSA may have been “intended to create a regime which could be become universally accepted. But there [was] no intention of imposing that regime; any attempt to do so would have been illegal”. This situation could apply to the SEAFRC.

Jackson (2002) indicated that circumstances where a contracting party must deal with similar subject matters in different agreements is not new, neither to fisheries nor to international law under the Vienna Convention.¹⁴ However, it could become more common, not only in the case of SEAFRC but also for other fisheries agreements adopted after UNFSA’s entry into force. For example, the International Tribunal for the Law of the Sea (ITLOS) rulings in 2000 on disputes between Australia and New Zealand on one hand, and Japan on the other under the 1993 Convention for the Conservation of Southern Bluefin Tuna (CCSBT) (CCSBT 1993) clearly do not exclude the right of any party to such a dispute to invoke specific LOSC provisions.¹⁵

In the case of SEAFO, application could be further complicated by one difference between the LOSC dispute settlement procedures and those of UNFSA, particularly if not all SEAFRC Parties are parties to the UNFSA. The UNFSA Article 30.(5) requires application by a court or tribunal of relevant LOSC, as well as UNFSA, provisions along with those of any relevant regional or global fisheries agreement “as well as generally accepted standards for the conservation and management of living marine resources and other rules of international law not incompatible with LOSC”. SEAFRC Article 24 applies to all contracting parties whether or not they are parties to UNFSA. The question of potential conflicts between the dispute resolution procedures of other regional fisheries arrangements and those under the LOSC in relation to the SADC Fisheries Protocol are discussed in Section 4.2.9.

It is also notable that SEAFRC drew on the experiences of other RFMOs. In particular, its articles on the functions of the Commission and Scientific Committee (Articles 8 and 10 respectively), decision making (Article 17) and implementation (Article 23) have much in common with similar CCAMLR articles [Articles IX, XV, XII and IX.(6)]. However, despite considerable agreement between the coastal states some of CCAMLR’s specific provisions outlining application of the precautionary approach or addressing ecosystem management (CCAMLR Article II) did not find favour in the final SEAFRC draft. The exact reasons for this are not clear. One explanation might be that international debate on these topics remains inconclusive and protracted. The complexity of the principles to be addressed was thus probably the *prima facie* reason for reluctance to subsume CCAMLR provisions rather than intransigence.

¹⁴ Article 30 of the *Vienna Convention on the Law of Treaties* (Website: <<http://www.un.org/law/ilc/texts/treaties.htm>>) regulates the application of successive treaties relating to the same subject matter.

¹⁵ See paragraph 52 of the *Award of the Arbitral Tribunal on the Southern Bluefin Cases (New Zealand vs Japan; Australia vs Japan)*, 4 August 2000. Website: <http://www.itlos.org/strat2_en.html>.

3. WESTERN CENTRAL PACIFIC FISHERIES COMMISSION

3.1 Background

The Western Central Pacific fishery is responsible for approximately 60 percent of the world's tuna catch and far exceeds catches taken in the Indian, Atlantic and Eastern Pacific Oceans (Aqorau 2001; FAO 2002). Annual catches are valued at between US\$1.5 and 2.0 thousand million and represent the single most important element in the economies of the Pacific Island states (Murphy 2001). While stocks were not generally under threat, in the late 1980s growing distant-water fishing capacity coupled with an increased likelihood of over-fishing, along with possible detrimental consequences to the economies of the Pacific Island states, raised concern on the future sustainability of such stocks. As a consequence, steps were initiated to protect these resources and ensure that a sound institutional framework was in place prior to the need for management measures¹⁶ to restrict catches or fishing effort.

Negotiations for an international arrangement for the management of highly migratory stocks in the Western Central Pacific have lasted for over a decade. One early initiative to negotiate such an agreement for the southern albacore fishery broke down in 1991 due to a dispute over the proposed arrangement's scope between the major protagonists - the Pacific Island states on one hand, and the distant-water fishing states on the other (Aqorau and Bergin 1998). In 1993, this initiative was revived (Doulman 1999), spurred on by the UNFSA negotiations, and the Western and Central Pacific Ocean was the only area without an international agreement for managing highly migratory species. The South Pacific Forum Fisheries Agency (FFA) convened the first Multilateral High Level Conference (MHLC) in 1994 to commence negotiation of a comprehensive agreement for the region.

The Conference met on seven occasions over the next three years. Its sessions became increasingly discordant with the Conference Chair in particular being criticized for favoring Pacific Island states at the expense of other fishing states' interests. Among other criticisms, the Chair was accused of refusing to admit the EC as a participant, relying too heavily on UNFSA text¹⁷ and trying to influence the negotiations' outcome by confining discussion to his own draft negotiating text. In the end, the final WCFC text was adopted by vote on 5 September 2000. Nineteen states voted in favour of the text with two (Japan and Korea) voting against it. China, France and Tonga abstained (MHLC 2000).¹⁸ A resolution was also adopted to set up a Preparatory Conference (PrepCon) to establish the WCPFC Commission. The PrepCon has met three times since the Convention's adoption and has completed work on a number of issues. The EC and Russia were admitted as participants at PrepCon 2 in early 2002, and Japan returned to participate later that year in PrepCon 3.

¹⁶ *Welcoming Address by President Imata Kabua, President of the Marshall Islands* (MHLC 1997).

¹⁷ Ambassador Satya Nandan served as MHLC Chair. He was also the Chair of the UNFSA negotiations.

¹⁸ The Final Act was signed by Australia, Canada, Cook Islands, China, Federated States of Micronesia, Republic of the Fiji Islands, France, Indonesia, Republic of Kiribati, Republic of the Marshall Islands, Republic of Nauru, New Zealand, Republic of Palau, Independent State of Papua New Guinea, Republic of the Philippines, Republic of Korea (with reservation), Independent State of Samoa, Solomon Islands, Kingdom of Tonga, Tuvalu, United States of America, Republic of Vanuatu and by representatives of New Caledonia and Chinese Taipei. The Convention was signed by Australia, Canada, Cook Islands, Micronesia, Fiji, Indonesia, Marshall Islands, Nauru, New Zealand, Nauru, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Tonga, Tuvalu, United States, and Vanuatu.

3.2 The Convention

3.2.1 General

The WCPFC was technically the first agreement concluded post-UNFSA as it was finalized slightly before SEAFRC, although the latter has already entered into force (Section 2.1). The WCPFC will enter into force on ratification by three states north of 20°N and seven states south of 20°N. Alternatively, it will enter into force if ratified by 13 states after September 2003 (WCPFC Article 36). As of 4 November 2002, only four instruments of ratification had been filed, all by states south of 20°N.¹⁹

The Convention's objective is to ensure effective management, long-term conservation and sustainable use of highly migratory stocks in the Western and Central Pacific Ocean, in a manner compatible with both the LOSC and the UNFSA (WCPFC Article 2). When it enters into force, the WCPFC (Article 9) will establish a Commission charged with various functions. The modalities of the Commission and its functions are at the top of the PrepCon agendas. To date, the Commission is charged with determining total allowable catches (TACs), adopting conservation and management measures for target as well as non-target species, compiling and analyzing statistical and scientific data, adopting generally recommended international minimum standards for responsible conduct of fishing operations and establishing cooperative mechanisms for effective MCS and enforcement (WCPFC Articles 9 and 10). The Commission will rely on advice from a scientific committee as well as a technical and compliance committee (Articles 11-14). The latter will be responsible for reviewing compliance and making recommendations to the Commission. It is also charged with reviewing the implementation of MCS and developing enforcement measures. There are obviously many similarities between the WCPFC and SEAFRC in respect of these particular provisions (see Section 2.2).

3.2.2 Area of application

As outlined in Article 3, the WCPFC applies to all areas, including the high seas and EEZs, in the Western and Central Pacific (Figure 2). The Convention Area encompasses all waters from south of Australia to north of Japan, including the EEZs of all the Pacific Island states. The Area's boundary abuts the Indian Ocean Tuna Commission boundary in the west and overlaps with the 1949 Convention for the Establishment of an Inter-American Tropical Tuna Commission (IATTC) Area²⁰ in the east. Both these factors were points of contention during the WCPFC negotiations. The Area's northern boundary is effectively 4°S, although the northern extremity is not bounded by the 150° W meridian.

3.2.3 Stocks covered

Subject to the species listed in LOSC Annex I, but excluding suaries and such other species as the Commission may determine, the WCPFC applies to all highly migratory fish stocks found in the Convention Area [WCPFC Articles 1 and 3.(3)]. Conservation

¹⁹ The Republic of Fiji, Republic of Marshall Islands, Independent State of Papua New Guinea and the Independent State of Samoa. See WCPFC/BP.1/Rev.5, 4 November 2002. Website: <<http://www.ocean-affairs.com/WCPFC%20BP1820.Rev5.pdf>> In early 2003, Australia announced that it would soon ratify the WCPFC (Australian Department of Agriculture, Fisheries and Forestry Information Note (14 March 2003). Website: <<http://www.affa.gov.au/content/output.cfm/ObjectID=CA6A8BDB-4E2A-9DF90F8E9D6232D9>> and became the ninth country to ratify on 11 September 2003.

²⁰ The texts of the 1993 Agreement for the Establishment of the Indian Ocean Tuna Commission and the Convention for the Establishment of an Inter-American Tropical Tuna Commission are available on Websites: <<http://oceanlaw.net/texts/iotc.htm>> and <http://www.iattc.org/PDFFiles/IATTC_convention_1949.pdf> respectively.

FIGURE 2
The Western Central Pacific Fisheries Commission Area



and management measures to be adopted by the Commission thus apply either throughout the entire migratory range of the stocks or to specific areas as determined by the Commission (WCPFC Article 3). This is significantly different to the SEAFO Commission that cannot adopt measures for waters under national jurisdiction. However, as for SEAFO Article 19, high seas and EEZ measures should be compatible. All measures adopted by the WCPFC Commission and the coastal states should be in accordance with UNFSA principles. Consequently, WCPFC Articles 5 to 8 repeat many similar UNFSA provisions including use of the best available scientific advice and taking into account the precautionary approach and ecosystem concerns (UNFSA Articles 5 and 6).

3.2.4 Openness and transparency

WCPFC Articles 21 and 22 clearly indicate recognition for the need for openness and transparency in the Commission's work. The elements are similar to those in SEAFC Articles 8, 18 and 22. However, in contrast to SEAFC, the WCPFC conditions for accession [Article 35.(2)] are more restrictive and require a specific invitation (based on consensus of all WCPFC Commission Members) for any party to join the Commission after the Convention's entry into force.

3.2.5 Decision-making

As for SEAFC, and as a general principle, all WCPFC decisions are to be taken by consensus [Article 20.(1)], particularly when these relate to the setting of TACs or levels of total fishing effort. Consensus-based decision-making applies to measures that exclude particular vessels. Except where the Convention requires a decision to be taken by consensus, in the event of failure to secure consensus, decisions may be taken following the voting procedure set out in Articles 20.(2) and (3). Under these circumstances, substantive decisions are to be taken by a double three-quarters

majority.²¹ However, under Article 20.(4), the Chairman has power to appoint a conciliator to reconcile any differences blocking attainment of consensus when the Commission requires that any decision should be consensus-based.

Again, as for SEAFRC Article 23, WCPFC Articles 20.(6) to 20.(9) provide for an objection procedure to decisions and the institution of an attached review procedure including the appointment of a review panel in accordance with conditions set out in Annex II. This complicated decision-making mechanism, while not too dissimilar to that of SEAFRC, is designed to ensure that no one party, or block of parties, unduly influences the WCPFC Commission's work. Whether it will work in practice or whether it will result in deadlock and endless submission to the review procedures, remains to be seen. At least, and unlike SEAFRC, such review constitutes an intermediary step between deadlock and dispute. This is likely to be simpler to apply than a full dispute resolution procedure.

3.2.6 Contracting party obligations

Commission members (i.e. "Contracting Parties") are obliged to enforce WCPFC provisions and any related conservation or management measures adopted by the Commission under both Articles 23 and 25. Similar to SEAFRC Article 6, WCPFC Article 23 provides for the provision of specific information [Article 23.(2)], some control over nationals and for the gathering of information on fishing activities [Article 23.(5)]. Under the latter provision, and at the request of any contracting party, or when supplied with relevant information, contracting parties must fully investigate any alleged violation and report on the conduct of such investigation, including any action taken or proposed to be taken. Such a report is to be made to the requesting contracting party and to the Commission within two months of the date of request. The outcome of any investigation must also be reported when completed.

Under Article 25, and if satisfied that there is sufficient evidence of an alleged violation by one of its vessels, a flag state is required to refer the case to its authorities to institute legal proceedings and, where appropriate, detain the vessel. Where a serious violation of the WCPFC, or its conservation and management measures has occurred, flag states must also ensure that the vessel involved ceases its activities [Article 25.(4)] and does not resume fishing in the Convention Area until such time that there has been compliance with any outstanding sanctions imposed by the flag state under Article 25.(7).

To facilitate legal proceedings, all Contracting Parties are obliged, to the extent permitted by their national laws, to establish arrangements for making evidence available to the prosecuting authorities of other WCPFC Contracting Parties [Article 25.(5)]. Therefore, investigations and judicial proceedings are to be carried out expeditiously and the sanctions imposed should be sufficiently severe to secure compliance and to discourage future violations [Article 25.(7)]. Further, such sanctions should be aimed at depriving the offenders of the benefits accruing from their illegal activities. Action may also be taken against offending fishing vessel masters or officers. This may result in withdrawal of fishing permits and, or, suspension of fishing authorization. Annual reports to the Commission on compliance and imposition of sanctions for any violation are to be provided [Article 25.(8)].

Other provisions of the WCPFC [Article 25.(11)] urge contracting parties to take action, consistent with international law to deter fishing vessels from fishing in the Convention Area when such vessels have operated in violation of WCPFC measures and until such time as action is taken by the flag state concerned. They also provide [Article 25.(12)] for the development of non-discriminatory trade measures

²¹ Three-quarters of the FFA Member States and three-quarters of the other Contracting Parties.

to be applied to parties, or entities, which undermine conservation and management measures adopted by the Commission.

A major difference between the WCPFC and SEAFRC is that the latter is less specific on the details of compliance measures (SEAFRC Article 16) and does not mix these with contracting party obligations (SEAFRC Article 13). Further, SEAFRC Article 6 states that all contracting parties are commission members. This qualification is not made in WCPFC Article 9, and the inter-changeable use of the terms “Contracting Parties” and “Commission Members” in the operative paragraphs of the various Articles discussed in this Section could lead to confusion.

3.2.7 Control measures

Flag state measures

The WCPFC outlines detailed flag state duties (Article 24) and steps to ensure compliance and enforcement (Article 25). In contrast to the minimalist approach adopted by SEAFRC (Section 2.2.7), the WCPFC provides considerably more detail on such matters as a regional observer programme (Article 28), the conduct of transshipping (Article 29) and at-sea boarding and inspection procedures (Article 25). Indeed, a primary objection by Japan, Korea and others to the draft convention was that it “contained too many words”²² and over-specified contracting party obligations better left to the discretion of the Commission once it is established. By implication, it would appear that the SEAFRC negotiators were more open to such views and so developed the rather less detailed enforcement and compliance regime discussed in Section 2.2.7.

Much of the substance of the WCPFC articles highlighted in the previous paragraph deal with enforcement-related matters and repeat, or otherwise incorporate, UNFSA provisions. With many of Japan’s proposals for revision being all but ignored, tensions were heightened, which probably resulted in Japan refusing to participate in a number of key small drafting groups, ultimately voting against the text and not signing the final Act (MHLC 2000).

Under the WCPFC, flag states are obliged to ensure that their vessels comply with Commission measures and do not engage in activities to the contrary. The details set out in Article 24 largely mimic those of SEAFRC Article 14, in respect of the need for vessels to be authorized to fish only when the flag state is able to effectively control them. National registers of authorized vessels are to be compiled and provided to the Commission. They should be updated expeditiously when necessary [Article 24.(4) and (5)].

When operating on the high seas, vessels are required to follow the terms and conditions for fishing laid out in WCPFC Annex III. These address conditions attached to compliance with national laws, obligations with respect to observers, regulation of transshipments, reporting requirements and enforcement measures (e.g. marking of vessels). In this regard, flag states are required to use satellite VMS systems on their vessels fishing in the WCPFC area [Article 24.(8)]. These systems will transmit simultaneously to the Commission and the flag state, a requirement that is more advanced than the dual VMS reporting system operating in the North-East Atlantic Fisheries Commission (NEAFC) (NEAFC 1980) and the NAFO area (NAFO 1979). It is a centralized system. As far as possible, and under Article 29, transshipments by contracting party vessels are to be conducted in port. Transshipments at sea [Article 29.(4)] are only permitted in accordance with Article 4 of WCPFC Annex III.

²² Statement of Japanese delegation at MHLC 3 as reflected in Newsletter No. 269 (24 July 1998) from the Japanese Ministry of Agriculture, Forestry and Fisheries. From Website: <<http://www.maff.go.jp/mud/269.html>>.

Transshipment from purse-seine vessels is prohibited [Article 29.(5)]. Again, these requirements go beyond those of the SEAFC.

Finally, WCPFC Annex III clearly sets out the conditions for fishing. These include compliance with respect to international laws (Article 3), obligations with respect to observers (Article 4), regulation of transshipments (Article 4), reporting requirements as per UNFSA Annex I and other general matters relating to enforcement (such as complying with lawful instructions from an identified Commission Member, vessel identification, communication procedures and stowing and securing of gear when passing through national waters) (Article 6). This particular Annex gives effect to the various considerations associated with establishing a “probable cause” to be pursued in the assumption of enforcement action

At-sea boarding and inspection

WCPFC Article 26 specifically requires the Commission to establish procedures for boarding and inspection of fishing vessels in the Convention Area including on the high seas. All vessels used for such boarding and inspection are to be clearly marked and identifiable as being authorized to undertake these activities [Article 26.(1)]. In early drafting, the negotiating text simply subsumed UNFSA (Article 22 of the Agreement) boarding and inspection provisions into the WCPFC.²³

As observed in the SEAFC negotiations (Section 2.3), such cross-referencing was considered unacceptable by some parties, most notably Japan and Korea. In the end the wording was diluted to provide a specific cross-reference to UNFSA Article 21 and 22 as a fallback provision. In the event that the WCPFC Commission is unable to agree on boarding and inspection procedures or on suitable, equivalent measures within two years of the Convention’s entry into force, UNFSA Articles 21 and 22 are to be applied as part of the WCPFC. In these circumstances, boarding and inspection, and any subsequent enforcement action, will be conducted in accordance with UNFSA procedures and, or, any such additional procedures that the Commission may agree upon. Whichever scheme is applied, contracting parties are required to ensure that their vessels accept boarding by authorized inspectors according to the WCPFC procedures and that inspectors comply with such procedures. Put simply, the Commission is obliged to adopt a non-flag based boarding and inspection scheme. Should it fail in this task, UNFSA provisions will apply.

As the WCPFC is not yet in force, the PrepCon Meetings are being used to elaborate the boarding and inspection scheme further. PrepCon 2 established a working group to deal with MCS issues in general.²⁴ During PrepCon 3, the working group adopted a list of principle elements to be included in a WCPFC boarding and inspection scheme. These included details such as the scheme’s definition, scope and objectives, vessels and personnel authorized to conduct boarding and inspection activities on the high seas in the Convention Area, standardized training for enforcement personnel, guidelines governing boarding and inspection procedures and guidelines governing the use of force. Mechanisms are also being developed to co-ordinate Secretariat actions with those of contracting party and flag state enforcement authorities and particularly between the latter.²⁵ Undoubtedly, the inspection and boarding scheme outlined above should be linked to the WCPFC’s broader enforcement and compliance provisions. As the scheme is only part of a more comprehensive compliance and enforcement regime, this may diminish its priority.

²³ See Chairman’s Draft *Convention* Texts in Documents MHLC/WP.1 (22 June 1998); MHLC/WP.1/Rev. 1 (26 June 1998); MHLC/WP.1/Rev. 2 (19 February 1999); MHLC/WP.2 (20 July 1999); MHLC/WP.1/Rev.3 (9 September 1999); MHLC/WP.1/Rev. 4 (16 September 1999).

²⁴ Working Group III: Monitoring, Control and Surveillance, Summary Report by the Chairman of the Working Group to the third session of the Preparatory Conference, WCPFC/PrepCon/21, 22 November 2002.

²⁵ See Footnote No. 24.

There appears to have been a general feeling during the WCPFC negotiations that the use of force should be limited to situations when the safety of life (e.g. of members of a boarding and inspection party) and, or, property (e.g. the vessels involved) is threatened. In addition, UNFSA Article 21.(18) needed to be taken into account since this extends liability to states for damage or loss attributable to unlawful, or unreasonably excessive, actions during boarding and inspection. Such consideration reflect developments in NAFO where Canadian inspectors are being, or have been, charged or sued in Spanish courts over events occurring during at-sea inspections (Caldwell 2002, McDorman 1994). Despite these contentious issues, the working group appears to have gone some way in elaborating a WCPFC boarding and inspection scheme at PrepCon 4.

Port state measures

As in SEAFAC Article 15, port state measures are specifically included in the WCPFC (Article 27). In the case of the WCPFC, these were particularly contentious with Japan, Korea and others arguing that the exercise of port state jurisdiction in relation to high-seas fisheries is not consistent with the LOSC. However, such arguments were not accepted and the WCPFC provisions (Article 27) are identical to those in UNFSA. As such, SEAFAC Article 15.(1) and WCPFC Article 27.(1) are similar and confirm a port state's right to take measures to promote the effectiveness of sub-regional, regional and global conservation and management measures. Specifically, in the WCPFC's case [Article 27.(1)], there is the additional caveat that in taking such measures, no fishing vessels of any state should be discriminated against. By implication, and in combination with Article 27.(2), this would allow WCPFC parties to inspect both contracting and non-contracting party fishing vessels when these are voluntarily in the former's ports. Such inspections may focus on, *inter alia*, documents, fishing gear and catch on board. Article 27.(3) then allows WCPFC contracting parties to adopt regulations prohibiting landings and transshipments when it has been established that the catch has been taken in a manner undermining the effectiveness of the Commission's conservation and management measures. Finally, and akin to SEAFAC Article 15, nothing in WCPFC Article 27 affects the exercise of sovereignty by any WCPFC contracting party over their ports consistent with international law. If international law allows port states to apply stronger measures they may do so, if not, then such measures should be based on, and limited to, WCPFC provisions.

Non-flag state enforcement

While responsibility for WCPFC enforcement clearly rests with the flag state, the Convention provides other mechanisms to augment its execution. The most interesting and revolutionary of these establishes a regional observer programme (WCPFC Article 28) and outlines its various elements. Unlike other RFMO observer programmes (e.g. in NAFO and CCAMLR), the WCPFC programme is co-ordinated [Article 28.(2)] by the Secretariat (established under Article 15). In addition, it is envisioned [Article 28.(3)] that observers are independent and impartial, i.e. not appointed by, or answerable to, a particular flag state, although the nationals of each contracting party are entitled to be included in the programme [Article 28.(6).(a)]. Observers are authorized, trained and certified in accordance with procedures agreed to by the Commission [Article 28.(6).(c)], which may enter into contracts for the provision of observer services [Article 28.(2)].

Essentially, the WCPFC observers are to be truly international and impartial, along the lines of the programme run by the IATTC²⁶ but may go farther as the number

²⁶ See Annex. II of the 1998 "Agreement on the International Dolphin Conservation Programme".
Website: <<http://www.ceanlaw.et/texts/aidcp.htm>>

of observers supplied by the Secretariat is not limited to 50 percent of the total. Nevertheless, the WCPFC programme remains subject to later decision(s) by the Commission on its applicability and extent [Article 15.(7)].

Unlike the CCAMLR Scheme of International Scientific Observation (CCAMLR 2002), which expressly avoids any application of enforcement, the WCPFC programme empowers observers to monitor implementation of conservation and management measure, including the reporting of any findings to the Commission in this regard [Article 15.(6).(e)]. Contracting parties are required to ensure that all their vessels operating outside areas under the national jurisdiction of a single contracting party (i.e. on the high seas or in areas under the jurisdiction of more than one contracting party) are prepared to accept an observer if required by the Commission [Article 28.(4)].

In addition to monitoring the implementation of conservation and management measures, WCPFC observers are required to monitor catch and scientific data as well as report the results of such observations [Article 15.(6).(e)]. However, they should not unduly interfere with the lawful operations of the vessel and should carry out their activities with due regard to the vessel's operational requirements, communicating regularly with the master to this end [Article 15.(6).(d)]. Obviously, this raises some questions as to what an observer is expected to do when an operation is deemed to be "unlawful". To avoid potential conflict, WCPFC observers are not allowed to undertake any of the observations or actions specified above when a vessel is within the EEZ of its flag state, unless the flag state agrees [Article 15.(5)].

Other non-flag state based measures comprise actions taken jointly by contracting parties [e.g. under Article 23.(5)] or those against non-contracting parties (Article 32) where the WCPFC allows contracting parties to take measures to deter the activities of non-contracting party vessels undermining the effectiveness of measures adopted by the Commission [Article 32.(1)].

WCPFC contracting parties are mandated to exchange information on activities of non-contracting party vessels fishing in the Convention Area [Article 32.(1)]. In addition, the Commission can draw the attention of any flag state whose vessels, or nationals, are (in the Commission's opinion) affecting the WCPFC's implementation [Article 32.(3)]. Commission members, either individually or jointly, may request non-parties to ensure that their vessels cooperate fully in implementation of the Commission's measures. As in SEAFC Article 19, co-operating non-contracting parties are eligible to enjoy the benefits of participating in the fishery commensurate with their commitment to comply, along with their record of compliance, with Commission measures for relevant stocks [Article 32.(4)]. However, as with SEAFC, this particular provision remains silent on how such commitment would be assessed and by whom. Nevertheless, WCPFC Article 32 has much in common with UNFSA Article 17.

WCPFC Article 25.(10) provides for any contracting party to draw such activity to the attention of the flag state concerned and, as appropriate, to the Commission as well, when there are reasonable grounds to believe that a fishing vessel flying the flag of any state has undermined the effectiveness of Commission measures. To the extent permissible under national law, the reporting contracting party may then supply the flag state with supporting evidence. It may also provide a summary of such evidence to the Commission. The Commission cannot circulate the attached information until the flag state has had reasonable time to comment on the allegation and submitted evidence, or object to it as the case may be. Contracting parties may also take action in accordance with UNFSA and international law to deter fishing vessels from fishing in the Convention Area, until such time as appropriate action is taken by the flag state [Article 25.(11)] when such vessels have engaged in activities that undermine the effectiveness of, or otherwise violate, Commission measures.

3.2.8 Other provisions

Other WCPFC provisions deal with various institutional matters. As with SEAFIC Article 30, WCPFC Article 4 addresses the non-prejudicial relationship with LOSC. WCPFC Articles 5 and 6 deal with principles for conservation and management and application of the precautionary approach respectively. These particular Articles follow those of UNFSA more closely than the comparable SEAFIC Articles.

The WCPFC Article 6.(1).(a) specifically sets out the requirement for contracting parties to apply stock-specific reference points from UNFSA Annex. II. In this Article it is also stated that UNFSA Annex. II forms an integral part of the WCPFC – a far more specific cross-reference than any in SEAFIC. WCPFC Article 7 sets out that the conservation and management principles in Article 5 should also be applied to areas under national jurisdiction within the Convention Area where highly migratory stocks may be found. Similar considerations occur in Article 8 on the compatibility of measures on the high seas and in areas under national jurisdiction.

WCPFC Articles 9 to 16 address institutional matters attached to the work of the Commission and its subsidiary bodies, including the Secretariat. Financial arrangements are detailed in Articles 17 to 19. As with SEAFIC [see Section 2.2.4 and SEAFIC Article 12.(1)] the principle of cost-effectiveness is applied [Article 9.(5)]; unlike SEAFIC, any arrears of more than two years in a party's financial contributions attracts interest on outstanding monies and disqualifies the party concerned from participating in decision-making until all arrears are paid. [Article 18.(3)]. The latter provision is similar to that of CCAMLR's Article XIX.(6). While similar conditions concerning non-payment were raised during the SEAFIC negotiations, there was general agreement that they were discriminatory and not appropriate. It was also felt that they ran contrary to the strong recognition by the SEAFIC negotiators that the organization was to be an "open" one.

Other WCPFC articles recognize the special requirements of developing states (Article 30), procedures for dispute settlement (Article 31) and good faith (Article 33). In respect of Article 31, the provisions set out in UNFSA Part VIII are applied *mutatis mutandis*. Both Articles 30 and 33 replicate much of what is contained in UNFSA Articles 24 to 26 and 34 respectively. In the former case there are obvious similarities with SEAFIC Article 21 with the major exception that WCPFC Article 30.(3) provides for establishing a special fund to facilitate participation by developing states, especially small island developing states.

3.3 Relationship with UNFSA and other instruments

The SEAFIC and WCPFC have much in common with UNFSA, however in both, detailed cross-referencing to UNFSA appeared to obstruct negotiations. Despite Japanese objections in both forums, cross-referencing to UNFSA in the WCPFC text is far more extensive, detailed and specific than in SEAFIC – particularly in respect of compliance and enforcement (WCPFC Article 26). The reasons for this are not readily apparent. A contributory factor could be that more Pacific Island states were UNFSA signatories compared to SEAFIC coastal states. While both state categories probably had more to lose by not applying UNFSA provisions in detail, in the former case the weight of numbers was sufficient to counter the interests of distant-water fishing states. Despite this, cross-referencing to UNFSA remains patchy in both the WCPFC and SEAFIC texts.

A particular difference between the SEAFIC and WCPFC is the way of dealing with dispute resolution. SEAFIC's dispute resolution provisions (SEAFIC Article 24) attempt to address both straddling and discrete high-seas stocks. This requires explicit cross-referencing to both the LOSC and UNFSA. It also intimates that UNFSA provisions apply whether SEAFIC parties are party to the Agreement or not. On the other hand, such complications do not prevail for the WCPFC and the dispute resolution provisions

are applied only in respect of UNFSA Part VIII, although express application to non-UNFSA Parties is also applied.

Unlike SEAFIC, and in deference to the nature of the stocks concerned (migratory as opposed to straddling and discrete), the WCPFC Area also includes areas under national jurisdiction. This difference may have as much to do with history and politics as with geography or the biology of the stocks concerned. All three instruments (SEAFIC, WCPFC and UNFSA) deal in detail with the special needs of developing states. However, the most obvious and probably most telling difference with SEAFIC is that WCPFC makes no attempt to address the question of fishing opportunities. As a consequence, SEAFIC Article 20 goes far to give effect to UNFSA Article 10 to 12. A reason for this divergence could be the perceived value of the target species.

Doubtless, the WCPFC negotiations on allocation became complicated by the contradictory needs of the negotiating parties, including differences in expectation and influence between the coastal states and those of the distant-water fishing fleets. (Incidentally, the latter possessed both the means and historic precedent to fish in the region.) In both the SEAFIC and WCPFC negotiations over allocation, the arguments were essentially the same. Coastal states maintained that the respective Commissions should only allocate high-seas quotas (i.e. fishing opportunities), leaving these states with the sovereign rights to set national quotas and determine EEZ access conditions. Most of the distant-water fleets, those from Japan in particular, favored both in-zone and high-seas allocation procedures based on historic fishing levels, a factor favoring distant-water fleets. The situation has been mirrored by heated debate on the same issues in ICCAT years (Jackson 2002). By removing their EEZs from the equation, and by exhibiting political accommodation, the SEAFIC negotiators were able to finalize the allocation of fishing opportunities and set some guiding principles.

Two factors may have contributed to SEAFIC's success in this regard. First, the ICSEAF experiences of the three African coastal states undoubtedly increased their political resolve to counter distant-water fleet interests. Second, the perceived value of the straddling stocks likely to be concerned was both unknown, but probably not high. This reduced the distant-water states' perceptions of what they had to lose. Finally, and perhaps cynically, the less politically-charged, SEAFIC negotiations may not have been of such intensity so that a specific provision on abuse of rights was seen as unnecessary. This did not appear to be the case in the WCPFC negotiations when all parties seemed to feel that a restatement of UNFSA Article 34 was in their collective interest.

4. SOUTH AFRICA DEVELOPMENT COMMUNITY FISHERIES PROTOCOL

4.1 Background

In the South-East Atlantic, the Southern African fisheries are predominantly industrially. Some 90 percent of the catches are landed in Angola, Namibia and South Africa. Artisanal and recreational fisheries are more common on the Western Indian Ocean coast where they have greater socio-economic importance. The annual mean catch for the entire SADC region (Fig. 1) is about 1 900 000 t, roughly equivalent to 25 percent of sub-Saharan marine protein production. In Namibia the fisheries sector contributes more than 35 percent of gross domestic product (GDP) and employs more than 12 000 people. In South Africa, the annual revenue from coastal resources (fisheries, infra-structure and tourism) has been estimated at more than US\$17 500 million (approximately 37 percent of the country's GDP) while the total value of SADC fishery exports in 2002 was just under US\$900 million (FAO 2002).

Depletion of fish stocks by unsustainable harvesting has been a major concern to many SADC countries for over a decade and for longer in countries such as Namibia. Most of the region's coastal and marine resources have suffered from unsustainable levels of exploitation, driven by increasingly efficient harvesting methods. This has resulted

from an ever-growing need for edible protein driven by population increase (including urban migration to coastal areas), rising economic demand from the developed world, lucrative export markets and expanding tourism demands (Sherman 2003). These factors affect not only the SADC coastal states, but also land-locked countries and distant-water fishing countries' operations (UNEP 2002). Marine pollution from land-based activities and degradation of coastal areas is also increasing along with use of coastal areas. In addition, sea level rise, a product of global warming, may result in inundation of major coastal settlements and coastal infrastructure, causing population displacement and associated ecosystem damage.

To address these issues, the SADC initiated in Fisheries Protocol in Windhoek, Namibia in February 1997; a Draft Protocol was produced in December 1999 and sent to all member states for comment. The Protocol was approved by the SADC Fisheries Ministers²⁷ in Maputo, Mozambique (UNEP 2002) and signed by all SADC heads of state in Blantyre, Malawi on 14 August 2001.

4.2 The Protocol

4.2.1 Scope, objective and principles

Scope

The Protocol (Anon. 2001b) (Article 2) applies to living freshwater and marine resources and aquatic ecosystems within the jurisdictions of SADC parties. It attempts to preserve the rights and obligations of the parties in respect of such resources where their ranges extend outside areas under national jurisdiction, or on to the high seas. A major impact of this provision is that UNFSA rights and obligations are explicitly recognized, as are those under LOSC Article 116 -119. The Protocol's Article 2 focuses on fishing and related activities by state nationals and international activities outside SADC that conform with the Protocol's objectives.

Objective

The Protocol's primary objective (Article 3) is to promote the responsible and sustainable use of living aquatic resources and aquatic ecosystems in the interests of SADC Parties as a whole. Five key objectives are identified:

- i. promote and enhance food security and human health
- ii. safeguard the livelihood of fishing communities
- iii. generate economic opportunities for nationals in the region
- iv. ensure that future generations benefit from renewable aquatic resources and
- v. alleviate poverty with the ultimate objective of its eradication.

The Protocol enjoys a high level of support in the SADC community, probably the result of the detailed consultations held with various stakeholders in each of the member states. The Protocol has a close affinity with Articles 10 and 11 of the Code of Conduct (Anon. 1998b), particularly Article 10.2.2, which highlights the need to consider economic, social and cultural factors when assessing the potential value of coastal resources.

Principles

Article 4 outlines the five primary principles on which the Protocol is based. The Protocol's implementation is established on a national basis, with responsibility for shared resources being shared and dependent on co-operation between the parties concerned. The other four principles are essentially socio-economic and endeavour to

²⁷ The SADC Parties comprise: *Angola, Botswana, *Democratic Republic of the Congo, Lesotho, Malawi, *Mauritius, *Mozambique, Namibia*, *Seychelles, *South Africa, Swaziland, *Tanzania, Zambia and Zimbabwe (*Coastal States).

- i. ensure participation of all stakeholders in promoting the Protocol's objectives
- ii. take appropriate measure to regulate use of living aquatic resources and protect such resources against over-exploitation while creating and enabling environment and building capacity for their sustainable utilization and
- iii. promote gender equality and address potential inequalities.

4.2.2 Stocks covered

Article 1 applies the Protocol to all aquatic ecosystems, fish and fish stocks. It provides definitions for the terms: “exotic species”, “fish”, “fish stocks”, “highly migratory species”, “resources” and “shared resources” as well as various activities associated with fishing including the term “trans-boundary” (Table 5). The definitions focus the Protocol on fishing and “all activities associated with the exploitation of fish, including processing, marketing, transportation, and trade of fish and fish products”. Both “illegal fishing”²⁸ and “nationals”²⁹ are defined. Similarly, “stakeholders” are seen as “all persons whose interests are either directly or indirectly affected by fishing and fishing-related activities under the Protocol”. The Protocol broadly addresses fisheries-related activities, including ecosystem protection and socio-economic issues.

TABLE 5
Some key definitions from Article 1 of the SADC Fisheries Protocol

<i>Aquaculture</i>	All activities aimed at producing in restricted areas, processing and marketing aquatic plants and animals from fresh, brackish or salt waters
<i>Critical habitat</i>	A habitat that is essential for maintaining the integrity of an ecosystem, species or assemblage of species
<i>Exotic Species</i>	Those species that are not indigenous or endemic to a specific area
<i>Fish</i>	Any aquatic plant or animal, and includes eggs, larvae and all juvenile stages
<i>Fishing</i>	All activities directly related to the exploitation of living aquatic resources and includes transshipment
<i>Fish stock</i>	A population of fish, including migratory species, which constitutes a coherent reproductive unit
<i>Highly migratory species</i>	Species of fish which move seasonally from one ecological area to another
<i>Related activities</i>	All activities associated with exploitation of fish, including processing, marketing, transportation and trade of fish and fish products
<i>Resources</i>	All aquatic ecosystems, fish and fish stocks to which this Protocol applies
<i>Shared resources</i>	Shared aquatic ecosystem, shared fishery and shared fish stock
<i>Subsistence fisheries</i>	Fishing activities where fishers regularly catch fish for personal and household consumption and engage from time to time in the local sale or barter of excess catch
<i>Transboundary</i>	Populations, natural systems, activities, measures and effects, which extend beyond the effective jurisdiction of a state party and
<i>Transshipment</i>	Unloading of all or any of the aquatic resources on board a fishing vessel to another fishing vessel either at sea or in port without the products having been recorded by a port state as landed.

²⁸ “Illegal fishing” is defined as any fishing or related activity carried out in contravention of the laws of a SADC state party or the measures of an international fisheries management organization accepted by a state party and subject to the jurisdiction of that state party.

²⁹ A “national” is defined as a person(s) who is a citizen of a state party, including any body corporate, society or other association of persons established under the laws of such a party.

4.2.3 National responsibilities

Article 5 urges parties to take measures at national and international levels to harmonize their fisheries legislation, policies, plans and programmes to promote the Protocol's objectives. It calls for adoption of measures to ensure that nationals and judicial persons act responsibly when using living aquatic resources, within and beyond, national jurisdictional limits.

The Protocol mandates authorization to fish for vessels flying SADC party flags in the regions' waters. It is foreseen that such authorization should only be granted when a party can effectively exercise its responsibilities.³⁰ Parties are requested to ensure that vessels or nationals fishing in waters covered by the Protocol take appropriate steps to ensure they comply with measures adopted under it, and do not engage in activities that undermine the effectiveness of such measures. Finally, parties are requested to ensure that aquatic living resources in areas under their national jurisdiction are not endangered by unsustainable harvesting practices.

4.2.4 International relations

In Article 5, the Protocol parties are urged to establish common positions so as to undertake co-ordinated and complementary actions in relevant international organizations and forums identified in Protocol appendices 1 and 2 (Table 6), particularly in respect of LOSC, UNFSA and the Compliance Agreement (Anon 1998c). Such action is envisaged to include facilitation of trans-boundary activities and movements pursuant to the Protocol's objectives.

TABLE 6

Marine fisheries and other conventions and agreements of significance to the Southern Africa marine environment Adapted from "International Environmental Governance: Multilateral Environmental Agreements (MEAs), United Nations Environment Programme (UNEP/IGM/1/INF/3/2001)

Biodiversity-Related Conventions	
Convention on Biological Diversity (CBD)	1992
Convention on International Trade in Endangered Species (CITES)	1973
Convention on Migratory Species (CMS)	1979
International Coral Reef Initiative (ICRI)	1995
Regional Seas Programmes and Agreements	
Global Programme of Action for the Protection of the Marine Environment from Land-based Activities	1995
Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region (Abidjan)	1981
Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (Nairobi)	1985
Marine-Related Conventions	
International Convention for the Prevention of Pollution of the Sea by Oil (amended in 1962 and 1969)	1954
International Convention on Civil Liability for Oil Pollution Damage (amended 1976, 1981, 1984)	1969
International Convention Relating to Intervention in the High Seas in Cases of Oil Pollution Casualties	1969
Amendments to the International Convention for the Prevention of Pollution of the Sea by Oil, 1954, Concerning Tank Arrangements and Limitation of Tank Size	1971
International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (amended 1976, 1984, 1994)	1971
Convention Relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material	1971
Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft (amended 1983, 1989 and again in 1989)	1972
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (amended)	1972

³⁰This is in deference to the key designation associated with Flag State responsibility detailed in Article III of the *FAO Compliance Agreement* (Anon. 1998c).

Protocol Relating to Intervention in the High Seas in Cases of Marine Pollution by Substances Other than Oil	1973
International Convention for the Prevention of Pollution from Ships (MARPOL)	1973
Convention on Limitation of Liability for Maritime Claims	1976
Protocol to the International Convention on Civil Liability for Oil Pollution Damage	1976
Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships (MARPOL), 1973	1978
Amendments to Annexes to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter Concerning Incineration at Sea	1978
Protocol to Amend the International Convention on Civil Liability for Oil Pollution Damage.	1984
International Convention on Salvage	1989
International Convention on Oil Pollution Preparedness, Response and Cooperation	1990
Protocol of 1992 to Amend the International Convention on Civil Liability for Oil Pollution Damage, 1969	1992
Protocol of 1992 to Amend the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage	1992
1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972	1996
Protocol of 1996 to amend the Convention on Limitation of Liability for Maritime Claims, 1976	1996
International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea	1996
Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972	1996
Oceans-related Conventions	
Convention on the Territorial Sea and the Contiguous Zone	1958
Convention on the High Seas	1958
Convention for the International Council for the Exploration of the Sea (amended 1970 and 1975)	1964
United Nations Convention on the Law of the Sea	1982
Agreement Relating to Implementation of Part XI of the United Nations Convention on the Law of the Sea	1994
Fisheries Conventions	
International Convention on the Regulation of Whaling (IWC)	1946
Protocol to the International Convention on the Regulation of Whaling	1956
Convention on Fishing and Conservation of the Living Resources of the High Seas	1958
Agreement concerning Co-operation in Marine Fishing	1962
ICCAT (amended 1984 and 1992)	1966
CCAMLR	1980
Protocol Relating to Modification of ICCAT	1984
Convention on Fisheries Cooperation among African states bordering the Atlantic Ocean	1991
Convention for the Conservation of Southern Bluefin Tuna (CCSBT)	1993
Agreement for the Establishment of the Indian Ocean Tuna Commission (IOTC)	1993
FAO Compliance Agreement	1993
FAO Code of Conduct	1995
United Nations Fish Stock Agreement (UNFSA)	1995

4.2.5 Management of shared resources

Protocol Article 7 aims at resolving potential disputes on the status of shared resources. Disputes can be referred to the SADC Integrated Committee of Ministers for resolution. While this could be applied to disputes concerning inland waters, Article 7.(2) ensures that consideration is given to the rights and obligations of state parties under the LOSC, and other compatible agreements, which do not affect their rights or performance of such obligations under the Protocol. It is envisaged that Protocol parties are able to assume the LOSC dispute resolution mechanism; a situation consistent with Article 30 of the Vienna Convention (see Section 4.2.9).

Article 7 also sets the conditions for the exchange of information on shared resources [Article 7.(3)], coordination of shared resource management [Article 7.(4)] including development of management plans [Article 7.(5)] and a variety of other actions. These latter include promotion of stakeholder participation [Article 7.(7)], elimination of over-fishing and reduction of fishing capacity [Articles 7.(8) and (9)], and legislation enabling rapid response to issues associated with utilization of shared resources [Article 7.(10)].

4.2.6 Harmonization of legislation and law enforcement

Harmonization of legislation

Article 8 stipulates that Protocol parties should harmonize their legislation to ensure that all illegal fishing and related activities by nationals and legal persons of a SADC state party are deemed as offences under the national law of the party concerned. Article 8 also notes that parties need to establish appropriate arrangements to enable co-operation in respect of “hot pursuit” of vessels that violate laws of one party and enter, or try and escape to, the jurisdiction of another. The Protocol urges parties to co-operate in enforcing effective legislation through adopting measures such as (a) procedures for the extradition to another party of persons charged with offences against the fisheries laws of one party and, or, serving a sentence under the laws of that party, (b) establishing region-wide comparable levels of penalties for illegal fishing by non-SADC-flag vessels, (c) consulting over joint actions to be taken when there are grounds for believing that a vessel has been used for purposes that undermine the Protocol’s effectiveness and (d), establishing mechanisms for the registration of international and national fishing vessels to serve as compliance instruments and for sharing of information on fishing and related activities.

Enforcement

Protocol Article 9 sets out the conditions for effective enforcement subject to the national responsibilities outlined in Article 5 [see Section 5.(iii).(c) above]. These are summarized in Table 7.

4.2.7 High-sea fishing

In Article 11, the Protocol takes account of the rights and obligations of LOSC Articles 116-119 relating to management of high-seas fishing. Specifically, the Protocol urges parties to:

- recognize that all states have an equal right for their nationals to engage in fishing on the high seas
- work towards effective management living resources on the high seas
- collaborate in the establishment of common positions and policies aimed at effectively managing high-seas living resources and
- support the activities of international organizations that conserve and manage living resources on the high seas.

4.2.8 Protection of the aquatic environment

Article 14 of the Protocol urges parties to conserve aquatic ecosystems, including their biodiversity and unique habitats, insofar as these contribute to the livelihood and aesthetic values of the people and the region. Parties are called on to apply the precautionary approach to ensure that activities within their jurisdiction do not cause excessive transboundary adverse impacts. As such, they are required to co-operate with relevant SADC institutions and other relevant international agencies to protect endangered living aquatic species and their habitats including compiling lists of endangered species, introducing measures to progressively replace fishing gear and

TABLE 7
Some law-enforcement components addressed by Protocol Article 9

a) State parties shall take adequate measures to optimize use of existing fisheries law-enforcement resources
b) State parties shall co-operate in the use of surveillance resources with a view to increasing cost-effectiveness of surveillance activities and reducing the costs of surveillance to the Region and two or more state parties may conclude an arrangement to co-operate in the provision of personnel and the use of vessels, aircraft, communications, databases and information or other assets for the purposes of fisheries surveillance and law enforcement
c) State parties may designate competent persons to act as fisheries enforcement officers or on-board observers in order to carry out activities on behalf of two or more State Parties
d) A State party may permit another state party to extend its fisheries surveillance and law enforcement activities to its inland water bodies and the exclusive economic zone and, in such circumstances, the conditions and method of stopping, inspecting, detaining, directing to port and seizing vessels shall be governed by the national laws and regulations applicable to the waters where the fisheries surveillance or law enforcement activity is carried out
e) State parties shall strive to harmonise technical specifications for vessel monitoring systems and emerging technologies of interest to fisheries surveillance activities
f) In applying these provisions, state parties are called on to co-operate, either directly or through international fisheries organizations or arrangements, to ensure compliance with, and enforcement of, applicable international management measures.

other technologies that are hazardous to the environment, promoting broad awareness by all stakeholders of the need for protection of the species and their habitats and seeking alternative economic activities for those whose livelihoods affect the survival of endangered species. Other than its reference to the precautionary approach, Article 14 is consistent with other Protocol articles and exhibits a degree of socio-economic bias.

4.2.9 Other provisions and institutional arrangements

Other provisions

Other Protocol articles deal, *inter alia*, with establishing common SADC positions on subsistence, artisanal and small-scale commercial fisheries (Article 12), a rudimentary code of conduct for aquaculture (Article 13), human resources development (Article 15), trade and investment (Article 16) (Table 8), science and technology (Article 17) and exchange of information (Article 18). These articles strive to promote specific issues, at both a regional and international level that are related to the special needs of developing states³¹ (e.g. UNFSA Articles 25 to 26 and Code of Conduct Article 5) Other articles address collection and sharing of data (e.g. UNFSA Annex I), responsible aquaculture development (Code of Conduct Article 9), post-harvest practises and trade (as per Code of Conduct Article 11) and fisheries research (Code of Conduct Article 12) (FAO 1998b). In these terms, the Protocol clearly aims at codifying and harmonizing many of the Code of Conduct's provisions on a regional basis.

Access Agreements

Protocol Article 10 calls for harmonization between the parties of the terms and conditions for fishery access by Non-SADC parties to resources covered by the Protocol. Article 10.(2) indicates that such agreements should be non-discriminatory (i.e. similar provisions should be applied in all SADC states' waters). Article 10.(3)

³¹ All the SADC Parties are effectively developing states.

TABLE 8
Trade and investment provisions of Protocol Article 16

(a) The Protocol calls on Parties to promote sustainable trade and investment in fisheries and related goods and services by
(i) Reducing barriers to trade and investment;
(ii) Facilitating business contacts and exchange of information; and
(iii) Establishing basic infrastructure for the fisheries sector.

(b) It also calls on Parties to create favourable economic conditions to support sustainable fishing and processing activities to promote regional food security and fisheries development.

(c) With regard to the establishment of joint ventures, the Protocol urges Parties to give special consideration to
(i) Ensuring sustainability of living aquatic resources
(ii) Preventing over-fishing and excess fishing capacity
(iii) Promoting regional food security
(iv) Promoting trade in fish products in the Region
(v) Promoting value-added processing
(vi) Establishing a favourable cross-border investment regime and
(vii) Ensuring that nationals and their vessels comply with applicable domestic and international laws.

allows for joint negotiation by SADC parties on foreign fishing access agreements with a regional or sub-regional dimension, especially for highly migratory species. This final clause appears to be directed at forming a negotiating “power-block” within the various tuna commissions (most notably ICCAT).

Institutions

SADC is required to establish a oversight committee to ensure the Protocol’s effective implementation (Article 19)³² for which parties are called on to allocate the necessary funds (Article 20).

In regards to dispute resolution, Article 23 binds the Protocol parties to refer disputes on the Protocol’s interpretation or application to the SADC Tribunal. As drafted, the relationship between this particular provision and Article 7 is not entirely clear (Section 5.2.5). During the Protocol’s negotiation, South Africa questioned whether Article 23 might not draw into question the SADC Tribunal’s competence to deal with disputes of the kind likely to arise in connection with the Protocol on matters customarily assumed to fall under the LOSC. For political reasons, particularly in the interests of presenting a united faith in SADC’s efficacy, the matter was taken no further. However, on the Protocol’s signing by the SADC Heads of State, South Africa went on record as emphasizing that Article 23 should in no way be seen to compromise the rights of LOSC parties in relation to matters covered by that Convention – a position consistent with international law and Article 30 of the Vienna Convention (see Footnote 15).

4.3 Relationship with UNFSA and Other Instruments

A comparative analysis of the Protocol’s intended impact clearly indicates a strong regional push for SADC Members to review their relevant legislation and to establish whether these

- contain clear statements in relation to the scope of application and the authority responsible for fisheries management

³² For more information on the SADC Protocol and its Sector Coordinating Unit – Website: <<http://www.schoemans.com.na/sadc/>>.

- facilitate broad participation in fisheries management including co-management
- support and implement policies and provide a range of fisheries management mechanisms and measures, including the use of fishing rights or quotas, and management planning
- facilitate implementation of the Compliance Agreement, Code of Conduct and the UNFSA
- implement a full range of monitoring, control and surveillance³³ MCS) and enforcement action and in this context:
 - i. consider possible adoption of administrative processes and penalties to enforce fisheries laws
 - ii. increase the levels of penalties
 - iii. enhance port state enforcement to address lack of essential capacity and resources to undertake enforcement and other MCS activities, introduce ‘long-arm’ enforcement, protect confidentiality of information, particularly where it concerns fishing operations and where the use of VMSs for vessel positions and catch reports are anticipated.

There is little doubt that the Protocol represents one of the first major attempts to codify many of the broader legal obligations set out in UNFSA and the Code of Conduct. One of its significant impacts will be to focus regional action by the SADC on, e.g. harmonizing legislative provisions, ensuring effective implementation of relevant fisheries agreements such as the SEAFC, develop common management and enforcement measures and promote sustainable utilization of aquatic resources in the face of socio-economic needs and demands. The Protocol clearly constitutes a political manifesto as well as a fisheries management instrument – both qualities likely to affect its eventual success.

5. DISCUSSION

Growing concern over the finite nature of many of the world’s natural resources along with widening recognition of the aspirations of developing states pre-occupied the post-colonial world of the late 1970s and early 1980s. These concerns, rooted in the “common heritage of mankind” debates of the United Nations General Assembly in 1967, culminated in the Convention on the Law of the Sea being opened for signature on 10 December 1982 in Montego Bay, Jamaica. As emphasized in its introduction (Anon. 1983) the LOSC was an attempt to establish true universality in efforts to achieve “a just and equitable economic order” governing ocean space. An attached and equally profound principle was that effective governance of the oceans could be viewed as an important contribution to the maintenance of peace, justice and progress for all people of the world.³⁴

The LOSC constitutes a “package” that is the product of the circumstances prevailing at the time the Convention was negotiated.³⁵ This required that “every individual provision of the text be weighted accordingly throughout the text thereby producing intricate impartiality as a basis for universality” (Anon. 1983). It was these strengths that rendered the LOSC’s provisions difficult to apply effectively; a consideration compounded by geography and economic disparity. As a result, Paragraph 17.49 from Agenda 21 of the 1992 UN Conference on Environment and Development attempted to provoke states to take effective and appropriate action, both bilaterally

³³ “Surveillance” means the monitoring and supervision of fishing and related activities to ensure compliance with control measures (SADC Protocol Article 1).

³⁴ Paragraph 1 of the *LOSC Preamble* (Anon. 1983).

³⁵ Such circumstances included the large number of negotiating states, the often conflicting interests cutting across traditional lines of negotiation by region, the strong need for the Convention to be flexible in practice so as to be durable over time and the need not to encroach on the sovereignty of states (Anon. 1983).

and multilaterally, at sub-regional, regional and global levels to ensure that high-seas fisheries are managed in accordance with LOSC provisions. This particular injunction culminated in the convening of the 1992 UN Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks pursuant to paragraph 1 of UN Resolution 47/192. The subsequent negotiating process resulted in the UNFSA.

It should be apparent that during the UNFSA negotiations, the South-East Atlantic and Western Central Pacific regions, in particular, recognized that there were gaps in the fisheries agreements existing at that time. Such gaps directly affected the potential sustainability of straddling and highly migratory fish stocks in the two regions. At the centre of this recognition was that affected states should empower themselves to compete with other states (particularly with distant-water fishing fleets), which had had easy access to resources in the past. The four main principles in this process can be identified as follows.

- i. Developing fairer ways of allocating fishing opportunities. These would aim to “level the playing field” between fishing rights based on historic performance and the aspirations of developing states, which for political or economic reasons had been excluded from potential benefits associated with fish resources found in their respective regions.
- ii. Providing for fair and equitable access to fishing opportunities to states that did not share previous access.
- iii. Reducing access to fishing opportunities for stocks that had been exploited beyond sustainable levels on a fair and equitable basis.
- iv. Managing fishing capacity so that it is more evenly distributed between developing and developed states, but not at the expense of sustainability of target stocks.

Lutgen (1999) reviewed 22 FAO and Non-FAO regional fisheries organizations or arrangements. She focused on measures taken by these bodies to address contemporary fisheries issues and found that RFMOs had until then made efforts to implement the conservation and management measures provided for in post-LOSC fishery instruments. At the global level, such efforts are strongly dependent on effective co-operation between RFMOs (Lutgen 2000). To evaluate Lutgen’s conclusion, Appendix I identifies the key topics addressed by the three instruments reviewed in this paper. They are cross-referenced to the most relevant UNFSA Articles.

Appendix I illustrates the high level of convergence between SEAFC and WCPFC, despite the differences highlighted in Sections 2.3 and 3.3. This indicates that in at least two regions considerable and independent efforts to develop the necessary policies to facilitate implementation of conservation and management measures post-UNFSA have attained a remarkably similar result. Therefore, both SEAFC and WCPFC’s clear identification of their objectives provided for improved international standards of ocean governance, particularly through application of the precautionary approach, harmonization of measures, elaboration of flag and port state duties, and the setting up of workable compliance and enforcement regimes. The Protocol goes further and attempts to provide the political and socio-economic framework to mobilise the political will to enhance co-operation and to co-ordinate regional application of agreements such as SEAFC.

The SEAFC, WCPFC and SADC fisheries protocols therefore represent the first and only fruits of contemporary efforts aimed at providing equity, equality and sustainability in the execution of commercial exploitation of fish stocks at a regional level. If effective, they should greatly contribute to sustainable fisheries by securing global food security, the primary objective of the Kyoto Declaration and Plan of Action (Anon. 1995)³⁶.

³⁶ *Kyoto Declaration and Plan of Action on the Sustainable Contribution of Fisheries to Food Security*. (1995). Website: <<http://www.fao.org/fi/agreem/kyoto/H@F.asp#>>.

6. CONCLUSIONS

The UNFSA provides a blueprint for regional arrangements aimed at ensuring sustainable utilization of straddling and highly migratory fish stocks. While such agreements can be tailored for specific regional applications, their general objectives and underlying principles remain the same. Therefore the impact of post-UNFSA agreements, such as SEAFRC and WCPFC should greatly contribute to ensuring responsible and improved governance of the oceans' fishery resources.

Rayfuse (2000) has emphasized that there is little doubt that eventual state practice for regional instruments such as SEAFRC and the WCPFC will clarify their inter-relationships with UNFSA. This is not only self-evident in respect of some of UNFSA's strengths, but also in terms of SEAFRC's objective to regulate discrete high-seas stocks. The SEAFRC process will test whether such precedent setting, or innovative, developments are workable when combined with other measures, e.g. control of individual nationals and industries.

The close similarities between SEAFRC and UNFSA are readily apparent. The SEAFRC Preamble expressly recognizes this link, which is reinforced by the large degree of commonality in text despite apprehensions exhibited by some of the negotiating parties. While UNFSA provided much of the basis for many SEAFRC provisions, it remains to be seen how these will be applied in practice, particularly in respect of allocating fishing opportunities. For WCPFC, the most distinctive feature is its attempt to provide essential detail for a compliance and enforcement regime compatible with, but not apart from, UNFSA. SEAFRC on the other hand is not as prescriptive and only future state and institutional practices will indicate how effective these two approaches have been compared to each other.

The SADC Protocol constitutes a model for how essential regulatory provisions may be put into practice to address political and socio-economic needs. The Protocol is thus the "sharp-end of the anticipated outputs from fisheries agreements such as SEAFRC and WCPFC. There is much to be gained from SADC states making sure that the Protocol is effective so that the entire RFMO "process" is seen to benefit distant-water and developing states alike. All the SADC states should be seen to participate in the process, while other states should be encouraged to develop similar arrangements to identify their own particular regional and political needs. Such initiatives should lay the ground for the next developmental phase in ocean governance – the consideration of discrete stocks on the high seas. SEAFRC's future success here is obviously crucial, especially in light of growing global concern at the ecologically damaging and economically unfair practice of IUU fishing (FAO 2001).

Finally, it should be clear from Table 9 that the future effects of SEAFRC, WCPFC and the SADC Protocol are likely to be profound and hold great significance for the future legitimate governance of the oceans, including the high seas. These effects are as much a result of the need to address the issues highlighted in Section 5 as they are to ensuring a more equitable approach in dealing with the inalienable "right to fish the high seas". It is therefore concluded that the three fishery instruments considered in this paper represent the dawn of a "new age" in fisheries management; an age that will be consistent with the direction set by LOSC and UNFSA.

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TABLE 9

Some anticipated outcomes from SEAFC, WCPFC and the SADC Protocol

-
- Proof of effectiveness with future experience
 - Fairer and more equitable allocation of fishing opportunities
 - “Level Playing Field” to balance fishing rights based on historic performance with developing state aspirations (especially when prevalence of historic/political exclusion in region)
 - Allow for fair & equitable access to fishing opportunities by states denied, or without, previous access
 - Equitably/fairly reduce access to stocks exploited beyond sustainable levels
 - More even distribution of fishing capacity between developing & developed states
 - Some precedent for managing discrete high seas stocks (SEAFC’s future application)
 - Combat ecologically-damaging/economically-unfair IUU fishing
-

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APPENDIX I

SUMMARY DETAILS ON THE UNFSA, SEAFC, WCPFC AND SADC FISHERIES PROTOCOLS

(Adapted from Doulman 1999)

TOPIC	UNFSA	SEAFC	WCPFC	PROTOCOL
Origin	UN Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks (1992-1995) Manage high seas fisheries consistent with LOSC (especially Articles 63-64)	Namibia and coastal states post-UNFSA (1996) Replace ICSEAF to promote sustainable utilization of high seas resources in interests of region's fishing industries	FFA and USA at UNFSA time in context of USA/South Pacific Fisheries Treaty 1993/94 reviews Pacific Island states concern on sustainability and equitable economic benefit from region's migratory stocks	SADC Workshop (1997) Need for consistent regional promotion responsible and sustainable use of living aquatic resources subject to international agreements
Process name	UN Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks	Meeting of coastal states and Other Interested Parties on a Regional Fisheries Management Organisation for the South-East Atlantic Ocean	Multilateral High-Level Conference on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean	SADC Fisheries Protocol Negotiations
Organization name	Co-ordination of RFMO's (New and to be Formed)	Southeast Atlantic Fisheries Organisation (SEAFO)	Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean	SADC Fisheries Protocol Oversight Committee
Convention name	Agreement for the Implementation of the United Nations Law of the Sea of 10 December 1982 relating to Straddling Fish Stocks and Highly Migratory Fish Stocks	Convention on the Conservation and Management of Fishery Resources in the South-East Atlantic Ocean (SEAFC)	Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean	SADC Fisheries Protocol
Convention area	Global (i.e. Not Defined)	High seas areas outside national jurisdiction - approximately FAO Statistical Area 47 bounded at 6 °S, 20 °W, 18 °E and 50 °S (Fig. 1) (Article 3)	Roughly to boundaries of IOTC in west, IATTC in east, CCAMLR in south and 4 °S in north. EEZs included (Fig. 2) (Article 3)	SADC Region (Fig. 1) Waters under national jurisdiction (freshwater and marine) and high seas
Species covered	Straddling Fish Stocks and Highly Migratory Fish Stocks excluding sedentary species under LOSC Article 77	Straddling/discrete stocks on high seas. Excludes sedentary species under LOSC Article 77 and highly migratory species in LOSC Annex I Limited assessment past/potential catches	Highly migratory stocks of species in LOSC Annex I Mainly skipjack, yellowfin, bigeye and albacore tuna. Good historic catch data record maintained by FFA	All aquatic ecosystems, fish and fish stocks to which Protocol applies
Signature Entry into force	4/12/1995 11/12/2001	20/4/2001 13/4/2003	5/9/2000 Not yet in force	14/8/2001 Not yet in force

TOPIC	UNFSA	SEAFC	WCPFC	PROTOCOL
Objective	Ensure long-term conservation and sustainable use of straddling and highly migratory fish stocks through effective implementation of the LOSC (Article 2)	Long-term conservation and sustainable use of fishery resources (straddling and discrete stocks) in convention area (Article 2)	Long-term conservation and sustainable use of highly migratory fish stocks in Convention Area under LOSC and UNFSA (Article 2)	Promote responsible and sustainable use of living aquatic resources for various socio-economic benefits (Article 3)
General principles	Give effect to management of straddling and highly migratory fish stocks by adopting scientifically-based measures, applying precautionary approach, environmental protection etc. including data gathering and conservation measure enforcement (Article 5)	Give effect to management of Convention area's fishery resources by adopting scientifically-based measures, applying of precautionary approach, environmental protection etc. (Article 5)	Give effect to management of convention area's fishery resources by adopting scientifically-based measures, applying of precautionary approach, environmental protection etc. including data gathering and conservation measure enforcement (Article 5)	National responsibility, protect resources against over-exploitation accounting for various socio-economic needs (Article 4)
Precautionary approach	Details approach and guidelines on application of reference points. Special mention of new and exploratory fisheries (Article 6 and Annex. II)	Caution in the face of uncertainty and cross-reference to reference points in the UNFSA Annex. II and Code of Conduct (Article 7)	Identical to UNFSA Article 6, including direct reference to the UNFSA reference points (Article 6)	Protect aquatic environment applying "precautionary principle" through co-operation and common standards for protecting areas and habitats (Article 14).
Compatibility of measures	Compatibility of national and international measures. Co-operation on high seas (Article 7)	Compatibility of national and international measures. Avoid undermining the LOSC Articles 61 and 119 (Article 19)	Compatibility with national and international measures. Largely duplicates the UNFSA Article 7 and reinforces need to implement Convention's principles in national areas (Article 8 and 7 respectively)	Contracting Party legislation to be harmonized, including commonality of sanctions (Article 8)
Contracting party obligations	Not specifically identified. Some details provided on State obligations in ensuring co-operation under RFMO or other relevant arrangement(s) (Article 10)	Detailed provisions on, inter alia, data collection/exchange/ submission, ensuring effective measures. Co-operation to ensure compliance by flagged vessels and nationals and limitation of access to Party flagged vessels (Article 14)	Outlines obligations. Detailed provisions include prompt implementation of measures, data submission etc., taking measures to ensure compliance by flagged vessels and nationals (including procedures to be followed on alleged violations) (Article 23)	Co-ordinate cross-SADC action in accordance with principles, national responsibilities, international relations and shared resources (Articles 4 to 7)
Flag State duties	States only to authorize fishing vessels in manner not undermining RFMO measures and when able to assume responsibility for flagged vessels. Details measures to be applied and entreats States to ensure MCS measures are compatible with any regional system in force (Article 18). Also outlines Flag State compliance and enforcement provisions (Article 19)	Ensure flagged vessels comply with SEAFO measures, possess authorization to fish, details measures to give effect to control of flagged vessels and urges need to ensure that vessels do not undermine measures by unauthorized fishing in convention and adjacent areas (Article 14)	Ensure flagged vessels comply with measure, possess authorization to fish in all Convention Area, details measures to give effect to control of flagged vessels and urges need to ensure such vessels do not undermine measures by unauthorized fishing in Convention and adjacent areas and mandates VMS deployment (Article 24)	No specific reference to flag state responsibilities although implicit in respect of references to application of national jurisdiction, especially in direct/indirect cross-reference to the LOSC and UNFSA [Articles 6.(2) and 11]

TOPIC	UNFSA	SEAFC	WCPFC	PROTOCOL
Port state duties	Empowers port states to take measures consistent with international law and RFMO provisions (Article 23)	Similar to the UNFSA Article 23 - Port State measures consistent with international law (Article 15)	Similar to UNFSA Article 23 – Port State measures consistent with international law (Article 27)	Implied in law enforcement provisions (Article 9)
Compliance and enforcement	Details co-operation in enforcement, sub-regional enforcement co-operation and basic boarding/inspection procedures (Articles 20 – 22 respectively)	Establishes MCS framework as alternative system under UNFSA Article 20.(15). Details for first Commission meeting, but interim guidelines provided (Article 16 and SEAFC Annex)	Details MCS framework, including schemes for boarding/inspection, observers and regulating transshipment (UNFSA Articles 20-25). Also outlines terms and conditions for fishing and information requirements (Articles 25, 26, 28, 29, Annexes III and IV)	Calls for pooling of MCS and enforcement capabilities, human resource development and transfer science/ technology (Articles 9, 15 and 17)
Control of nationals	No specific mention. Implied in ensuring national “industries” co-operation [Article 10.(c)]	Specific reference to nationals and industries (no prejudice to Flag State Responsibility) [Article 13.(3)]	Similar to SAEAFIC but with some elaboration [Article 23.(5)]	Specific application to nationals [Article 2.(a)]
Fishing opportunities	Limits resource access to RFMO participants and members. Indicates considerations to be taken into account in determining nature/ extent of participatory rights for new entrants [Articles 8.(4) and 11 respectively]	Details considerations for determining fishing opportunities with caveat that Commission may agree rules. (Article 20)	No consideration of fishing opportunity allocation	No direct consideration of allocation. Recognises economic equity in application of sustainable resource use, providing access to third parties and promoting trade/ investment (Articles 3, 10 and 16)
Good faith and Abuse of rights	Specific provisions (Article 34)	Subsumed into contracting party obligations [Article 13.(8)]	Specific provision (Article 33)	Builds on SADC principles of regional co-operation under Articles 4 and 5 of the 1992 SADC Treaty but not specifically mentioned in Protocol
Non-contracting parties (NCPs)	Specific provisions emphasizing duty not to undermine RFMO measures and need to adopt regulations consistent with the UNFSA (Articles 17 and 33)	Call for co-operation, exchange of information, taking of internationally-acceptable steps to deter NCP activities undermining measures. NCPs to enjoy benefits commensurate with commitment to comply with measures (Article 22)	Call for co-operation, information exchange, taking internationally-acceptable steps to deter NCP activities undermining measures. NCPs enjoy benefits commensurate with commitment to comply, and compliance record for measures (Article 32)	Not expressly mentioned but subsumed in cross-reference to the LOSC and UNFSA [Article 1.(2)]
Decision-Making	Not specified	Consensus with opt out on exceptional circumstances. No provision for breaking deadlock . Immediate resort to dispute resolution provisions (Articles 17 and 23)	Generally consensus, opt out provided in case of voting against decision and capacity to appoint review panel to break deadlock (Article 20)	Not specifically mentioned, but subsumed as under the SADC Treaty (i.e. consensus unless decided otherwise)

TOPIC	UNFSA	SEAFC	WCPFC	PROTOCOL
Budget	Not specified	Budget adopted by consensus. Equal for first three years then part equal and part calculated from catch levels. Some recognition of capacity to pay and cost-efficiency (Article 12)	Budget by consensus. Based on assessed contributions as adopted (taking into account equal basic fee and other criteria for remaining portion). Recognise ability to pay. No voting on arrears for two years. Interest payable on arrears. Special fund for developing States [Articles 17, 18 and 30.(3)].	No specific reference, but call for provision of necessary funds (Article 20)
Dispute resolution	Resolution by peaceful means, including prevention of disputes and definition of technical disputes. (Articles 27 to 29) Procedures for settlement under, mutatis mutandis provisions of LOSC Part XV, other LOSC and UNFSA provisions and provisional measures pending settlement (Articles 30 and 31)	As per LOSC Part XV and UNFSA Part VIII. By implication former applies to discrete stocks and latter to straddling stocks. Also applies to SEAFC Parties not party to the LOSC and, or UNFSA (Article 24)	Direct application of the UNFSA Part VIII (Article 31)	Implied for shared stocks as in the LOSC Part XV otherwise by reference to SADC Tribunal [Articles 7.(2) and 23]
Developing States	Specific considerations, including recognition of needs, forms of co-operation and provision of assistance (Articles 24 to 26)	Recognition of special needs subsuming provisions of the UNFSA Articles 24 to 26 (Article 21)	Recognize qualified special needs of small island developing states. Establish special fund for developing states [Articles 30 and 30.(3)]	Preamble and various provisions recognize need to uplift SADC Parties (all Developing States) by promoting Protocol as a whole
Real interest	Real interest in fisheries leading to support for RFMO [Article 8.(3)]	Perfunctory promotion of co-operation for "real interest" (Preamble) Implicit condition in allocating fishing opportunities (Article 20)	No direct referenced, but implicit in pre-negotiation (see Molenaar 2000)	No direct reference

Managing living marine resources multilaterally: some threshold questions

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1. INTRODUCTION

Ocean life ignores the jurisdictional lines that humans draw in the water. Over the past half-century, human efforts to manage the exploitation of ocean life that cross our jurisdictional lines or occur solely in the global commons have met with decidedly mixed results. As this Conference considers options to improve the management of deep-sea fisheries, it is reasonable to ask what approaches to multilateral management of ocean life have worked so far and which have not worked.

This paper draws on the experience of the United States in negotiating multilateral agreements for the management of ocean life, both binding and non-binding, and in participating in multilateral organizations responsible for implementing these agreements. Reflecting on this experience, this paper considers two threshold questions: (a) whether any new approach for managing deep-sea fisheries should take the form of binding or non-binding measures (or some mix of the two)? And (b), whether such measures should apply in all marine areas or solely on the high seas?

This paper concludes with some brief thoughts on a number of elements that maximize the possibility for effective multilateral management of ocean life, which in an ideal world would be part of any new measures to improve the management of deep-sea fisheries.

2. COMPETITION OR COLLABORATION?

We live in a world of nations that jealously guard their sovereignty. The first instinct of almost every government in the international arena is to protect and promote its own national interests. In approaching the management of shared living marine resources in past decades this instinct has generally led governments to seek to maximize the rights of their own nationals and vessels to exploit the resources in question and to minimize their own obligations to regulate or supervise such exploitation. In other cases, this instinct has led governments not to participate at all in multilateral management efforts or to ignore obligations they may have undertaken.

We need not look hard or far to assess the results. A significant number of the world's most valuable fish stocks have become depleted through overfishing, habitat degradation, pollution and other causes. Overall, FAO reports that more than

¹ The views expressed in this paper are solely those of the author and do not necessarily reflect those of the U.S. Department of State or of the United States Government generally.

70 percent of ocean fisheries for which data are available are either overfished or are fished at their maximum capacity. In the coming years production from many key fisheries will likely decline. Demand for fisheries products, however, will continue to increase. The prospect of this growing shortfall poses our greatest challenge today.

3. RECENT MULTILATERAL EFFORTS

In the early 1990s, the international community was forced to recognize that the capacity of harvesting operations in many key fisheries had outpaced both the reproductive capacities of those resources as well as the tools used by governments and international organizations to regulate those fisheries. Unresolved jurisdictional disputes between states over certain valuable fish stocks were producing heightened conflict and inhibiting effective conservation.

The 1992 Cancun Conference on Responsible Fishing and the 1992 United Nations Conference on Environment and Development (UNCED) set in motion a series of steps designed to address these problems. At the global level, these included the negotiation of two new treaties to regulate ocean fisheries, the 1993 FAO Compliance Agreement and the 1995 UN Fish Stocks Agreement (UNFSA). The FAO also adopted a comprehensive non-binding instrument, the 1995 Code of Conduct for Responsible Fisheries. The United Nations General Assembly established a moratorium on the use of large-scale driftnets on the high seas, which became effective in 1993. Other global instruments have included, among others, four International Plans of Action (IPOAs) negotiated and adopted under FAO auspices dealing with fishing capacity, conservation and management of sharks, seabird bycatch and illegal, unreported and unregulated (IUU) fishing.

Several new multilateral regimes – regional fisheries management organizations, or RFMOs, governing ocean fisheries in specific regions have also arisen to join the ranks of those that existed. RFMOs, old and new, have begun to take stronger steps to control fisheries in their respective regions more effectively. Quotas, gear restrictions, closed areas and other controls on fishing are being applied to more and more stocks and are growing increasingly strict. For example, many critical stocks under the purview of the Northwest Atlantic Fisheries Organization remain under moratoria. The International Commission for the Conservation of Atlantic Tunas (ICCAT) has imposed farsighted rebuilding programs for North Atlantic swordfish and Western Atlantic bluefin tuna. Fishing for pollock in the high-seas portion of the Bering Sea has been prohibited under a multilateral agreement for roughly a decade following the collapse of that stock from overfishing in the early 1990s.

Multilateral measures to monitor and control fishing operations at sea have grown much more sophisticated. To list just a few examples, an expanding number of fishing vessels must report catch and effort data, must accept independent observers on board and must use satellite-based vessel monitoring systems (VMS). Some RFMOs now require their members to prohibit fish from being landed or transshipped in their ports in situations where the fish may have been harvested illegally. Mandatory catch certification and trade documentation schemes are proliferating. The use of multilateral trade restrictions, adopted and imposed through RFMOs, is another tool in increasing use. Other trends include calls for the reduction and elimination of subsidies to the fisheries sector and the growth of eco-labeling schemes.

The international community now also accepts, at least in principle, that ocean fisheries must be managed as part of the ecosystems in which they take place. Measures to reduce bycatch of juvenile fish and non-target species are now common features of many multilateral management efforts. RFMOs, more generally, are grappling with the need to take account of the effects of fishing on associated and dependent species. New concerns are arising, particularly at conferences such as this, on the effects of certain fishing methods on benthic ecosystems, including seamounts, oceanic ridges, deepsea corals and other sensitive features of the ocean floor.

4. TO TREATY OR NOT TO TREATY

In considering the possibility of new multilateral measures to regulate deep-sea fisheries, a threshold question arises – should such measures be crafted to be legally binding or should they be adopted in a non-binding format? The answer is far from obvious. As noted above, some of the multilateral measures adopted in recent years have taken the form of treaties or, in the case of certain measures adopted by RFMOs, have otherwise created legally binding obligations, at least for the members of the respective RFMOs. Other instruments, sometimes referred to as contributing to a body of “soft law,” have been voluntary in nature, including the Code of Conduct for Responsible Fisheries, the UNGA resolution establishing the high-seas driftnet moratorium and the FAO IPOAs.

Which is best? The UNFSA provides a useful example of the trade-offs inherent in the choice. The UN Conference that developed the UNFSA engaged in considerable debate over whether it should produce a treaty or some non-binding instrument. The majority of delegations, whose views ultimately prevailed, argued that only a binding instrument would command the respect and induce the changes in fishing practices needed to address the problems at hand. A minority of delegations (principally those representing the major high-seas fishing states) favored a non-binding instrument.

Today, the UNFSA is generally recognized to be making a valuable contribution to the management of ocean fisheries in part because its legally binding status gives it a heightened stature in the pantheon of international instruments. Few would deny that governments tend to pay greater attention to commitments contained in instruments that have been approved at the highest levels in their respective systems, i.e. legally binding instruments. The prospect of compulsory and binding dispute settlement, a feature available only in binding instruments, may also enhance compliance with the UNFSA over time.

On the other hand, the decision to craft the UNFSA as a treaty has had the following consequences.

- The negotiation of the UNFSA almost certainly took longer, perhaps considerably longer, than it would have if it were a non-binding instrument. As anyone who has ever participated in multilateral negotiations will acknowledge, the level of debating and word-smithing associated with binding instruments is significantly more intense and usually takes more time to complete.
- The language of the UNFSA almost certainly contains more, perhaps considerably more, caveats and watered-down provisions than it would have if it were a non-binding instrument. Governments are typically less willing to accept strictly worded obligations in binding agreements.
- It took six full years following the adoption of the UNFSA in December 1995 for the treaty to enter force. Had it been crafted as a non-binding instrument, its provisions would have been operative immediately.
- As of this writing, only 32 states are party to the UNFSA. Few of the major high-seas fishing states other than the United States have yet bound themselves to the treaty, although the European Union is reportedly close to becoming a party. Many other states, however, have made no commitment to comply with the UNFSA.

By contrast, the UN General Assembly resolution that established a moratorium on large-scale high-seas driftnet fishing, a non-binding instrument, has been as effective as any treaty in changing fishing behavior. Following adoption of the resolution, governments dismantled the large driftnet fleets that previously operated in the Pacific Ocean. On the other hand, this resolution may be the proverbial exception that proves the rule. The international community adopts numerous non-binding instruments on fisheries every year that seem to have little effect in improving the management of fisheries.

A comparison of the FAO Compliance Agreement and the Code of Conduct for Responsible Fisheries reveals similar trade-offs. The Compliance Agreement, a treaty, was supposed to deal head-on with the phenomenon of the reflagging of fishing vessels to avoid management measures. Prior to its negotiation, governments had already agreed in non-binding instruments (the Cancun Declaration and Agenda 21) to end this practice. However, when confronted with the reality of accepting a binding obligation to prohibit such reflagging, some governments (and the European Union) refused. The negotiators of the Compliance Agreement had no choice but to change course, and ultimately produced a treaty that establishes specific “flag State responsibilities” for vessels fishing on the high seas. Even these obligations, as valuable as they are, remained in legal limbo for almost ten years, as it took that long for 25 states to bind themselves to the Compliance Agreement. Flag states that are not party to this treaty² – and there are more than 190 potential flag states in the world – are not bound by its provisions.

The Code of Conduct for Responsible Fisheries, a non-binding instrument, does not carry the legal force of a treaty such as the Compliance Agreement. Those states that do not abide by it are guilty “only” of a failure to fulfill a moral or political commitment. The Code has nevertheless provided a widely accepted set of standards for the management of all fisheries. All FAO member states (which include the vast majority of states generally) are equally committed to observe the Code. Moreover, there was no “lag time” between its adoption in 1995 and its effectiveness.

In looking ahead to possible new measures to manage deep-sea fisheries, the choice between a binding or non-binding format may not necessarily be an “either/or” proposition. The international community could consider the development of one or more non-binding instruments at the global level to be supplemented or followed by binding measures adopted regionally. This thinking informed the creation of the four FAO IPOAs, non-binding instruments that envision further action at the national and regional levels, some of which should be legally binding.

It must be noted that some existing RFMOs have the competence to adopt binding measures for deep-sea fisheries within their region, including the Northeast Atlantic Fisheries Commission, the Southeast Atlantic Fisheries Organization and the Commission for the Conservation of Antarctic Marine Living Resources. Binding measures adopted by such organizations could take effect relatively quickly, as there is no need in such situations for the prolonged ratification procedures that typically attend the entry into force of treaties.

Another approach might entail the development of non-binding instruments at either the global or regional level as possible preludes to binding instruments at the same level. This worked well in a different arena, that of international human rights, where the UN adopted non-binding declarations that set fundamental standards and later crafted binding instruments on the same subjects.

5. AREAS OF APPLICATION

The deep seas include areas under national jurisdiction as well as the high seas. A second important question is whether any new multilateral measures should cover both areas or should apply only to fisheries on the high seas. Again, the answer is not obvious.

Under international law, coastal states have the power to regulate deep-sea fisheries in waters under their national jurisdiction³. As a legal matter, there is no ‘governance gap’. The high seas, by contrast, are part of the global commons. While all states have

² As of this writing, 25 States and the European Union have become party to the Compliance Agreement.

³ Coastal States also have exclusive jurisdiction over fisheries for sedentary species on their continental shelves, which for approximately 30 States extend beyond 200 miles from their shore (i.e. their territorial sea base lines).

the right for their nationals to fish on the high seas and the obligation to regulate them as they conduct such fishing, fully effective measures for deep-sea fisheries on the high seas can be achieved only through multilateral cooperation. To date, such cooperation has left ‘governance gaps’ in a number of critical high-seas regions relative to deep-sea fisheries.

In light of these gaps, one approach would be to focus on the development of measures for the high seas only. This approach might hope or assume that coastal states would act responsibly in adopting comparable measures for the regulation of deep-sea fisheries within areas under their respective national jurisdiction. Indeed, to the extent that the deep-sea fisheries are for straddling stocks, the UNFSA calls for the development and implementation of such compatible measures.

The flag states whose vessels conduct deep-sea fisheries on the high seas may have a different perspective, however. They would likely point out that, if unregulated deep-sea fisheries pose a threat to the fisheries they target and to the broader ecosystems in which they take place, those threats are just as real when unregulated deep-sea fisheries occur in waters under national jurisdiction. They would note, for example, that seamounts located under EEZs are just as vulnerable to overfishing and habitat degradation as seamounts under the high seas. While coastal states have the authority to adopt measures for these fisheries in their own waters, few have actually done so and fewer still are enforcing those measures effectively.

The argument that conservation concerns are just as real on one side of the 200-mile line as the other flows into a second argument based on fairness. Those fishing on the high seas will regard it as inequitable to impose new restrictions on high-seas fishing if coastal states are not prepared to adopt those same restrictions for fishing within their zones. Coastal states already control waters in which more than 90 percent of the total catch of marine fish occurs. To those conducting the relatively small fraction of ocean fishing on the high seas, proposals for further restrictions on their activities may look like just another attempt at the extension of coastal state control.

On the other hand, the pursuit of new measures to regulate deep-sea fishing on both sides of the 200 mile line may significantly delay or even prevent their adoption. Some coastal states regard their sovereign rights and jurisdiction over fisheries in waters under their national jurisdiction as sacrosanct. They are often unwilling to even consider the possibility of accepting new international obligations affecting the management of these fisheries. In the negotiations leading to the UNFSA, many coastal states refused until the end to concede the applicability of that treaty to any waters other than the high seas. Even today, some coastal states have remained non-parties to this treaty because they do not wish to accept the obligations set forth in Articles 5-7 of the UNFSA relating to fisheries in their waters.

Those advocating an approach to improved management of deep-sea fisheries limited to high-seas areas can also point to several important precedents. Article 66 of the 1982 UN Convention on the Law of the Sea, along with regional treaties relating to salmon fisheries in the North Atlantic and North Pacific Oceans, basically prohibit salmon fishing on the high seas. The UNGA driftnet moratorium applies only on the high seas. So, too, does the FAO Compliance Agreement.

6. CONCLUSION: ELEMENTS OF A SUCCESSFUL APPROACH

There may be no ‘right answer’ to either of the important questions posed above. The success of any approach to improve management of deep-sea fisheries will depend primarily on the political will of governments, the vast majority of which have not yet expressed any detailed view on this subject. Until more governments respond in earnest to the concerns that are being raised, primarily by scientific and academic institutions, by environmental organizations and by some fishing interests, these questions will remain largely hypothetical.

In hopes that these concerns will trigger responses by responsible governments, and in hopes that these responses will lead to the adoption of measures to improve the management of deep-sea fisheries, the following might be considered as elements to maximize the chances of success.

- i. Sound and independent scientific advice.* To succeed, multilateral regimes for managing ocean life must have access to sound scientific advice that is developed and presented as freely as possible from political pressure.
- ii. Management measures that respect that advice.* A high correlation exists between the stocks that are depleted and those for which scientific advice on fishing limits is ignored. Moreover, instead of erring on the side of caution when scientific information is poor, the common tendency is live for the day and hope for the best.
- iii. Equity in the allocation of both rights and obligations.* Regimes that balance the competing interests of all participants are likely to be perceived as the most legitimate, which should in turn promote higher levels of compliance with agreed fishing rules. Among the many balances to be found are, (a) those that have historically participated vs. new entrants, (b) coastal states vs. distant water fishing states and (c), developed states vs. developing states. The ICCAT allocation criteria adopted in 2001 demonstrate just how many different interests may need to be taken into account.
- iv. Strong monitoring, control and enforcement mechanisms.* Many tools exist to promote compliance with multilateral measures, as described in the FAO IPOA on IUU Fishing and the related FAO Guidelines on implementation of this IPOA. Finding and applying the right combination of tools in any given fishery is the challenge we face.
- v. Controls on capacity.* Overall, there are simply too many vessels chasing too few fish, particularly in tuna fisheries. For deep-sea fisheries, we need an assessment of actual fishing capacity and the sense of whether this capacity must be capped or reduced.
- vi. Ways to deal with “bad actors”.* Those vessels that fail to observe multilateral rules, particularly those “free-rider” vessels that fly the flags of states and entities that are not bound by the rules, can completely frustrate well-intended management and conservation efforts. The irresponsible vessel owners and masters in question are facing increasingly determined action by those who play by the rules, but more must be done.

The way ahead: principles and criteria for management and governance of human impacts on the deep sea

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1. INTRODUCTION

The deep-sea environment is an important part of global systems and habitat and is intimately linked as a complex bio-geo-physical system to air, land and freshwater systems. It has a range of functions and values. The High Seas are part of the global commons under the 1982 United Nations Convention on the Law of the Sea (LOSC). Some deep-sea areas are within 200 nm of land, others are beyond. Some aspects of the deep seas are already under management by a variety of multilateral agencies – and finding “fit” among these will be a major challenge.

Human activities in the deep sea outside of national control are only partially controlled by existing agreements. Some uses deplete or degrade the environment and resources. Other uses and values are non-consumptive but are harmed or impeded by other uses or impacts. There is no overall environmental protection regime, especially for biodiversity and ecosystem function protection, though regional fisheries agreements, the international Seabed Authority and a patchwork of other agreements provide the frameworks for, and in some cases actual, but not always effective, controls to limit harvests, extraction or impacts. International agreements are designed to move from a situation of open to limited access for a variety of activities and impacts.

There is a substantial “genealogy” of agreed, or suggested principles, and criteria for international governance, law and environmental management. This paper does not canvass all the prior principles, but rather discusses a small subset of particular concern in relation to certain aspects of the governance and management of human uses of, and impacts on, the environment and resources. The purpose of the paper is to distill principles and criteria for governance and management that are of interest in the design and implementation of institutions and measures for the governance and management of human impacts on, and management of, the deep-sea environment and resources.

Definitions of “deep” vary, but can be 400 m depth and deeper (ICES 2003a,b). While different scholars and jurisdictions use differing reference points the exact definition is not material to the discussions below.

Graham, Amos and Plumptre (2003) define governance as “the interactions among structures, processes and traditions that determine how power and responsibilities are exercised, how decisions are taken, and how citizens or other stakeholders have their say”.

The public or common concerns, interests and property

The oceans and deep sea, if they are outside national boundaries, are variously seen as owned by none or owned by all. Assertions of ownership are a human construct and the notion that one species owns the planet and all other species is regarded by many as improbable from both an ethical and an evolutionary perspective (Fox 1990). Paradigms of stewardship, guardianship and responsibility supply an alternative basis for making decisions.

Damage to the environment consists essentially of what property rights theorists would call private “taking” of public good – or the “property” of all. As the rapid depletion of the orange roughy stocks in the Indian Ocean (Lack, Short and Willock 2003) and the rampant illegal, unreported and uncontrolled (IUU) fishing for toothfish in the Southern Ocean vividly demonstrate, in the absence of effective controls, fisheries, other ocean resources and the host environment are open access resources subject to competitive depletion, significant, and at times, irreversible damage with losses to many and gains to a few.

The LOSC notion of the seas as “Common Heritage of Mankind” may have been an attempt to find language that avoided the term property but fails adequately to convey the sense that humans are one of many species dependent on the sea and its biophysical processes. Other language, such as the “Common Interest of Humanity” or the “Common Concern of Humanity” are discussed by Kiss (1999) as a basis for international law and rules to express the basis for the international community to act. This notion or principle of “common concern” can apply in some senses to all the planet’s inhabitants: since we are all interdependent. To do so is to avoid the “human chauvinism” that sees the Earth and non-humans as at human disposal. This is not to suggest that human and non-human interests always coincide, any more than that those of individual nations fully coincide on all issues, or that those of individuals do. Rather the point is, that there are some things where there is common interest and the state of the planet and its inhabitants and the rules that govern these is one.

In the international arena, the United Nations, its charter and its organisations are one crucial part of the landscape. Institutional arrangements for governance are mostly focussed on a variety of problem-based, use-based, regional or sectoral (e.g. fishing, mining, pollution control, maritime transport, science, meteorology, biodiversity) agreements. Since the environment is affected by a range of human activities, it may not be enough to manage these impacts through individual agreements and governing bodies. Some agreements are either dated and fail to incorporate ecosystem-based management principles or are ill-suited to considering a wider range of issues than was envisaged when they were negotiated.

Environmental and resource management regimes increasingly recognize that the ecological, cultural, social and economic aspects of problems must all be faced – and that institutional forms and arrangements both reflect and distribute power. These have a significant influence on how decisions are made and their outcomes. Technological changes obviously can transform uses, harvesting and monitoring and enforcement – be these at sea or on land.

Enthusiasm for new arrangements must be tempered by knowledge that the process of setting up any new agreement and its administering body is contentious, laborious, time consuming and may run the risk of unravelling what has previously been agreed. The expression of aspirations for the future and for control of humanity’s powers to harm have to wrestle with national and sectional self-interest, and a status quo in the international realm, and frequently also natural jurisdictions, with inadequate and sometimes inept or powerless controls. The achievement of controls is obviously prey to bargaining holdouts, defections and slack, negligent or corrupt implementation.

The Public Choice school of economic thought has enlivened us to the potential failure of governments and also to the potential for regulator capture by the economic

interests of those agencies that are set up to manage resources and the environment as agents for the wider community. This should not lead us to abandon fisheries and marine management but rather to take great care in the institutional design for governance and management and the criteria that are applied in making governance and management decisions.

Inadequacies of current arrangements, however, are not hard to find and integration of management of human uses and impacts is strongly needed. In considering principles and criteria for the management and control of human impacts on the deep sea, it is worth bearing in mind that these could be applied to either a new agreement and governance regime or to the operations and decisions of the existing patchwork of agencies and decision making, if the existing gaps or deficiencies can be bridged, remedied or tolerated. Further, international decisions and agreements on the environment and resource management must, like all other environmental impacts management systems, face up to the distributional and ethical content of decisions.

2. SOURCES OF HUMAN IMPACTS ON THE DEEP SEA

There is a wide range of human uses of, and impacts on, the deep sea – but some of these, such as climate change, already have their own international agreements (e.g. the United Nations Framework Convention on Climate Change and the Kyoto Protocol). Impacts on the marine environment and biodiversity include those from fishing, legal or illegal, direct impacts of fishing gear on the benthos, bycatch and incidental mortality and ghost fishing from lost fishing gear. Regional fishing agreements provide some basis for the regulation of fishing but there is extensive illegal, unregulated and, or, unreported fishing. Subsidisation of fleets intensifies these pressures and will need to be considered in both economic and environmental forums.

Mining and prospecting on the high seas are managed under the auspices of the International Seabed Authority and has its own set of effects on the environment. The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP 1990) estimated that 80 percent of marine pollution comes from the land and fresh water systems. Plastic debris and other pollutants remain of considerable concern (Gregory 1998).

Bioprospecting remains largely unregulated, both within many EEZs and in the high seas. It is already clear from work on seamounts that they have high levels of species endemism, even allowing for the paucity of information on the distribution of species (Koslow and Gowlett-Holmes 1998). Electricity generation, military activities, dumping and pollution all may have adverse environmental impacts. Dumping and pollution are already addressed by the international community, but the impact of military activity is the subject of resistance to controls.

3. EXISTING GOVERNANCE ARRANGEMENTS

3.1 Sources of principles and criteria for governance and impacts management

Principles and criteria for both the process and content of international agreements on the governance of the deep sea can be gleaned from previous precedents and agreements, from existing and emerging international law, from disciplinary theory and experience. Useful insights can be gained from the international literature and disciplines of public policy and governance theory, ethics, economics, law, institutional and organisation theory, and environmental and resource management theory and practice.

3.2 Hard and soft international law

Sources of international law relevant to the deep sea include: the Charter of the United Nations and UN General Assembly Resolutions; the UN Environment Programme;

UNESCO and various scientific agreements and obligations; The UN Food and Agriculture Organization and particularly the Code of Conduct on Responsible Fisheries. Central to deep-sea management is the 1982 UN Convention on Law of the Sea, the derivative 1994 Implementing Agreement relating to Part XI relating to the issue of deep-seabed mining and the 1995 Agreement on the Implementation of the Provisions of the Law of the Sea Convention Regarding Straddling Fish Stocks and Highly Migratory Fish Stocks (referred to in this paper as the Fish Stocks Agreement).

The LOSC makes the high seas a global commons and guarantees rights carried over from the 1958 Convention on the Territorial Sea and the Contiguous Zone and the 1958 Convention on the High Seas. The high seas are not “open access”. The LOSC confers certain freedoms: of navigation, of overflight and laying of cables and pipelines, of fishing, of the creation of artificial islands and of scientific research (Art 87). None of these rights is untrammelled. All are subject to the unqualified obligation on states to “preserve and protect the marine environment” (Art 192), (rights to exploit are conditional on such protection (Art 193)), the obligation to observe the reservation of the high seas for peace and to the obligation of benefit sharing. It is not necessary that the benefits be financial. The UN Convention on the Law of the Sea is now understood to be both treaty law and, through widespread adoption and implementation, also to have become customary international law.

The 1992 UN Conference on Environment and Development (UNCED) set in place a consensus on important principles of sustainable development, captured by the Agenda 21 statement and the Rio Declaration. The international community underscored the significance of biodiversity protection in the 1992 Convention on Biodiversity (CBD) and subsequent elaborations. The 1992 Framework Convention on Climate Change and the derivative Kyoto Protocol, which though not yet in effect, represents clear international concern at anthropogenic greenhouse gas emissions and commitment to action, albeit with notable exceptions.

The World Conservation Union (IUCN) to which a substantial number of governments belong provides an interesting model of governance where both governments and civil society interact, with the common cause of conservation. IUCN has 76 state members, 114 government agencies, and non-governmental organizations, both national (735) and international (77). IUCN’s statutes together with its mission, objectives, goals, resolutions and recommendations provides a set of processes and policies that have wide acceptance and form reference points for many governments. IUCN has often been the development ground for international environmental law, including the Convention on Biodiversity. IUCN has commissions who contribute expertise – from both government and non-government bases. Four-yearly World Conservation Congresses allow for examination and discussion of issues and for dialogue between the governmental and non-governmental organizations – which is supported intersessionally by regional and national committees.

MARPOL, the London Convention and other pollution control agreements and treaties serve a duty of care, to avoid harm to the environment, to cooperate in addressing risks and environmental harms. The precautionary principle and the polluter pays principles are also part of these agreements.

Core principles of regard for the environment for its intrinsic qualities rather than simply to satisfy human values underpin a range of domestic and international agreements, including the Antarctic Treaty and the Madrid Environmental Protocol. Peace, science and forbearance for the sake of the future and security underpin the Antarctic Treaty System (ATS) including the Antarctic Treaty (1961), the Convention on the Conservation of Antarctic Marine Living Resources 1981 (CCAMLR), and the 1991 Madrid Protocol to the Antarctic Treaty on Environmental Protection. The Antarctic Treaty set in place a system of governance over a vast area of territory

where humans are late-comers and where human control and sovereignty are not only contested internally but externally to the Treaty. The Antarctic Treaty made clear the primacy of peace and science. CCAMLR established the first ecosystem-based marine management regime.

Initially, the ATS faced a crisis of legitimacy during the 1980s when an apparent “rich countries’ club” seemed set to divide property rights to minerals among the powerful and opinion-leading nations. That crisis of legitimacy was only resolved when the ATS abandoned the Antarctic minerals regime negotiated from 1982-88 in favour of the Madrid Protocol on environmental protection and its various annexes. CCAMLR, however, now faces its own crisis: as some member countries prove unwilling to confront each other effectively about IUU fishing and diplomatic considerations triumph over good resource and environmental management. Widespread IUU fishing by vessels and nationals of countries in CCAMLR and some non-members, mean that the tragedy of poor access controls is being all too vividly played out.

The need for future-regarding policies and actions and the need to observe the limits and carrying capacity of the environment to withstand human impacts are to be found, elaborated and developed in the successive international agreements or declarations in the Stockholm Declaration 1972, the World Charter for Nature 1982, Agenda 21, the Rio Declaration of 1992 and the World Summit on Sustainable Development 2002. Equity in sharing benefits, both present and future, are also embedded in these agreements, but, as with the LOSC, it is clear that protection of the environment is regarded as a binding constraint and any use made of the environment and resources is contingent on respect for the future and for ecological processes.

The FAO Code of Conduct on Responsible Fishing (FAO 1995) and the associated International Plans of Action (IPOAs) on the Management of Fishing Capacity, Shark Fisheries and Incidental Catch of Seabirds in Longline Fisheries are an important set of management considerations (FAO 1998). The Code provides principles and standards applicable to the conservation, management and development of all fisheries. It also covers the capture, processing and trade of fish and fishery products, fishing operations, aquaculture, fisheries research and the integration of fisheries into coastal area management.

Sands (1995) notes the priority accorded to the conservation of biodiversity and “the protection of oceans and seas (including coastal areas) and marine living resources” by the 1992 UN Conference on Environment and Development. This priority was reinforced by both the 1992 Convention on Biodiversity and by the World Summit on Sustainable Development 2002 (Articles 30 to 34 and 36). These include the following summary of relevant articles:

- 30. (b) Promote the implementation of chapter 17 of Agenda 21;
- (d) Encourage the application by 2010 of the ecosystem approach
- (e) Promote ocean policies and mechanisms on integrated coastal management;
- 31. To achieve sustainable fisheries, the following actions are required at all levels:
 - (a) Maintain or restore stocks to levels that can produce the maximum sustainable yield with the aim of achieving these goals for depleted stocks on an urgent basis and where possible not later than 2015;
 - (b) implement the relevant United Nations and associated regional fisheries agreements
 - (c) Implement the 1995 Code of Conduct for Responsible Fisheries
 - (d) Urgently develop and implement International Plan of Action for the Management of Fishing Capacity by 2005 and the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing by 2004.
- 32 (a) Maintain the productivity and biodiversity of important and vulnerable marine and coastal areas

- (c) Develop and facilitate the ecosystem approach, the elimination of destructive fishing practices, the establishment of marine protected areas including representative networks by 2012;
33. Advance implementation of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities and the Montreal Declaration on the Protection of the Marine Environment from Land-based Activities
34. Enhance maritime safety and protection of the marine environment from pollution by actions at all levels to...
36. Improve the scientific understanding and assessment of marine and coastal ecosystems as a fundamental basis for sound decision-making.

4. PRINCIPLES FROM INTERNATIONAL LAW

Sands (1995) canvasses a wide range of sources of international law and agreements and identifies and documents principles of international environmental law as including:

- “a) the obligation reflected in Principle 21 of the Stockholm Declaration and Principle 2 of the Rio Declaration, namely that states have sovereignty over their natural resources and the responsibility not to cause environmental damage;
- b) the principle of preventative action;
- c) the principle of good neighbourliness and international co-operation;
- d) the principle of sustainable development;
- e) the precautionary principle;
- f) the polluter-pays principle; and
- g) the principle of common but differentiated responsibility.”

He notes that the obligation not to cause environmental damage applies both within national territories and jurisdictions and to areas beyond national jurisdiction and that this obligation is extensively reproduced and reaffirmed. Other principles of international law include freedom of the high seas, common heritage, peaceful settlement of disputes, principles of international co-operation and prior informed consent.

5. PRINCIPLES OF GOOD GOVERNANCE

Graham, Amos and Plumtre (2003) articulate five good principles of governance, derived from UNDP principles of good governance (1997), which they present as follows:

The five good governance principles	The UNDP Principles on which they are based
1 Legitimacy and Voice	<ul style="list-style-type: none"> • Participation • Consensus orientation
2 Direction	<ul style="list-style-type: none"> • Strategic vision, including human development and historical, cultural and social complexities
3 Performance	<ul style="list-style-type: none"> • Responsiveness of institutions and processes to stakeholders • Effectiveness and efficiency
4 Accountability	<ul style="list-style-type: none"> • Accountability to the public and to institutional stakeholders • Transparency
5 Fairness	<ul style="list-style-type: none"> • Equity • Rule of Law

Much, but not all, of their grouping and elaboration of principles is adaptable to the deep sea.

6. THE LISBON PRINCIPLES FOR SUSTAINABLE GOVERNANCE OF THE OCEANS 1997 AND RELATED IDEAS

The Lisbon Principles for Sustainable Governance of the Oceans (Soares 1998) are relevant to the governance and management of the High Seas. These, reported by Costanza *et al.* (1998), include:

- Responsibility – access to environmental resources carries responsibilities relating to environment, society and efficiency, including non-depletion and fairness.
- The spatial scale and time frames of management and governance must match those best suited for sustainability, with capacity to straddle both generations and nations.
- Precaution in decision making is required when there is uncertainty.
- Responsiveness to changed circumstances, understanding and insights is required by decision makers to enable adaptive management.
- Full costs and benefits from natural resource use should be reflected in prices.
- Participation of all stakeholders is important in the development and implementation of decisions regarding the environment and resources and
- The incentives of consumers and private operators must be realigned to those of society.

Rayner (1999), in discussing the implementation of the Lisbon principles, makes several useful points. In examining diversity in the management of uncertainty and coordination he notes the need to overcome two major challenges, (a) to act under uncertainty, natural and human-induced and (b), to coordinate between and within agencies and jurisdictions. He also notes that while the notion of efficiency is well defined it is not universally valued but there is more consensus on efficiency than with the principles of equity for which there is no consensus. In adapting Young's (1993) approaches for making fair allocations of resource (proportionality, priority and parity) he suggests that the components of proportionality, encompassing contribution, seniority and need are such that they should be determined by administrative allocations made by an adjudicating authority.

Priority, by contrast, is an allocative principle achieved by competition, in time or in right – as now applies in open access fishing or in much water allocation. Parity is the third distributional principle: this is equal shares to each claimant. Young uses the example of proportionality and parity combined, to explain claims for Asian countries to take more on the grounds that their larger populations are more dependent on seafood protein. Principles of responsibility and consent apply both to nations and to operators – responsibility extends to liability for damage, a measure that may also achieve efficiency in internalizing costs.

Rayner (1999) suggests that because the notion of fairness is contested and without consensus, we should recognize the need for fair institutions and rules of process and contest. He points out that the LOSC essentially already goes some way to make some entitlements and obligations clear. Concentrating on fair rules for contest allows varying values to be considered in resolving contests, focussing on achieving joint action even when principles of equity are in dispute.

The work of Ostrom, (1990), Ostrom, Gardner and Walker (1994), Ostrom *et al.* (2002) has examined the capacity and criteria for communities to manage resources. Ostrom's work allows us to judge from the situational, societal and resource variables perspective that for success in common pool resource management the deep sea does not qualify for a hands-off, no-government management. There is no local community of people. There is significant conflict over objectives, there is great difficulty in monitoring and there is significant scope for unobserved poaching.

Bakker (2004) canvasses good governance principles for water management, and suggests that good governance builds on principles that create objectives and policies (in Graham, Amos and Plumtre's 2003 terms); and are accountable, responsive and

adaptive and require good information. He notes that governance processes must be open, transparent and facilitate participation of stakeholders, be effective and efficient and respect the rule of law.

7. PRINCIPLES FROM PUBLIC POLICY

The extensive public policy literature documents a number of common principles or criteria for management and governance (Hogwood and Gunn 1984, Quade 1989, Weimer and Vining 1989). These note that public policy and governance should reflect the following.

- i. *Effective.* This requires appropriate problem definitions, diligence, the choice of the right data, analysis, instruments, institutions forms and structures, monitoring, enforcement and adaptation. The weak point of CCAMLR in trying to contain IUU fishing is the unwillingness of states to speak bluntly to each other and the unwillingness of some states to discipline their nationals, vessels and traders for engagement in IUU fishing. In the deep sea, one part of the solution to this is to provide for a standing pool of professional observers, inspectors and regulators to avoid national diplomatic considerations that usually inhibit multilateral agencies from confronting IUU fishers and poachers. A second part of the solution is provision for third party standing (such as NGOs) in regulatory agencies deliberations and for taking action in national and international courts and tribunals. This is one means of making for more transparent, frank and less compromised decision making.
- ii. *Transparency of documentation.* This is essential for good public policy. Real-time reporting by electronic means, which are verifiable, is a further essential element to achieving effective monitoring. In this, technology advances are on the side of effective monitoring and reporting. Commercial secrecy must take second place to verifiable reporting so that poaching and other such activity is not provided with a cloak to hide behind. Flags of convenience are the bane of the international system – the world community must tackle these and find ways of removing the shelter that they provide to wrong-doers.
- iii. *Accountable to the principals.* In the case of the deep sea, the principles are the whole of humankind, non-humans conceived as the whole ecosystem or ecosphere, and the future.
- iv. *Transparent and participative.* There are both intrinsic and instrumental reasons for direct access to decision-making processes by civil society. Intrinsic arguments focus on the rights of civil society to engage with governmental processes as part of democratic underpinnings of governance and accountability of governance (Webler and Renn 1995). Instrumental arguments suggest that civil society and NGOs enable access to expertise, information and insights not necessarily available to states or multilateral agencies. They may also bring a willingness to break collusive silences when there is state or multilateral malpractice or sloppiness of monitoring and compliance or enforcement. Inclusion of the public and transparent processes militate against corruption and slackness, enhance the quality and legitimacy of decisions and the willingness of those who have to comply (Webler and Renn 1995).
- v. *Clearly defined processes, open to all governments and to non-governmental actors.* The institutions of any new agreement must be representative of the world community, and in their activities, open to input from the public and stakeholders. Disclosures must be made in a timely fashion. Participatory processes require not only putative opportunities for input but assistance to non-commercial interests to have input. Otherwise decision making will inevitably be dominated by vested interests. Such assistance should be provided by the competent authorities as part of the budget for governance arrangements.

- vi. *Fair and non-discrimination.* Like must be treated alike (the principle of horizontal equity), though unlike may, following the principle of vertical equity, be treated differently from each other in order to secure equal opportunity. Fairness applies to both process and outcomes and has an intertemporal dimension.
- vii. *Protective of the interests of the future.* Temporal nepotism should not be allowed so that the interests of the present do not dominate the interests of the future. This is particularly relevant when there are activities in the deep sea, such as trawling, that can destroy biota hundreds or thousands of years old, such as reef corals or long-lived fish.
- viii. *Use good information and make timely decisions.* Deferring decisions in the pursuit of perfect information may prevent otherwise good outcomes.
- ix. *Recognize risk, uncertainty and ignorance and manage with learning and adaptability.* This would factor in reviews and opportunities for adjustment. Capricious change is to be avoided, but certainty cannot be guaranteed and may transfer risk to others or the environment.
- x. *The precautionary principle should apply.*
- xi. *Abide by the rule of law and principles of sound administration.* This includes international law.

8. ECONOMIC PRINCIPLES

There are many economic principles relevant to governance and management. These are:

- i. *Agents to act in the interests of the principals.* The commons is held in trust for all, and as such should be administered for all, not principally for the miners, fishers or bio-prospectors who wish to exploit or extract resources.
- ii. *Principle of control of access.* Economic analysis suggests that it is not possible to achieve efficiency with open access¹. One of the purposes of an agreement for the management of human activities and impacts in the deep sea is to define access rules and permits and to make clear how natural capital is to be maintained, what impacts are unacceptable and which may be tolerated under which circumstances (Prugh 1995).
- iii. *Principles of efficiency.* Environmental management should aim at achieving efficiency, both static and dynamic (over time), but there is an unresolved debate over appropriate discount rates. Since discount rates are important influences of resource exploitation. This will require consideration of inter-temporal ethics.
- iv. *Principle of recognition of all costs and benefits.* The principle of efficiency requires recognition of all services, goods, ecological and bio-geophysical functions of the marine environment, including the value of the marine environment *in situ*. It is not efficient to disregard impacts on the environment or the future.
- v. *Discount rate divergence and the public good nature of environmental protection and conservation requires mechanisms for collective choice.* Long-lived, slow growing ecosystems and their biota are likely to be at risk from discount rate driven 'impatience'. Private and social discount rates may well diverge. If society prefers to retain ecosystems, mechanisms to restrain private impatience are required. The aspects of the marine environment that are recognized and valued by different players as important may also be strikingly different, so mechanisms for collective choice must be designed.

¹ Garrett Hardin's *Tragedy of the Commons* is now believed by many as having mis-diagnosed the problem as being of the commons when the problem is in fact poorly specified or inadequately enforced access controls. See, e.g. Bromley (1991).

- vi. *Full internalization of costs.* Principles of economic efficiency (and equity) also require that full costs are faced by those who cause environmental harm, and that there is full internalisation of management and scarcity (i.e. resource rental) costs. This should not however extend to control by those who pay the costs of management decisions.
- vii. *Realignment of private incentives to public incentives.* Economic influences, such as incentives to externalize costs, to free load or to operate according to discount rates that exceed those that society deems just, must be recognized and controlled so that incentives are re-aligned by smart interventions that achieve social goals cost effectively.
- viii. *The principle of defence of non-market values with rules.* Principles, criteria, institutions and rules for allocations of access to the deep sea are required to align private incentives with the interests of society and the future. Creation of markets within these rules is possible, but there can be no efficient allocation through markets in the absence of such rules because of the complexity of bio-geophysical systems and natural capital, the multiplicity of ecological functions and the physical or ethical non-substitutability of financial capital for natural capital.
- ix. *Independence of governance from capture.* Good governance principles identified by the Public Choice school of economics and by various theories of good governance from political science and economy stress that governance should not be captured by vested interests. This principle suggests that governance of human activities and impacts on the deep sea should not become the primary province of those who wish to exploit it.

This is not to say that there should not be opportunities for input by stakeholders into decisions by the management agency or agencies – but care must be taken to resist proposals, often founded on notions of reducing difficulties of compliance, that those doing the harvesting should have dominant control over resource management decisions. Such proposals are often founded on situations of management where there is only one use – such as harvest. Where there are management objectives with multiple values at stake, including *in situ* uses and values and foot-loose harvesters with few ties that bind, as may occur in the deep sea, then self-management approaches are unlikely to work well.

- x. *Total economic value.* Instrumental arguments for the value of bio-geophysical and other services and goods from the environment have built on the work of ecologists, oceanographers, climatologists and others. Attempts by ecological and environmental economists to provide monetary valuations of these ecological services and other benefits to humans are controversial and varied (see for instance Ecological Economics Vol 25, No 1 April 1988). Many of these attempts are designed to express the wide range of non-consumptive values attached to these uses of the environment. These are known to economists as “Total Economic Value” (TEV). The calculation of TEV can offend some by its reductionist approach that obscures interdependencies and commodification of the environment. It is commonly done to stress to decision makers the legitimacy and significance of the non-market values of services and goods from the environment and the ecological functions.
- xi. *Cost effectiveness.* Considerations of distributive policy within the rules defined and imposed by ethical effectiveness should minimize all costs, including environmental and transactions costs.
- xii. *Acceptance and compliance.* Governance arrangements in international affairs have to be agreed to by states of varying power who in turn have to be capable of influencing and binding players who can exert considerable skill and resources to thwart controls. Agreements have to be achieved within the realities of power.

Arrangements to promote compliance include real-time monitoring, participation in rule formation and effective sanctions.

xiii. Funding mechanisms not to undercut effectiveness and fairness. Effective monitoring, compliance and enforcement measures are needed and these must be funded in ways that do not undercut effectiveness, fairness and accountability.

xiv. Adequate funding as a pre-requisite to access to resources. Any agreements to open areas to fishing or other biodiversity-impacting activities could be contingent on resource rental payments to suitable authorities or governments with some of this revenue used to cover the cost of management and research, to assist public engagement in decision making, for enforcement and for sharing of other revenues for poverty alleviation. Funding must, in the first instance, be by participating governments who may recover some costs from extractive and other commercial users (eg energy generators) and others who cause harm or undertake activities that must be managed. Disbursement of funds, however, must be undertaken and administered independently of sources of revenue, but with consultation with all stakeholders.

New Zealand's Quota Management System has demonstrated the danger that those who manage fisheries will come to regard harvesters as more important than society and its values for whom the Ministry of Fisheries is supposed to be the agent (Wallace 1998, 1999). An international agency or agency would have to have a clear governance regime in which those with non-extractive interests were represented, given voice, part of decision making and seen as having legitimacy. In New Zealand this attitude of legitimization of fishing industry control has become encapsulated in the slogan of "user pays, so user says" (Wallace 1998). Institutional arrangements to prevent industry capture of management and enforcement need to ensure that user-pays funding does not provide a short route to industry capture of management and governance.

xv. The principle of mutual assurance of restraint. Restraint in harvesting, mining and the provision of environmental protection and conservation benefit all, but like other public goods, are subject to free-loading. Commitments by both states and operators and other measures are needed to provide "mutual assurance" that all will play their part in achieving forbearance, enforcement of harvesting limits, and protecting the environment.

xvi. Principle of good information, reliable real-time reporting. Nations and multilateral agencies need good real-time monitoring, real-time verification of vessel locations, harvesting activities, product verification and unloading using technologies that are not subject to falsification.

xvii. Principle of enforcement and effective "credible threats". Since there are many incentives to break rules, "credible threats" are required to poachers or other IUU activity to deter and penalize non-compliance.

9. FAIRNESS PRINCIPLES

9.1 Distributive principles

This is a particularly difficult set of principles on which to achieve agreement, especially for principles for intragenerational equity. Rules of process and participation distribute power and so may remove distributive gains and losses. We need to bear in mind Rayner's advice not to try to solve these issues down to the last details, but to devise fair processes for future contests. The LOSC, the Convention on Biodiversity and other instruments already embody both principles and rules.

9.2 Future regarding principles

Provision for the future is the subject of a considerable literature, much of it underpinning the concept of sustainable development. Domestic and international

instruments frequently include the formulation of the World Commission on Environment and Development (WCED 1987): that “Sustainable development is development that meets the needs of present without compromising the ability of future generations to meet their own needs.” Principle 3 of the Rio Declaration states that “the right of development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations”. The WCED formulation has the great merit of wide international acceptance, but the reference to “future generations” can lead to both narrow anthropocentrism and to sterile arguments as to what constitutes a future generation (D’Amato 1990, Brown Weiss 1990).

Edith Brown Weiss’s principles were developed using four criteria:

- i. The general acceptability of principles across time, culture and economic and political systems.
- ii. There must be equity among generations both in terms of using up resources and in terms of providing for future generations.
- iii. Independence – we should not have to predict values (preferences) of future generations
- iv. Clarity – they must be clear to apply.

Weiss came up with three principles that fulfil these criteria:

- i. *Conservation of Options*. Each generation should conserve the diversity of the natural and cultural resource base to preserve options for tastes, values and problem solving of future generations, and because of the entitlement of the future to diversity.
- ii. *Conservation of Quality*. Each generation has the entitlement to receive the planet in no worse condition than that received by the preceding generation.
- iii. *Conservation of Access*. Each generation must ensure that its members have equality of access to the legacy of the past, and equal responsibility to the future. (This is essentially an intra-generational fairness requirement).

These principles constrain action but do not dictate them.

Lothar Gündling (1990) suggests that these obligations to the future imply:

- i. The obligation to pursue a preventative (precautionary) policy regarding possible harm to the environment.
- ii. The obligation to reduce environmental pollution [in our context any form of environmental harm, including invasive species] to a minimum.
- iii. The obligation to develop technologies that do not harm the environment. This suggests the need to reconsider some of the most damaging technologies such as bottom trawling.

Taking a different tack, provision for the future can be separated into “needs to have” and “needs to be free from”. The former includes intact ecosystems, future supplies of food and resilient and productive ecosystems capable of continuing with ecological and biophysical systems intact. Preserving opportunities implies that irreversible, long term or significant damage would be unacceptable.

It often helps too to examine the “freedoms from”. High in this list is likely to feature invasive species, pollution and depletion of biodiversity and other environmental damage.

10. ENVIRONMENTAL AND NATURAL RESOURCE MANAGEMENT PRINCIPLES

10.1 Sustainability, natural capital and ecosystem-based management

To be sustainable resource use must maintain ecosystem functions, bio-geophysical systems and natural capital must not be significantly depleted, degraded or polluted. Environmental and resource management must extend to ecosystem-based management, i.e. avoidance of environmental impacts and where possible remedy and mitigation.

Ethical obligations including those for the future imply rules both within the framework of the constitution of any governing body and incorporated into subsequent decision rules.

The need to limit impacts and stress on the environment should be part of any constitution and agreement. Decision theoretic approaches that map out potential scenarios and decision rules in the case of a variety of situations with the capacity for rapid response should form part of measures to cope with uncertainty. Ecological sustainability and commitment to the future requires recognition of the importance of “natural capital” and the non-substitutability of ecosystem services and other services from the environment by human-made capital. Thus, the principle of avoidance of environmental harm and maintaining stocks and ecosystem processes should become core principles of management.

10.2 Ecosystem-based management is required

Ecosystems, such as the deep seas, are part of the biosphere and are not capable of being managed successfully in a reductionist way, i.e. one that fails to value ecosystem functions. A necessary but insufficient condition for this is that individual stocks are maintained in healthy abundance and distribution. Ecosystems must be maintained and so biodiversity in its full range and function. Where harm or depletion occurs, and be the charge to those responsible, the value of any losses of natural capital from human uses and impacts should be assessed and sheeted home to those who cause damage or depletion in order that externalities are internalized.

10.3 Principles of information sufficiency, impacts assessment

Both environmental and natural resource management practices in many domestic jurisdictions and international regimes require some form of information sufficiency test and impacts assessment. We can identify a principal of information sufficiency such that an activity cannot proceed in the absence of data. An example is the CCAMLR requirement of “No data, no fish” – where fisheries were closed if necessary data was unavailable (CCAMLR 1990, 1991). However, formulations for use of the “best available data” while worthy, may allow delay while the question of whether the data are the “best” is contested, as CCAMLR has experienced.

The Principle of Impacts Assessment is related to the information sufficiency test and requires that any use of the environment requires prior assessment of the environment and the impacts of the activity. This requires consideration of cumulative effects as well as the specific proposed use or activity. The Antarctic Environmental Protocol, CCAMLR and many domestic environmental and resource management regimes require such assessments.

10.4 Duty to consider alternatives

It is common in modern environmental management to consider alternatives, both for proposed uses or activities and for proposed control measures. Part of considering alternatives is strategic environmental assessment and sustainability analysis. Both are part of modern environmental and resource management (Thérivel and Partidário 1996).

10.5 Scale matching

Human activities and impacts occur at several scales, which management must match, but more particularly, management also needs to match the scales of the ecotypes and populations of the environment and the areas of impacts. Thus, environmental management must “fit” the scale of the environment and the human geography.

10.6 The principle of closed until opened

This principle implies that there is an access regime in place, rather than there being open access. Unacceptable impacts mean there should be no activity and access is closed unless opened. The onus of proof is on the proponent operator, their state or agents to show no harm will occur or there is a sufficiently low risk of harm. This provides incentives to reduce harm. Such processes of decision making must be open and transparent.

10.7 Principles for governance and management design for risk management, learning and adjustment

The design of management and governance must recognize the multiple sources of uncertainty, ignorance and risk, with their companion requirements of caution, learning, review and adjustment of institutions, control decisions, entitlements and duties. Uncertainty, ignorance and risk require recognition of the possibility of change, of design defects in institutions and that things may go wrong. These require design for adjustability, which is also needed as the world, knowledge and, values change. Monitoring must be effective, verifiable, and subject to evaluation and effective response.

Decision scenarios and rules or trigger points developed in advance with agreed reference bases and prior agreed processes provide rules that facilitate agreement. Such prior rules hasten rapid reactions and responsiveness without sacrificing inputs from interested parties and fair process. Provisions must, however, remain for dealing with unforeseen outcomes. One of the implications is that management instruments should not hinder non-capricious adjustments of controls. Given the apparent optimism of many deepwater fishery managers, being able to correct errors for over-optimism and resist pressures from vested interests is crucial. Privatisation of the rights of access may make this more difficult.

10.8 Precautionary principle

The precautionary principle is now widely recognized as an important part of environmental and resource management where there are complex ecological systems, inventive humans with incentives to beat regulations, ignorance of ecosystem relationships and human impacts and uncertainty about how people will respond to regulatory and other controls. The precautionary principle recognizes the need for learning and the need to change, as more information becomes available. It has a range of expressions, but in essence implies that, in the presence of uncertainty, authorities should avoid actions with the potential for significant or irreversible harm, should adopt an information sufficiency principle and should not allow the absence of definitive proof to delay taking action that may be needed to protect the environment.

10.9 Recognition of legitimacy of a wide range of uses, interests and values

Caddy (1999) defines the “wide use” approach to marine and fisheries management as that which recognizes both the non-commercial and non-extractive uses and values of marine creatures and their environments, as well as the commercial uses. Within national jurisdictions this is reflected in participatory environmental and resource management. It includes those who value the many *in situ* functions and uses of marine organisms and structures and their part in ecosystems. Ecosystem-based management is designed to recognize that marine organisms and structures are part of ecosystems and that they have ecosystem functions. Fishing and other harvesting have a range of consequences within ecosystems and their biotic and abiotic components and systems and hence the concern to control these impacts.

11. PRINCIPLES AND CRITERIA FOR GOVERNANCE AND MANAGEMENT OF THE DEEP SEA – WAYS FORWARD

11.1 Definitions

The broad definition of “good governance” of UNDP (1997) further developed by Graham, Amoz and Pluntre (2003) is used here to develop and organize the applications of the principles to the deep sea. These are legitimacy and voice, direction, performance, accountability and fairness.

11.2 Legitimacy and voice

Governing bodies must provide for input from representatives of the full range of consumptive and non-consumptive values and uses. Non-market uses and values attached to the deep sea must be considered. As affirmed by Agenda 21 and national and international practice, public participatory processes can add quality, legitimacy and accountability to governance, including multilateral governance. Participation should also be accepted as a democratic right.

11.3 Direction

Sustainability is already a well-established and accepted objective for management of the commons. Much direction has already been established with the LOSC, the Convention on Biodiversity, the World Summit on Sustainable Development and the UN General Assembly resolutions in relation to ocean management. Principles that apply include:

- Strong sustainability with no loss of natural capital, i.e. harvesting must not damage natural processes or diminish the carrying capacity of the deep sea.
- Responsibility to avoid significant environmental harm, to develop non-destructive technologies (e.g. to avoid trawling) and to manage on appropriate scales and time frames.
- A precautionary approach and responsiveness to new information and changed circumstances when there may be adverse consequences for the environment.
- Effectiveness and efficiency, including the recognition of all sources of value and all kinds of costs.
- Realignment of private and social incentives to avoid the otherwise dominant incentives to over-exploit and to externalize costs.

11.4 Fairness

Fairness requires equity and the rule of law. Equity refers to both process and outcomes and relates to participation and intra-generational and inter-generational fairness. Developed and developing countries, commercial and non-commercial stakeholders require unequal treatment to provide equal opportunities. “Leveling the playing field” requires assistance to those such as environmental non-governmental organisations (ENGOS) and other disadvantaged parties. This should be funded from contributions from those who impose or seek to impose impacts, possibly from resource rents. This provides “voice” to those otherwise unable to participate.

Allocation rules are highly problematic. They could follow the Rawlsian maximin principle² (Rawls 1971), or inverse allocation to the stock already taken, or damage done. There will be pressure for “side payments” to induce compliance. This arrangement violates the polluter, depleter and degrader pays principles, which should apply but is sometimes required to achieve agreement. Those whose actions generate the need for management ought to pay the costs of that management – without capturing management – is a related principle.

² The maximin principle is that of improving (or maximizing) the position of the worst off in society).

The interests and needs of the future must be protected, following Brown-Weiss (1990), to preserve environmental quality, access and options. Gündling's (1990) operationalizing of these principles translates them into the following obligations

- i. the obligation to pursue a preventative (precautionary) policy regarding the environment
- ii. the obligation to reduce environmental pollution to a minimum
- iii. the obligation to develop technologies that do not harm the environment and
- iv. strong sustainability - the principle of management that natural capital must be protected.

11.5 Compliance with international law and obligations

The rule of law requires compliance with international law and obligations.

11.6 Performance

'Performance' requires the application of a range of criteria and principles that apply to institutions, and to the environmental and resource management they undertake. Governance and management arrangements should be effective, transparent and diligently enforced.

Institutions should be representative, transparent, accountable and effective. Any resource use should be subject to scrutiny and assessment for environmental impact and information sufficiency. Institutions need to be capable of taking necessary action and imposing rules to provide incentives for compliance and innovation while allowing for sanctions and other controls. Effectiveness requires decision systems and processes sufficiently encompassing to achieve buy-in of states to participate and for them in turn to be committed to effectively controlling their nationals and vessels.

Areas should be closed to activities unless explicitly opened. The onus of proof should be on the proponent to realign incentives to reduce harm. This requires assessment of effects prior to deciding whether to allow an activity in a particular area. A precondition for opening some areas to activities should include setting aside protected areas as a hedge against mistakes and management failures, which can be expected. Marine reserves and other protected areas are required to guard against endemic management failures. A significant percentages of each ecotype, in the order of 20-40 percent should be required as no-take marine reserves. Pauly and Mclean (2003) recommend there be at least 20 percent but work by Lauk *et al.* (1998) suggests that, as a precautionary fisheries management measure, about 50 percent of a fishery area should be protected.

Movement from open-access fishing and other largely uncontrolled activities such as bioprospecting will require mutual assurance and the pressure of public opinion and enlightened states and probably some demonstration of the medium and longer term benefits.

Governance and management arrangements must be designed with the expectation that future changes will be made. Recognition of risks and provision for adjustment – whether to institutional rules or to actual levels of exploitation – are needed. Sensible and environmentally responsible investment must not be treated to capricious expropriation or change, but neither should it be immune from necessary change because the environment, or resources themselves have changed, or that our understandings of the changes have grown. Privatisation of rights should be avoided since these are virtually impossible to reverse.

The spatial dimension to management and ecosystem-based management are two of the major changes that ecosystem protection will require. However, this should not be construed as a recipe for spatial property rights, since property rights regimes do not ensure the protection of slow-growing biota or the consideration of non-market values. Environmental management measures require environmental

assessment, impact assessment, requirements for demonstration of the ability to avoid adverse environmental effects and commitments to meeting certain standards and environmental performance targets.

Effectiveness of management of human activities and impacts in the deep sea require limits on the degree of extraction and their impacts, with reference points that have agreed rules such that they can be triggered when conditions require. Pauly and Maclean (2003) recommend a drastic reduction of fishing effort by three to four fold in most areas of the oceans. This will require forbearance and mutual assurance. Information and advice from all parties would likely strengthen decision making so long as default settings pending an agreement were precautionary so that there were no incentives to unnecessarily extend negotiations.

If access to a fishing area is closed unless opened by due process, then there will be a greater incentive for fishers and others to find means of fishing or other activities that have low impacts. For example, trawling and dredging are destructive to the sea floor and benthic communities. If such impacts are deemed unacceptable, then different methods such as using long lines with suitable controls on setting, bait types, times and areas could replace more damaging methods.

Independence from vested interests for management and environmental assessments is an important part of the principle of independence of management. Decision processes that allow for research and other expertise commissioned independently of extractive users or their governmental champions would be a guard against undue influence of managers on scientists to modify their advice. The separation of the payment for fisheries access or environmental management from commissioning of researchers, impact assessment and auditing is an important element of this. Such research should be funded by the industry through resource rentals but not commissioned by them. Peer reviews by other industry-independent experts and open public discussions with all interested parties would provide both insights and some check against possible industry capture of the management process.

Provision of standing for NGOs and others in the dispute resolution procedures of the agency or agencies with responsibility will allow civil society to take action in the event that nations of the responsible multilateral agencies are slow or reluctant to act. Processes to trigger pre-ordained or negotiated quick responses when adverse indicators of environmental or stock health showed should be available to non-governmental and governmental environmental agencies as a check against unresponsive agencies that hesitate on account of diplomatic paralysis or industry pressure.

Human activities and impacts have both immediate and cumulative effects. Management must be organized along scales of various sizes to match the spatial, ecological and physical effects of activities – but these management regimes need to recognize political and economic institutions too. Thus broad environmental management plans must match ecotype scales and those of the activities and their impacts.

12. SUMMARY OF PRINCIPLES AND CRITERIA

Using the Graham, Amos and Plumtre (2003) framework derived from that used by the UNDP, the principles and criteria and some of the measures these imply can be summarized as follows:

• Legitimacy and Voice	Public and stakeholder participation Consensus to open areas or allow activities Accessibility of decision making to all countries and to NGOs Regard for the future Non-capture by vested interests Conservation of options, quality and access
• Direction	All utilization to be sustainable Preservation of natural capital including environmental processes Responsibility to avoid environmental harm and take preventative action Responsibility to cooperate to avoid environmental harm and deleterious resource impacts Non-hinderance of needed environmental protection Precautionary approach Polluter, degrader and depleter pays Maintenance of freedom of navigation Equitable access for use and benefit "Wide use" approach
• Performance	Ecosystem-based management of human impacts and access Effective management and maintenance of natural capital: diligence, use of accurate data, analysis, instruments, institutions, rules, adaptation, monitoring, reporting and enforcement Precautionary management Informed decision making with sufficient information Responsiveness of institutions and decision making to new information, knowledge and conditions Adaptable management with reference points and previously agreed reference points, rules and parameters Efficiency – consideration of all costs and benefits, and all values Realignment of incentives including the reversal of the onus of proof to demonstration of the probable safety of human activities Matching of the scale of management to the respective activity, effects and ecosystems Real time monitoring and verification not subject to false reporting. Standing professional observer team and inspectorate Management design that incorporates reviews, avoids hindering necessary change but also avoids capricious change. Removal of shields from accountability such as flags of convenience. Independence of management and research from control by vested interests. Avoidance of damaging technologies. Insurance measures, such as implementing marine protected areas over 20-40 percent of the marine area.
• Accountability	Responsible to the world community Transparency, timely disclosure and participative Open to third party dispute processes Accountability to the public and to institutional stakeholders Open to all Government and non-government interests
• Fairness and Equity	Maintenance of natural capital, including biodiversity, abundance, range, complexity, biophysical processes, habitat and structures Allocation of access on 'fair' principles (not 'grandparenting'): Liability for causing environmental harm Resource rentals Charging of application of the Rule of law – international and, if applicable, national Sharing of benefit Polluter, depleter and degrader pays principle Funding by governments with cost recovery for direct beneficiaries Full costs and benefits charged in market prices Internalisation of all costs

13. CONCLUSIONS

The survey of appropriate principles and criteria for governance and management of the deep sea is, as it must be, derived from principles already well established in international law and environmental and resource management practice. This survey marshalled these principles as a navigational aid for thinking about how the international community and national communities responsible for the management of human activities and impacts in and on the deep sea can tackle the large and sometimes “too hard” tasks that communities face. Important aspects of any management system for the deep sea should include principles and criteria relating to legitimacy and voice, accountability, direction, performance, fairness and equity. The argument that tackling the problems is too hard is no longer acceptable: if human activities in the deep sea are allowed, then there must be recognition of the complex environment impacts and economic incentives that prevail. Allowing activity requires control of activity. That in turn requires fair, effective and accessible institutions that have the confidence of both nations and civil society and the competence and will to take effective action.

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Subsidies and deep-sea fisheries management: policy issues and challenges¹

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1. INTRODUCTION

The issues of fisheries subsidies and the depletion of deep-sea fisheries have become increasingly prominent in international policy discussions in recent years. Deep-sea fisheries began to increase in importance in the 1970s, coinciding with declines in shallow-water fisheries and the extension of the Exclusive Economic Zone to 200 nautical miles under the UN Convention on the Law of the Sea. Improvements in technology in terms of larger vessels and more robust fishing gear helped expand the ability of fleets to exploit deep-sea resources. It is estimated that around 40 percent of the world's trawling grounds are now in waters deeper than the continental shelves (Roberts 2002, p. 242). In its latest report on the state of world fisheries, the FAO reported that world catches of oceanic species had reached almost 8.5 million tonnes in 2000, just under 10 percent of the production from marine capture fisheries (FAO 2002, pp. 13-14)².

The phenomenon of sequential stock depletions, particularly with respect to orange roughy and more recently Patagonian toothfish, has focussed attention on the relative fragility of deep-sea fisheries and has led to calls for improved management of these resources. In releasing its latest report on deep-sea fisheries, the International Council for the Exploration of the Sea (ICES) warned that "several deep-sea stocks are now heavily exploited and in some cases severely depleted" and "suggested that there should be an immediate reduction of fishing pressure on fully exploited or overexploited deep-sea stocks" (ICES 2003b). Non-governmental organisations, such as the World Wide Fund for Nature, have also highlighted the need to protect deep-sea stocks and there have been calls for the increased use of marine protected areas to protect deep-sea fish resources and the associated marine environment (WWF 2003).

Fisheries subsidies reform has also been at the forefront of recent international developments, particularly with respect to the links to overcapacity and high-seas fishing. At its Fourth Ministerial Conference in Doha, Qatar, in November 2001, the World Trade Organization (WTO) undertook to "clarify and improve WTO disciplines on fisheries subsidies, taking into account the importance of this sector to developing countries" (WTO 2001b, para. 28). This was followed at the World Summit on Sustainable Development in Johannesburg by a call to "eliminate subsidies that

¹ The views expressed in this paper are those of the author and do not necessarily represent the views of the OECD Committee for Fisheries or the Member countries of the OECD.

² This covers epipelagic and deep water species that occur principally on the high seas. The FAO notes that some of these species, particularly the oceanic tunas, are also caught within EEZs and hence the figure for high-seas fish catches may be overstated to some (unknown) extent.

contribute to illegal, unreported and unregulated fishing and to over-capacity, while completing the efforts undertaken at the WTO to clarify and improve its disciplines on fisheries subsidies ..." (United Nations 2002, para. 30(f)). Discussions are continuing in the WTO Negotiating Group on Rules on how to proceed on addressing the mandate provided in the Doha Declaration³. Work on analysing the effects of fisheries subsidies is underway in other inter-governmental organisations, including the OECD, the FAO and UNEP. The need to take action on fisheries subsidies has also been strongly supported by environmental groups (e.g. WWF 2002a, b).

The linkages between subsidies to the fisheries sector and deep-sea fisheries exploitation are addressed in this paper. The main conclusion reached here is that the bioeconomic and management characteristics of deep-sea fisheries make them particularly vulnerable to overexploitation, even in the absence of subsidies to the fisheries sector. The provision of subsidies will increase the expected net returns from fishing and lead to increased pressure on stocks. However, the impact of subsidies will depend very much on the management arrangements in place for the particular fisheries, particularly the type of management regime, whether management controls (such as total allowable catches or effort) are correct and the effectiveness of enforcement. In the absence of effective management, subsidy removal, which may be justified on economic grounds, will not necessarily result in reduced fishing pressure on deep-sea stocks.

Data on the types and amounts of subsidies in OECD countries for the period 1996-2000 are presented to provide some background on the size and composition of subsidies. The bio-economic and management characteristics of deep-sea fisheries are then discussed. The economic and environmental effects of subsidies under various types of management arrangements are outlined and the implications for deep-sea fisheries discussed. Finally, some of the major challenges for subsidy reform and the improved management of deep-sea fisheries are addressed.

2. SUBSIDIES TO THE FISHERIES SECTOR IN OECD COUNTRIES

The last few years has seen a great deal of effort devoted to defining fisheries subsidies and developing frameworks for categorising and measuring subsidies. This has occurred in a range of forums and has resulted in a variety of definitions and classification frameworks. Porter (2002) provides a review of the various classification schemes that have been used by the OECD, APEC and the United States. The FAO has undertaken a number of expert consultations which addressed, among other things, the issue of what constitutes a fishery subsidy (FAO 2000, 2003a). Long debates over subsidy definitions are common to many other sectors where subsidy discussions are underway (Steenblik 2003).

According to some experts, subsidies should be broadly defined and could include all government actions – including the absence of correcting interventions – that potentially can affect (positively or negatively) the benefits of firms active in the fishery sector, in the short or the long run (FAO 2001, pp. 4-5). However, this does not appear to be a useful operational definition as it includes the full range of management actions that could possibly be applied to the fisheries sector and also requires some judgements to be made about the extent to which these actions deviate from what is perceived as "optimal".

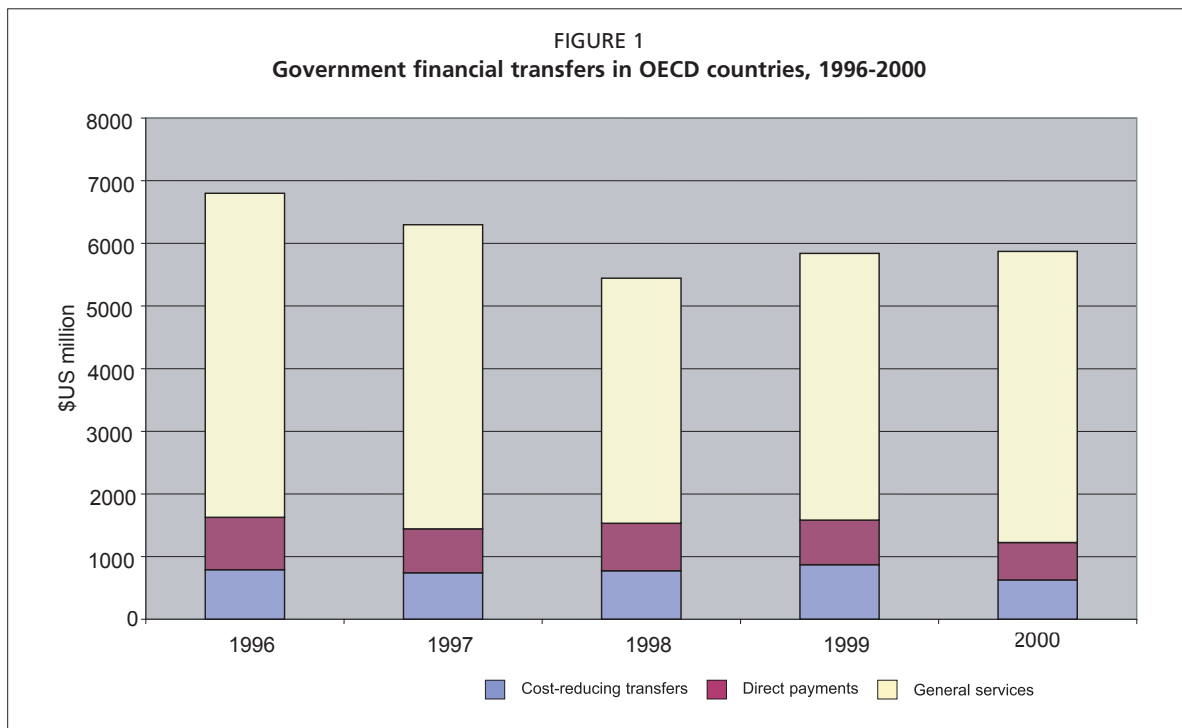
It seems more tractable to employ a narrower definition of subsidy, which covers the direct transfers made by governments to support the fishery sector (such as grants, direct payments, etc.), as well as the government programmes which are "off-budget" but which confer a direct monetary benefit (such as tax exemptions, loan guarantees,

³ Schrank (2003, pp. 43-7) provides a brief review of the evolution of the discussions within the WTO on fisheries subsidies.

insurance underwriting, etc.). This is the definition that was adopted by the OECD in its study, *Transition to Responsible Fisheries* (OECD 2000). Government financial transfers (GFTs) cover direct payments, cost-reducing transfers and payments for general services.⁴ Direct payments are transfers that enhance the revenue of recipients and are paid from government budgets (that is, financed by taxpayers) directly to fishers. Examples include price support payments to fishers, grants for new vessels, grants for modernisation, vessel decommissioning payments, buyouts of licences and permits, buyouts of quota and catch history, income support and unemployment insurance (see OECD 2000, p. 130 for a more detailed listing of subsidies included in each category).

Cost-reducing transfers are payments from the government to fishers that reduce the costs of fixed capital and variable inputs. In this regard, they are a revenue-enhancing transfer that may affect the operating decisions of fishers with respect to output or the levels and types of inputs employed. Examples include fuel tax exemptions, subsidized loans for vessel construction and modernisation, provision of bait services, loan guarantees, underwriting of insurance costs, interest rebates, transport subsidies and government payment of fees for access to other countries' waters.

General services is a catch-all category that covers transfers that are not received directly by fishers, but that reduce the costs faced by the sector as a whole. About half of this category includes expenditures on research, management and enforcement. General services also comprise expenditures by governments to support prices (for example, by withdrawing fish from markets) and expenditures on infrastructure that benefit the industry as a whole (in contrast with cost-reducing transfers that benefit individual fishers directly). Examples of the latter include stock enhancement schemes and investments in fishing ports.



⁴ A category of market price support was also included in the classification that covers gross transfers from consumers and taxpayers to fishers arising from policy measures (normally trade measures) creating a gap between domestic market prices and border prices of specific commodities. Market price support was not estimated for the *Transition to Responsible Fisheries* study due to technical and data difficulties. However, OECD (2003a, p. 18) provided an approximate value of market price support at \$US 1 thousand million a year based on tariff revenue data for fish and fish products.

TABLE 1
Government Financial Transfers and Production, OECD Countries, 2000 (preliminary)

	Direct Payments (A) \$US million	Cost Reducing Transfers (B) \$ USmillion	General Services (C) \$ US million	Total Transfers (D) \$ US million	Total Landed Value (TL) \$ US million	GFTs as % of total landings %
Australia	..	56	26	82	1,011	8
Canada	209	69	230	476	1,418	34
European Union	295	322	278	895	6,255	14
Belgium	6	..	..	6	82	7
Denmark	6	..	2	8	404	2
Finland	0	4	7	11	21	53
France	60	9	98	167	952	18
Germany	1	8	..	9	150	6
Greece	18	15	30	62	233	27
Ireland	..	..	..	..	..	..
Italy	93	7	51	151	1,422	11
Netherlands ¹	0	..	..	0	446	0
Portugal	2	..	24	26	252	10
Spain	109	132	46	287	1,355	21
Sweden	1	2	18	21	106	20
United Kingdom	..	4	1	5	833	1
Iceland	..	16	26	31	735	4
Japan	19	37	2,807	2,864	12,021	24
Korea	34	68	214	316	3,667	9
Mexico	..	..	..	..	1,044	..
New Zealand 2	..	..	27	15	..	..
Norway	2	18	85	105	1,112	9
Poland	..	..	..	..	91	..
Turkey	..	..	0	0	..	..
United States of America 3	67	14	952	1,032	3,638	28
OECD Total	625	600	4,647	5,816	30,992	19

..: not available; 0 refers to data between 0 and 0.5.

¹ Turnover Dutch fisheries estimate.

² Total transfers are net of the amount of cost recovery.

³ Includes an estimate of market price support (that is, transfers from consumers to producers). Source:

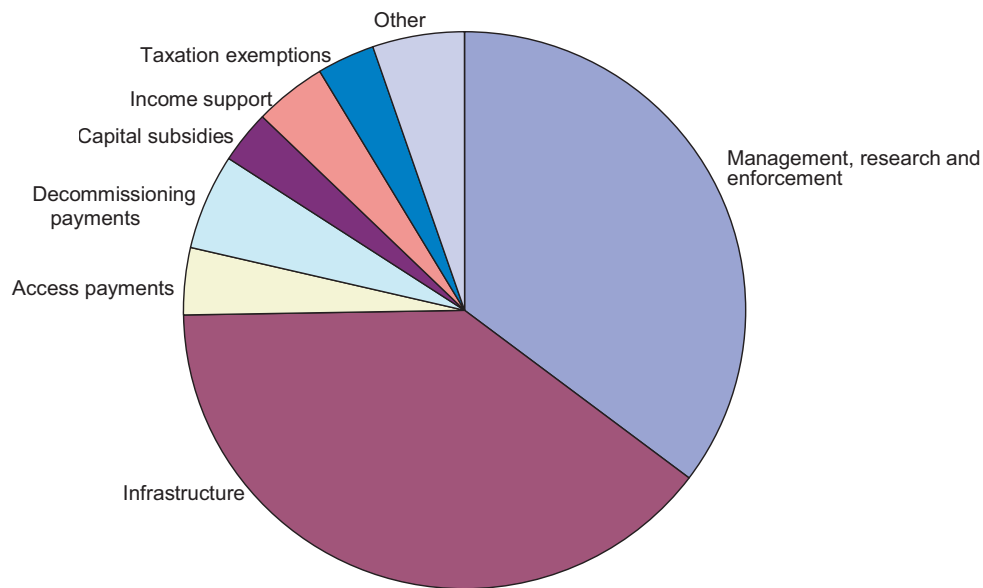
GFTs in OECD countries have fluctuated over the period 1996 to 2000 (Figure 1). From a level of around \$US 6.8 thousand million in 1996, GFTs declined to around \$US 5.5 thousand million in 1998 before increasing to be close to \$US 6 thousand million in 2000 (all in nominal terms).⁵ It was noted in OECD (2000) that the estimated total is probably too low as it does not include significant support items by some countries such as tax concessions, non-payment of fishing port berthing fees, support to builders of fishing vessels and regional and local government expenditures in many countries. The value of GFTs as a percentage of the gross value of production has remained relatively steady at around 18-19 percent over the period. Table 1 provides details of GFTs by country for each of the categories for 2000.

The main uses of transfers in OECD countries are for providing fisheries infrastructure, ensuring the sustainable use of fish stocks, dealing with fishery adjustment pressures, modernising fleets and acquiring access to fisheries in other countries' waters. The largest component of GFTs is for general services, which accounted for 76 percent of total GFTs in 1996 and 71 percent of the total in 2000 (Figure 1). Research, management and enforcement expenditures account for around half of the expenditure on general services and for approximately 30 percent of the total GFTs in each year (Figure 2). The bulk of the rest of general services expenditure is devoted to the provision of fisheries infrastructure (including support for construction of port facilities for commercial fishers). Expenditures on direct payments and cost-reducing transfers account for between four – six percent of the gross value of fisheries production. These expenditures consist mostly of payments for vessel modernisation, vessel building, decommissioning of vessels, licence retirement, income support and unemployment insurance.

⁵ Note that there are some data gaps for some countries over the period, particularly for 1998 and 1999.

Inclusion of the data for the omitted countries could be expected to add around \$US 120 million and \$US 150 million to the totals in 1998 and 1999, respectively.

FIGURE 2
OECD GFTs by Programme Objective, 1997



It is not possible, based on the data available at this stage, to identify or quantify the subsidy programmes that are provided to operators in deep-sea fisheries or that will have a direct or indirect effect on deep-sea fisheries. However, it is clear that some types of subsidies are more likely to have an impact than others. For example, subsidies to vessel construction and modernisation have long been recognized as having contributed to the existing over-capacity in the world's fishing fleet. As fishing opportunities in national exclusive economic zones (EEZs) have declined as a result of overfishing and improved management (reducing the fishing capacity needed in the EEZs), the excess capacity has shifted to the high seas and other EEZs in search of new fishing opportunities. This often meant a shift to deep-sea stocks. Indeed, in some cases, this shift was supported by governments in an effort to assist the transition of fishers out of overexploited fisheries (Haedrich, Merrett and O'Dea 2001). Similarly, subsidies supporting exploratory fishing in the deep-seas or research into the development of improved fishing gear and technology are likely to have an effect on deep-sea fish resources. However, further research is required at the level of national subsidy programmes in order to identify those subsidies that may affect deep-sea resources either directly or indirectly.

3. BIOECONOMIC AND MANAGEMENT CHARACTERISTICS OF DEEP-SEA FISHERIES

3.1 Introduction

Deep-sea fisheries are relatively loosely defined from a biological perspective. In general, deep-sea fisheries are defined as fisheries carried out in waters deeper than around 400-500 m (ICES 2003a, Koslow *et al.* 2000). Stock assessments for deep-sea stocks are mostly undertaken according to species in geographically defined areas. Prominent species often mentioned in relation to deep-sea fisheries include orange roughy, Greenland halibut, pelagic armourhead, Patagonian toothfish and blue grenadier. In brief, deep-sea species are generally characterized as having a slow growth

rate, being long-lived and having low fecundity (Gordon 2001). They also tend to aggregate around ocean banks and seamounts. Orange roughy, for example, live up to 125 years, reaching maturity and a reproductive age at around 20-25 years (Koslow *et al.* 2000). Other species, such as sablefish, which populate the slopes and open seafloor, tend to be not quite so long-lived (50-60 years), mature earlier at around 5-10 years but are also slow-growing. The slow growth of deep-sea species is largely explained by the low levels of food in the ocean depths that they inhabit.

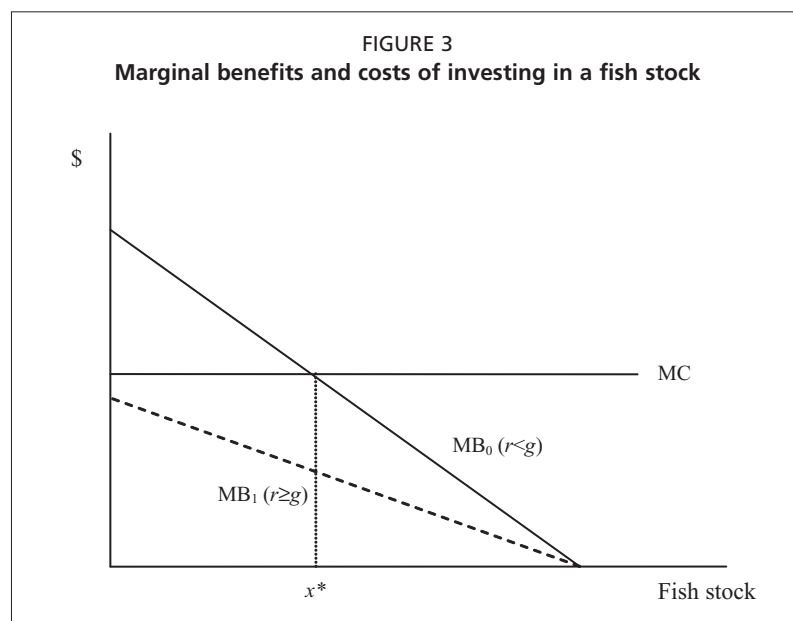
From an economic perspective, the characteristics of deep-sea fisheries (slow growth, low productivity, etc.) mean that they are particularly vulnerable to overexploitation. This can be demonstrated using some basic results from fisheries economics, particularly that based on capital theory, and a simple model of a fishery is provided in the appendix to this paper to illustrate the key points. There are five aspects to the deep-sea fisheries problem that are particularly relevant to the economic dimension:

- the low natural growth rate combined with constant harvesting costs
- a divergence between private and social rates of time preference
- high initial catches in deep-sea fisheries
- high capital costs and excess fishing capacity and
- management arrangements for deep-sea fisheries.

3.2 Low natural growth rates and constant harvesting costs

One of the basic results from the economics of renewable resources employing capital-theoretic models provides a key insight as to the vulnerability of deep-sea species (see Clark 1990, pp.59-62). Where the low natural growth rate of a fish stock is less than the discount rate and the costs of harvesting are constant, it is optimal for a single owner of the stock to extract the resource sooner rather than later and to invest the proceeds in other assets. By viewing the fish stock as an asset that can be drawn down (through fishing) or increased (by refraining from fishing), the owner has the option to invest in the fisheries asset or in some other asset depending on the rates of return available for the different forms of assets. As is demonstrated in the Appendix, the efficiency condition for allocating capital between alternative uses, such as between the fish stock and some other investment (for example, a bank), is that the rate of return on the two investments should be equal at the margin. The fish stock yields a rate of return determined by the biological production function, the alternative asset (money) yields the interest rate. If the rate of interest is greater than the intrinsic growth rate of the stock, then the size of the optimal fish stock is zero — the stock should be fished out and the proceeds invested in the alternative asset which will provide a greater rate of return.

This is illustrated in Figure 3, which depicts the marginal benefits and costs of investing in a fishery. The ordinate represents the size of the fish stock while the abscissa represents marginal benefits and costs in monetary terms. The marginal benefit of investing in the fish stock (MB_0) is downward sloping since the marginal benefit derived from holding an



additional unit of stock will decline as the stock gets larger. If the interest rate (r) is lower than the intrinsic growth rate (g) and if there is a constant cost of harvest (MC), then the optimal stock size will be x^* where the marginal benefit and marginal cost of investing in the fishery are equal. If the interest rate is equal to or higher than the intrinsic growth rate, then the marginal benefit curve will rotate downwards to MB_1 and the optimum size of the fish stock will be zero.

This result rests on two key assumptions. First, it assumes that there is a sole owner of the fish stock. This is equivalent to having the government manage the stock and providing fishers with perfectly enforceable property rights to exploit the stock. Second, the assumption of a constant harvest cost is consistent with fish stocks that exhibit schooling behaviour or have spawning aggregations, as is the case for many deep-sea species (Koslow *et al.* 2000, Gordon 2001). In these cases, the catch per unit of effort is largely independent of the level of the fish stock; the area occupied by the fish stock contracts to a smaller volume as the stock declines, with the result that the stock retains its density. This characteristic of deep-sea species is one of the reasons that serial depletion of stocks is observed and highlights the particular vulnerability of the stocks.⁶

It is worth noting that the same result can occur when there are high prices for the target species in the marketplace. This is currently the case for Patagonian toothfish. A high price will increase the marginal cost of investing in the fish stock and could increase the pressure on the stock. However, the story is more complex than may first appear; many deep-sea species do not have ready-made markets (as they are often relatively unknown to retailers and consumers) and so some effort has to be put into developing new markets for particular species. This can be a risky undertaking, and fishers' expectations about the success of future marketing ventures need to be taken into account when analysing the effects of price expectations on their decisions to exploit new fish stocks.

3.3 Divergence between social and private rates of time preference

While there are circumstances where it may be economically optimal to fish down a stock to extinction, it is not necessarily optimal to do so from society's perspective. Indeed, the effort being put into addressing the world's fishery problems by governments suggests that they do not seem to embrace the concept of optimal extinction. In Figure 3 above, it was assumed that the interest rate reflected the social rate of time preference and there was no divergence between the way that individual fishers or companies and society as a whole viewed the future. However, there are a range of reasons why the social rate of time preference may be lower than the private rate of time preference.

First, private agents tend to be myopic in the face of uncertainty and so will greatly discount benefits that might accrue in the future. We can see this in the case of those high-seas fisheries where there are no entry restrictions or property rights in place, which would reduce the incentives to "race to fish". There is no incentive for fishers to invest in conserving the stock as they are unlikely to reap the benefits. Second, the attitude of private fishers to risk is likely to differ from that of society as society is better able to pool and spread risk. Third, there is more than just the fish stock at stake. Deep-sea fisheries occur in areas of high biodiversity, which are also relatively fragile (Roberts 2002; Koslow *et al.* 2000). Fishing imposes external costs in the form of impacts on other species and on the ecosystem that are not taken into account by fishers. It is natural to assume that society would take a longer term view on these

⁶ The analysis does not change significantly when the assumption of constant harvesting costs is relaxed. If harvesting costs are stock-size dependent, the MC schedule will be upward sloping. It will, however, no longer be economically optimal to fish the stock out as the cost of extracting the last fish would be prohibitive. This may not be the case, though, where stocks exhibit critical depensation as it is possible that extinction may occur if the optimal stock level is sufficiently small.

external costs, on the existence values attached to species and ecosystems, and on the needs of future generations who accordingly have a lower rate of time preference than private agents.

As a result of these factors, it is likely to be the case that the private discount rate will be higher than the social discount rate. This can be reflected in Figure 3 by interpreting MB_0 as the marginal benefit schedule corresponding to the social discount rate and MB_1 as that reflecting the discount rate of private fishers. So what is optimal from a social perspective (x^*) may not necessarily be optimal from a private perspective. This divergence between private and social discount rates is a common justification for government intervention to ensure that the intertemporal allocation of goods and services reflects social as well as private preferences (Weimer and Vining 1992). Admittedly, this issue arises in a range of policy areas, not just in relation to deep-sea fisheries. However, the bioeconomic characteristics of deep-sea species (especially their low growth rate) means that they are likely to be particularly vulnerable to this problem.

3.4 High initial catches

A reasonably common feature of deep-sea fisheries is the high catches that are obtained in the initial phases of fishing activity. Preliminary surveys reveal large stocks and high yields may be realized during the development and fishing-down phases of the fishery, but then drop off quickly as the older, reproductive age classes are removed from the fishery (Roberts 2002; Haedrich, Merrett and O'Dea 2001). The slow growth and low natural mortality lead to an exceptionally low productivity for many deep-sea species. For example, the sustainable yield for orange roughy has been estimated at only about one – two percent of the virgin biomass, yet the catches have been significantly higher than this level in almost all orange roughy fisheries to date, at least in the initial stages of the fisheries (Clark 2001).

In the absence of entry restrictions to a developing deep-sea fishery, the high initial catches and high expected profits will attract additional effort to the fishery. To the extent that fishing fleets are able to shift operations around the world at relatively short notice, the news of a potentially profitable developing fishery can set off a “race to fish”. The speed and degree of fishers’ responses will depend on how easily they can transfer gear (boats, nets, etc) from other fisheries to the developing fishery, the cost of such transfer and the rapidity with which new entrants can learn about the distribution of the fish stock and any new fishing techniques required. It will also depend on the restrictions that flag states impose on vessels flying their flag when undertaking fishing outside their EEZs.

3.5 High capital costs and excess fishing capacity

The speed and extent of new entrants in a developing deep-sea fishery will be influenced by the capital costs involved in developing capacity to increase effort and by the amount of idle capacity or latent effort that can be brought to bear on newly discovered fish stocks. Deep-sea fisheries tend to be more capital-intensive than fisheries on continental shelves. Larger vessels tend to be the norm for these fisheries, and the fishing gear, winches, navigation and fish-finding equipment and on-board storage facilities are more expensive and specialized than for vessels engaged in other fisheries. As a result, there may be some delay in new capacity being constructed and brought into a fishery, other things being equal.

However, other things are not always equal and are unlikely to be so given the current state of world fisheries where there has long been a widely acknowledged situation of excess capacity (FAO 1991, 2003). This excess capacity has a low, or zero, opportunity cost and so will only need to cover the variable costs of fishing operations in order to be encouraged to undertake fishing operations. It is also relatively mobile

and may have the ability to quickly respond to new fishing opportunities. Combined with the characteristics listed above, particularly with respect to low or constant harvesting costs, the pool of excess capacity places deep-sea fish stocks at an even greater risk of overexploitation.

3.6 Management arrangements for deep-sea fisheries

There are four possible jurisdictional arrangements for deep-sea fisheries. First, they may occur entirely within national EEZs. In this case, they would fall under the fisheries management regimes in place for other fisheries within EEZs. These regimes vary widely around the world, covering the spectrum from open access through to individual transferable quota (ITQ) schemes. OECD countries, for example, employ a range of management measures with an emphasis on catch and effort controls. Some countries employ market-based management instruments such as ITQ schemes (OECD 1997, 2003a).

Second, deep-sea resources may occur as transboundary stocks between adjoining EEZs or as straddling stocks between EEZs and the high seas. They may or may not be subject to management in these cases. Third, deep-sea fisheries could occur entirely outside EEZs, but may be under the control of a regional fisheries management organisation (RFMO). The FAO provides an inventory of regional fisheries bodies, which includes management bodies, advisory bodies and scientific bodies (FAO 2003b) and a number of these are heavily involved in managing and assessing deep-sea resources (including, for example, the North-East Atlantic Fisheries Commission and the Commission for the Conservation of Antarctic Marine Living Resources) or in providing scientific advice (such as ICES). Finally, deep-sea fish stocks may occur on the high seas and not be under the control of any RFMO.

It is not possible to determine precisely how many of the current deep-sea fisheries lie outside national EEZs, and fall into one of the last three categories of jurisdictional arrangements. However, it is expected that a high proportion of deep-sea fisheries lie in this latter group, primarily because the depth of water they occupy would place many of them outside EEZs. The management instruments used in this group are primarily effort-based, with some RFMOs also employing catch quotas. As is discussed in the next section, these instruments will affect the incentives facing fishers in the presence of fisheries subsidies. There are, of course, no restrictions on catch or effort in the case of purely high-seas fisheries.

These management characteristics make deep-sea fish stocks relatively more vulnerable to overexploitation for two reasons. First, it has been observed by a number of commentators that management often comes too late to many deep-sea fisheries, partly as a result of the inadequate knowledge base used to make decisions about allowable catches and effort. For example, Haedrich, Merrett and O'Dea (2001) remark that "assembling the data needed for conventional management will take a long time, in fact often far longer than a deep-water fishery may be expected to last." This is primarily a result of the relative slowness with which the effects of fishing pressure show up in catch data and the difficulty in developing adequate data to support models of population and growth dynamics. In addition, conducting sampling surveys in deep water is expensive and time-consuming. As a result, the science and underlying biology of many deep-sea species is not well understood, despite significant progress in recent years made through such groups as the ICES Working Group on Biology and Assessment of Deep-Sea Fisheries Resources (ICES 2003a).

A second feature of the management arrangements is that enforcement of regulations is difficult and costly due to the isolated nature of many of the fishing grounds. This relates to both the prevention of illegal fishing and to the enforcement of effort controls, catch quotas and regulations relating to discards and incidental catch. Enforcement has been a particular concern in fisheries such as that for Patagonian toothfish in the

Southern Ocean, where illegal, unregulated and unreported fishing has been a major problem in recent years (CCAMLR 2002). The expected net benefits from undertaking illegal fishing, taking into account the probability of detection and capture, are high in many cases. In addition, illegal fishers have a high discount rate and have no incentive to conserve stocks.

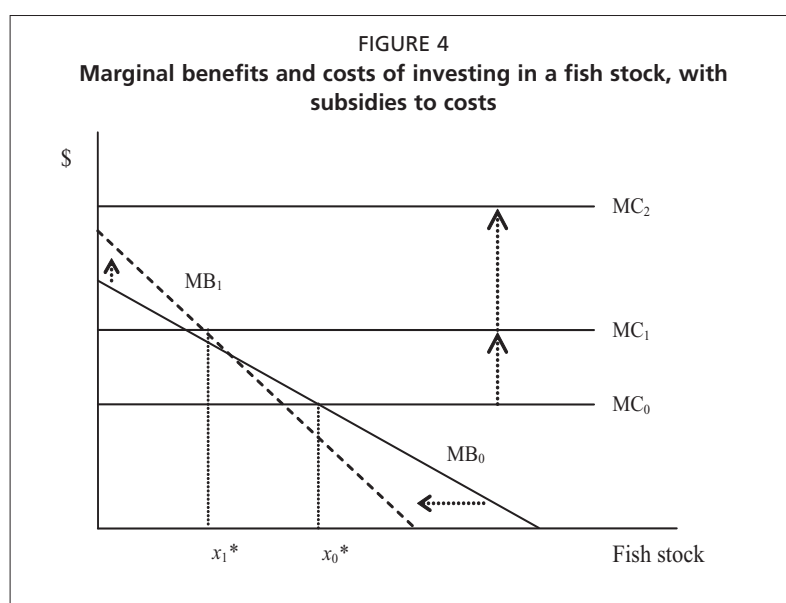
The result is that it is difficult to set appropriate management measures based on solid biological information for many of the deep-sea fisheries and to enforce them once set. This increases the vulnerability of deep-sea fish stocks to fishing pressure, even in the absence of subsidies. And, adding subsidies to the picture exacerbates the situation.

4. ECONOMIC AND ENVIRONMENTAL EFFECTS OF SUBSIDIES

The basic economic and environmental effects of subsidies are relatively straightforward and well-documented in the literature on fisheries, at least at the theoretical level (e.g. Arnason 1998). Relatively little empirical work has been done on the impacts of subsidies on sustainability, trade and economic growth, particularly when compared to other sectors such as agriculture (FAO 2000). At least part of the reason lies in the complex dynamic bio-economic interactions that need to be modelled in assessing the effects of subsidies on individual fisheries; this is not a trivial task and requires considerable data. Nevertheless, it is still possible to gain significant insights from a qualitative analysis of the effects of subsidies, which will help inform policy discussions.

In the absence of management measures to constrain entry, effort or catch in a fishery, the provision of subsidies will serve to increase profits in the short term. Subsidies to variable costs will reduce the costs of operations, subsidies to capital costs will reduce the costs of buying and upgrading vessels and gear, and subsidies to incomes of fishers (including price support) will increase revenues. All these effects, both singly or together, will initially increase profits and will attract increased effort to the fishery, either in the form of increased effort from existing fishers or from new entrants to the fishery. Over the longer term, these profits will be eroded as a result of falling catch-per-unit-of-effort, reflecting an increase in effort and a depletion of fish stocks. Hence the long-term economic effect of a subsidy on aggregate profits in the industry will be small, or non-existent if all the fishing operations were identical. Intra-marginal operators may experience increased profits if, for some reason, they enjoy a cost advantage over the marginal operator.

Building on Figure 3, the effects of subsidies on the stock investment problem can be easily illustrated. If the government provides a subsidy to costs, this will raise the marginal cost of investing in the stock from MC_0 to MC_1 (Figure 4). The difference between the price received by the fishers from an additional unit of fish and the cost of extracting that fish now rather than later is increased such that it reduces the incentive to constrain catch as the opportunity cost of the fish conserved today increases as a result of the subsidy. Because



the marginal benefits from investing in the stock also depend on the costs of harvesting, the provision of a subsidy will rotate the marginal benefit schedule (from MB_0 to MB_1 for example), although the equilibrium stock level will not be affected as the subsidy affects costs and benefits equally. Equating marginal benefits and marginal costs will then reduce the optimal stock size from x_0^* to x_1^* , with the magnitude of the final effect on stock depending on the slope of the marginal benefit schedule. If the subsidy is sufficiently large, the marginal cost of investing in the stock may increase to, say, MC_2 at which point it would be economically rational to fish the stock out. So it is readily apparent that, in the absence of management, the provision of subsidies will have an adverse impact on those fish stocks with the characteristics of deep-sea species — subsidies are likely to exacerbate their inherent vulnerability.

4.1 Interaction with fisheries management

Fisheries management will influence the effects of subsidies on important variables, including the status of fish stocks. The extent to which this occurs will depend on both the type of management regime in place and the effectiveness with which it is enforced. It is important to emphasize that any management regime is only as effective as its enforcement, so the theoretical advantages of one regime over another may not necessarily be realized if enforcement is lacking. Building on the framework developed in Hannesson (2001) and OECD (2003c) management regimes can be classified according to three key aspects:

- extent of catch controls
- extent of effort controls and
- existence of rights-based structures.

In fisheries managed by catch control, subsidies will not have an effect on fish stocks or catches of fish (by definition), provided that the catch is set at a sustainable (equilibrium) level and effectively enforced. If there is no control on fishing effort (through restrictions on the number of boats or how they are used), the higher profits initially caused by subsidies will lead to increased fishing effort in much the same way and for the same reasons as when there is open access. The erosion of profits in the longer term will be caused by increased competition for a given catch and less efficient use of capital. As a result, the marginal resource rents are still competed away.⁷

Effort controls primarily take the form of restrictions on the number of vessels that are allowed to operate in a fishery, the amount of time they are allowed to fish, restrictions on the fishing gear and techniques that may be used, or some combination of these factors. The provision of subsidies under effort controls will increase profits in the short term, as in the case of catch controls. Unlike catch controls, which have one dimension (amount of fish caught), there are many dimensions to fishing effort and it may be difficult for fisheries managers to identify and control all the variables that determine the effective effort that fishers can bring to bear on a fish stock.⁸ For example, effort regulations in a particular fishery may specify restrictions on boat size, engine power and days at sea, which still leaves scope for fishers to expand fishing effort

⁷ As noted in Hannesson (2001), the effect of subsidies on the actions of the fishers, and hence on the fish stocks, will also depend on whether the fish stock is initially under-exploited or over-exploited (i.e. whether fish stocks are above or below the level providing maximum sustainable yield. This distinction is particularly significant when considering the short term and long term effects of particular types of subsidies under different management regimes. However, for most subsidies under consideration, there is no difference in the long-term effects on fish stocks whether the stocks are initially under-fished or over-fished.

⁸ This does not mean that catch controls are without problems. Issues of discarding, bycatch and catch monitoring can be significant in catch-controlled fisheries. The critical point is the number of factors the fisheries manager has to assess and regulate in determining what is an appropriate level of fishing effort is increased by the multi-dimensional nature of fishing effort.

by increasing the use or effectiveness of other inputs such as labour and the amount or type of fishing gear.⁹ Vessel owners are likely to respond to the increased profits by expanding effort along uncontrolled dimensions, for example through investment in new and more efficient boats, through upgrading of existing boats, and by adding new gear or equipment to existing boats or using them more intensively. Over the longer-term, increased effort will erode resource rents and will reduce target fish stocks.

The addition of structures based on property rights to the use of catch and effort controls adds a further dimension to the available menu of management regimes. Property rights can be used in conjunction with either catch controls or effort controls, with the most common form of property right being individual quota rights (which may or may not be tradable). Rights-based regimes significantly alter the incentive structure facing fishers. They no longer have the incentive to race for fish as they can concentrate their efforts on catching their allowable catch in order to maximize profits. Nor do they have an incentive to increase the capacity and fishing power of their vessels beyond that which is needed to catch their allocation at minimum cost. With individual quotas the total catch will therefore be taken at a lower cost than with a race for the fish. Subsidies will raise the profits in the industry, which will raise the market value of the individual quotas if these are transferable. The quotas themselves would act as barriers to entry to the industry, as fishing would be impossible unless by having access to an individual quota, either by holding it directly, or by leasing it from somebody else (if such arrangements are permitted; in some countries the leasing of quotas is not permitted).

Individual rights can also be defined for fishing effort, although this is less common in practice. It is also problematic in terms of effective enforcement as the incentive to increase effort along uncontrolled dimensions remains; effort rights can generally only be defined along a limited number of dimensions (such as boat length, gross tonnage, days at sea, power, etc). The effects of subsidies in rights-based regimes will therefore be restricted to a transfer from taxpayers to the holders of the rights, with the value of the rights increasing as a result.

The long-term effects of subsidies under the different combinations of management parameters are summarized in Table 2. At this stage, it is important to note that the stylized analysis rests on a number of strong assumptions concerning the appropriateness of management controls and the effectiveness of monitoring and

TABLE 2
Summary of long-term effects of subsidies under alternative management parameters

Management regime				
Rights based		Not rights based		
Catch controls	Effort controls	Catch controls	Effort controls	No catch or effort controls
No effect on catch or stocks, if catch limits effectively enforced No effect on effort Higher value of fish quotas	No effect on stocks, if effort effectively controlled Higher value of effort quotas If effective effort increases, reduced stocks and reduced resource rent	No effect on catches or stocks, if catch limits effectively enforced Greater effort and more vessels Same or lower revenue Higher costs and lower industry profits Negative resource rent	No effect on effort or stocks, if effort effectively controlled Higher revenues Higher profits Incentive to expand effort along uncontrolled dimensions If effective effort expands, reduced stocks and reduced resource rent	Greater effort and more vessels Reduced stocks Negative resource rent Lower catch, lower revenue and higher costs if initially overfished Higher catch, higher revenue and higher costs if initially underfished

⁹ The problems of 'input stuffing' associated with effort regulations are highlighted in a number of studies, including Beddington and Rettig (1984) and OECD (1997).

enforcement. First, it is assumed that allowable catch and effort levels are set optimally with respect to the long term equilibrium of the fishery. Second, it is assumed that the management regimes are perfectly and effectively monitored and enforced. While these assumptions have facilitated the analysis undertaken to date, relaxation of some or all of these assumptions will increase the complexity of the analysis and may alter some of the conclusions. Relaxation may also assist in better explaining real world behaviour. For example, weak enforcement of catch limits in a fishery with or without property rights could mean that the effects of a subsidy on the environment are closer to those associated with open access.

As with most of the other literature on fisheries subsidies, the analysis in this paper necessarily abstracts from critical political economy aspects of the real world of subsidies and may mean that the effects of subsidies are likely to be less clear cut than the stylized analysis suggests. These aspects relate, among other things, to the power of interest groups to influence the outcomes of policy decisions and can be potentially significant for determining the outcomes of subsidy provision, both on the environment and in terms of economic and social outcomes. For example, under a catch control regime, the provision of transfers is likely to encourage lobbying for larger TACs, which are often decided in political forums (Hannesson 2001). They may also make monitoring and compliance more difficult, partly because industry has less of a stake in the health of the fish stocks and partly because the increasing participation in the industry will make it more difficult to monitor the total catch and ensure compliance of individual vessels. While this may also happen under systems with property rights, it is less likely to occur as the market value of quotas or fishing licenses depends on the long-term health of the stocks. In another example, the continued provision of subsidies for income support in a particular fishery may occur for largely political reasons even though the management of the fishery is not sufficiently well-designed or enforced to ensure the sustainability of the fish stocks. In such a case, political priorities, together with ineffective management, may represent one of the limiting obstacles to reform of subsidies regimes.

4.2 Classifying fisheries

So how do the stylized regimes depicted in Table 2 reflect fisheries in the real world, particularly deep-sea fisheries? As noted earlier, most OECD countries manage their fisheries with catch controls, effort controls and a combination of the two, with some countries employing rights-based regimes in some of their fisheries (mostly ITQs but with some examples of effort-based rights regimes). OECD (2003b) classified OECD countries into three broad groups according to whether the countries' fisheries management was based on predominantly output controls, predominantly input controls or a mixture of input and output controls. The study found that most of the OECD countries fell into the mixed input and output controls, with relatively few in the category of predominantly output controls. So it is difficult to make broad generalisations about the effects of subsidies in the various countries.

Turning to the case of deep-sea fisheries, it has already been observed that most of these fisheries will be subject either to no control or to control through an RFMO. For those fisheries that are not subject to control (that is, open access), the impact of subsidies will obviously be significant, particularly given their bioeconomic characteristics as discussed above. For those fisheries subject to management through regional organisations, it appears that some are managed through effort control and some through catch control. For example, most deep-water species in the regulatory area of the North-East Atlantic Fisheries Commission are managed on the basis on effort restrictions (aggregate power, aggregate tonnage, fishing days at sea or number of vessels), while redfish are managed according to limits on national catches (NEAFC 2002a, b). Stocks of Patagonian toothfish are managed by the Commission

for the Conservation of Antarctic Marine Living Resources on the basis of catch limits for countries who are party to the Convention. How the national allocations are then managed (for example through transferable quotas, etc) is the decision of the individual countries.

In the case of those deep-sea fisheries that fall under national jurisdiction, it seems that the predominant management measure is through effort control. For example, the effort restrictions applied from 1996 by the European Union in member states for some ICES areas were based upon thousands of kilowatts of engine power multiplied by the number of days at sea, differentiated by gear type (trawl or fixed) (Gordon 2001). Some countries use catch controls, such as Australia as in the case of Patagonian toothfish taken from its EEZ.

4.3 Implications for deep-sea fisheries

4.3.1 Effects of subsidies

Subsidies are highly likely to have an adverse effect on deep-sea fish stocks. By their very nature and location, these fisheries are mostly open access or are regulated under schemes which, in practice, tend not to reduce the incentives to increase effort when subsidies are provided to the industry (depending on the effectiveness of enforcement). The high initial catches associated with deep-sea fisheries mean that the effect of subsidies will be to further increase profits in the short term and may accelerate the process of new entry to the fishery. There are usually difficulties in imposing rights-based management regimes, which may reduce (but not eliminate) the underlying incentives to expand effort that exist in pure catch and effort control fisheries. Moreover, there are concerns over the effectiveness of enforcing regulations; lack of enforcement will exacerbate the effects of subsidies as fisheries are then closer to the open access end of the management spectrum and subsidies will have a greater impact on catches and stocks. In addition, IUU fishing in deep-sea fisheries will reduce the benefit to legitimate operators of “investing” in the stock through restraining effort.

Given the capital-intensive nature of most deep-sea fisheries, the relative mobility of fishing fleets and the low opportunity cost of vessels, subsidies that encourage the expansion of capacity, either within the particular fishery or more generally, are likely to be particularly significant for deep-sea fisheries. Three categories of subsidies are relevant in this context and worthy of closer examination: subsidies to vessel construction and modernisation; decommissioning payments; and subsidies to particular types of research.

4.3.2 Subsidies to vessel construction and modernisation

This category of subsidies has long been regarded as one of the contributors to the current situation of excess capacity in world fisheries. As discussed earlier, the increased profits from any subsidy can encourage additional effort into a fishery, even with catch and effort controls. The use of vessel construction subsidies is likely to exacerbate this effect by altering the relative prices of capital and other inputs (such as labour, fuel, etc.) and, in the absence of subsidies to these other inputs, will encourage a greater use of capital than would otherwise have been the case. Moreover, new vessels are generally able to bring more effective effort to bear on a fishery as they include improvements in technology and power. The case of subsidies to vessel modernisation is slightly different as the expansion of effort takes place through the upgrading of existing capital to improve capacity and so increase effective fishing effort, rather than through the creation of additional boats. However, while the number of vessels may not increase as a result of the subsidy, the effective effort that can be applied can increase within certain technical bounds.

In the medium to longer term, the excessive capitalisation in the sector that may result can place pressure on management authorities to relax catch limits (or not to tighten them if the fishery is overfished) to enable the individual boats to earn at least some revenue. In addition, there is also likely to be pressure to shift the excess capacity to other fishing grounds or to develop new fishing grounds, sometimes with the aid of government assistance. For example, a number of countries and country groupings assist their fleets by providing payments for access to other countries' waters or to undertake joint ventures. As these payments are not generally recouped from the fishers, they may be considered to comprise a subsidy. There are also cases where subsidies are provided to undertake exploratory fishing in order to develop new fishing grounds with at least partly the objective of soaking up excess capital.

4.3.3 Subsidies for vessel decommissioning

Subsidies for vessel decommissioning are often viewed as one mechanism for overcoming the excess capacity problem. In general, these subsidies are payments for permanent vessel withdrawal through buy-back programmes, permanent licence withdrawal and transfer of vessels to other fisheries (either domestically or internationally). It is one of the largest items of government financial transfers in OECD countries after expenditure on management, research, enforcement and infrastructure (Figure 2). The design and implementation of decommissioning and licence schemes varies significantly both between and within countries. For example, some countries require that decommissioning payments be tied to the physical scrapping of vessels while others allow vessels to be shifted to another fishery (in which case the payment is for the removal of capacity from a particular fishery rather than reducing the overall capacity in the country or globally). Other schemes are intended to remove latent capacity instead of capacity that is currently engaged in fishing.

There has been significant debate about the efficacy of many of these schemes in achieving their objectives both from an environmental and economic perspective (Arnason 1999, Holland, Gudmundsson and Gates 1999, Munro and Sumaila 1999). If there are no controls in place in a fishery, then such subsidies will have no effect on fish stocks as new vessels will enter the fishery to replace the scrapped vessels.¹⁰ If there are catch controls, the effect on fish stocks will be zero as, in the absence of barriers to entry, the vessels being decommissioned would be replaced by new vessels. If the fishery is initially over-fished, then the subsidies will have no effect on stocks unless the allowable catch is also reduced. Such a combination of policy changes would have the effect of reducing capacity, reducing catches and increasing stocks. In the case of rights-based regimes, the effects of vessel decommissioning schemes on fish stocks would be negligible. The owners of the quota or effort rights would primarily benefit from capacity leaving the fishery.

The provision of decommissioning subsidies also has an impact on the risk faced by fishers in their investment and production decisions. The existence of vessel and licence buy-back programmes can create expectations in the industry that the government will cover losses that may arise from excess investment in vessels, thereby reducing the risk-adjusted discount rate used in making investment decisions. Munro and Sumaila (2001, p. 25) conclude that subsidies used in vessel buyback schemes, if they come to be widely anticipated by industry, “can, and will, have a decidedly negative impact” on resource management and sustainability.

¹⁰ An exception to this may arise if the capacity of the fleet and the level of effort have expanded beyond the long term equilibrium level, but vessels are remaining in the fishery as revenues may still be sufficient to still cover their variable costs. In this case, decommissioning subsidies may assist in the adjustment to the long-term equilibrium.

4.3.4 Subsidies to research

Successful fisheries management plans must be based on knowledge about the fish stocks involved and the ecosystem in which they are embedded. The better the research the greater is the potential success of the fisheries management plan, although there are likely to be diminishing marginal returns to research at some point. In most countries, the government meets the costs of research while some countries, such as Australia and New Zealand, recover some of the costs of research from industry (OECD 2003b).

The government provision of research reduces industry costs as they would otherwise have to bear the costs themselves. A usual justification for the public provision of research is that it is a public good and that the benefits from the research flow beyond the fishing sector to the broader community. While this is true for many kinds of research (such as general research into ecosystem functioning, etc), it is not necessarily universally the case. Some forms of research may have a significant impact on the input costs of fishing operators. For example, research into improved gear technology, gear selectivity and so on is primarily directed at improving the productivity of fishing operations. Much of this research benefits the industry directly and it is not clear that the public good arguments usually associated with publicly funded research necessarily apply (Arnason and Sutinen 2003, Cox 2003). The extent to which research can be classed as a public good is therefore something of a grey area¹¹.

In the case of deep-sea fisheries, there is a strong justification for undertaking publicly-funded research into the basic biology and dynamics of the target fish stocks and supporting ecosystem. In the absence of government intervention, there is unlikely to be sufficient investment in research into these areas by the private sector. However, there appears to be less rationale for government support for research aimed at improving the productivity of fleets targeting deep-sea species, such as research into improved fish-finding technology, the refinement of gear for deep-water fishing and the exploration of new fishing grounds.

5. ISSUES FOR SUBSIDY REFORM AND THE MANAGEMENT OF DEEP-SEA FISHERIES

The interaction between fisheries subsidies and deep-sea fisheries is complex and much remains to be done to further explore the linkages empirically. However, the theoretical insights presented in this paper, coupled with the real-world experience from deep-sea fisheries, highlights a number of issues in relation to subsidies and deep-sea fisheries management that need to be addressed. These relate to the need for

- improved transparency on subsidy provision
- further empirical evaluation of the effects of subsidies
- identification of subsidies particularly harmful to deep-seas fisheries
- improved management of deep-sea resources and
- effective enforcement of management measures.

The amount of information currently available on fisheries subsidies does not provide sufficient detailed information to allow the effects of subsidies to be readily identified and assessed and there is considerable scope for improving the transparency on subsidy programmes. Some subsidy programmes are notified to the WTO, but these only relate to those programmes that come under the WTO definition of subsidies. It is also not clear the extent to which countries comply with the requirement to lodge subsidy notifications. For the period 1995 to April 2001, 14 countries and the European Union had notified a total of 191 subsidies to

¹¹ Research aimed at improving stock assessments is such a grey area. It benefits the industry by improving the knowledge base on which management settings are based. It also benefits the broader community in terms of an improved understanding of the marine resources of the community. Moreover, it is hard to exclude anyone from the benefits of such research and, once undertaken, it is generally available to whoever can make use of it.

the WTO (Table 3). Whether this comprises the full set of notifiable fisheries subsidies remains uncertain as there is no independent verification of the notifications and, to date, there has not been a dispute involving fisheries subsidies which would help assess the data in the notifications. Ongoing work by the OECD to measure and assess GFTs will assist in improving transparency of fisheries subsidies. The OECD definition of GFT is more inclusive than the WTO definition, covering a greater number of subsidies, but coverage is restricted to OECD countries.

TABLE 3
Notifications to the WTO on fisheries subsidies, January 1995 to April 2001

	Sector				Total
	Harvesting	Shipbuilding	Processing	Other	
Canada	4				4
Japan	6			1	7
Korea	6	2	2	1	11
Norway	16	1	1	4	22
Philippines	1				1
Poland	3				3
Senegal	1				1
Slovakia	1				1
United States	5				5
EEC	75	9	9	34	127
Iceland	1		1	3	5
Tunisia				1	1
Singapore	1				1
Turkey	1				1
Thailand				1	1
Total notifications	121	12	13	45	191

Source: WTO (1998, 1999, 2001a).

There is also a need for further empirical evaluation of effect of subsidies on deep-sea fisheries and on fisheries in general. Much of the work to date, and that presented in this paper, has been largely theoretical. While these studies provide a solid basis on which to proceed, they fall short of the depth of analysis that is required at the level of individual subsidy programmes. Importantly, such in-depth analysis will necessarily need to address the effectiveness and strength of management (including management settings, monitoring and enforcement) and the governance/institutional settings within which management takes place.

Identifying those categories of subsidies that are particularly harmful to deep-seas fish resources is an important aspect given the urgency associated with the conservation of these stocks. Traditional analytical frameworks, such as benefit-cost analysis, may be too data-intensive and time-consuming to provide policy makers with timely advice on policy alternatives. Alternative policy tools, such as the checklist developed by the OECD as part of its work on environmentally harmful subsidies, may augment the analyst's tool kit in providing advice on subsidy reform and the expected effects on deep-seas stocks (see OECD 2003c).

The introduction of management measures may offset some of the effects of subsidies. However, the extent to which this occurs will depend on the type of management measures employed and the effectiveness with which they are enforced. The use of innovative management measures may assist in this regard. For example, the use of marine reserves to protect important stocks and ecosystems is being explored in many

areas, although its use as a fisheries management tool remains controversial. Haedrich, Merrett and O'Dea (2001) propose moving towards management based on deep-sea ecosystems rather than focussing solely on individual species management (see also Hilborn and Walters 1992). The use of rights-based regimes could also be further explored, particularly within national jurisdictions and within RFMOs. A particular problem for deep-sea fisheries is the speed needed to respond to developments in terms of introducing management measures, usually on the basis of limited information. Flexibility and speed in terms of management response and enforcement is desirable but hard to implement, particularly in international fisheries and on the high seas. Greater cooperation between stakeholders and managers may help in this area. A recent example of this is the Coalition of Legal Toothfish Operators in the CCAMLR region.

Improving management regimes for deep-sea stocks will not be sufficient without ensuring effective enforcement of regulations. As discussed earlier, the theoretical advantages of the various combinations of management parameters will be reduced, perhaps substantially, if the management measures are not effectively enforced. This is a particular problem for deep-sea fisheries, at least partly due to IUU fishing. The role played by national governments in managing their fleets outside their national EEZs will be particularly important. The UN Convention on the Law of the Sea and other international instruments place specific responsibilities on flag states in managing vessels flying their flags when undertaking activities on the high seas and in RFMO areas. Many countries place restrictions on their vessels operating in these areas, but there is scope for improvements in both the coverage of vessels and the enforcement of existing regulations. Port states also have responsibilities specified in international law regarding the monitoring of fish catches. Programmes such as catch documentation schemes play a role in improving transparency, monitoring and enforcement. The extent to which subsidies hinder the implementation and effectiveness of current and future regulations for addressing deep-sea fishery problems needs to be further explored.

6. CONCLUSION

This paper has addressed the twin issues of fisheries subsidies and deep-sea fisheries, two high-profile issues that are currently prominent in the international policy agenda. It is clear that deep-sea fish stocks have bioeconomic characteristics that make them particularly vulnerable to over-exploitation. These species are long-lived, slow growing and have low productivity. These conditions and the consequent vulnerability of the stocks, exist irrespective of whether subsidies are provided. The provision of subsidies to fishing operators will reduce their costs and increase their revenues and is likely to place increased pressure on stocks and so exacerbate the vulnerability of deep-sea fish stocks, in particular to overexploitation. The extent to which this occurs will depend on the type of management system in place and, importantly, the effectiveness with which management regulations are enforced. However, the bioeconomic characteristics and location of deep-sea fisheries present significant enforcement challenges. Removing or reducing subsidies will relieve pressure on stock biomasses to some extent. However, it will not remove it entirely; the underlying vulnerability of deep-sea stocks to depletion will remain. As a result, it is important to pursue subsidy reform and improved management and enforcement of deep-sea fisheries simultaneously.

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APPENDIX

Model of investment in fish stock

Using a simple model of investment in the fishery (drawing upon Clark 1990), the key insights into the relationship between the rate of interest (discount rate) and the growth rate of the fish stock can be illustrated. The economic production function can be written as

$$H = AE\alpha x^\beta$$

where

H = harvest

E = effort

x = stock (biomass)

A = catchability coefficient

α and β = parameters such that $\alpha + \beta = 1$ (as in the Cobb-Douglas production function).

If the catch per unit of effort is independent of the level of the stock size, then $\beta = 0$ and $H = AE$. The unit cost of harvest is given by $cE/H = c/A$, where c is the cost of a unit of effort.

For illustrative purposes, a simple biological production function, such as the logistic growth model, can be used to illustrate the stock dynamics. In this function, K is the virgin biomass (in the absence of fishing), b is a constant of integration and g is the intrinsic growth rate of the stock.

$$x(t) = K/(1 - be^{gt}).$$

For biomass levels below K , the fish stock is growing at

$$\dot{x} = gx(1 - x/K).$$

Now introducing harvesting at a constant rate of H so that

$$\dot{x} = gx(1 - x/K) - H.$$

Sustainability requires that $\dot{x} = 0$ so the annual harvest should be set equal the growth rate of the stock. The benefit of investment in the fish stock is the value of the increase in the sustainable harvest resulting from the increase in fish stock. The increase in sustainable harvest is given by the derivative of H with respect to x

$$dH/dx = g(1 - 2x/K) \quad (1)$$

The net value of the benefit to increasing the stock by one unit is given as

$$MB(x) = [(p - c/A)g(1 - 2x/K)]/r.$$

where

$MB(x)$ = marginal benefit from investing in the fish stock

r = interest rate.

The efficiency condition for allocating capital between alternative uses is that the rate of return on the two investments should be equal at the margin. In terms of

Figure 3 in the main body of the text, the marginal benefit schedule is downward sloping in terms of the size of the fish stock so as the size of the fish stock increases, the additional benefit from reducing the harvest declines.

The marginal cost of investing in the fish stock is the opportunity cost of not catching an additional unit of fish and allowing it to escape to increase the stock in the future. This is equal to price less the unit catching cost of the additional number of fish which are not harvested. Under a constant cost scenario, the marginal cost of investing in the stock is then

$$MC = p - c/A. \quad (2)$$

Setting equation (1) equal to equation (2), the rule for determining the optimal fish stock is obtained as

$$r(x) = g(1-2x/K) = r \quad (3)$$

And solving for x in terms of r and g

$$x^* = (K/2)(1 - r/g)$$

For alternative values of r and g , it is possible to determine the optimal fish stock from equation (3):

$$r = 0 \Rightarrow x^* = K/2 > 0,$$

$$r \geq g \Rightarrow x^* \leq 0,$$

$$0 < r < g \Rightarrow x^* > 0.$$

That is, at a zero discount rate and for values of interest rate between zero and the intrinsic growth rate, the optimal fish stock will be greater than zero. For values of the interest rate greater than the intrinsic growth rate, the optimal stock will be zero.

Now assuming the government provides a subsidy (s) to the costs of operation. The marginal cost of investing in the stock will increase from

$$MC_0 = p - c/A \quad \text{to} \quad MC_1 = p - (c - s)/A$$

and $MC_0 < MC_1$ for all values of x . At the same time, the marginal benefits schedule also depends on c , and so the provision of a subsidy to costs will rotate the marginal benefit schedule with the intercept on the vertical axis in Figure 4 being higher than that without the subsidy and the intercept on the ordinate being closer to the origin. The equilibrium stock level will, however, be determined as in equation (4), which is independent of c and s , so that the effects of subsidies on the marginal benefits and costs are cancelled out.

Requirements for managing deep-seas fisheries¹

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We affirm that none can have property in the seas, whether taken in the whole, or in respect to its principal branches. The cause which obliged mankind to desist from the custom of using things in common has nothing to do with this affair; for the sea is of so vast an extent that it is sufficient for all the uses that nations can draw thence, either as to water, fishing, or navigation. Huig de Groot (1583-1645).

1. NATURE OF THE PROBLEM

1.1 The fisheries

Until most recently the incentives that existed to drive the development of deepwater fisheries were few. First, the abundance of shallow-water continental shelf fish resources satisfied market demand and provided for profitable activities by most fishing operators. Second, the great depths of many fish resources now routinely exploited made their capture difficult as this required larger and more powerful fishing vessels, development of appropriate fishing techniques and in particular, expensive and complex acoustic systems to locate fish aggregations and then enable them to be successfully targeted by the fishing gear. When deepwater fish were found in association with bottom features such as seamounts, acoustic systems were essential to enable the fish to be caught without loss of trawls through bottom hang-ups. Further, many of the fishes that were found were unknown to consumers, looked unmarketable, required specialized processing and, for certain species, had rather low flesh yields.

Few deepwater fisheries are of long standing and those that are – the Portuguese (Madeira) line fishery for black scabbard fish (*Aphanopus carbo*) and Pacific Island fisheries for snake mackerels (Gempylidae) and cutlass fish (Trichiuridae) were initially exploited by artisanal fisheries whose effects upon the resources were sustainable. This situation changed as a consequence of two developments, one driving the other. First, in the period leading up to the conclusion of the 1982 Law of the Sea Convention, more and more countries staked claims to national exclusive economic zones thereby displacing the operations of many distant water fishing countries from the near-shore fishing grounds they had traditionally fished. Many of these vessels were large and had the capacity to fish in deep waters. Second, the limit of 200 miles that was claimed, and secured as the offshore limit of control by the coastal states, in all but a few cases, exceeded the distance to the shelf break– if distant water fishing nations were to

¹ The views expressed in this paper are those of the authors expressed in an individual capacity. They are not necessarily those of the Food and Agriculture Organization.

continue to operate, the slope and deeper waters became their only option as an area they could fish.

Deepwater fish species have been prosecuted in the North Atlantic, notably for red fish (*Sebastes* spp.) and to a lesser extent for cusk (*Brosme brosme*) and ling (*Molva molva*), prior to the adoption of 200 nautical mile Exclusive Economic Zones (EEZs). Following the expansion of distant water fishing, notably by the Soviet Union and Japan, in the years leading up to the adoption of 200 nautical mile EEZs, new resources were being discovered and exploited. Well known among these is the orange roughy (*Hoplostethus atlanticus*), a species that inhabits slope waters, those of seamounts and above the deep-sea floor, most notably around New Zealand and Southeast Australia where this commercial fishery initially began.² The fishery for orange roughy and associated species such as a suite of oreos later spread to the Walvis Ridge in the Southeast Atlantic, the Southwest Indian Ocean and a small fishery exists in the Bay of Biscay.

Fishes targeted by deepwater fisheries are often characterized as being particularly vulnerable to depletion because they are not only slow growing, indeed, their growth may be so slow that for a long time, the results of the first aging studies were received with incredulity. Further, certain deepwater species live to a great age; several of those harvested commercially have longevities of more than 100 years. Spawning may occur irregularly over periods of years and for some species, now fished for over a decade, no evidence of recruiting classes has been evident. Those species that aggregate in association with bottom features, e.g. for spawning, are particularly vulnerable to capture and as with pelagic schooling species, may retain a high level of vulnerability to capture independent of stock size, i.e. while stock sizes are declining, catch rates may remain relatively high.

As important as it is to note the sensitivity to overfishing of many deepwater species, at the same time, it should be recognized that other deeper water species have longevities not too dissimilar to that found in shelf species, e.g. the alfonosinos (*Beryx* spp.) and associated species such as boarfish (*Pseudopentaceros* spp.), cardinal fish (*Epigonus* spp.) and bluenose (*Hyperoglyphe* spp.).

1.2 Current basis for participation in deepwater fisheries

1.2.1 Operational requirements

Because of the extreme conditions, access to deepwater fishing is first restricted to those who can organize operations of vessels able to fish in deep waters. In the past this has meant that operators have tended to be well established companies with access to the appropriate vessels and sufficient operating capital to put large vessels to sea for extended periods, support their operations, sometimes on a near hemisphere scale, and operate when revenues are received often months after incurring the first campaign expenses. When new high-seas resources are first exploited, this may require access to good intelligence on the success, and thus whereabouts, of other operators, possession of the necessary operating expertise and associated processing and marketing ability. Thus, participants in these fisheries tend to come from a relative small pool of operators even when taken on a global scale. Despite this, sufficient companies exist that new fisheries can expand if not dramatically then unexpectedly when information on the availability of resources becomes common knowledge (see, e.g. Willing 2003).

1.2.2 Legal arrangements

The last decade has seen increasing attention to the problems caused by inadequate controls over high-seas or deepwater fishing, by definition outside direct national

² Interestingly, orange roughy was first described from the Azores in the mid-Atlantic, hence its scientific trivial name, '*atlanticus*'.

jurisdiction. While the problems caused by non-compliance with fisheries regulations are not new, the 1990s brought the problems in managing high-seas stocks, particularly those associated with straddling and highly migratory and stocks, into sharp relief. The entry into force of the United Nations Convention on the Law of the Sea (LOSC)³ in 1994 provides the cornerstone of the high seas regime. In addition to this convention other ‘hard law’ instruments have been developed to fill lacunae identified in the provisions of LOSC. These instruments include the United Nations Fish Stocks Agreement (UNFSA)⁴ and the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (the FAO Compliance Agreement).⁵ In parallel to, and nested within these instruments, are voluntary, hortatory, (also termed ‘soft law’) instruments such as the Code of Conduct for Responsible Fisheries.⁶ The Code of Conduct provides opportunities for the development of subsidiary, specialist instruments – International Plans of Action – that are key elements of an emerging regime governing high seas fisheries. The development of the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU) builds upon, and reinforces, these other instruments creating a new framework or regime for high seas fisheries,⁷ but its effectiveness is yet to be proved.

One indication of the scope and direction of these legal and policy developments can be seen in the focus given to fisheries at the World Summit on Sustainable Development (WSSD) held in Johannesburg in August–September 2002. WSSD outcomes include

- encouraging the application of an ecosystem approach to sustainable development of the oceans by 2010
- maintaining or restoring depleted fish stocks to levels that can produce the maximum sustainable yield ‘on an urgent basis’ by 2015
- putting into effect FAO international plans of action by the agreed dates
- establishing marine protected areas consistent with international law by 2012
- establishing a regular process under the United Nations for global reporting and assessment of the state of the marine environment and
- eliminating subsidies that contribute to IUU fishing and overcapacity.

There are significant challenges in the shift to ecosystems-based approaches as identified in the WSSD outcomes, particularly in relation to fisheries that have traditionally been seen as a core component of the concept of high-seas freedoms.

1.3 Origins of the concept of “Freedom to fish”

Fishing has long been accepted as a part of a high seas freedom. The freedom to fish is a concept that is first associated with the work of Grotius, although the origins of this principle in the freedom of the seas have been traced back to Roman law. The elaboration of the concept of a freedom to fish in the seventeenth century and its acceptance into customary practice in following centuries was incorporated into the codification of the law of the sea through the latter half of twentieth century. The codification of a freedom to fish on the high seas was incorporated into Part VII of LOSC, in particular Article 87. This article elaborates the ‘freedom of the high seas’ that includes ‘freedom of fishing, subject to the conditions laid down in section 2’. Article 87 (2) notes that

³ 1833 UNTS 396.

⁴ *Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks*, also known as the United Nations Fish Stocks Agreement (UNFSA). The United Nations Fish Stocks Agreement entered force on 11 December 2001. For a review of this agreement see Hayashi (1999) and Doulman (1995).

⁵ *Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas*, FAO, Rome, 1995. See also (1994) 33 ILM 968.

⁶ *Code of Conduct for Responsible Fisheries*, FAO, Rome, 1995.

⁷ For an assessment of this ‘international ocean regime’ see Joyner, (2000).

‘these freedoms shall be exercised by all states with due regard for the interests of other states in their exercise of the freedom of the high seas’.⁸ This, in theory, reinforces the balancing of ‘rights’ and ‘obligations’ that permeates the LOSC. In practice, however, the freedom to fish has generally reflected all the problems of open access resources; few incentives for individuals to voluntarily constrain effort, problems in ensuring compliance with conservation measures when established through regional organizations and difficulties of enforcing such measures.

1.4 Open access and common property – Implications for management of deepwater resources

Arguably, the concept of *Open Access* in relation to exploitation of marine fisheries resources had its greatest applicability prior to the negotiation of the LOSC. Following this development, at least for those countries who accepted its provisions and had legal control of their vessels when they fished on the high seas, exploitation of high seas fisheries was subject to the requirements of a country to: (a) observe their treaty obligations (see Art. 116 (a)); (b) the duty to adopt measures... for the conservation of living resources (Art. 117); (c) co-operate with each other in the conservation and management of living resources in the areas of the high seas. (Art. 118) and (d); take measures ... to maintain or restore populations of harvested species at levels which can produce the maximum sustainable yield (Art. 119 (a)).

However, even where high seas fishery management arrangements exist (and where some of the desiderata negotiated in the 1982 Law of the Sea Convention and related instruments have a chance of being implemented) problems of access to, and allocation of, stocks remain. When a new entrant accedes to a regional fisheries management or conservation commission (accepting the entrant’s interests in the fishery – see following) there is an expectation of them being able to participate in harvesting the allowable catch at a level that has been deemed to be appropriate by the other members of the relevant commission. Unavoidably, this reduces the potential harvest available to existing members of the commission. It is perhaps a moot point whether this situation should be described as *open access* or *common property*. If the management regime is open to whoever claims that they will abide by the conventions rules, then in operational terms there is no distinction between this and a truly open-access situation. Alternatively, those who already belong to a fishing convention might argue that the resource is managed under a common property arrangement, i.e. the resource is harvested in common among those who have accepted the rules of the commission or management arrangement.

In any event, if the objectives of management were to obtain the most economic welfare possible from a fishery resource, the operational effect is the same — if membership of a fisheries arrangement is open to new entrants who qualify equally with existing members for access to harvest the resource, the commercial conditions will exist that result in dissipation of economic rent as are described, essentially without exception, in all contemporary bio-economic reviews of fisheries management starting with the seminal work first of Graham (1943), then more formally by Scott Gordon in 1954. Still it is relevant to review what the consequences of open access and common property, as access arrangements, may be in commercial fisheries.⁹

Where there is no arrangement or management regime to determine and control the amount of harvest that is to be taken from a fisheries resource, fishing operators will enter the fishery as long as financial returns from their operations are profitable and exceed those that can be obtained elsewhere. Thus, what determines the level of fishing effort exerted in the fishery, at least in the shorter term while resources are available,

⁸ LOSC Art. 87 (2).

⁹ Many authors have noted that common-property fishery regimes, especially subsistence, or traditional-practice fisheries, may function within effective customary management arrangements.

will be the ability to cover costs and opportunity costs of capital. As the resource is fished down, catch per unit effort (or its economic equivalent) will decline until, on aggregate, costs equal revenues and a bio-economic equilibrium is achieved. However, should subsidies be provided, then fishing may remain profitable at even lower levels of resource biomass and rates of harvest.

Companies based in different countries will operate under different cost structures. Further, when they prosecute high-seas fisheries, to avoid domestic rules on conditions of employment that impose otherwise higher costs of operations, it is not unusual that their operations are structured in the least costly way. Vessel may be re-flagged in another country and crews employed from locations that offer lower costs while still providing essential levels of skills. Complex arrangements may be entered into to mask the 'beneficial owners' of such vessels, further limiting the reach of flag-state control and the costs associated with such controls.

Where surplus fleet capacity exists and vessels are laid up, many fixed costs (especially for depreciation) may be deemed sunk and in this case the costs determining whether a vessel can operate profitably will be even less, resulting in the bio-economic equilibrium being even lower – at lower levels of resource biomass that offer lower rates of catch per unit effort. This has been the situation with many of the large ex-Soviet vessels that no longer have access to past fishing grounds. This situation can also arise where fleet renewal programmes (whether subsidized by other sectors of a country's economy, or by regional economic agreements) result in vessels being displaced from controlled entry fisheries or by fleet buyback programmes that remove vessels from a particular fishery, but not from fishing in general, so exporting the problem of excess capacity to some other unfortunate area of the world.

Do these phenomena operate in deepwater high-seas fisheries? That is, are deep-sea fisheries resources being depleted, or at least reduced, to levels at which sustainable benefits are significantly less than they may otherwise be? At least some examples indicate that the answer is unequivocally yes but closer examination of specific high-seas demersal fisheries shows that the situation is not simply one of the lowest-cost operators (using older low-cost vessels and crews recruited from offshore and paid low salaries) displacing those who retain operations based in higher cost countries and using newer, and often purpose-designed, vessels. However, operating pressures do seem to continue to drive high-seas deepwater fisheries to the point where they operate at the bio-economic equilibrium.

Deep-sea demersal fisheries require a suite of particular skills. First, aimed trawling on deepwater fish aggregations that are often associated with seamounts or similar seafloor features requires particular skills if the gear is not to be lost. In at least one type of wide-spread deepwater fisheries, it is not unusual to find that the skippers and officers come from the few countries where such fishing techniques have been pioneered. Second, deepwater species require particular processing skills. The price that may be received for a particular deepwater species may be acutely dependent on the ability of the operator first to ensure that once caught, its quality is maintained,¹⁰ and second, to process it in a manner that achieves highest prices on international markets.¹¹ Thus low-cost low-revenue operators may operate beside those who have higher costs but also achieve higher revenues. Third, deep-sea resources are marked by their relative scarcity – total catches tend to be small when compared with landings from

¹⁰ Vessel operators may handle some species by hand and install expensive sprinkler systems to rapidly chill freshly caught fish prior to processing.

¹¹ Soviet vessels operating the southern Indian Ocean, though aware of the existence of orange roughy resources, avoided catching them as their sale in the Soviet Union had been prohibited because of the purgative effects when roughy fillets are eaten that not had the sub-surface oils removed during processing by deep skinning.

traditional shelf-based demersal fisheries.¹² The companies that are most successful in their sales operations carefully regulate supply to avoid price reductions through demand-supply market imbalances. Low cost operators, who, because they are often more highly financially geared, may be price-takers and must accept low prices that are further depressed by their inability to add value through vertically-integrated onshore processing plants or by their need to sell their stocks whatever the current supply and demand situation.

These problems are accentuated by difficulties in management driven by the traditional characterisation of such fisheries as open-access, common-property resources. Despite increasing constraints on the traditional unfettered 'freedom' to fish on the high seas emerging in both hard and soft law instruments negotiated in the 1990s – discussed following – fundamental problems remain in terms of the open-access nature of deep-sea fisheries resources (Stokes 2000, UN 1992). The LOSC gives 'all states' the right to fish on the high seas,¹³ effectively constraining the effectiveness of other provisions within the LOSC that emphasise a duty on states to cooperate on the management of such stocks.

1.5 Resource management requirements

Effective administration of deep-sea fisheries resources, no less than those found within national EEZs, has various administrative requirements if they are to provide sustainable harvests. These may be summarized as follows

- Catch & effort monitoring
- Resource research and analysis
- Provision of resource management advice
- Fishery operational planning
- Compliance & enforcement of regulations.

Providing advice on desirable levels of fishing effort, or total allowable catches (TACs), requires that fishery-related information is available that permits the status of stocks to be assessed against agreed reference points. At a minimum this requires that fishing operators provide accurate data on the operations, i.e. where catches were taken, how much were caught and of what species. Information on the size composition of the catch and, or, body parts that would permit ageing the fish for use in production models must be collected and analysed if yield-effort analyses are to be undertaken – an activity that characteristically underlies the management of fish resources.

However, experience from actual fishery situations supports the common sense view that commercial operators are reluctant, if not loath, to provide information, either voluntarily or under duress, that they believe may threaten their commercial competitiveness. This understandable attitude creates particular problems for management of many high-seas fisheries. For some species, harvesting locations that provide commercially viable catch rates depend on where the target species aggregate, e.g. for spawning. Exclusive knowledge of this information is of self evident commercial advantage, especially when initial high catch rates may decline rapidly as a consequence of harvesting. Thus, local populations or sub-stocks may be depleted before a managing authority, if one were to exist, becomes aware of the existence of the fishery. This problem is compounded by other difficult-to-resolve practices. High-seas deepwater resources may exist as local, relatively small, populations that are targeted by a relatively small number of vessels (e.g. <10 and sometimes only a couple of vessels). In these cases it may be that only one or two vessels from a particular country or company are involved in the fishery. Assuming that flag-state regulations exist that require the fishing companies to report their operating data to the national authority,

¹² Global orange roughy and oreo fishes comprised only 0.38% of general demersal fish landings in 2001; toothfish – only 0.28%.

¹³ LOSC Article 116.

national legislation governing confidentiality of data (whether it be fish catch or tax returns) provided to the government may prevent national authorities from making data available for analysis. The lack of availability of ‘commercial – in confidence’ data, no matter the accepted good intentions of those needing the data, or the need for such data to provide appropriate resource management, provide serious constraints on the ability to provide management advice.

Management of fisheries at the national level commonly undertakes other basic administrative research and support activities that, as yet, are not done for high-seas fish stocks. These can be summarized as follows

- Strategic policy & planning
- Socio-economic research & analysis
- Management of fishing entitlements (i.e. Access rights).

National governments also commonly develop oceans policies¹⁴ that articulate in detail their scientific, commercial and social objectives for oceans management and their legal or treaty obligations. Social and commercial considerations, e.g. maintaining communities, supporting regional development and equality of opportunities may form politically important aspects of such policy statements. Moving from a sectoral-based arrangement (fisheries management) to commitments to integrated management that underpin contemporary initiatives in oceans policy is difficult (see Foster and Haward 2003). Achieving agreement on what fishing entitlements will be usually proves to be the most difficult issue on which to reach agreement, not least because it often results in win-loose situations among competing stakeholders, e.g. splitting a TAC between two different gear sectors or regions, or differential access to fishing grounds with the introduction of marine protected areas.

Conservation and environmental issues affecting the high seas have been addressed (though not satisfactorily resolved), as noted earlier, in the United Nations Law of the Sea Convention. A consistent approach to the management of deep-sea high-seas fishing entitlements remains unresolved, reliant on a variety of approaches established under different arrangements.

1.6 Governance issues to be resolved

1.6.1 *Who are the stakeholders?*

It is our view that successful governance¹⁵ of high-seas deep-sea fisheries requires the creation of the same incentive structures that enable effective management within national jurisdictions. At the core of this requirement is the need to align the interests of all stakeholders so that they share common objectives (see, e.g. Metzner (2002) for further discussion on this point). To do this requires identifying who stakeholders are within the context of high-seas deep-sea fisheries and what are their interests.

There are three primary stakeholders in the case of deepwater high seas fisheries:

- i. the “community of nations” who have the capacity (right?) to negotiate and agree on a convention for management of deepwater fisheries resources and conservation of deepwater fisheries habitat
- ii. commercial fishing companies that have the capacity to exploit high-seas deepwater fisheries resources and
- iii. coastal states that have fish stocks that straddle the boundary of their EEZs and the high-seas.

¹⁴ See, e.g. <http://www.cos-soc.gc.ca/engage/toc_e.asp> for Canada’s Oceans Strategy; <http://www.oceans.gov.au/the_oceans_policy_overview.jsp> for information on Australia’s ocean policy; <<http://www.oceans.govt.nz/>> for New Zealand’s Oceans Policy.

¹⁵ Taken here as the manner in which something is governed or regulated – the methods of management and systems of regulations.

Only the first two of these stakeholders are considered here though management issues of straddling stocks must also be considered in terms of managing high-seas stocks. In principle, an acceptable basis, through the UN Fish Stocks Agreement¹⁶ exists to resolve them. Two other groups of stakeholders may deserve particular attention:

- i. countries whose vessels participate in these fisheries, either under their own flag, or through some form of re-flagging, or joint-venture agreement and
- ii. countries that claim special interests in the deepwater fisheries.

One basis for claiming special interest may be geographical proximity, e.g. Mauritius may consider its interests in southwest Indian Ocean fisheries deserve greater recognition than say those of Moldavia or Malta. Another basis for asserting favoured treatment or rights might be historical participation, pioneering involvement in the development of a particular fishery and, or, past investment in research and management activities related to the fishery. Such possible claims are alluded to in the LOSC Article 119 (a), which refers to the qualification of management “measures ... taking into account fishing patterns”. Within this context, the Convention also refers to “the special requirements of developing States” but without further elaboration.

1.6.2 Governance objectives

In our view, the objective of fisheries governance of high-seas deepwater fish resources should be to derive maximum economic welfare benefits. This should include considerations of appropriate pricing of externalities such as conservation of biodiversity, protecting fisheries habitat and use of an agreed discount rate in valuing future benefits. In practice, the wide diversity in preferences regarding rates of discounting future benefits and societies’, or at least decision makers’, attitudes to risk mean that except in some particular circumstances, “maintaining or restoring populations of harvested species as levels “which can produce the maximum sustainable yield”^{17,18} is likely to remain at the core of management objectives.

2. HIGH-SEAS FISHERIES

2.1 Issues of governance

Critical provisions in relation to the governance of high-seas fisheries are found in Parts V and VII of the LOSC. Articles 63 and 64 indicate that coastal states¹⁹ and other states shall cooperate over the utilisation of straddling and highly migratory stocks. The limitations are clearly apparent in these articles, particularly with the emphasis on cooperation between coastal and distant-water fishing states. A number of commentators have examined the development of regimes governing the oceans,²⁰ noting that the ‘bulk of this ocean law has been created during the last three decades (Joyner 2000: 200). The 1990s saw increased focus and concerted action to address problems emerging in the ‘management’ of high-seas fishing.²¹

¹⁶ See, for example the *United Nations Convention on the Law of the Sea*; the *Agreement relating to the implementation of Part XI of the Convention*, and the *Agreement for the Implementation of the Provisions of the Convention relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks*.

¹⁷ LOSC Art. 119 (a).

¹⁸ Noting the variety of ways that maximum sustainable yield may be defined.

¹⁹ LOSC, Article 61 notes that ‘the coastal state shall determine the allowable catch of the living resources of its exclusive economic zone’ but also introduces the need to ‘take into consideration the effects on species associated or dependent upon harvested species with a view to maintaining or restoring populations of such associated and dependent species’.

²⁰ See, for example, the collection of papers in *Ocean and Coastal Management*, 43 (2000), particularly the paper by Douglas M. Johnston and David L. VanderZwaag (2000).

²¹ Ibid. See also Johnston and VanderZwaag (2000).

Effective governance of high-seas fisheries will build on what has been termed ‘operational interplay’ between instruments.²² As Stokke (2000) notes, where “activities impinge on similar or connected activities, operational interplay can be a way to avoid normative conflicts or wasteful duplication of problem-solving activities”.²³ One key element of such operational interplay is the application of relevant conservation and management measures whether a state is a member of an regional fisheries management organization (RFMO) or not. The Compliance Agreement, and more importantly the LOSC, support relevant provisions of the UNFSA.²⁴ Despite the broadening of the high-seas regime through the development and entry into force of hard law instruments and soft law agreements, the effectiveness of these remain unclear while major distant-water fishing states reject critical provisions of the UNFSA. The high-seas regime’s effectiveness is further weakened by a lack of agreement over the reach of provisions that extend compliance and enforcement regimes away from the traditional ‘flag state’ regime embedded in the LOSC.

2.2 The concept of common heritage

The mid-to-late 1960s saw increasing concerns over the inadequacy of the outcomes of the 1958 Geneva conventions. These concerns were given significant impetus by the advocacy of Arvid Pardo, Ambassador of Malta to the United Nations who argued that the world’s oceans should be the ‘common heritage of mankind’. Pardo’s speech was a reaction against the ‘creeping jurisdiction’ of coastal states asserting rights over the seabed and water column from the late 1940s onwards (Pardo 1967). The Maltese initiative to address this problem was to lead to a United Nations General Assembly resolution establishing a conference to address the development of a comprehensive approach to the law of the sea. The concept of the common heritage of mankind was to be at the core of the discussions at UNCLOS III and embedded directly into the LOSC.

2.3 Codification of the ‘Law of the sea’

The development of ‘customary’ law of the sea was based on the acceptance of a number of key principles that had evolved from the debates in the seventeenth century and the work of Grotius and his critics. Attempts to codify the law of the sea in the twentieth century met first with failure with the collapse of the Hague Conference in the late 1930s. Following the action of the United States in proclaiming sovereignty over their adjacent continental shelf in 1947, a number of states took similar action. These actions led to the first United Nations Conference on the Law of the Sea (UNCLOS I) being held in Geneva in 1958. UNCLOS I resulted in, *inter alia*, the drafting of Convention on Fishing and the Conservation of the Living Resources of High Seas.²⁵ This convention entered into force in March 1966 and was “not a success” attracting support of only 37 states although “its provisions in relation to fisheries management are illuminating” (Kaye 2001). The 1940s and 1950s saw a number of fisheries conventions that applied to the high seas and instruments concluded such as the International Convention on the Regulation of Whaling of 1946.

²² Stokke, (2000).

²³ Ibid.

²⁴ Identified as having status as a ‘sacred text’ by Johnston and VanderZwaag, (2000:143).

²⁵ In addition to the Convention on Fishing and the Conservation of the Living Resources of High Seas, the 1958 UNCLOS I conference negotiated the Convention on the Territorial Sea and Contiguous Zone; the Convention on the High Seas; and the Convention on the Continental Shelf (UN 1958).

2.4 The Third United Nations Conference on the Law of the Sea (UNCLOS III)

The Third United Nations Conference on the Law of the Sea (UNCLOS III) was the most complex multilateral treaty negotiation undertaken under the auspices of the United Nations. UNCLOS III, held between 1974 and 1982, involved 15 sessions of negotiations totalling 585 days. These negotiations concluded with agreement over the Law of the Sea Convention 1982 comprising 320 articles and 9 annexes. This convention is at the centre of regimes governing high-seas fisheries and provides the basis for a comprehensive 'constitution for the oceans'.²⁶ The LOSC is built upon a key principle – elaboration of rights of states brings related obligations and responsibilities. LOSC is a classic hard law instrument that includes mandatory provisions – language that includes the words 'states shall ...' Despite these provisions the LOSC is centred on traditional concepts such as flag state responsibility and has a weaker focus on fisheries outside the exclusive economic zone, merely exhorting states to seek cooperative arrangements to manage these fisheries

2.5 Post UNCLOS III

2.5.1 *The United Nations Fish Stocks Agreement.*

The United Nations Fish Stocks Agreement (UNFSA) was developed to fill lacunae identified in the provisions of the LOSC, most notably in relation to straddling stocks, but also those affecting management of highly migratory stocks. The United Nations sponsored conference that gave rise to the UNFSA was mandated by the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in June 1992. The UNFSA, negotiated between 1993 and 1995, entered into force in December 2001. The UNFSA is linked directly to the LOSC, and thus reinforces 'traditional' flag states responsibility for high-seas fisheries.

The UNFSA does, however include significant non-flag state enforcement powers. State parties who are members of regional or sub-regional fisheries management organizations may detain vessels that have engaged in activities that undermine the effectiveness of the organization's conservation and management measures on the high seas until such time as appropriate action is taken by the flag state.²⁷ A port state has the right and duty to take certain measures such as inspect documents, fishing gear and catch on board vessels when such vessels are voluntarily in its ports (Art. 23 (2)). Port states may adopt regulations prohibiting landings and trans-shipments where it has been established that the catch has been taken in a manner which undermines the effectiveness of subregional, regional or global conservation and management measures on the high seas (Art. 23 (3)).

The UNFSA provides that where a competent RFMO exists, states should either become members of that body, or they should agree to apply the conservation and management measures established by such organizations. Only states that are members of RFMOs, or which agree to apply the relevant RFMO conservation and management measures, shall have access to the fishery resources to which these measures apply. Membership of relevant RFMOs is open to states having a 'real interest' in the fisheries concerned. While not defined this is a test to be determined by the existing membership of the RFMO.²⁸ The potential of these bodies is illustrated by measures such as limiting or refusing port access and, or, introducing trade-related controls to deter catches from non-party vessels that have been initiated in several RFMOs.²⁹

²⁶ T. B. Koh, (1983).

²⁷ Art. 21 (8), also Art. 23 (1). See Stokke (2000) who describes the provisions of port state controls as 'a more controversial element of compliance regimes', p. 220.

²⁸ The definition of 'real interest' is still contested.

²⁹ The problem has been traditionally addressed by RFMOs through resolutions and diplomatic demarches aimed at persuading particular non-party states to withdraw an authorisation of vessels

2.5.2 The FAO Compliance Agreement

The FAO Compliance Agreement seeks to ensure that there is effective flag state control over fishing vessels operating on the high seas.³⁰ It was created to deter the practice of re-flagging of vessels to avoid compliance with conservation and management rules for fishing activities on the high seas. The Compliance Agreement is an integral part of the Code of Conduct (see following)³¹ and is a legally binding instrument. It is designed to apply to all fishing vessels that are used, or intended, for fishing on the high seas (Art. II (1)), although parties may exempt vessels of less than 24 metres in length (Art. II (2)). The exemption of vessels under 24 metres in length has been seen as a major weakness, but this provision must be read in conjunction with Art. III (b) of the Compliance Agreement. If a party exempts vessels less than 24 metres in length parties ‘shall ... take effective measures in respect of any fishing vessels that undermines the effectiveness of international conservation and management measures’ (Art. III (1) b).

The Compliance Agreement also allows a port state “to promptly notify the flag state” if it “has reasonable grounds for believing that a fishing vessel has been used for an activity that undermines the effectiveness of international conservation and management measures.” (Art. V (2)). This provision also states ‘that parties may make arrangements’ to enable the port state ‘to undertake such investigatory measures as may be considered necessary.’ (Art. V (2)). FAO is also requesting, on an *ad hoc* basis, that countries that have not accepted the Compliance Agreement make information available for the organization concerning their vessels authorized to fish on the high seas. A database to support the implementation of the agreement has already been established (Art. VI.).

2.5.3 Other approaches

As indicated above, the 1990s were noteworthy for the development of new ‘hard law’ instruments (containing some innovative provisions) addressing high-seas fishing. These instruments provide important bases for future regimes and governance. At the same time the last decade has also seen considerable efforts to develop non-binding, ‘soft law’ agreements addressing fisheries issues. These approaches are important and may be significant influences in improving governance by establishing norms and values that over time may gain widespread acceptance and use. The Code of Conduct for Responsible Fisheries (FAO 1995) and the development of subsidiary, specialist, instruments – International Plans of Action – are examples of such alternative approaches.

The Code of Conduct’s general principles note that states and users should use selective and environmentally safe fishing gear and practices. It is a voluntary instrument (Art. 1) that is directly linked to ‘relevant rules of international law’, including the LOSC.³² The code contains six thematic areas or chapters for which guidelines should be developed: (a) fishery management practices; (b) fishing operations; (c) aquaculture development; (d) integrating of fisheries into coastal area management; (e) post harvest practices and trade and (f), fishery research. The Compliance Agreement is an integral part of the code. States should ensure compliance with, and enforcement of, conservation and management measures. States authorising fishing and fishing-support vessels flying

or to comply with relevant fisheries management regulations through effort limitation and national regulation. It should be noted that in the UNFSA non-members or non-participants are not discharged from their obligations to cooperate, such as not issuing licenses for straddling or highly migratory fish stock subject to conservation and management measures by regional organisations. There is also a duty on members of RFMOs to exchange information on non-member fishing operations. Parties are also obligated to encourage non-parties to become parties and adopt appropriate laws.

³⁰ See *Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas* Art. III.

³¹ Compliance Agreement Preamble.

³² Ibid.

their flag should exercise effective control over those vessels.³³ The code ‘provides guidance that may be used where appropriate in the formulation and implementation of international agreements and other legal instruments, both binding and voluntary’ (Art. 2 (d)). It is this provision that has been used to support the development of a series of International Plans of Action (IPOAs). The initial IPOAs addressed reducing fishing capacity, conservation of sharks, and protection of seabirds.

The International Plan of Action to Prevent, Deter and Eliminate IUU Fishing (IPOA-IUU) reinforces the provisions of the LOSC, the UNFSA and the Compliance Agreement and has direct relevance to issues of governance of high-seas fishing. Australia raised the problem of IUU fishing at the United Nations Food and Agriculture Organization’s Committee on Fisheries (COFI) meeting in February 1999. At the FAO Ministerial Conference in Rome following COFI, FAO declared that it would develop a global plan of action to deal effectively with all forms of IUU fishing³⁴ to be tabled at the next COFI meeting in February 2001. This decision was supported by a number of member states, and entities including Australia, Canada and the European Community. As with other IPOAs, the IPOA-IUU is voluntary, and ‘elaborated within the framework of the Code of Conduct’.³⁵ The Code of Conduct provides the basis for ‘the interpretation and application of the IPOA and its relationship with other international instruments’³⁶ including vessel flying ‘flag of convenience’, through coordinated efforts by states, RFMOs and other relevant agencies including the FAO. The IPOA was adopted by ‘more than 110 countries’ and was seen as providing ‘the international community [with] a powerful tool’³⁷ to fight IUU fishing. The IPOA-IUU, linking traditional flag-state responsibilities with port state and market or trade-related measures, reflects significant development in the development of the governance of high-seas fisheries.

3. OPTIONS FOR GOVERNANCE

3.1 Current approaches

The accepted model for management of high-seas fisheries has been the creation of regional fisheries bodies. Where these arrangements exist, prosecution of deep-sea fisheries may be subject to such legal arrangements, when and where those doing the fishing choose to comply with them. In the case of deep-sea fisheries that are wholly within national EEZs, then their exploitation is subject to the relevant provisions of the Law of the Sea that deal with coastal state rights and responsibilities over the EEZs³⁸. This Article effectively confers sovereign rights over how these resources are managed by the coastal state. Where the deepwater resources straddle the offshore limit of a state’s EEZ, then their management, in terms of the Law of the Sea is subject to Article 63 (2)³⁹ and requires states to seek to agree on measures needed for resource conservation.

³³ See; generally Art. 8.2 ‘Flag State Duties’.

³⁴ FAO *The Rome Declaration on the Implementation of the Code of Conduct for Responsible Fisheries*, adopted by the FAO Ministerial Meeting on Fisheries, Rome 10-11 March 1999. Par 12 (j).

³⁵ Report of the Expert Consultation, Document AUS:IUU/2000/3. Expert Consultation on Illegal, Unreported and Unregulated Fishing Organized by the Government of Australia in Cooperation with FAO, Sydney, Australia 15-19 May 2000. Appendix D par 4.

³⁶ Ibid. par 5.

³⁷ FAO Press Release 01/11 ‘New International Plan of Action Targets Illegal, Unregulated and Unreported Fishing’

³⁸ Article 61, Conservation of the living resources.

³⁹ Article 63. *Stocks occurring within the exclusive economic zones of two or more coastal States or both within the exclusive economic zone and in an area beyond and adjacent to it.* 2. Where the same stock or stocks of associated species occur both within the exclusive economic zone and in an area beyond and adjacent to the zone, the coastal State and the States fishing for such stocks in the adjacent area shall seek, either directly or through appropriate sub-regional or regional organizations, to agree upon the measures necessary for the conservation of these stocks in the adjacent area.

Where multilateral agreements exist to regulate and manage deep-sea resources on the high seas, then these arrangements affect the operations of the vessels under the control of the states that have acceded to the fisheries agreement. There are presently about thirty active regional fishery bodies, nine of which have been established under the FAO Constitution. They vary considerably in size from bilateral agreements such as the International Pacific Halibut Commission, to those such as Convention on the Conservation of Antarctic Marine Living Resources CCAMLR (24 members) and the North Atlantic Fisheries Organization (17 members) and in the nature of their objectives and manner of operation (FAO 2003).

How fishery entitlements are managed depends on the particular fisheries arrangement. In the case of NAFO, proposals for the allocation of catches take into account the interests of Commission members whose vessels have traditionally fished within that area. In the allocation of catches from the Grand Bank and Flemish Cap, Commission members give special consideration to Canada because its coastal communities are primarily dependent on fishing for stocks related to these fishing banks and it has undertaken extensive efforts to ensure the conservation of such stocks. However, in the past, members could opt to dissent to quotas that had been recommended by the Commission. Meltzer (1994) reports that from 1986 until the early 1990s, the EEC for its fleets had been setting unilateral quotas that were many times higher than those set for the EEC by the NAFO. Meltzer reports that the NAFO Convention objection procedure allows member countries to dissent to quotas set by the organization and there is no compulsory dispute settling procedure. However, it should be noted that over the last decade, considerable progress has been achieved in reaching consensual agreement of what national shares of TACs should be for specific stocks and the need for formal votes on shares has been avoided by direct negotiations between delegations.

In the case of CCAMLR, based on the advice of its Scientific Committee, and with due regard to a precautionary approach, total allowable catches (TACs) are set for various exploited fish stocks. Quotas are not assigned to particular members, instead, the commission monitors total catches and when the TAC has been reached the fishery is closed. In this regard the fishery may be considered the common property of the member countries to the extent that they can persuade other stakeholders, e.g. port states, importing and re-exporting countries to abide by, and support, the regulations the Commission has adopted to ensure that participants follow its conservation guidelines.

Not all high-seas deep-sea areas are covered by fishing agreements. In the case of the southern Indian Ocean, when the Indian Ocean Fisheries Commission was disbanded by the Food and Agriculture Organization in 1999 to enable the formation of the Indian Ocean Tuna Commission, there had been no successful preparations for a replacement organization and subsequent fishing for deep-sea demersal resources has continued outside of an agreement of any kind.⁴⁰

The decision making process established under such agreements establishing regional organizations is also an important factor. Organizations that operate on a consensual approach to decision making (e.g. CCAMLR) may only progress at a rate that satisfies all parties. Such decision-making has been criticised as leading to lowest common denominator or ‘minimal tolerable consensus’ approaches. The requirement for consensus creates opportunities for veto positions enabling states to block measures. It should be recognised that other voting systems can also create opportunities for reserving positions and that once consensus is gained a measure is clearly supported

⁴⁰ Unfortunately, the dissolution of the Indian Ocean Fisheries Commission followed by only a few months the discovery, or at least, significant expansion of commercial exploitation of deepwater demersal species in the southern Indian Ocean. The subsequent significant reduction in fish resources biomass occurred in the absence of any potential regulatory authority.

by all members. This support may not of course translate into action, particularly where vessels operate outside flag state control. This also leads to the problem of ‘free riders’; those who gain the benefits of collective actions without sharing the costs of such actions. The free-rider problem is at the core of IUU fishing. Addressing the free-rider problem is clearly an important issue for governance of high-seas fisheries, with action centering on improved compliance with management measures, improving enforcement and encouraging non-parties to join appropriate organizations and commit to cooperative action to manage stocks.

Under the UNFSA, a key function of RFMOs is the development of ‘participatory rights’ that include ‘allocation of allowable catches or levels of fishing effort’. This is a difficult and contentious issue with RFMOs varying considerably in their methods of allocation. These vary from national allocations (e.g. CCSBT), through broad-based TACs (e.g. CCAMLR) to no allocation method (e.g. IOTC). Allocation methods may include a range of tools including closures as soon as a TAC is reached – what has been termed an ‘olympic-style’ fishery, as used, for example, by CCAMLR. Effort limitations can be used, e.g. limiting number of vessels or gear, and these can be set in conjunction with other measures. ICCAT, for example, has developed complex criteria for allocations, yet arguably the more complex the criteria the less effective it will be. Catch history is the traditional basis for arguing for allocation. This can sometimes be seen to reward unsustainable practices. One possible development would be a stronger international commitment opposing claims of past ‘unregulated’ catch as the basis for allocations under RFMOs.

The UNFSA provides that where a competent RFMO exists, states should either become members, or they should agree to apply the conservation and management measures established by such organizations. Only states which are members of RFMOs, or which agree to apply the relevant RFMO conservation and management measures, shall have access to the fishery resources to which these measures apply. Membership of relevant RFMOs is open to states having a ‘real interest’ in the fisheries concerned. While not defined, this is a test to be determined by the existing membership of the RFMO. Certain criteria for determining ‘real interest’ by RFMOs are found within UNFSA. These include fishing patterns and practices, contributions to conservation and management of stocks, collection and provision of data, and the conduct of scientific research on the stocks. These criteria are supplemented by consideration of the needs of coastal communities; coastal states that are ‘overwhelmingly dependent’ on exploitation of living marine resources and the interests of developing states. Catch history is not the only criteria in determining ‘participatory rights’ in RFMOs. The importance of other criteria was identified in the early years of CCAMLR – ‘no [provision of] data, no fish’ – became shorthand for determining interests and allocation.

3.2 Developing countries

Reference to the special needs of developing countries⁴¹ are common in international protocols and declarations though it is rare that a useable definition is given of what a “developing country” is or what their needs are. As noted earlier, the LOSC (Art. 119(a)) in relation to conservation of the living resources of the high seas refers to

⁴¹ The World Trade Organization has no definition of “developing” country – members may declare themselves as a “developed” or “developing” country. However, other members can challenge the decision of a member to make use of provisions available to developing countries. For the Development Assistance Committee of the OECD, “developing country” means a country on Part I of their list of aid recipients. Other organisations have their own definitions. The World Bank uses the term to refer to low and middle-income countries assessed by reference to per capita GNP. The United Nations Conference on Trade and Development has different income thresholds from the World Bank and other organisations often have a “developing country” category of membership.

“the special requirements of developing States.” A recent (October 2002) motion of the UN General Assembly, relating to sustainable fisheries, notes as follows:

- “Calling attention to the circumstances affecting fisheries in many developing States, in particular African States and small island *developing States* and recognizing the urgent need for capacity-building to assist such states in meeting their obligations under international instruments and realizing the benefits from fisheries resources,
- Invites States and international financial institutions and organizations of the United Nations system to provide assistance according to Part VII of the Agreement, including, if appropriate, the development of special financial mechanisms or instruments to assist *developing States*, in particular the least developed among them and small island *developing States*, to enable them to develop their national capacity to exploit fishery resources, including developing their domestically flagged fishing fleet, value-added processing and the expansion of their economic base in the fishing industry, consistent with the duty to ensure the proper conservation and management of those fisheries resources.”

The report of the WSSD⁴² notes that to achieve sustainable fisheries the following actions are required

“(e)Encourage relevant regional fisheries management organizations and arrangements to give due consideration to the rights, duties and interests of coastal States and the special requirements of developing States when addressing the issue of the allocation of share of fishery resources for straddling stocks and highly migratory fish stocks, mindful of etc. ... on the high seas ...”.

It would seem reasonable that the intentions of such references to developing countries in the texts of international treaties and conference outcomes reflects international concerns about the inequity of the distribution of benefits to be derived from high-seas fisheries resources. However, the assumption that the appropriate response to this situation is “to assist developing States, in particular the least developed among them to enable them to develop their national capacity to exploit fishery resources” maybe dangerously naïve in the case of deep-sea fish resources and deserves careful consideration. As noted earlier, successful participation in deep-sea fisheries involves capital-intense marine operations complemented by well-developed processing and marketing expertise if operations are to have any chance of success. If not, attempts at assistance often result in the dissipation of the investments through ill-conceived and environmentally unfriendly “aid”. Even given these skills, many otherwise well-managed fishing companies lose money in deepwater fishing and soon stop operations after limited trial fishing.

Experience in deepwater fishing activities suggests that assisting developing countries to enter deepwater fishing, if they do not already have the expertise that is required, is likely to encumber their Treasuries with debt, misplace scarce human resources and divert efforts from areas where wealth-creating activities are likely to be successful. This is not to say that such countries should have no call on a share of the benefits that can be derived from high-seas fisheries, rather some other basis must be found whereby this can be done. Assisting new entrants, from developing states or otherwise, into fisheries that, with few exceptions, will further endanger already fully exploited stocks and, at a minimum, certainly reduce net benefits as catch rates fall as might total catches. Avoiding a reduction in potential benefits from existing fisheries caused by the entry of new participants may only be avoided if existing operators agree to forgo some part of their share in existing harvests and, or, reduce the level of their

⁴² Plan of Implementation, Section IV – Protecting and managing the natural resource base of economic and social development, Paragraph 30 (e).

fishing operations. But, as yet, negotiations of international fisheries organizations action show that hopes for voluntary reductions in fishing activities are unlikely to be fulfilled.

3.3 Lessons available – the International Seabed Authority

There are an ever increasing number of organizations and instruments that have some interest in, or effect on, the management of marine resources beyond national jurisdiction, that is outside the coastal states Exclusive Economic Zone. The International Seabed Authority (ISA), established through the LOSC, is the only institution that has an exclusive focus on areas beyond national jurisdiction.⁴³ The ISA is responsible for the management of the international seabed ‘area’ defined as being the common heritage of mankind ‘in such a manner to give effect to the principles contained within Part XI of the LOSC.’⁴⁴ These principles include equitable treatment of all states and the ‘equitable sharing of financial and other economic benefits derived from activities in the Area.’⁴⁵ The ISA is guided by detailed provisions within the LOSC and while it is focused on seabed minerals its governance structure and the principles underpinning this structure may have broader application and provide lessons for the governance of high-seas deepwater fisheries.

3.4 Institutional requirements for effective governance

Governance of high-seas deepwater fisheries requires effective management institutions and activities no less than those found and needed within national jurisdictions. These mechanisms and actions consist first of undertaking the scientific and technical activities needed to determine appropriate levels of harvest and how such harvesting should be done in relation to, e.g. constraints to protect bottom fauna or predator species competing for the same target resource. Once agreement is reached on the appropriate TAC, it is essential that participants do not have the option of “dissenting” or registering an “objection” so that they can continue to fish and so contribute to over-fishing. This is most likely to happen when a member’s time preference, or discount rate, is high and they are prepared to forgo greater long-term benefits for those that are more immediate. This may happen when a fleet is near the end of its operational life and the owners do not intend to replace them. In this case, they will have little incentive to promote the long-term interests of the fishery, but wish, rather, to gain the maximum benefit from their assets before they are scrapped.

Second, mechanisms must exist to enforce rules and regulations or otherwise ensure compliance with requirements for conservation. These days this may mean compulsory participation in high-seas vessel monitoring systems (VMSs), provision of tow-by-tow data on catch and fishing locations in an accurate and timely manner to the management authority, willingness to accept (and pay for) fisheries observers on, if need be, a full time basis and agreement to permit inspectors to board and examine the catch, log books and fish processing records when required.

Third, a system must exist that is responsible for administering the management and, subject to agreement, determine the level of levies needed to pay for management costs (Schrack, Arnason and Hannesson 2003). Procedures must be in place to receive members’ funds and deal with the situations where participants (be they countries or companies) do not pay their assessments.

⁴³ M. Bliss presentation on ‘Institutional Gaps’ at Workshop on the Governance of High Seas Biodiversity Conservation, 16–20 June 2003, Radisson Plaza Hotel, Cairns, Australia.

⁴⁴ S. Nandan ‘Current and Foreseen Activities of the International Seabed Authority in Relation to the Resources and Environment of the Deep-seabed’ presentation at Workshop on the Governance of High Seas Biodiversity Conservation, 16–20 June 2003, Radisson Plaza Hotel, Cairns, Australia.

⁴⁵ LOSC, Article 140 (2).

4. ISSUES OF ORGANIZATION GOVERNANCE — OWNERSHIP AND ENTITLEMENTS

A fundamental difference between governance of fisheries resources on the high seas and those within a state's EEZ, and thus subject to the provisions of the Law of the Sea, and those resources that are absolutely within territorial waters, is that management of the fishery resources in these latter waters is under the aegis of the state. As such the state has sovereign⁴⁶ control and can decide if it wishes to allocate catch entitlements to individuals or 'legal entities' and if so, how such entitlements may be exercised. In an operational, if not legal, sense the state may be deemed to 'own' the resource in that it has the power to determine how it is exploited. Indeed, it is not uncommon for national legislation to refer to marine fisheries resources as a patrimony and in some countries, divestiture of ownership by the state is impossible under their national constitution. But, note here, it is the functional aspects of the nature of control over 'ownership' of the entitlement that is most important, and not the legal basis defining the characteristics of the entitlement or property right.

A state's powers that derive from sovereign control of its fisheries resources manifest in two critical ways that provide it with the potential to derive maximum economic benefits from its marine resources. Through the power to control access to the resource or, equivalently, being able to determine the conditions of access or harvesting entitlements, the state can impose a management structure that avoids many of those characteristics that lead to over-fishing and dissipation of rent. These primarily arise from competitive fishing to maximize an company's shares of the quota, e.g. often set as a TAC. But, with the evolution of rights-based fisheries management, the potential benefits from sovereign control go far beyond this. The state has the power to implement policies that create incentives for the industry themselves to promote good management and in this way, the industry's incentives coincide with those required to maximize the economic rent that can be derived from the fishery. That is, adopting policies so that those who harvest the resource share in any future increase in catches arising from investments they themselves make in conservation of the resource, whether from funding scientific research, enforcement of regulations, or jointly deferring short-term benefits by voluntarily reducing catches to avoid growth and recruitment over-fishing, or even short-term price reductions from supply-demand imbalances in fish markets.

A central feature of sovereign control is that participants in a fishery can be assigned a catch entitlement, usually referred to as an Individual Quota. This benefits the recipient in numerous ways that have been extensively documented.⁴⁷ First, when operators know in advance what their annual catch quota is they can plan their capital investments (i.e. the number and type of fishing vessels required to harvest their quota.) and operations with much greater certainty and least cost. Second, they can match their harvesting to peak market demand and thus maximize the revenues that can be obtained for their limited quota. This may also have safety implications as operators, when they have assured catch quotas (often referred to as security of entitlement), can avoid competitive fishing in inclement weather.

The third major advantage of exerting sovereign control over fisheries resources is that those in whom control is vested can insist that the operators who are granted entitlements, i.e. some form of property right to their catch entitlement, pay for the benefits they receive. Such payments usually take one, or both, of two forms. When there are formal rights associated with a catch quota, many sovereign management regimes implement a practice of recovering the management costs from the participants. This has a number of advantages. The first is that of equity – those directly benefiting

⁴⁶ Jensen (2000) provides further insights on this topic in this context.

⁴⁷ See for example FAO (2000).

from a privileged access to the resource rightly pay for the management costs that they create. This is often an easy policy battle to win for when fishing rights are secure and have a reasonable degree of exclusivity intelligent operators accept that investing in management will provide them further benefits through sustained or expanded individual quotas. The second benefit is that when management funding depends on national treasuries to provide an adequate budget, such disbursements are usually subject to competition for funds from other sources, perhaps entirely unrelated to fisheries, or similar sectors of the economy. Governments inevitably have recurrent financial shortages (if not crises) and when they occur, funding against all budgetary lines is likely to be reduced. Policies that create close links between those paying and those receiving the benefits are also more likely to achieve an appropriate balance between the marginal expenditures on management and the marginal benefits that are produced.

The second attraction of providing fishing entitlements that endow the holder with valuable rights is that such policies provide the basis to demand payment of rent for exploiting the resource, over and above payments made to cover the management costs. Clearly, the better the nature of the rights that are associated with the entitlement, the more valuable they will be, and thus, the more rent that may reasonably be asked and received. The policies of national management regimes vary in regard to the collection of resource rents from those who possess catch quotas. One view at the national level is that resource rents are collected through the normal taxing of company profits. In some jurisdictions, resource rents have been recovered by an annual tax of a certain percentage of the quota that is held and which is then auctioned, with the quota-holder who is taxed having the first preference to re-purchase their taxed levy.

In the context of deep-sea fisheries on the high seas, an important issue is whether policies and management practices of national jurisdictions that have been successful in ensuring the sustainability of fisheries within EEZs can be used on the high seas given that there is no corresponding sovereign body. Consideration of these issues, both in general and in particular are not without precedent. As noted, in 1971 Malta proposed the adoption of the common heritage concept at the United Nations General Assembly not only with regard to the seabed beyond national jurisdiction but also to the ocean space as a whole beyond national jurisdiction. As Carroz (1984) noted, this proposal was revised in 1973 and conceived the creation of new international institutions with fairly wide powers over the entire ocean space and its resources. However the proposal failed to receive much support, and neither did the less ambitious proposals subsequently submitted by Lebanon, Kuwait and Singapore, which envisaged the establishment of a new organization to regulate the exploitation of all living resources outside the territorial sea or which assigned this task to the prospective International Seabed Authority. However, when agreed upon, UNCLOS III gave little consideration to suggestions concerning international regulation of fisheries beyond EEZs or the outer limit of the continental shelf. China suggested the creation of an international organization to regulate fisheries in areas beyond national jurisdiction. Pakistan and Guyana suggested that the entire space beyond national limits be treated as a single entity with no distinction between living and non-living purposes. These countries proposed that the international Seabed Authority be vested with comprehensive powers covering all resources."

More recent and more concrete proposals have addressed the potential for more effective management regimes on the high seas. Stone (1993), in a paper that focuses on the need for environmental protection of global commons, proposed the creation of a Global Commons Trust Fund that would have responsibility for a range of issues that went beyond those simply of fisheries. This fund, he proposed would underwrite the policing of fisheries agreements, noting that at present (that was 1993) this relied too heavily on the fishing fleets' self-monitoring. He believed that a number of

sources could be tapped for revenues, including, e.g. a 0.5 percent tax on fish landings, including those from EEZs and expressed the view that it was indefensible that coastal states should snatch all of the wealth with no accounting just because they happened to be closer to the resource.

France and Exel (2000) provide a particularly dismaying description of the consequences of the open access regime provided for by UNCLOS III and the inevitability of resource depletion once the existence of high-seas resources becomes common knowledge. They provide examples in recent years where this has occurred within a few years of stocks being discovered. While they note that there is no single cause for the problems of high-seas management, they conclude that lack of effective access-rights is certainly one of the biggest. In giving credit to the progress achieved with UNCLOS III, they believe that the challenge of dealing with international rights was too great at the time this agreement was negotiated. Despite these constraints, the fishing company which employed these authors worked with their (Australian) national government, which in turn attempted to collaborate in developing management mechanisms with the governments of other flag states involved in high-seas fisheries their company were prosecuting. However, France and Exel report, these efforts foundered because of the lack of definition of high-seas rights, other than those of open access.

5. A GLOBAL FISHERIES TRUST

5.1 Initial steps

There exist more than 30 regional fisheries bodies (FAO 2003) comprising a wide range of activities, target species that ought to be managed, geographical areas, institutional competencies and histories. Many can rightly be described as famous and accord great respect, while others are barely known even in their region of competency and show limited functionality. Thus, in proposing the creation of a new global fisheries body, indeed one that to be effective would require the types of powers traditionally found only within national jurisdictions, the inevitable challenge to contend with, whether true or not, will be that a new body will create more bureaucracy and burden those who at the present time must do this job within the context of existing institutional arrangements. Added to such challenges must be the realization that in even the most optimistic scenario, it would be no less than five years before such an arrangement could be functional and, based on the time required for other arrangements to come into force, i.e. from when there was agreement to when sufficient states had ratified the agreement, a period of twenty years for agreement might not be unrealistic. If this were to be the case, then sufficient experience now exists to indicate that most, if not all, the resources that such an arrangement would be designed to safeguard will be gone. Indeed, given that newly discovered deepwater resources may be depleted over periods of a few months to two-to-three years, one might be excused for forgoing the attempt to address the problem.

However, such defeatism may not be entirely justified. Not all deep-sea resources offer little hope of sustainable exploitation and even for those fisheries that target fish of enormous longevity, low biological productivity and unknown recruitment relationships, evidence exists that several offer hope of sustainable exploitation. Further, issues of fish habitat protection and ecosystem considerations require that at least some degree of coordinated monitoring and analysis of the deep-sea's fish resources be maintained if the little data that does exist on fishing operations is not to be lost and the invaluable information it represents along with it.

5.2 Institutional requirements

Creating a global fisheries trust faces two primary challenges. First, assuming that its creation would require support and agreement from a wide range (majority) of states, many of whom may have no involvement in high-seas deepwater fisheries, incentives would be needed to gain their support for such an initiative. Further, even if many of the states have no present, or future likely, involvement in high-seas deepwater fisheries, they may (reasonably?) assert that as part of the international community, they have standing in determining how net benefits from high-seas fisheries that arise from effective management of such resources are to be distributed. This challenge may be termed the *Rent Distribution Issue* — the concept that a global fisheries trust would have some form of tenure of the fisheries resources in question. That is, such a trust would hold in escrow for the world, rights to extract resource rents, or royalties through management of high-seas deepwater fishery resources.

The second challenge would be to convince fishing operators, both of distant-water fishing nations and of coastal states with straddling stocks, whether they fish on the high seas or not, that an effective and encompassing arrangement will better protect their interests than do current management arrangements. As France and Excel's views (2000) show, at least some companies recognize that such an arrangement will be in their interests. Probably the major concern of existing high-seas fisheries operators will be that any new high seas fishing arrangement is not, whether by stealth or otherwise, an extension of sovereignty by coastal states over adjacent marine areas or the high-seas part of the range of straddling stocks. They will wish to ensure that any past, or present, fishing activities on their part are able to continue in the future. Indeed, some countries may insist that at least the opportunity exists for them to expand their high-seas fishing activities or develop new ones. This challenge may be termed the *Catch Entitlement Issue* — that is, that any new high-seas fisheries arrangement can provide secure catch entitlements to existing fishing operators with negotiated conditions of exclusivity and other rights-related conditions.

These two issues that will dominate any discussions relating to the creation of a global high-seas deepwater fisheries trust — that of payment of management costs, and rent or royalties for harvesting high-seas resources in exchange for agreed conditions for providing catch entitlements — are complementary negotiating issues and can be separated and dealt with independently. Indeed, this may be the only way of proceeding with such a proposal.

5.3 Institutional options

Current experience indicates that no existing regional fishery body has all of the powers they desire and need to ensure that the fisheries they administer can be managed to provide high levels of sustainable benefits. It may be possible that these deficiencies could be addressed by re-opening the conventions that determined their arrangements so as to address whatever particular deficiencies exist, but if circumstances have changed considerably since the respective fisheries arrangement were first negotiated, this may result in an unavoidable renegotiation of many other unrelated articles of their conventions. Such a process may take as long to negotiate as a new, and more preferable, option. For many fisheries arrangements there may be a fair, if not high, degree of satisfaction in how the arrangement is fulfilling its mandate and the members of such arrangements may feel strongly that there is little or no need to consider a new and untested management approach. In such cases the challenge would be to complement existing competencies through an additional global arrangement and at the same time avoid duplicating institutional mandates that are already well satisfied.

If it is true that the challenge of achieving effective high-seas deepwater fisheries management is global in extent and can only be addressed on this basis, then the need will be to implement arrangements first for high-seas areas where there are no

agreements, e.g. the southern Indian Ocean, and then, perhaps, to accommodate existing conventions by complementing their activities with those that are global in nature and for which regional arrangements are inadequate. In this regard, it would be unwise to underestimate the, perhaps understandable, antipathy to the creation of new global organizations. But on the other hand it would be counter productive to fail to recognize the benefits from such an approach or its essential need. By skilful negotiations assisted by appropriate incentives it should be possible to create a global body that in the first place complements existing regional arrangements, by undertaking those management responsibilities where there are no existing regulatory mechanisms.

Where there is a need for activities on a global basis that are already undertaken, or attempted, regionally, a global fisheries trust could supplement existing regional arrangements. Examples of such activities would include global high-seas VMSs and global implementation and management of catch documentation systems as it may be assumed that the need for such reporting systems will expand as progressively more stocks become heavily exploited, if not depleted, as they attract the attention of those who choose to operate outside the arrangements of existing conventions. Balancing the need for well integrated global management functions is the recognition that many of the operational requirements of a global organization will be best served through a regional structure with appropriate responsibilities undertaken on a devolved basis.

While the majority of existing RFMOs exist outside of the United Nations system, it is difficult to conceive that this would also be the case should a global fisheries trust be established. Whether it would be more appropriate to create a new organization, or add such a proposed mandate to an existing one, is at this conceptual point a matter for future evaluation.

5.4 Fishing access and catch entitlements

Experience at the national level shows that the conferring of catch allocations to fishery participants is the most contentious and difficult step when a rights-based approach to management is adopted. However, sufficient experience now exists to show that despite this, the problem can be resolved. There appear to be two options that reflect the importance that may be given to differing considerations when providing for catch allocations or entitlements. For one, a system of preferences that favours certain countries (e.g. coastal states or developing countries) may be implemented and what ever quota remains is then available for 'non-preferred' states. There are various reasons why this would be a deficient policy. To start, it would be difficult, if not impossible to assess the relative merits of claims to preference and then, were they to be granted, it would be at the cost of maximizing the benefits to be gained from the resource. A preferable way of recognizing the claims of states to be favoured, should this be an accepted policy objective, would be through preferential shares of resource rents that were to be collected from those prosecuting the fisheries.

As an alternative to a system of allocations by evaluation of social merit, many national practices offer examples that have elements of potential applicability. Most commonly, national regimes when granting catch entitlements have based the initial quota allocations to an operator based upon their past catches using a variety of formulas that differ mainly in the period used in setting the share rather than the underlying principle. Where there is no basis for determining a historical right, the allocation may be sold by auction or tender. There are reasons why auctions should be used only after careful evaluation, but in theory there are a number of reasons why such an approach would find much support. First, an auction would result in the trust receiving the maximum value for the catch entitlements it holds in escrow. This would in turn maximize royalty payments to the beneficiaries no matter what allocation formula for the catch was decided upon. Second, it would have the advantage of being

transparent and, if “rule by the market place” was acceptable, fair. No restrictions should be placed on who could bid for quota.⁴⁸ In national contexts, there are often fears that auctions favour those with a competitive advantage in accessing capital and these entities may not be those who are capable of creating the most benefits from a fishery. Whether this would be a consideration in a global context requires further elaboration.

As in other avenues of commerce, the revenues that are received from the sale or lease of catch entitlements will depend on what is being sold. It is a well established experience that fishing entitlements that have the characteristics of strong property rights⁴⁹ are the most valued. Entitlements that are secure (i.e. not liable to arbitrary or unwarranted forfeiture), have reasonable duration (note that operators developing new fisheries will require multi-annual entitlements), are exclusive (when operators, through their own investments increase the productivity of the resource, they should not have to unfairly share the returns of those investments with new entrants) and are transferable, will achieve the highest bid in any auction or tender system.

Rarely are all these attributes to be found absolutely in national fishery quota systems, and what ever suite of characteristics is decided upon should depend on the characteristics of the particular fishery to which they apply. In any event, however it is considered to be appropriate, a global fisheries trust may decide to stint the characteristics of the catch entitlements, e.g. limit the relative share that may be held by any one operator (or country?), or the length of time that an entitlement is valid. While negotiating these issues is usually difficult, there is ample experience at the national level to show that when the incentives to succeed exist, a resolution will be possible.

Should a trust be able to grant catch entitlements to fishing operators, it is likely that concerns about market concentration will arise. Most high-seas deepwater resources are relatively small (see Footnote 5). Many stocks may be specific to a single local seamount complex and support no more than one, or a few, vessels even when fished on a seasonal basis. In these situations, there may be major advantages in providing a single operator with exclusive rights to an area, analogous to a territorial user right (TURF).⁵⁰ In any event, it is unlikely that there need be fear of market concentration because of exclusivity over access to a particular stock.

6. NON-CONSUMPTIVE CONSIDERATIONS

The perception of high-seas deepwater fisheries as yet another environmental tragedy in the making has spawned a plethora of political campaigns, international conferences, initiatives and agreements, described above. Put together, these actions and initiatives signify a growing political commitment to sustainable fishing. The last two decades has seen increasing focus on the importance of what has been termed ecosystem-based management, first pioneered in the 1982 Convention on the Conservation of Antarctic Marine Living Resources and gaining greater salience with the discussions at, and outcomes from, UNCED in 1992, reinforced by pronouncements of the WSSD in 2002.

As a result there is an increasing tendency to frame fisheries issues in terms of concepts such as ‘integrated management’, ‘the precautionary approach’, ‘inter-generational equity’, ‘stewardship’ and the ‘maintenance of biodiversity’. These concepts address a broader concern than simply the sustainability of the stock. Institutional arrangements providing governance of high-seas deepwater fisheries will need to address these issues.

Ensuring the maintenance of high-seas stocks and protecting the biodiversity of deepwater fisheries leads back to broader concerns expressed four decades ago over

⁴⁸ Though it may be desirable to ban from bidding operators who contravened fishery regulations.

⁴⁹ See Scott (2000) for an elaboration of these concepts.

⁵⁰ See Christy (1982) for an exposition on Territorial Users Rights (TURFs).

the resources of the oceans as the common heritage of mankind. The problem of these resources as public goods under open-access regimes reinforces the difficulties in governance addressed above. Despite increasing attention to the need for ecosystem-based management to be applied to the world's fisheries, with WSSD setting a target date of 2010 for the application of such approaches, limited attention has been placed on the mechanism to fund the introduction of such management approaches. The creation of a global fishery trust could resolve this deficiency.

7. MOVING AHEAD

Developing a global governance arrangement for high-seas deepwater fisheries will be challenging. Progress in implementation of instruments, even when there is widespread acceptance of the need for action may be slow. Where such instruments contain provisions – either rights or obligations – that are seen by some states as contentious, the process of agreement and ratification can be difficult. Objections have been raised where initiatives have been proposed that extend or develop the provisions contained within the LOSC that, in the words of Johnston and VanderZwaag (2000), has assumed the status of 'sacred text'. Alternative approaches that focus on the opportunities to build acceptance of measures through 'soft law' processes provide mechanisms to advance issues and perhaps see the emergence of customary law as these measures gain broader agreement and support over time. Observations over the negotiation of the IPOA-IUU indicate that states are, however, adopting formal treaty-making tools and procedures (e.g. reservations and declarations) in these non-binding, hortatory instruments. Formal, Track I approaches are necessary to gain acceptance of institutional forms that 'bind' parties to obligations contained in an instrument.

Alternative approaches may, however, have utility in advancing discussion of appropriate institutional forms and governance arrangements affecting high-seas deepwater fisheries. Track II approaches that facilitate discussion outside formal state-to-state diplomacy can help advance issues and overcome constraints posed within the formal Track I arenas. Track II approaches can build on civil society's concerns over the state of the world's fisheries and oceans and the agenda set at WSSD to examine options for governance arrangements for high-seas fisheries. As Track II initiatives gain strength the ideas and outcomes can feed into formal intergovernmental processes. Such 'bottom-up' processes may help sustain important political constituencies during what inevitably will be difficult formal negotiations.

Opportunities to consider such governance arrangements may arise through the agenda of the United Nations Informal Consultative Process on the Law of the Sea (UNICPOLOS) that has already addressed issues such as high-seas marine protected areas on its agenda. UNICPOLOS provides one forum that encompasses the benefits of Track II approaches within a more formal framework. Other avenues are also available. The FAO's biannual meeting of the Committee on Fisheries (COFI) provides opportunities for a UN Specialist Agency to discuss the governance of deep-sea fisheries. Discussion of such issues during the annual debate at the UN General Assembly on the UN Secretary-General's Report on the Law of the Sea may provide further opportunities.

8. CONCLUSION

The governance of deepwater, high-seas fisheries raises many issues. This paper has noted that, notwithstanding the significant developments in the law of the sea regime over the past three decades, there are limitations in the current legal framework and management arrangements affecting deep-sea fisheries in areas outside national jurisdiction. Given the increasing constraints on fleets operating in areas within national jurisdictions, high-seas areas deepwater resources are likely to be increasingly targeted in coming years. This development may well parallel the concern over management of

straddling and highly migratory stocks that emerged in the 1990s, which gave rise to an innovative management instrument by focusing on extending tools and approaches embedded in the 1982 Law of the Sea Convention.

This paper has provided a necessarily brief survey of issues that are central to considerations of governance and management of deepwater, high-seas fisheries. Governance focuses on institutions and processes providing both frameworks and context for decision-making. Deepwater fisheries in areas beyond national jurisdiction clearly lack a sufficient governance framework, being the residual from the coastal states and distant water states' 'rights' found within the Law of the Sea Convention.

One way forward will be to look back, back to the innovative proposals from Malta (and other states) in early, preliminary discussions prior to the opening of the Third United Nations Conference on the Law of the Sea. This initiative proposed establishing an institution responsible for fisheries beyond national jurisdiction, based on the concept of such fisheries as the 'common heritage of mankind'. This would have paralleled the approach adopted for deep-seabed minerals with the International Seabed Authority. While the Maltese proposal did not gain currency in the early 1970s we argue that such an approach, based on the experience gained by institutions such as the International Seabed Authority, could provide the basis for managing deepwater high-seas fisheries. This paper proposes a deep-seas 'trust' as a mechanism to address current lacunae in the law of the sea regime with respect to deepwater fisheries outside of national jurisdictions.

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Governance and management of living marine resources and fisheries on the continental slope and in the deep sea - a legal framework and some points of departure

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1. DEEP-SEA RESOURCES AND FISHERIES IN WATERS UNDER NORWEGIAN JURISDICTION

Fisheries in the deep sea utilize both pelagic (mid-water) and demersal (bottom-associated) resources. In the deep sea, there are four pelagic zones: the mesopelagic zone (150–1 000 m), the bathypelagic zone (1 000–3 000 m), the abyssopelagic zone (3 000–6 000 m) and the hadal zone (deep ocean trenches). The major deep-sea pelagic resources are species that inhabit the mesopelagic zone but migrate to near-surface layers to feed. Examples from the Northeast Atlantic include the blue whiting (*Micromesistius poutassou*) and small lantern fish and euphausiids that some consider to be potential fishery targets. There are no fisheries in the bathypelagic or deeper zones. Demersal species live on, or near, the seafloor, and in the deep-water region demersal habitats comprise the continental slope, ranging from the shelf break down to the continental rise and beyond to the abyssal plains of 3 000 m or more.

The deep-water areas near the Norwegian mainland (Figure 1) are the deep fjords, the deep slope and channel of the north-eastern North Sea (Norwegian Deep or Trench, including the Skagerak), the slope towards the Norwegian Sea off western and northern Norway (north of 62° N) and the pelagic realms of the Norwegian Sea.

Deep-water fish can be divided into three main categories: mesopelagic, benthopelagic and benthic. In Norwegian waters there are fisheries for species of all categories, but mainly in the upper slope waters and the fjords. The main deep-sea fish species of Norwegian waters are:

Species targeted by fisheries:	Main types of gear:
Blue whiting (<i>Micromesistius poutassou</i>)	Mid-water trawl, bottom trawl
Greenland halibut (<i>Reinhardtius hippoglossoides</i>)	Trawl, longline
Redfish (<i>Sebastes marinus</i>)	Trawl, longline
Deepwater redfish, redfish (<i>Sebastes mentella</i>)	Trawl, longline
Greater silver smelt (<i>Argentina silus</i>)	Trawl

Blue ling (<i>Molva dypterygia</i>)	Gillnet, trawl
Tusk, torsk (<i>Brosme brosme</i>)	Longline, trawl
Ling (<i>Molva molva</i>)	Longline, gillnet, trawl
Roundnose grenadier (<i>Coryphaenoides rupestris</i>)	Trawl
Anglerfish, monkfish (<i>Lophius piscatorius</i>)	Gillnet
Atlantic halibut (<i>Hippoglossus hippoglossus</i>)	Trawl, longline, handline, gillnet (mainly bycatches, but also some limited target fisheries)

Species taken as bycatches and marketed:

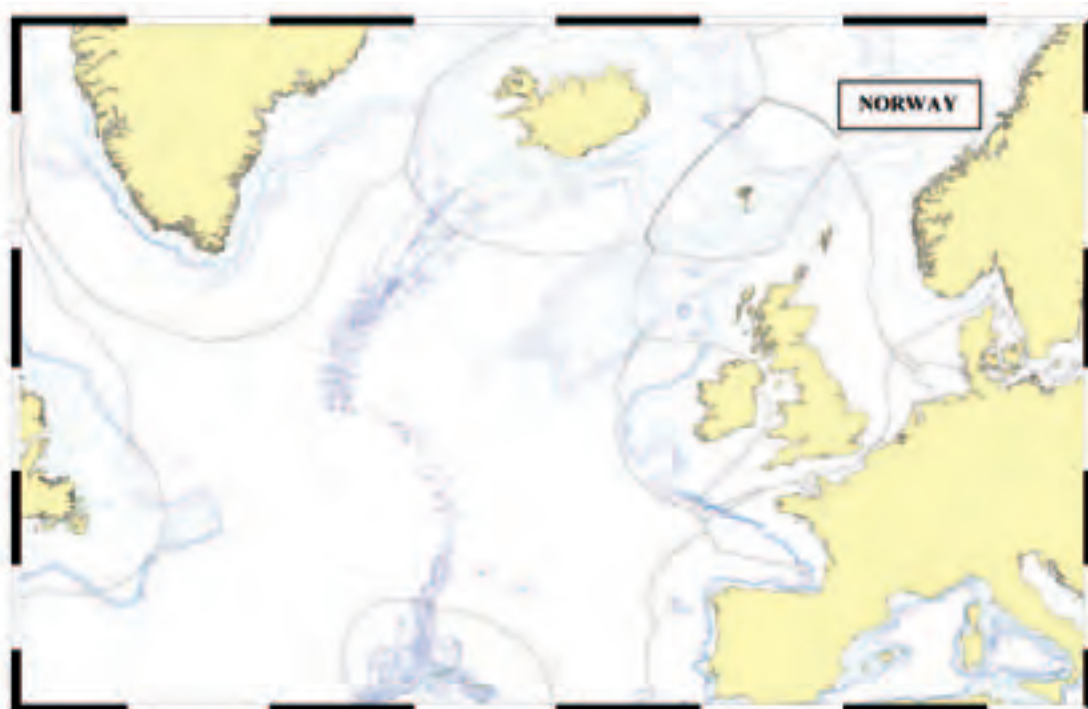
Jelly cat (<i>Anarhichas denticulatus</i>)	Trawl, longline, gillnet
Conger, conger eel (<i>Conger conger</i>)	Longline, gillnet
Greater forkbeard (<i>Phycis blennoides</i>)	Longline
Roughed grenadier (<i>Macrourus berglax</i>)	Longline, trawl

Species taken as bycatches but not usually marketed:

Rabbit-fish, rabbit ratfish (<i>Chimaera monstrosa</i>)	Trawl
Velvet belly (<i>Etmopterus spinax</i>)	Trawl
Greenland shark (<i>Somniosus microcephalus</i>)	Trawl, longline
Skates (several species)	Large skates caught by longlining and trawling may be marketed

These are the species that are landed from fisheries in Norwegian waters. Other species would have to be added if Norwegian fisheries in other waters, e.g. the slope off the British Isles, Faeroes, Iceland, Greenland and on the Mid-Atlantic Ridge were included.

FIGURE 1
North Atlantic showing national Exclusive Economic Zones



2. JURISDICTIONAL ISSUES IN RELATION TO DEMERSAL FISHERIES

Demersal species that are not sedentary and that occur within the exclusive economic zones (EEZs) of a coastal state come within the scope of the sovereign rights of the state in accordance with the rules and provisions of Part V of the 1982 United Nations Convention on the Law of the Sea (LOSC). In areas under Norwegian fisheries jurisdiction, this includes relatively isolated populations of deep-sea species such as Greenland halibut, grenadiers, greater silver smelt, forkbeards, ling, blue ling and tusk. It must be recognized, however, that for several of these species, the level of isolation, and thus knowledge of stock structures remain uncertain though the scientific evidence for isolation is limited.

Demersal species that are sedentary form part of the natural resources referred to in Part VI of the LOSC, which consist of mineral and other non-living resources of the seabed and subsoil, as well as living organisms belonging to sedentary species. Such species are defined in Article 77, paragraph 4, as being “organisms which, at the harvestable state, either are immobile on or under the seabed or are unable to move except in constant physical contact with the seabed or the subsoil”. Examples of such organisms are bivalves such as oysters and mussels, sea anemones and attached algae. All the deep-sea species that are of commercial interest are mobile, i.e. they can move varying distances without “constant physical contact with the seabed”. Typical demersal species such as skates, some flatfish and perhaps wolf-fish, and certain benthic sharks could, however, be included in the definition of sedentary species, but Norwegian research using tagged fish has shown that even flatfish such as Greenland and Atlantic halibut migrate over long distances, even hundreds of kilometres.

Article 68 specifies that Part V does not apply to sedentary species as defined in Article 77, paragraph 4, of the LOSC. It thus appears to except such species from the rules of Part V on foreign access, requirements to ensure rational conservation and optimum utilisation and the obligation to co-operate with other states as regards shared stocks. Several regional fisheries management organizations, such as the North East Atlantic Fisheries Commission (NEAFC), thus exclude sedentary species from their scope of application in accordance with Article 77 no 4. It could, however, be argued that there is no reason why general obligations relating to sustainable management, use and conservation set out in the LOSC should not apply to these species as well, since this is a dominant theme throughout the Convention.

Sedentary species and habitats occurring outside the EEZs will, in so far as they are found on the continental shelf as defined in Article 76 of the LOSC, also come within the scope of the sovereign rights and continental shelf jurisdiction of the coastal state in accordance with Part VI. The Commission on the Limits of the Continental Shelf set up under Annex II of the LOSC has only recently started reviewing submissions for the establishment of the limits of the continental shelf beyond 200 nautical miles, and no states parties are under any obligation to make such submissions until 2009 at the earliest. The process of delimiting the areas of extended continental shelf that will be under national jurisdiction is, therefore, likely to take many more years.

3. OBLIGATIONS TO CO-OPERATE IN THE CONSERVATION AND MANAGEMENT OF DEMERSAL SPECIES

The LOSC obliges coastal states to co-operate in the conservation and management of stocks occurring within the exclusive economic zones of two or more coastal states, both within the EEZs and in an area beyond and adjacent to it (see Article 63). Such shared stocks may also include non-sedentary deep-sea species such as grenadiers, sharks, greater silver smelt and Greenland halibut.

Most deep-sea resources in the Northeast Atlantic comprise species whose stocks are shared as they are found in two or more EEZs or are species that occur both on the high seas and in EEZs. However, the population structure of all deep-sea species is

poorly understood. Modern population genetic studies have only been carried out for redfish, and to some extent, for blue whiting, and even for these species no consensus on population structure has been reached. There are plans for more work on other deep-sea species, but the necessary funding has not yet been forthcoming.

High-seas fishing is in principle open to all states (see Article 87 of the LOSC). However, Article 87 also states that this freedom must be exercised with due regard for the interests of other states and also with due regard for the rights under the Convention with respect to activities in the Area. Section 2, Part VII, of the LOS Convention (Articles 116-119) states that the right to engage in fishing on the high seas is further subject to treaty obligations and to the rights and duties as well as the interests of coastal states (see for example Article 63, paragraph 2, and Articles 64 to 67 of the Convention).

Further, states have obligations to take such measures with respect to their respective nationals as may be necessary for the conservation of the living resources of the high seas (Article 117) and to co-operate with other states in conservation and management of these resources (Article 118). Further, the LOSC obliges coastal states and other states that fish for highly-migratory species to co-operate directly or through appropriate international organisations to ensure conservation and promote the objective of optimum utilisation of highly-migratory species throughout the region, both within and beyond the EEZs of coastal states (see Article 64 of the LOSC). In regions where no appropriate international organisation exists, the states concerned are obliged to co-operate to establish such an organisation and to participate in its work. These provisions apply to all living resources, including demersal fish that are not sedentary as defined in Article 77 of the LOS Convention. The 1995 United Nations Fish Stocks Agreement further defines and elaborates these obligations with respect to straddling stocks and highly-migratory stocks.

The International Council for the Exploration of the Sea (ICES), which is the scientific advisory body to NEAFC, has classified most of the commercial deep-sea resources in the Northeast Atlantic as overexploited. There have been many warnings that the development of deep-sea fisheries is not sustainable and the immediate reduction of fisheries on deep-sea stocks has been recommended many times. NEAFC has started the process of establishing an appropriate management regime for deep-sea species. Ad hoc measures limiting the fishing effort have been agreed to for 2003. However, these measures are rather vague and no agreement has been reached on how to calculate effort or the reference period that should be used as a management basis. The parties to NEAFC Convention at a meeting in May 2003 discussed the matter further and reached a preliminary agreement for measures for 2004, including a plan for collection of scientific data. The proposed management measures are still not sufficiently comprehensive as no common understanding about the aforementioned criteria was reached. In addition, little is known about the stock structure of the species in question. Thus, it is not known whether there are different stocks, whether these are straddling stocks (i.e. occur both in the high seas and in national zones of NEAFC parties, or whether particular stocks occur only in the high seas, i.e. discrete stocks. The matter was further considered at their annual meeting in November 2003. However, the lack of data makes it unlikely that consensus will be reached on a fully-fledged management system for these species at that meeting.

4. SPECIES AND ECOSYSTEMS OF THE AREA

Species and ecosystems outside the extended continental shelf as defined in the LOSC Article 76 are by definition in the “Area”, which is to be managed by the International Seabed Authority (ISA) in accordance with Article 134, paragraph 4, and Article 136 of the LOSC. The ISA’s competence applies to all “resources” in the Area, meaning “all solid, liquid or gaseous mineral resources *in situ* in the Area at or beneath

the seabed, including polymetallic nodules". In extracting resources from the Area and with respect to all other activities, the Authority is obliged to take all "necessary measures to ensure effective protection for the marine environment from harmful effects which may arise from such activities" and shall adopt appropriate rules, regulations and procedures for "the protection and conservation of the natural resources of the Area and the prevention of damage to the flora and fauna of the marine environment".

It is questionable whether the Authority has the mandate and the competence to manage the living marine resources of the Area. It is also quite clear that the rules and regulations pertaining to the Area do not have any effect on the legal status of the waters superjacent to the Area (see Article 135) but some habitats and ecosystems are found in the subsoil under the Area and here the situation is less clear.

5. ENVIRONMENTAL CONSIDERATIONS – CONSERVATION AND PROTECTION OF BIOLOGICAL DIVERSITY IN DEEP-SEA AREAS

Deep-sea species tend to be more vulnerable to exploitation than species living in the more productive habitats near the surface or in shallow shelf and coastal waters. Often they have life-history patterns characterized by long life spans, a high age at first reproduction, slow growth and limited fecundity. This holds for many commercially exploited fish species and also for invertebrates that are actually or potentially affected by fishing activities.

The cold-water coral reefs of the Northeast Atlantic are an example of a vulnerable type of habitat. Biological diversity is particularly rich on these reefs and they are of major importance for fisheries, research and even as a source of marine genetic resources. Between 30 and 50 per cent of all coldwater coral reefs in Norwegian waters have been damaged or crushed as a result of bottom-trawling activities. It is uncertain whether destroyed reefs will regenerate and, even if they do, this will probably take a long time. Some coral reefs within the limits of Norway's EEZ have been given protection against certain fishing practices. These include the Sula ridge, the Iver ridge and the world's largest coldwater reef, the Røst reef, which was discovered in 2002. The use of fishing gear that is dragged along the bottom and that may come in contact with the reefs is prohibited in the protected areas.

Other particularly vulnerable deep-sea habitats are seamounts, hydrothermal vents (chemosynthetic ecosystems) and deep-sea trenches. Within the area of Norwegian jurisdiction there are no seamounts or hydrothermal vents similar to those known from the mid-Atlantic area further south. However, investigation of the extension of the Mid-Atlantic Ridge from Iceland northwards to the Arctic Ocean is an area of future interest.

The term 'seamount' usually refers to large isolated elevations of volcanic origin on the deep-sea floor. Several underwater sea-floor peaks that may be classified as seamounts have been identified from the new multibeam bathymetry data set of the Norwegian Sea acquired by the Norwegian Petroleum Directorate. These seamounts are related to the Mohns Ridge and the Knipowitch Ridge, the mid-ocean spreading ridges between Norway and Greenland north of Jan Mayen Is., and to a submarine ridge along the Jan Mayen Fracture Zone between the Vøring Plateau and Jan Mayen. These features rise between 1100 and 2200 m from the seafloor, and their summits reach up to a water depth of 1 500 to 600 m. A number of these seamounts are situated within the EEZ of Norway; several others are located on the extended continental shelf of Norway in the sense of Article 76 of the LOSC. So far, the seamounts of the Norwegian Sea have not been the subject of systematic marine biological research and their associated fauna is unknown. However, recent preliminary video studies by the Institute of Geosciences of the University of Bergen show high amounts of biological activity, including a rich benthic fauna concentrated on these seamounts. Further research is of crucial importance for the assessment and future management of these resources.

Underwater hydrothermal vents are hot water springs on the seabed associated with volcanic activity and are characteristic of the mid-ocean spreading ridges of the world's oceans. They are known to be the habitat of specialized faunas not seen elsewhere. Recently, earth scientists from the University of Bergen identified an interesting hydrothermal vent with a rich microbiological fauna on the Mohns Ridge just north of Jan Mayen. The scientists also found indications of several more vents along the Mohns and Knipowitch spreading ridges, and they expect that further research will confirm their existence and reveal still more. If so, most of these vents will be located within the EEZ of Norway and it is expected that some will also be identified on the Norwegian continental shelf beyond the EEZ. Again, further research is needed, both for scientific and for management reasons. There are no submarine trenches in the sense of subduction zones in the North Atlantic.

Article 8, *litra a*), of the Convention on Biological Diversity (CBD) requires Parties as far as possible to “establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity”. A protected area under the CBD differ from “a particularly clearly defined area”, as mentioned in Article 211, paragraph 6, of the LOSC, and is understood to be “a geographically defined area, which is designated or regulated and managed to achieve specific conservation objectives” (see Article 2). At the same time it is clear that with regard to the marine environment, the rights and obligations set out in the CBD must not be in conflict with those laid down in the LOSC (see Article 22, paragraph 2). The establishment of protected areas in the high seas would appear to be in conflict with the prohibition of the LOSC Article 89, under which “no state may validly purport to subject any part of the high seas to its sovereignty”. Equally, Article 137, paragraph 3, of the LOSC states that no claim, acquisition or exercise of any rights with respect to minerals recovered from the Area by any state or natural or juridical person shall be recognized. Further, it is quite clear that no marine scientific research activities can constitute the legal basis for any claim to any part of the marine environment or its resources.

It would thus appear that while state parties may undertake to designate protected areas under Article 8, paragraph a), of the CBD in areas under their jurisdiction and in accordance with the LOSC, no such areas can be established on the high seas.

6. FLAG-STATE JURISDICTION AND CONTROL OVER FISHING VESSELS ON THE HIGH SEAS

Articles 91-94 of the LOSC and the 1995 UN Fish Stocks Agreement give flag states a legal basis to exercise effective jurisdiction and control over ships flying their flag, including fishing vessels. At the core of these obligations is provision of a genuine link between a fishing vessel and the flag state that makes it possible to exercise effective flag-state jurisdiction.

The duties and obligations of flag states with respect to fishing vessels are specified in the FAO Code of Conduct for Responsible Fisheries, which is global in scope and relates to all living aquatic resources, and in the 1993 FAO Compliance Agreement. The latter forms an integral part of the FAO Code of Conduct for Responsible Fisheries and has recently entered into force. It applies to “international conservation and management measures” adopted and applied in accordance with the LOSC. Thus, it is not limited to species covered by the 1995 UN Fish Stocks Agreement.

The focus of the FAO Compliance Agreement is the authorisation of fishing on the high seas and the development of the concept of flag-state responsibility and of mechanisms to ensure the free flow of information on high-seas fishing operations. Article III (3) prohibits a party from authorising a fishing vessel to fish on the high seas unless it is satisfied, taking into account the links that exist between it and the vessel concerned, that it is able to exercise effectively its responsibilities under the Agreement

in respect of that vessel. It is thus up to flag states to ensure that the concept of flag-state responsibility is given meaningful substance and to exercise effective flag-state jurisdiction, also in relation to demersal fisheries.

Of particular concern is the growing trend in the use of “flag of convenience” (FOC) by fishing vessels. Flagging and re-flagging of vessels is easy and in some cases entails no more than a few moments’ work on the internet. “FOC” is a term often used in relation to states with open shipping registers. In a fisheries context, the term could have a wider application as the problem partly stems from the fact that it is “convenient” to use some specific flags to avoid binding conservation and management measures. In principle, states with restricted shipping registers could thus be regarded as FOC in relation to fishing. Under the LOSC flag states are obliged to ensure that their vessels follow relevant rules. However, some states are willing to sell their flag, with no questions asked, in exchange for the licence fee while exerting no control over the vessel’s activities.

7. PORT STATE MEASURES

International calls for enhanced port state measures are closely linked to the lack of effective exercise of flag-state jurisdiction and control. If all flag states exercised effective flag-state jurisdiction in relation to their fishing fleets, port state control would be more-or-less superfluous. The underlying principle formulated in Article 23 of the 1995 UN Fish Stocks Agreement is “the right and the duty” of a port state to take non-discriminatory measures in accordance with international laws in order to “promote the effectiveness of sub-regional, regional and global conservation and management measures”. Emphasis needs to be put not only on the “right”, but also on the “duty”, and some minimum requirements for port state controls should be developed.

In order to establish a workable system, port states should adopt harmonized mandatory obligations for control of foreign fishing vessels. Some RFMOs have already introduced some port state duties. MOUs would have a wider application as not all port states are members of a RFMO. There are regions where RFMOs are unlikely to be established and appropriate port measures might involve more than one RFMO. It may, however, be appropriate in most cases to link such a system to the existing RFMOs.

Parties to a RFMO are most likely both fishing nations and states having responsibilities as port states. This may facilitate mandatory port state control for both contracting and non-contracting party vessels as a part of the organisation’s conservation measures, which could have a great impact on IUU fishing. However, vessels conducting IUU fishing move from one region to another and are therefore not the concern of one RFMO alone. In order to establish a comprehensive system, developing a MOU on port state control between such bodies could be a way forward. In that context port states should have the duty to take action against vessels that have participated in IUU fishing in areas managed by other regional bodies. Therefore, RFMOs should be encouraged to enter into multilateral agreements on port state control. Such cooperation would be essential in areas where IUU fishing is the concern of two or more regional bodies.

8. SUMMARY AND FUTURE ACTIONS

Future efforts to ensure the long-term conservation and sustainable use of deep-sea resources, improve co-operation between states to that end, avoid adverse impacts on the marine environment, preserve biodiversity and maintain the integrity of marine ecosystems in the high seas, must be based on harmonisation of treaty obligations and involve all relevant international organisations and treaty bodies. Any new regimes concerning deep-sea resources and ecosystems should be based on a global agreement building on the 1982 UN Law of the Sea Convention and modelled on

the 1995 Implementation Agreement relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. A global agreement for the implementation of the relevant provisions of the LOSC as well as other relevant conventions, such as the Convention on Biological Diversity, would best serve the purposes mentioned above and contribute to the maintenance of international peace and security.

At the same time, international calls for more effective enforcement by flag states, port states and coastal states must continue as well as efforts to ensure the universal acceptance of and adherence to existing instruments such as the LOSC, the 1995 UN Fish Stocks Agreement and the FAO Agreement to Promote Compliance with international Conservation and Management Measures by Fishing Vessels on the High Seas (the 1993 FAO Compliance Agreement), as well as the FAO Code of Conduct for Responsible Fisheries and related Action Plans. Consultations on future directions of the governance and management of deep-sea fisheries and ecosystems should take place at the UN General Assembly and in co-operation with all relevant Law of the Sea institutions, including the International Seabed Authority, UN agencies and organisations as well as Convention on Bio-diversity related bodies.

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Part 1: Conference reports

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