Australian Society for Fish Biology
Workshop Proceedings

Establishing meaningful targets for bycatch reduction in Australian fisheries

Hobart 24-25 September 1998

Colin Buxton & Steve Eayrs (editors)

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FISHERIES RESEARCH & DEVELOPMENT CORPORATION

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CSIRO MARINE RESEARCH

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Foreword

Pat Dixon

President
Australian Society for Fish Biology

This workshop entitled *Establishing meaningful targets for bycatch reduction in Australian fisheries* continues a series that commenced in 1985 by the Australian Society for Fish Biology. The major objective of the workshops has been to focus national expertise on an issue that has regional or national significance. The proceedings are now widely regarded as the benchmark of current knowledge on the subject area.

In the face of international efforts to manage fisheries under an environmentally sustainable development framework, this workshop was a timely examination of bycatch issues in Australian fisheries. Bycatch is a major component of fisheries worldwide and considerable effort is now being focussed on ways of reducing the number of unwanted species in the catch. Clearly Australia is at the forefront of this field and can provide international leadership on methods of addressing the problem.

The workshop provided a summary of the status of bycatch in the breadth of Australian fisheries from prawn trawling in the Northern Prawn Fishery, lobster fisheries in the south and recreational fisheries to tuna longlining in Commonwealth waters. The problems are diverse. Attention was also focussed on several important generic issues such as defining bycatch, sustainability, trophic consequences, discarding and extension services. Importantly the views of different stakeholders were canvassed, including industry and conservation.

The proceedings follow the established format of recent years with papers delivered by invited speakers followed by rapporteurs' reports of the ensuing discussion. As expected these were detailed and thought provoking.

Several people contributed to the success of the workshop. The workshop topic was developed under the auspices of the *FRDC Effects of Trawling Subprogram* and Colin Buxton, Ian Poiner and Steve Eayrs had the difficult job of putting it all together. They were ably assisted by the '98 ASFB conference committee, in particular, Cathy Bulman who worked tirelessly to provide all of the logistical support with help from Caroline Sutton, Naomi Clear, Anne Preece and Russ Bradford of the CSIRO who recorded the proceedings. Don Hancock also helped with the proofreading of the text.

The Society gratefully acknowledges the Fisheries Research and Development Corporation, the Tasmanian Aquaculture and Fisheries Institute and the Australian Maritime College who provided financial support for the workshop, and the CSIRO Marine Research who hosted the meeting and provided the venue and logistical support.

Finally, these proceedings could not have been produced without the effort of the editors, Colin Buxton and Steve Eayrs.

Message from the FRDC

Peter Dundas Smith

Executive Director
FRDC

As Australia's leading investor in fisheries research and development the Fisheries Research and Development Corporation (FRDC) was proud to be the principal sponsor of the 12th Australian Society for Fish Biology Workshop entitled: *Establishing meaningful targets for bycatch reduction in Australian fisheries.*

The FRDC is committed to helping Australia's fishing industry to be the world's best – internationally competitive, highly profitable and ecologically sustainable.

A key element in achieving ecologically sustainable fisheries is addressing the issue of bycatch – not only reducing unwanted catch but also increasing the usage of underutilised species by finding new products and new markets.

Through its various programs the FRDC is a key partner in the many national projects which are addressing the bycatch issue – from production to the plate.

We believe that the workshop demonstrated the dynamic partnership between industry, research and community in addressing the issue – providing a benchmark against which further progress towards our aim can be made.

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Introduction

Colin Buxton

Chairman – 1998 ASFB Workshop Organising Committee and Director of the Tasmanian Aquaculture and Fisheries Institute

Ladies and gentlemen, welcome to Hobart and the 12th Australian Society for Fish Biology (ASFB) Workshop entitled: *Establishing meaningful targets for bycatch reduction in Australian fisheries.* This year the workshop is a joint project between ASFB and the Fisheries Research Development Corporation's Effects of Trawling Subprogram.

In the 1990s bycatch has become a major issue in world fisheries with estimates of as much as 40 percent of the world's catch being discard or under-utilised species. There is a premium on addressing this issue, particularly in terms of the sustainability of bycatch. Australia has a long, and more recently rich history of addressing the bycatch problem, especially in our demersal prawn trawl fisheries. Blubber chutes have been used for years in the estuarine prawn trawl fisheries in New South Wales and recent work in the Northern Prawn Fishery has seen the introduction and acceptance of bycatch reduction devices with twofold benefits: the first to reduce the catch of large animals, including turtles, sharks, rays and seabed debris; the second improved quality of the catch through lessening the damage done by this large material in the net. Following extensive research the Commonwealth has recently introduced a seabird threat abatement plan to address the catch of seabirds in the tuna longline fishery.

The topic of this year's workshop was chosen to address the next stage of addressing the problem – establishing bycatch targets.

Recognising that this is an ambitious task and that establishing targets for all fisheries is beyond the scope of this meeting, the goals of the workshop are to:

- clearly define the problem;
- discuss issues associated with bycatch particularly in the context of sustainability of the ecosystem;
- detail our knowledge base and identify shortcomings in research; and
- discuss two case studies.

We hope that this will provide a substantial framework for our deliberations over the next two days.

The program for the first day contains a mix of short presentations with the opportunity to discuss issues both after each talk and in the general sessions. On day two we will examine two case studies, the NPF and the Oceanic Longlining Threat Abatement Plan.

I would like to thank our main sponsor, the FRDC Effects of Trawling Subprogram, as well as the Australian Maritime College and the Tasmanian Aquaculture and Fisheries Institute for their generous financial support. I would

also like to thank my co-convenors, Ian Poiner and Steve Eayrs, for their help with the program and especially Cathy Bulman of the ASFB Conference Organising Committee for her assistance behind the scenes.

Without further ado it gives me great pleasure to call on Mr Stuart Richey, well known Tasmanian fishing personality, Chair of the Tasmanian Fisheries Industry Council and Vice-Chair of the Australian Fisheries Management Authority Board, to present his address and open the workshop.

Opening Address

Stuart Richey

Chair of the Tasmanian Fisheries Industry Council and
Vice-Chair of the Australian Fisheries Management Authority Board

Thank you for those kind words of introduction and for the opportunity to present some thoughts today on the important issue of bycatch.

Over the past few years, bycatch from fishing operations has become a high profile and highly emotive issue. I think we can all see that if we don't manage bycatch properly we could end up with a degraded environment, unproductive or unsustainable fisheries, possible fishery closures, and loss of jobs and income. On the other hand if we do handle bycatch properly, the prospects of a continued healthy environment, viable fisheries, employment, income and fresh seafood for the Australian community are good.

I don't think anyone likes to see waste or environmental damage, no responsible person likes to see a drowned albatross or a stranded turtle, yet those are the sorts of images that we are seeing more often on television and in the other media. Those sorts of images get people fairly emotional. All sorts of people are now forming views about bycatch.

What we are seeing with bycatch, and fishing generally, are public perceptions being moulded by typically alarmist and unbalanced media reports, like graphic TV footage of birds or mammals being caught, injured or killed, or juvenile fish being discarded. Such pictures, misrepresentative as they may be, paint more than a thousand words. Because of such perceptions, I think that how we, the broader fishing community, handle this issue of bycatch will play a big part in how we fare into the 21st century.

That's not to say that we haven't already made some excellent progress on bycatch and bycatch reduction, which I will mention later in my talk. But, as a result of these growing perceptions, I think the public and a wide range of government and non-government groups are closely monitoring how we, as the broader fishing community, are dealing with and performing on the issue of bycatch.

It is unfortunate, but many of these people, in the absence of other information, will judge our performance largely by what they read in the newspapers, hear on the radio or see on television. As someone who is often out on the water fishing and also actively taking part in fisheries management and research, I can tell you that I'm not happy about that! It doesn't help me sleep any better at night knowing that media reports with images such as turtles or dugongs caught in nets are going to air. It upsets me to know that these reports may unjustly jeopardise the future, not just of the industry, but of all Australians who enjoy fresh healthy seafood and benefit from the jobs and income that fishing generates.

As a fisheries community, how can we respond to such adverse reports and the perceptions that they create?

To address bycatch and to be able to demonstrate our performance with bycatch reduction, the fisheries community needs to be rock solid in its approach, clear about its aims and definitions and to set targets by which we, or anyone else, can actually measure our performance. As I understand it, those are among the key reasons for holding this workshop and I hope that we can all in some way help progress these bycatch issues here over the next two days.

I deliberately opened my talk today with what you might call the prickly side of bycatch. I did that to stress the importance of what we are doing here, to set the scene a bit and hopefully provoke a few thoughts on the issue. I like to think that every potential problem presents an opportunity for a solution or a better way of doing things. That is certainly the case with bycatch. For example, the bycatch issue is giving us both a reason and an opportunity to develop more selective gear and also to find markets and make better use of our under-utilised catch. That has to be a good thing.

As I stated before, the Australian fishing community has already made considerable progress on the issue of bycatch and bycatch reduction. It would be fair to say that we are streets ahead of many nations in aspects of addressing bycatch. The mandatory use of tori poles on longliners is just one example that comes to mind. By the same token we should keep looking to what has been done around the world so that we are not re-inventing the wheel or the square mesh panel or whatever it might be. In particular, I'm thinking in terms of gear design and bycatch reduction devices. Let's see what has been done by other countries, test their designs, adapt them to our conditions, just as we have done with the bycatch reduction and turtle exclusion devices in the Northern Prawn Fishery (NPF).

In the remainder of this talk I would like to acknowledge some of our other advances, talk about some of the success stories, why they were a success and add a few thoughts on where we go from here.

Firstly, I should say a few words on the development of a bycatch policy for Commonwealth fisheries. This developing policy has already been a significant step forward in our effort to address bycatch. The Australian Fisheries Management Agency (AFMA) has played a pivotal role in developing this policy to date and it is worth noting that the ministerial Standing Committee on Fisheries and Aquaculture has now adopted the Commonwealth policy as a basis for developing a national bycatch policy. I think this is a tremendous tribute to AFMA's efforts and to the taskforce that drafted the document.

Amongst other things, the Commonwealth Bycatch Policy paves the way for the Australian industry to meet Australia's obligations for managing our seas and fisheries. This includes meeting our international obligations such as those under:

- the United Nations Convention on the Law of the Sea;
- the United Nations agreement on straddling fish stocks and highly migratory fish stocks; and
- the Food and Agriculture Organisation's code of conduct for responsible fishing.

What I particularly like about the Commonwealth Bycatch Policy is that it not only sets the big picture framework but provides practical guidelines for developing bycatch action plans for each major Commonwealth fishery. Based on the draft policy, AFMA has developed more detailed guidelines for the management advisory committees on key components of fishery specific bycatch action plans. Under the Commonwealth policy, bycatch action plans for major Commonwealth fisheries are due to be completed within a year of the policy launch. To its credit though, the management advisory committee for the NPF was particularly pro-active and developed an action plan for the fishery even before the Commonwealth policy and guidelines were drafted.

At a practical level, the Commonwealth Bycatch Policy is designed to complement existing initiatives and provide further protection for species such as albatrosses, dugongs and turtles. What I find most pleasing about the policy is the emphasis on a partnership between the various stakeholders in the fisheries community. I think this is critical for achieving realistic goals, practical solutions, and effective management measures. For example, I think it is absolutely vital that industry be included in the research and management loops at the earliest possible stage, when we do this I think we maximise the chance of achieving practical, workable outcomes.

In this regard, some of the things that have been happening in the South East Trawl Fishery (SEF) over recent months have been very encouraging. I refer to the workshop at the end of July on maximising yield and reducing discard in the SEF. This workshop was notable for the strong attendance by members of the fishing industry as well as other stakeholder groups. Better still, the workshop provided the opportunity for industry members to help clarify the issues and have their say in the development of a FRDC-funded research proposal addressing discarding in the fishery. Industry participants at the workshop strongly supported finding solutions to discarding problems and said they would back research which would achieve this. The industry members also stressed the importance of industry involvement in both developing and undertaking the project.

Since then the industry has been involved in helping to draft the proposal for a project to evaluate the ability of various modified trawl gear to reduce catches of small fish. It is worth noting that the proposed research would be carried out on available industry-nominated vessels with close involvement and communication with industry. I can't think of too many cases where industry has had such an involvement in developing a research proposal. It is also worth noting that, under this proposal, the ability of gear to reduce discards would be measured against bycatch targets and indicators in the bycatch action plan for the fishery. This plan is being developed by a working group of the South East Trawl Management Advisory Committee (SETMAC).

To me, this is a prime example of how research is being successfully aligned with management objectives and how the early involvement of industry and other stakeholders is helping to achieve the best results. I should mention that significant progress towards the development of a bycatch action plan has already been made in the SEF. SETMAC recently looked at the scope of such a plan and endorsed a range of options to be considered in developing this plan.

Key issues and objectives for this bycatch action plan are likely to include:

- discarding and how to reduce it;
- the impacts of trawling – how to keep these to a minimum while maximising yields;
- investigation of alternative management strategies including things like voluntary or

mandatory gear modifications, species substitution, marine protected areas or other forms of closure; and importantly

- the issue of public awareness. How we raise it and change the public perceptions of trawling and its impacts.

While I am talking about bycatch initiatives in Australia, it would be an oversight not to mention the work that has been and continues to be carried out in the NPF.

As I mentioned earlier, the NPF Management Advisory Committee (NORMAC) was first cab off the rank as far as developing a bycatch action plan for the fishery and it is pleasing to see that the development of that plan is one of the case studies that we will be looking at during this workshop. The plan was largely driven by growing public concerns and the United States trade embargo on prawn imports from countries not using certified turtle devices.

Of course, collaborative bycatch research has been carried out in the NPF for a number of years now and I think we can all learn from that experience. In particular, the way the bycatch reduction gear, supershooters, Nordmore grids, fish eyes and the like, are being developed, tested and modified for Australian conditions, is excellent. As I said before, we shouldn't try to re-invent the wheel on any of this. If somebody overseas has developed something for excluding turtles from prawn trawls or reducing our catch of non-target species or juvenile fish, let's have a look and see if it will work here.

To their credit, that's exactly what the NPF researchers have done. A key reason that the NPF research has been so successful to date, and a key reason why mandatory introduction of turtle exclusion devices in the year 2000 has gained industry support, is that the industry has been involved from the early stages. I can't stress enough the importance of industry involvement in bycatch work and particularly in gear development.

In the NPF, the operators have helped to develop, modify and trial the gear, they have had scientists on their boats and, most importantly, they have been able to see how the various nets work on their fishing vessels. This means that they haven't had to rely just on what a scientist has told them but have been able to judge for themselves how well the nets are excluding the unwanted catch and retaining the prawns. In this way, the operators have become a party to the research and it is much easier for them to accept new methods.

In the lead-up to the mandatory introduction of bycatch reduction devices, NORMAC has appointed a bycatch reduction device sub-committee to help bring together relevant research and information. Again, it is good to see this sub-committee is made up of net manufacturers, trawl operators, gear researchers and AFMA management and compliance staff.

I've talked a fair bit about the involvement of industry in research and management but, of course, the people who are actually out on the boats catching the fish have a big part to play in this whole issue of bycatch. In everyone's interests, fishing operators have a responsibility to minimise the catch of non-target species, particularly any marine mammals, reptiles or seabirds, and to minimise discards and waste associated with fishing.

In this regard, the recent release of the *Code of Conduct for a Responsible Seafood Industry* has been an excellent initiative and full credit to the Australian Seafood Industry Council (ASIC) for bringing that together. The code, which is based on the FAO Code of Conduct for Responsible

Fishing, sets out the principles and standards of behaviour for responsible practices that give rise to effective conservation, management and development of resources with due regard for the ecosystem and biodiversity. It specifically addresses bycatch and discarding and covers the commercial catching, aquaculture, processing and marketing sectors of the industry. It should be noted that the code is voluntary, except in so far as parts of it are legally binding through legislation or agreements.

In the industry, we need to keep raising the awareness of each operator, not only to the code itself, but to the sorts of practices that will reduce bycatch and help sustain fisheries and their supporting ecosystems. I think it would be fair to say that most operators don't want to see waste or damage to the resource that is providing their future income, but, as with most education projects, we still have a way to go in achieving 100 per cent uptake.

Even before the broad industry code of conduct was released, the SEF industry association showed great initiative in developing an industry code of conduct for responsible fishing, which was also based on the FAO code, and was specific to the SEF.

The code provides more detailed guidelines and standards of behaviour for fishing operators than the broad industry code. The trawl fishery code includes a number of specific standards and practices for reducing waste and bycatch, such as:

- developing and employing selective gear;
- discouraging the use of inappropriate gear and practices;
- fostering biodiversity, population structure, ecosystem and fish quality; and
- sharing information on new developments and requirements.

Like the broad industry code, the SEF code is voluntary, except in so far as parts of it are legally binding through legislation or agreements. It was provided to operators in the fishery as an attachment to the recently released management plan.

There can be no doubt that industry has important obligations relevant to bycatch and fishery specific codes of conduct, whether they be attached to the management plan or not.

In talking about Australian bycatch initiatives I should also mention the work being done in our tuna and longline fisheries and, in particular, in developing the threat abatement plan for the incidental catch of seabirds. Various initiatives and measures to reduce seabird bycatch in tuna longlining have been undertaken over recent years and immediately I think of things like:

- use of tori poles on foreign boats;
- voluntary use of thawed baits and night setting;
- mandatory use of tori poles for all vessels in southern waters; and
- development of bait casting devices.

The threat abatement plan released by the Minister for the Environment in August this year, includes further requirements designed to reduce the seabird bycatch. These include:

- requirements to set lines at night;
- requirements to use weights on the branch lines; and
- implementation of a pilot observer program to monitor seabird bycatch and identify any particular problem areas.

AFMA was closely involved in the plan's development over the past year, in consultation with the fishing industry, conservation groups and scientists. Release of the plan followed a three-month public consultation period and

AFMA is looking to implement a package of regulations relevant to the threat abatement plan over the next year. It is pleasing to see that AFMA and Environment Australia are seeking further industry input through a specially designed survey to help target further education strategies relating to the plan. As I've indicated before, it is a big plus if you can get broad industry support prior to implementing various regulations or programs.

In conclusion, I think most of us would agree that there are a lot of good things happening in Australia in terms of addressing the bycatch issue and I think that workshops like this are taking us in the right direction. We do need to be more meticulous in setting the bycatch framework and parameters than we have been in the past and I think the Commonwealth Bycatch Policy and individual action plans are helping us to do that.

We also need to be more thorough in our definitions, our targets and performance measures. While we have made some headway in these areas, I sincerely hope that we can progress them further at this workshop today and tomorrow. At the end of the day we need to find practical and cost-effective solutions to the challenges we are facing. We need to set realistic targets, and develop sound strategies to achieve sensible outcomes.

I think it is fair to say that we will never eliminate bycatch while we have anyone, commercial, recreational, whoever, throwing a net or a line in the water. What we need to do is find the balance between minimising bycatch and ensuring that we have continuing viable fisheries for the benefit of all Australians. I think to do that we have got to continue to work closely together. You can call it collaboration or a partnership approach, but the bottom line is that two, three or thirty three heads are better than one.

As I indicated earlier, there are some potentially serious consequences if we don't handle the bycatch issue. However, as a community, we have the opportunity to ensure that the agenda is not stolen by extremist, sentimentalist or alarmist views.

It gives me pleasure to declare this workshop open and I wish you well in your deliberations.

Session 1

An overview of bycatch in selected Australian fisheries

Chairperson:	Nick Rawlinson
Speakers:	David Brewer Julie Robins Ian Knuckey Geoffrey Liggins Dennis Heinemann Stewart Frusher David McGlennon
Rapporteurs:	Nick Rawlinson Steve Eayrs

Northern Prawn Fishery status report

David Brewer

CSIRO Marine Research
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Abstract

Australia's Northern Prawn Fishery (NPF) catches average 8,000-10,000 tonnes of prawns per year, worth between A$100 and A$150 million. However, it also takes roughly eight to ten times that amount in unwanted bycatch, much of which dies. The majority of the bycatch is several hundred species of small fish, but animals of greater public concern such as turtles, sharks and sea snakes are also caught. In the past five years several Fisheries Research & Development Corporation (FRDC) funded projects have focussed on describing this bycatch, developing and testing devices to reduce the amount of bycatch caught and assisting fishers to begin using some of these devices. There is now a body of evidence showing that turtle excluder devices (TEDs) and bycatch reduction devices (BRDs) can reduce the amount of unwanted bycatch from prawn trawl catches, without significant loss of prawns. A summary of the research relating to bycatch in the NPF is presented.

Future bycatch issues in the NPF may include: the impact of prawn trawling on elasmobranchs due to recent increases in the price of fins and their vulnerability to overfishing; the unknown impacts of trawling on sea snake populations; how the performance of TEDs and BRDs should be assessed; and setting targets for bycatch reduction. Setting targets should act to increase the level of bycatch reduction and the rate of improvement in TED and BRD performance, however, benefit-based incentive should be the cornerstone of any target setting action.

In the NPF where there is a range of bycatch species, separate targets are needed for each group, based mainly on what can feasibly be achieved. For example a target for sea turtles catch reduction can feasibly be set at 90% or more, but for finfish it is not realistic to set an initial target of any more than a 20-30% reduction. How these targets are measured should also be carefully considered.

Introduction

The Northern Prawn Fishery (NPF) first started in the late 1960s, and includes about one million square kilometres of Australia's northern tropical seas (Figure 1). During its history there have been many changes including fluctuations in catches, prawn prices and profitability, eventually leading to effort reduction (Robins and Somers 1994). Until the 1970s most of the fishing effort was directed to catching banana prawns (*Penaeus merguiensis*), but since the late 1970s more than double the effort has been directed towards fishing for the higher-priced tiger prawns (*Penaeus semisulcatus* and *P. esculentus*). Today the NPF is one of Australia's most valuable fisheries with annual production of about A$100 million (Dann and Pascoe 1994). It currently supports 127 trawlers that catch between 8,000 and 10,000 tonnes of prawns per year. Detailed information on the history, stocks, economics, marketing and management of the fishery is summarised in Pownall (1994) and Taylor (1998).

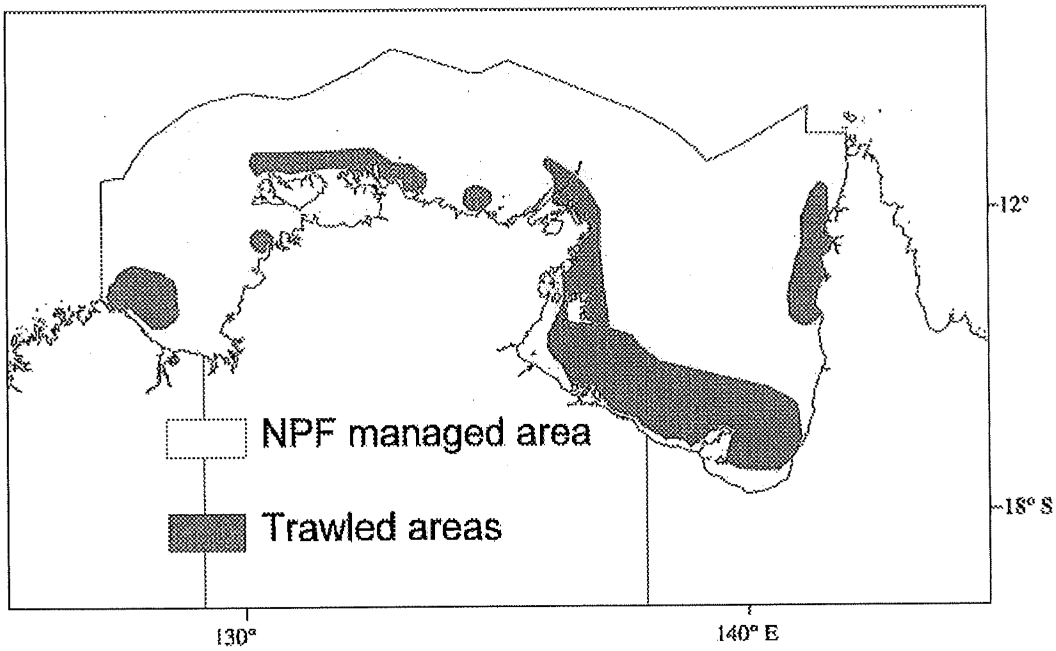

Figure 1. Northern Australia showing the Northern Prawn Fishery managed area and the portion that has some level of prawn trawl effort (AFMA).

This paper presents a status report on what we currently know about NPF bycatch, by describing what is caught as bycatch, issues to be resolved, results obtained so far and factors that may influence setting realistic targets for bycatch reduction in this fishery.

1. What is caught as bycatch?

A definition of bycatch

For the purposes of this study bycatch is defined as all the non-retained catch. Target species and byproduct (e.g. large fish, squid, and Moreton Bay bugs) are not bycatch, but everything else that is caught and discarded is bycatch, including species where some part is kept (shark fins) and the rest discarded.

Composition of NPF bycatch

The NPF covers a vast geographical range and it is not surprising that the composition of the bycatch differs between fishing areas (Figure 2).

In the tiger prawn fishery, the bulk of the catch is made up of small finfish while prawns comprise 5%-20% of the catch. When fishing on banana prawn schools (*Penaeus merguiensis*), the catch can be up to 100% prawns, but occasionally may be 100% finfish bycatch.

Catches of fish are mostly small, unwanted species that die and are discarded into the sea. NPF trawlers catch over 400 species of finfish. Prawn trawls are not well designed to catch larger mobile fish and those that are caught are either discarded or kept as byproduct.

NPF trawlers catch more than 40 species of sharks, rays and sawfish (elasmobranchs), although most are rare in the catch. They make up more than 10% of catches by weight in many areas (Figure 2), but less than 1% by numbers. Usually only one or two elasmobranchs are caught per trawl. Most are relatively small sharks or rays (<5 kg) but some may be very large animals.

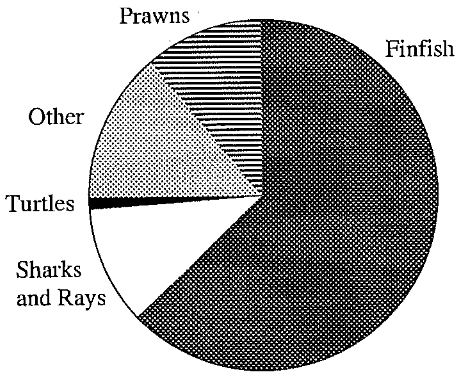

Figure 2. A generalised representation of the catch on NPF trawlers.

The remainder of the catch is made up of small amounts of a variety of species, including byproduct species such as squids, cuttlefish and Moreton Bay bugs; unwanted sea bed animals such as sponges and other benthic invertebrates; and marine reptiles such as turtles and sea snakes.

2. The bycatch issues

Sea turtles

Declines in sea turtle populations are a major concern worldwide. In Queensland, declines in the number of female sea turtles nesting in rookeries on the east coast were reported in the 1980s by government and conservation organisations. The numbers of leatherbacks *(Dermochelys coriacea),* are considered to be dangerously low. Queensland east coast prawn trawlers were known to catch turtles and were partly blamed for the decline. This concern flowed on to the NPF where prawn trawling and sea turtles also coincide.

Six species of sea turtles live in the prawn trawling areas of the NPF: the flatback (*Natator depressa*), olive ridley (*Lepidochelys olivacea*), green turtle (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) (Poiner *et al.* 1990). The first four nest on beaches adjacent to trawling areas in the NPF (Cogger and Lindner 1969; Bustard 1972; Limpus *et al.* 1983; Limpus and Reed 1985). Loggerheads are listed as 'endangered' in Australian waters, while olive ridley, green and hawksbill turtles are 'vulnerable' under criteria within the *Endangered Species Protection Act 1992.* Concerns for the impacts of prawn trawling on these species in the NPF influenced the funding of several research studies and raised the participation level of conservationists in the issue.

Poiner and Harris (1996) assessed catch rates and mortalities of sea turtles in the NPF. They found that 567 (± 140) drowned in trawl nets in 1989, and 943 (± 187) drowned in 1990. However, they suggested that trawl-induced drowning is not the major impact on turtle populations, although measures to reduce drowning and delayed mortality would be desirable. In the meantime, trawling has been nominated as a 'threatening process' to turtles under the *Endangered Species Protection Act 1992.* This act essentially states that any process (e.g. prawn trawling) that represents a threat to a species that is vulnerable to extinction can be nominated as a 'threatening process'. If the nomination is upheld, then that process must introduce a suitable threat abatement plan or risk being prohibited. Prawn trawling in Australia, including the NPF, is currently under such assessment.

The NPF has been pro-active in addressing the turtle issues by providing logbook data on sea turtle catches, participating in sea turtle workshops and trials of turtle excluder devices (TEDs). The Northern Prawn Fishery Management Advisory Committee (NORMAC) has developed a 'Bycatch Action Plan' (Anon 1998) that includes the compulsory use of TEDs in all prawn trawling starting no later than the beginning of the season in the year 2000. Preliminary assessments indicate that TEDs can virtually eliminate sea turtles from trawl catches without significant loss of prawn catch (e.g. Brewer *et al.* 1998).

Small fish

Australia's tropical seas are among the most productive in the world, supporting highly diverse, demersal communities. More than 400 species of fish are taken as bycatch in the NPF. A study by Pender and Willing (1989) reported that more than 30,000 tonnes of unwanted organisms (mainly fish) were discarded from NPF trawlers in one year. These discards dominate prawn trawl catches, with the ratios of unwanted bycatch to prawns reaching 20:1 or higher in some areas, (Pender *et al.* 1992a; Brewer *et al.* 1998). These catches of small fish, mostly discarded dead, are a cause for concern for fishers, scientists and other groups.

In a survey of the bycatch concerns of fishers, small fish ranked highly as a group that they would most like to remove from catches (Rawlinson and Brewer 1995). They occur in virtually every trawl, usually in large numbers. Reducing fish bycatch numbers would reduce sorting times and improve prawn quality.

Australian fisheries are obliged under the *Commonwealth Fisheries Management Act 1991* to "ensure that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development and the exercise of the precautionary principle, in particular the need to have regard for the impact of fishing activities on non-target species and the long-term sustainability of the marine environment". Currently, there is not sufficient information to assess whether prawn trawling is causing long-term changes to the many species of fish taken as bycatch. This uncertainty has also contributed to the concerns over fish bycatch in the NPF.

Sustainability of demersal communities

As noted above, there is a requirement for Australian fisheries to be managed in an ecologically sustainable manner, including all non-target species and the marine environment. This has implications beyond the impacts on species that are taken by the gear. Examples include direct mortalities on species that escape through trawl meshes during trawling, indirect impacts on benthic invertebrates, changes in species composition due to selective harvesting by trawls and impacts on species that eat the discarded bycatch (seabirds, sharks, cetaceans, etc). Although some of these sustainability issues are difficult to address, it is essential for the future of the fishery that our knowledge of all impacts on non-target organisms is greatly improved.

US trade embargo

We recently saw an example of how strong conservation lobbies can threaten trawl fisheries. In 1996 the Earth Island Institute won a ruling in the United States Court of International Trade that prohibited the importation of shrimp from countries not using turtle excluder devices. Australia was one of the countries embargoed.

Although we export less than 1% of our wild-caught prawns to the United States, and although an appeal to the World Trade Organisation to overturn the ruling is currently being considered, it demonstrates the degree of influence that conservation groups can have on fisheries management.

Future issues

The impacts of the *Commonwealth Fisheries Management Act 1991* and the *Endangered Species Protection Act 1992* on the prawn trawling industry are ongoing. This effectively means that the NPF's impacts on the marine environment and specifically on potentially vulnerable species, will be continually assessed. It is difficult to predict what the main future issues will be, but some of the most apparent are the impacts on elasmobranchs, sea snakes, benthic communities and ongoing assessment of the performance of TEDs and bycatch reduction devices (BRDs).

Elasmobranchs

Prawn trawls appear to be very good at catching epibenthic elasmobranchs. These include sting rays, guitar rays (or shovel-nose rays) and sawfish. Although the catchability of these and other elasmobranchs is not known, they occur commonly on NPF sorting trays (one per 1.5 trawls off Weipa [Brewer *et al.* 1998]).

The concern for these species stems from several sources: anecdotal evidence of their declines over the last decade; the recent surge in finning large elasmobranchs for Asian markets (guitar rays and sawfish have very large and 'desirable' fins); and their reproductive strategy. These fish are live bearers, have long gestation periods and produce only small numbers of pups, making them more susceptible to overfishing than most other species (Last and Stevens 1994). Most of these rays are listed as having 'uncertain' status under the *Conservation Status of Australian Fishes 1997*.

Recent research has shown that the introduction of BRDs should greatly reduce catches of large rays by excluding them through an escape hole in the net before they reach the codend (Brewer *et al.* 1998). Notwithstanding this, the impact on smaller species of rays may not change after TEDs and BRDs are introduced into the fishery.

Several species of sharks are commonly caught in NPF trawls, and have also recently suffered higher mortalities due to the recent upsurge in finning. On the other hand, there are arguments that shark populations may be artificially high from the availability of large numbers of discarded fish, and that larger numbers of some species of sharks will eat larger numbers of commercially important prawns (Brewer *et al.* 1991). For these reasons, fishers have an interest in the viability of shark populations.

Sharks are also more susceptible to overfishing than other species and for most of the same reasons as the rays. Most species of sharks may be more mobile and less catchable than rays, but without information on their catchability and population status, it is very difficult to assess vulnerability. Catches of all sizes of sharks should decrease with the introduction of TEDs and BRDs (Brewer *et al.* 1998), but it is not clear by how much.

Sea snakes

Like sea turtles, sea snakes have the potential to be a specific target for protection by conservation groups. However, unlike turtles, their vulnerability has not been assessed.

There are at least 14 species of sea snake caught by NPF trawlers and more than 120,000 individuals are caught in the Gulf of Carpentaria each year (Wassenberg *et al.* 1994). About 48,000 of these do not survive but this number could be halved with the introduction of certain TEDs and BRDs (Brewer *et al.* 1998).

There are no logbook data that can track changes in sea snake populations and very little is known about their population sizes, catchability, or biology. Without some of this information it is difficult to assess the vulnerability of sea snakes to trawl impacts, and equally difficult to counter potential claims that they may be threatened in the NPF.

Performance assessment of BRDs

There have been at least 18 different versions of TEDs and BRDs used in research trials in the NPF, with a selection of these trialed on NPF trawlers. All of these trials improved the performance of TEDs and BRDs in the NPF. TEDs and BRDs will be compulsory from the start of the fishing season in the year 2000. Until TEDs and BRDs are used consistently by the whole fleet, an accurate assessment of their performance cannot be made. Regular assessment of the performance of TEDs and BRDs will be a vital tool for managers and industry in this climate of increasing concern over the impacts of trawling.

3. What research has been done?

There is a large body of literature reporting the research and development associated with the NPF over the past 25 years but comparatively little has focussed on bycatch populations, bycatch reduction and bycatch survival (Table 1).

The studies of fish bycatch and fish populations are from limited areas in the NPF. While this provides a baseline for future comparisons there is very little information on most other groups and for much of the NPF. Data on sea turtles and sea snakes are limited and very little is known about benthic invertebrates that occur in NPF bycatch. Current FRDC-funded projects are describing or monitoring NPF bycatch and will greatly improve our knowledge of most of the groups caught as bycatch.

There is limited information on the performance of various TEDs and BRDs in the NPF, but a current FRDC-funded study will increase our knowledge of their performance in the fishery. There is very limited knowledge on the damage to animals that escape from TEDs and BRDs or their survival rate, and nothing known about what escapes or survives from standard trawl nets. There is also little known on the fate of discarded catch after sorting in the NPF, the behavioural reaction of animals to trawls or TEDs and BRDs, and unseen mortalities of trawling such as the impacts of trawls on seabed animals.

4. Setting targets for bycatch reduction – issues and action

Why set targets?

The question of whether targets should be set for bycatch reduction is not a straightforward one. A bycatch reduction program must have the ultimate aim of reducing the impacts of trawling on non-target species. Minimising trawl impacts on non-target species, setting aside suitable Marine Protected Areas (MPAs) or a combination of the two may achieve this.

The only way to assess the state of demersal communities is quantitative analysis. Their response to fishing can be gauged by comparing fished and unfished areas (e.g. Pitcher *et al.* 1997), or by comparing current with historical data sets from the same fished areas (e.g. Harris and Poiner 1991). The same type of quantitative assessment can measure changes brought about by reducing bycatch.

A general process for managing bycatch reduction is shown in Figure 3, including a role for setting targets for bycatch reduction.

Table 1. Summaries of research to date on NPF bycatch.

Research category	Reference	Summary of results
NPF bycatch studies	Willing and Pender 1989	Length-weight relationships for 45 fish and invertebrates from the NPF fishery
	Pender and Willing 1990	NPF bycatch market potential study
	Ramm, Pender, Willing and Buckworth 1990	Patterns of abundance within fish communities caught by NPF trawlers
	Harris and Poiner 1991	Changes in species composition of prawn trawl bycatch from south east Gulf of Carpentaria (GOC), after 20 years of fishing
	Pender, Willing and Ramm 1992	Distribution, abundance, size and use of NPF bycatch
	Wassenberg, Salini, Heatwole and Kerr 1994	Capture of sea snakes in prawn trawlers in the GOC
	Poiner and Harris 1996	Capture and mortality of sea turtles in the NPF
	Eayrs, Buxton and McDonald 1997	A guide to BRDs in Australian prawn trawl fisheries
Related community studies	Rainer and Munro 1982; Rainer 1984	Studies of demersal fish and cephalopod communities in the south east GOC
	Okera and Gunn 1986	Exploratory trawl surveys in NPF waters
	Blaber, Brewer, Salini and Kerr 1990	Population ecology of fishes in north east GOC
	Harris and Poiner 1990	Bycatch of the prawn fishery of Torres Strait
	Brewer, Blaber and Salini 1991	Feeding studies of predatory fishes caught on prawn trawl grounds of the north east GOC
	Salini, Blaber and Brewer 1992	Feeding studies of sharks caught on prawn trawl grounds
	Blaber, Brewer and Harris 1994	Population ecology of fishes of the GOC
	Salini, Blaber and Brewer 1994	Feeding studies of predatory fishes caught on prawn trawl grounds of the GOC
	Martin, Brewer and Blaber 1995	Population ecology of small fishes of the GOC
NPF bycatch reduction	Eayrs, Rawlinson and Brewer 1997	Reducing bycatch in Australia's NPF
	Rawlinson, Eayrs and Brewer 1997	Moving towards more responsible fishing practices in Australia's NPF
	Brewer *et al.* 1998	An assessment of 16 bycatch reduction devices in NPF trawl grounds
Bycatch survival	Hill and Wassenberg 1990	Fate of discards from prawn trawlers in Torres Strait
	Farmer, Brewer and Blaber 1998	Damage to NPF bycatch trawl escapees from diamond and square-mesh codends

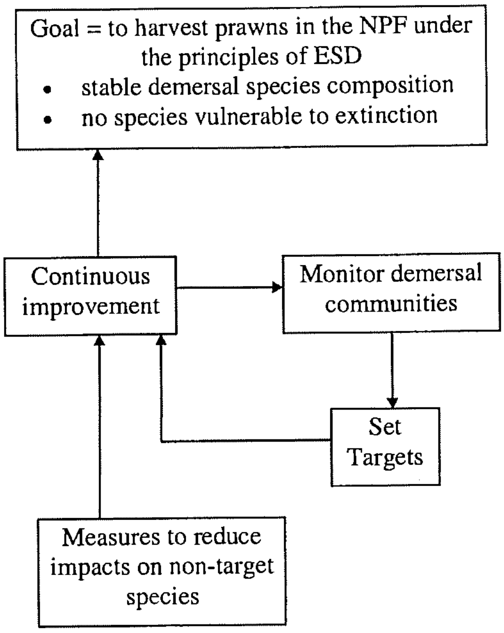

Figure 3. Diagram showing a method for managing bycatch reduction using target setting.

The level of bycatch reduction is likely to increase over time, through a process of continuous improvement. Any response in demersal communities can be monitored, and if necessary, targets can be set to continue or improve this process.

The role of target setting can be used in several ways:

- to alter the level of bycatch reduction if it is deemed necessary for the fishery to achieve ESD; and
- to increase the rate of improvement in bycatch reduction 'technology' by having a 'stretch goal', by creating a focus where it otherwise would not occur.

This model will operate with or without target setting. However, improvements in the levels of bycatch reduction are likely to be faster if targets are set than if the fishery is merely expected to use bycatch reduction devices without any particular level of performance.

Enforced targets for bycatch reduction are one way to improve the performance of bycatch reduction devices in the fishery. However, a better way to make changes to fishery practices is by way of benefit-based incentives that encourage fishers to make the changes themselves. There is no doubt that fishers in the NPF would rather catch less bycatch (Rawlinson and Brewer 1995), but there is a concern that using bycatch reduction devices will cause losses in prawn catches. Once fishers begin to use TEDs and BRDs in the NPF in the year 2000 they may have a strong incentive to improve their performance.

Part of encouraging this process is to continue to promote the benefits of using TEDs and BRDs. These benefits include:

- increasing the value of the catch by removing most of the large animals that can physically damage valuable export quality prawns (Brewer *et al.* 1998; Salini *et al.* in press);

- a potential increase in product quality from reduced catch sorting times by way of significantly reducing catches of small unwanted fish (Robins-Troeger *et al.* 1995).
- reducing threats to and criticism of the industry from community groups by greatly reducing catches of threatened species and reducing impacts on other non-target species (Robins-Troeger *et al.* 1995);
- increasing the catch of prawns by reducing the weight of bycatch in the codend, which produces a wider swept area throughout the time of the trawl (Brewer *et al.* 1998; Broadhurst and Kennelly 1996); and
- enhancement of future prawn stocks by reducing catches of juvenile and sub-adult prawns (Brewer *et al.* 1997).

These incentives may act in the same way as enforced target setting, causing continuous improvement, and removing the need for targets. However, this will only work if fishers want to improve both the bycatch reduction performance as well as the prawn catching performance of TEDs and BRDs. If fishers only concern themselves with maintaining prawn catches, then targets for bycatch reduction may have to be set.

How to set targets

Bycatch composition varies greatly between fisheries and so does the ability to exclude bycatch from catches using BRDs. In general, it is easier to achieve high levels of bycatch reduction in fisheries with less diverse bycatch. The same is true for fisheries where the target species differ in size and/or behaviour to the target species. In the NPF, there are different bycatch groups (sea turtles, sharks, rays, small fish, sea snakes, etc) and the bulk of the bycatch (fish) is highly diverse. Furthermore, most of these fish are small species about the same size as the commercial prawns. Consequently, reducing bycatch from NPF catches is a complex task and targets should be carefully set according to what is feasible for this fishery.

So far, scientific research and other sea trials in the NPF have shown that TEDs designed specifically to exclude large animals from catches can operate very effectively. Some TEDs can reduce catches of sea turtles and other large animals by up to 100% without significant loss of prawns (Brewer *et al.* 1998). For these large animals, high targets of >90% reductions in catches are feasible. However, the same target for reductions in catches of small fish is not feasible. So far, reductions in catches of small unwanted fish, without loss of prawns, have not yet exceeded 22% (Brewer *et al.* 1997), and a target between 20 and 30% is more feasible. If the will is there, the bycatch-reducing performance of TEDs and BRDs will be improved by fishers as they continue to use them, and targets may be increased accordingly.

Targets can be set in this way for all of the different types of bycatch groups, but not without prior knowledge of the feasibility of reaching these targets. Furthermore, continuous improvement and adjustment of targets will require periodic assessments of (i) the performance of TEDs and BRDs and (ii) changes to demersal community stability due to changes in fishing practices, such as the use of TEDs and BRDs.

How to measure targets

Inappropriate measures of bycatch reduction can be misleading. For example, comparing the weight of bycatch in trawl catches from year to year (or the ratio of bycatch to prawns) is difficult without accurately adjusting for other sources of variation. Bycatch exclusion from trawls may be improved from one year to the next, but if fish populations are larger in the second year, the absolute catch of unwanted fish may not have decreased.

It may be better to assess TED and BRD performance by directly comparing the catches of a twin-rigged NPF vessel – one net fished with and one net without a TED and BRD. This comparison, made for many pairs of trawl catches, will give a relative performance of TEDs and BRDs that is less affected by variations in species abundances. Thus, a standard measure of a percentage or proportional reduction in catch due to the effect of the TED and BRD can be achieved.

This is just one example of a potential method for measuring targets of TED and BRD performance. The most important issue is that careful consideration should be given to the type of measure used, so that real changes in performance of TEDs and BRDs can be assessed.

Other factors to consider

It has been shown on the NW Shelf of Australia that selective trawling can change the species mix of the demersal fish community (Sainsbury 1987). The use of TEDs and BRDs may act in a similar way by selectively removing some species from the catch more effectively than others. Although TEDs and BRDs can minimise trawl impacts on species that can be excluded, they may add another level of complexity to the impacts of prawn trawling on the demersal communities. These and similar impacts can only be measured by comparing current data with historical data sets, and by monitoring for such changes in the future.

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Status report on bycatch within the Queensland Trawl Fishery

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Abstract

The Queensland Trawl Fishery is a complex multi-sector fishery extending 2,500 km along the Queensland east coast. About 800 otter-board trawlers record between 85,000 and 90,000 boat-nights (predominantly a night-time fishery) of fishing effort in offshore waters annually. In addition, about 210 beam trawlers record an average of 6,500 boat-days (predominantly a day-time fishery) annually in riverine and inshore areas. Trawling takes place over a diverse range of benthic communities and seabed habitats. Fishing effort is distributed non-uniformly, with a major proportion occurring in the Great Barrier Reef World Heritage Area.

Bycatch is a characteristic feature of the Queensland Trawl Fishery and, in this paper, is defined as that part of the catch that is discarded at sea. An assessment of the status of bycatch in the fishery is presented, based on a review of relevant literature. Major conclusions from the assessment are that, a) the species composition has been documented in some sectors of the fishery, but no reliable estimates of total bycatch have been published, and b) impacts of trawling on the populations of bycatch species and the ecosystem remain scant. Despite this uncertainty, there are strong social and political pressures in Queensland to reduce trawl bycatch. Current issues pertaining to bycatch in Queensland fall into the following categories: i) inter-sector conflict, ii) impact on benthic community and habitat structure, iii) wash-up of dead fish on beaches, iv) capture of unwanted species, and v) capture of threatened or protected species.

The Queensland Fisheries Management Authority is the primary agency responsible for the management of the fishery, but the Great Barrier Reef Marine Park Authority also has responsibility for parts of the fishery that occur within the Great Barrier Reef World Heritage Area. The agencies work in collaboration and both have policies to reduce trawl bycatch in order to maintain biodiversity, to ensure fisheries are ecologically sustainable and to minimise the 'waste' of fisheries resources.

The fishery

The Queensland Trawl Fishery encompasses all Queensland jurisdictional waters from the Queensland/New South Wales border at about 28°S, to the northern tip of Cape York Peninsula (10°30'S, 142°30'E). This includes areas of the continental shelf, several major embayments and the Great Barrier Reef World Heritage Area. World Heritage status places a duty upon the managing agencies to ensure the identification, protection, conservation, presentation and transmission to future generations of the cultural and natural heritage of areas listed under the World Heritage Convention (Valentine *et al.* 1997). It also increases the public's expectations and scrutiny of fisheries management (Tanzer *et al.* 1997).

The Queensland Trawl Fishery is a commercial fishery with restricted entry. It is the largest and most valuable commercial fishery in

Queensland, with annual landings valued between A$120 and A$130 million (Williams 1997). Logbook data indicate that between 85,000 and 90,000 boat-days of fishing effort each year are recorded each year, with about 10,000 t of landings. Targeted species include about 12 species of prawns (Penaeidae), two species of scallop (*Amusium* spp.) and one species of whiting (*Sillago robusta*). Several non-targeted species are also retained, including blue swimmer crabs (*Portunus pelagicus*), shovel-nosed lobsters (*Thenus* spp.) and squid (*Photololigo* spp., *Sepioteuthis* spp.). Two main categories of fishing apparatus are used: i) beam trawls in designated rivers and inshore areas targeting mainly banana and greasyback prawns, and ii) otter-board trawls targeting prawns, scallops and whiting.

The Queensland Trawl Fishery is one of the most complex in Australia in terms of its fleet size and diversity, the range of environments in which the fishery occurs, and the seasonal and spatial distribution of effort. In order to structure this report, we identified eight sectors within the fishery, based on the region, type of fishing gear and species targeted. The sectors are beam trawl, Moreton Bay, stout whiting, eastern king prawn, scallop, banana prawn, red spot king prawn, and tiger/endeavour prawn (Figure 1). Bycatch is common to all sectors, but its composition and the associated social and environmental issues vary between them. A summary of the status of bycatch within each sector is presented (Table 1). Where the data permit, preliminary estimates of the total bycatch of the sectors were made using either the ratio method or the catch per unit effort (CPUE) method (Andrew and Pepperell 1992). The ratio method is based on observed or sampled bycatch:prawn catch weight ratios. Total bycatch is then estimated as the product of the ratio and the total prawn catch. The CPUE method relies on bycatch per unit of fishing effort, with total bycatch estimated as the product of bycatch CPUE and the total fishing effort. Andrew and Pepperell (1992) provide a review of the merits and drawbacks of each method.

Bycatch summaries by fishing sector

The beam trawl sector

About 210 vessels have beam trawl endorsements in Queensland (Anonymous 1998). Trawling occurs in rivers and inshore waters between Moreton Bay and Rockhampton, and to a limited extent near Bowen and Mackay (Figure 1). Logbook data indicate this sector expends about 6,500 boat-days of fishing effort annually, producing an average catch of about 400 t of prawns, valued at A$2.4 million in 1996 (Reid and Campbell 1999). Target species consist mainly of greasyback prawns (*Metapenaeus bennettae*), school prawns (*M. macleayi*) and banana prawns (*Penaeus merguiensis*), marketed locally for consumption or recreational fishing bait. Trawling occurs mostly during the day, but may extend into the night, depending on the abundance of prawns. Beam trawling is not permitted on weekends.

Bycatch issues

The fishery is highly visible occurring in rivers and inshore areas, close to several population centres (Brisbane, Bundaberg, Rockhampton and Mackay). The main issues in this sector are: i) conflict with recreational fishers over the catch of juvenile angling species such as bream, whiting and flathead, ii) concerns about the disturbance to benthic communities and habitat structure by recreational fishers and conservation groups, and iii) conflict with the otter-trawl sector over the size of the prawns caught (i.e. debate over whether to harvest abundant small size-classes in rivers or fewer and larger size-classes offshore). Public perception of the composition, amount and ecological impact of the bycatch varies widely.

Table 1. Sectors of the Queensland Trawl Fishery: a summary of bycatch.

Sector and target species	Catch & value (tonnes, A$ millions)	Effort (avg. days fished)	Bycatch issues	Bycatch extent & characterisation	Preliminary bycatch estimates
River & inshore beam trawl *Metapenaeus macleayi* *M. bennettae* *Penaeus merguiensis*	400 t A$2.4 m	6,500	Catch of juvenile prawns; impact on benthic habitat; catch of angling species	2 bycatch studies, 2 bioeconomic bycatch studies; several species are recreationally or commercially important fish, average bycatch:catch ratio 3.5:1	1,415 t bycatch
Otter trawl					
Moreton Bay *M. bennettae* *P. esculentus* *P. plebejus*	640 t A$4.5 m	11,500	Catch of angling species, blue swimmer crabs, and sea turtles; impact on benthic habitats; public perception	52% crustaceans; bycatch:catch ratio 3.2:1 to 6:1; bycatch rate about 35 kg/hr	4,000 t bycatch (1,700 t – 6,300 t) 3,000 sea turtles caught annually
Eastern king prawn *P. plebejus*	1,800 t A$25 m	18,500	Mostly relate to effort in inshore areas (i.e. <20 m); include sea turtle catch, and fish washups on beaches; occurs partially within the GBRWHA	66%-86% fish; bycatch greatest inshore; bycatch:catch ratio for inshore 11.2:1(but highly variable)	Unknown total bycatch weight. 250 sea turtles caught annually
Scallop *Amusium balloti* *A. pleuronectes*	1,200 t A$30 m	12,700	Catch of sea turtles and sea snakes; impact on benthic habitat; occurs within the GBRWHA	No comprehensive studies; bycatch unquantified	Unknown total bycatch weight 200 sea turtles caught annually
Banana prawn *P. merguiensis* *P. indicus*	600 t A$6 m	5,000	Fish washups on public beaches; a highly visible inshore day-time fishery; catch of angling species and sea turtles; occurs mostly within the GBRWHA	8 species accounted for 50% of all individuals in samples of commercial bycatch; highly skewed bycatch:catch ratio; average bycatch:catch ratio of 5:1	Unknown total bycatch weight, study underway 350 sea turtles caught annually
Red spot king prawn *P. longistylus* *P. latisulcatus*	800 t A$9 m	13,000	Impact on benthic habitat; damage to benthos; catch of sea turtles and sea snakes; occurs within the GBRWHA	High species diversity; bycatch dominated by fish; variable depending on location; bycatch catch rates of 55 kg/hr	8,000 t bycatch 65 sea turtles caught annually
Tiger & endeavour prawn *Penaeus esculentus* *P. semisulcatus* *P. monodon* *Metapenaeus ensis* *M. endeavouri*	3,200 t A$45 m	27,000	Fish bycatch washups on beaches; catch of angling species, sea turtles and sea snakes; impact on benthic habitat; occurs within the GBRWHA	Dominated by fish (75%); variable depending on location; high bycatch:catch ratios; bycatch catch rates of 38 kg/hr	10,260 t – 19,200 t bycatch 1,600 sea turtles caught annually
Stout whiting *Sillago robusta*	2,400 t A$4 m	12,500 hrs	Some conflict with prawners; occasional catch of sea turtles	Mostly fish; highly variable; avg 3.3:1; likely to be reduced due to marketing of bycatch species	unknown

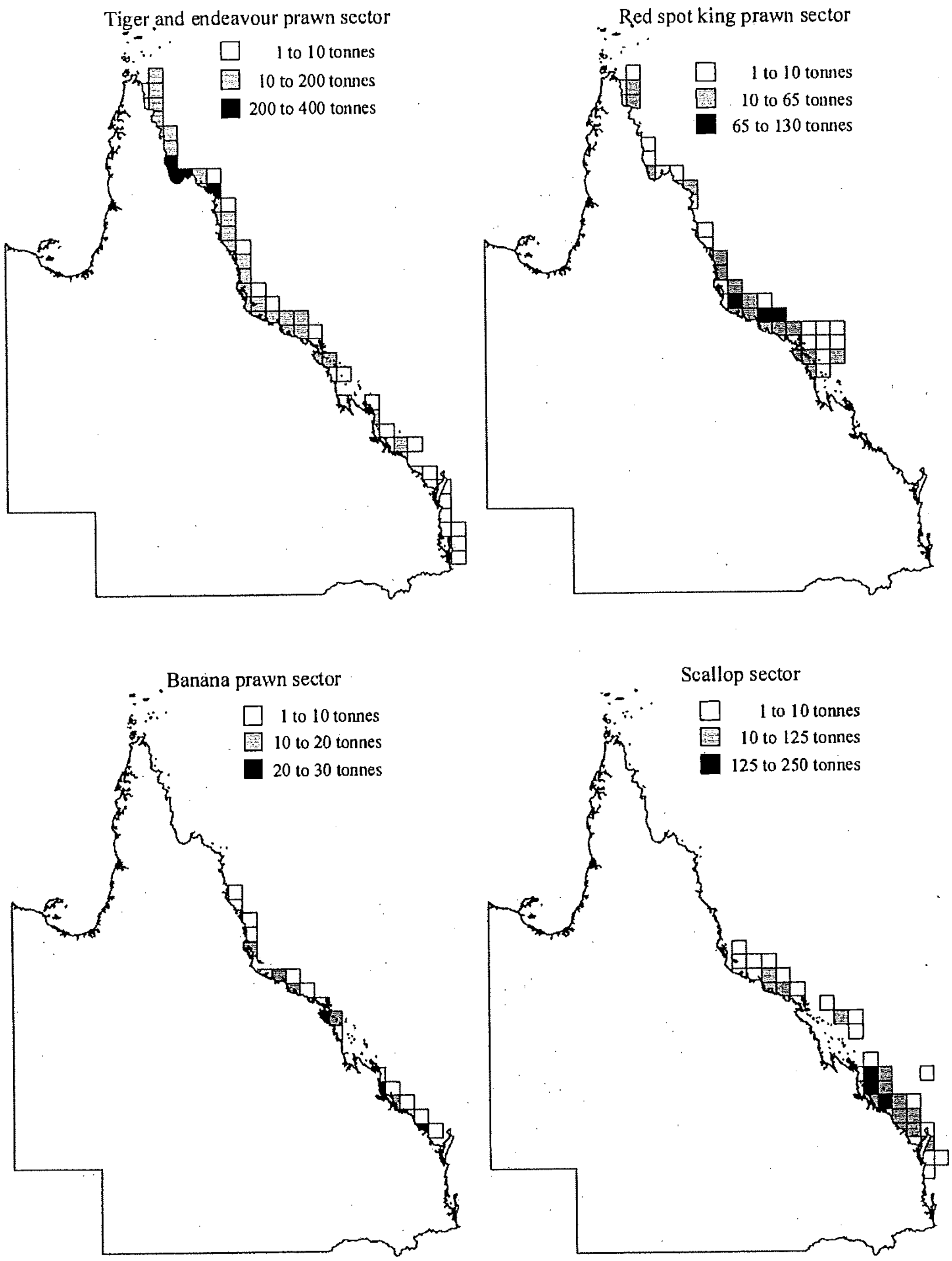

Figure 1. Spatial distribution of the average annual catch within eight sectors of the Queensland Trawl Fishery. Landings are derived from the commercial logbook database held by the Queensland Fisheries Management Authority and are pooled across 30 nautical mile grids, except for Moreton Bay and the beam trawl sector (pooled by management area). [a]Estimates for the beam trawl sector are derived from Reid and Campbell (1999).

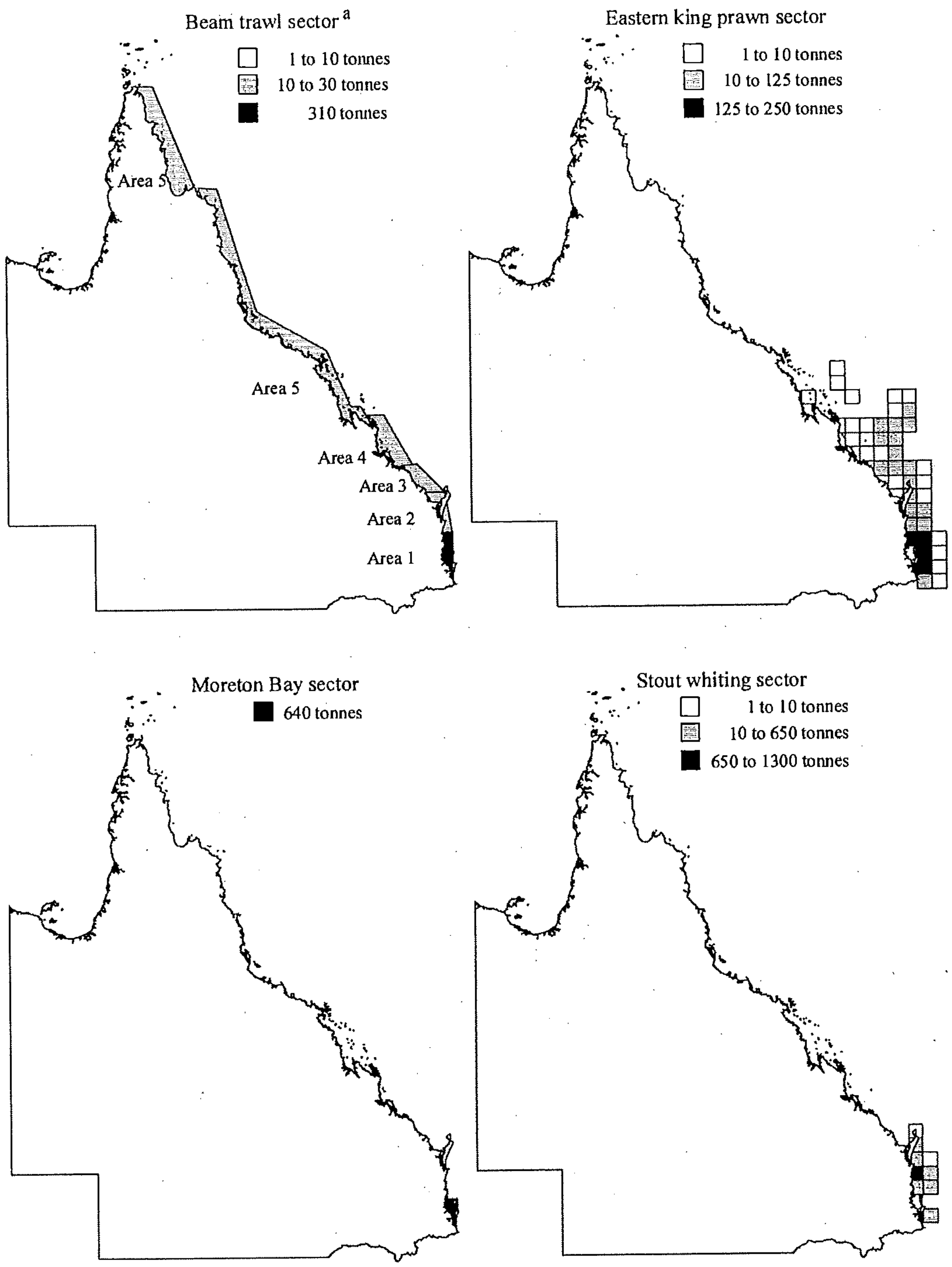

Figure 1. cont.

Extent and characterisation of the catch

There have been two main studies of bycatch in Queensland beam trawl fisheries (Dredge 1983; Hyland 1988). Dredge (1983) examined the bycatch of beam trawlers operating in the Burnett River, near Bundaberg. He recorded 108 fish species, nine of which were important commercially or recreationally. These were dusky flathead (*Platycephalus fuscus*), bar-tailed flathead (*Platycephalus indicus*), gold-lined whiting (*Sillago analis*), winter whiting (*Sillago maculata*), grunter (*Pomadasys* spp.), yellowfin bream (*Acanthopagrus australis*), jew (*Argyrosomus hololepidotus*), king salmon (*Polydactylus sheridani*) and sea mullet (*Mugil cephalus*). Three species comprised over 67% of the total number of fish caught. These species were dollar fish (*Leiognathus* sp.), catfish (*Neoarius australis*) and perchlet (*Ambassis marianus*). Dredge (1983) commented that it was difficult to interpret the implications of the beam trawl bycatch without some knowledge of the stocks of the fish that are caught. The incidental catch of some species was variable through time, making extrapolations difficult. One of the possible environmental effects of this fishery was the removal of fallen mangrove timber that may act as habitat for some species.

Hyland (1988) reported 93 species from 51 families in bycatch from the beam trawl fishery in the Moreton region (southeast Queensland). The composition of beam trawl catches by major taxononic group were also reported (Table 2). Sixty-nine fish species occurred in samples from the Logan, Brisbane, Pine and Caboolture Rivers. Hyland (1988) reported a high diversity of fish species in river beam trawls, although most species captured were numerically scarce. The 12 most common fish species were southern herring (*Harengula castelnaui*), river perch (*Johnius vogleri*), silver biddy (*Gerres oyeana*), winter whiting (*Sillago maculata*), yellowfin bream (*Acanthopagrus australis*), perchlet (*Ambassis marianus*), estuary catfish (*Arius australis*), puttynose perch (*Polydactylus multiradiatus*), trumpeter (*Pelates quadrilineatus*), siphonfish (*Siphamia roseigaster*), weeping toadfish (*Spheroides pleurostictus*) and estuary anchovy (*Thrissina aestuari*). About 10 had importance as recreational or commercial species. These included river perch (*Johnius vogleri*), winter whiting (*Sillago maculata*), sea mullet (*Mugil cephalus*), yellowfin bream (*Acanthopagrus australis*), tailor (*Pomatomus saltatrix*), golden trevally (*Gnathanodon speciosus*), gold-lined whiting (*Sillago analis*), tarwhine (*Rhabdosargus sarba*), summer whiting (*Sillago ciliata*) and dusky flathead (*Platycephalus fuscus*). Hyland (1988) reported that the survival of fish bycatch from beam trawls was variable. Yellowfin bream (*Acanthopagrus australis*) was suggested to be resilient to beam trawling, while river perch (*Johnius vogleri*) suffered high trawl-induced mortality.

Estimate of total bycatch

Hyland (1988) noted that while crude estimates of the total beam trawl bycatch could be obtained by extrapolation, it would not be possible to quantify mortality rates from beam trawling without some knowledge of the natural mortality rates of the populations in question. Using an annual total catch of 400 t of prawns (Reid and Campbell 1999) and Hyland's (1988) breakdown of the catch composition from the Logan River (Table 2), the total tonnage of bycatch from Queensland's beam trawl fishery is estimated to be in the order of 1,415 t per year.

Reid and Campbell (1999) undertook a bioeconomic analysis of the impact of beam trawling on both recreational and offshore trawl fishing sectors in Queensland. They partitioned the beam trawl fishery into four areas and estimated the impact for each area. Species of recreational importance, determined from recreational fisher surveys, included yellowfin bream, flathead, river perch, trevally, tailor,

Table 2. Composition of beam trawl catches from the Logan River (Hyland 1988).

Taxonomic Group	**Catch (by weight) (%)**
Penaeidae	22.04
Sergestidae	0.08
Caridae	1.92
Squillidae	0.02
Teuthoidae	0.08
Brachyura	5.76
Elasmobranchii	6.68
Teleostomi	63.42
– catfish	39.14
– 'trash'	7.8
– potential bait fish	0.66
– food fish	15.82

mulloway and grunter. The analysis concluded that returns from beam trawling in the main fishery area (Double Island Point to the NSW border) were more than sufficient to justify the long-term continuation of the current level of investment in the fishery. In two other areas they found that returns were sufficient, but not quite sufficient in the fourth area to justify current levels of investment.

Beam trawl operators have often used 'blubber chutes' (grid-like structures in the trawl codend) to reduce catches of jellyfish. Recently, researchers involved in the FRDC-funded project to extend the use of bycatch reduction devices (Project No. 96/254 *Commercialisation of bycatch reduction strategies and devices into northern Australian prawn trawl fisheries*), have noted an increase in the development and use of grids by beam trawl operators to further reduce catches of fish and other bycatch species (J. Robins, pers. comm.). Although the impact of the devices is unquantified at present, anecdotal evidence suggests that they are likely to reduce the weight of the bycatch by about 20%.

The stout whiting sector

This relatively new fishery has developed since 1991 and consists of five vessels with endorsements to target stout whiting (*Sillago robusta*) using modified prawn trawls. The entire catch is exported and valued at about A$4 million annually. Standard prawn trawl nets are modified for targeting stout whiting by adding sweeps of about 120 m length, between the net and the otter-boards. Operators target schools of stout whiting, mainly between the 40 and 100 m depth contours from Sandy Cape (24°42'S, 153°15'E) to Caloundra (26°48'S, 153°8'E). Although officially closed between 1st January and 31st March, fishers continue fishing for stout whiting during this period using standard, non-modified, prawn trawl nets. Fishing effort was estimated to be about 12,500 hrs per year, with a catch of about 2,400 t (Williams 1997).

Bycatch issues

There is some conflict between the stout whiting trawl sector and the established prawn

Table 3. Composition of total catch in samples from the stout whiting fishery (A. Butcher, unpublished data).

Grouping	**Average weight of total catch (%)**
Target species	22.7
Commercial non-target fish	1.2
Recreational fish	4.6
Fish of no commercial or recreational value	62.8
Crustaceans	2.2
Mollusca	5.7
Others	0.9

trawl sector that operates concurrently in the same areas. In March 1998, a number of dead loggerhead turtles (*Caretta caretta*) washed ashore in the Southport area. The deaths were attributed by some to the stout whiting sector and by others to the prawning sector. Another bycatch issue within this sector is the extent of unwanted fish bycatch. Nets used in the trawl whiting fishery are modified to herd and catch fish, and therefore the fish bycatch is likely to differ from that of prawn trawlers operating in the same area. Anecdotal evidence suggests that because the bottom type in the fishery is predominantly bare sand, the impact of trawling on benthic habitats is likely to be relatively low (Gibbs *et al.* 1980).

Extent and characterisation of catch

The stout whiting sector has been required to use observers and to allow catch samples to be taken by researchers because it is a developmental fishery. Bycatch was recorded as part of the monitoring process and includes two species of shark, three species of ray, 68 species of fish, 17 species of crustaceans and isopods, five families of echinoderms, several species of mollusc as well as bristle worms, whips and sea salps (A. Butcher pers. comm. 1998). Stout whiting ranged from 1.5% to 60.0% of the total catch, but averaged 22.7% (Table 3). Teleost fish dominated the bycatch. Species of other commercial or recreational value averaged 5.8% of the total catch (range 1% to 10%) and included tailor (*Pomatomus saltatrix*), flathead (*Platycephalus* sp.), mackerel (*Scomberomorus* spp.) and spangled emperor (*Lethrinus nebulosus*). Operators in this sector have since developed markets for some of the bycatch fish species, such as *Nemipterus* sp.. The effect of utilising some of the bycatch would be to lower the bycatch:catch ratio that was recorded during the sampling program.

Two of the five operators have voluntarily adopted turtle excluder devices (TEDs). The TEDs not only reduce the incidence of turtle captures, but the fishers involved have also reported lower incidental captures of large stingrays.

The Moreton Bay sector

The Moreton Bay sector differs from others in the Queensland Trawl Fishery, in that it is primarily defined by location rather than by catch composition (Figure 1). It also has separate management measures relating to maximum vessel length, trawl-net head-rope length and mesh size (Anonymous 1998).

Table 4. Estimates of total annual bycatch from the Moreton Bay trawl fishery. Assuming a) 640 tonnes of prawns caught in Moreton Bay per year, b) 10 hours of trawling per night, c) 11,500 nights trawled per year. Ranges determined using upper and lower 95% confidence intervals of mean bycatch catch rates.

Source	Bycatch ratios and catch rates	Method	Estimate of bycatch (tonnes)	Bycatch range (95% CL) (tonnes)
Wassenberg & Hill (1989, 1990)	6:1 discards:catch	Ratio	3840	–
	36±8.9 kg/hr trawled	CPUE	4140	2093–6187
QDPI (unpublished data)	3.2:1 (discards:catch)	Ratio	2048	–
	34.6±10.3 kg/hr trawled	CPUE	3910	1657–6300

Logbook data indicate that an average of about 640 t of prawns was trawled from Moreton Bay annually for the period 1991 to 1996. The fishery recorded an average of 11,500 boat-days of effort over the same period; accounting for about 14% of the total effort in the Queensland Trawl Fishery. Effort peaks in January and declines to a minimum in July. The main species are greasyback prawns (*Metapenaeus bennettae*), eastern king prawns (*Penaeus plebejus*) and brown tiger prawns (*P. esculentus*). Fishers commonly retain and market several smaller or less abundant species, including endeavour prawns (*Metapenaeus endeavouri, M. ensis*), hardback prawns (*Trachypenaeus fulvus*) and New Guinea prawns (*Metapenaeopsis novaeguineae*). Squid and blue swimmer crabs are also retained for marketing and make a significant contribution to fishers' incomes.

Bycatch issues

Bycatch and the effects of trawling in Moreton Bay have received considerable attention mainly because of the close proximity to the city of Brisbane. Incidental catch of fish is a source of ongoing conflict between recreational fishers and trawler operators. Species of particular concern are bream, snapper, whiting and flathead. There is also conflict between trawler operators in Moreton Bay and those operating farther offshore over the size at which eastern king prawns are harvested. Eastern king prawns move rapidly through the bay as they undertake a northern, seaward migration. Moreton Bay also supports significant populations of loggerhead turtles and green turtles (*Chelonia mydas*). Sea turtles are a relatively frequent catch of Moreton Bay trawlers (i.e. >1 per week per vessel, (Robins 1995) and there is concern over the impact of this capture on population numbers (Limpus and Reimer 1994).

Extent and characterisation of catch

Several studies have been undertaken on the sub-littoral, benthic fauna of Moreton Bay. While some of these studies have addressed broad ecological objectives (Jones 1973; Burgess 1980; Stephenson *et al.* 1982a; Stephenson *et al.* 1982b), others have focused on the problem of trawl bycatch (Wassenberg and Hill 1989; Robins 1995; Robins-Troeger *et al.* 1995).

Stephenson *et al.* (1982a, b) examined factors affecting the catch rates and distribution of species trawled from three sites in Moreton Bay, sampled monthly for 13 months. They recorded 117 species and based their analyses on 60 to 70 species that were represented frequently in the catches. The most numerically dominant species, apart from prawns, included small fish (*Leiognathus* spp., Apogonidae, *Paramonacanthus* spp.) and crabs (*Charybdis callianassa*). Trawl site was generally the most important factor affecting catch rates, followed by time of day and then port/starboard net and tidal direction. A high proportion of species showed strong annual cycling, with prevailing warm and dry conditions affecting abundance of many species between years.

Wassenberg and Hill (1989) reported a bycatch composition by weight of 52% crustaceans, 15% elasmobranchs, 8% bony fish, 18% echinoderms, 3% cephalopods and 4% debris. They reported that 85% of crustaceans survived trawling (8 hours after capture) while only about 20% of teleost fish survived. The average weight of discards collected per trawl was 36 kg (s.d. = 8.9, n = 12).

Research trials of TEDs in northern and western Moreton Bay found that non-commercial bycatch accounted for 85% to 95% (by weight) of the total catch in standard commercial nets (Robins-Troeger *et al.* 1995). Seventy-nine species of teleost fish, three species of ray and 15 species of invertebrates were recorded in bycatch samples. Dominant fish species (by weight) were cardinal fish (*Apogon poecilopterus*, *A. fasciatus*), grinners (*Saurida undosquamis*), ponyfish (*Leiognathus moretoniensis*), red bigeye (*Priacanthus macracanthus*), long-tailed catfish (*Euristhmus lepturus*), puttynose perch (*Polydactylus multiradiatus*) and siphonfish (*Siphamia roseigaster*). Several species of recreational importance were also caught, including tailor (*Pomatomus saltatrix*), gold-lined whiting (*Sillago analis*), mackerel (*Scomberomorus* sp.) and snapper (*Pagrus auratus*) (QDPI unpublished data). Commercial trials of TEDs in eastern and southern Moreton Bay recorded an average bycatch:prawn catch ratio of 3.2:1 (≅ 76% bycatch by weight) in standard nets during November 1995 (QDPI unpublished data). This ratio decreased to 1.8:1 (≅ 64% bycatch by weight) if marketable bycatch (blue swimmer crabs and squid) was included. Average weight of bycatch per hour of trawling was 34.6 kg (s.d. = 10.3, n = 37), similar to that reported by Wassenberg and Hill (1989).

Estimates of total bycatch

Estimates of the total annual bycatch from the Moreton Bay trawl fishery are provided in Table 4. Two estimates are made using the ratio method (i.e. total prawn catch x bycatch:prawn catch ratio) and two using the CPUE method (i.e. bycatch per unit effort x total effort). Estimates range from 1,657 t to 6,187 t per year.

The impact of trawling on sea turtles has received considerable public attention and was the subject of a research project aimed at estimating the total catch and mortality of sea turtles within the Queensland Trawl Fishery. Robins and Mayer (1998) estimated 3,199 (± 325 s.e.) turtles are caught annually by Moreton Bay trawlers. Most were loggerhead turtles, (*Caretta caretta*) (76%), with virtually all of the remainder (21%) being green turtles, (*Chelonia mydas*). The low reported mortality rate of less than 1% appears to reflect the relatively short tow durations (i.e. <90 mins., avg. 76 mins) characteristic of the Moreton Bay fishery (Robins and Mayer 1998).

The eastern king prawn sector

This fishery is based on a single species (*Penaeus plebejus*), comprised of a single straddling stock shared between New South Wales and Queensland. In Queensland, the fishery occurs in waters south of 21°S to the Queensland/New South Wales border (28°S). It produces about 1,800 t of eastern king prawns annually and accounts for about 20% of total effort in the Queensland Trawl Fishery. The main difference between the eastern king prawn fishery and the other trawl sectors is that fishing occurs farther offshore (up to 250 km) in deeper, more oceanic waters to depths of about 300 m (Figure 1). Tagging studies have shown *P. plebejus* undertakes a significant migration, generally in a northerly direction (Ruello 1975; Glaister *et al.* 1987; Montgomery 1990). Individuals remain in shallow estuaries and embayments for very short periods (Lucas 1974; Coles and Greenwood 1983) before migrating. The fishery tracks the movement of the prawns, beginning early in the season as an inshore fishery, then moving to offshore waters later in the season.

Bycatch issues

Despite the high level of fishing effort in this sector of the trawl fishery (about 18,500 boat-days per year), bycatch from the eastern king prawn fishery has generated comparatively little social or political concern in Queensland. This is because fishing occurs predominantly at night and well offshore. Occasionally, fish bycatch washes onto adjacent beaches causing public concern. In addition, the Queensland Environmental Protection Agency expressed concern over recent catches of sea turtles by vessels near the Southport bar by trawlers targeting school prawns and eastern king prawns.

Extent and characterisation of catch

There is scant information on the composition or quantity of bycatch in the eastern king prawn sector of the Queensland Trawl Fishery. Preliminary information on bycatch rates and species composition was collected during commercial trials of the AusTED in shallow waters adjacent to Fraser Island (Robins *et al.* 1997). Bycatch:prawn catch ratio averaged 11.2:1 in standard commercial nets, but was highly variable (s.d. = 10.27,n = 32). This is similar to a bycatch:prawn catch ratio of 8.8:1 reported at inshore sites of the NSW eastern king prawn fishery during commercial testing of square-mesh panels by NSW Fisheries (Broadhurst and Kennelly 1997). There is some evidence to suggest that the bycatch:prawn catch ratios decline as depth and distance offshore increase (Broadhurst and Kennelly 1997).

Samples of bycatch collected from standard trawl nets during the commercial trials of the AusTED adjacent to Fraser Island contained 68 species of fish, 18 species of crustaceans and a limited number of molluscs and cephalopods (Robins *et al.* 1997). Fish comprised between 66% and 85% of the bycatch. The 10 most abundant fish species were stout whiting (*Sillago robusta*), leatherjacket (*Paramonacanthus filicauda*), tongue sole (*Paraplagusia* sp.), toadfish (*Torquigener hicksii*), flathead (*Platycephalus longispinous, P. arenarius, Suggrundus harrisii*), grinners (*Saurida* sp.), spiny headed flounder (*Engyprosopon grandisquama*) and red spot gurnard (*Lepidotrigla argus*). Other species particularly abundant in the samples were blue swimmer crab (*Portunus pelagicus*), three spot crab (*Portunus sanguinolentus*) and saucer scallop (*Amusium balloti*).

Estimates of total bycatch

The total tonnage of bycatch produced by the eastern king prawn sector is unknown and the preliminary data collected during commercial TED trials are insufficient for use in estimating the bycatch. Sea turtle bycatch was estimated to be 246 (± 36 s.e.) turtles per year (Robins and Mayer 1998). Species composition was predominantly loggerhead turtles (47%) and green turtles (36%), caught incidentally during trawling in shallow, coastal waters (i.e. <40 m). In general, the incidence of trawl-induced turtle mortality in this sector was rare (Robins and Mayer 1998), partly because relatively few turtles were caught.

The scallop sector

Scallops are taken throughout the Queensland Trawl Fishery but are caught mainly between Hervey Bay (25°S) and Hydrographers Passage

(20°42'S). Annual catch is about 1,200 t (meat weight) valued at about A$30 million (Williams 1997). The catch consists of two species. *Amusium balloti,* often referred to as the reef scallop, is caught predominantly in southern offshore waters, while *Amusium pleuronectes,* also known as the mud scallop, is caught predominantly in northern inshore waters. The trawl nets used for scalloping have a larger mesh size and thicker ply (60 ply) than those used by prawn trawlers. *Amusium* spp. has a comparatively good swimming ability and readily swims up off the bottom when disturbed by the trawl gear. Underwater video footage of scallop trawls contacting the sea floor suggests the gear has a similar mode of operation and impact to that of prawn trawls (QDPI unpublished video footage).

Bycatch issues

This sector has a relatively low profile with respect to bycatch because its occurs predominantly in waters that are several kilometres from the coast. Sponges commonly occur in the bycatch and there is concern over incidental catches of sea turtles and sea snakes. The ecological sustainability of scallop trawling is a bycatch issue in this sector, particularly because much of the sector occurs within the Great Barrier Reef World Heritage Area.

Extent and characterisation of catch

Bycatch from the scallop sector has not been comprehensively documented. In some areas, the composition of the bycatch is likely to be similar to that of the tiger prawn or red spot king prawn sectors as the trawl nets used by these sectors are similar. The main difference is mesh size; the mesh size used during scallop trawling is larger (75 mm) than that used during prawn trawling (38 to 60 mm). Anecdotal reports from commercial fishers suggest that sea snakes occur in the bycatch, but their frequency of occurrence is unknown. The composition of the bycatch is currently being examined using samples collected from an annual stock assessment survey of the scallop fishery (M. Dredge, pers. comm. 1998).

Estimates of total bycatch

At present no reliable estimates of total bycatch can be made due to a lack of data. Sea turtle bycatch was estimated to be 203 (± 74 s.e.) turtles per year (Robins and Mayer 1998), comprised mainly of loggerhead turtles (39%), green turtles (27%) and flatback turtles (*Natator depressus*) (27%).

The banana prawn sector

Compulsory logbook data indicate an average of 600 t of banana prawns (*Penaeus merguiensis*), worth about A$6 million, are caught in Queensland coastal waters annually (Williams 1997). Catches are strongly influenced by rainfall and show greater yearly variation compared with other prawn species. Most of the catch is taken between 17°S and 25°S in selected areas off Cairns, Townsville, Mackay, Gladstone and Bundaberg (Figure 1). The fishery is seasonal with most of the catch landed between February and May. This sector is relatively small, representing 5-10% of total effort in the Queensland Trawl Fishery (Table 1).

Bycatch issues

Despite the fishery's relatively small scale, bycatch from the banana prawn trawl sector has attracted a great deal of social and political concern. This disproportionably high level of concern is due largely to trawling operations and trawling discards being highly visible to the residents of coastal towns. Fishing takes place during daylight in shallow (<15 m) coastal or estuarine waters. As a consequence, bycatch sometimes washes up onto beaches where it is encountered by recreational fishers, tourist operators or local residents. Conservationists have expressed concern over

Table 5. Numerically dominant bycatch taxa in the Queensland banana prawn trawl fishery, collectively accounting for about 50% of all individuals found in the bycatch. Data are preliminary and based on a current FRDC-funded study (A. Courtney, unpublished data).

Species	Number in samples	Composition of total bycatch (%)
Leiognathus splendens	15,026	9.1
Johnius vogleri	12,532	7.6
Charybdis callianassa	11,769	7.1
Leiognathus bindus	11,557	7.0
Pomadasys maculatum	8,263	5.0
Metapenaeus sp.	8,091	4.9
Caranx para	7,907	4.8
Terapon theraps	7,192	4.4

the incidence of threatened sea turtles that are caught, while recreational fishers are particularly concerned over the impact on angling species.

Extent and characterisation of catch

A research project funded by FRDC (Project No. 96/257 *Ecological sustainability of bycatch and biodiversity in prawn trawl fisheries*) is in progress and includes a component to describe bycatch from the Queensland banana prawn trawl sector. Preliminary results from this study, based on sub-samples from 184 standard net trawls, indicate that the bycatch is comprised of about 316 species, and characterised by small demersal fish, pelagic fish, portunid crabs and penaeid prawns. Eight species comprise about 50% of all individuals in the bycatch (Table 5). Pony fishes (Leiognathidae) numerically dominate, accounting for about 24% of all individuals sampled, followed by penaeid prawns (other than banana prawns). Other numerically important species include the sharp-toothed croaker (*Johnius vogleri*), a small portunid crab (*Charybdis callianassa*) and blotched javelin-fish (*Pomadasys maculatum*). Composition of the bycatch varies with latitude and distinct groups can be discerned along the coast. The bycatch:prawn catch weight ratios are highly variable and display a skewed distribution with a mode at about 5:1. Two green turtles and sea snakes were part of the bycatch. The most common sea snake was *Lepemis hardwickii* (141 individuals), followed by *Hydrophis elegans* (43), then by *Disteira major* (6) and *Disteira kingii* (4). Sea snake catch rates averaged about 1.0 individual per trawl per net.

During commercial trialing of bycatch reduction devices (BRDs), the bycatch:prawn catch ratios of standard nets was highly variable, ranging from 1.4:1 to 19.4:1, but averaged at 2.7:1 (J. Robins, unpublished data). The prawn catch represented 27% of the total catch, but ranged from 4.91% to 41.35% (n = 35 tows sampled).

Estimates of total bycatch

Estimates of total bycatch in the banana prawn sector will be an output of the above FRDC project. Sea turtle bycatch was estimated to be 342 (± 79 s.e.) turtles per year (Robins and

Table 6. Abundance and biomass of taxonomic groups, from Jones and Derbyshire (1988).

Group	Abundance of taxa		Abundance of individuals (%)	Biomass (%*)
	Number	%		
Pisces	272	57	38.3	75
Crustacea - 30% portunid crabs - 61% coral prawns - 8% commercial prawns	91	19	41.8	20
Echinodermata	50	11	15.8	2
Mollusca	49	10	3.7	1
Other animals	15	3	0.4	2

*estimated

Mayer 1998). Species composition was 41% green turtles, 38% loggerhead turtles and 16% flatback turtles.

The red spot king prawn sector

A trawl fishery for red spot king prawns (*Penaeus longistylus*) and blue-leg king prawns (*Penaeus latisulcatus*) occurs in offshore waters within the Great Barrier Reef lagoon, mainly north of 21°S (Figure 1). Red spot king prawns are caught generally in the vicinity of reefs and account for about 70% of the catch. Fishers generally do not differentiate between the two species when recording their catch. Logbook data indicate a total of about 800 t are landed annually.

Bycatch issues

Bycatch issues in this sector include: i) the impact of trawling on benthic communities, habitat structure and the adjacent reef ecosystem, ii) the catch of threatened and protected species, such as sea turtles, sea snakes and pipefish, and iii) the effect of trawling on the World Heritage values of the area.

Extent and characterisation of catch

Several studies have documented the trawlable fauna of parts of this sector (Jones and Derbyshire 1988; Dredge 1988, 1989; Watson and Goeden 1989; Watson *et al.* 1990). Jones and Derbyshire (1988) reported 477 taxa from their trawl survey, of which 3.8% had commercial importance. Fish comprised an estimated 75% of the weight of the bycatch (Table 6). Flatfish (Bothidae and Paralichthyidae), goatfish (Mullidae), leatherjackets (Monacanthidae), grinners (Synodontidae) and threadfin bream (Nemipteridae) dominated the catch by numbers. Few species were considered to be typical of coral reef associated fishes.

Watson and Goeden (1989) reported that about 4% of bycatch had some commercial value. In total, 38% of the bycatch were fish and 42% crustaceans (by number). Dredge (1988) reported bycatch weights of 18 kg to 30 kg (30 minute tows, 6 fathom nets) during research sampling of inter-reef sites. He suggested there was a seasonal change in the biomass of the bycatch which decreased from May until December.

Table 7. Discards by taxonomic group from 43 inter-reef trawls in the Green Zone, reproduced from Poiner *et al.* (1999).

	Number (%)	Weight (%)
All fish	64	60
All sponges	na	7
Hard corals	0	3
All crustaceans	25	13
Crabs (brachyurans) only	23	10
All molluscs	7	4
Bivalves only	6	1
Cephalopods only	1	1
All echinoderms	2	7
Total number or weight analysed	13,768	564 kg

Watson *et al.* (1990) reported that there was little clear pattern in the abundance of species between the wet and dry seasons in north Queensland. They used similarity measures and multi-dimensional scaling to group bycatch assemblages from several sites sampled by demersal trawls each month for two years. Faunal composition was more affected by the location of the sites than by time. Inter-reef sites in the study had high abundances of *Metapenaeopsis* spp., *Penaeus longistylus* and *Portunus tenuipes.* The bycatch was characterised by large numbers of threadfin bream (*Nemipterus celebicus*), grubfish (*Parapercis nebulosa*), oblong leatherjacket (*Paramonacanthus japonicus*) and a crab (*Portunus argentatus*).

A recent study in the northern Great Barrier Reef assessed the impact of trawling on areas open and closed to commercial trawling (Poiner *et al.* 1999). The study also collected information on the trawlable fauna of the cross-shelf closure (about 12°S) and adjacent areas. The mean catch rate of fish bycatch was 13.1 kg/hr, in research trawls in offshore/inter-reef (= inter-shoal) sites. The mean catch rate of invertebrate bycatch was 41.9 kg/hr. Fish were the dominant taxonomic group (Table 7).

While anecdotal reports suggest that sea snakes are likely to contribute to bycatch, there is scant information on their catch rates or composition for this sector.

Estimate of total bycatch

Two preliminary estimates of the total annual weight of bycatch in the red spot king prawn sector were made. The first, using the ratio method, estimated total bycatch to be in the order of 8,000 t, based on an average offshore bycatch:prawn catch ratio of 10:1 (Hill *et al.* 1999) and a total red spot king prawn catch of 800 t (Table 8). The second estimate used the CPUE method and was based on the product of a nightly bycatch (fish + invertebrates) of 550 kg per vessel (Hill *et al.* 1999) and an average total fishing effort of 13,000 boat-nights (Robins and Mayer 1998), resulting in an estimate of 7,150 t (Table 8). Although these estimates are similar, their reliability is largely dependent upon the assumptions and representativeness of the sampled bycatch rates. Sea turtle bycatch was estimated to be 65 (± 45 s.e.) turtles per year and comprised of 46% flatback turtles, 20% green turtles, 20%, loggerhead turtles and 13% Pacific ridley turtles (*Lepidochelys olivacea*) (Robins and Mayer 1998).

Table 8. Preliminary estimates of total annual bycatch in the red spot king prawn sector.

Source	Discard data	Method	Mean (tonnes)
Hill *et. al* (1999) QFISH logbook data	10:1 discard in offshore areas, assume 800 t prawn catch	Ratio	8,000 t
Hill *et al.* (1999), Robins and Mayer (1998)	55 kg/hr x 10 hrs x 13,000 nights effort	CPUE	7,150 t

The tiger and endeavour prawn sector

Tiger prawns *(Penaeus esculentus, P. semisulcatus, P. monodon)* and endeavour prawns (*Metapenaeus endeavouri, M. ensis*) are the main target species of trawlers working the coastal, inshore waters of the Queensland coast north of about Mackay (21°30'S). This is a major sector of the Queensland Trawl Fishery, representing 32% of total effort and valued at A$45 million per year (Williams 1997). It occurs primarily within the Great Barrier Reef World Heritage Area.

Bycatch issues

Bycatch issues pertain to: i) the impact of trawling on benthic habitats, benthic communities and the ecosystem, ii) the impact on threatened and protected species such as sea turtles, sea snakes, saw fish and pipefish, iii) the washup of dead fish on public beaches and iv) the World Heritage status of much of the trawled area.

Extent and characterisation of catch

Research on the tiger and endeavour prawn sector has been focussed primarily on the target species, but a number of studies have characterised the bycatch in certain areas in north Queensland; (Dredge 1988; Dredge 1989; Jones and Derbyshire 1988; Watson and Goeden 1989; Watson *et al.* 1990). The inshore and coastal sites examined in these studies (Townsville to Lucinda) include tiger prawn trawl grounds in the central Great Barrier Reef. Coastal sites sampled with an 11 fathom net (30 minute tows) had an average sample bycatch of 13 to 19 kg (Dredge 1988). Bycatch weights at inshore sites were more variable, ranging from 25 kg to 54 kg per sample. The study also identified some seasonal variation, with the biomass of bycatch peaking in May and falling to a minimum in November. Watson *et al.* (1990) reported that variation in bycatch weight was not related to the proximity to the coast, nor was it related to depth or any of the other physical parameters recorded. Coastal sites that were considered typical tiger prawn trawl ground yielded large numbers of javelinfish (*Pomadasys trifasciata*), grinner (*Saurida tumbil*), goatfish (*Upeneus sundaicus*), dragonet (*Callionymus belcheri*), redspot monocle bream (*Scolopsis taenipterus*), naked headed catfish (*Euristhmus nudiceps*), mud scallop (*Amusium pleuronectes*) and toadfish (*Torquigener whitleli*). They were also characterised with higher numbers of twin banded rock cod (*Epinephelus sexfasciatus*), large scaled grunter (*Terapon theraps*) and a crab (*Charybdis truncata*) than sites representative of the red spot king prawn sector (Watson *et al.* 1990).

The recent study located in the northern Great Barrier Reef (Hill *et al.* 1999) also collected information on the trawlable fauna of the cross-shelf closure (about 12°S) and adjacent areas. Research trawls reported a mean fish catch rate in inshore (= lagoon) areas of 17.2 kg/hr and an invertebrate catch rate of 13.1 kg/hr. Fish were the dominant taxonomic group in the discards (Table 9, Chapter 6, Poiner *et al.* 1999).

Table 9. Discards by taxonomic group from 79 inshore trawls in the Green Zone, reproduced from Poiner *et al.* (1999).

	Number (%)	Weight (%)
All fish	74	72
All sponges	na	13
Hard corals	0	0
All crustaceans	13	7
Crabs (brachyurans) only	11	5
All molluscs	12	5
Bivalves only	11	3
Cephalopods only	1	1
All echinoderms	1	1
Total number or weight analysed	36,289	1,315 kg

Short-term sampling of bycatch in the tiger prawn sector occurred during commercial trialing of turtle excluder devices (TEDs) and BRDs in north Queensland (Robins *et al.* 1997). From commercial trawling undertaken between Townsville and Hinchinbrook Island, average bycatch:prawn catch ratios of 5.7:1 (range 3.1:1 to 42.8, n = 8) for the Palm Island area and 16.3:1 (range 8.6:1 to 31.5:1, n = 8) for the Hinchinbrook Island area, were obtained. Samples taken from commercial vessels recorded 113 and 90 species of fish, crustaceans and molluscs (sponges, echinoderms were not examined) for the two areas fished respectively. BRD trialing during commercial trawling in the Townsville area recorded an average bycatch:prawn catch ratio of 4.8:1 (range 3.4:1 to 9.9:1, QDPI unpublished data) in standard trawl nets. Prawn catch represented 17% of the total catch, but ranged from 9.1% to 22.6% (n = 14). Sea snakes (*Lapemis hardwickii* and *Hydrophis elegans*) were caught occasionally in the standard trawls. Commercial BRD trials adjacent to Cape Flattery (14°57'S) recorded an average bycatch:catch ratio of 4.3:1 (range 3.1 to 4.9, QDPI unpublished data). Prawn catch represented 18.8% of the total catch, but ranged from 16.8% to 24.6% (n = 15).

Estimates of total bycatch

Two estimates of total bycatch in the tiger/endeavour prawn sector were calculated. Using the ratio method, a bycatch:prawn catch ratio of 6:1 in inshore areas (Hill *et al.* 1999) and an average annual catch of 3,200 t (Williams 1997), total annual bycatch is estimated to be in the order of 19,200 t. Using the bycatch CPUE method, which is based on the product of an average nightly bycatch rate of 380 kg per vessel (Hill *et al.* 1999) and an average annual fishing effort of 27,000 boat-nights (Robins and Mayer 1998), total annual bycatch is in the order of 10,260 t.

These estimates are preliminary and need to be qualified by a brief discussion of the assumptions and limitations of the two approaches. For example, the estimate of 19,200 t per year obtained from the ratio method is likely to be biased upwards because the catch estimate of 3,200 t is likely to be high for this fishing sector due to the inclusion of incidental catches of tiger and endeavour prawns from other sectors (i.e. the scallop, red spot king prawn sectors, the eastern king prawn sector and the banana prawn sector). In contrast, the estimate obtained using the bycatch CPUE method of 10,260 t is heavily influenced by the use of a single bycatch rate estimate of 380 kg per boat-night (from Hill *et al.* 1999), although bycatch rates for this sector are likely to vary spatially and temporally.

Sea turtle bycatch in the tiger and endeavour prawn sector was estimated to be 1,636 turtles per year (Robins and Mayer 1998). Species composition is predominantly flatback (40%), green turtles (34%) and Pacific ridley turtles (13%).

Summary

The bycatch issues

Several bycatch issues are common across sectors of the Queensland Trawl Fishery. Inter-sector conflict is most prevalent when the sectors of the fishery occur adjacent to population centres with a recreational fishing contingent (e.g. beam trawl, banana prawn sector, Moreton Bay) or when there is conflict between overlapping sectors of the commercial fishing industry over resource allocation (e.g. blue swimmer crabs). Concerns over impacts on benthic communities and habitat structure are common to almost all sectors, the exceptions being the eastern king prawn and stout whiting sectors, which occur mainly in oceanic waters. The impact on benthic communities and habitat structure is a growing issue for sectors occurring within the Great Barrier Reef World Heritage Area (e.g. the tiger/endeavour prawn, red spot king prawn, banana prawn and the scallop sectors). The wash up of dead fish on beaches is an issue mostly for inshore sectors (i.e. Moreton Bay, beam trawl, banana prawn) and the inshore portions of the tiger and endeavour prawn sector of north Queensland. The capture of unwanted species and the subsequent 'waste' of these animals is an issue common throughout the fishery, although the magnitude of the problem varies considerably between sectors. The incidental capture of protected species such as sea turtles and sea snakes is also an issue in all sectors of the fishery. Again, the magnitude of the problem varies between sectors and is mostly a direct correlation between the abundance of a particular protected species and the intensity of trawling effort.

The extent and characterisation of bycatch and the knowledge base

Several studies have contributed to a growing checklist of demersal fauna vulnerable to trawling in all sectors of the Queensland Trawl Fishery, with the exception of the eastern king prawn and scallop sectors. While some studies also provide estimates of bycatch:prawn catch ratios, these were obtained mostly during research activities, and as such, may not be truly representative of commercial fishing activities. Our understanding of the temporal and spatial variation in the ratios within sectors is generally poor. Caution is required when extrapolating results across entire sectors, especially for the tiger/endeavour prawn and the red spot king prawn sectors, as these encompass vast areas (over 10° of latitude) and a wide range of benthic communities.

Although there are no reliable estimates of total bycatch of the Queensland Trawl Fishery, the available information can be used to derive crude estimates for most sectors of the fishery (Table 1). An exception to this is the estimate of turtle bycatch which was the subject of a specific research project.

There is virtually no quantitative information from which to draw conclusions about the long term impact of bycatch in the Queensland Trawl Fishery. As an industry, prawn trawling commenced in the early 1950s and expanded northwards from the Moreton Bay and Bundaberg region. Unlike the Northern Prawn

Fishery, there is scant information on the species composition or abundance of bycatch during the early days of the fishery.

Policies and management of the bycatch issue

The Queensland Fisheries Management Authority (QFMA) is the agency primarily responsible for the management of the fishery. The QFMA, through the Fisheries Management Advisory Committee (TrawlMAC), has developed a management plan for the Queensland Trawl Fishery (Anonymous 1998). The plan considers bycatch a significant issue and acknowledges the need to reduce the impact of trawling on non-target species and communities, and recognises that trawling affects some fisheries' habitats. To this end, the plan seeks to minimise all impacts of trawling on non-target species and ensure that any impacts on threatened or endangered species are negligible and acceptable to key conservation agencies.

Reducing the impact of trawling on bycatch species is primarily being achieved through the introduction of turtle excluder devices (TEDs) and bycatch reduction devices (BRDs). TEDs have been defined as a device or modifications to the trawl net that allow turtles to escape immediately from the net. BRDs have a more generic description of excluding bycatch from the trawl net. Examples of BRDs include square-mesh panels, radial escape devices, bigeyes and fisheyes. (Technically a TED is a type of BRD). The QFMA has adopted a 'phase-in' approach to TEDs and BRDs to allow fishers to prepare for changes associated with bycatch reduction. It includes the compulsory use of TEDs in high risk areas from 1st May 1999, including Moreton Bay, the inshore waters south of Cape Moreton and coastal waters up to about six nautical miles from the shore in the following areas:

- the coastline from Round Hill Head to Gategers Bay (southern Hervey Bay);
- Repulse Bay;
- Cleveland Bay, and waters off Magnetic Island;
- Cape Grafton to Cape Flattery; and
- waters between Cape Melville and Portland Roads.

An ongoing risk assessment process will review additional areas in which TEDs may be needed.

BRDs were made compulsory in day time prawn trawling operations as of 1st May 1999. The management plan for the fishery aims to have all trawlers working within five nautical miles of the coast using BRDs by 1st January 2000, and then BRDs used by all trawlers fishing in the Great Barrier Reef Marine Park by 1st January 2001[1].

The Great Barrier Reef Marine Park Authority (GBRMPA) also has an interest in the Queensland Trawl Fishery, especially in regard to ensuring that fishing activities within the Great Barrier Reef World Heritage Area conform to the principles of ecological sustainable development and do not detract from the World Heritage status of the area. The QFMA and the GBRMPA recognise the public expectation that reduction in trawl bycatch is desirable for maintaining biodiversity and minimising 'waste'.

In conclusion, bycatch associated with the Queensland Trawl Fishery generates a wide range of economic, social and ecological issues. While initiatives are currently underway to document and reduce bycatch, our understanding of the ecological impacts pertaining to trawl bycatch remain poor.

[1] Ongoing negotiations between State and Commonwealth Governments.

This aside, the most immediate problem facing industry and management is a lack of statistically robust targets upon which to focus bycatch reduction initiatives. The long-term result of this scenario is that while bycatch initiatives will continue to be introduced, we will not be able to precisely quantify their impact on the populations of bycatch species.

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Focussing on bycatch issues in Australia's South East Trawl Fishery

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Abstract

Australia's South East Fishery (SEF) is a complex multi-species, multi-gear fishery which operates over a large area from shallow coastal waters to depths of over 1000 m. As such, it consists of various sub-fisheries whose distinct catch composition and bycatch issues are defined by the gear, areas, depths and seasons fished. Trawling is the main method used in the fishery and observer programs have provided extensive data on the species and size composition of both the retained and discarded trawl catch. Bycatch of birds, turtles and dolphins was virtually non-existent but seals were caught in a low percentage of shots. Benthos also accounts for a relatively small proportion of the catch. The discarding of fish by trawlers was the biggest bycatch issue in the SEF although discarding levels and the composition of the discarded catch varied considerably throughout the fishery. The lowest levels of discarding were in the target fisheries for spawning orange roughy and blue grenadier, where less than 10-30% (by weight) of the total catch was discarded. In the mixed species fisheries in western Bass Strait and off the east coast of New South Wales, up to 50% of the catch may be discarded. Quota species were often discarded. These commonly included small blue grenadier, spotted warehou and blue warehou in the west, whilst small redfish, ocean perch, flathead, mirror dory and recently blue grenadier, were major discards in the east. Some commercial non-quota species were widely discarded including barracouta, southern frostfish and jack mackerel. Considerable discarding of small non-commercial species including New Zealand dories, whiptails and cucumber fish was highlighted. Due to the numerous and complex reasons behind discarding of fish by trawlers in the SEF, a variety of methods to minimise discarding may be considered including changes to management, marketing and gear selectivity. However, if any are to be successful, they will require close cooperation between industry, managers, researchers and other interest groups.

Introduction

Australia's South East Fishery (SEF) has evolved over this century from a small steam trawl fishery to a complex multi-species, multi-gear fishery which operates on the shallow coastal waters off south eastern Australia to depths of over 1000 m off the continental shelf. A range of gear types is used in the fishery, including Danish seines, droplines, longlines and traps, but most of the catch is taken by otter trawls. Although the SEF is managed as a single fishery, it can be considered as a variety of distinct sub-fisheries defined by the gear, areas, depths and seasons fished. This was evident in the species composition of the catches from the various sub-fisheries (Klaer and Tilzey 1994; Smith *et al.* 1997).

SEF catches include over 80 commercial species, and 22 species or species groups comprise 95% of the catch (Tilzey 1994). Sixteen of these species are under quota management. While trawling often targets quota species or other species of high commercial value, generally it is considered a relatively non-selective fishing method. As such, many fish are captured that have little or no commercial value and are subsequently discarded. Some commercial species, including quota species may also be discarded. This usually relates to the complex interaction of market demand, quota value, leasing costs, quota availability and the economic viability of retaining the fish (Liggins and Knuckey 1999). Nevertheless, such discarding is unproductive and time consuming for fishers and is seen as a waste of a potentially valuable resource. Also, whilst the effects of discarding on factors such as biodiversity, food chains or species interactions have yet to be established at an ecosystem level, the practice attracts negative publicity for the industry. Furthermore, under the *Fisheries Management Act 1991* the SEF is required to be managed according to the principles of ecologically sustainable development and have regard to impacts on non-target species and the long-term sustainability of the marine environment. For these reasons, it is necessary to consider ways of reducing the level of discarding by trawlers in the SEF.

On a world-wide scale, when genuine efforts to reduce bycatch and discarding in trawl fisheries have been undertaken, they have often been successful (e.g. Hall 1996; Kennelly 1997). In achieving this, Kennelly (1997) highlighted certain common protocols. The first was the identification and quantification of the retained and discarded catches through a comprehensive observer program. Next, industry and scientists needed to work together to determine and trial various ideas in order to find the best solution/s to the problem. The final step was to publicise the results amongst all industry members and other interest groups.

Considerable progress has already been made in this process within the trawl sector of the SEF. The composition of the catches taken by SEF trawlers has been monitored over a number of years by scientific observers on vessels working off the coast of New South Wales (Liggins 1996) and throughout the SEF as part of the Integrated Scientific Monitoring Programme (ISMP) (Knuckey 1997; Garvey 1998). These projects provide extensive quantitative information on the species composition of both the retained and discarded catch. Such information was presented at a recent workshop where industry, scientists, managers and other interested groups discussed ways of addressing the trawl bycatch/discarding issues in the SEF. This paper presents these issues and the outcomes of the workshop.

Collection of data

The information on the catch composition of SEF trawlers has been collected by a variety of projects. The first was a joint Fisheries Research and Development Corporation and NSW Fisheries Research Institute funded project entitled "The interaction between fish trawling (in NSW) and other commercial and recreational fisheries" (Liggins 1996). This project began in 1993 and consisted of an observer program run on SEF trawlers working out of the NSW ports of Eden, Ulladulla and Newcastle/Tuncurry. In 1994, the Bureau of Resource Sciences employed observers to collect information on the species composition and length-frequency of the retained and discarded catch of trawlers working in other areas of the SEF. Meanwhile, port-based fish measurement and otolith collection was being conducted by the various State agencies. In 1996, both the at-sea and port-based monitoring off NSW and the rest of the SEF was integrated and managed by the Australian Fisheries Management Authority (AFMA), as the ISMP. This program, currently run by the

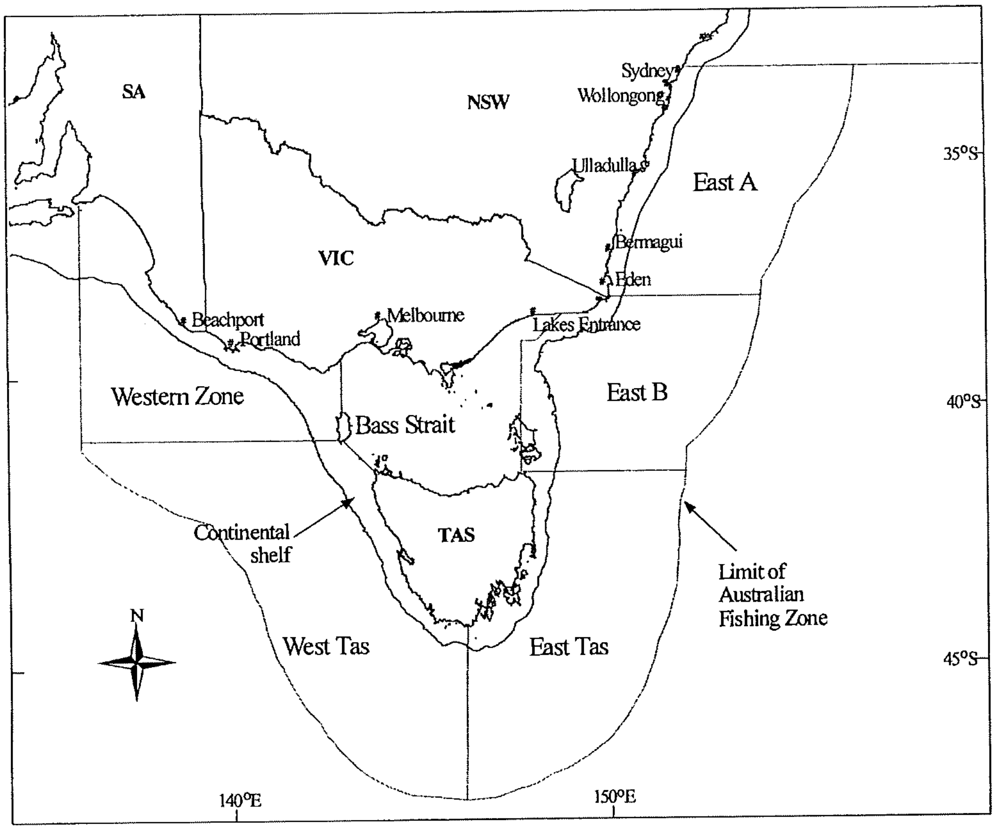


Figure 1. Zones used to summarise the spatial distribution of sub-fisheries in the South East Fishery.

Marine and Freshwater Resources Institute in Victoria, was designed to provide estimates of the total catch (retained and discarded) of quota and non-quota species and the size/age composition of priority species of the SEF. To achieve this, observers collected information from a representative cross-section of fishing trips undertaken by trawlers working in each of the zones of the SEF (Figure 1) throughout the year. On each fishing trip, observers usually sampled every shot, estimating the retained and discarded weights (or numbers) of every species caught. Length-frequency measurements were also taken from a sub-sample of these catches to provide a size distribution of both the retained and discarded catch of key species. In addition to the on-board sampling, length-frequency data and otoliths for age determination were collected from quota species and selected non-quota species at each of the major SEF ports. In this manner, the overall composition of the catch taken by trawlers throughout the SEF and the proportion and size range of the different species that were retained and discarded has been obtained.

Based on catch compositions and spatial/temporal patterns in the fishery, Tilzey (1994) identified 16 separate sub-fisheries within the SEF. The bycatch issues in each of these sub-fisheries is likely to be different, and this very detailed information is not presented here. Instead, we provide a general overview which summarises catch compositions in the eastern zones of the SEF (East A and East B), western Bass Strait (Western Zone) and the

Table 1. Description of definitions used in this paper to classify the catch taken by SEF trawlers.

Definition	Description
Total catch	All fish and other material caught by the trawl.
Retained catch	The component of the total catch that is kept by the fisherman and returned to port.
Discarded catch	The component of the total catch that is discarded back into the water.
Fish	Includes scalefish (teleosts) and sharks and rays (elasmobranchs).
Benthos	Includes rocks, sponges and bottom debris.
Quota species	The 16 quota species are blue grenadier, ling, orange roughy, redfish, mirror dory, john dory, ocean perch, flathead, school whiting, silver trevally, jackass morwong, gemfish, blue eye trevalla, blue warehou, spotted warehou and royal red prawn.
Commercial species	Species which can have a market value. Commercial species, which includes all quota species, may be either retained or discarded.
Non-commercial species	Fish which to date have no commercial value. By definition, non-commercial species are never a part of the retained catch.

target fisheries for spawning blue grenadier and orange roughy. This was based on observer data collected during 1996 and 1997. A few broad definitions used to classify the catch are described (Table 1) to help explain the catch composition and utilisation of these fisheries. The percentage (by weight) that each main species or species group comprises within both the retained and discarded catch is presented graphically using pie diagrams.

Results and discussion

The data presented in this paper summarise information only from the shots observed by ISMP observers on otter-board trawl vessels. It does not include data from Danish seine or non-trawl vessels. There has not been equal coverage of vessels within each zone, nor has the coverage necessarily been designed to provide accurate estimates of discarding. For these reasons, the results should not be extrapolated to provide estimates of the entire SEF, especially considering the fact that various 'sub-fisheries' may exist within each of the broad areas described. The sampling design of the ISMP was modified in 1998 so that in future, such extrapolations can be undertaken within specified levels of precision for the major quota and non-quota species.

Catches of birds and mammals

The capture of 'charismatic megafauna', (birds, mammals, turtles, etc.) in SEF trawls was rare. Since monitoring SEF trawl catches began, many thousands of shots have been observed and the capture of birds, turtles and dolphins was negligible. Rates of seal (Otariidae) captures vary in different areas, but generally, seals were caught in a low percentage of shots across the SEF (<1.5%). Depending on what stage the seals were caught in the trawl, they may have been alive when released and still be recorded as 'discarded'.

Catches of benthos

Benthos is a very broad term that applies to anything lying on or attached to the bottom. In the ISMP observer work, benthos referred to the rocks, corals, sponges, etc. and other bottom debris that was brought up in the net. There was usually a small amount of benthos collected by demersal trawls. The amount varied in the different areas of the fishery, but overall it usually accounted for a low

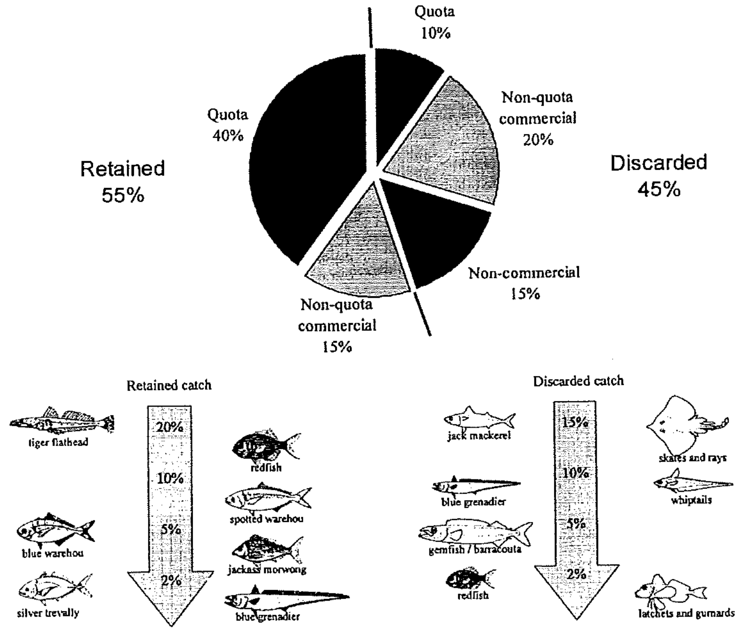


Figure 2. Composition of the retained and discarded catch of fish by board-trawlers in the eastern zones of the SEF. Data from 1996 and 1997 ISMP, pooled over East A and East B zones.

percentage (<3%) of the total catch weight of an average 1,000 kg shot.

Catches and discarding of fish

It is important to note that the results presented here have been pooled over two years (1996 and 1997) and over broad areas. Thus, while they provide a general overview of the different trawl bycatch issues in a few areas of the SEF, they do not accurately describe what may be caught in any particular shot. This is because catch composition can change depending on a wide range of factors including depth, season, moon phase, weather, and targeting practices. The summaries do, however, give an overview of the general catch composition in broad areas of the SEF and the species that comprised the bulk of the discarding.

Eastern zones

Overall, about 55% of the fish caught in the eastern zones was retained and most of these were quota species (Figure 2). Redfish (*Centroberyx affinis*) and tiger flathead (*Neoplatycephalus richardsoni*) dominated the retained catch in this area but ling (*Genypterus blacodes*), blue warehou (*Seriolella brama*) and silver warehou (*Seriolella punctata*), silver trevally (*Pseudocaranx dentex*), jackass morwong (*Nemadactylus macropterus*) and blue grenadier (*Macruronus novaezelandiae*) were also common. Other quota species in the retained catch included gemfish (*Rexea solandri*), mirror dory (*Zenopsis nebulosis*), ocean perch (*Helicolenus* spp.) and royal red prawns (*Haliporoides sibogae*). The main non-quota commercial species that were retained included arrow squid (*Nototodarus gouldi*), various shark species and southern frostfish (*Lepidopus caudatus*).

Quota species also comprised about 20% of the discarded catch. During 1996, small redfish (<20 cm) were also one of the most commonly discarded quota species, but this decreased

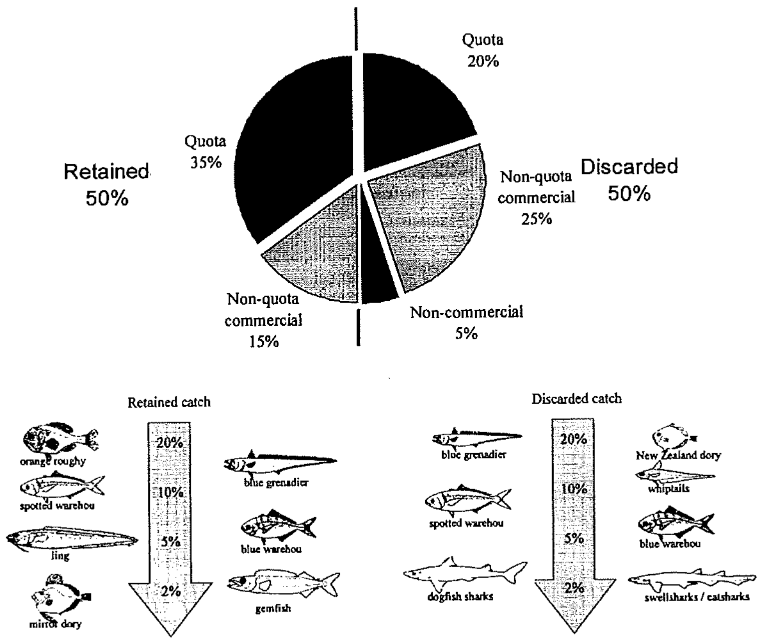
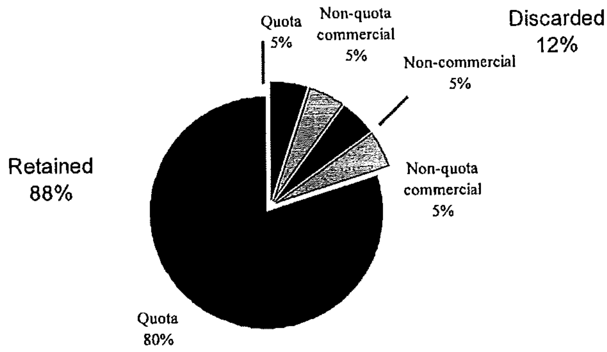


Figure 3. Composition of the retained and discarded catch of fish by board-trawlers in the western zone of the SEF. Data from 1996 and 1997 ISMP.

noticeably in 1997. This high-grading has been occurring off the NSW coast for numerous years, although the rate of discarding has varied both spatially and temporally (Liggins 1996). The development of a surimi market for these smaller redfish has probably helped reduce the levels of discarding in recent years. High discard rates have also been recorded for mirror dory off NSW (Liggins 1996) but have reduced significantly in 1996 and 1997, except in eastern Tasmania (Knuckey 1998). Small ocean perch (more often the inshore species *Helicolenus percoides*) were another quota species commonly discarded (Liggins 1996). This practice was still apparent during 1996 and 1997 although due to their small size, they did not form a large percentage of the discarded catch by weight. Significant amounts of small blue grenadier (usually below 50 cm length) were also discarded. Small blue grenadier were a significant component of the discarded catch in many areas of the fishery. While the data were not presented here, information from previous years shows that this has not always been the case. The large catches of small blue grenadier in recent years have been attributed to one (and possibly more) strong year classes now entering the fishery (Smith 1998). This highlights the temporal aspects to discarding in the SEF that have not been considered in the current paper.

Other commonly discarded species that can be of commercial value included jack mackerel (*Trachurus declivis*), barracouta (*Thyrsites atun*) and southern frostfish. Whiptails (Macrouridae), cucumber fish (*Chlorophthalmus* spp.), latchets (*Pterygotrigla* spp.), gurnards (*Lepidotrigla* spp.) and various species of skates, rays (Rajidae) and swellsharks (*Cephaloscyllium* spp.) were the main non-commercial species often discarded in the eastern zones. Whiptails (also called rattails) formed a major component of the discarded catch in many areas of the SEF. They were nearly always less than 50 cm in length and



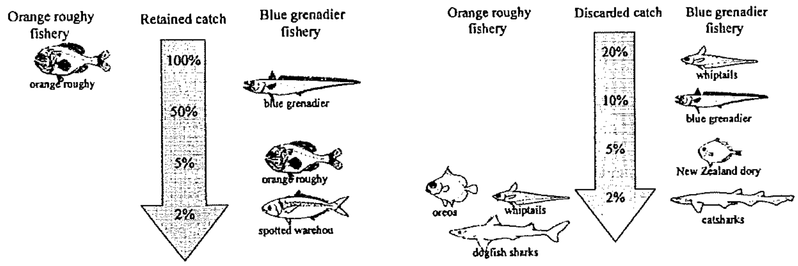


Figure 4. Composition of the retained and discarded catch of fish by board-trawlers targeting spawning orange roughy off the east coast of Tasmania and blue grenadier off the west coast of Tasmania. Data from 1996 and 1997 ISMP.

were of a similar size and shape to the small blue grenadier being discarded.

Western zone

Similar to the eastern zones, half of the fish caught in the western zone were retained and about 70% of these were quota species (Figure 3). The retained quota species consisted mainly of orange roughy (*Hoplostethus atlanticus*), blue grenadier, blue and spotted warehou, ling and western gemfish. Arrow squid formed a major portion of the retained non-quota species and any squid greater than 20 cm mantle length were usually retained (Knuckey and Ryan 1997). Various species of oreos (Oreosomatidae), dogfish (Squalidae), dories (Zeidae), latchets and shark were also kept.

Quota species that were discarded in significant numbers in this area included blue grenadier, blue warehou and spotted warehou. As in other parts of the SEF, the significant discarding of blue grenadier in 1996 and 1997 consisted of the newly recruited small fish (<50 cm) that were extremely abundant in these years. The other main quota species that formed a significant part of the discarded catch to the west of Bass Strait were blue and spotted warehou. While a certain amount of high-grading of these species occurred, much of the discarding resulted from individual large shots where only a small percentage of the shot was retained and little sorting of the catch occurred.

Dogfish, barracouta and southern frostfish were among the most commonly discarded non-quota commercial species. The non-commercial species that were discarded comprised mainly whiptails, New Zealand dory (*Cyttus novaezealandiae*), rubyfish (*Plagiogeneion macrolepus*) and draughtboard shark (*Cephaloscyllium nascione*).

Target fisheries

Targeting of specific fish by trawlers occurs in various areas of the SEF and often results in lower levels of discarding. The best examples of target fisheries in the SEF are the winter spawning fisheries for orange roughy off the east coast of Tasmania and blue grenadier off the west coast of Tasmania. The levels of bycatch and discarding in these fisheries were very low. Pooled over both fisheries, about 90% of the catch was usually retained, and this was dominated by the target quota species (Figure 4). In fact, these fisheries had a high number of 'clean' shots, where virtually all of the catch consists of one species which was retained.

In the orange roughy fishery various species of deepwater oreos were caught, which may be either retained or discarded. Any whiptails and dogfish were also usually discarded. In the blue grenadier winter fishery off Tasmania's west coast, orange roughy and spotted warehou were sometimes caught with the blue grenadier. Some shots targeted species other than blue grenadier. Although the quota species were usually retained, small blue grenadier were sometimes discarded and spotted warehou were also discarded if caught in large numbers. Non-commercial species such as whiptails, sawsharks (Pristiophoridae), swellsharks and New Zealand dory were discarded. However, in the factory vessels that have recently entered the blue grenadier spawning fishery, nearly all of the bycatch is retained, either as fillets, minced product, or for use as fishmeal (ISMP unpublished data).

Addressing the bycatch issues

The composition of the catches taken by SEF trawlers varied considerably between the different areas. This was reflected in the different retained and discarded components of the catch throughout the fishery. As a result, defining the discarding issues that confront the trawl sector of the SEF is not simple and developing viable solutions may also be difficult. Nevertheless, as a step forward in this process, a workshop was held with participants from industry and various research, management and conservation agencies (government and non-government) to discuss these issues. A variety of options to address the discarding problems were proposed. These can be categorised into three major areas:

- *Management* – Development of bycatch management objectives with clear targets and indicators; re-examination of management measures to minimise the discarding of quota species;
- *Marketing* – Programs to develop new markets and/or products for discarded species – converting discards to commercial species, and the removal of marketing impediments;
- *Gear selection research* – Development of technological fixes (modified gear) to reduce discarding. This will require input from fishers, an understanding of the behaviour of the fish, and quantification of the impact of modified gear on long-term yields and bycatch.

It was highlighted at the workshop that all of these areas need to be addressed to provide a comprehensive means of improving bycatch and discarding practices. To just concentrate on one of these areas would not be an adequate approach. Work is already progressing in some of these areas. Management issues such as quota species substitution have been the focus of workshops and other AFMA and South East Trawl Management Advisory Committee initiatives. Potential processing and marketing of commonly discarded species has been trialed for New Zealand dory and whiptails and work is progressing on the development of surimi markets for small redfish. The workshop initiated discussions between the Fisheries

Research and Development Corporation (FRDC), key industry members and research organisations to develop a coordinated approach to these marketing approaches.

There was acknowledgment at the workshop that management and marketing areas should continue to be addressed. Further discussion concentrated on what aspects of gear selection research could be undertaken. It was highlighted that many similar problems had been tackled in fish trawl fisheries elsewhere in the world and that common net modifications such as square-mesh panels and various sorting grids and devices should be trialed in the SEF. In addition, it was felt that the use of video footage to monitor the behaviour of fish in the trawl was a crucial component of a project to investigate gear modification. With such a wide range of discarded species and different compositions in eastern and western areas of the SEF the potential scope of such a project was very broad. It was decided to undertake the work in only two areas of the SEF (off the coasts of southern New South Wales and western Victoria), and to initially focus on the reduction of the capture of small fish only. It was considered that if small fish were not caught, it would make a significant impact on high-grading of quota species and the overall levels of discarding in the SEF. Industry was fully supportive of this approach but emphasised the need for industry involvement in the development and undertaking the project. The workshop recommended that a collaborative project be developed to investigate trawl gear modification as a means of reducing the levels of discarding in the SEF. This has since been funded by FRDC and commenced in January 1999 (FRDC Project 98/204, "Effects of Trawling Subprogram: Maximising yield and reducing discards in the South East Trawl Fishery through gear development and evaluation").

In summary, bycatch and discarding in the SEF have been well defined and quantified through research by various observer programs. This has enabled the real issues to be highlighted so that means of improving the problems can be discussed and trialed. The cooperative approach between industry, managers, researchers and other interest groups has yielded positive initiatives. Through a range of management, marketing and gear modification changes in the fishery, it is hoped that future levels of discarding by SEF trawlers will be significantly reduced.

Acknowledgments

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Factors affecting discarding in the South East Fishery – implications for stock assessment and bycatch reduction

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Abstract

*Stock assessments for species caught in the South East Fishery (SEF) and other interacting fisheries depend, among other things, on accurate determinations of total catches (both retained and discarded components) and size (age) distributions of these catches. The need to reduce discarding is partly determined by evaluation of the consequences of discarding for stocks and subsequent yields from the fishery. The likely effectiveness of strategies to reduce discarding (e.g. modifications to gear selectivity, spatial and temporal closures, changes to minimum legal length (MLL) regulations, total allowable catch/individual transferable quotas (TAC/ITQs), trip-limits, market development) is aided by analysis of patterns of discarding (magnitudes and size distributions) relative to: i). retained catches; ii). spatial and temporal scales of interest (latitude, depth, years, seasons); iii). existing management regulations (MLLs, TACs); iv). market forces (prices/volumes). This paper discusses these concepts based on data derived from observer surveys in the SEF with particular emphasis on stock assessments and analyses of patterns of discarding for two SEF quota species, redfish (*Centroberyx affinis*) and tiger flathead (*Neoplatycephalus richardsoni*).*

Introduction

Fish discarded at sea represent real losses from populations, so stock assessments that ignore the discarded component of catch may be erroneous and the potential biomass and yield from stocks may be reduced (e.g. Saila 1983; Hilborn and Walters 1992; Alverson *et al*. 1994). In addition to such direct effects, the capture and discard of fish may have more complex effects on community structure including habitat degradation, influences on species interactions and their consequent cascading effect through the trophic web (e.g. Hutchings 1990; Sainsbury 1991; Andrew and Pepperell 1992; Kennelly 1997). Evaluation of these effects of discarding, partially determines the need for reducing discards in any fishery. The need to reduce discarding may also result from negative publicity associated with the practice and consequent threat to the fishing industry and the reality that the capture and subsequent discard of large quantities of fish carries with it costs in terms of wear and tear on fishing gear and sorting time for crews.

Fundamental to any assessment of the effects of discarding on stocks or of the need to reduce discards in a fishery is an evaluation of the composition (species, quantities, size-distributions) of discarded catches (Saila 1983; Alverson *et al.* 1994; Kennelly 1997). The process of stock assessment, the design of long-term monitoring programs and selection of appropriate strategies for reducing discards is further aided by analysis of patterns of discarding (magnitudes and size distributions) relative to: i). retained catches; ii). spatial and temporal scales of interest (e.g. regions, depth, years, seasons); iii). existing management regulations (minimum legal length (MLL) legislation, total allowable catch (TAC)/ individual transferable quota (ITQ) schemes); and iv). market/economic forces (prices/ volumes).

The composition of discarded catches by trawlers operating in the South East Fishery (SEF) has been monitored off the NSW coast since 1993 (Liggins 1996; Liggins 1997) and throughout the SEF as part of the Integrated Scientific Monitoring Program (ISMP) (see Knuckey and Liggins, 1999 and references therein). At-sea observer-based surveys and port-based surveys provide estimates of magnitudes and size – and age – distributions of retained, discarded and total catches. Knuckey and Liggins (1999) provide a general overview of issues relating to discarding in the SEF and differences in the composition of discards among the major regions and sub-fisheries of the SEF (eastern zones, western zone, and target fisheries for orange roughy and blue grenadier off the east and west coasts of Tasmania respectively). In this paper, we present examples of analyses that examine factors affecting discarding in SEF waters off NSW (with particular reference to redfish, *Centroberyx affinis,* and tiger flathead, *Neoplatycephalus richardsoni*) and discuss their relevance to stock assessment and bycatch reduction across the SEF.

Factors affecting discarding

Variability of discard rates among regions, years and seasons

Comparisons of discard rates among regions, years and seasons have been made for that component of the SEF off the south coast of NSW and fish trawling in NSW occurring north of the SEF (for details of data collection methods and analyses see Liggins, 1996). Analyses of variance were used to test for differences in discard rates across three regions ('North' north of the SEF, Ulladulla, Eden), three years (1993, 1994, 1995) and four quarters of the year (Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec). In addition to presenting a summary of the key results from these analyses, graphical comparisons of catch rates are presented in this paper for two SEF regions (Ulladulla and Eden) for the five-year period 1993-1997.

Mean total catch (retained and discarded for all species, kg) per fisher-day and mean retained catch (kg) per fisher-day did not vary significantly among the three years surveyed for any of the three regions. There was, however, a significant difference in total catch rate among the three regions, catch increasing with latitude (632 +/- 33 kg for North; 2,205 +/- 98 kg for Ulladulla; and 4,175 +/- 139 kg per fisher-day for Eden) (and see Figure 1). Independent of region and year, catch rate was maximal in the third quarter of the year, July-September. Quantities of fish discarded (mean kg per fisher-day) also increased with latitude (376 +/- 20 kg for North; 828 +/- 97 kg for Ulladulla; and 2,319 +/- 134 kg per fisher-day for Eden) and were significantly greater during the third quarter of each year in each region and also significantly greater during 1995 compared to the previous two years. Various interactions between the factors region, year and quarter were significant for discarded catches of three logical groupings of species: SEF quota species,

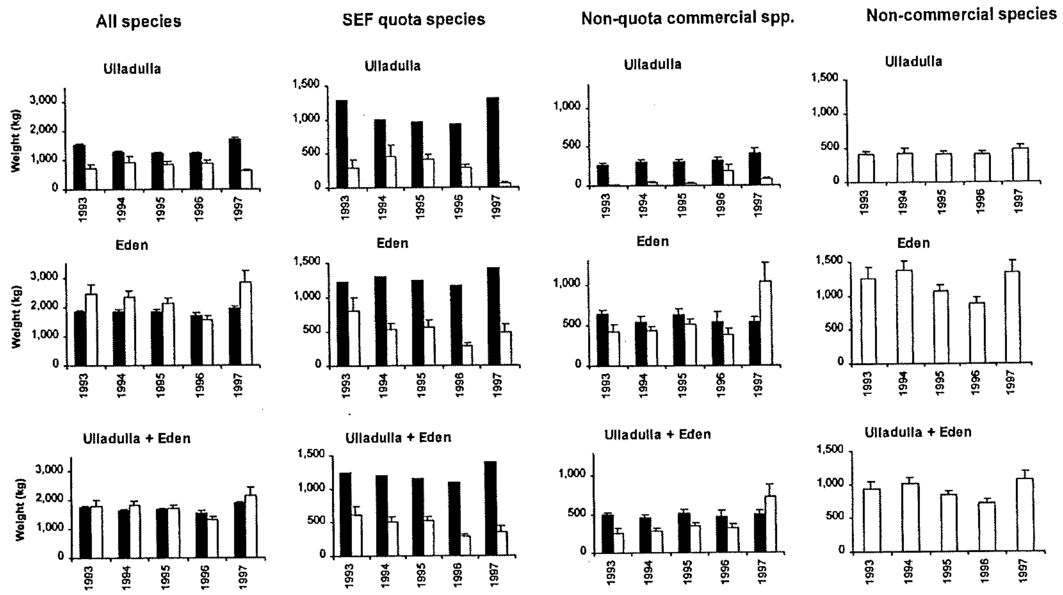

Figure 1. Annual mean catch rates (kg per fisher-day, +/- 1 se) for retained (black bars) and discarded (white bars) components of catch for four partitions of total catch (all species combined, SEF quota species, non-quota commercial species, non-commercial species), by Ulladulla and Eden trawlers during the period 1993-97.

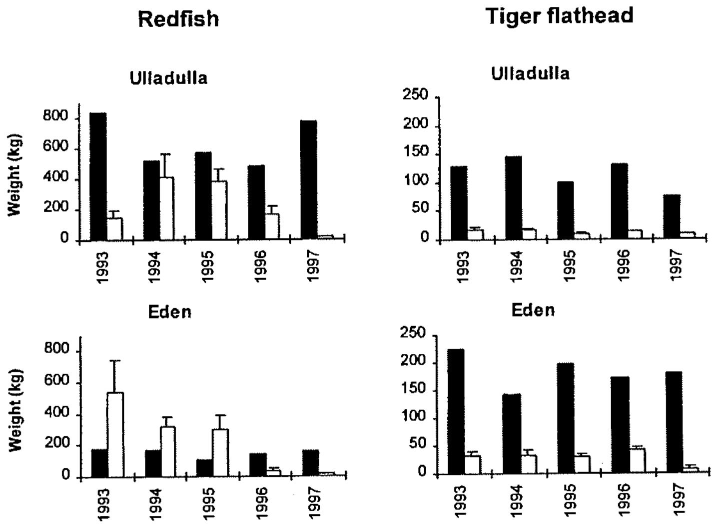

Figure 2. Annual mean catch rates (kg per fisher-day, +/- 1 se) for retained (black bars) and discarded (white bars) catches of redfish and tiger flathead, by Ulladulla and Eden trawlers during the period 1993-97.

non-quota commercial species and non-commercial species. Catch per fisher-day for these partitions of catch generally increased with latitude. Patterns of catch across the four quarters of each year were less consistent. Note that for the various partitions of total catch presented in Figure 1 (all species combined, SEF quota species, non-quota commercial species, non-commercial species), catch rates for the retained components of catch are relatively stable across the period 1993-97 whilst rates of discard show greater inter-annual fluctuations.

Patterns of discard rates (kg discarded per fisher-day) among regions, years and quarters for individual species were species-dependent. For example, the quantity of tiger flathead discarded per fisher-day did not vary significantly between years but did vary between regions dependent on quarter. In particular, note the stability of discard rates for tiger flathead at Ulladulla and Eden across the five-year period 1993-97 (Figure 2). Variation in discard rates for redfish across these spatial and temporal scales was more complex with a significant interaction between regions, years and quarters. Note that, over the period 1993-97, discard rates (kg per fisher-day) at Eden show a decline whilst discard rates at Ulladulla show an increase followed by a decline (Figure 2). Similarly, variations in the proportion of catch discarded differ markedly between these regions (Figure 2). Equivalent analyses for other species (see Liggins 1996, 1997) demonstrate the species-dependence of patterns of variation across these scales.

Variability of size-distributions of discards among regions and years

Size distributions of discards and of total catches (retained and discarded catches) of redfish varied considerably between the Ulladulla and Eden fleets and among years (Figure 3). Moreover, the contribution of discards to size-distributions of total catches of redfish was dependent on both region and year. Note that discards dominate the size distributions of total catches by the Eden fleet during the period 1993-1995. Another important feature of these size-distributions is the overlap of distributions for retained and discarded fish and that the amount of overlap was inconsistent between regions and among years. Clearly, the range of sizes of fish that are sometimes retained and sometimes discarded differs between ports and varies from year to year.

In contrast, size-distributions of retained catches, discarded catches and total catches of tiger flathead show greater stability across regions and years (Figure 4). There is virtually no overlap in the distributions of retained and discarded tiger flathead. A minimum legal length of 33 cm (total length) applies to tiger flathead in NSW and fish less than this length (approximately 32 cm fork length) are discarded and those greater than this length retained (Figure 4).

Size-distributions for ten SEF quota species, representing the combined catches of fleets from three NSW regions ('North', Ulladulla and Eden; but these distributions are dominated by SEF catches from Ulladulla and Eden), over the period 1993-95, are shown in Figure 5. Generally, for these and other commercial species (Liggins 1996), discarding is size-selective with fishers routinely high-grading catches, but to varying degrees dependent on species. The real exception here is eastern gemfish for which size-distributions of retained and discarded catches covered a similar range of sizes (this is discussed later). Note also, that there is considerable variation, among species, in: i). the sizes of fish retained; ii). the sizes of fish discarded; and iii). the overlap of distributions for retained and discarded fish.

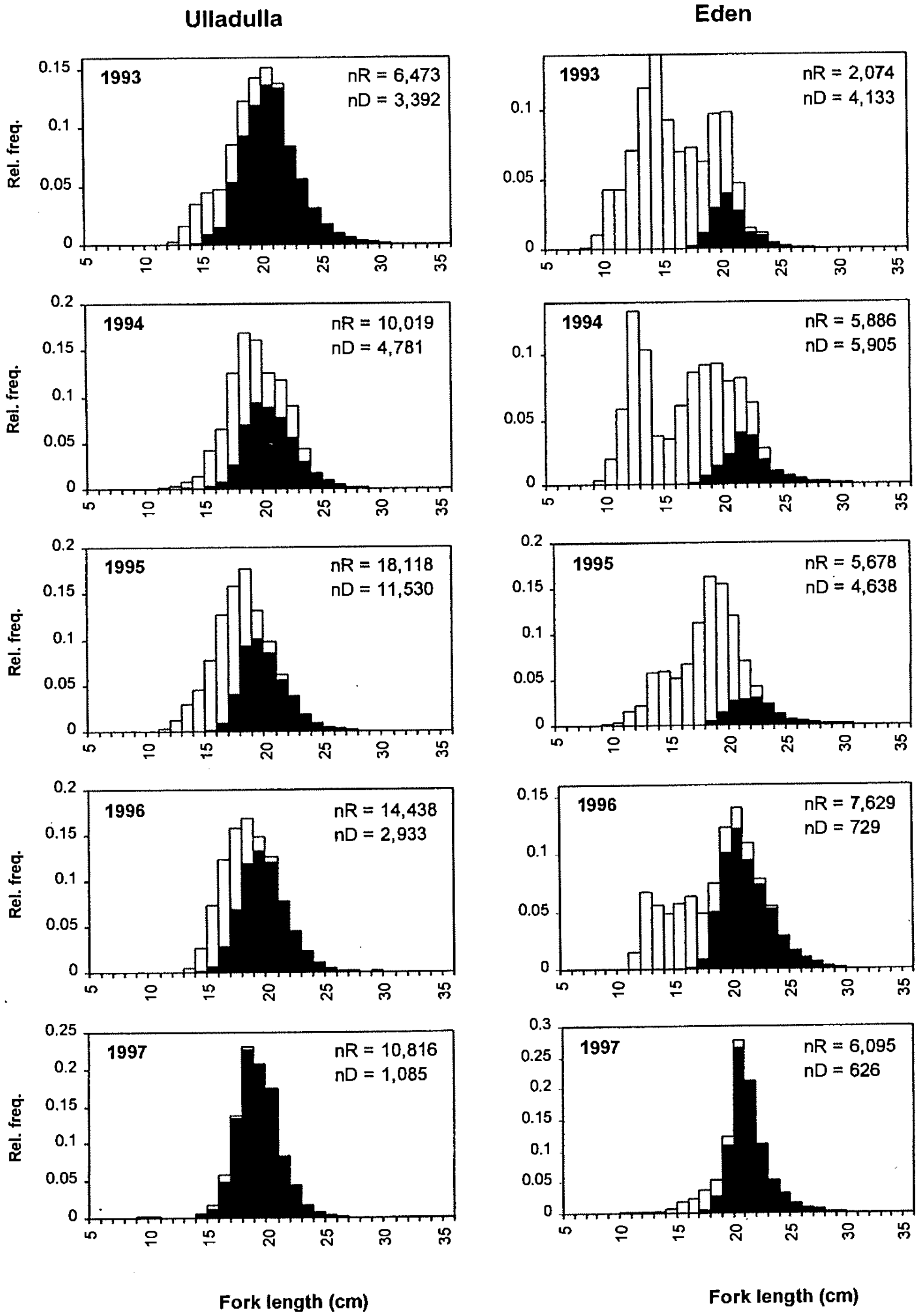

Figure 3. Annual size-distributions (relative frequencies) for retained (black bars) and discarded (white bars) catches of redfish by Ulladulla and Eden trawlers for the period 1993-97. nR and nD indicate samples sizes for retained and discarded fish respectively.

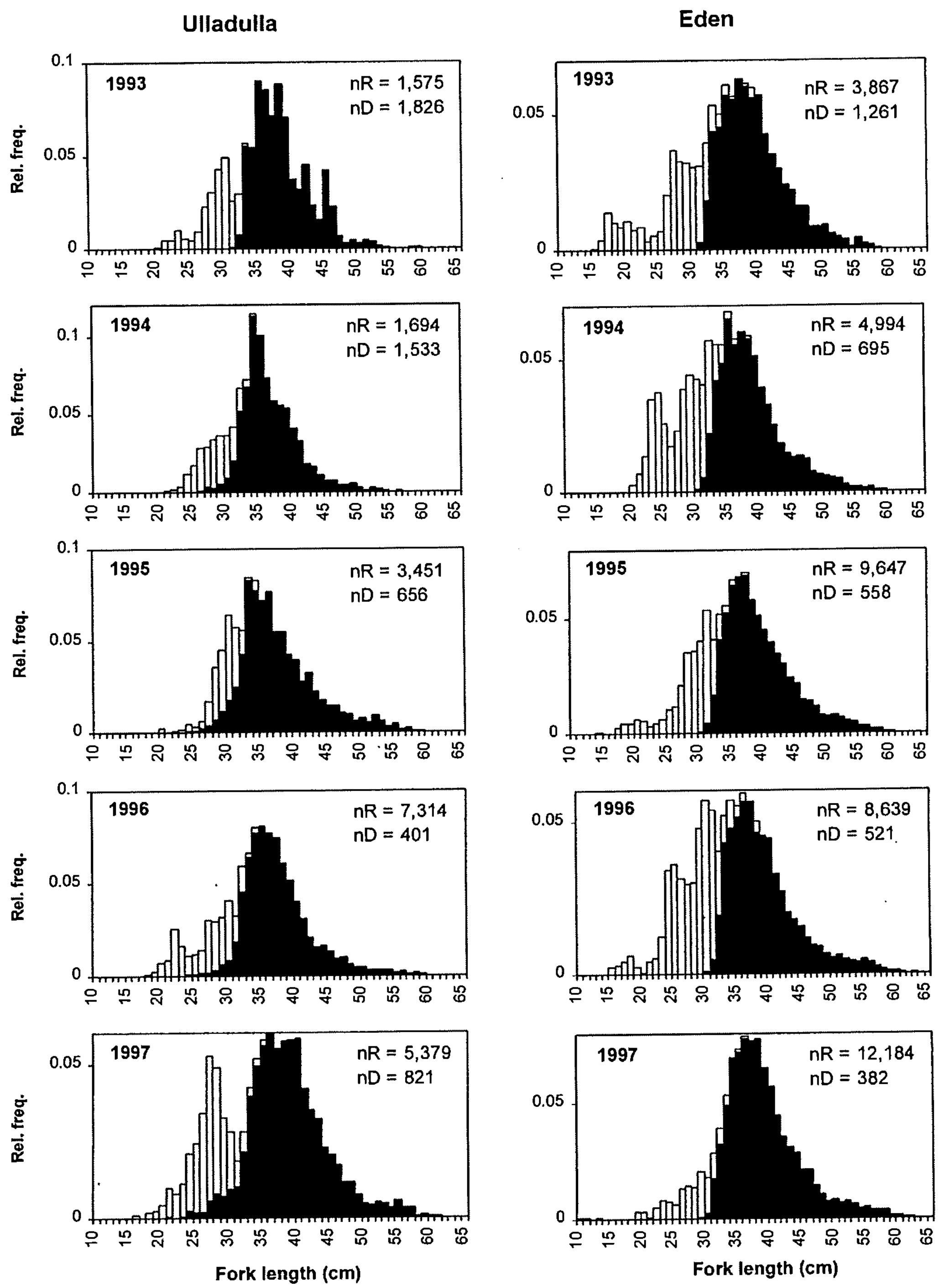

Figure 4. Annual size-distributions (relative frequencies) for retained (black bars) and discarded (white bars) catches of tiger flathead by Ulladulla and Eden trawlers for the period 1993-97. nR and nD indicate samples sizes for retained and discarded fish respectively.

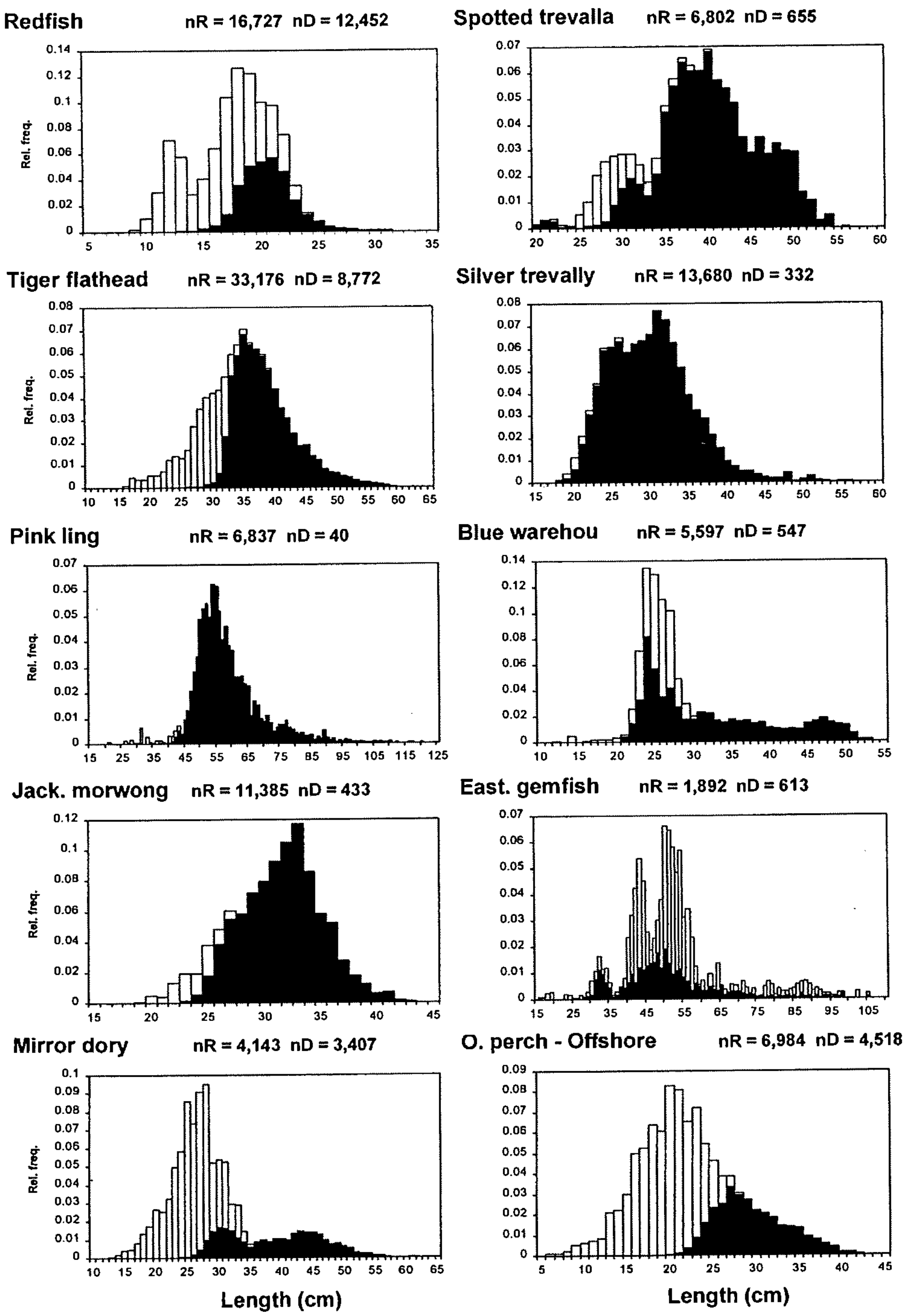

Figure 5. Size-distributions (relative frequencies) for retained (black bars) and discarded (white bars) catches of 10 SEF quota species by trawlers from three regions of the NSW coast ('North', Ulladulla and Eden) for the period 1993-95.

Variations in discarding associated with depth

Redfish show a length-dependent distribution with depth, small fish occurring more frequently in shallow inshore waters and large fish in deeper offshore waters (Chen *et al.* 1997). As redfish are routinely high-graded by trawlers operating from both Ulladulla and Eden (Figure 3) we predict a depth-related trend in discarding of redfish. Data derived from the observer survey were used to test this prediction. Mean retained and discarded catch rates, mean weight per fish and the proportion of the catch discarded were calculated for 50 m depth strata for the Ulladulla and Eden fleets and for each year between 1993 and 1995. Trends were similar for both fleets and for each year. The mean weight per fish of redfish in catches increased with depth and the proportion of the catch discarded decreased as depth increased (Figure 6 presents these results for Ulladulla and Eden, data pooled across 1993-95).

Association between minimum legal length legislation and discarding

Minimum legal lengths are legislated for two quota species in NSW, tiger flathead (33 cm total length) and jackass morwong (28 cm total length). Catches did not come close to TACs for either of these species during the period 1993-97 (Tilzey 1998). The minimum legal length was the main factor determining retention or discard of tiger flathead (Figure 4). Although the quantities of jackass morwong discarded were not great, the minimum legal length of 28 cm total length (approx. 25 cm fork length) appears to be the principal factor determining retention or discard for this species (Figure 5). Note that there is some discarding of legal-sized morwong. As expected, MLLs explain the sizes at which discarding occurs for other commercial species with MLLs (e.g. snapper, other flathead species, see Liggins 1996).

Influence of TACs/ ITQs and trip-limits on discarding

The only species for which catches came close to TAC in 1995 or 1996 were orange roughy-eastern sector (>100% in 1995 and 1996), blue warehou (87% in 1995), ling (93% in 1995 and 90% in 1996) and spotted warehou (86% in 1995 and 89% in 1996) (Tilzey 1998). Discarding is inconsequential for orange roughy and ling (Liggins 1996, 1997; Knuckey and Liggins 1999). The combined fleets of Ulladulla and Eden discarded an estimated 23% of blue warehou in 1995 and 1% in 1996 (Liggins 1997). Assuming discard rates were similar in other sectors of the SEF and combining estimates of discards with landed catch, the TAC was caught in 1995 but not in 1996. Combining estimates of discards of spotted warehou (6% for Ulladulla and Eden in 1995 and 10% in 1996 and similar in other areas of the SEF) with landed catches, total catch is still below the TAC. We conclude that TACs are not directly causing the discard of significant quantities of quota species in the SEF. Direct effect can only be attributed to TACs if the total catch of a species (landings plus discards) exceeds the TAC in any year. Note, however, that the existence of TACs may, in combination with market considerations, influence discarding of species in circumstances where the TAC is not caught.

Whilst TACs were not directly the cause of significant discarding during 1995 and 1996, there is some evidence that the TAC for redfish played a significant role in forcing the discard of redfish by the Ulladulla fleet in 1994 (Liggins 1996). The existence of the so-called '3nm loophole' meant that prior to 1994 TACs/ITQs could not practically be enforced for several species in NSW. In 1993, with a TAC of 601 t, 538 t was declared as being taken in SEF waters and 1,533 t declared as taken in State waters (Tilzey 1998). It is recognised that many fishers

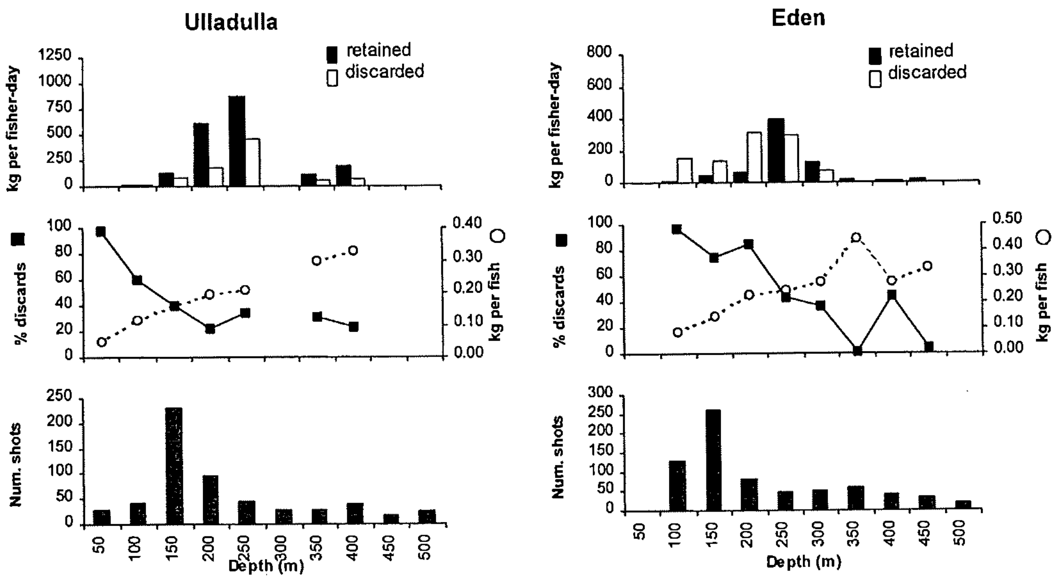

Figure 6. Mean catch rates for redfish (retained and discarded, kg per fisher-day), proportion of total catch weight of redfish discarded and mean weight of redfish in catch, for 10 depth strata (0-500 m in 50 m increments), for Ulladulla and Eden (data pooled over the period 1993-95). Number of tows sampled within each stratum shown in bottom panel.

reported catches that were actually taken in SEF waters (outside 3 nm) as having been taken in NSW waters (inside 3 nm). These fish were not subtracted from the ITQs held by these fishers. Since 1994, trip limits applying to NSW waters have been introduced for several quota species, reducing (but not eliminating) the capacity for fishers to exploit the loophole. It appears that the introduction of a trip-limit for catches of redfish from NSW waters (inside 3 nm) in 1994, increasing the pressure of the TAC on fishers, changed the pattern of discarding of redfish for the Ulladulla fleet. In 1993, the mean catch of redfish at Ulladulla was 980 +/- 46 kg per fisher-day of which 839 kg was retained and 141 +/- 46 kg was discarded. In 1994, NSW Fisheries introduced a trip limit for redfish caught inside 3 nm (initially 300 kg per day, then 500 kg per day in 1994) – reducing the capacity for fishers to exploit the 3 nm loophole. Mean catch rate for redfish in 1994 was 929 +/- 160 kg per fisher-day (similar to 1993) but the retained catch of 522 kg per fisher-day was lower than in 1993 and the discarded catch of 407 +/- 160 kg per fisher-day was higher than in 1993. Moreover, there was an increase in the size at which redfish were discarded (see Figure 3). These observations are consistent with the explanation that an increase in the effectiveness of the TAC/ITQ system as it applied to redfish in this year, influenced the discarding practices of fishers at Ulladulla.

A combination of a TAC of zero and trip limits (see Tilzey 1998) for eastern gemfish between 1993 and 1996 resulted in some discarding of this species during this period and explains the size-distribution of discards in Figure 5. Catches of gemfish observed on several fishing trips (targeting mirror dory) greatly exceeded the trip limit and gemfish were discarded across the range of sizes in the catch. This represents an extreme example of the interaction between a TAC, trip limits and discarding.

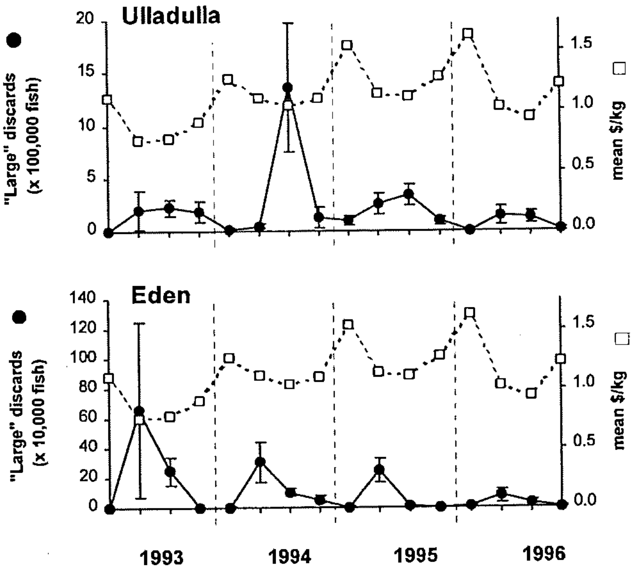

Figure 7. Quarterly mean price ($/kg) paid for small/medium/ungraded grades of redfish by Sydney fish markets (white squares) and mean number of 'large' redfish discarded per fisher-day (+/- 1 se), for each quarter, by Ulladulla and Eden trawlers, for the period 1993-96. Note that 'large' (w.r.t. discards) is defined, for each region and year, as the subset of discards comprising redfish greater than the length at which 33% of the catch was retained. For Ulladulla 'large' discards were defined as discards >= 17 cm in 1993, 18 cm in 1994, 1995 and 1996 and for Eden, 20 cm in 1993, 21 cm in 1994 and 1995 and 18cm in 1996.

Influence of markets/economics on discarding

Non-commercial species are, by definition, discarded because no market exists for these species. This category comprises numerous species – the observer survey of catches by trawlers off NSW (Liggins 1996) identified 220 non-commercial taxa (>220 species).

Fishers report that market forces and economics contribute to their decision to retain or discard many of the commercial species (e.g. Tilzey 1998). The price paid to fishers per kg of fish for many species is dependent on size, and prices paid vary with market volume and this fluctuates both seasonally and over shorter time-scales. A preliminary investigation of the association between market volumes, prices and discarding of redfish between 1993 and 1996 was reported in Liggins (1997). Note that catches of redfish were high-graded in each of these years at both Ulladulla and Eden (Figure 3). Between 1993 and 1996, redfish less than 15 cm length were always discarded, those longer than 23 cm were always retained and those between 15 cm and 23 cm were sometimes retained and sometimes discarded. During the same period, there was a seasonal (quarterly) pattern in total weights, total values and mean prices ($ per kg) for redfish handled by the Sydney fish market (SFM). The quantity and total value of redfish handled by SFM peaked during the middle months of each year and the mean price paid per kg of redfish was at its lowest at these times. Large quarterly volumes of redfish were associated with low prices per kg. The same trends existed when this analysis was restricted to 'small', 'medium' and 'ungraded' redfish supplied to the SFM but mean price per kg was lower because small fish are less valuable than large redfish.

Given that redfish between 15 cm and 23 cm were sometimes kept and sometimes discarded by the Ulladulla and Eden fleets over the period 1993-96 and fishers report that fluctuations in market prices affect their decision to retain or discard, it was predicted that discard rates for the largest sizes of redfish discarded in any year at Ulladulla or Eden would be related to market price. Figure 7 demonstrates a relationship between discards of 'large' (note definition in caption to Figure 7) redfish and quarterly price per kg for 'small', 'medium' and 'ungraded' fish through the SFM. It was appropriate to restrict SFM price and volume data to these grades because these grades correspond to the sizes of fish discarded. For the largest sizes of redfish that were sometimes kept and sometimes discarded, discards were greatest during the middle months of the year, when quantities of landings were high and mean price paid per kg was low (Figure 7). The results of these analyses confirm the claims of fishers that discarding of redfish is partially driven by market prices and volumes.

Conclusions about factors affecting discarding in the SEF

It is logical and convenient to summarise factors affecting discarding in the SEF with respect to different partitions of the catch: non-commercial species; non-quota commercial species; and SEF quota species. For each of these partitions, quantities and size-distributions of discarded catches vary across several spatial scales (sectors of the SEF adjacent to NSW, Victoria and Tasmania; among regions within these sectors; with depth) and temporal scales (years, seasons or quarters) and the patterns of variation across these scales are species dependent.

Non-commercial species (>220 species and approximately 56% of total discards and 28% of total catch in waters off the NSW coast, Liggins 1996) are discarded because there is no current market for these species.

Discarding of non-quota commercial species (approx. 130 species, 16% of total discards and 8% of total catch off NSW, Liggins 1996) is size-selective and market and economic considerations drive the discarding (resulting in high-grading) of the majority of non-quota-commercial species in the SEF. For the minority of species for which MLLs are legislated, discarding occurs below the minimum legal length.

Discarding of quota species (16 species, approx. 30% of total discards and 15% of total catch off NSW, Liggins 1996) is also size-selective. MLL legislation clearly influences discarding of two species (tiger flathead and jackass morwong). Note, however, that it cannot be assumed that there would be no discards of these species in the absence of minimum legal lengths. As for many other species, it is likely that there would be market resistance to the smaller sizes. Moreover, in the absence of a MLL, increased retained catches may result in some fishers reaching their ITQ, resulting in discards due to a combination of the TAC/ITQ system and markets/economics.

At present, based on 1995 and 1996 data and with the exception of eastern gemfish, TACs/ITQs do not directly force discarding of quota species in the SEF because TACs are not directly limiting catches. Market and economic considerations are the major factors driving discarding of quota species. Note, however, it is possible and we believe likely, that discarding may also occur as a result of interactive effects of the TAC/ITQ system and market/economics. We consider two scenarios in which discarding may result from such an interaction. In the first scenario, the TAC for a species is not caught, but some individual fishers reach their ITQ and choose, for reasons of economics, to discard excess catch of this species rather than purchase surplus quota from other fishers. In this scenario, the existence of the TAC has clearly influenced the economics-based decision of the fisher. In another scenario, individual fishers discard some portion of their catch early in the year, in the belief that they can catch and land their ITQ later in the year and secure a better price. Whether or not the fisher does catch their ITQ that year, their decision to discard early in the season was driven by a combination of economics and the existence of the TAC/ITQ system. It is therefore difficult to distinguish between the direct effects of market/economic influence and interactions between market/economic and TAC/ITQ forces.

In addition to the reasons for discarding and factors affecting discarding discussed above, discarding also occurs for a much broader reason – because the unwanted fish are caught in the first place. While this statement may seem obvious, it does emphasize the influence of gear selectivity on the quantities and sizes of fish caught and subsequently discarded.

Implications for stock assessment

Rates of discarding (per fisher-day and expressed as a proportion of total catch) and patterns in size-distributions of discards relative to size-distributions of retained catches vary considerably among species in the SEF. Therefore, the consequences of omitting or not having estimates for periods in the history of the fishery are also dependent on species. Moreover, assessment methodologies vary in their sensitivity to omission of information about discards.

Stock assessments in the SEF rely primarily on analyses of catch and effort data combined with some information on age and length composition of the catch (Tilzey 1998). More comprehensive modeling and analysis has been carried out or is currently being developed for several species (orange roughy, eastern gemfish, blue grenadier, blue warehou and redfish) (Tilzey 1998). Ranging from relatively unsophisticated analyses of trends in catch and CPUE through to the more complex models based on catch-at-age, these assessment methodologies are all reliant on catch data from the commercial fishery. Since the commencement of the ISMP and NSW observer program in 1993, information about discards has increasingly been incorporated in assessments of SEF species (Tilzey 1998).

The inclusion of information about discarding is an important development because it has been demonstrated in several fisheries that the inclusion of data about discards in stock assessments can, in some cases, drastically alter perceptions of the status of exploited stocks and, in particular, changes in yields that could potentially result from changes in regulations (e.g. Saila 1983; Pikitch 1991; Alverson *et al.* 1994). Alverson *et al.* (1994) and ICES (1986 cited in Alverson *et al.* 1994) have reviewed the impacts of discarding on various types of assessment. In particular, retrospective assessments that combine estimates of catch-at-age (or length) with relative indices of stock abundance produce trends in stock size and fishing mortality rate and if discards are primarily juveniles and are not included in assessments of this type, fishing mortality will be underestimated, as will the stock size of small fish. Inclusion of discards of adult fish will have positive effects on estimates of stock biomass and stock numbers-at-age. Note that, in the SEF, high-grading and discarding of juveniles is prevalent across many species including SEF quota species for which assessments are made (redfish, gemfish, mirror dory, ocean perches, tiger flathead, blue warehou, and blue grenadier) and furthermore, discarding of adult fish occurs for several of these species (e.g. redfish, gemfish). Moreover, Alverson *et al.* (1994) underline that the importance of discards to model-based predictions for a fishery depends on the types of predictions being made. Long-term calculations such as equilibrium yield or yield-per-recruit, particularly under conditions of variable discard proportions, are the most sensitive to the inclusion of accurate estimates of discarded catches in assessments. Again, variable discard proportions (annually) are a feature in the patterns of discarding for several species taken in the SEF, redfish in particular. Lack of data about discards is particularly serious when attempting to assess impacts of changes in gear selectivity on yields (ICES 1986), this being one of the core objectives of a project about to start in the SEF (see Knuckey and Liggins 1999).

Whilst it is a significant development that information about discards is now being incorporated in assessments for SEF quota species, several issues relating to discarding and stock assessment methods require further consideration. The issue of how to handle the lack of data about discarding practices for years prior to 1993 is problematic as fishers' recollections of past rates of discarding and sizes of discarded fish are imprecise and potentially biased.

Another problem relates to the linkage between stock assessments and management objectives for the fishery. Management strategies and performance indicators for the majority of quota species are phrased in terms of CPUE without specifying whether this CPUE includes or excludes the discarded component – for example: "to ensure that CPUE is maintained above its lowest annual average level from 1986 to 1994" (Tilzey 1998). For species with variable rates of discarding this is an important issue and the lack of information about discards prior to 1993 is an obvious problem.

Data describing the size-distributions of discards of quota species from the SEF has extended our knowledge of the range of sizes of fish caught by trawl gear. For example, redfish are caught at sizes down to 10 cm but not retained until about 16 cm, tiger flathead are first caught at approximately 15 cm but not retained until 33 cm in length. To make inferences about abundances of these small sizes of fish in stocks (relative to abundances of size-classes or ages-classes of fully-recruited fish) from their abundances in catches requires an understanding of species-specific size selectivities of the gears used. Whilst such information is not currently available, this issue is being addressed as part of the project, soon to commence, concerning bycatch reducing gears (see Knuckey and Liggins 1999).

The identification, since 1993, of the wide range of species discarded, estimates of quantities of discards and the potential consequences for stock assessments and the fishery, underline the importance of long-term monitoring that specifically includes monitoring of the discarded component of catch. This has been acknowledged by AFMA and the South East Fishery Assessment Group (SEFAG) and has resulted in the development of the ISMP, a sampling program designed to collect catch and size- and age-distribution data (including discarded catches) from all geographic components of the SEF. Not only does this ongoing program provide the necessary data for stock assessment, it will provide a means to assess the success of measures adopted to reduce discarding.

Implications for bycatch reduction strategies

The functional alternatives available for reducing losses to any fishery from discarding are restricted to: i). catching fewer of the species/sizes that are discarded; ii). reducing the mortality associated with capture and discard; iii). retaining greater quantities of the species/sizes that are discarded (Alverson *et al.* 1994). Although no studies of the mortality associated with capture and subsequent discard have been done for fish caught by trawling in the SEF it is likely that the mortality is very high. The majority of discards are dead or in apparently poor condition when discarded (personal observations). Relatively long tow duration, the depths in which fishing occurs and the physical effects of these factors contribute to a high mortality. Consequently, the greatest opportunities for reducing discards from trawling in the SEF relate to i and iii above.

Spatial and temporal closures to fishing are one means of reducing the catch of species/sizes that are currently discarded if locations or times associated with consistently high levels of discarding can be identified. However, the species-specific spatial and temporal variability identified for SEF catches precludes options like closures as a general solution unless the reduction of discards of specific species is assigned priority over others. However, the understanding of the species-specific variabilities of discarding at the spatial and temporal scales examined for the NSW coast and the other sectors of the SEF provides a sound basis for determining the impacts on catches and on fishing operations in different areas if priorities and targets for the reduction of discards for specific species are set.

Development and implementation of modifications to fishing gears that selectively reduce the capture of species or sizes of fish that are currently discarded provides another strategy that potentially may limit the capture of fish currently discarded. This strategy is potentially very useful in the SEF given our observations that high-grading is a common feature of discarding practices for quota species and other commercial species. A project to investigate gear modification as a means of reducing discarding is soon to commence in the SEF (Knuckey and Liggins 1999). Following determination of the species-specific and size-specific selectivities of alternative designs of gear, the benefits and costs of implementing these gears in different areas of the SEF can be evaluated using existing knowledge of spatial and temporal patterns of magnitudes and size-distributions of retained and discarded catches. Gains associated with reduction of discards may offset losses in retained catches at some locations (and/or times) but not at others. Such analyses will only be possible when information about species-specific and size-specific selectivities of alternative gears is available. The degree to which gear modifications can exclude unwanted sizes of commercial species without impacting too severely on retention of the species and sizes of fish targeted in the SEF will ultimately determine the utility of this strategy.

A general conclusion resulting from our consideration of factors affecting discarding concerns the influence of markets and economics on discarding practices. Development of new products and markets, so that species currently regarded as non-commercial are utilised, provides a significant opportunity. The knowledge we now have of the species composition of the non-commercial component of SEF catches, the quantities caught in the various regions and the annual variability of these catches provides the basis for economic analysis of the commercial feasibility of innovative utilisation of this resource.

Having concluded that interactive effects of the TAC/ITQ system and markets/economics play some role in discarding of quota species (because TACs are not caught for quota species for which discarding is an issue), we argue that further examination of this issue is warranted. Identification of the barriers that result in quota not being transferred among fishers so that discards of quota species may be landed rather than discarded may suggest a means of actively promoting or providing an added incentive for trading and redistribution of quota.

Acknowledgments

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Seabird bycatch in tuna longlining fisheries in Australia

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Abstract only

The most important bycatch issue in tuna fisheries in Australia is the incidental mortality of seabirds, especially a number of vulnerable or endangered species of albatross. Data collected from 1991-1996 by fisheries observers in the Japanese SBT fishery in the AFZ have produced estimates that range from 900-3,700 seabirds killed per year. Approximately 75% of the carcasses recovered in that fishery have been albatrosses. Over this period of time the effort in this fishery varied from 6-26 million hooks, and the bycatch rate varied from 0.07-0.18 birds per thousand hooks. Bycatch rates north of 30°S are zero or near zero, while south of that latitude the rates can be considerably higher. A similar rate and pattern of seabird bycatch has been observed in the domestic tuna fisheries on the east coast, but because the fishing effort is much lower many fewer seabirds are estimated to have be killed. The impact of the incidental mortality estimated for these fisheries must be seen in context of the total tuna longlining that occurs in the Southern Hemisphere, where the effort in the estimated Japanese and Taiwanese fisheries was around 160-170 million hooks in the 1980s, but grew rapidly in the early 1990s and was over 220 million hooks by 1994. Mitigation measures and gear, such as the use of bird-scaring lines, night setting, weighting of lines, bait casting and thawing, have been developed in recent years. Research has shown the proper use of one or more of these measures can substantially reduce the bycatch rate, but the measures have not been widely adopted and there is not yet strong evidence that bycatch rates are declining overall as a result of their use.

Bycatch in the Tasmanian rock lobster fishery

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Abstract

The bulk of Australia's rock lobster fisheries is based on the western rock lobster, Panulirus cygnus *and the southern rock lobster,* Jasus edwardsii. *Both species are caught by pots which have been considered to be relatively selective for the species being harvested. Lobsters are attracted to pots by baits which also have the ability to attract a variety of other carnivorous species. In Tasmania, pots without escape gaps have caught over 30 fish species, 10 crustacean species and 10 other invertebrate species during recent lobster fishing surveys. Although the catch rate of non-lobster species is low, with over 15 million pot lifts being undertaken annually in Australia, there is the potential for significant bycatch. Due to the concern that undersized lobsters were being damaged and stressed by repetitive capture prior to growing to legal size, escape gaps were introduced into rock lobster pots to facilitate escapement of undersized lobsters. This study illustrates the extent of bycatch in Tasmania from pots without escape gaps, the impact of escape gaps on bycatch and discusses recent conflict between the finfish and rock lobster industries over the blue-throat wrasse* Notolabrus tetricus.

Introduction

Rock or spiny lobsters are the basis for valuable fisheries throughout southern and western Australia (Brown and Phillips 1994). These fisheries are based on traps or pots and are considered to be target-specific in comparison with trawl, longline and gillnet fishing methods as few non-lobster species are caught per pot lift. With over 16 million commercial pot lifts undertaken annually in southern and western Australia (Table 1) there is the potential to harvest significant amounts of bycatch.

In Tasmania, nearly two million commercial pot lifts are recorded each year with the potential for 10,500 pot lifts to be undertaken daily for the 10 months of the fishing season (Frusher 1998). In addition, more than 6,000 pots are licensed to recreational fishers (Lyle and Smith 1997). As the majority of commercial rock lobster potting is in water depths greater than 18 m, barotrauma presents a problem for most finfish species, many of which may not survive being returned to the sea.

Tasmanian rock lobster fishers state that they only see a couple of fish in each shot of 50 pots. This seemingly low number translates to around 420 fish per day or 126,000 fish per year. Lyle (1998) reports that approximately 11 tonnes of finfish were recorded in the 1995/96 general fish log books as bycatch in rock lobster pots, and that this declined to 6.4 tonnes the following fishing season. This difference is more likely to reflect inaccuracy in reporting than real declines in bycatch.

Inaccuracies in bycatch recording are attributed to the following:

- fishers cannot be bothered to fill out a second logbook (scale fish bycatch needs to be recorded in a separate logbook to the rock lobster logbook);
- fishers believe that they only had to fill out the general fish logbook if they were retaining fish for commercial sale and thus fish that were discarded or used as bait did not need to be recorded; and
- fishers are concerned that new management plans would restrict the amount they could catch if they were seen to be catching large quantities of fish.

The recent development of a 'live' fishery for wrasse has seen this species become the third most important scale fish species by weight in Tasmania (Lyle 1998). This targeted fishing has increased in recent years with the wrasse catch increasing by 32% between the 1995/96 and 1996/97 fishing seasons.

Although only 600 kg and 200 kg of wrasse were recorded in the general fish logbooks as bycatch from lobster pots in 1995/96 and 1996/97 respectively (Lyle 1998), rock lobster fishers often claim that they catch a 'couple of kelpies per shot', which would equate to more than half the commercial wrasse catch in either 1995/96 or 1996/97 (Lyle 1998). Wrasse are primarily used by rock lobster fishers as bait and this may explain the low recorded numbers in the general fish logbook.

In developing a management plan for the wrasse fishery there was concern from rock lobster fishers that they would be deprived of a traditional source of free and fresh bait. Conversely, scalefish fishers were concerned that a valuable species was being wasted as bait, not maximising the value that could be achieved when sold on the 'live' fish market. The Scalefish Fishery Management Plan (Anon 1998) dealt with this by allocating differing quantities and grades (live and dead) of wrasse to the different catching sectors (i.e. gillnet, rock lobster and hook fisheries). While the allocation mechanism has offset the conflict over the utilisation, there is concern about the sustainability of the resource. Wrasse have strong reef associations and are considered to not travel between individual reefs that are separated by sand regions (Barrett 1995). With increased fishing pressure in addition to bycatch from lobster pots, this behaviour could lead to localised depletions.

The development of 'live' overseas markets has also seen the development of a giant crab fishery. The Tasmanian giant crab fishery is valued at over A$4 million and is the State's third most important single species fishery by value. Traditionally, giant crabs were a bycatch in lobster pots and the current fishery in Tasmania is restricted to lobster fishers. In discussions leading up to the formulation of a management plan for giant crabs, options for management varied from a separate giant crab fishery without provisions for their harvest as bycatch, to a fishery based entirely on the harvest of giant crab as bycatch of the rock lobster fishery.

Although these conflicts do exist, there are no data available on bycatch in rock lobster pots in Australia. This paper presents basic information on the magnitude of bycatch in rock lobster pots in Tasmania and evaluates the impact of escape gaps, which have become mandatory in many lobster fisheries over the last decade (Table 1). Escape gaps facilitate the escape of undersized lobsters and thus minimise the potential for damage as they are hauled to the surface, removed from pots and released. They would also be expected to reduce bycatch.

Table 1. Annual number of rock lobster pot lifts undertaken in southern Australia.

State	Species[1]	Management zone	Number of pot lifts	Period	Escape gaps	Source
WA	WRL	All	10,500,000	Year	Y (3)	R. Melville-Smith (WAFish)
	SRL	All	350,000	Year	Y (1)	
SA	SRL	Northern	718,183	96/97	N	R. McGarvey (SARDI)
		Southern	1,756,860	96/97	N	
Vic	SRL	Western	778,971	96/97	Y (1)	D. Hobday (MAFRI)
		Eastern	217,013	96/97	Y (1)	
Tas	SRL	All	1,853,701	1997	Y (1 – 2)	S. Frusher (TAFI)
Total			**16,174,728**			

[1] WRL = western rock lobster (*Panulirus cygnus*)
SRL = southern rock lobster (*Jasus edwardsii*)

Methods

Research pots were made of steel and were trapezoid in shape with a square base of 0.6 m^2, a top of 0.5 m^2 and a height of 0.4 m. At the base of the pot was a bar 10 mm from the bottom to facilitate tying the mesh to the sides of the pot and another bar 57 mm above this. Pots were covered with 35 mm mesh which extended to the bottom bar to create pots without escape gaps and to the upper bar to create pots with a 57 mm high escape gap around each side of the pot. Each pot had a single neck entrance of 250 mm diameter located centrally in the top.

Commercial wooden and steel pots were used on the north west coast of Tasmania. Although commercial pots vary in size, they must not exceed 1,250 mm x 1,250 mm x 750 mm. Wooden pots have steel vertical bars which slope inward at the apex to form a 'beehive' shape. The top of the pot has a single neck entrance of at least 200 mm. Wooden sticks which have been soaked and heated to increase flexibility are woven around the steel vertical bars. Gaps between the woven sticks vary from approximately 20 mm to 45 mm. Commercial steel pots have a similar 'beehive' shape and consist of steel rods bent and welded horizontally around the vertical steel bars approximately 100 mm apart. Commercial steel pots are covered with a mesh usually of approximately 35 mm square. Commercial pots had two 57 mm x 200 mm escape gaps located between 100 mm and 150 mm up from the floor. Escape gaps could be closed by meshing over the gap.

During each sampling period, between eight and 12 shots were undertaken. Each shot consisted of setting between 50 and 80 pots in the late afternoon and hauling these pots the following morning. From October 1992 to August 1998, 2,040 pots were sampled in three main regions around Tasmania (Table 2). To determine the effect of escape gaps, 10 research pots with escape gaps were randomly deployed

Table 2. Sampling periods and pot type used in estimating bycatch.

Region	Sampling periods	Years sampled	Pot type[1]	No. pots sampled each sampling period	Escape gaps open
West coast of King Island	Feb, May, Sep	Sep 1992 to May 1995	C	960	No
East coast of Tasmania	Mar, Jul/Aug, Oct/Nov	Oct 1992 to Mar 1998	R	400	No
		Oct 1993 to Jul 1994	R	80	Yes
		Jul/Aug 1998	C	60	Yes
South coast of Tasmania	Mar, Jul/Aug, Oct/Nov	Oct 1992 to Mar 1998	R	450	No
		Oct 1993 to Jul 1994	R	90	Yes

[1]C = Commercial pot, R = Research pot.

amongst 50 research pots without escape gaps during each shot from October 1993 to July 1994.

As the escape gaps in research pots were around the entire base, it is possible that the retention rate of bycatch would be lower than commercial pots where it is mandatory to have either one escape gap of 57 mm x 400 mm or two escape gaps of 57 mm x 200 mm in Tasmania. Preliminary results were obtained from 60 commercial pots with escape gaps open set randomly amongst research pots on the east coast in July and August 1998.

Bycatch from each pot was counted and identified to species level where possible.

To quantify the potential catch from rock lobster pots without escape gaps the two major groups of commercial finfish caught in lobster pots, wrasse and leatherjackets, were examined.

Results and discussion

Potential harvest

Rock lobster pots without escape gaps catch a wide range of both finfish and invertebrate species (Table 3). With the exception of those species of commercial importance such as the giant crab, and other species used as bait, most are returned to the water. Barotrauma is a problem for finfish as the majority of commercial rock lobster potting is carried out in water depths of greater than 18 m.

To quantify the potential annual catch of wrasse and leatherjacket from lobster pots without escape gaps, the catch rate from research and commercial pots with escape gaps closed has been multiplied by the total number of pot lifts undertaken annually (Table 4). As both wrasse species prefer shallower water (Figure 1), Table 4 has been divided into deep and shallow water depths to reflect the different distributions of these fish. In addition to the purple and blue

Table 3. List of species and numbers caught in 18,302 rock lobster pots from 1992 to 1997.

Crustaceans: 9 species		
Hermit Crab	*Strigipagurus strigimanus*	88,486
Rough Rock Crab	*Nectocarcinus tuberculosis*	9,253
Cleft Fronted Shore Crab	*Plagusia chabrus*	606
Great Spider Crab	*Leptomithrax gaimardii*	65
Giant Tasmanian Crab	*Pseudocarcinus gigas*	49
Pie Crust Crab	*Cancer novaezealandiae*	25
Others	3 species	15
Finfish: ~33 species		
Rosy Wrasse	*Pseudolabrus psittaculus*	2,192
Degen's Leatherjacket	*Thamnaconus degeni*	2,175
Barber Perch	*Caesioperca rasor*	1,980
Blue-Throat Wrasse	*Notolabrus tetricus*	1,452
Purple Wrasse	*Notolabrus fucicola*	883
Southern Conger Eel	*Conger verreauxi*	865
Red Gurnard Perch	*Helicolenus papillosus*	690
Draughtboard Shark	*Cephaloscyllium laticeps*	539
Bearded Rock Cod	*Pseudophycis barbata*	558
Brown-Striped Leatherjacket	*Meuschenia australis*	505
Velvet Leatherjacket	*Meuschenia scaber*	389
Morwong	*Nemadactylus macropterus*	231
Toothbrush Leatherjacket	*Acanthaluteres*	99
Scorpaenid – Unidentified		88
Senator Wrasse	*Pictilabrus laticlavius*	80
Butterfly Perch	*Caesioperca lepidoptera*	51
Others	17 species	97
Molluscs: ~21 species		
Octopus	*Octopus maorum*	647
Others	~20 species	96
Echinoderms: ~7 species		
Starfish and Urchins	7 species	38

throat wrasse, the toothbrush leatherjacket is also primarily caught in shallow water reef regions (<18 m), whereas the Degen's, brown striped and velvet leatherjackets show no major preferred depth range in the regions sampled.

Based on these catch rates, the potential harvest of wrasse from rock lobster pots is only slightly less than the commercial harvest and the leatherjacket catch is nearly twice the commercial catch (Table 4). In addition to the bycatch in commercial lobster pots, there would also be a bycatch in recreational lobster pots, not to mention recreational gillnet and hook fisheries. As recreational pots are set in shallow water, barotrauma would not be expected to be a problem and these species could be discarded alive. However, recreational fishers state that they use the wrasse and leatherjackets as bait.

The potential bycatch from lobster pots estimated in Table 4 assumes an even

Table 4. Comparison of commercial catches of wrasse and leatherjacket from the scalefish sector with potential catch estimates from experimental (expt.) rock lobster pots without escape gaps. The catch from experimental pots has been divided into shallow (0-18 m) and deep (19-61 m) to highlight the depth distribution of the different species.

	Catch from expt. pots (No.)		Catch rate from expt. pots (No./pot lift)		Possible commercial catch (No.)		Commercial scalefish catch 1996/97[1] (No.)
	Deep	**Shallow**	**Deep**	**Shallow**	**Deep**	**Shallow**	**All**
Wrasse							
Blue-throat	230	1,222	0.039	0.098	37,322	65,133	
Purple	24	859	0.004	0.069	3,828	45,859	
Total	**254**	**2,081**	**0.014**	**0.166**	**152,142**		**181,000[2]**
Leatherjackets							
Degen's	1,355	820	0.074	0.065	70,817	43,200	
Brown-striped	265	240	0.014	0.019	13,398	12,628	
Velvet	178	211	0.010	0.017	9,570	11,299	
Toothbrush	6	93	0.0003	0.007	312	4,652	
Total	**1,804**	**1,364**	**0.098**	**0.109**	**165,876**		**89,000[3]**

[1]Source Lyle (1998)
[2]Assumes an average weight of 600 g. A. Jordan (pers. comm.)
[3]Assumes an average weight of 300 g. A. Jordan (pers. comm.)

distribution of each species around the coast. Regional variation in catch rates, indicates that the two commercially important species of wrasse are most abundant on the sites sampled on the east coast and that purple wrasse is also abundant in shallow south coast regions (Figure 1). The potential bycatch estimates are possibly overestimates as Frusher (1997) reports that commercial rock lobster fishing effort has shifted away from the east coast to deeper waters off the west coast. However, fishers state that the recently introduced quota management system will increase the harvest of shallow water lobsters as these are preferred by the markets (Williamson *et al.* 1998).

Effect of escape gaps

The effectiveness of escape gaps to reduce bycatch is presented in Table 5. All pots which had escape gaps tied were steel pots. These were compared with steel pots with open escape gaps on the south and east coast and with stick pots with open escape gaps on the east coast only.

As a larger number of pots without escape gaps were used there will be a greater incidence of bycatch due to the increased effort. To minimise this bias, Table 5 only includes species where there was a probability of at least one individual being caught in the smaller number of pots with escape gaps sampled in each location. For example, if the catch rate of a species was 0.015 in pots without escape gaps and 60 pots with escape gaps were sampled, the probability of being caught in the pots with escape gaps is 0.9. As this is less than one, this species would not be included in Table 5.

Escape gaps are an effective means of reducing bycatch in rock lobster pots with most finfish and invertebrates catches being reduced by over 80%. Larger species such as draughtboard sharks

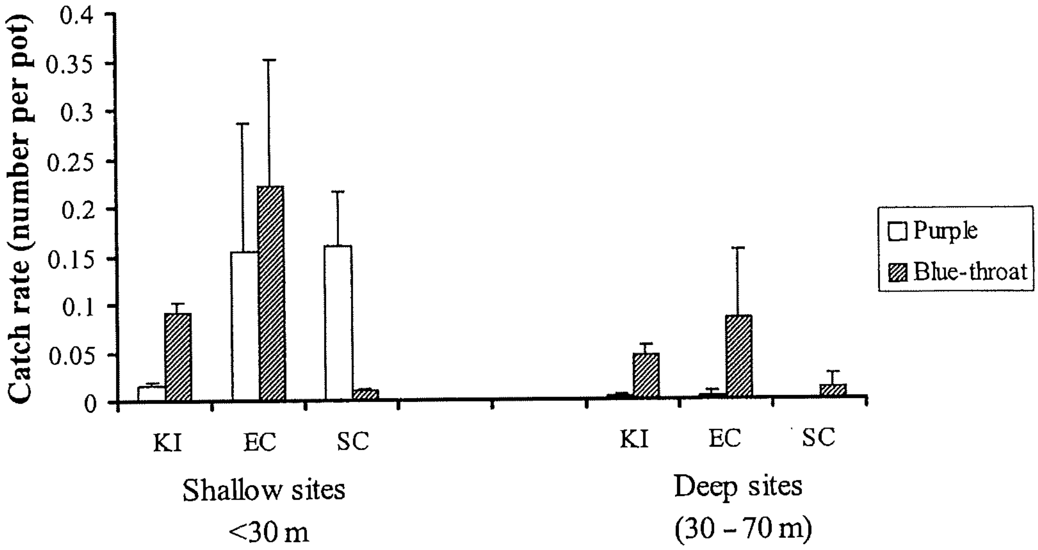

Figure 1. Catch rate of purple and blue-throat wrasse in rock lobster pots set in shallow and deep waters in the northwest (King Island – KI), east coast (EC) and south coast (SC) of Tasmania.

would not be able to utilise escape gaps to leave pots and, as expected, escape gaps had a negligible effect on these species.

The lack of striped trumpeter in this study reflects the distribution of this species. Fishers report catches in pots from offshore deeper water regions that were not included in this study. Striped trumpeter is a large fish and would be expected to be retained in pots even with escape gaps. The recording of this species as bycatch in the general fish logbooks and the absence of sharks support fishers' statements that they only record 'saleable' fish, striped trumpeter being a premium market fish.

Although only 60 commercial stick pots were sampled in this study, there are indications of differences in the retention rate of bycatch species between steel and stick pots. The stick pots used in this survey had two small escape gaps positioned higher in the sides of the pot compared with the escape gaps in the steel pots that were closer to the bottom and around the entire base of the pot. Differences in retention rates between pot types could therefore be attributed to either the physical composition of the pots or the configuration of escape gaps.

The reason for the higher retention rates of bearded rock cods and southern conger eels in stick pots compared with steel is uncertain. These species are retained in pots used in the commercial fishery as they are the second and third most important bycatch species recorded in the general fish logbook.

The cause of the increased numbers of octopus found in stick pots with escape gaps open compared with steel pots with escape gaps closed is also uncertain. It is not unusual for retrieved pots to have lobster remains which are indicative of octopus predation, but not to have the octopus. Octopus are a major predator of rock lobster in pots although it is unclear whether the bait or the lobsters have attracted the octopus to enter the pots. The increased numbers of octopus in stick pots may be associated with the natural

Table 5. Reduction in bycatch of rock lobster pots due to the inclusion of escape gaps (esc. gaps).

Coast/pot type	south/steel	east/steel	east/stick
Pots sampled (esc. gaps / no esc. gaps)	247 / 1219	236 / 1039	60 / 296
Species		**% reduction**	
Hermit Crab	92.4	96.3	66.7
Rough Rock Crab	96.6	74.2	100.0
Southern Conger Eel	87.3	86.2	17.8
Rosy Wrasse	100.0	100.0	97.8
Draughtboard Shark	7.5	-3.6	IN[1]
Cleft-Fronted Shore Crab	91.2	83.7	100
Purple Wrasse	90.7	100.0	100
Great Spider Crab	75.9	IN	IN
Bearded Rock Cod	86.7	81.7	38.3
Degen's Leatherjacket	100.0	94.2	100.0
Octopus	100.0	95.4	-146.7
Blue-Throat Wrasse	100.0	96.4	100.0
Brown-Striped Leatherjacket	75.3	35.0	93.0
Velvet Leatherjacket	100.0	76.8	100.0
Red Gurnard Perch	34.2	92.2	71.0
Butterfly & Barbers Perch	100.0	100.0	100.0
Toothbrush Leatherjacket	IN	80.0	IN
Triton Shell	IN	-46.8	IN

[1]IN = Insufficient data

materials used in these pots and the darker internal environment created by the thickness and closer spacing of the sticks.

Conclusions

The results from this study indicate that rock lobster pots have the potential to impact on southern coastal reef communities. Bycatch of commercial finfish species is significant relative to volumes harvested by targeted fishing, although the incorporation of escape gaps to reduce catches of undersized lobsters is also effective in reducing the number of bycatch species. Further studies on the number of escape gaps could further improve current lobster pot design to minimise bycatch although improved recording of the bycatch is required if logbook data are to be used to quantify the amounts caught.

Recommendations

1. Escape gaps should be mandatory in all rock lobster fisheries.
2. Evaluation of the extent in both number and position of escape gaps be undertaken.
3. Recording of bycatch in logbooks should be improved to include bycatch that is returned (dead or injured) or not 'saleable'.

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Bycatch in Australian recreational fisheries: Is it an issue?

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Abstract

Bycatch in Australian recreational fisheries has received little formal research attention, with only two Tasmanian studies discussing the issue in relation to their results. However, the data from other published studies, together with some unpublished data from the authors' work, have been used to make a preliminary assessment of the magnitude of bycatch in this sector. Incidental harvest (non-target species) was generally low (<30%) for line fisheries but varied significantly in a net fishery depending on the target species. Discard ratios (fish released) were generally between 30% and 50% in most line fisheries but were higher for the Northern Territory barramundi fishery. Total bycatch (incidental harvest + discards) data were very limited and varied from 33% to 80%. Given the magnitude of recreational catches in Australia, these results suggest that bycatch could be numerically important and should be considered as part of recreational fisheries management regimes.

Introduction

Formal assessment of bycatch in Australian recreational fisheries has been very limited. A literature search revealed only three references to the subject in any form (Williams and Schaap 1992; Elmer 1996; Lyle and Campbell 1998). Williams and Schaap (1992) noted that juvenile sharks were vulnerable to recreational gillnetting in nursery areas in coastal Tasmania. They combined surveys of recreational gillnetting effort with research-generated catch rates using similar gear to estimate the potential incidental mortality of sharks, and concluded that gillnetting may be a significant source of mortality. This was the only study located which quantified any aspect of recreational fisheries bycatch.

As part of a general discussion of bycatch in Queensland's fisheries, Elmer (1996) discussed its relevance to line fishing, which is the gear type most commonly used by recreational fishers. He noted that line fishing was not incorporated into the FAO global assessment of bycatch (Alverson *et al.* 1994), but was capable of producing both incidental and discarded catches. Subject to careful handling, he believed that survival was generally high for line-caught fish returned to the water.

A recent article (published immediately after this ASFB workshop), discussed levels of bycatch in the Tasmanian recreational net fishery (Lyle and Campbell 1998).

Table 1. Incidental harvest in the Tasmanian recreational net and line fisheries (Source: J. Lyle, unpublished data).

Method	Target species	Target species (%)	Incidental harvest (%)
Net	Warehou	51.5	48.5
	Flounder	83.0	17.0
	Mullet	66.5	33.5
	Atlantic salmon	38.1	61.9
Line	Flathead	88.0	12.0
	Australian salmon	70.4	29.6
	Barracouta	83.9	16.1
	Tuna	48.0	52.0

Greater attention has been paid to the bycatch of recreational fishing activities in the United States. This is particularly apparent in the south-east US where recreational fishing for prawns using trawl gear is permissible, and has led to the need for bycatch reduction devices on recreational gear (Wallace and Robinson 1994; Griffith and Rulifson 1997). A comprehensive study of recreational fishery bycatch in Galveston Bay found that two fish were caught and released for every fish landed, and that this amounted to 1.2-3.5 million fish released over a six year period (Saul 1992).

Australian studies

Given the lack of formal discussion on bycatch in Australian studies, we have used a number of reports and unpublished data to investigate the potential magnitude of the issue. The range of studies provides reasonable regional coverage but is not intended to be exhaustive. In hindsight, the apparent lack of interest in bycatch is surprising as there is a substantial Australian literature on recreational fishery catches, some of which includes species targeted and numbers and species released. Reporting of the latter has been a more recent phenomenon but is increasingly incorporated into survey designs and analysis.

The terms we have used to describe bycatch follow the conventions in McCaughan (1992) where incidental harvest = retained non-target species, discarded catch = catch returned to the sea and bycatch = the sum of incidental harvest and discarded catch. It should be noted that the discarded catch can be usefully further divided into target species and non-target species (either of which can be returned for legal or personal reasons).

To fully categorise bycatch, the following information is needed:

- target species;
- catch composition by species; and
- discards by species.

In most cases, data were not available at this level of disaggregation. Studies are therefore addressed in order of increasing utility for full bycatch assessment.

The Tasmanian net fishery is one of few recreational net fisheries in Australia, and a recent statewide diary study investigated target species and retained catch of the fishery (Lyle and Campbell 1998). It is noteworthy that incidental catch levels varied substantially between target species, ranging from 17% when flounder were targeted up to 62% when Atlantic salmon were targeted (Table 1).

Table 2. Summary of bycatch in selected Australian recreational fishery studies.

State	Area / fishery	Incidental harvest (%)	Discard ratio (%)	Bycatch ratio (%)	Source
TASMANIA	net	17-62			Lyle (unpub)
	line	12-52			Lyle (unpub)
NT	reef		39.9		Coleman 1998
	non-specific target		35.6		Coleman 1998
	barramundi	15.3	64.2	79.5	Coleman 1998
NSW	Clarence River		39.7		West & Gordon 1992
	Richmond River		36.6		West & Gordon 1992
QLD	All		49.8		RFIS Newsletter July 1998[1]
SA	Gulf St Vincent – all	9.2	31.0	40.2	McGlennon (unpub)
	Gulf St Vincent – bottom	20.2	44.9	65.1	McGlennon (unpub)
	Gulf St Vincent – surface	15.8	17.2	33.0	McGlennon (unpub)

[1]Published by the Queensland Fisheries Management Authority

This demonstrates the differences that can occur even when similar gear is used. Although net fisheries are not common in Australia, they are generally subject to concerns relating to bycatch. The same study also provided information about targeting and catches for line fishing (Table 1). Again incidental harvest levels varied considerably depending on target species, from 12% for flathead to 52% for tuna. While this study collected valuable information on incidental catch, it would be particularly useful to collect data on discarded catch, and allow a full analysis of bycatch especially for the net fishery.

A different level of disaggregation is available from Northern Territory and New South Wales studies, which show the number and proportion of discards but not the target information needed to characterise incidental harvest (Table 2). The Northern Territory recreational fishery report provided data on species composition for fishers with 'no target' and targeting 'reef fish' (Coleman 1998). In both cases, discards comprised 35-40% of the total catch, and the number of fish involved was high (163,745 and 285,941 respectively). The New South Wales study of the Clarence and Richmond Rivers did not report target species but estimated numbers of fish released from data collected during interviews with fishers (West and Gordon 1994). Again, discard levels were between 35-40% of the total catch (Table 2) and absolute numbers were high (241,880 and 129,053 respectively).

A recent example from Queensland based on diary data (Recreational Fishing Information System Newsletter July 1998) shows a higher level of discards of nearly 50% (Table 2). Regional disaggregation showed variation between 42 and 58%. This report signified the impact a tag and release fishery can have on discard rates, by noting that 94% of Australian bass were released. This type of development demonstrates the value of categorising releases (discards) by type (i.e. legal, personal preference, tagged, etc).

In the data presented so far, full quantification of bycatch has not been possible due to missing information on either incidental harvest or discarded catch. However, the Northern Territory study provides a full breakdown of catch for fishers targeting barramundi (Coleman 1998). The retained harvest of barramundi was 93,993 fish but this represented only 15.3% of fish caught. Incidental harvest (i.e. fish other than barramundi retained) represented 20.5% of the catch, while total discards accounted for the remaining 64.2%. The discarded catch contained approximately equal proportions of the target and non-target species. Total bycatch in this fishery was therefore 79.5% (four out of five fish) of the catch and equated to nearly 300,000 fish.

A further level of disaggregation is available from unpublished data on the South Australian marine boat fishery, where discarded fish were categorised by fishers during interviews. These categories were typically either legal (undersize, exceeded bag limit, berried female crustaceans) or personal (not table fish, too small for eating, etc). The data presented for Gulf St Vincent (which is predominantly line fishing) show a high level of target species harvest and only a small incidental harvest (Table 2). Total discard levels are proportionately low (31%) but, because of the scale of the recreational fishery in the area, amount to nearly 900,000 fish. Discards in this fishery comprised 16.7% illegal target species (15.8% undersize) and 14.2% unwanted non-target species.

The advantage of characterising discards can be seen from a comparison of the recreational fishery for King George whiting (KGW) in Gulf St Vincent at two separate times. Based on creel survey interviews, targeted KGW fishing produced a discard rate of 28.1% undersize in 1994. The minimum legal size was increased by 2 cm in 1995. When the fishery was surveyed again in 1997 (in the same area and season), the discard rate for undersize fish had increased to 46.1%. Although discard mortality for undersize fish of this species is relatively low (3.0%; Kumar *et al.* 1995), the increase in overall mortality needs to be recognised. In particular, these types of impact need to be assessed when management changes are proposed.

Just as some spatial variations in bycatch levels were evident from the Queensland data, and between target species for the Tasmanian net and line fisheries, so are variations evident in the South Australian fishery between surface and bottom fishing targets (Table 2). Total bycatch levels increased from 33.0% in surface fishing to 65.1% for bottom fishing. Where management concerns about bycatch in recreational fisheries arise, therefore, careful definition of the study is required (spatial extent, gear type, fishing activity).

Summary and conclusions

Although data for assessing bycatch in Australian recreational fisheries are limited, the case studies presented here give some indication of the magnitude of the issue. Discard rates are commonly 30-40% of the total catch with total bycatch anywhere between 33% and 80%. Given these levels, the impact of bycatch should be considered as part of any management regime for recreational fisheries.

Of the categories which constitute bycatch, it seems that the discarded catch deserves most attention from recreational fisheries managers. Although line-caught fish are often considered to have high survival rates, the magnitude of the overall catch could generate significant absolute mortality from even quite low mortality rates. This effect may be even more important given the estuarine and inshore distribution of recreational fishing activity, and the correlated distribution of nursery and juvenile fish habitats.

The National Recreational and Indigenous Fishing Survey planned for 1999/2000 offers the opportunity to comprehensively quantify bycatch in Australian recreational fisheries for the first time.

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Discussion of Session I

Chaired and recorded by Nick Rawlinson

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Each presentation was followed by a time for questions, after which the session was opened for more general comments and discussion.

Following *David Brewer's* presentation, Ian Poiner (CSIRO Marine Research) mentioned that in addition to the author's coverage of bycatch-related research in the Northern Prawn Fishery (NPF), the Australian Fisheries Management Authority (AFMA), Bureau of Resource Sciences (BRS) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) were updating the present baseline of turtle catches in the fishery. He added that AFMA was monitoring and recording the uptake of modified fishing gear and new technologies in the NPF. This monitoring process was seen as vitally important not only for this fishery but also for other Australian fisheries. He commented that the presentation had concentrated on two important aspects of bycatch: first, the level and nature of bycatch, and secondly the fate of the discards. However, major issues that were becoming increasingly important in trawl fisheries around the world and the NPF, were non-retained bycatch and physical changes to the seabed. He asked David Brewer to comment on future research and development within these areas for the NPF.

David Brewer replied that to date very little research had been done in these areas in the NPF. However, there was a large research project on the Great Barrier Reef that had investigated the effects of trawling on benthic communities. This research primarily investigated the 'unseen' bycatch. As this issue had received less publicity, it has had a lower profile and had therefore received less attention in terms of research. He added that CSIRO was currently investigating the impacts of trawling on species biodiversity in the NPF. The species compositions of catches from trawled and protected areas were being compared. The numbers of vertebrates, invertebrates and benthos were being quantified.

Stewart Frusher (TAFI) commented that Ian Munro had carried out studies in the Gulf of Carpentaria prior to the opening of the NPF. This work had shown that there were large communities of sponges in the Gulf. Stewart Frusher asked whether anyone had followed-up on the work undertaken by Munro.

David Brewer mentioned work by Rainer and Poiner, although he was not exactly sure what type of data were available. He noted that historical data were vitally important for comparative purposes and assessing changes over time.

At the end of the presentation by *Julie Robins,* David Brewer stated that intensive trawling had been carried out in the Moreton Bay for many years and that crustaceans dominated the bycatch in this fishery. He asked Julie Robins whether the bycatch composition within this fishery had changed over the years.

Julie Robins stated, with some reservation, that the catch composition within this fishery had changed over the years. Endeavour prawns dominated catches nowadays although tiger prawns used to be more prolific. She also referred to previous work by Wassenberg and Hill, which showed sand crabs were a major scavenger of bycatch. She then postulated that the high level of discards in this fishery may have provided more food for sand crabs and boosted their numbers over time. The relatively high bycatch levels of sand crab today reflect this.

David Brewer remarked that changes in the composition in bycatch over time was a very important issue and suggested that the participants of the workshop give this some consideration.

After the next presentation, Murray MacDonald (Fisheries Victoria) stated that *Ian Knuckey's* talk focussed on finfish bycatch and asked why invertebrate bycatch, particularly epibenthos, was not mentioned. Was it because invertebrate bycatch is not a problem in this fishery? Or was it because there was a lack of evidence to make a judgement on this subject?

Ian Knuckey replied that it was mainly due to epibenthos accounting for a relatively small proportion of the catch. He continued by adding that despite invertebrates and epibenthos representing a small amount of bycatch in terms of weight, this catch did consist of a large number of species. However, fish was by far the largest component of the bycatch in the South East Fishery (SEF).

Murray MacDonald asked whether the physical impact of trawling on bottom habitat was seen as an important factor in this fishery.

Ian Knuckey mentioned that CSIRO was undertaking a large project looking at the ecological impacts of trawling. However, trawling in the SEF had been carried out for many years, suggesting these fishing grounds would have already been modified. He added that BRS were mapping the area of the fishery that is subjected to trawling and was trying to pinpoint the areas subjected to the greatest trawling pressure. Results to date suggested that only a small percentage of the total area encompassed by the fishery was trawled.

Malcolm Haddon (AMC) stated that *Geoff Liggin's* presentation concentrated on redfish and showed this species has a high discard rate. He asked what the impact would be on subsequent stock assessments of other species with lower discard rates and if the actual level of discarding was unknown

Geoff Liggins replied that this would not be an issue for species with low discard rates. Redfish had been chosen as a consistent example to show the size distribution of the discards and how they dominate the catch. In fact, similar trends in size distributions are observed with other species including mirror dory, the inshore and offshore varieties of ocean perch in New South Wales and blue grenadier. Geoff then added that for each of these species it is important to include discards in stock assessments. He reiterated that redfish is not the only species for which this occurs and it was chosen as an example to make this important point.

Richard Tilzey (BRS) made the observation that there had been flow-on effects to discarding brought about by management measures. Since the introduction of ITQs to this multi-species fishery, there had been a shift away from target fishing for individual species, except those that seasonally aggregate, e.g. orange roughy and blue grenadier in the winter. The move towards taking a much more mixed catch allows fishers to spread the quota over the year, which steadies supply and yields better prices. He added that whether this new fishing strategy had resulted in more bycatch was unknown because it had not yet been quantified.

Derek Staples (BRS) asked for some clarification on whether the research program Geoff Liggins had described was set up for carrying out stock assessments since he had implied that the information was being used for other purposes.

Geoff Liggins replied the catch information was being used for stock assessment purposes and that in his presentation he was underlining the importance of including catch discard information in stock assessments. Discard information for redfish has definitely been included in recent assessments by Kevin Rowling and Kay Radway-Allen, and routinely included for blue grenadier and blue warehou, as well as the status reports produced for the SEF. He was just highlighting the importance of the monitoring program to collect this information. To emphasise this point, Geoff Liggins showed a graph of redfish to highlight a striking change in size distribution over a five-year period, which would not be noticeable if discard information had not been included. He stated that without including the discard information, a major component of the mortality from the fishery would be excluded.

Colin Buxton (TAFI) asked why there were fewer smaller fish in the fishery nowadays and whether this was due to changes in fishing gear.

Geoff Liggins replied that across the time period shown it appears to be simply a function of recruitment, as there had not been major changes in the spatial distribution of fishing effort (both in terms of area and depth) over the five-year period. It could be that environmental factors have influenced the distribution of that size group but it is most likely due to recruitment.

After the presentation by *Dennis Heinemann*, Albert Caton (BRS) stated that in the 1980s the Taiwanese carried out a significant amount of drift netting in the Indian Ocean, and then subsequently shifted to the Pacific Ocean. He asked Dennis whether this drift net fishing could have had an impact on albatross numbers.

Dennis replied that this was quite possible. However, due to a lack of data on the Taiwanese fishing activity there were no estimates of the actual level of fishing effort in this region and no estimates of bycatch rates. This was unlike the Japanese fishery from which detailed information had been collected through the observer program.

Ian Poiner asked if there was an explanation for the 28% increase in population sizes of albatross in the Croset Islands. Dennis Heinemann stated that he was not sure if this increase in population was sustainable. For most of the seabirds the breeding area is limited and since large numbers of adults have been removed from the population, younger birds had been reproducing, resulting in an increase in the number of breeding pairs. As population counts are based on the number of breeding pairs, and since the increase in numbers reported is due to breeding pairs recruiting at an earlier age, there is going to be a limit to how long this can continue. If this was true, we could expect the population to level off or maybe even decline again.

Ian Poiner asked whether this rise in population numbers could have been related to any mitigation measures. Dennis Heinemann replied they could not be related at the levels recorded.

After *Stewart Frusher*'s presentation, Paul McShane (SARDI) said that one of the problems in South Australia was the predation of rock lobster by octopus. According to Stewart's data, the use of escape gaps in pots reduced octopus bycatch to zero. Paul then queried how the figure of 100% reduction in octopus bycatch related to the level of predation by octopus in that fishery.

Stewart Frusher replied that octopus remained a problem in the Tasmanian fishery and annually accounted for A$1-2 million worth of product.

It was greatest in stick pots, perhaps because this was a less hostile environment and the octopus stay inside the pot for longer periods. It may also have to do with the number of lobsters in the pot. Octopus are attracted by the bait first and then they will attack the lobsters, usually the largest first. This causes panic amongst the remaining lobsters and they start to shed legs etc. There was a big reduction in the number of octopus in the pots that had escape gaps all around but not those with only two escape gaps.

Bruce Wallner (AFMA) stated that Stewart Frusher had portrayed an overly bleak picture of the bycatch in lobster pots by making statements such as "they all die because they have swimbladders". He pointed out that not all bycatch species (crustaceans and sharks) experience this trauma and that no data were presented on the real mortality rate of shallow-water species with swim bladders such as wrasses. Bruce then suggested that a lot of the bycatch may be returned alive and survive the ordeal. He asked Stewart to comment on this point.

Stewart Frusher agreed that crustaceans would be returned alive. Sharks were a minor component of the bycatch but some draughtboard sharks, cat sharks and sting-rays were caught. Fish were the most dominant component of the bycatch and some of the wrasse were hauled up from 10-30 metres. When wrasse and leatherjackets are hauled from these depths they generally show signs of baratrauma. However, Stewart Frusher agreed that he did not believe there was a major bycatch problem in this fishery as mandatory escape gaps in pots had proven to be very effective in excluding bycatch.

Bruce Wallner asked if these trends were the same across other lobster fisheries.

Stewart Frusher said that he did not know, and that he had found it very hard to find other people who have collected information on bycatch in lobster fisheries.

Duncan Leadbitter (Ocean Watch) posed two questions to *David McGlennon*. First, did he perceive the retention of juvenile fish as a bycatch issue, and second, whether the entanglement of wildlife such as pelicans caught in lines and turtles taking hooks was a problem.

David McGlennon said that the juvenile (undersized) fish had been included in the harvest data in his presentation. In response to the second question he stated that in South Australia the entanglement of wildlife had not been a major issue, and he considered this to be a greater problem in game fisheries where live-baits were trolled.

David Brewer asked whether discard mortality, especially for juveniles, was a critical issue in recreational fisheries.

David McGlennon replied that there was a reasonable amount of literature on hooking mortality that was relevant to recreational fisheries. However most of the literature stated huge variation in the figures from these experiments. It was very hard to experimentally mimic an 'average' recreational fishing activity and therefore he was critical of some of these experiments even though there is a large amount of literature on the subject. At the individual fisher level, it depended very much on the level of care given by the fisher.

Malcolm Haddon stated that dolphin capture in set nets was a big problem in New Zealand. He then asked David McGlennon to comment on this from an Australian perspective. Malcolm then questioned David further on whether marine mammals getting caught in passive nets was an issue in Australia.

Jeremy Lyle (TAFI) responded on behalf of David McGlennon in relation to Malcolm's second question. Jeremy stated that as far as he was aware there were no reports of dolphin entanglements in recreational fishing gear in Tasmania and if this had been the case the stories would have certainly made the press. However, stories of bird entanglements e.g. herons and diving birds in the river, do make the press. Alerts are published in the newspapers to ask recreational fishers to leave their nets out of the water when the mutton birds are in the river feeding on krill. However, he did not have any hard data on the level of entanglements.

Colin Buxton mentioned that past studies on recreational fisheries in South Africa had shown that there was a lot of selective grading going on. Anglers would have a tendency to keep all the fish they had caught during the day, but then only take home the five largest in a bag, the remainder of the catch being discarded or shared out amongst others. He asked David McGlennon whether this was a problem in Australia.

David McGlennon stated that this did occur in Australia but he had no idea of the extent of the problem. He continued that it would only be an issue in fisheries where there were bag limits on particular species. Up to the present time it had not been a major issue and he had not regularly seen this practice.

The chairman thanked all speakers and participants for their contributions.

Session 2

Some of the issues associated with bycatch reduction in fisheries

Chairperson: Murray Johns

Speakers: Aubrey Harris
Ilona Stobutzki
Paul McShane
Malcolm Haddon

Rapporteurs: Kerry Truelove
Aubrey Harris

How do we define bycatch?

Aubrey Harris

Fisheries Resources Branch
BRS, PO Box E11, Kingston ACT 2604

Abstract only

The term 'bycatch' has been in scientific and popular literature for over half a century with overlapping and sometimes contradictory interpretations. It persists as a generic term for the incidental catch from fishing operations. Efforts to establish a precise universal definition have been unsuccessful.

A main source of disagreement is the extent that several recognised components of fishing catch and mortality are included as 'bycatch'. For example, 'bycatch' has been used, narrowly, to identify only discards, or, broadly, for every source of mortality other than the target catch – including incidental retained catch, discards, unobserved mortality due to gear and indirect mortality from fishing.

The components of catch and mortality included as 'bycatch' nationally and internationally are reviewed. Some definitions, though functional elsewhere, are restrictive and inappropriate considering the scientific and public concerns related to this issue in Australia.

Assessing the response of bycatch communities to prawn trawling

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Abstract

Assessing the response of bycatch communities to prawn trawling requires a knowledge of: a) the distribution and intensity of prawn trawling effort and b) the response of individual species to prawn trawling. In Australia, prawn trawling effort is highly aggregated at both large (across the area of the entire fishery) and small (within 6 nm grids) spatial scales. In a given year, therefore, relatively large areas are not trawled or only lightly trawled and bycatch communities will not be impacted at a similar level across the fishery. The response of individual species will be a function of the rate at which they are depleted by trawling and the rate at which they recover. Two approaches have been used to assess the response of different groups of bycatch species. Firstly a manipulative experimental and modelling approach for sessile benthic, invertebrate species on the Great Barrier Reef. Secondly, criteria that use biological and ecological information to reflect a species' vulnerability to trawling are used for mobile vertebrate bycatch species in the Northern Prawn Fishery.

Introduction

Prawns are trawled in the waters of nearly all Australian States and Territories (for a description of the industries see Kailola *et al.* 1993). Historically, research on this industry has focussed on the prawns themselves, investigating their biology, ecology (e.g. Somers 1994a) and assessing the stocks (e.g. Glaister *et al.* 1990; Somers 1994b). Recently, however, the focus has widened to the question of the environmental impacts of trawling (e.g. Poiner *et al.* 1998). In this paper we will describe one area of CSIRO Marine Research's work on these impacts: new approaches to assessing the response of bycatch communities to prawn trawling. We are applying these approaches to two tropical prawn fisheries: the far northern Great Barrier Reef proportion of the Queensland Trawl Fishery (GBR) and the Northern Prawn Fishery (NPF) (Figure 1).

In assessing the impact of prawn trawling on bycatch communities two important factors that should be considered are: (a) the prawn trawling effort and (b) the response of individual bycatch species. First, we discuss the intensity and spatial distribution of prawn trawling effort and the implications of this for bycatch communities. Second, we describe two approaches to finding out how individual species respond to prawn trawling. The first, in the Great Barrier Reef (GBR) is a manipulative experiment and modelling approach to look at the responses of sessile benthic invertebrate species. The second approach, in the NPF, assesses the sustainability of mobile vertebrate bycatch using criteria which reflect the vulnerability of different species to prawn trawling. These two techniques differ in their data requirements and are applicable to different situations.

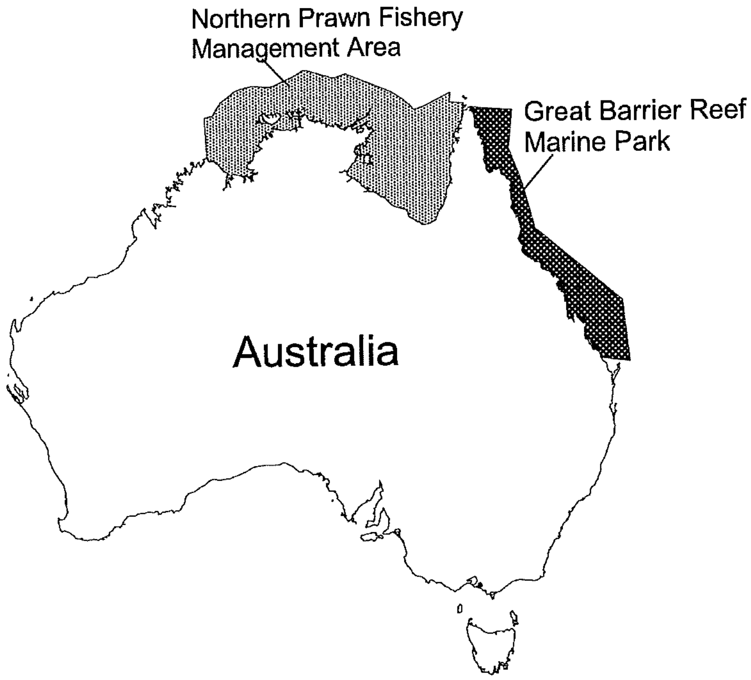

Figure 1. The location of the Great Barrier Reef Marine Park portion of the Queensland Trawl Fishery and the Northern Prawn Fishery.

Prawn trawling effort patterns

To assess the impact of prawn trawling on bycatch communities a clear understanding of the distribution of trawling effort is required at both large (across the entire fishery) and small (localised areas) spatial scales. Prawn trawling is often thought of as having an even impact over the fished areas. However, there is increasing evidence that this is not the case: prawn trawling effort is highly aggregated.

In the GBR it is clear that although the fishery is spread over a very large area, effort (in 6 nm grids) tends to be aggregated (Figure 2). In 1996, over 27% of 6 nm grids on the continental shelf were not trawled, and of the grids trawled, 70% were trawled at relatively low effort. Less than 30% of the trawled grids have high effort levels (Figure 2), i.e. greater than 1,000 hr y^{-1} of trawling, which is the equivalent of covering an entire 6 nm grid once if the trawl paths are laid out uniformly on the sea bed. The most intensive 20% of the effort is concentrated into less than 5% of the trawl grounds.

A concentrated pattern of fishing effort is also seen in the NPF (Figure 3). The total effort in this fishery is lower: around 2,000 days in 1996 (NPF annual catch statistics) compared to 92,000 days for the Queensland Trawl Fishery (excluding Moreton Bay [QFMA, Draft Management Plan]). There are only 126 boats in the NPF (Brewer, this volume), but over 800 in the Queensland Trawl Fishery (Robins and Courtney, this volume). Of the NPF managed area, only 25% is trawled, and of the trawled area, most is trawled relatively lightly. Only about 25% of the trawled grids have high effort (>1,000 hr y^{-1}). Almost 80% of the catch in this fishery comes from about 20% of the grids fished (D. Die, unpublished data).

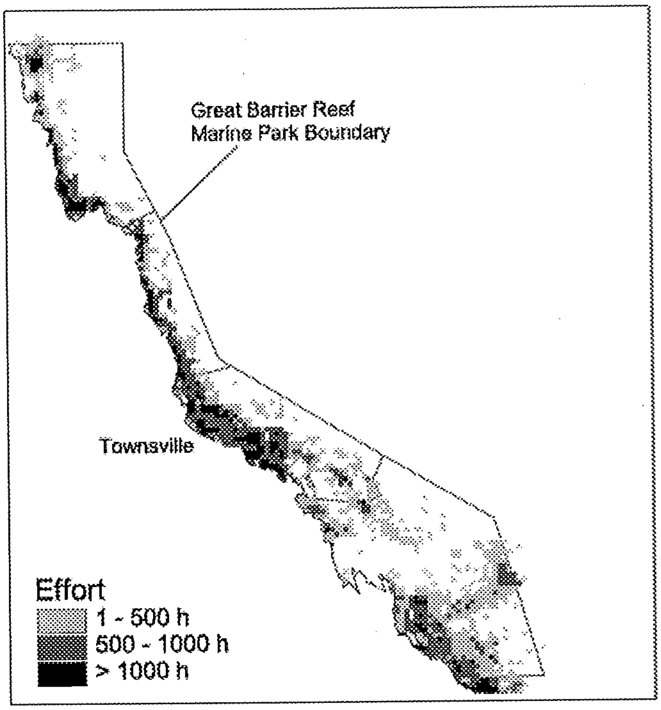

Figure 2. The distribution of 1996 estimated trawl effort, at the scale of 6 nm grids, in the Queensland Trawl Fishery. It is based on the number of boat days multiplied by an average of 10 hours per day (night). These data were derived from QFISH logbooks, courtesy of QFMA (F. Pantus, unpublished data). The effort levels have been estimated from logbook information recorded at the 6 nm grid and 30 nm grid resolution.

Effort at a finer spatial scale also appears to be highly aggregated. Information on trawling effort within 6 nm grids is rare for most fisheries (Rijnsdorp *et al.* 1996). However, data from global positioning system (GPS) plotters used by the NPF have been used to look at fine-scale effort patterns (M.Haywood, unpublished data). There is also some information from the trials of vessel monitoring systems (VMS) in the Queensland Trawl Fishery (N.Gribble, unpublished data). Both data sets show that effort is highly aggregated at fine scales. For example, over four consecutive nights the GPS track shows a trawler repeatedly trawling the same ground, which had a high catch (Figure 4). Large areas of the grids were not trawled. This pattern of aggregated effort within a 6 nm grid means that, even within high-effort grids, substantial areas of the grid may be only lightly trawled or untrawled.

The implication of this highly aggregated nature of prawn trawling (at both the large and small spatial scales) is that bycatch communities are unlikely to be impacted at similar levels across the fishery. The response of bycatch communities will, therefore, vary spatially across the managed area, in relation to the intensity of trawling.

Responses of species to trawling

Not only effort levels will influence the responses of bycatch communities to trawling; the response of individual species is also a factor. We are applying two approaches to two

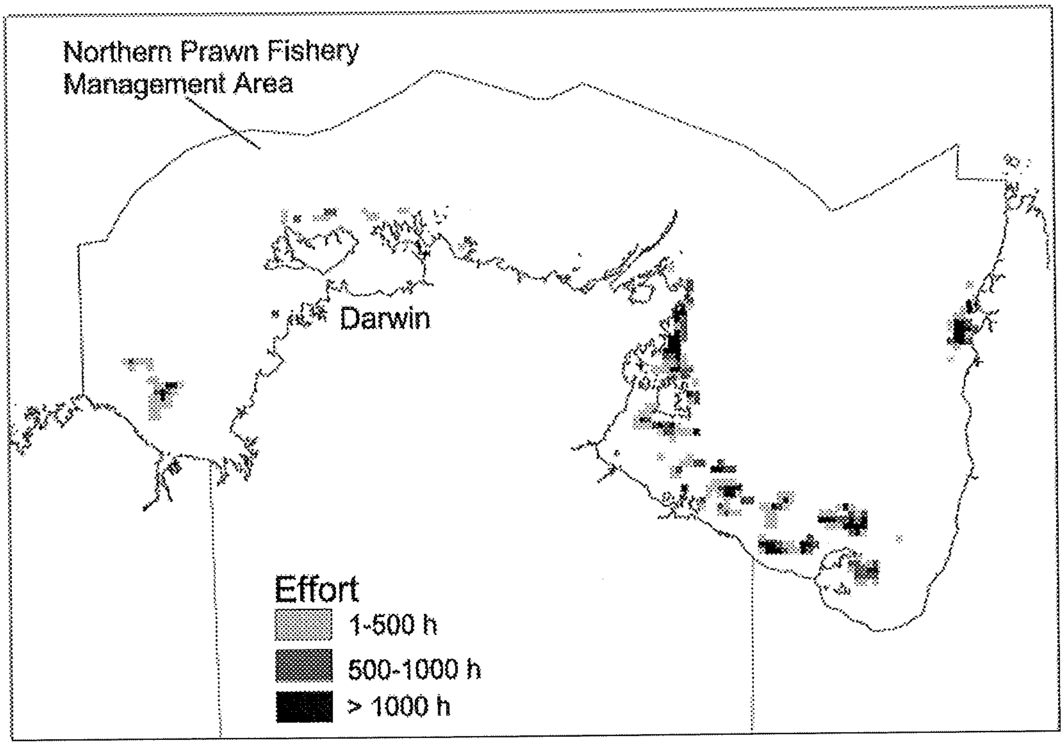

Figure 3. The distribution of 1997 prawn trawl effort in the Northern Prawn Fishery, at the scale of 6 nm grids. These data were derived from AFMA logbooks, based on the number of boat days multiplied by an average of 14 hours per day (night). Areas where effort was less than 10 boat days or less than five boats are not shown due to confidentiality.

bycatch groups to examine the responses of individual species.

Invertebrate bycatch of the Great Barrier Reef

A manipulative experimental and modelling approach was used on the GBR to look at the responses of sessile benthic invertebrate bycatch species to trawling. Their responses will be influenced by the rate at which the population is depleted by trawling and the rate at which the population can recover after this depletion. A repeat-trawl experiment was conducted to determine depletion rates, which were then modelled with estimates of recovery rates and different levels of trawling effort (see Poiner *et al.* 1998; Pitcher *et al.* in press, for full details).

For the repeat-trawl experiment, six tracks, 1.5 nm long were trawled 13 times each. The estimated depletion rate of sessile benthic invertebrates ranged from about 5% to 37% biomass/trawl, depending on the taxon. Populations of species with different depletion rates (5%, 10% and 20% biomass/trawl) were then modelled to determine the influence of a year of trawling at different intensities of effort. Effort was modelled as aggregated within the 6 nm effort grids, that is the cumulative distribution of effort among 6 nm grids was used as an empirical distribution function to distribute effort within the 6 nm grids. After one year of simulated effort, the proportion of a population remaining depends on the depletion rate of the species and the

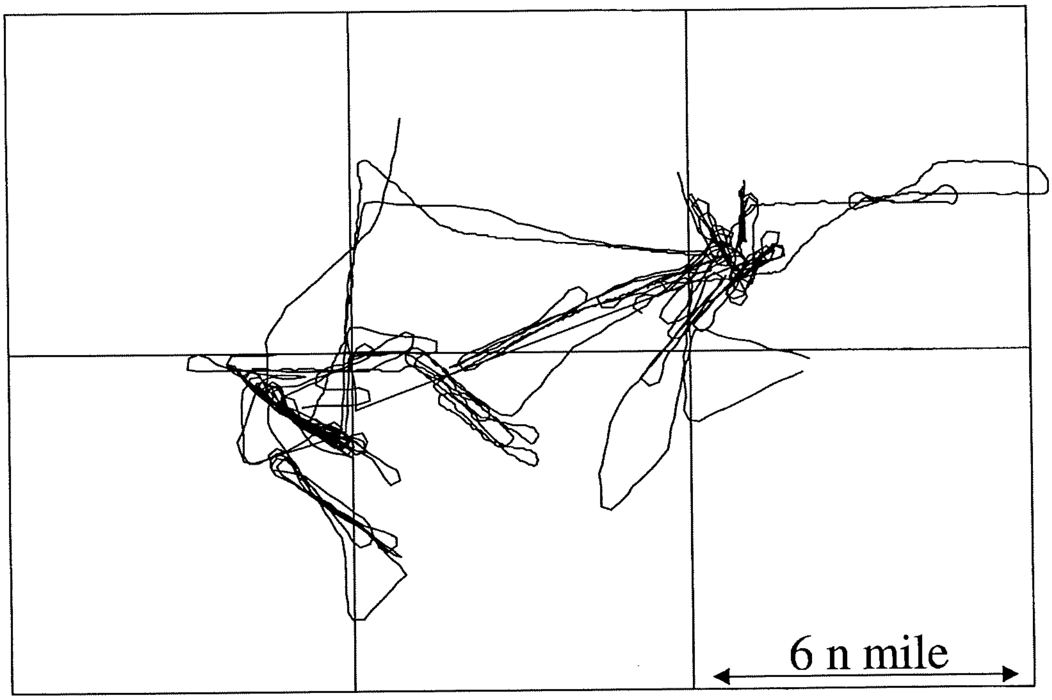

Figure 4. Fine-scale effort patterns: the track of a single trawler in the Northern Prawn Fishery over four consecutive nights within 6 nm grids (M. Haywood, unpublished data).

effort levels (Figure 5). Species that are depleted at a higher rate are reduced more rapidly, and to lower levels as a percentage of the original population, than other species. This model, however, incorporates only depletion rates.

The recovery rates of species will also influence their response to trawling. Quantitative information on the recovery dynamics of sessile benthic invertebrates is the focus of a current project on the GBR. The recovery rates were therefore modelled using a logistic population growth model with a range of likely recovery rates, from slow to fast (see Poiner *et al.* 1998 for full details). The model integrates effort levels, depletion and recovery rates to look at the changes in population levels after 20 years of trawling effort (Figure 6).

The results of the model show that, as effort increases the proportion of the original population size that remains decreases in all species (Figure 6). The reduction in population size is greatest for the most vulnerable species, those with high depletion rates and low recovery rates. Differences in the responses of species change the composition of the bycatch communities. Trawling would reduce the proportion of vulnerable species in the community, while the less vulnerable species (those with low depletion rates and fast recovery rates) would become more dominant.

Northern Prawn Fishery vertebrate bycatch

As with most tropical prawn trawl fisheries, the tiger prawn fishery in the NPF has a very diverse vertebrate bycatch of over 500 species. The managed area of the fishery is large: more than 1 million sq km. Current CSIRO research is assessing the responses of the vertebrate bycatch species to trawling in order to

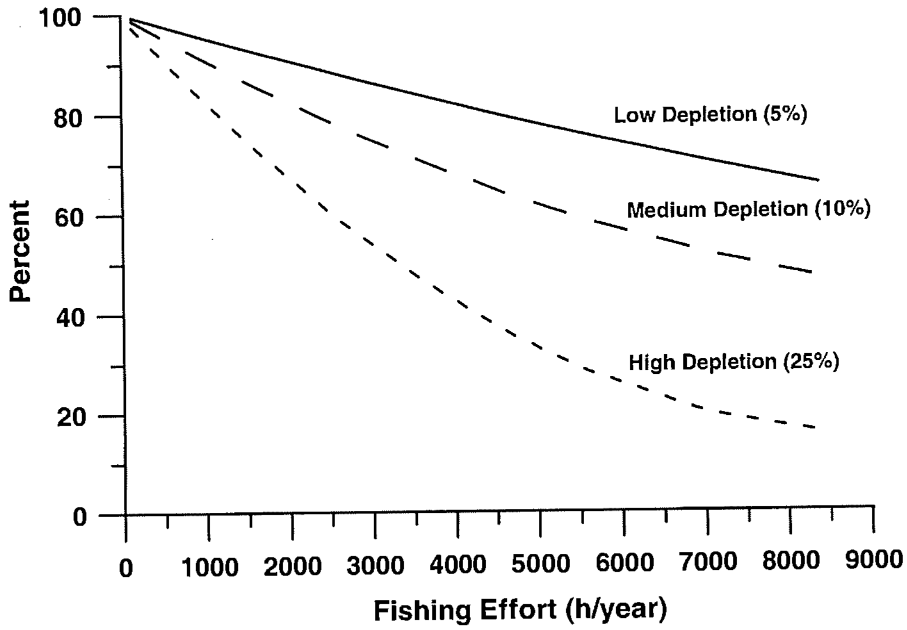

Figure 5. The proportion of populations of species, with different depletion rates (shown as % biomass/trawl), that would be left after one year of trawling at different effort intensities, modified from Poiner *et al.* (1998).

determine their vulnerability (FRDC Project 96/257). The response of each species is being assessed against criteria chosen to reflect the depletion and recovery rates of the species (Figure 7).

The depletion rates of species will be examined in terms of criteria that estimate the proportion of the population taken by trawling. The criteria are the distribution of species, and the catch rates. The distribution of individual species will be compared to the distribution of trawling effort in the NPF. Although the NPF covers a large area, only a relatively small area is trawled (Figure 3). The depth range of the trawling is also narrow: 90% is between 10 and 45 m. The geographic and depth distribution of individual species will therefore be compared to the geographic and depth distribution of the trawling to determine what proportion of the population may be impacted.

We also compare the catch rates of species by prawn trawlers and by research surveys both inside and outside the trawl grounds. This will determine whether species are caught commonly or rarely by trawlers and how this reflects their natural abundance. It will determine whether species rarely caught by trawlers are actually rare species or whether trawlers are inefficient at catching them. Conversely for species caught commonly, we will determine whether they are naturally abundant in the managed area. As the tiger prawn fishery in the NPF takes place only at night, species that are more vulnerable at night will have a greater proportion of their population affected. We will therefore compare day and night catches to look at the diel behaviour of species.

The recovery rates of species will be calculated by examining criteria such as the reproductive biology and the life stage caught by the

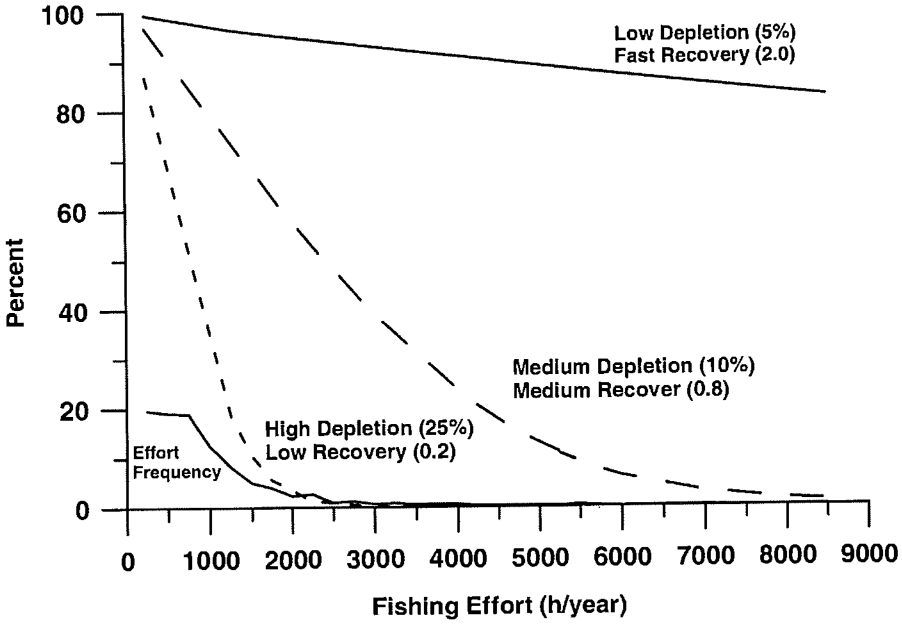

Figure 6. The proportion of populations of species, with different depletion (shown as % biomass/trawl) and recovery rates (r values for logistic population growth), that would be left after 20 years of trawling at different effort intensities, modified from Poiner *et al.* (1998).

trawlers. The reproductive biology of the species includes their age/size at first reproduction, how often they reproduce, how fecund they are and the survivorship of the young. The life stage caught by the trawlers is also relevant because if they are catching mainly pre-reproductive animals, the species may have a slower recovery rate than a species that loses mainly post-reproductive animals to the trawlers.

These criteria will enable us to assess the vulnerability of a bycatch species to trawling and the likelihood of its population surviving current levels of capture. For example, a naturally rare species that is long-lived, slow to mature, bears two live young every two years, and is caught mainly as pre-reproductive adults, probably cannot sustain continued exploitation as bycatch. In contrast, a species that is abundant throughout the fishery, short-lived, matures at a few months of age, produces millions of eggs several times a year, and is caught in large numbers by trawlers after the adults have reproduced, is probably sustainable.

Each of the over 500 vertebrate bycatch species will be classified as: a) too little information to determine whether they are sustainable; b) probably sustainable; or c) probably unsustainable as bycatch (Figure 7). The last group should be monitored and measures taken to reduce their bycatch to sustainable levels. This approach will highlight species that might disappear from the current bycatch community if their take is not reduced.

This approach addresses the issue of the sustainability of the current bycatch community. It may be that these species are those that have survived trawling until now, while very vulnerable species may have disappeared. However, this study does not attempt to describe species that may have

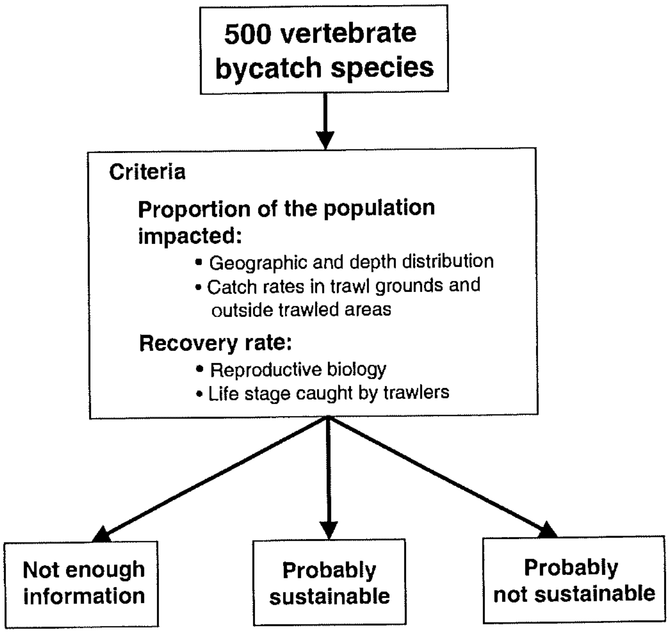

Figure 7. The criteria used to assess the response of vertebrate bycatch species in the Northern Prawn Fishery and the likely outcomes.

disappeared from the region due to fishing. Determining whether species have completely disappeared from the trawling region requires comparisons with data collected prior to the commencement of trawling (e.g. Harris and Poiner 1991). The results of the modelling on the GBR suggest that bycatch communities may become dominated by the less vulnerable species. Changes in community composition due to trawling have also been suggested by previous work (Sainsbury 1988; Harris and Poiner 1991). The second approach will highlight species that may have decreased significantly due to trawling, or conversely, species that can sustain this fishing pressure.

The two approaches discussed above differ in several ways. The depletion experiment and modelling approach is useful for sessile benthic invertebrates, but probably not for mobile vertebrate species. Depletion experiments for mobile species are less likely to be successful due to the mobility of the animals. The second approach, using criteria to estimate depletion and recovery, could be used for both sessile and mobile species. The first approach, however, considers 'unseen' mortalities, where species are damaged or killed but do not appear in the nets on the trawler. Such mortality could damage ecosystems but little research has attempted to address this issue. The second approach would be inappropriate for species that are not captured by the nets.

The information needs of the two approaches differ. The first approach requires direct measures of depletion and, preferably, recovery rates, effort distribution at a fine scale (e.g. <6 nm) and species distributions at about the same scale as the effort distribution. The second approach uses catch rates, catchability and distribution patterns to estimate depletion rates. Recovery rates are estimated from life history information. In the second approach the information on effort distribution and species distribution can be at a medium scale, coarser than for the first method. The choice of approach would, therefore, depend on the species of interest and also the type and scale of available information.

Acknowledgments

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Trophic consequences of prawn trawling: linking bycatch to benthos

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Abstract

*Intensive research in the past decade has succeeded in developing technology to reduce the bycatch in prawn fisheries. Although many prawn fisheries are still to apply such technology, the incidental capture of fish and other biota in prawn trawls can be substantially reduced. Despite these advances, however, it is unlikely that bycatch will be eliminated and the challenge of determining the ecological consequences of this and other aspects of prawn trawling activity remains. In contrast to studies of the acute damage to benthic communities arising from prawn trawling, the trophic consequences of prawn fishery discards remain relatively un-studied. In Spencer Gulf, South Australia, the prawn fleet efficiently targets aggregations of prawns and, as a consequence, bycatch is a small proportion of the total catch (usually less than half). Nevertheless, discarded fish such as monocanthids and carangids have potential to provide an energy subsidy to scavengers such as blue crabs (*Portunus pelagicus*) and prawns themselves (*Penaeus latisulcatus*). Examination of scavenging patterns on discards with techniques such as stable isotope analysis can provide insights into the trophic linkages and potential importance of energy subsidies for food web dynamics in this system.*

Introduction

Recent research on the bycatch from prawn trawls has concentrated on developing gear that can reduce the retention of material other than prawns in prawn nets. This is not surprising, as many commercial fisheries for prawns have been threatened with closure or even closed (Chong *et al.* 1987) as a result of demonstrably high bycatch retention (Andrew and Pepperell 1992; Alverson *et al.* 1994). Relatively little research has examined the ecological consequences of prawn trawling in relation to discards of bycatch (Kennelly 1995). Instead, studies of the impact of trawling have focussed on acute impacts such as the removal of erect epibiota by bottom trawlers (e.g. Sainsbury 1988). More general environmental impacts of other trawling activities have been well reported and recently reviewed by Lindeboom and de Groot (1998). Research results suggest that acute damage from prawn trawling activity can include substantial habitat modification. Unfortunately, the necessary 'before' data are rarely, if ever, available to compare against present community composition on fishing grounds and assess the potential impact of prawn trawling.

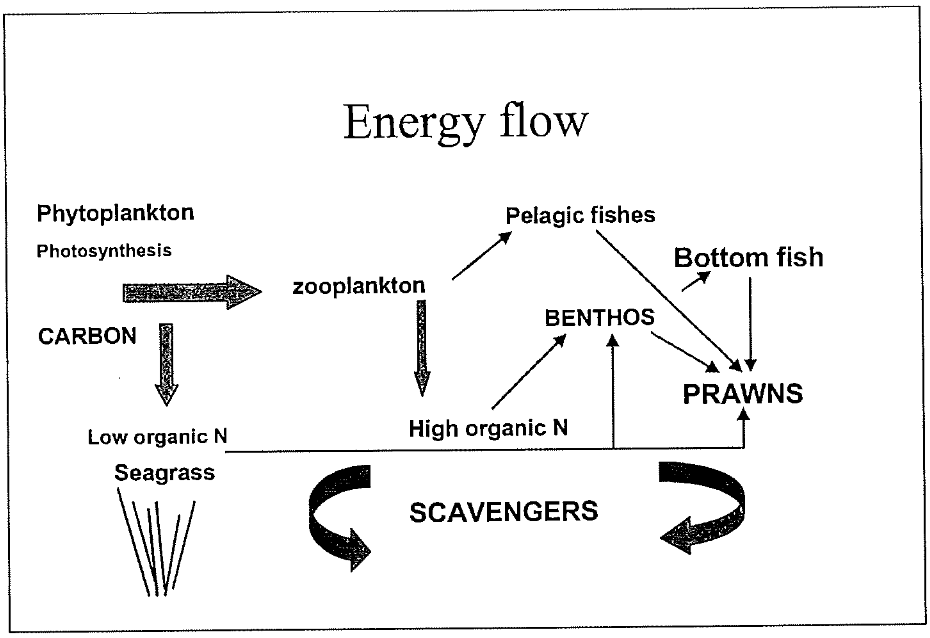

Figure 1. Representation of hypothetical energy flows related to plant and animal-derived carbon and nitrogen. Interactions involving bottom fish (flounder), benthos and prawns are shown in the context of existing prawn trawling operations of Spencer Gulf.

Most prawn fleets catch more bycatch than prawns (Andrew and Pepperell 1992; Alverson *et al.* 1994; Kennelly 1995). Unwanted material is discarded and survival rates for animals returned to the water are low (Hill and Wassenberg 1990). Surface scavengers such as seabirds and marine mammals feed on discards and the remaining material sinks (Hill and Wassenberg 1990). This biological material, usually small finfish, potentially offers an energy subsidy to benthic or even pelagic communities, providing food resources that would otherwise be unavailable. Thus, the discards from prawn trawlers may modify trophic interactions by short circuiting food chains and increasing energy flows to scavengers and meio- or microbenthic communities. The importance of natural detrital shunts and food subsidies to food webs is now receiving increased attention and has been shown to have some important effects (e.g. Polis and Hurd 1996). Here, we discuss the possible effects of human-induced discard subsidies with reference to the Spencer Gulf prawn fishery in South Australia.

The Spencer Gulf prawn fishery

Spencer Gulf (Figure 1) is a reverse estuary with surface water temperatures ranging from 12-25 °C (Noye *et al.* 1982; Smith and Veeh 1989). The fishery for prawns (*Penaeus latisulcatus*) in Spencer Gulf is limited entry (39 vessels, ≤22 m) and operates for 65-72 days each year. It is the largest temperate penaeid fishery in Australia producing 1,650-2,600 t annually with spatially focussed fishing directed by research surveys that reveal aggregations of large prawns. No trawling takes place from late December to March or from mid-June to November. Studies of the bycatch from the Spencer Gulf fishery (Carrick and McShane, in prep.) show that the weights of bycatch to prawns are generally low by world standards,

Table 1. Composition of prawn trawls in Spencer Gulf (aggregated data). Data are percentage composition by number caught (from Carrick and McShane in prep.).

Species	Common name	Percentage composition
Penaeus latisulcatus	Western king prawn	66.3
Pseudocaranx wrighti	Sand trevally	10.5
Thamnaconus degeni	Degens leatherjacket	5.7
Portunus pelagicus	Blue swimmer crab	3.7
Repomucenus calaratus	Spotted stinkfish	1.6
Acanthaluteres spilomelanurus	Bridled leatherjacket	1.2
Scobinichys granulatus	Rough leatherjacket	1.2
Metapenaeopsis sp.	Strawberry prawn	1.2
Parequula melbournensis	Southern silverbelly	1.2
Sepioteuthis australis	Southern calamari	0.9

consistent with the effective targeting of prawns in the Gulf.

Fates of discards

Trawl shots of about 60 min duration generally retain about 300 kg of prawns and 150 kg of bycatch. The bycatch is dominated (97% of the weight of the total bycatch sampled) by 15 species of small finfish (mostly <50 grams) from 10 families, particularly monocanthids and carangids (Carrick and McShane, in prep.). However, the composition of the bycatch varies temporally and spatially. For example, blue crabs (*Portunus pelagicus*) are dominant in prawn trawls in the north of the Gulf but rare in the south (Carrick and McShane, in prep.). In some cases, large elasmobranchs dominate by weight. Once discarded, small fish (about 1,000/trawl) float on the surface before sinking to the bottom (see Harris and Poiner 1990).

Other discards are mostly blue crabs (about 60/trawl) that are generally returned alive and presumably swim to the bottom (Harris and Poiner 1990; Hill and Wassenberg 1990).

Unlike other coastal systems, sea birds are comparatively rare in Spencer Gulf and are not considered to be important scavengers of bycatch (*cf.* Hill and Wassenberg 1990; Camphuysen *et al.* 1993) particularly as the fishery operates at night. Instead, marine mammals, particularly the common dolphin (*Delphinus delphis*) and the bottlenose dolphin (*Delphinus truncatus*) are the most commonly observed surface scavengers of discards (Carrick, pers. obs.). Dolphins have been observed to be selective in their feeding preferences with monocanthids avoided and species such as squid (*Sepioteuthis australis*) and red mullet (*Upeneichthys vlamingii*) targeted despite their comparatively low frequency as discards (Table 1). Thus, most of the common discards such as the carangid *Pseudocaranx wrighti* and the monocanthid *Thamnaconus degeni* (together constituting more than 50% of the numbers discarded) may be expected to arrive at the sea floor (see Harris and Poiner 1990; Hill and Wassenberg 1990).

Trawling occurs in waters between 15 and 30 m depth at a trawl speed of 2.5-3 knots (Carrick and McShane, in prep.). Small fish would take between three and six minutes to travel to the seafloor (Hill and Wassenberg 1990) whereas crabs (*Portunus pelagicus*) take less time to reach the bottom (Wassenberg and Hill 1990). As bycatch is discarded while underway it would be spread over a distance of about 500 m depending on water movement, and an area of more than 5000 m^2. Thus the densities of discards, given the assumptions above and typical bycatch discard rates (Carrick and McShane, in prep.), may be expected to be less than one individual (or 80 g) per five square metres. This estimate is much less than general discard rates of bycatch from trawlers (Andrew and Pepperell 1992; Lindeboom and de Groot 1998).

It is likely that blue crabs, given their abundance in Spencer Gulf (Carrick and McShane, in prep.), are among the main scavengers of discards from prawn trawls (Wassenberg and Hill 1987, 1990) – similar to the situation found for other trawling operations (e.g. Ramsey *et al.* 1998; see also Lindeboom and de Groot 1998 for a more general account of scavenging on trawl discards). Thus, there is obvious potential for discards to provide a food subsidy to this species, perhaps with consequent effects on growth and fecundity. However, there is also another interaction that must be taken into account because large numbers of crabs (>60/trawl) can be caught in the north of the Gulf (Carrick and McShane, in prep.). Many of these crabs will be returned alive to the benthos but redistributed on the seafloor. At present, however, the relative importance of these interactions is poorly understood as is the more general question of trophic linkages among the benthic species of Spencer Gulf and the interaction with discards from prawn trawlers.

Linking bycatch to benthos in Spencer Gulf

One of the few attempts to link bycatch to benthos for a prawn fishery is for the Gulf of Mexico (Sheridan *et al.* 1984). The approach these authors adopted was to construct a simple trophic mass-balance model to summarise the patterns of energy flow through the system. In contrast to Spencer Gulf, the contribution of organic material *via* discharge from a major waterway (the Mississippi River) made elucidation of the relative contribution of bycatch discards tenuous (Sheridan *et al.* 1984). For the present purpose, however, although not without problems, the general approach provides a framework for considering the trophic dynamics and the potential consequences of prawn trawl discards for Spencer Gulf.

In contrast to the Gulf of Mexico, Spencer Gulf is an oligotrophic coastal system with nutrient additions occurring at low levels, primarily through point source discharges to the north (Noye 1984; Smith and Veeh 1989). Seagrasses are the dominant marine plants along the coastal margin occupying an estimated 3600 km^2 (Shepherd 1983) and, unlike most coastal systems, may provide a greater supply of carbon to the benthos than phytoplankton (Smith and Veeh 1989). Prawns and other detritivorous scavengers may therefore ultimately be dependent on seagrass productivity (Newell *et al.* 1995). In Sheridan *et al.*'s model, high-nitrogen organic material primarily of animal origin (e.g. discards) was distinguished from low-nitrogen organic material of plant origin (Figure 1). The difference in photosynthetic carbon assimilation by seagrasses and other marine plants (Benedict *et al.* 1980) provides an opportunity to further discriminate carbon provenance and to identify carbon pathways (Marguillier *et al.* 1997). In this respect, the analysis of stable isotopes of carbon, nitrogen, and sulphur in organic matter shows promise for determining food web structure and the flow of organic matter through various trophic pathways (Peterson *et al.* 1985; Peterson and Fry 1987; Michener and Schell 1994). Application of such techniques, together with targeted feeding trials (Newell *et al.* 1995), can provide insights into the fates and consequences of prawn trawl discards.

Ecologically, demersal fish communities of Spencer Gulf appear to have relatively simple structure. Most fish in the Gulf are small and there are relatively few major predators on prawns compared with other fisheries (*cf* Sheridan *et al.* 1984). However, flounder (*Pseudorhombus jenynsii*) are a major predator of prawns in Spencer Gulf (Carrick, unpublished data). Prawn trawling has been shown to locally deplete populations of flounder (Carrick and McShane, in prep.) and flounder at fished sites are smaller than those from unfished sites. These findings suggest an interaction with prawn trawling activity and predators of prawns. One consequence of reduced predator abundance is reduced predation mortality for prawns. The findings of Sheridan *et al.* (1984) suggested further enhancement of prawn populations through increased energy availability from bycatch discards. However, in Spencer Gulf, it may well be that relatively low densities of bycatch reach the benthos and that the trophic subsidy is small. Even so, there are persuasive reasons for examining trophic interactions and ecological processes in Spencer Gulf. First, simple calculations relating to discard densities on the seafloor can be notoriously misleading. For example, the calculation takes no account of the spatial and temporal patchiness of fishing effort and the consequent effects on the distribution of discards by the fleet as a whole. At local scales and in certain seasons, discard densities may reach levels that significantly enhance food availability for benthic scavengers. This may still be insufficient to lead to enhanced growth of individuals or populations, but may lead to the aggregation of scavengers on fishing grounds thereby increasing their vulnerability. Second, while benthic scavengers may not benefit, highly mobile vertebrates, which forage in the water column and can adapt their behaviour to take advantage of a ready food resource, may. Third, it is only by undertaking a scientifically defensible program of field research, that one could defend the legitimacy of concluding that the effects are negligible. Finally, and more strategically, the process of evaluating the role of discards will be a significant first step to elucidating the trophic relationships between key components of the Spencer Gulf ecosystem. If we are to fully evaluate the role that fishing plays in ecosystems these steps need to be taken.

Acknowledgments

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Discarding as unaccounted fishing mortality – when does bycatch mortality become significant?

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Abstract

A general age-structured simulation model was used to investigate the different impacts of a range of different discarding rates upon subsequent generations of the organisms involved. The intuition under test was that discarding would have a greater negative impact upon long-lived, relatively slow growing species than upon relatively fast growing, short-lived species. Model parameters were thus selected to simulate hypothetical species which had differing life-history characteristics. These were exposed to differing rates of discarding and the impacts upon year-class strengths, reproductive value, and the risk of growth overfishing were determined. Extreme dumping of undersized fish only occurs under exceptional circumstances of recruitment, therefore there is no necessity to introduce fishing gear that does not target undersized fish. While this dumping does not seem to constitute a threat to stock integrity, it does represent a high level of wastage of potential future yield. This yield can only become available for capture or for increasing the spawning stock size by introducing more selective fishing gear.

Introduction

The bycatch in some fishing operations includes target fish that are discarded as being 'undersize' or otherwise not wanted. These include those fish less than a legal minimum size as well those fish for which there would be no profitable market or for which the fisher has no quota. When discarding of such small or unwanted fish occurs in large quantities, it appears possible that this would be harmful to the stock and productivity. At very least it is clear that the stock assessment process should take such discards into account or be biased by a possibly important amount. These intuitions especially arise when the discards are of juvenile or undersized fish and equal or exceed the landed catch. Recent examples of such juvenile discarding in Australia include redfish in New South Wales waters (Tilzey 1998) and blue grenadier from the south east trawl fishery (Punt 1998).

This present work is a beginning at investigating the implications for stock sustainability and potential yield of discarding of undersized target fish.

The objective was to determine under what conditions the biomass of undersized individuals caught could equal or exceed the biomass of retained individuals. Following intuitions about

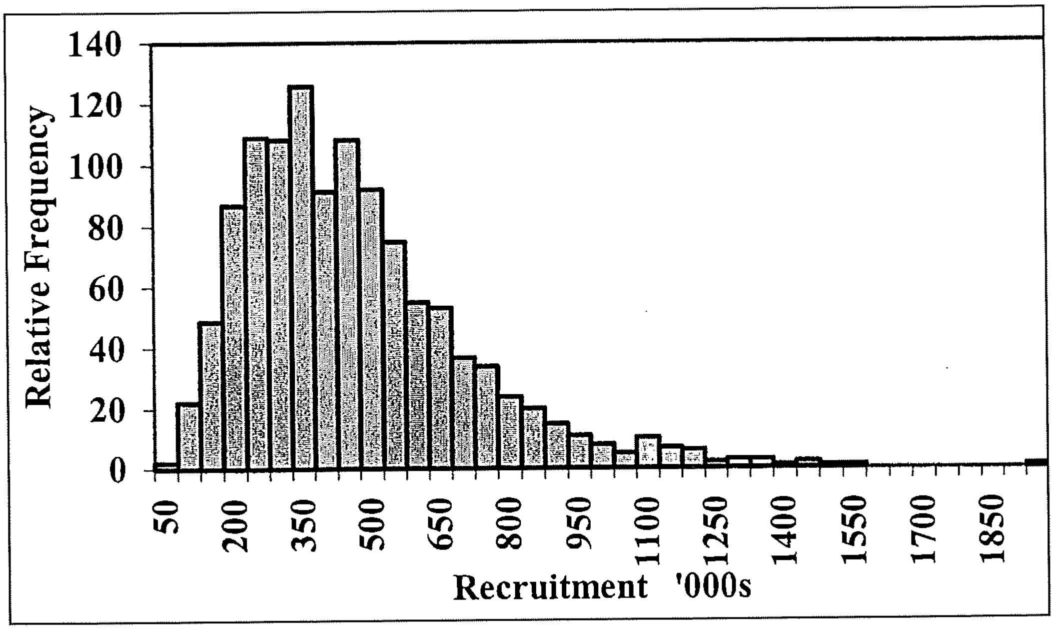

Figure 1. Relative frequency of different recruitment levels that could have arisen in the simulation. Recruitment levels are in thousands. Note the log-normal form.

such discarding the particular question to be answered was 'Is the weight of discarded juveniles only likely to equal or be greater than the amount of adults landed when juvenile numbers expand in years of good recruitment?' This leads to a second question which is 'Can one avoid catching large numbers of juveniles simply by altering fishing behaviour?'

The model

To answer the questions of interest an age-structured, size-based population model was developed. Being size-based permitted the application of fishing mortalities to different particular lengths *via* given gear selectivity curves. This was necessary so as to determine the detailed size-structure of the catch. The model was also made age-structured so that the changes in fish numbers through time could be modelled more traditionally. This structure permitted a relatively simple implementation of modelling the growth in length of individuals within each of the population's cohorts.

As with all single species population models, the model was a combination of processes describing growth, recruitment and mortality. Growth was modelled explicitly through the model being length-based. Fishing mortality was applied to each size category taking size selectivity of the fishing gear into account.

Each iteration of the model represented a year passing and produced a frequency distribution of the numbers of new recruits in each of the available length-classes. In the present model, the number of recruits is unrelated to the modelled stock size, this will be simple to alter in later versions of the model. The actual number of recruits, was modelled by randomly sampling under a log-normal distribution:

$$N_R = e^{N(\mu,\sigma^2)} \quad (1)$$

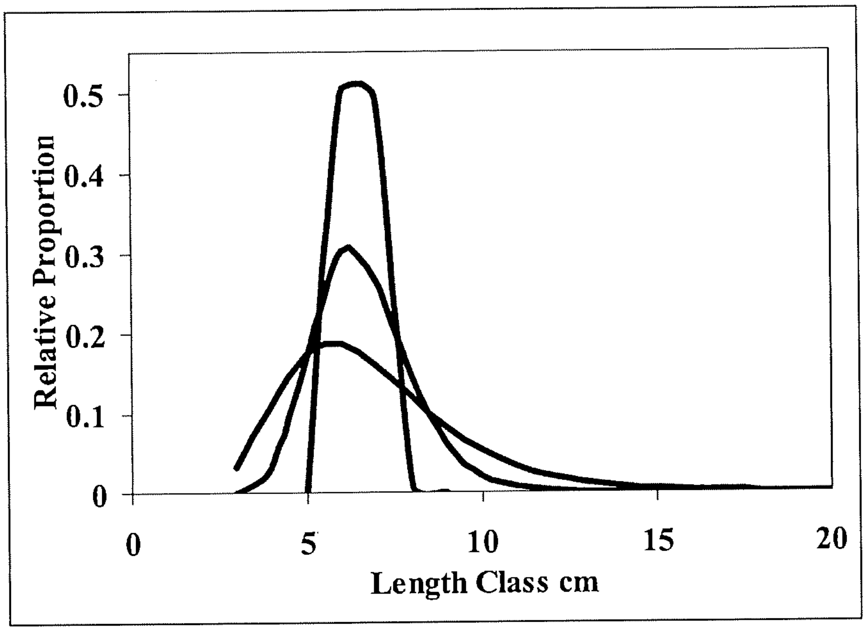

Figure 2. Three size distributions of juveniles produced by the log-normal generator in equation 2. Clearly, the highest curve has the smallest variance and the lowest curve has the highest variance. The variances are selected at random for each new set of recruits. These curves typify the range of recruitment size ranges produced by the model runs.

N_R is the number of recruits, and $N(\mu, \sigma^2)$ is a normal distribution with mean = 13 and variance = 0.5 (Figure 1). The expected proportion of the cohort in each of the length classes was described by a log-normal probability density function:

$$f\left(L_i, L_t, \sigma^2\right) = \frac{1}{\sqrt{2\pi\sigma}} e^{\frac{-\left((L_i - L_t)^2\right)}{2\sigma^2}}$$

$$P\left(L_i\right) = e^{f\left(L_i, L_t, \sigma^2\right)} \qquad (2)$$

where $P(L_i)$ is the proportion of the recruits to be found in length category L_i (1 cm categories). L_t is the mean expected length of a fish at an expected age of 0.15 years. The variance term, σ^2, provided for changes between iterations and was chosen *via* a normal random process with mean 0.15 and variance 0.25, with the added constraint of a minimum of 0.1. Equations (1) and (2) together produce a wide range of recruitment levels and distributions (Figure 2):

$$N_{R,i} = N_R P(L_i) \qquad (3)$$

where $N_{R,i}$ is the numbers of recruits in size class i.

A transition matrix with rows and columns for size classes 3 cm to 75 cm was used to drive the growth of the members of each size-class from year to year. This determined how the proportions in each size-class within each age-class altered every year.

The transition matrix was constructed in the following way. The expected increment in growth, ΔL, for each of the 1 cm size-classes was determined using the Fabens version of the

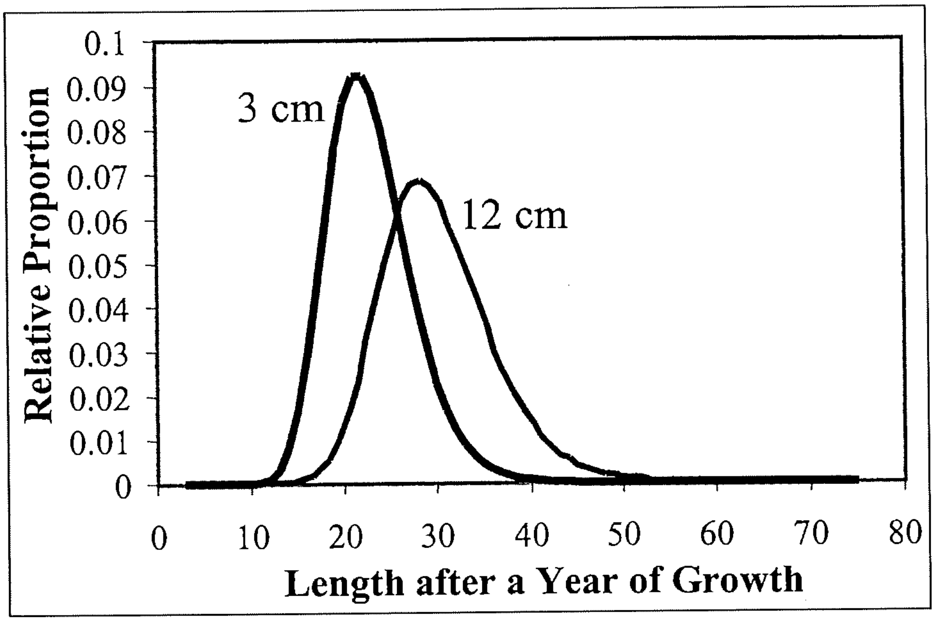

Figure 3. Relative proportions of different lengths of fish after growing for one year starting from 3 and 12 cm. The expected increments in body size were 18.92 cm and 16.59 cm respectively.

von Bertalanffy growth curve (Fabens 1965):

$$\Delta L = (L_\infty - L_i)(1 - e^{-K\Delta t}) \quad (4)$$

where L_∞ and K are the usual von Bertalanffy growth constants and L_i is the starting length of the size-class. The model was run on a time scale of years so the time increment Δt reduced to 1 in each case.

The fish from each 1 cm size-class were not all expected to grow by the amount predicted by Equation (4), instead each size-interval was expected to give rise to a log-normal distribution of potential final sizes:

$$P(L_j) = e^{f(L_j, \Delta L + L_i, \sigma^2)} \quad (5)$$

where $\mathbf{P(L_j)}$ is the proportion of the animals growing from size-class $\mathbf{L_i}$ to become size-class $\mathbf{L_j}$, **ΔL** is the predicted length increment for size-class $\mathbf{L_i}$, and σ^2 was the variance of this log-normal distribution. In this instance σ^2 was set at 0.2 except for the larger $\mathbf{L_i}$ in which case σ^2 was reduced until the proportion predicted not to grow (i.e. stay in $\mathbf{L_i}$) was less than 0.1% (Figure 3).

Of course we are most interested in determining the ratio of undersized fish to other sizes in terms of weight. The relationship between length and weight was assumed to be of the exponential form:

$$W_i = aL_i^b \quad (6)$$

where $\mathbf{W_i}$ is the weight of length class *i*, $\mathbf{L_i}$ is the length, and *a* and *b* are constants.

To determine the expected distribution of sizes from year to year the transition matrix **T** was generated, using equation (5) to fill in the columns, there being one for each size class (3 cm to 75 cm). This transition matrix contained

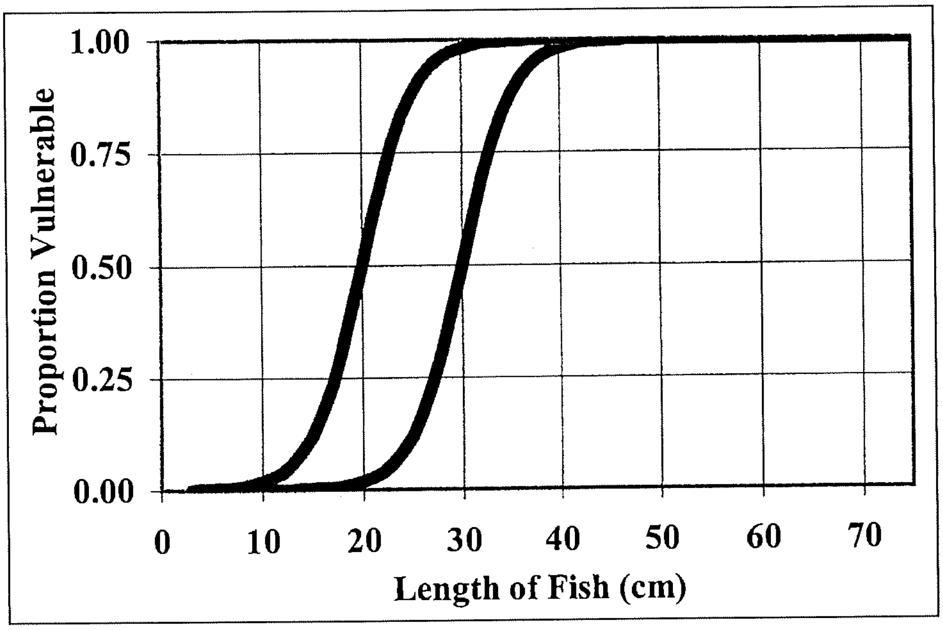

Figure 4. The two selectivity curves used in the model. The leftmost curve a = -8 while the rightmost curve a = -12. For both curves b = 0.4. Clearly, the 50th percentile is at 20 and 30 cm respectively.

the expected proportions of derived sizes from each starting size-class. The transition matrix was used to project the proportional size distribution in each age-class with each passing year. With each step of the model, the impact of natural mortality was included.

In the model both natural and fishing mortality are converted to annual mortality rates and expressed as the complementary annual survivorship rates. Thus, the impact of natural mortality was included by using an annual survivorship **S**:

$$S = e^{-M} \tag{7}$$

where **M** is the instantaneous natural mortality rate. Hence, starting from the distribution of recruited fish (Equation [3]) and moving forward year to year, the expected numbers of fish in each size-class, without fishing, was:

$$N_{a,i} = \mathbf{T}.N_{a-1,i}S \tag{8}$$

where $\mathbf{N}_{a,i}$ is the number of animals of age *a* in size-class *i*.

The annual fishing mortality $\mathbf{A}_i$ imposed upon each size-class was a function of **F**, the instantaneous fishing mortality and v_i the selectivity coefficient for the given size class. The selectivity curve used was a standard logistic relationship:

$$v_i = \frac{1}{1 + e^{-(a + bL_i)}} \tag{9}$$

where ***a*** and ***b*** are the logistic constants, $\mathbf{L}_i$ is the length of size-class *i*, and v_i is the proportion vulnerable to fishing for size-class *i*.

The annual fishing mortality rate **A** was allocated to each size-class by including the selectivity value for each particular size-class *i*:

Table 1. Population parameters used in the particular runs of the model.

Parameter	**Value**
L_{∞} von Bertalanffy	76 cm
Ko von Bertalanffy	0.3
t0 von Bertalanffy	-0.15
Length to Wt constant *a*	0.01
Length to Wt constant *b*	3.2
M natural mortality	0.3
F fishing mortality	0.3, 0.6 or 0.9
Selectivity *a*	-8 or -12
Selectivity *b*	0.4
Mean recruitment (log scale)	13
Variance of recruitment (log scale)	0.5
Average age of 0+ when entering model	0.15 year
Average length of 0+ fish (log scale)	6.00 cm (0.12415)
Minimum legal size	30 cm

$$A = e^{-F} \qquad (10)$$

$$A_i = v_i e^{-F}$$

where **F** is the instantaneous fishing mortality, **A** is the annual survivorship after fishing mortality, $\mathbf{v_i}$ is the proportion of size class **i** vulnerable to fishing, and $\mathbf{A_i}$ is the survivorship of size-class **i** after the imposition of fishing mortality *via* the selectivity curve.

Hence, after the imposition of both natural and fishing mortality (in the form of annual survivorship rates), population numbers are defined as:

$$N_{a,i} = \mathbf{T}.N_{a-1,i} S A_i \qquad (11)$$

The number of fish taken from each size-class in each cohort can be found by subtracting equation (11) from equation (8). In this way, the size- and age-structure of the commercial catch can be determined.

Two selectivity curves were used to produce two sets of analyses, which demonstrated the effect of altering fishing behaviour so as to avoid the smaller, unwanted fish (Figure 4).

Analyses

The model was set up using an array of constants for the population parameters used (Table 1).

Prior to imposing any fishing mortality, the model was run for 50 years to generate a non-equilibrium age- and size-structure (Figure 5). After this a fishing mortality rate was imposed which was set at either 0.3, the same as the natural mortality, 0.6, or 0.9 (three times the natural mortality). The population model was then run for 2,000 generations to permit the full range of potential recruitment levels to be expressed.

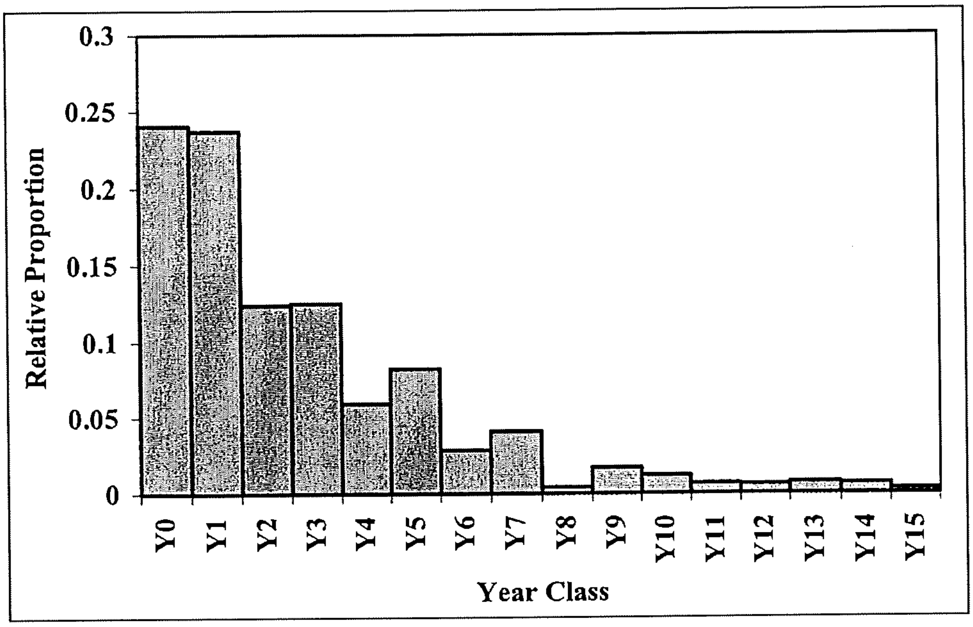

Figure 5. A typical age-structure from the model when ***F*** was set at 0.001 and the population was iterated for 50 years. Note the strong and weak year-classes.

The age-structure of the population changed markedly with the impact of the differing levels of fishing mortality. As expected, the highest fishing mortality gave rise to the least number of active age-classes in the population (Figure 6). Clearly, the reduction in the number of larger animals available when fishing mortality rates are high, automatically leads to higher proportions of the catch being undersized.

An outcome from the model was the ratio by weight of the undersized catch to the legal-sized catch. We were attempting to answer the question of how often the catch by weight of juvenile fish equals or exceeds that of acceptable sized fish.

Despite the range of recruitment built into the model (Figure 1) and the different fishing mortality imposed, there were no occasions in which the weight of juveniles equaled that of adults (Figure 7).

Not surprisingly, the proportion by weight of juvenile fish was higher when high levels of fishing mortality reduced the standing crop of available adult fish to relatively low levels (Figure 7). But even when ***F*** was three times the natural mortality, the highest ratio by weight observed was 1:0.92 (adults:juveniles), and such events were rare (one in 2,000 trials). It thus appears that even with the worst case scenario one would only expect to obtain approximately equal quantities by weight of undersized and retained fish. To obtain greater than landed weight with less than a worst case situation something more extreme is required.

The highest values of the ratio of undersized to legal-sized came about when the total population size was at its smallest through a run of relatively poor recruitment which was followed by a high level of recruitment. This suggested that giving occasional exceptional high recruitment years might lead

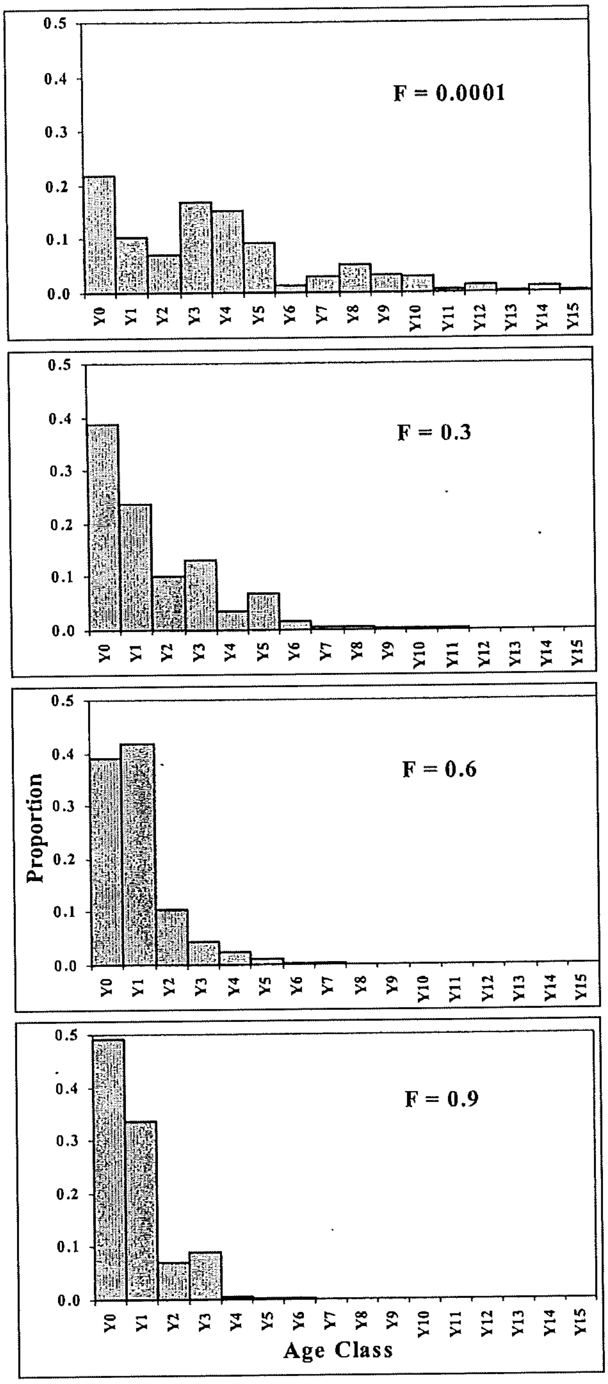

Figure 6. Typical age-structures from the model when *F* was set at different values and the population was iterated for 50 years. Note the strong and weak year-classes. Compare the top panel with Figure 5 to see the effect of variable recruitment. Note the contraction in year classes in the population with increasing *F*.

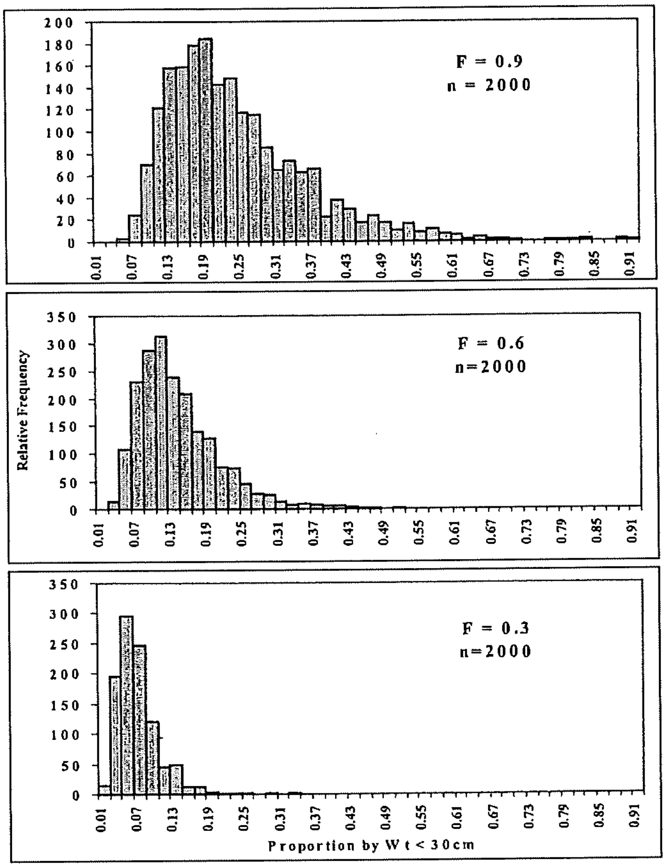

Figure 7. Relative frequencies of the ratio of undersized to retained fish by weight. In all cases M = 0.3. The categories are midpoints of ranges 0.02 (=2%).

to the observed high levels of undersized discarding.

To test this idea, the model was given a particular value of $\boldsymbol{F}$ (0.1, 0.3, 0.6, or 0.9), run for 50 generations, and then a recruitment of 25,000,000 was introduced. Such a recruitment level is two orders of magnitude greater than normal. Only in this exceptional way was it possible to predict the capture of greater weights of juvenile or undersized fish than of legal-sized fish (Table 2; Figure 8).

Discussion

The population model was arranged so that under circumstances of no fishing mortality the population could persist with numbers varying but neither increasing nor decreasing over any long periods. With fishing mortality added, persistence was continued but with the average standing crop of the population reduced by a level dependent upon the severity of the fishing mortality. Under all defined conditions, strong and weak year-classes arose and were able to be followed through time both in terms of their effects on age and size-structure.

Despite this suggesting that the model provides a realistic representation of nature, it remains only a model. Nevertheless, the model provides an indication of the conditions required to

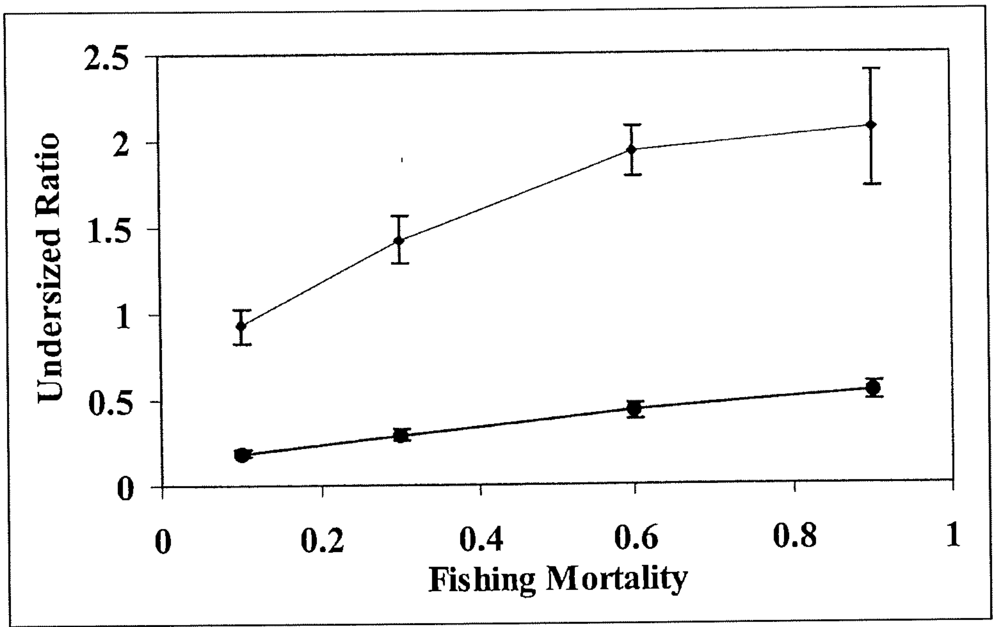

Figure 8. The mean ratios of undersized to retained fish after exceptional recruitment. The top line relates to a selectivity centered on 20 cm fish while the lower line is centred on a selectivity of 30 cm fish.

capture a weight of undersized fish equal to or greater than that retained.

Qualitatively, the results produced were similar despite changing the particular details of the character of individual growth and of natural mortality rates.

The model could easily be developed further: 1) by introducing a relationship between mature stock size and recruitment; 2) improve the method of generating the transition matrix; 3) permit the possibility that individual growth rates will be reduced given high levels of recruitment; 4) permit the implications of changing selectivity to be investigated by making the model multi-species and include species with different selectivity characteristics and catchabilities. Despite these potential modifications, the model in its present state is such that some conclusions can be drawn.

The analysis indicated that under conditions which we can term 'normal' (i.e. those which lead to persistence and long-term stability) there is no way of obtaining very high levels of undersized landings. Certainly, it is the case that using fishing gear that does not select for undersized fish is a simple way of reducing the catch of undersized fish. This was shown to be the case even with exceptional levels of recruitment entering the fishery. But given fishing gear that selected for undersized fish, very exceptional levels of recruitment were required to give rise to a high ratio of undersized to retained fish.

This suggests that the dumping of high levels of undersized fish, when it reaches relatively extreme levels, will not be causing irreparable stock damage because of the implied high recruitment levels. Nevertheless, such dumping is still wasteful of future potential yield. The faster the fish grows the more significant

Table 2. Ratios of undersized fish (<30 cm) to acceptable sized fish. Model run for 50 generations at a particular *F*, and then a recruitment of 25 million was introduced. A ratio of one implies there would be an equal weight of undersized to legal-sized fish. In each case there were 20 replicate runs. Two selectivity curves were used: one centred on 20 cm and the other centred on 30 cm. Numbers in brackets are standard deviations.

Fishing Mortality *F*	Ratio, 20 cm Selectivity	Ratio, 30 cm Selectivity
0.1	0.928(0.104)	0.189(0.018)
0.3	1.424(0.140)	0.291(0.033)
0.6	1.931(0.145)	0.433(0.047)
0.9	2.061(0.336)	0.544(0.052)

this wastage could become. The model demonstrated very clearly that using size-selective gear which avoided catching the undersized fish is a simple way of reducing the wastage of potential future yield. Whether this is a sensible management suggestion would also depend upon what other species are targeted by the gear and what their relative value is compared with the species being dumped.

In conclusion, because extreme dumping of undersized fish only occurs under exceptional circumstances of recruitment, there is no necessity to introduce fishing gear that does not target undersized fish. While this dumping does not seem to constitute a threat to stock integrity, it does represent a high level of wastage of potential future yield. This yield can only become available for capture or for increasing the spawning stock size by introducing more selective fishing gear.

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Discussion of Session 2

Chaired by Murray Johns

Department of Primary Industry and Energy
Canberra ACT 2600

Recorded by Kerry Truelove and Aubrey Harris

Department of Primary Industry and Energy
Canberra ACT 2600

Murray Johns thanked the workshop convenor and recalled that papers heard in the morning sessions reminded all of the extent of the problem. There were numerous photos of bycatch and sometimes it was difficult to spot the prawns especially with ratios of up to 20:1 bycatch to the target species.

Following the presentation by *Aubrey Harris,* Malcolm Haddon (TAFI) noted that management had only recently started taking into account discards as had been defined today. He asked if it was a realistic expectation for any work to be done on other sources of mortality. Included were unobserved mortality during escape from nets and subsequent death of live discards.

Aubrey Harris replied that there had already been work done in Australia and elsewhere on unobserved mortality. For example, there had been work on the mortality due to lost gear in the South East Fishery and the mortality of fish escaping through prawn trawl nets in the Northern Prawn Fishery. It would be addressed depending on the priorities and issues in particular fisheries. He had been in an international technical consultation two years previously where unobserved mortality was raised as an important bycatch issue by Frank Chopin, previously of the Australian Maritime College. Frank knew of several fisheries where the extent of unobserved mortality could be as high as the observed mortality. Aubrey considered that unobserved mortality was an issue and it had to be dealt with.

Lindsay Joll (Western Australian Fisheries) mentioned that Aubrey hadn't touched on what he called the psychology of bycatch, that is, it seemed to be okay if something moved from a discard to an incidental catch. There seemed to be a belief that a dead fish that was eaten was better than a dead fish that was thrown over the side.

Aubrey thought that this was an interesting point. He agreed that it was better to eat a dead fish than to discard it.

Murray MacDonald (Fisheries Victoria) stated that we seemed to be restructuring the English language in order to suit the whims of politicians and bureaucrats. Surely the word "catch" meant what it said: the fish that were taken, whether discarded or kept. The other undefined mortality was fish that weren't caught, but which died as a result of things such as ecosystem changes – and which had nothing to do with catch. We should, surely, retain standard English definitions and if we wanted to refer to these other sources of mortality then we should find some other definition for them.

Aubrey Harris clarified that the unobserved mortality related to the fishing effect of the gear on the animal. From the definitions of bycatch adopted by the OECD, the National Marine and Fisheries Service, and the FAO there were clearly general concerns that had led to the inclusion of this component of mortality as bycatch. The broadening definition was a sign of the times and the concerns.

In response to *Ilona Stobutzki*'s paper, Bruce Wallner (AFMA), acting as a devil's advocate, asked whether we should spend a lot of money doing this sort of species response work, or should we take a different tack and convince the Australian public that fishing was like wheat farming, with consequences that have to be accepted as part of this primary industry.

Ilona Stobutzki said that she wasn't sure that the public would be convinced and it could be costly for industry to depend on this approach. With the approach taken in the NPF, she thought there was a lot better chance of convincing the community there are some species that can sustain fishing and that the situation was not as bad as reflected on TV or on emotively graphic slides. On balance it was not as bad as it looks.

Bruce Wallner said that his concern as a manager was that once the path of cataloguing species responses was started, it may be seen as unsatisfactory to demonstrate that some species are sustainable. There would always be the argument that unless you've catalogued everything there will be some species that really aren't sustainable.

Ilona Stobutzki agreed with this.

Ian Poiner clarified that the approach presented by Ilona takes care of the management fears. He agreed that it would not be possible to determine the sustainability of some 500 species based on a traditional fisheries approach. What had been presented was a way of examining the status of particular species such as turtles or sea snakes, and whether they really had a sustainability problem. He didn't think that the wheatfield approach would be accepted especially in the face of some species, for example loggerhead turtles, going along the path of severe depletion.

On a technical question of the presentation, Bob Miller (AFMA) wanted to know if the depletion rate was based on a pre-survey study of the abundance of the flora on the seabed, on the biota on the bottom or if it was it a relative decline in the numbers of observable bycatch. Ian Poiner clarified that it was based on monitoring with a range of sampling devices from fish trawls, prawn trawls, dredges, videos, drop cameras and acoustics. So, there was a range of sampling data that allowed the measurement of real mortality of even those species not retained as bycatch. One of the issues that had to be taken into consideration is that a prawn trawler is a very inefficient sampler of most of these benthic species.

Duncan Leadbitter (Ocean Watch) commented that where the boundaries were drawn in a managed area is important and wanted to know if Illona had overlaid the IMCRA bioregions on the area investigated.

Ilona Stobutzki agreed with this. Her recent examination of the IMCRA bioregions in the

NPF indicated that the smallest bioregion had the highest proportion of trawling at 60% of the area. Areas with the highest effort were about 40% and there were bioregions that weren't trawled at all. At a bioregion level, she thought none seemed heavily impacted, though she reserved judgement on this.

Colin Buxton (TAFI) wanted to know if there was any correlation between the catch of prawns and the degradation of habitat. Were fishing effects working in concert with habitat effects?

Ian Poiner (CSIRO Marine Research) responded that in the NPF fishery, one could argue that despite some concerns about current levels of effort, it had been sustainable as a fishery for 20 or 30 years. What was currently coming out of some of the work looking at the fine scale distribution of effort in relation to bottom habitats were some interesting patterns of areas that were unfished for a variety of reasons. Adjoining heavily-fished areas have high catch rates so there is a likely habitat relationship in the fine scale distribution of effort which had been found to be much more aggregated than previously thought.

After the presentation by *Paul McShane,* Colin Buxton (TAFI) wanted to know what effect prawn trawling had on seagrass, since it was important as a primary source of carbon, and there was an implication in Paul's talk that the discards would effectively substitute for a loss of seagrass.

Paul McShane replied that there was no direct effect on seagrass, and prawn trawling didn't occur near seagrass beds, at least to the extent that it caused physical damage. He had considered seagrasses merely because they might be the primary drivers of the whole system. In that case, processes that are detrimental to seagrass – such as land runoff, pollution, land management activities – would flow through and have a negative effect on the prawn industry. Establishing these ecological linkages would allow us to start to understand what sort of human perturbation influenced the ecosystem. The attention has tended to concentrate on the prawn trawling activity itself, rather than realising that prawn trawling activity occurs in an ecosystem subject to fairly profound land-based activities, which would influence the activities and the health of those fisheries.

Ian Poiner wanted to know if Paul had considered whether the discard material was going to have much of a trophic influence on the system given the relative low levels of bycatch, square mesh codends which would halve the discards leaving about 2,000 tonnes of which a fair bit would consist of crabs that survive. Even in the very high bycatch areas of northern Australia, the amount of material that actually gets to the bottom is in the order of grams per metre square per year.

Paul McShane didn't think that the discard levels would modify the fluxes very much but the environmental performance of South Australian prawn fisheries was not the particular concern. The reverse was the case since he was quite excited about promoting the management practices that currently apply in that fishery. He thought the opportunity existed to actually get to grips experimentally with some of these processes because of the physiography of Spencer Gulf. An option would be to exaggerate the signal so that it could be measured in relation to the natural perturbations in that system, providing an opportunity of a natural laboratory to get a better understanding of the system and perhaps other ecosystems with similar sorts of fisheries. He considered it fair to say that we've got a very, very poor understanding of the trophic consequences of prawn trawling, or indeed any prawn or trawl activity. There was a need to get to make more informed judgements and comments about the influence of commercial fishing in relation to the marine environments of Australia.

Aubrey Harris (BRS) was interested in Paul's comment that the discards went directly to meiofauna, and eventually to the prawns, and his reference to Gulf of Mexico studies. Studies undertaken in northern Australia showed that prawn trawl discards were quickly eaten by scavengers instead of going to meiobenthos. The ecosystem model used by Browder in the Gulf of Mexico had not been based on a study of the fate of the discards as undertaken in Australia. Were there particular considerations present in the Gulf of Spencer that would suggest this more direct path or was it based on the discard literature?

Paul replied that there weren't, but that he was looking at broadening the focus to include other trophic linkages in the system. If discards were eaten by crabs or other scavengers, then that was an obvious fate. He was also interested in those other animals that rotted, were degraded, or were stirred up by trawling and what effect these had on existing pathways such as the carbon pathway through seagrasses that provides material ending as food for prawns, or fish, or crabs. Though it's likely that this signal may be relatively low compared with other activities that drive the system, the significance of its effect still has to be established in South Australia.

Thanking *Malcolm Haddon* for his talk, the chairperson suggested that one conclusion coming out of the talk was the need for more research.

Patrick Houghton (MAFRI) drew Malcolm's attention away from modelling and remarked that a difficulty was the perception that the bycatch problem was greatest in years with large recruitment effects. In the King George whiting fishery in Port Phillip Bay, where they had only four year classes in the fishery, when a big pulse of one-plus fish was caught as a bycatch, it was very visible and created much negative publicity. Public perception was perhaps an area that needed to be addressed in big recruitment years, rather than stock assessment.

Malcolm Haddon agreed that public perception needed to be addressed and that was what stimulated him to look at this particular obvious issue for the blue grenadier. There was need for a public relations exercise to demonstrate that the loss was just a few grains by the side of the road compared with what was really out there. That was hard to do and technical modelling was not the only way but it could be a positive and scientific way of assisting the public come to that conclusion.

Elkana Ngwenya (Australian Maritime College) pointed out that, as with the African elephant, there may come a time when recruitment levels of protected species are very high and a form of culling might be necessary. He asked whether public opinion would ever accept such a scenario.

Malcolm Haddon admitted he had avoided the problem in his modelling by focussing on juveniles and noted that, even when recruitment was smaller, bycatch didn't seem to have an effect in the model. He noted that a species like the Irish skate in the Irish Sea, which was a bycatch species in a fishery targeting short-lived, rapidly-growing flatfish, appeared to have gone extinct.

Marc Wilson (Australian Maritime College) suggested that perhaps one aspect that could be changed in the model would be to look at differences in the catchability of juveniles.

Malcolm responded that he could certainly force his model to become significant by changing such assumptions but whether it would be plausible was another matter.

Ian Knuckey (MAFRI) highlighted the density dependence aspect of the model in view of huge recruitment events.

Malcolm considered this a good point and remarked that he had taken a very conservative view. Normally fishing mortality was greater in the older age classes, and density dependent effects on growth rates of large groups, smaller. Despite trying hard to say it was bad, he couldn't get a bad answer. It seemed the little fishes were good at responding in the way needed to recover.

Session 3

What are the obstacles to establishing bycatch targets in Australian fisheries?

Chairperson: Paul McShane

Speakers: Darryl McPhee
Duncan Leadbitter

Panelists: Barry Evans
Duncan Leadbitter
Murray Johns
Steve Eayrs
Julie Robins
Darryl McPhee

Rapporteur: Martin Smallridge

Bycatch: the Queensland fishing industry's perspective

Darryl P. McPhee and Ted D. Loveday

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Abstract

The Queensland fishing industry asserts that there are three key factors that need to be addressed when dealing with bycatch issues. Firstly, the bycatch 'problem' must be clearly defined. Secondly, solutions to defined problems must be sought cooperatively between the industry, government agencies, and pragmatic conservation groups. Thirdly, solutions to defined problems must be clearly communicated to the industry. Commonsense needs to be applied by enforcement officers and fisheries management agencies during the development phase of gear modifications aimed at solving bycatch issues.

Introduction

The Queensland commercial fishery is very diverse. The amounts and types of bycatch and the degree to which bycatch is considered a problem varies between fisheries. There are large multi-species prawn trawl fisheries, net fisheries (including haul nets, ring nets, general purpose nets, various set nets, and tunnel nets), crab fisheries which use pots to catch various crab species, line fisheries which harvest a wide range of reef fish, and harvest fisheries for a range of animals including bloodworms, yabbies, trochus, rock lobster, aquarium fish, and *bêchedemer.* In this paper we discuss:

1. The need to clearly define the bycatch problem.
2. The need to cooperatively seek solutions to the defined problem.
3. The Endangered and Threatened Species Awareness Course.
4. The need to remove legislative impediments to developing and trialing solutions.
5. The role of conservation groups.

The need to clearly define the bycatch problem

Simply stating to the industry that bycatch is a 'problem' is not sufficient. The Queensland fishing industry no longer takes the word of a scientist, environmentalist, or manager on face value. Rather, it examines in detail the science behind key management decisions, judges management decisions on how they address the defined problem and how they meet the objectives and principles of ecologically sustainable development (ESD).

A bycatch problem must be clearly defined. Resource sustainability and biodiversity concerns are valid. Social concerns are valid, and there are other legitimate concerns. How a problem is defined strongly influences the approach chosen in seeking its solution (Frazer 1992). If the problem is sustainability of a particular bycatch species (e.g. loggerhead turtles – *Caretta caretta*) then possible ways to solve it include modifications to gear or area closures. If the problem is a social one, for example of discarded fish washing up on beaches, a potential solution is development of new markets for the currently unwanted bycatch species.

The need to cooperatively seek solutions to the defined problem

Solutions to bycatch issues are likely to emerge with cooperation between the fishing industry, government agencies and pragmatic conservation groups. With this in mind it is interesting to compare what has unfolded in Queensland with respect to minimising the impact of prawn trawling on marine turtles and minimising the impact of mesh netting on dugong.

Minimising the impact of trawling on marine turtles through development and trialing of turtle exclusion devices (TEDs) has been approached cooperatively with several government agencies and the fishing industry involved. The project, we believe, is a success. A growing number of fishers are trialing and using TEDs ahead of their mandatory use in areas of high interaction between marine turtles and trawling. A major reason for success of the project is that it has been successful in getting solutions out of the textbooks and into the water. Fishermen have been provided with easy-to-understand information on TEDs and a range of people whom they can contact for further help on issues. Additionally, a brochure developed by Queensland Commercial Fishermen's Organisation (QCFO) with the aid of government agencies, also highlights in simple diagrams the correct techniques to maximise survival rates of any captured marine turtles.

The success of the program for the development and trialing of TEDs in Queensland contrasts markedly with the situation experienced in the United States. Attempts to negotiate and mediate a solution to the interaction between trawling and marine turtles in the United States broke down, resulting in escalating conflict and litigation (Margavio *et al.* 1993; Moberg and Dyer 1994; Tucker *et al.* 1997).

Unfortunately, several of the mistakes made in the United States in attempting to mitigate the interaction between marine turtles and trawling were made in Queensland with respect to the interaction between dugong and mesh nets. The mistakes included a lack of recognition of social and economic factors in decision making, and emotive and unsubstantiated claims by some conservation groups.

Initially, the Commonwealth Government announced a mesh netting ban for the protection of dugong that would have put 400 fishers out of work without compensation. The economic impact, social dislocation, and the potential for translocation of fishing effort were not fully considered before this initial decision was made. Additionally, many of the nets proposed to be banned, such as light ply nets used in shallow water to catch species such as whiting (*Sillago* spp.) and mullet (*Mugil cephalus*), posed no risk to dugong. Had a well considered compensation package been put on the table initially, together with an attempt to modify or prohibit the use of only nets that were a potential risk to dugong, the conflict between the commercial fishing industry, conservationists and the Commonwealth Government would have been greatly mitigated. The issue was only resolved after the establishment of the independently chaired Dugong Protected Areas Advisory Group that reviewed technical issues regarding netting and the biology of dugong, as well as economic factors.

The Endangered and Threatened Species Awareness Course

The QCFO in conjunction with biologists developed a nationally accredited Endangered and Threatened Species Awareness Course. The course was part-funded by Coastcare. The course is a module for trainee master fishers. Additionally, courses have been conducted throughout the State for existing master fishers and over 300 fishers have attended. The two-day course involves teaching fishers to use a simple but effective key to identify the species of marine turtles, marine turtle resuscitation techniques, and the life history and general biology of marine turtles, cetaceans and dugongs. The course also provided explanations and highlights the significance of legislation, treaties and conventions such as CITES, the United Nations Convention on the Law of the Sea, the Commonwealth Endangered Species Protection Act, and the Queensland Nature Conservation Act.

There are several positive outcomes from the course. Firstly, while the level of interaction between individual trawl fishers and marine turtles is generally low, the course highlights that even low mortality levels from incidental capture may cause population declines. An issue with the United States trawl-marine turtle conflict was that individual fishers did not associate their trawling activities with declining marine turtle populations (Tucker *et al.* 1997). Secondly, the overview of relevant legislation, treaties and conventions provided in the course allows fishers to understand their environmental obligations. Importantly, fishers can begin to understand that there are significant global pressures on fisheries to minimise or eliminate mortality of endangered or threatened species. Thirdly, improving the ability of fishers to identify specific marine turtle and dolphin species may have significant benefits for the monitoring of these species in the future.

The need to remove legislative impediments to developing and trialing solutions

Fishermen are often happy to voluntarily modify their gear to try to minimise bycatch. However, the prescriptive nature of regulations often does not lend itself to experimentation to solve problems. For example, a recommendation of the Draft Recovery Plan for Marine Turtles is to develop ways to minimise the entanglement of marine turtles in crab pot ropes. Fishermen were happy to trial alternative methods of setting crab pots before the release of the plan. However, enforcement officers actually attempted to prosecute fishers for their efforts because their crab pots were not set in the manner prescribed in the current *Fisheries Regulations 1995.* A similar situation occurred with fishers trialing bycatch reduction devices in the tunnel net fishery. These issues were resolved, but they draw attention to the need to align all stakeholders in addressing conservation issues.

The role of conservation groups

There are many issues upon which the majority of conservation groups and commercial fishers agree, including concerns about habitat degradation, water quality and the importance of environmental flows. With respect to bycatch issues, pragmatic conservation groups can act as effective watch dogs, ensuring the industry is actually making positive steps to solving problems rather than just paying lip service to them. Representatives from conservation groups are invited to participate on Management Advisory Committees (MACs) and Zonal Advisory Committees (ZACs) which are administered by the Queensland Fisheries Management Authority. The committees are the principal forums for discussion of fisheries management issues in Queensland. The input of conservation groups into these committees has and will continue to be extremely valuable.

Conclusion

Bycatch issues must be clearly defined. Solutions to defined problems must be sought cooperatively between the industry, government agencies and pragmatic conservation groups. Solutions to bycatch issues must be clearly communicated to the industry. Commonsense needs to be applied by enforcement officers and fisheries management agencies during the development phase of gear modifications aimed at solving bycatch issues.

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Regarding bycatch – an industry point of view

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One can't ignore the many tonnes of incidental catch that is wasted whilst in the operation of prawn trawling.

However, all prawn fisheries should not be looked upon as having equally the same amount of bycatch, and all blatantly labelled as rapists of the sea. Each fishery should individually educate the public about their work practices – some being favourable and others with room for improvement. Once these areas of concern are defined, achievable targets can be set to improve work practices for the future. When any goals are met the public should be made fully aware of progress. All of this must be done with equal representation and full cooperation of scientists, biologists, policy makers, government and especially stakeholders in the industry.

As for Spencer Gulf in South Australia, this fishery is quite unique when comparing its bycatch ratio to any other prawn fishery in the world. With a bycatch to prawn ratio of 0.54:1, it is very low compared with others of about 8:1 and up to 22:1. Also by having short shots (av. 50 min) in relatively shallow depths (av. 22 metres) the survival rate of bycatch is increased. With the majority of bycatch being blue swimmer crabs, BRDs have been trialed (to reduce the damage done to prawns by crabs in trawl) with the help of the National Marine Fisheries Service from the United States. Initial tests have resulted in a loss of prawn catch, suggesting that to recover the loss, more trawling time would be required to maintain present catches. This would certainly do more damage to the benthos than is done now. Further tests are to be carried out. With the way crabs are handled today, research has shown that they have a survival rate of 95%. These crabs are returned to the sea very quickly, with the use of crab bags (a larger mesh bag inside coend) which separates the majority of prawns from the crabs into the coend. After this, the prawns are emptied from the coend onto the sorting table and the crabs are emptied from the crab bag onto a mesh grid. The few remaining prawns, amongst the crabs, then fall through the correctly spaced bars onto the sorting table, with the crabs staying on top of the grid. This allows the grid to be inclined, so the crabs can fall back over the side or stern of the vessel, unharmed. This work practice, coupled with a proven harvesting strategy that allows on average only 75 nights per year and trawling on only 15% of the entire Gulf, demonstrates that this fishery has relatively low impact on the ecosystem.

With such long periods for seasonal closures when no trawling occurs the Gulf is able to regenerate. Over a 30-year period this fishery, showing its annual catch is constant and that it is caught in the same areas each year, suggests that it is very sustainable. It also suggests that damage to the benthos should be minimal. In terms of determining the effect of trawling on the benthos and unobserved mortality, it indicates that if the target species is maintaining its level then the bottom habitat is recovering sufficiently to support not only that species but the whole benthic community as well.

If programs are set up to monitor all species present in the fishery, and show that their populations are constant annually, it should indicate that the present levels of bycatch are acceptable and that the benthos is also in a healthy state.

The public perception of bycatch must be addressed by educating the masses before any real long-term meaningful outcome can be met.

An environmental view of bycatch

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Abstract

The nature and scope of interest in bycatch has changed in recent years due to the widening of the range of stakeholders in fisheries management. In years gone by bycatch was an issue for the commercial sector (due to competition between fisheries), for the recreational sector (concerned about the size and composition of the commercial catch) and fishery managers. The involvement of environmental and other public interest groups has elevated the priority of bycatch issues and also broadened the role of fishery managers, who are now expected in some quarters to be ecosystem managers rather than harvest managers. As such, for those involved in the ecologically sustainable development (ESD) debate in 1990/91 it would appear that the recommendations of the Fisheries Working Group are being implemented. The public exposure, via the media, of bycatch issues is as much a result of the effectiveness of environment groups at making such issues public as the well-established public interest in environmental matters in general. Such public exposure generates political action but the solutions can be variable in terms of whether they further ESD. The perspectives, skills and objectives of environmental groups are as diverse as those of any other sector with an interest in fisheries management. Moreover, there are clear overlaps between the views of many groups and the views of other stakeholders. Environmentalists can have both positive and negative effects on the implementation of ESD. Some positive results are a greater focus on marine wildlife protection. Some negative results can arise from the blanket use of the precautionary principle. What is unfortunate is that the whole bycatch issue is focussed very much on the commercial sector. Issues such as wildlife interactions, discards and the take of juvenile fish are also relevant for the recreational sector. Moreover, there are few if any management advisory committees (MACs) in existence for recreational fisheries and thus few opportunities for environmentalists to exercise their pursuit of holistic approaches to fisheries ecosystem management.

It took me many attempts to put this paper together. I got hung-up on trying to define what an environmental point of view was. I accepted that fisheries management is now just one arm of environmental management and therefore a fisheries issue is also an environmental issue. I further got caught in the trap of accepting that everyone has a legitimate point of view on the environment. I quickly worked my way into a blind alleyway that said there was not really such a thing as an environmental view of bycatch.

However, anyone involved in the fisheries management world knows full well that people espousing 'an environmental view' have influenced policy and legislation and now have formal seats at management tables. What are they saying and could it be used to define just what is 'an environmental point of view'? More importantly, how do environmentalists contribute to fisheries management and how can managers and scientists make use of their skills and commitment?

Just what is an 'environmental point of view'?

In short the views of environmentalists can be summarised as:

- there is a need to exercise more caution when determining harvest strategies;
- there is a need to ensure that species that are not of direct economic interest get a fairer go; and
- there is a need to ensure that those with an interest in the marine environment that is not related to the taking of animals or plants have a fair say.

Not surprisingly such broad statements cover a huge number of exceptions and interpretations. For those thinking "Well, I think those things" you can understand how I got caught in the loop of saying "We're all environmentalists now". For those who didn't, the rapidly changing world of fisheries management and public perceptions about fishing, fisheries management and the environment is leaving you behind.

Demands for greater caution are not unique to environmentalists. Everyone here could think of an example where managers and/or fishers have called for a halt in some aspect of resource allocation, for example the issuing of new licences. However, on balance it would be fair to say that many of the world's fisheries problems have not been caused by an excessive commitment to caution.

Environmentalists believe that being advocates for caution is not only essential for the future of the fisheries but a defining aspect for what constitutes an environmental view of fisheries. As with all debates where there are no clear answers, the question of what the right balance of caution and use is remains a fertile field for discussion.

Turning to the issue of giving a fair go to species that are not of direct economic interest, many environmentalists believe that there has been insufficient attention paid to this matter. Furthermore, they contend that loss or decline of some species has been tacitly accepted by many in the fisheries world as the cost of doing business.

Whilst this may be true in many circumstances it is true that there are many cases where fishers and fisheries scientists/managers have acted on concerns over bycatch. For fishers, many of these concerns have their roots in allocation disputes such as the ongoing complaints from anglers about prawn trawling impacts on juvenile fish, many species of which are valued angling species.

Speaking up for those species for which there is no economic value is another defining aspect of what constitutes an environmental point of view in the fisheries arena. Concerns over such species are more widely held than just by environmentalists. Most of the information on the plight of such species, or concerns over the modification of aquatic ecosystems caused by fishing, comes from scientific research. However, scientists are not campaigners and change is generally slower in the absence of active campaigning.

Where are these views coming from?

As I've said, there is a huge range of points of view on the environment, even within the ranks of those who call themselves environmentalists. In a book entitled *The Roots of Modern Environmentalism,* Pepper (1989) provides a comprehensive analysis of the diversity of environmental points of view.

Pepper describes how those environmentalists generally labelled as extremists have beliefs that modern society is off on the wrong path with respect to resource use and other aspects of society. Called Deep Ecologists they call for new approaches to economic activity and social relationships and a new relationship with nature. In short they seek the 'simple life' which emphasises an almost pantheistic relationship with the natural environment. At the other end of the scale are those who believe that whatever hole humanity finds itself in, a solution will be devised.

Between these two extremes can be found a comfortable spot for just about everybody here, but I'd guess most here would consider themselves resource stewards. This camp recognises that humans have almost complete dominion over nature and thus have responsibility for ensuring its wise use.

Pepper also describes the environmental perspectives of the various religions, Marxists and free marketeers. It's clear that there are many paths to enlightenment but whether those paths lead to the same point is yet to be seen!

Without repeating all of Pepper's book the point I wish to make is that the perspective of those who propound an 'environmental point of view' is as diverse as the views of fishers or, indeed, fisheries scientists and managers. The main thing to remember is to ensure that they come from an organisation that the peak non-government, environment bodies feel comfortable with.

Why are these views treated with suspicion?

Why is it, then, that the involvement of environmentalists has been greeted with much suspicion by the more traditional participants in the fisheries world? I think there are a number of answers to this.

Firstly, the public profile given to 'environmental' points of view generally focusses on the contributions of extremists. This contrasts with the fact that the perspectives of environment groups on many issues cover a range of points of view. Extremists can be found in all areas of fisheries management but, in the eyes of the public, environmentalists have more legitimacy as they are perceived to not have an economic stake in the decision making.

Secondly, environmentalists are generally good campaigners, making up for their lack of economic clout by utilising the high media profile of environmental issues in general to shed light on government and industry inaction. Such exposure causes embarrassment and the response of many to such embarrassment is to shut the door.

Thirdly, environmentalists are strong advocates of the non-consumption of fisheries resources, at least in some areas. Whereas protected areas have been used for many years to protect sensitive stocks or life stages or to solve allocation disputes the wider use of such areas and the fact that fisheries agencies may lose jurisdiction to nature conservation agencies is a source of friction.

What are the benefits of an involvement by environmentalists in fisheries management?

Whereas the extremists get the limelight the fact is that there is an increasing number of environmentalists who contribute in a thoughtful and constructive way to fisheries management. A number have direct fisheries management experience, either with government, scientific bodies and even industry.

Having such people contributing to fisheries management helps keep the focus on sustainability and ensures that the concept of ecosystem management remains on the agenda. Moreover, such an involvement ensures that issues not of direct financial imperative are addressed in a timely manner.

In the particular case of bycatch, environmentalists can provide a perspective on the need to manage resource use in a way that ensures that components of the marine environment that have no economic value (either currently or in the future) are protected.

What impact has an environmental point of view had on fisheries management?

Earlier I said that the changes to fisheries management and public perception may be leaving some behind. The past 10 years has seen a revolution in the legislative and public policy approaches to fisheries management.

In 1991 the government and scientific, industry, environmental and non-governmental organisations (NGO) participants in the ESD process recommended that fisheries management should be conducted "in an ecosystem framework". Leaving aside the practical difficulties of making this happen there was at least an acknowledgment that the 'traditional' approach to fisheries management, that is, relying on the determination of single species exploitation rates, had its flaws.

This agreement has been reflected in many fisheries acts, almost all of which have undergone major rewrites in the past five or six years. The management imperatives in such legislation are much broader than they were 20 years ago.

Moreover, there has been a huge upsurge in government activity on marine management especially in regard to marine parks and the involvement of non-resource users. Like it or not, non-traditional views on the use of marine resources are being listened to more than ever before. Not only do such views come from more than just environmentalists but the ears of those listening are not confined to fisheries agencies.

The view that fisheries agencies are too close to industry, and that there should be an agency that is not so close looking over the shoulders of fisheries managers, is a strong one. One only has to look at the changes in water and forest management, at least in New South Wales, to see how this separation of regulator and operator philosophy has implications for fisheries management. Some environmentalists see fisheries managers as being answerable to nature conservation managers on more issues than just wildlife and protected areas. The flip side is that 'arms length' environmental managers rarely seem to have a full understanding of the industry they are regulating and, as such, the potential benefits of co-management are lost.

Some final comments

Adding balance to debates over the use of fisheries resources, especially in the area of bycatch management, is a major benefit of having environmentalists involved in the fisheries management process. There is rarely any simple answer to many of the questions surrounding the acceptability of the inevitable impact of human resource use. It is therefore important to ensure that decisions made are derived from discussions involving a variety of points of view.

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Caveat

Ocean Watch is a non-profit organisation funded by the NSW commercial fishing industry. Traditional environmental groups do not consider it an environmental group.

Ocean Watch has worked on many environmental issues in concert with environmental groups since its inception in 1989. In the majority of cases our views and actions with respect to pollution and the loss of fish habitats such as wetlands are no different from those of any other environmental group.

The views expressed in this presentation are mine, gained from having nearly 15 years involvement in marine environmental management. I do not purport to provide the views of those who consider themselves environmentalists. Neither do I provide an 'industry' view.

Discussion of Session 3

Chaired and recorded by Paul McShane

SARDI Aquatic Sciences
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Present Address: Faculty of Fisheries and the Marine Environment
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Following the presentation by *Darryl McPhee,* James Scandol (FRI Quantitative Training Unit for Fisheries) asked what opportunity industry saw to add value to product by reducing bycatch and accordingly altering their marketing strategy?

Darryl McPhee replied that they saw a lot of opportunity, for example, in the development of a fishery for live (export) product where there is a need to avoid juveniles of target species and to get as clean a catch as possible to increase its value. In prawn fisheries, catches taken with TEDS or BRDs are cleaner. They don't have turtles flopped on them to become instant prawn cutlets. These are positive benefits to reducing bycatch.

After *Duncan Leadbitter*'s presentation Marc Wilson (AMC) said he was interested in the comments concerning the perception that fisheries agencies might be seen as being too close to the problem by some of the environmentalists. He asked how this would be resolved particularly in the light of further comments that one needed to get closer to the fishing industry to address some of these problems.

Duncan Leadbitter replied that he did not have a solution to that dilemma. Looking at how forestry and water management have been going, there is certainly a separation of what is called regulator and operator philosophy. Policy is written by an agency or body completely separated from the resource management agency. The latter operates within that policy framework and then relates to industry. You could then become quite close to industry and work that way, but whether fisheries agencies are comfortable with having policy written by a separate body is something that they will have to confront in the future. There are probably some areas where that is already happening. If one looks at how the Endangered Species Act operates and the way trade and wildlife legislation works, there is a separate body overlooking how things operate. How that gets played out in the future depends on how comfortable agencies and the stakeholders feel about yet another change. From industry's perspective, having yet another signature on final 'ye's or 'no' adds cost and becomes another bureaucratic minefield. Whether it adds value to the protection of the marine environment and the sustainability of the industry, he really didn't know.

Ian Poiner (CSIRO Marine Research) said he didn't think anyone would disagree about the role of other stakeholders, particularly environmental stakeholders from both the environmental groups and the environmental management agencies, becoming part of fisheries management. The model seems to be the Management Advisory Committee model with an environmental agency represented on the MAC. He asked whether this was seen as an effective model and why? Also, were there any other terrestrial examples that were better or more effective?

Duncan Leadbitter replied that having other stakeholders on the MACs was a good thing. There is a better understanding of different points of view. In some respects the MAC model is ahead of what is going on in the water reform, which is only in the process of approving the establishment of multi-stakeholder management committees. It seems to be the model that people have faith in.

Session 3 panel discussion – What are the obstacles to establishing bycatch targets in Australian fisheries?

Chaired and recorded by Paul McShane

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Introduction

The topic chosen for the panel discussion session is a provocative issue: Is it realistic to impose bycatch reduction targets in Australian fisheries? The panelists have been chosen as representing various stakeholder interests including industry, management and research. Each is likely to have different perspectives relating to bycatch targets.

There are formidable difficulties confronting those seeking to apply or enforce bycatch reduction targets. For example, Geoff Liggins drew attention to the variation in abundance of species in the South East Trawl Fishery. Interannual variation in the relative abundance of bycatch species can affect realistic interpretation of bycatch targets. Dennis Heinemann's presentation on seabirds demonstrated how difficult it is to have the resources to measure or quantify bycatch. How realistic is it to impose targets and how do they relate to management objectives? These are challenging issues, ones that do not offer easy solutions. The panellists will address these issues in a synoptic overview from their perspective.

The panellists have a prawn industry bias because prawn industries offer that mix of scientific input specifically related to the development of BRDs. Through researchers and industry working together there has been considerable attention to the mitigation, avoidance, or reduction of bycatch in Australian prawn fisheries. The nexus of management, conservation, public perception and science is exemplified in the bycatch reduction research currently undertaken in prawn fisheries.

A brief synopsis of perspectives

Barry Evans – commercial operator in the Spencer Gulf prawn fishery in South Australia. He is President of the Spencer Gulf and West Coast Prawn Fishermen's Association and Director of the South Australian Seafood Industry Council.

The Spencer Gulf prawn industry has been active in improving its work practices for some time. Current fishing practices result in some of the lowest bycatch of any prawn fishery. Recognising a public perception problem, the South Australian prawn industry has embarked on a promotion campaign with a brochure promoting environmentally favourable work practices. Feedback from the public has been great and positive. It is important that the public understand how prawn fisheries work in South Australia. Based on the western king prawn, our fishery operates for only 70-75 nights of the year, fishing a relatively small area of Spencer Gulf. The fishery is able to efficiently target aggregations of large prawns because of the close relationship with researchers involved in population surveys of prawns. Impact in terms of bycatch is minimal.

There are some problems with blue crabs because they can damage prawns. Furthermore, there is a commercial fishery for blue crabs and the prawn fishery is keen to avoid unfavourable interactions. Recently, the prawn industry has been involved with US scientists from the National Marine Fisheries Service in an attempt to reduce catches of blue crabs. This research is aimed at reducing crabs in the catch.

There are only 39 vessels operating in Spencer Gulf. Studies have shown that crabs caught survive. Equipment used on three or four of our prawn trawlers automatically sorted the bycatch with no handling. This is a good practice. Trawlers do not operate in waters where seagrasses are found (<10 m depth). Prawn trawling does not therefore have an effect on seagrass.

We have also developed a relationship between conservationists and fishers through the South Australian Prawn Industry Committee and associated projects with the Conservation Council. They have been happy to cooperate and participate in this process.

Duncan Leadbitter – Executive Director of Ocean Watch Australia, an environmental advisory body to the commercial fishing industry and program manager for SeaNet, an environmental extension service for the commercial fishing industry.

I'd like to add a few different perspectives. Firstly, there are some legislative drivers for having indicators of performance as part of state-of-the-environment processes at the national level and I think in most States. State-of-the-environment reports are produced every two to three years. There is a compelling demand for quantitative indicators in a large number of areas of human activity, of which fisheries is one. The hard work will be for fisheries – developing indicators, setting goals and evaluating them.

Secondly, all stakeholders would like to know whether the right thing has been done and, if successful, to move on to something else or, if not, to recognise that there is more work to be done.

There are conceptual problems in working out what indicators are, and how to do it. We can look at other industries and other resource users to see how these are devised and to use them as moving targets.

For example, in NSW in relation to pollution discharge, an industry is required to sign a pollution reduction program agreement. Rather than solve all problems immediately, they set a series of rolling targets. Negotiations occur between industry and government but unfortunately these are not generally open to public scrutiny.

The third thing that needs to be recognised is the issue of setting up baselines. For example, in South Australia a 90% reduction in bycatch has little meaning when they are already achieving impressive results. What is the baseline? It is important to agree on targets. The MAC process may be one way of approaching this. Stakeholders have a good understanding of the process and the capacity for change.

Lastly, in some cases it may not be possible to have a numerical target. A principle of continuous improvement as seen in other industries may be a more achievable goal. Researching every aspect of the particular problem at hand might be too expensive and the best thing to do is implement some generally agreed change. So in the prawn industry, BRDs are being used even though all aspects haven't been fully researched in all parts of the industry. This is a practical application of the precautionary principle. Continuous improvement is the philosophy that is used in other industries. It has been used on the supply side in the fishing industry in terms of quality assurance and it may be appropriate to use it in bycatch reduction as well.

Murray Johns – Fisheries Policy Manager at the Department of Primary Industry and Environment in Canberra.

My perspective is from the policy manager or advisor, not the fisheries manager, and is about where we would like to see this whole issue of bycatch going. Bycatch is a serious issue in Australia from a point of view of policy and national good. There are many interest groups including the fishing industry, recreational fishers, traditional fishers, government, NGOs and the general community. Everyone wants a slice of the cake and one must balance the different perspectives within that slippery term 'national good'. This is in an area where the goal posts are constantly changing. Public opinion and expectations are also changing and are increasingly being influenced by the media.

We need to keep the momentum moving forward nationally because we need to maintain marine and estuarine ecosystem integrity and sustainable fisheries to the benefit of all. This momentum should be kept ahead of public opinion which tends to sensationalise the issues. There is a need to keep ahead, adopt a cooperative and collaborative approach between researchers, managers, recreational fishers and the community.

Funding is also an issue not covered in the workshop to date. There have been many millions spent on BRD research. Much of this funding has come from the public purse through FRDC, NHT, CSIRO, State fisheries research agencies, all largely supported by public funds. There are also industry contributions but most are in-kind. The beneficiaries of such research are the community.

Research is just a means to an end. What we want is the implementation of BRDs and monitoring programs to evaluate performance. Research and monitoring needs to be practical, commonsense and cost-effective. Things are moving a little slowly in the adoption of BRDs. Maybe there needs to be better extension.

Lastly, the public needs to be informed as to what is happening. We need a fair and accurate description of research and bycatch reduction as it is being implemented and also need to expose misinformation.

Steve Eayrs – lecturer at the Australian Maritime College with a strong background in gear technology and experience in commercial prawn fisheries.

I have been involved for many years in the Northern Prawn Fishery. More recently I have been involved in an extension program headed by Julie Robins. There are 120 boats in the NPF and we have a couple of technicians showing fishers how to tune and get the best out of BRDs. Not an easy job getting from boat to boat. Currently, the fleet has about a 40% adoption rate with maybe 50% next year. Industry is currently developing its own devices and I guess soon we'll be out of a job.

I'd like to highlight a few concerns for the discussion. First we are aware of legislation on BRDs and TEDs coming into force in January. I am concerned industry is unclear as to the differences between TEDs and BRDs. These devices are being used right across the Gulf of Carpentaria. Do we have to use them in all locations? Some BRDs are species specific, some perform better than others in reducing bycatch.

When is enough, enough? In relation to bycatch reduction targets, 100% for turtles is perhaps achievable but what about fish? Targets of 20% or 50% will be difficult to measure. How do you know when the target has been achieved? When is the job done? For example, you can't measure fish coming into the net so how do we know when we have reached a target if it is not 100%?

Julie Robins – leads an extension program based at QDPI, extending bycatch reduction technology to fisheries in Queensland, Northern Territory and South Australia.

Sustainability is a journey not a destination. This relates to what Steve has just said in terms of whether we are ever going to get there. With turtles it took a long time to convince fishers that it was an issue and that cumulatively every turtle taken had an effect and that each individual fisherman needed to address the problem.

On the other hand fishers can relate to bycatch reduction in general because they don't want to catch the fish. However, in relation to targets, they say that their bycatch has been sustainable for years and they ask why they need to reduce their catch?

This is an important point. Why are we reducing bycatch? Is it for sustainability reasons or is it a moral issue of not wanting to see waste? Again we need to have clear definitions and goals.

If the message is sound it can be sold to fishers. There is a lot of latent goodwill in wanting to maintain a good environment. Managers should give good reasons why they should reduce the impact on bycatch and help with technological solutions. They need to justify spatial or seasonal closures. Fishermen will accept such initiatives if reasonable justification is provided.

Darryl McPhee – advocate for the Queensland Commercial Fishermen's Association.

Speaking last I'd say that most of the issues have been covered. I agree with Julie that we need to define the problem then define the target and a way of reaching it. For example, if the problem is bycatch washing up on beaches then the target might be to stop bycatch washing up on the beach.

Another issue is the apparent one-way nature of this as industry views it. We keep closing things, adding more and more modifications to gear. But what about when things don't work – do we reopen the grounds? Is there political will to do this?

Discussion

Richard Tilzey (BRS) commented that in relation to bycatch targets it may be a mistake to look for a general solution. It will vary with fisheries and species. He agreed that the first task was to define the problem and each fishery will have its own specific set of problems. Moreover, was it a real problem rather than a perception? Malcolm Haddon's model was very good in this respect. The expression 'waste not want not' goes right to the issue of the public perception problem.

Derek Staples (BRS) pointed to Duncan Leadbitter's comment that the state-of-the-environment reporting indicators were equivalent to goals. Working at the national level he was yet to find these goals. He wanted to know what these goals were at the state level. Also, what was the analogy with bycatch?

Duncan Leadbitter replied that the state agencies generally do not have answers. At the state-of-the-environment working group that he was working on, all the problems that had been encountered at the national level were occurring at the state level. The more you look at the problems the harder they get. Sometimes out of frustration, a target figure is chosen and is worked towards as a political imperative. There is this dynamic thing that involves public policy where people who are outside the scientific arena step in and make a figure happen that then has to be worked towards. In other industries and in the fishing industry there have been cases where arguments that it isn't a real problem but a perceived problem have fallen over. Whole fisheries have closed because in the public's mind perception is reality.

The Chair asked Derek Staples to expand on the specific goals in relation to environmental performance in Europe.

Derek Staples said they set targets for just about everything – air pollution, water quality, etc. that state that by some year they will reach some target. In Australia we have done it differently, with a more general approach, without fixing hard goals but rather an explicit objective to improve or at least maintain a *status quo*.

Colin Buxton (TAFI) wanted to add to Richard Tilzey's comment by saying that it was often difficult to characterise a fishery in terms of bycatch because many fisheries were complex and had different components or sectors. The NPF was an example and Julie Robins had described this well. Colin wanted to know how one defined the fishery for the purposes of introducing bycatch – could we generalise or would we be specific and address different sectors in different ways?

Duncan Leadbitter suggested that it would come down to a balance between costs and practicalities. You can divide it up into any number of complex units but the costs of managing and monitoring become prohibitive. From this perspective it is probably better to have some blanket target. Even if it is just a generic goal.

Julie Robins said that some species of turtles will have blanket levels applied as bycatch targets. They will be set at a Commonwealth rather than state level. She agreed though that we will need to recognise individual sectors in some of our larger fisheries.

The Chair noted that there were strict bycatch targets applied in New Zealand in relation to seabirds and Hooker sea lions. In some cases, zero bycatch limits.

Murray Johns noted that sometimes targets can be externally set in which we have no say, for example, the United States embargo on prawn imports. Fortunately few prawns are exported to the United States. The impact would have been greater if Japan had embargoed imports. In such cases we would have to set targets as a matter of necessity.

Barry Evans noted that the setting of bycatch targets must be done on a state-by-state basis. South Australia has no turtles or dugongs. It has the lowest bycatch ratio of any prawn fishery in Australia. Bycatch is not seen as a problem.

For the South East Trawl Fishery there is a management problem not a bycatch problem. One must be careful in setting targets. It is an individual fishery thing.

Ian Poiner suggested the reason for going down the target route was to define the problem. This enables the continuous improvement mentioned by Duncan Leadbitter. Bycatch ratios are inappropriate in problem definition. There needs to be a baseline and one must be able to measure a baseline. This is a big issue for some fisheries and there is some doubt that an overall baseline could be set for the NPF. It may not be possible. Once a baseline is established it may be possible to set a target. You can control at a key producer level. A strategy of continuous improvement involving gear and gear certification involves problem of removing control and does not resolve the issue. For example, in the United States, huge sums of money are spent on gear certification for prawn trawlers but there is no performance measure. If the performance measure is related to prawns washing up on beaches it hasn't changed, it hasn't resolved anything. The industry is still blamed and it still costs lots of money.

There are other reasons to go down the target route such as having control over the solution. Define the baseline, measure it and monitor it.

James Scandol (FRI) drew attention to the issue of cost. BRDs costs money to develop and to implement. Who pays? He believed Canberra would argue that it should not come out of general revenue. Should seafood consumers be paying? Is that right? What economic levers could be used to reduce bycatch?

Murray Johns disagreed on the question of Canberra not paying, saying most of the money in this area of research is public money. It is a community resource and the community should benefit. Industry is also a beneficiary from bycatch research and was contributing in various ways.

The Chair noted that in South Australia considerable amounts of prawn industry funds have been spent on bycatch reduction and environmental research. There has been a substantial contribution by FRDC. However, work by Jack Forrester and John Watson from the National Marine Fisheries Service on bycatch reduction in the Spencer Gulf prawn fishery was paid for by industry.

Duncan Leadbitter commented on the question of financial incentives to reduce bycatch. Mike Young's "Reimbursing the future" refers to economic incentives for sustainability. Fisheries offer tradeable rights. Markets demand sustainable solutions. There isn't much response from fisheries agencies for novel solutions but in the agricultural world there is much interest. For example, the National Farms Association promotes tax breaks for farmers to put up fences along water courses. Financial tools are under-utilised in fisheries because they are based on regulation.

Marc Wilson (AMC) said the problem was similar to the one faced on TACs. Some fisheries will be able to set targets but others cannot because they do not have benchmarks. There is likely to be a mix of a host of different approaches. What we can say, however, is that we have two reasons to progress this, one being conservation, the other being public perception. In his view the MAC process provides a means of stakeholder involvement and sharing of duties.

Malcolm Haddon commented in relation to public perception. Should bycatch be stopped or should it be stopped from washing up on the shore? Perception is not necessarily reality. Targets set against public perception might not be what is required for sustainability. So how much notice should be taken of public perception?

Darryl McPhee agreed and added that it would not solve the problem from industry's view, but would lead to another problem. That's the way it worked. One can bend to public perception in some cases but it is better to have education programs to change public perception.

Elkana Ngwenya (AMC) drew attention to the economics of the issue. If BRDs increased efficiency then they would be adopted by industry. Alternatively the solution might be marketing bycatch. Public awareness is related to option value, conserving the resource for the future. There is also an issue of user conflict. For instance sand crabs caught as bycatch by another fishery denies access to sand crabs in the sand crab fishery. Given this, are we going to find an objective function that will summarise or make us all better off subject to individual constraints?

Paul McShane noted that there were economic incentives for the Gulf St Vincent prawn fishery to use BRDs because it increased the value of the catch by at least 10%. Furthermore, as the gear was more efficient it increased the catch of the more valuable larger prawns. Not surprisingly there was widespread, indeed 100%, adoption of BRDs in that fishery. In an extreme case economic perceptives relate to the prospect of fishery closure as we have seen in Port Phillip Bay with the scallop fishers because of the perception that their fishery causes environmental damage. Thus the stakes are pretty high economically.

Colin Buxton drew attention to Julie Robin's comments on zero bycatch as a target. He was concerned about accepting a zero bycatch target for any species because that created a rod for industry's back – once set for one species it would become the logical extension for others. There was arguably some level of acceptable catch that was sustainable for most species but recognised that this was an emotional issue, especially for conservationists. He suggested that a TAC would be a better bycatch strategy option.

The Chair asked whether it would it be acceptable to have a TAC for, say, dolphins?

In response Colin Buxton said this was theoretically possible. If dolphin populations were healthy and humans had a sensible use for them, then there was nothing morally or environmentally wrong with exploiting them. Public perception swayed us on this. The important point was that in a scientific forum he believed that targets should be set against sustainability criteria, not emotional ones.

Julie Robins responded by saying that for turtles some species range across fisheries jurisdiction. She did not think that there would ever be a 100% elimination of the turtle bycatch from Australian prawn fisheries, but saw zero catch as a reasonable target. Major sea turtle conservationists agreed that a zero bycatch target is unrealistic. She noted, however, that limits were often imposed from afar at a Commonwealth level, without regard for the characteristics of a particular fishery. She believed that it was much more realistic to have localised targets or goals for specific, particular fisheries. For some species there will be cross-fisheries targets and for others there will be within-fishery targets.

Ian Poiner stated that an important principle was to set targets that were achievable. A zero target is dangerous, for example, for the Patagonian toothfish.

Duncan Leadbitter said Colin Buxton would be pleased to know that in the tuna/dolphin issue the major environment groups accepted a bycatch of 5,000 dolphins in that fishery. They were not eaten but they became a food supplement for sea cucumbers. There was a protest by another environment group that called Greenpeace "dolphin killers" because they accepted a bycatch of 5,000 dolphins.

Duncan Leadbitter wanted to raise the problem associated with setting a TAC for, say, turtles, that one is then obliged to pay the cost of establishing this and the cost of measuring the outcome. With a trans-regional animal like the turtle, the main impacts are coming from outside Australia. You then start to enter some areas of costs and quotas, and all sorts of things which would also become difficult to administer and inaffordable. Setting the goal at zero is a trade-off against cost.

Darryl McPhee said the fishing industry could not guarantee that there won't be a marine turtle kill from trawlings. Then, again, the fishing industry is not going to guarantee that one won't be hit by a meteorite. Functionally with the net fishery in Queensland we do have a zero bycatch limit of dugongs, it may be written in the legislation as close to zero as possible, but we are dealing with public perception. We are also dealing with 'world heritage area' which sets the bar just that little bit higher.

Peter Gehrke (NSW Fisheries) stated that there was a fundamental issue trying to set targets for bycatch reduction that hasn't been effectively addressed today. Whether to focus on reducing bycatch for its own end or whether we are talking about reducing the impacts. If we are talking about reducing the impacts, which maybe at a population level or ecosystem level, then those things need to be measured, and there have been attempts to do this for albatross. If we are talking about simply reducing bycatch itself, the question is how are you going to set realistic targets, for example, 10%, 20% reduction? We don't know whether that reduction is having any beneficial effect unless you can define the impact that bycatch is having in the first place. If you are talking on the other hand about simply reducing bycatch from an efficiency perspective of operation then you can repeatedly reset targets just to improve efficiency. What types of bycatch reduction are needed to reduce impacts to a manageable level and what are the cost efficiencies?

Murray Johns replied saying that there is cost efficiency for the industry to reduce bycatch even though it is not affecting sustainability. The other issue is a moral issue, i.e. how much can we continue to catch, waste and kill?

Peter Gehrke said, that to clarify the issue from a point of view of pest control, it would be desirable if we could go out and remove all the carp from the inland rivers, but if we were to remove 50% of the carp would we improve the environment? Do we need to quantify the impacts? If you set a target of, say, 20% in a particular fishery, but the reduction was having no measurable effects on the impact of the bycatch in that particular fishery, would people in the fishery pursue it?

Barry Evans replied saying that the biggest problem in the Spencer Gulf prawn fishery was the blue crab fishery. It is a problem for them because it damaged the prawns, so if we can get rid of them it is going to lift our return but, at the same time, if it is going to cost us loss of prawns by trying to get rid of them then we wouldn't bother to do it. Because of the practices that we've got at the moment, and we will improve on those as time goes on, I think we can just about get to where we want to go with it.

Peter Gehrke said this was a question of economic efficiency. Optimising the value of catch whether by reducing damage to prawns or the cost of removing crabs from the catch.

Dave Brewer (CSIRO) wanted to comment on the setting of goals. He emphasised the need for a precautionary approach because it was difficult to know whether reducing fish bycatch in the NPF by a percentage was having any effect or not. The only way to do it properly is to set a goal. He believed that there was nothing wrong with setting a goal of zero for turtles because it was feasible. It would at least force the operation to strive for a goal of zero. If a small fish was vulnerable, that didn't necessarily mean that you have to set a goal of zero for that small fish because it may not be feasible. With information you can set feasible goals. If you know enough about your fishery and you have done some baseline research you can set feasible goals where it is appropriate.

Bruce Wallner said that NORMAC, in developing its bycatch action plan, wrestled with the whole concept of targets. In the NPF there was a strong background of work and they had the option of setting realistic targets for turtles and fish bycatch. They made a conscious decision not to put targets in for one reason – fear. This could be broken down into three parts.

1. Fear that the target set was meaningless, e.g. 95% reduction of turtles may still mean that loggerhead turtles become extinct.
2. Fear that it was logistically difficult and costly to measure performance against those targets with sufficient precision.
3. Fear about what if one doesn't reach the target? There is also a fear of specifying in the plan what the management response will be.

Dave Brewer said he didn't believe this was taking a precautionary approach. You still need to strive to improve the situation in some way. You need to head toward some sort of goal to reduce bycatch.

Steve Eayrs asked how one would know when the target had been reached? If only allowed to catch 20% of dollar fish how would the fisher know when this was being achieved?

Dave Brewer said that this would have to be measured. It was relative. By putting a BRD on one side of the net and taking it out on the other side and having a look at what effect the BRD is having.

Steve Eayrs countered that with known variations across the NPF it was hard to generalise both in time and space.

Dave Brewer replied by suggesting Steve Eayrs was refusing to take the precautionary approach.

Tongue in cheek, Steve said that unless Dave could come up with the answer on January 1st, he would announce that he had a 50% fish excluder and would wait for Dave to prove him wrong.

Duncan Leadbitter noted that there were plenty of other industries that were regulated without necessarily having a response signal in the environment. Pollution controls on most polluting industries are not set on the basis of demonstrating a benefit to the environment. They are set on the basis of meeting some agreed goals of performance. In many cases there are no regional variations because they give economic distortions which result in industries going to the areas where the pollution controls are most lax. In some cases there are no benefits. My car doesn't pollute the air in a country town but it contributes to Sydney's pollution problem. I still pay for the catalytic converter and unleaded fuel because those are the rules for the whole of Australia. Some of this doesn't have to be dissected to death. At the end of the day there have to be some broad agreements on general directions within which agreements can be made on a fishery-by-fishery basis.

Frances Michaelis (Parliamentary Research Service). Do we have enough basic taxonomic and autecological information on some of these species? If we do have enough information, are we getting this information out to the fisheries managers, to the fishing industry and to the community? My concern is if we don't get this information out, we will have an agenda that is not set with scientific principles and not set by the managers but by people that are less informed about the issues.

Barry Evans was unsure he could answer this but wanted to raise a point that was being lost in the discussion. If one wanted to solve a problem with turtle mortality, it is a completely different issue to solving bycatch problems. To solve the problem with the turtle, trawl for an hour then pick your gear up, the turtles will still be alive. That will overcome that problem. You don't need devices in your net to do that. To solve the bycatch problem there are two issues:

1. All the quantities of small uncommercial fish the trawler is catching in the NPF.
2. In the South East Trawl Fishery I don't see bycatch as a problem, I see it as a management problem.

Albert Caton (BRS) noted that the great whales were in this category of charismatic species and in relation to exploitation had to be fully utilised. That was an important issue. If one was going to the trouble of catching something, finding ways of improving use was a good target. Once you have quantitative targets, issues of research, monitoring, analysing and looking at subsequent bycatch reduction targets get to be extremely expensive. To take the Japanese longline fishery as an example, shark finning is a political issue. Fins are kept and the bodies are dumped. In this fishery attempts were made to keep the carcasses to avoid wastage, but when there were no observers on board it was fairly apparent that the carcasses were dumped and the fins were being kept. With observers aboard, the trunks were kept as well. He made the point that if you are going to set targets you either get full cooperation from industry because it was to their advantage. Otherwise one faced really expensive monitoring or inspection/observer costs. Avoiding wastage as much as possible and generating cooperation were essential to the bycatch reduction issue.

Ian Poiner suggested that we needed to be very careful about the wastage argument. It was very much a public perception issue. In his opinion a more valid option for a 50,000 fish catch in the NPF would be to put it back into the system rather than taking it out and using it in fish meal. From an ESD perspective it would be must better left dead on the bottom.

Malcolm Haddon (AMC) asked whether we should only set bycatch targets on those species for which the imposed mortality is unsustainable? If so, who is responsible for demonstrating whether the bycatch mortality is too great?

Geoff Liggins (NSW Fisheries) added that we haven't talked much about the South East Fishery. It was fundamentally different to the discussion about the prawn trawl fisheries and he wanted to point out that in the SEF we are dealing with discard of target species as well as discard of non-target species. He didn't see there being any marked difference between the discard of the non-target species in the SEF and the discard of non-prawn species in the prawn fisheries. He debated the point that the SEF is fundamentally different to prawn fisheries. Secondly, there is an issue of discards of species that are targeted. There might be a different approach towards this issue of targets for those species. Following Malcolm Haddon's presentation Geoff Liggins was going to suggest that the appropriate model might be to charge the assessment groups who are responsible for the assessments of blue grenadier or redfish with the responsibility of taking into account the levels of discards occurring in the fishery. Thereby the issue and the necessity to do anything about the discards would be approached from the point of view of whether it was making any fundamental difference to achieving AFMA's objectives for these species. Using the argument that Malcolm Haddon was making in his talk, if it can be modelled, if it can be shown reasonably conclusively that the levels of discarding are not impacting on yields from the stock, then he believed that was a good reason for not paying very much attention to the reduction of discards in this case. He thought the capture and discard of the non-target species in SEF poses the same sort of problems as the bycatch in the prawn fisheries.

Julie Robins suggested that there were two reasons why bycatch and its reduction are an issue. One is sustainability and having sustainable fisheries. If bycatch of a species is unsustainable then that is why a reduction is needed. The other main reason why we seem to be wanting to reduce bycatch is for a moral, waste not want not, reason. That goes for all those other species such as dollar fish and numerous other species that may be sustainable at present catch rates but that don't deserve to be caught. They are two quite separate issues that need to be addressed. One is a sustainability issue, the other is a moral issue and that's where our targets need be addressed.

The Chair felt that this was a good point on which to end the discussion. Clearly it wasn't a simple task to identify bycatch reduction targets, and the issues of economics, sustainability and public perception all needed to be taken in to account.

Session 4

Commonwealth Bycatch Policy and the need for extension services

Chairperson:	Barry Evans
Speakers:	Katrina Maguire Duncan Leadbitter
Rapporteur:	Colin Buxton

AFMA and the Commonwealth Bycatch Policy

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Abstract

The Fisheries Management Act 1991 *was developed in a peak period of international concern over the environment. Major themes were ecologically sustainable development (ESD) and conservation of biological diversity. The Act's objectives also include reference to the need for AFMA to pursue ESD, minimise the impact on non-target species and exercise the precautionary principle. In addition, the Act was recently amended to require fisheries management plans to contain provisions that limit the take of non-target commercial species to a minimum. The recently endorsed South East Trawl Management Plan includes such a provision.*

As community concern over bycatch increased, and to meet our legislative, national and international obligations, AFMA established a working group in 1996 to develop a bycatch policy. Over time it was agreed that the policy should be a Commonwealth policy with endorsement from environmental and fisheries agencies. The draft policy was circulated for public comment in mid-1997 and is currently awaiting approval and release from the Minister for Environment, Agriculture, Fisheries and Forestry. The policy was developed to recognise that there are a range of different bycatch issues in each fishery by setting an overall approach to the development of bycatch action plans for individual fisheries. Significant concern has been expressed by a range of individuals and organisations over the need to manage the take of all species by fishers. AFMA has acknowledged that the sustainability of the marine environment is the underlying objective of fisheries management and that a range of measures exists to pursue that objective. The Commonwealth Bycatch Policy is one such measure.

The Fisheries Management Act 1991 (FMA) was developed in a peak period of international concern over the environment. At a conference in Rio de Janeiro in 1992 two major themes were ecologically sustainable development (ESD) and the conservation of biological diversity. In conjunction with these global discussions, Australia developed national strategies for ESD and the conservation of biological diversity and implemented the *Commonwealth Endangered Species Protection Act 1992*. The FMA objectives also include reference to the need for the Australian Fisheries Management Authority (AFMA) to pursue ESD, minimise the impact on non-target species and exercise the precautionary principle. In addition, the FMA was recently amended to require fisheries management plans to contain provisions that limit the take of non-target species to a minimum.

As community concern over bycatch increased, and to meet Australia's legislative, national and international obligations, AFMA established a working group in 1996 to develop a bycatch policy. Over time it was agreed that the policy should be a Commonwealth policy with endorsement from environmental and fisheries agencies. A Commonwealth bycatch taskforce consisting of representatives from industry, Environment Australia, CSIRO, Bureau of Resource Sciences and AFMA was established to develop the Commonwealth Bycatch Policy.

A draft policy was circulated for public comment in mid-1997 and is currently awaiting approval and release from the Ministers for Environment and Fisheries. The bycatch policy is being touted as a key initiative of the National Oceans Policy. The policy was developed to recognise that there is a range of different bycatch issues in each fishery by setting an overall approach to the development of bycatch action plans for individual fisheries. The draft policy suggests a range of tools for inclusion in bycatch action plans as a means of addressing the type of bycatch problem in each fishery. The range of available tools includes research, education, technical solutions and the use of sustainability indicators, and the draft policy provides for each fishery to determine the appropriate mix depending on the specific issues in that fishery.

Following much discussion the definition of bycatch in the draft Commonwealth Bycatch Policy is as follows:

While the term bycatch may refer to all non-targeted catch including by-product, discards and other interactions with gear, this policy will deal specifically with those aspects of bycatch that are not currently subject to commercial management provisions, namely;

i) that part of a fishers catch which is returned to the sea either because it has no commercial value or because regulations preclude it being retained, and

ii) that part of the "catch" that does not reach the deck of the fishing vessel but is killed as a result of interaction with the fishing gear.

There have been many hours of debate over the definition of bycatch, to the extent that the term 'bycatch' has essentially moved from being associated only with the 'charismatic megafauna' to a realisation that the sustainability of all species impacted by fishing and the need to maintain ecological integrity are imperative in the use and management of fisheries. However, the high level of uncertainty in the marine environment and the limited access to resources to improve our knowledge, balanced with the needs for sustainability meant that the definition of bycatch, adopted in the Commonwealth Bycatch Policy, provides for fisheries with different levels of knowledge. Significant concern has been expressed by a range of individuals and organisations over the need to manage the take of all species by fishers. AFMA has acknowledged that the sustainability of the marine environment is the underlying objective of fisheries management and that a range of measures exists to pursue that objective. The Commonwealth Bycatch Policy is one such measure.

There is a wide range of factors influencing the management of bycatch in fisheries, particularly from a global perspective. For example, the Food and Agriculture Organisation (FAO) established a series of technical groups to consider issues related to the incidental bycatch of seabirds in longline fisheries, and the management of sharks and fishing capacity. These technical working groups have formed the basis for the development of three separate plans of action for each issue. The FAO action plans will establish a process for countries to assess and, where appropriate, develop management strategies for dealing with these issues, as well as ongoing evaluation of the effectiveness of such measures. Australia is strongly of the view that the action plans should encourage regional and global collaboration in research and development of mitigation measures.

Current regional agreements such as Commonwealth Caught Southern Bluefin Tuna (CCSBT) recognise the need for collaboration and an Ecologically Related Species Working Group of CCSBT was established in 1996 to discuss, in particular, issues relating to the incidental take of seabirds during longline fishing operations. The development of a *Threat Abatement Plan for the Incidental Catch of Seabirds during Longline Fishing* has established the standards for addressing the seabird bycatch issue in Australian longline fisheries.

In addition, AFMA is adopting an ecosystem approach to the development of the sub-Antarctic fisheries through the application of stringent environmental conditions and assessment of the fisheries on a ecological basis, such as research and analysis of predator-prey relationships.

The draft Commonwealth Bycatch Policy emphasises the need for bycatch action plans to include requirements consistent with these other instruments influencing the management of bycatch.

The Northern Prawn Fishery has been the first to develop a bycatch action plan specifically for a fishery. The Torres Strait Prawn Trawl Fishery has also finalised an action plan and the Fisheries Research and Development Corporation has recently funded a project entitled "Maximising yield and reducing discards in the South East Trawl Fishery" which will underpin the development of a bycatch action plan in that fishery.

The threat abatement plan (TAP) for longlining has significant implications for the operations of tuna longline vessels and the principles of the plan will be incorporated into a bycatch action plan for all tuna fisheries, as well as the south east non-trawl and hook sector of the Southern Shark Fishery, where appropriate. The TAP recognises that a range of tools exists to address the bycatch issue and provides options for adoption of different mitigation measures.

With an ever-increasing focus on the marine environment, changes to Commonwealth environmental legislation in the Environment Protection and Biodiversity Conservation Act will have a significant impact on Commonwealth and possibly state-managed fisheries, particularly in Commonwealth waters. The draft Commonwealth Bycatch Policy is a recognition that the management of bycatch is an integral part of everyday fisheries management. The development of bycatch action plans will provide a basis for addressing bycatch issues at the fishery scale and translating those results at the international, regional and national scales.

Making progress on bycatch reduction – the need for extension services

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Abstract

There is little value in documenting a bycatch problem and testing solutions if the appropriate solution is never used. Cases of new gear designs sitting in sheds gathering dust are not unheard of in Australia. In comparison with the agricultural world, where the provision of extension services was just part of the research/adoption continuum, the provision of such services for fishers has not been a central part of the fisheries management culture. A reason for this is that farming is generally unregulated whereas fishing is heavily regulated and the regulatory culture is still strong in many fisheries administrations. Modern approaches to resource management place more emphasis on co-management and facilitating change rather than older style top-down, regulatory approaches. There are a number of examples in Australia where good extension work practised by scientists has resulted in a positive response from fishers.

Discussions with the people involved have revealed the following:

- *a need to have an established network and staff continuity;*
- *funding is needed;*
- *an extension program needs to be coordinated and long-term; and*
- *industry leaders are needed to increase the acceptance of change amongst their peers.*

Extension services are quite obviously of value and under-provided in Australia. A number of potential models for the provision of such services can be explored. One model is to rely on a project by project approach using researchers. Another is to have a government-funded, dedicated extension provider. Still another is to use private providers. Possibly a mix of models would be appropriate. Researchers and managers from not only fisheries agencies but wildlife management agencies as well should consider the need for extension services. Such services may not totally replace the need for regulation but they would increase the acceptance of regulations and thus the compliance rate.

Introduction

The transfer of information between stakeholders in the fisheries world remains one of the major challenges facing those with a commitment to sustainable fisheries. It is fair to say that many of the blockages that impede good management are driven by poor communication. One reason for this is that the various stakeholder groups use, evaluate and transmit information in different ways.

Extension services in the agricultural world

In the agricultural world there has been a long tradition of using extension officers to take the results of scientific research out to farming communities to increase the rate of uptake of the results and seek feedback from farmers regarding the effects of local conditions (Russell *et al.* 1989). The main type of information passed on included that which had commercial value, such as new growing or harvesting methods and conservation farming techniques. In recent years much of the commercial component has been taken over by private companies but extension work on conservation matters continues and has evolved to become part of the Landcare movement.

There is a relatively abundant literature associated with the use of agricultural extension officers. Social science researchers have provided feedback to the extension officers about the different groups of farmers and their needs with respect to information transfer.

Extension services and the fishing industry

The same type of extension services is not available to the fishing industry, at least not here in Australia. The situation is different in the United States where there is a formal extension service as part of the national Sea Grant program (Wilkins 1980).

Granted, here in Australia, there are some excellent examples of dedicated researchers ensuring that their research is taken up by fishers. Several examples spring to mind. Julie Robins from the Queensland Department of Primary Industries has worked closely with Queensland fishers to refine turtle excluder devices for the trawl fleet. Matt Broadhurst, who was with NSW Fisheries, and Steve Kennelly have also had successes working with prawn trawl fishers in New South Wales and, with Paul McShane, in South Australia.

Evaluations of the effectiveness of extension work are largely anecdotal. Broadhurst *et al.* (1997) report that their work has resulted in "many" fishers using Nordmore grids as opposed to blubber shoots. NSW Fisheries has reported higher BRD usage rates in fisheries where extension work has been more intense but how the data were collected is unknown (Anon 1997). In South Australia it is reported (FRDC 1998) that the whole of the Gulf of St Vincent prawn fleet began to use BRDs after scientists worked with fishers to ensure that the BRDs worked for the local conditions.

The industry has been fortunate to have such people. However, many industry people would claim they are few and far between and there remains an ongoing problem of research not being put to work – gathering dust on shelves as it is often described. Understandably, many scientists want to do science but a number to whom I have spoken have reacted positively to a suggestion that an ongoing extension service picks up where the science leaves off.

There have been a number of cases where new technology has remained unused, to the detriment of industry. While easy to make assumptions and accusations about the reasons for this, the lack of any consistent and focussed extension services undoubtedly plays a role.

The reasons why extension services have such a low profile are also open to speculation. There is little doubt that fisheries agencies have relied more on regulation to force change, an option generally not open to those in the agricultural field, especially in the area of environmental management.

An increasing realisation in many fisheries agencies is that a reliance on traditional command and control type approaches to fisheries management has failed to deliver sustainable fisheries and that a broader mix of management tools, involving property rights, co-management and extension services is needed.

Delivering extension services

The choice of delivery mechanisms for extension services is an important issue. Stakeholder support is vital. Top-down approaches do not work, especially if government is prescriptive about the solutions and relies on consultation rather than participation. To quote a little homily:

"Tell me and I'll forget…
Show me and I may remember…
Involve me and I'll understand…"
(Campbell 1990)

Some criticisms that have been levelled at the Soil Conservation Service (Campbell 1990) exemplify how a patronising and top-down attitude can fail to get people involved and fail to ensure that the new approaches to managing the land are widely distributed.

In the fisheries cases I mentioned earlier it is clear from the support given by fishers that this problem has been avoided. There are thus clear lessons for the design of any such program in Australia, whether such a program is delivered by industry or government. I think it's fair to say that it would be appropriate for a joint approach to the delivery of such services as this would marry both government and industry expertise.

A proposal for establishing an extension service for the fishing industry in Australia

This year the Australian Seafood Industry Council and the Australian Marine Conservation Society prepared an application for funding under the Coast and Clean Seas Program to establish an extension network for the industry that would have a focus on solving bycatch and related environmental issues. The project incorporated a previous but smaller concept developed by Ocean Watch and submitted to the Fisheries Action Program.

The aim of the proposal was to put extension officers into the industry offices in a number of Australian States with a mandate of working with fishers to solve some of these complex problems. The concept was based upon a mix of attributes from the Marine and Coastal Community Network, Landcare, the US Sea Grant extension service and the experiences of scientists here. The aim of the network is to become a long-term service to industry and government.

The extension officers will collaborate closely with government scientists and managers to ensure that there is a two-way flow of information (Gallaher 1990). Such an approach aims to result in better and more targeted research outcomes, a more rapid implementation of policy and, of crucial interest to industry, a clear demonstration to the public that it has made the long-term future of the marine environment a central part of doing business.

Yesterday, the federal Minister for the Environment, Senator Robert Hill, launched the Coalition Environment Policy. The following announcement was included in the policy launch:

"In the next Parliament, the Coalition will therefore:
provide A$700,000 over two years from the Marine Species Protection Program and the Fisheries Action Program to support a joint Ocean Watch/Australian Seafood Industry Council/Australian Marine Conservation Society initiative to establish a network of sustainable fisheries officers to promote environmentally sound fishing practices."

Here is the basis for an extension service that we aim to grow and ensure that it persists over time. We believe that it could be a service to all fisheries researchers and agencies in whatever jurisdiction.

In the next few weeks there will be a steering committee established and meetings will take place to canvass the most appropriate locations for the extension officers. The commitment of fishing organisations and the willingness of fisheries agencies to work with independent fishing industry bodies will be key factors.

We look forward to the involvement of people from this audience in this new venture.

Postscript

In January 1999 the Federal Government released the Oceans Policy and has confirmed the availability of funding for the project. By the time these proceedings are published the project will be underway.

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SeaNet – an environmental extension service for the Australian seafood industry

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"SeaNet" in brief

The National Heritage Trust has granted funding to a consortium comprising the Australian Seafood Industry Council, the Australian Marine Conservation Society and Ocean Watch Australia to enable the establishment of an extension service (known as SeaNet) to promote sustainable fishing practices within the Australian seafood industry. This consortium is known as the Fisheries Extension Network Australia (FENA).

Aims of SeaNet

In pursuing its goal of facilitating the move to ecologically sustainable fisheries, SeaNet aims to achieve the following:

- increase the rate of uptake of new fishing gears and practices to aid bycatch reduction and environmental best practice;
- increase the rate of transfer of research-generated knowledge about new fishing gears and practices;
- facilitate liaison between members of the fishing fraternity (fishers, researchers, managers etc) on fisheries sustainability matters; and
- provide information, support and advice to fishers and others seeking to make changes to their fishing gear and/or fishing practices.

Basis for SeaNet

In the agricultural sector there has been a long (decades) history of making research available to farmers via formal extension programs. With the exception of some project-related exercises the same approach has not been taken in the fisheries sector. However, these project-related exercises have demonstrated the value of a focus on extension.

The need for extension has been highlighted in the FRDC Corporate Plan, the Standing Committee on Fisheries and Aquaculture Research Priorities and the draft National Policy on Bycatch.

SeaNet borrows from a number of existing and successful entities, namely:

- the US Sea Grant Extension Service;
- the Australian Marine and Coastal Community Network; and
- the Australian National Landcare Program and ethos.

The model we adopted was also influenced by feedback from researchers and fishers who agreed that such a service was timely, if not overdue.

How will SeaNet operate?

The level of funding made available (A$700,000) will enable the employment of extension officers over the funding period (two years). These extension officers will be employed by Ocean Watch Australia but will be hosted by a fishing industry body under a Memorandum of Understanding (MoU). Guidance will be provided by a steering committee comprising representatives of ASIC, AMCS, Ocean Watch and invited participants.

Current status

At present a contract has being signed on the basis of a discussion paper which outlined the structure and operational aspects of SeaNet. Currently, employees are being recruited, expressions of interest from industry associations have been sought, MoUs will be written and a business plan prepared.

The long-term view

The applicants view SeaNet not as a project but as a service that will have a longer life than the two-year Natural Heritage Trust funding period. We also aim to expand the service so that more fisheries can have the benefit of the extension officers.

Discussion of Session 4

Chaired by Barry Evans

Spencer Gulf and West Coast Prawn Association
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Recorded by Colin Buxton

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Following the presentation by *Katrina Maguire,* John Glaister (NSW Fisheries) asked for a clarification of the terms "ecosystem integrity" and "ecosystem approach" as an approach to management.

Katrina Maguire replied that it was something that was developing as they went along. It was perhaps best described as a step by step approach – gathering information at different levels. The work done by Environment Australia on the Interim Marine and Coastal Regionalisation (IMCRA) was an example. The Government had also stated they intended to develop regional plans for all large marine ecosystems around Australia, of which there were five or six. The first objective would be south east Australia and the objective would be to get communication going between the sectors in each ecosystem and improve management that way. The regional plans would be binding on any sector in that system.

An ecosystem approach had been used in the sub-Antarctic fishery which had consulted many non-fishing interests, for example, Tasmanian Parks and Wildlife, World Wildlife Fund for Nature. In terms of management it meant collecting information on ecologically related species, collecting baseline information on seals and seabirds and examining predator-prey relationships.

Malcolm Haddon (AMC) noted that to list a key threatening process was a relatively inexpensive process but to demonstrate that there was an actual threat or risk was both more difficult and expensive. He believed that management could get bogged down on this issue. He asked Katrina to comment on who had the burden of proof.

Katrina Maguire agreed that anyone could nominate a species or process under the Act. The process that Environment Australia had established was a committee to consider nominations which could co-opt a range of experts to assist with the process. They had also established a register for the purpose. Criteria that the committee rely on are those of the IUCN which are currently being reviewed.

Amongst the issues that needed to be addressed was the threat abatement plan. For example, with the recently nominated southern bluefin tuna, one of AFMA's positions has been that the development of a threat abatement plan would not significantly add to the conservation of the species. It was certainly a bone of contention for industry that it was so easy to nominate under the Act and that it took such a long time to put a counter submission together.

Francis McKalis (Parliamentary Research Service) said that there was new legislation before parliament to overhaul the Endangered Species Act and to replace it with an Environment Protection and Conservation Bill which had a major section on the management of Commonwealth fisheries. She asked for a comment on how the new legislation would relate to the existing Fisheries Management Act.

Katrina Maguire replied that the Gunn's decision saw AFMA enter an agreement with EPA to have assessments based on management plans rather than designating the granting of each licence or permit as an environmentally significant decision. For the last few years, therefore, they had been operating under an arrangement that was now being set out as legislation.

Ian Poiner (CSIRO Marine Research) noted that the policy was addressing three things: i) Stuff that lands on the desk. ii) Trophic interactions. iii) Unretained bycatch and physical impacts. He asked what the interaction between action plans and policy was in terms of annual review and performance decisions.

Katrina Maguire replied that the policy stated that an annual review should occur alongside the review of the five-year strategic plan, including public comment.

Ian Poiner then asked what would be done.

Katrina Maguire responded that action plans had performance measures built into them with targets that had to be achieved.The review would assess this and they expected that the research associated with action plans would lead to new actions that would be put into future plans.

Following the presentation by *Duncan Leadbitter,* Ian Poiner pointed out that, in the NPF, extension had not worked very well because of the nature of the fishery.Vessels were victualed at sea and did not return to base for a long period of time. Access to these vessels in terms of extension was very difficult. He asked how this might be overcome.

Duncan Leadbitter said that they recognised this but did not have any ready solutions to the problem. He noted that this was an area of potential research. He also felt that looking at the agricultural literature might give ideas as to how to deliver such services.

Ian Poiner said that another issue that was emerging, particularly in places like the NPF, was the difference between owners and operators. In dealing with the peak industry body one was dealing with company owners not skippers. It would be fair to say that there was a gap between what was decided at a peak industry body like a MAC and what was handed down to those on the ground. He asked if this was common in other fisheries and how extension should respond to this difference between power base and implementation.

Duncan Leadbitter replied that fishing associations ranged in size and in terms of organisational structure from grass root management to corporate activities. A lack of funding would make it impossible to cover everything.There was no need in some fisheries where there was already some service provided. In terms of assigning how this evolved over time they would be looking for feedback as part of their learning process.

Malcolm Haddon (AMC) commented that at a recent TasFRAB meeting FRDC made it clear that proposals that did not include explicit statements on how results would be extended to industry would be at a disadvantage.

Duncan Leadbitter said he was aware of this. The aim was to have something that continues after the research – not necessarily to ask scientists to do the extension.

Ian Smith (Queensland Fisheries Management Authority) noted that an important part of the extension work that Julie Robins' project was doing was to have technical staff who had a fishing background. This provided a greater credibility in an industry that had such a strong culture.

Duncan Leadbitter said that a lot of their feedback from the ASIC agreed with this. They had done the same in NSW on a project looking at waste on beaches.

Murray Johns (DPIE) stated that he applauded what Duncan had done with Ocean Watch and in finding support for this sort of work. He said that in 1996 when the United States banned imports from fleets that did not have BRDs, Canberra had put in a submission making the case for exemption based on a strong collaboration between research, industry and government. They had argued that they were handling the problem well without mandating the use of BRDs. In fact they had done exactly the same thing in 1992. What this showed was that they were hiding behind research and that little was being adopted. They were literally treading water. Murray believed that things had changed over the last few years and what Ocean Watch was doing was taking a bottom-up approach, using industry and getting the extension done.

Elkana Ngwenya (AMC) asked whether any attempts had been made to collect data during the extension work, particularly socio-economic data.

Duncan replied that the detail was still being resolved and that in his opinion it should not involve research. Rather it should work with researchers on any aspect including socio-economics.

Session 5

Case studies

Chairperson: Geoffrey Liggins

Case Study 1: Ian Poiner (Facilitator)
Case Study 2: Andrew McNee (Facilitator)

Rapporteurs: Geoffrey Liggins
Colin Buxton

Case studies

Chaired by Geoffrey Liggins[1]

Recorded by Geoffrey Liggins and Colin Buxton[2]

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The participants broke into two groups to discuss the case studies under the following headings:

- History
- Approach
- The plan
- Outstanding issues
- Relevance to other fisheries.

On returning to the session the facilitators of each group were asked to briefly summarise the discussion.

Case study 1: Developing a bycatch action plan for the the Northern Prawn Fishery – Ian Poiner (facilitator)

The group considered three questions:

1. What are the targets, if any?
2. What are the outstanding issues and where to next?
3. What is the relevance to other fisheries?

In addition to discussion of these questions the group highlighted two matters of overall importance. Firstly, that the new Environmental Protection and Biodiversity Bill was possibly going to have a significant impact on bycatch policy and resultant action plans. Consequently, any consideration of bycatch issues and action plans should be done bearing the content of this Bill in mind. Secondly, the group came to the conclusion that the role of non-fisheries stakeholders in the bycatch debate was growing and there was a real need to engage these stakeholders and to include them as part of the process.

What are the targets, if any?

In dealing with the development of any by-catch action plan it was important that the plan made an explicit statement of what the problems were. This has been a recurrent theme over the past couple of days because of the alternatives that the issue may be one of

- public perception; or
- an issue with a strong biological/ecological base; or
- some scenario in between these.

Based on a suggestion by Malcolm Haddon, the group thought that the process of target setting required several components to be in place if it was going to be effective. Associated with the target itself, there needed to be:

- measureable performance indicators;
- an appropriate monitoring program; and
- a review process.

It was also noted that there should be some flexibility in terms of setting and measuring performance with respect to target setting. Importantly, a target may not be a single fixed number but may be a trend.

Outstanding issues

In the NPF a number of outstanding issues were identified that mitigated against the effective establishment and implementation of bycatch targets. These included:

1. *Compliance and monitoring.* In relation to the scale of this fishery and the logistics of a compliance/monitoring program, one could argue that the probability of actually mounting a successful program with any guarantee of success was fairly low. It was considered that some things could probably not be monitored.

2. *The approach to reducing fish bycatch.* This component of the bycatch was particularly vexatious and the group questioned whether it was realistically possible to set targets for fish bycatch in this fishery. Several different options were possible depending on the approach taken. It was uncertain which of these options, for example, a gear solution or a sustainable bycatch solution, was most desirable. The group agreed that this needs further work.

3. *Definition and certification.* Given the nature of the plan – agreements in terms of uptake of different devices by specific years, for example, TEDs by the year 2000, the question of definition and certification is an outstanding issue. The approach to this problem was uncertain and needed clarification.

4. *Comprehensiveness.* It was recognised that the current plan only addressed one aspect of the three key issues in the Commonwealth Bycatch Policy: the material landed on the deck. It did not address the 'scavenger' or 'sea-bed' issues. These were acknowledged in the action plan but it was not clear when these issues would become part of the plan, what would trigger their inclusion and the process under which this would take place.

5. *Other fishing-induced mortality.* The group noted that BRDs could be put into nets that allowed fish to escape, but there was no appreciation of how many were dying as a result of passing through the BRD. Under this scenario it was recognised that BRDs were camouflaging the issue rather than doing anything about it.

Relevance to other fisheries

The diversity in prawn fisheries, from tropical to temperate, north coast to east coast, shallow beam trawl to offshore trawl, meant it was unlikely that there would be generic problems or solutions that applied to all fisheries. These were most likely to be fishery specific. Hence, each action plan would need to address those specific problems within a fishery. They would be different because of different ecologies, nature of bycatches and nature of the fisheries.

However, there were probably some shared issues that were across fisheries. Included were:

1. Some of the approaches documented in the NPF plan (definition of problems; staged approach) probably had relevance to other trawl fisheries and possibly other fisheries in general.

2. TED/BRD certification (if a fishery went down that route) was probably a general problem across all prawn fisheries.

3. Issues relating to physical impacts of trawls going across the bottom, unobserved mortality and the related issue of responding to IMCRA (identifying a national system of representative marine protected areas).

In conclusion, the group noted that the SEF, apart from the issue of physical impacts, had very different problems. Because it is so fundamentally different to prawn fisheries, the approaches outlined would be of limited value.

Case study 2: Developing a threat abatement plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations – Andrew McNee (facilitator)

This case study concerned the threat abatement plan (TAP) for the incidental catch of seabirds by oceanic longline fisheries. Clearly the subject was unfamiliar territory for most of the participants.The group was given a presentation covering background material which emphasised the following:

- the TAP was a published document;
- there was a statutory framework; and
- there was a target of 0.05 birds per 1,000 hooks.

Discussion proceeded immediately to the target value. The group identified a variety of issues with respect to the TAP and subsequently discussed in more detail:

- the role of science in target setting at two levels (technically-oriented targets; in contrast to versus more general targets that fulfil some social agenda); and
- industry involvement.

Outcomes of the discussions

Some participants were uncomfortable with the target that is in the TAP and considered that it did not have the characteristics they considered necessary or desirable. The group considered what the desirable characteristics for targets might be against the key issue – Why does one have targets?

There seemed to be two approaches to target setting, associated with 'specific' versus 'general' targets:

- seeking a conservation type objective that was a specific objective relating to a given species; and
- a more general target to fulfill some social desire to see something done (under this scenario a technical specificity was absent).

Depending on which type of target is adopted, there were implications for progressing the plan. It was suggested that the albatross TAP tended towards the second option. It was even possible that the TAP target may be achieved but that albatrosses may still become extinct.

Discussions then moved to the role of science at these two levels, namely specific versus general targets. If the TAP contained a 'specific' target that dealt with the conservation of albatrosses, science could provide a number of things:

- measurement of the risk or uncertainty of achieving particular aims;
- what is unknowable (the broad expectation 'out there' is that anything can be answered if enough time and expertise is thrown at it); and
- the stock assessment approach. This captures whole suite of particular actions and the group noted that, outside fisheries, this approach was probably not well understood. In conservation science circles there was probably not a strong understanding of this process. It delivers a capacity for technical status assessments; impacts of bycatch on species of interest; evaluation of mitigation in terms of effectiveness of devices and the

contribution this information can make to a particular issue.

For more 'general' targets, for example, if people want to see a reduction in the catches of albatross or whatever, there is a slightly different role for science. In this case, science could:

- tell you generally about the levels of bycatch that might be associated with achieving that particular target;
- determine what is achievable; and
- contribute to evaluation of devices and evaluation of trends to determine whether targets were being achieved or not.

Discussion of the role for industry in the process identified several key areas in which industry needed to collaborate:

- setting of targets and how the whole process of achieving those targets would work;
- development of mitigation devices and strategies for implementing mitigation;
- implementation of mitigation devices and strategies; and
- monitoring and evaluating whether these devices and strategies had been successful.

In conclusion it was argued that to some extent, these things might not have been particularly well enacted in the case of the TAP for seabirds. An important point was raised concerning the sort of language used with respect to industry involvement – 'participation' of industry versus 'consultation' with industry. Participation implied getting industry more closely involved.

Questions and comments

Ilona Stobutzki (CSIRO) asked what would happen if the target or the TAP was not achieved.

Andrew McNee explained that the implication was that the plan would 'trip' itself into a new plan and that it would need to be tougher. It had been discussed during development of the current TAP that there may need to be some kind of decision framework ahead of time. However, for a variety of reasons, the people involved with the process were not particularly keen to see this.

Session 5 – general discussion

Chaired by Geoffrey Liggins[1]

Recorded by Geoffrey Liggins and Colin Buxton[2]

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The chairperson presented a list of challenges or obstacles to establishing bycatch targets that resulted from the panel discussion the previous day. These were:

- a clear definition of differences between biological and socio-political objectives;
- inability to generalise approaches/ methodologies across fisheries and also problems of doing this within some fisheries given spatial variabilities;
- cross jurisdictional issues;
- poor understanding of baseline benchmarks;
- the option of a numerical target as opposed to a 'trend' approach; and
- lack of understanding in most fisheries with respect to trophic dynamics and physical impacts.

Comments and discussion were invited on: i) additions and amendments to this list (following consideration of the NPF and longline case studies), and ii) strategies for dealing with these challenges.

The chairperson noted that that the first challenge, that of distinguishing between biological and socio-political objectives, had been a repeated theme throughout the workshop and invited discussion on methodologies or approaches for dealing with selection between and definition of such objectives.

Murray MacDonald (Fisheries Victoria) stressed the need for those who are providing advice to politicians, particularly bureaucrats, to clearly distinguish between these types of objectives and to highlight the implications of adopting one or the other. He suspected that in most cases up until now, the fact that there was a choice and difference between these two types of objectives had not been apparent to policy-makers. A lot of discussion in Case Study 2 had centred around whether the TAP was really intended to identify and achieve specific biological/conservation objectives for albatross or whether in fact the objective for reduction of bycatch was a more general 'social' objective. The latter was perceived as a community requirement in terms of the activity being considered in some way undesirable. A reduction was therefore in the interests of the community in general and the conservation objective might be absolute in terms of numbers of seabirds of a particular kind.

The former was a more specific biological objective and setting that objective would require a quite different set of scientific inputs and would probably be far more expensive to achieve.

John Glaister (NSW Fisheries) agreed that Murray's point was a good one, although the general public might say that even one albatross was too much. If we were only talking about science and biological outcomes then one could argue that a lot of the bycatch, in the NPF for example, may not be significant in terms of the population dynamics (for those species with high fecundity and turnover). He argued that the major issue, particularly in the more populous states such as NSW, is really community pressure. Ill-informed or not, the community just doesn't like seeing bycatch.

The chairperson asked John Glaister whether he thought there was much scope for education of the broader community on such matters.

John Glaister answered that one always needed to very clearly specify what one was doing and why it was being done. If it was going to have no effect whatsoever in a population dynamics sense then that should be stated, rather than just saying that it was a conservation thing we are doing and it was good.

Murray MacDonald thought it important that we get away from the situation that has probably frequently occurred up until now – where the impression is given that there is a specific conservation objective but the tool that is used is a tool that is only appropriate in achieving a more general socially-oriented objective.

Colin Buxton (TAFI) underlined the importance of distinguishing between the information itself (status of stocks provided *via* research and stock assessment) and what was done with that information (the socio-political management arena). In other words science and management were clearly two separate issues.

Elkana Ngwenya (AMC) wanted to emphasise the economics part of the equation. The fishing business was about making money and all the gear modifications made and all the strategies adopted should be an attempt to maximise economic gains. This was subject of course to biological constraints and other technical constraints in the actual process of producing fishing effort. In other words it was important to recognise that there was always a trade-off of objectives. For instance we may have a political objective traded-off against an economic objective, but because in this case we have an interest in maintaining the viability of the fishery it meant that we were going to be stuck with more of a biological objective being traded-off against a political objective. It may be that the decision will have no relevance whatsoever to stock dynamics. If the decision supports an economic benefit there is going to be more support for that decision.

Ian Poiner thought that an important point had been made in a previous session with respect to the selection between specific biological/ecological and socio-political objectives. The difficulty or complexity of the ecological or biological question was not sufficient reason for adopting a socio-political type objective and/or target.

The chairperson then invited discussion about the possibility of providing general approaches to target setting that may be applicable across fisheries. What aspects of methodology or process could be generalised?

Richard Tilzey highlighted the obvious differences between single species and multi-species fisheries and that target setting was going to be more complex in multi-species fisheries.

Ian Poiner agreed that setting targets was going to be fishery-specific and fisheries problem-specific but he thought there were aspects of process that one goes through to develop a bycatch action plan that could be generalised across fisheries. It was important to separate process issues from the problem issues specific to fisheries.

Adding to this point, Murray MacDonald suggested that when objectives related to stock conservation it was more likely that they would be fishery-specific. In contrast, general socio-political objectives such as bycatch reduction (as a result of bycatch being seen as undesirable by the community) are more likely to be a generic target set across a number of fisheries.

Julie Robins stressed the need to be aware that setting targets in one fishery may have ramifications for other fisheries. She suggested that some of the targets that had been set with respect to TEDs and BRDs in the NPF fishery were setting a benchmark, against which other fisheries will be judged. Pressure will almost certainly come onto fisheries in which bycatch reduction was not being addressed.

Colin Buxton suggested that the precautionary principle was a useful option when, in the absence of research, we needed to move towards bycatch reduction in any fishery. He asked whether the group had any view as to what precautionary approach might be appropriate. Was there some generic position that could be adopted? He suggested that, in the absence of good science to provide a target, it could be something like: "We will attempt to reduce the levels against what they were last year".

John Glaister countered that while this sounded great in theory, there were particular problems with such an approach. For example, as discussed with respect to the NPF, there may be pronounced inter-annual variation in prawn catches and there would be problems if the bycatch target was expressed in terms of reducing the ratio of bycatch to catch of prawns. A poor year for prawns would result in a high ratio of prawn catch to bycatch. He pointed out that, by definition, some fisheries were going to take bycatch and trawling was one of them. He then asked for a point of clarification. It had been mentioned that trawling was being talked about as a key threatening process. Did this just refer to prawn trawling or was it trawling in general?

Katrina Maguire (AFMA) replied that the nomination was for otter-board trawling for prawns in tropical waters but that the NGOs were gathering momentum to put up proposals for otter-board trawling throughout Australia.

Bruce Wallner responded to Colin Buxton's question concerning a precautionary or generic approach. He thought, particularly for the issue of fish bycatch from some of the prawn trawl fisheries, one could build a fairly compelling argument for doing nothing. He suggested that the *status quo* is the precautionary approach – rather than any attempt at reduction. Some would advance the theory that such systems were sustainable. Where you have three decades of track record demonstrating a reasonably sustainable system, reducing the quantity of dead fish that is going into the water will potentially change the trophic balances. This may destabilise the system.

Malcolm Haddon commented that several statements of the form "...we've had two to three decades of fishing and it appears to be sustainable" had been made. He then pointed out that there had been 250 years of the northern cod fishery before it collapsed beyond recovery and that there were indications that the NPF is not as healthy as it was five or six years ago. The duration of a fishery was no guarantee of its sustainability. He supported the comment that a precautionary approach was important. Declines in habitat quality through the effects of fishing could be insidious. Any moves towards reducing impacts of fishing were worthwhile.

Dave Brewer agreed and argued in response to Colin's point on precautionary targets that target choice ultimately depended on what was feasible. He referred to successful attempts at bycatch reduction in South Australia (against a background of relatively low diversity) and in New South Wales (70% reduction for some species), and suggested that targets would need to differ for fisheries such as the NPF, a remote fishery with high diversity of bycatch. He did not see the point of aiming at a 50% reduction of bycatch for the NPF when it was not immediately achievable – it was better to start with what was achievable and improve on that through time. The final target would vary from fishery to fishery.

An unidentified speaker suggested that the target should be the implementation and use of BRDs rather than a target in the reduction of bycatch. Such an objective was achievable, regardless of the outcome on bycatch reduction.

Murray MacDonald distinguished between generic targets (for social reasons) and targets made for specific conservation objectives. He considered that the issue of 'what is achievable' was an important issue in setting targets for the former. In contrast, for targets associated with specific conservation aims for particular bycatch species, the really important issue was setting a target that was going to be effective in achieving the specific objective. In some cases this might be beyond what is thought to be currently feasible.

Referring to the two previous comments, Malcolm Haddon made the point that implementing TEDs/BRDs in all prawn trawls may be a fine objective, but that without certification of such devices, introduction would not necessarily affect a reduction. A formal process of certification needed to be implemented across all fisheries.

Ilona Stobutzki (CSIRO) agreed. It required effort on behalf of fishers to put TEDs into their trawls and they needed to be provided with good reasons for the use of TEDs.

In an attempt to place the discussion in a broader context, Richard Tilzey noted that the overzealous use of the precautionary principle was like giving the pope a condom.

Elkana Ngwenya (AMC) followed up on the issue of whether the fishers were going to be interested in using BRDs. He believed that they would be supported for at least two reasons. Firstly, introduction of BRDs could lead to new fishing grounds (areas that had perhaps not been fished because of an abundance of sponges in the catch). He noted that effort may be redistributed. Secondly, they would not wish to jeopardise marketing opportunities by failing to install BRDs (the threat of sanctions).

The chairperson then moved discussion on to the issue of baselines and benchmarks.

James Scandol (FRI) stated that it was very important to get an idea of variability of bycatch so that estimates of bycatch reduction could be determined rigorously.

Murray MacDonald referred to the previous discussions of bycatch of seabirds from longlining and said there were two approaches. For a specific conservation target, the same kind of information was required as is required for a stock assessment process (current status of species in question; level of impact of bycatch versus other kinds of impacts on that population, etc.). This was necessary to evaluate the importance of bycatch in determining fluctuations of the population in question and setting specific targets for the biomass for the species. For bycatch reduction objectives that were more generic (for broader social objectives), the baseline will be defined by where we were now in terms of some level of bycatch. Assuming the desirable trend is downwards, the target should be framed with regard to what is considered achievable.

The chairperson commented that, for some fisheries, there may be historical data that could also contribute to setting a baseline for targets associated with the more generic socio-political objectives.

Aubrey Harris (BRS) thought that this area deserved significant attention. Apart from a handful of fisheries, we simply did not know what and how much is caught. Moreover, in many fisheries there are large inter-annual effects that came into play. There is an important need to collect such information for other fisheries.

Following this comment, Patrick Coutin (MAFRI) reminded the group about the very poor understanding of bycatch from recreational fisheries and gillnet fisheries – there was still significant work to be done in these areas.

Bruce Wallner (AFMA) commented that bycatch, in its broadest definition, included animals that were not caught (other fishing induced mortalities). He did not think it likely that we would ever reach the point where a good baseline could be established for these unseen effects. Bruce was unsure how we should respond to this.

Duncan Leadbitter (Ocean Watch) discussed the issue of appropriate baselines for targets associated with objectives based on social and perception issues (picking up on Murray MacDonald's previous comment). He argued that the baseline became some measure of the existing management structure in the fishery and the issue then was whether action has been taken from there. The baseline need not necessarily be in terms of the amount of bycatch.

The chairperson noted that there had already been some discussion of specific numeric targets compared to more general or 'trend' targets, but invited further comments or questions with respect to advantages and disadvantages of these approaches.

Dave Brewer thought that it could be desirable to employ a combination of the two. Some sort of numerical target if one knew something about the fishery but that there were advantages associated with the flexibility of the trend approach.

The chairperson made the point that the selection between the alternatives partly depended on the consequences of setting a specific numerical target and not reaching the target by the specified time.

Ian Knuckey (MAFRI) commented on the advantages of the numerical or trend approach on the basis of discussions with fishers at a recent workshop with SEF fishers. Introduction of BRDs in the SEF (a multi-species fish trawl fishery) will have some cost in terms of the actual catch of fishers. Consequently, the important question is: What loss of catch is acceptable in order to achieve some level of bycatch reduction?

The chairperson clarified that this was in particular reference to multispecies fish trawls where one component of the catch would be foregone in order to reduce bycatch of others.

Ian Poiner said that Malcolm Haddon's talk had illustrated the need for establishing performance indicators as an inherent requirement for setting a target. He did not see this as an impediment.

Malcolm Haddon argued for the advantages of the trend approach over specific numerical targets. He noted that uncertainty and variability of fisheries data made the detection of significant differences in bycatch targets difficult to measure with any confidence.

The chairperson then suggested to Malcolm Haddon that logically one could argue that, in the process of stock assessment and fishery management, one would avoid the setting of objectives or specifying targets for stock levels or levels of harvest because of the consequences of uncertainty.

Malcolm Haddon replied that there was a difference between specifying a target for stock level and setting a harvest level. One could set harvest level without firm knowledge of stock size.

Katrina Maguire referred to the recent workshop on bycatch reduction in the SEF and reported that there was a clear message from industry that they wanted to work towards targets. Targets gave them opportunities to play with gear and come up with initiatives in order to achieve an objective.

Dennis Heinemann (CSIRO) discussed the importance of focussing on the contrast between the two approaches for setting objectives in terms of the end-points that might be reached and the benefits of pursuing such objectives. It was important to be mindful of the potential consequences of failing to meet those objectives. He provided two examples. For a numerical target (associated with a conservation objective) it was possible to spend a lot of money but never have any hope of achieving the objective. The case of the albatross was an example – what we did in Australia may have little effect on the population of this species, a species that is distributed on multiple islands and has a home range across the Southern Ocean. In the case of the trend approach, the real danger was that you may achieve your objective (a downward trend) but the underlying conservation objective might not be achieved. It was possible to generate some acceptable and realistic scenarios that would result in this situation for the albatross.

John Glaister agreed with this statement but noted that other issues were also present. John cited Ian Poiner with respect to NPF in which 100s to 1,000s of turtles were being killed as a result of trawling versus 10-20 thousand that are harvested in South-East Asia for food. Despite these numbers, there is still significant pressure to reduce turtle bycatch in the NPF.

Murray MacDonald also contributed to this issue. He argued that if you were serious about trying to set and achieve conservation objectives you had to have explicit targets. With cross-jurisdictional issues (particularly international cross-jurisdictional issues) there are going to be problems getting all parties to agree to the objective. Nevertheless, without specific targets, you are unlikely to achieve the conservation objective. In the case of objectives that are more generic for social reasons – you can afford to have a less explicit target because you are trying to demonstrate that you are achieving some sort of trend downwards.

The chairperson moved the discussion on to the problem of how the lack of understanding of trophic dynamics and physical impacts of fishing affected the process of setting meaningful targets for bycatch reduction.

Ian Poiner noted that unobserved mortality should be added to this point.

Patrick Coutin thought that underlying the public perception of the problems with bycatch was the general feeling that removing large quantities of fish from the ecosystem was having a detrimental effect on the environment. The lack of data and understanding meant we could not educate the community as to whether or not this is the case.

Following this point, Bruce Wallner noted that conservation groups were increasingly wanting to be participants in the target setting process. However, because they do not understand the specifics of the fisheries issues, there was a role for fisheries agencies to educate these groups so they could play a meaningful role.

Don Hancock referred to an issue raised earlier by Bruce Wallner – that we didn't have the baseline for an understanding of the ecological effects of all fisheries. He questioned whether we had that information for any fishery and argued the need for continually building the knowledge base. We had to identify what work was needed and, specifically, what was holding us back from understanding the key points we keep raising. If we adopt the attitude that a problem is too hard and costs too much, we will never get to the crux of the matter.

The chairperson ended the discussion on this note and thanked everyone for their contributions.

Summing up

Ian Poiner[1], Steve Eayrs[2] and Colin Buxton[3]

[1] *CSIRO Marine Research, PO Box 120, Cleveland QLD 4163 (speaker).*

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[3] *Tasmanian Aquaculture & Fisheries Institute, University of Tasmania, Marine Reseach Laboratories, Nubeena Crescent, Taroona TAS 7053.*

Rather than revisiting the outcomes of the case histories or covering the same ground as the final discussion, we felt it would be useful to highlight some of the more important issues raised.

- The best quote of the workshop came from Darryl McPhee in summing up the industry perspective: "An industry that does not embrace bycatch issues will be a short one indeed". This is a sobering thought and cuts right to the quick. It captures the notion that we don't have time to elegantly research many of the issues before taking action and the need to urgently address the concerns of the community for endangered species.

- The workshop clearly demonstrated that the entire bycatch issue needs to be tackled in a collaborative and cooperative way. If we, the R&D providers and federal, state and territory managers do not involve industry in all steps of the process we will not get very far.

- In terms of addressing the problem of setting targets, the most important take-home message was the complexity of the issue. This is a major challenge and by no means a trivial issue. There is a high degree of uncertainty in many areas and the level of understanding of the issues is generally inadequate.

- It is difficult, if not impossible, to generalise with respect to targets or outcomes either in a generic sense across fisheries or within fisheries. Most of the issues are fishery-specific, species-specific and in many cases, area-specific within a fishery.

- There is a need to be clear and precise in the definition of the problem. This needs to take into account a range of often differing objectives including both socio-political and biological ones. In the face of good scientific information that may suggest that a particular fishing operation is sustainable in terms of low levels of bycatch, we might still be confronted by a political or community demand for zero bycatch.

- Duncan Leadbitter illustrated the importance of extending research results as a key to success. We are beginning to see the importance of this in several fisheries around Australia already. We need also to examine other industries and learn from their example.

- It was recognised that technology transfer was possibly the fastest way to progress this matter, finding international examples with applicability to Australia and giving them a go here. This has been the approach successfully used with respect to TED and BRD work in prawn fisheries.

- Development of threat abatement plans and bycatch action plans as a process may be easily transferred from one fishery to the next. The similarity in these processes obviates the need to reinvent the wheel.

- A target is a point for which to aim but it may also be a trend.

- Assessing the performance of the fishery and the performance of the management objective towards a target is of crucial importance. To do this, targets need to be measurable, must be monitored and must have performance indicators. The key will be review and the flexibility to change as needed.

In summary, there can be little dispute that bycatch is a major issue confronting Australian fisheries. This was clearly stated in the presentations of Session 1 which gave status reports of the bycatch problems in some of these fisheries. At the workshop planning stage 12 months ago, the organising committee felt that we had enough information to consider setting bycatch targets, if not for all of fisheries, at least for some of them. Clearly, however, this workshop has demonstrated that we have some way to go. Several obstacles were identified, not the least of which is the lack of understanding of the ecosystem dynamics and the interactions between target and bycatch species.

This should not distract us, though, because what is also clear is that we have moved forward and we see that the end point is in our grasp. We are confident that the proceedings of our deliberations will form a platform from which we can move towards targets for all of Australian fisheries.

In closing we'd like to thank all of you for your contributions to the workshop, especially the excellent talks given by the speakers. We also thank our major sponsors, the FRDC Effects of Trawling Subprogram, TAFI and the AMC, and the workshop organising committee who put a lot of work into making this happen. Last but not least we thank Cathy Bulman and her team for their help with the organisation, teas and lunches, and the CSIRO for providing their excellent venue.

Program

Day 1 – 24 September

0830 Registration
0900-0910 Introduction – *Colin Buxton*
0910-0930 Opening address – *Stuart Richey*

The following talks will be 10-15 mins presentation with 5-10 mins of discussion of each topic, status reports on each bycatch issue, extent and characterisation of catch, knowledge base, research work etc.

Session 1

Chairperson – *Nick Rawlinson*

0930-0950 Northern Prawn Fishery status report – *Dave Brewer*
0950-1010 Queensland east coast trawl fishery status report – *Julie Robins & Tony Courtney*
1010-1030 Focussing on bycatch in Australia's South East Fishery – *Ian Knuckey*
1030-1100 Tea
1100-1120 Factors affecting discarding in the SEF – *Geoff Liggins*
1120-1140 Seabird bycatch in tuna longlining fisheries – *Dennis Heinemann*
1140-1200 Bycatch from rock lobster pots in Tasmania – *Stewart Frusher*
1200-1220 Is bycatch an issue in Australian recreational fisheries? – *David McGlennon*
1230-1330 Lunch

Session 2

Chairperson – *Murray Johns*

1330-1350 How do we define bycatch? – *Aubrey Harris*
1350-1410 How does bycatch impact on biodiversity and the ecosystem? – *Ilona Stobutzki*
1410-1430 Trophic consequences of prawn trawling: linking bycatch to benthos – *Paul McShane*
1430-1450 Discarding as unaccounted fishing mortality – when does bycatch mortality become significant? – *Malcolm Haddon*
1450-1530 Tea

Session 3

Chairperson – *Paul McShane*

1530-1550 Bycatch: An industry perspective – *Darryl McPhee & Ted Loveday*
1550-1610 An 'environmental' point of view on bycatch – *Duncan Leadbitter*
1610-1730 Panel discussion – What are the obstacles to establishing bycatch targets in Australian fisheries? *(Speakers after lunch and Murray Johns)*

Day 2 – 25 September

Session 4

Chairperson – *Barry Evans*

0830-0900 AFMA and the Commonwealth Bycatch Policy – *Katrina Maguire*
0900-0930 Driving change: The need for extension of services – *Duncan Leadbitter*
0930-1030 Case studies (see below)
1030-1100 Tea
1100-1230 Case Studies
1230-1330 Lunch

Session 5

Chairperson – *Geoff Liggins*

1330-1350 NPF summary – *Ian Poiner*
1350-1410 Longline summary – *Andrew McNee*
1410-1500 General discussion
1500-1530 Tea
1530-1600 Summing up – *Ian Poiner, Steve Eayrs & Colin Buxton*

Case Study 1: Developing a bycatch action plan for the Northern Prawn Fishery

Chair: *Ian Poiner*

- History
- Approach
- The plan
- Outstanding issues
- Relevance to other fisheries
    South Australia
    Queensland East Coast
    WA
    NSW
    SE Trawl

Case Study 2: Developing a threat abatement plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations

Chair: *Andrew McNee*

- History
- Approach
- The plan
- Outstanding issues
- Relevance to other fisheries
    Other longline fisheries

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