FINAL REPORT TO THE FISHING INDUSTRY RESEARCH AND DEVELOPMENT COUNCIL OF PROJECT NUMBER 87/78

'Courses and consultancy in fish stock assessment'.

Fisheries Resources Branch
Bureau of Rural Resources

INTRODUCTION

Following the success of previous programs of training courses in fish stock assessment conducted in 1983 and 1986 by Dr Carl Walters and Dr Ray Hilborn, the Fishing Industry Research Committee was approached for funding of a similar program planned for April/May 1988. Approval was gained for a program which included the additional services of Dr Rick Deriso for two training courses and consultancy services to state and Commonwealth fisheries authorities. The project was to be overseen by the Fisheries Resources Branch of BRR but the original planning was carried out jointly by BRR, Mr P Millington (WA Department of Fisheries) and Dr J Glaister (QDPI).

The three consultants have impressive backgrounds in the fields of resource management generally and fisheries science in particular. Details of their qualifications have been given in the initial application and final report of the previous consultancy (FIRTA 85/92).

FINAL PROGRAM OF TRAINING COURSES AND CONSULTANCY

Due to the limits placed on the size of courses and the large number of prospective participants it was decided to convene an additional introductory course in Hobart. No additional funding was required since Dr Deriso, due to unforeseen circumstances, could not assist in the full consultancy program and funds previously committed to part of his fees and travel costs could be used to finance the additional course (a statement of receipts and expenditure is given on page 4 of this report). The periods covered by training courses are detailed in Attachment I. Time spent at each state fisheries department was reduced accordingly and consultation in Darwin cancelled to allow for the additional introductory training course.

The consultants held discussions with all state fisheries departments except the Northern Territory, as well as the Commonwealth Department of Primary Industry and CSIRO. The itinerary included Western Australia which had not been visited during the 1986 program. In addition, a two day abalone workshop was convened by Dr P Sluczanowski (SA Dept. of Fisheries) to discuss stock assessment in Australian species.

Attachment II lists all course participants according to their institutional affiliations.

Attachment III summarises course and consultancy activities.

The consultants' own report is appended at Attachment IV.

The majority of material presented at the first introductory training course was recorded on video tape. Copies of the recorded tapes have been provided to the FIRDC secretariat.

REVIEW OF PROJECT

That this FIRTA project has contributed to the enrichment of Australian fish stock assessment knowledge is indisputable. This is in no small way due to the experience of the consultants and to their energy and enthusiasm throughout the consultancy eg. see details of the demanding course and consultancy schedule, long hours and frequent night sessions reported in Attachment I and III.

The rising costs of such consultancies, their short-term and necessarily general nature and the lack of ready access to the consultants after the courses, however, raise questions as to their suitability as a long term solution to our training needs.

The almost total lack of post-graduate training in fisheries resource assessment in Australia has been noted by the consultants. Whereas this is at the root of Australia's weakness in this area, the relatively small demand for fish stock assessment specialists may mitigate against the establishment of a permanent teaching facility at University level.

Several alternative solutions could be possible, including

(i) establishing a University position or two to combine fish stock assessment education with other natural resource management studies.

(ii) short-term and specialised workshops conducted by Australian and/or overseas fisheries scientists and academics.

(iii) sending Australian fisheries scientists overseas to attend courses, work with other specialists and examine recent developments.

Each of these approaches had different funding implications. For example, (iii) is most likely to be funded wholly by the employing research institute and already occurs from time to time in most institutes.

In order to tailor university positions and short courses and workshops to address current fisheries research needs, it would be desirable that the impetus comes from the fisheries research community rather than the universities. In the current environment whereby universities are being encouraged to seek extra funding from external sources, the research insitutes would have to provide such funding. The benefit for such a cost would be better trained staff giving better advice to management on the status of stocks,

and so more profitable fisheries.

RECOMMENDATION

It is recommended that FIRDC designate a small unfunded (at this stage) working group to investigate an appropriate course of action to improve fisheries stock assessment education in Australia.

STATEMENT OF RECEIPTS AND EXPENDITURE (As of 31/12/88)

Receipts	Salaries	$ 26 100.00
(FIRTA Grant 87/78)	Operational expenses	50 139.00
	Total receipts	**76 239.00**
Expenditure	Salaries	22 500.00
	Operating expenses	48 116.80
	Total expenses	**70 616.80**

Detailed statement of expenditure

Salaries and wages		Consultancy fees:	
		Dr Walters	9 000.00
		Dr Hilborn	9 000.00
		Dr Deriso	4 500.00
Total salaries and wages			**22 500.00**
Operating expenses			
	Travel:	Fares	18 854.58
		Travelling allowance	12 292.04
	Training courses:	Gympie	9 113.19
		Hobart	2 075.00
		Sydney	3 670.00
	Other expenses (including funds committed for duplication of video tapes)		2 111.99
Total operating expenses			**48 116.80**
TOTAL EXPENSES			**70 616.80**

ATTACHMENT I

ITINERARY FOR DRS WALTERS, HILBORN AND DERISO.

9/4/88	Walters and Hilborn arrive Sydney.
11/4/88-15/4/88	First introductory stock assessment course, Forestry Training Centre, Gympie
18/4/88-19/4/88	Consultancy with Qld Department of Primary Industries and Energy, Queensland Fish Management Authority, Brisbane.
20/4/88-21/4/88	Consultancy with Marine Science Laboratories staff, Queenscliff.
22/4/88	Consultancy with Tasmanian Department of Sea Fisheries staff, Hobart.
25/4/88	Deriso arrives Hobart.
26/4/88-30/4/88	Second introductory stock assessment course, CSIRO Marine Laboratories, Hobart.
2/5/88-3/5/88	Consultancy with South Australian Department of Fisheries, Adelaide.
4/5/88-6/5/88	Consultancy with Western Australian Department of Fisheries, Waterman.
9/5/88-13/5/88	Advanced stock assessment course, Macquarie University, Sydney.
14/5/88	Deriso departs Sydney
16/5/88-17/5/88	Abalone workshop, Fisheries Research Institute, Cronulla.
18/5/88	Consultancy with N.S.W. Department of Agriculture and Fisheries staff, FRI, Cronulla.
19/5/88	Consultancy with Commonwealth Department of Primary Industries and Energy staff, Canberra. Conclusion of consultancy.

ATTACHMENT II

LIST OF TRAINING COURSE PARTICIPANTS

GYMPIE	HOBART	SYDNEY
QDPI		
John Glaister	-	John Glaister
Ian Brown		Mike Dredge
Clive Keenan		Reg Watson
Tony Courtney		Ross Quinn
Frank Duncalfe		
Lew Williams		
Clive Turnbull		
Alf Hogan		
John Russell		
NSW Fisheries Research Institute		
Phil Gibbs	Julian Pepperell	Phil Gibbs
	Vince McDonall	Geoff Gordon
	John Harris	Steven Montgomery
		Kevin Rowling
		Dennis Reid
CSIRO		
David Brewer	Bruce Wallner	Bill Hearn
	Chris Crossland	Ian Somers
	Sebastian Rainer	Keith Sainsbury
	Vicki Wadley	Derek Staples
	Jeremy Fitzpatrick	Kevin McLoughlin
	Peter Young	
	Sally Wayte	
	Rolf Lindholm	
	Janice May	
	Richard McLoughlin	
	Kevin McLoughlin	
	Cathy Bulman	
	Dick Martin	
	Nick Elliot	

GYMPIE	HOBART	SYDNEY
Victorian Marine Science Laboratories		
-	Dorothy Huber	Peter Moulton
	Anne Withell	David Hobday
	James Andrews	David Smith
	David Molloy	Nick Dow
	Ian Knucky	Terry Walker
		Paul McShane
Tasmanian Department of Sea Fisheries		
-	Warwick Nash	Warwick Nash
	Bob Kennedy	Bob Kennedy
	Will Zacharin	Will Zacharin
	Grant Pullen	Grant Pullen
	Alex Schaap	Alex Schaap
	Diane Furlani	
South Australian Department of Fisheries		
-	Rod Grove-Jones	Keith Jones
	Andrew Staniford	Phillip Sluczanowski
	Neil Carrick	Karen Hill
	David Hall	
	Mervi Kangas	
N.T. Department of Ports and Fisheries		
Roland Griffin	-	-
Rick Buckworth		
Western Australian Department of Fisheries		
Chris Chubb	-	Norm Hall
Mike Moran		Nick Caputi
Rod Lenanton		
Rick Fletcher		

GYMPIE	HOBART	SYDNEY
Bureau of Rural Resources		
Peter Jernakoff Geoff Williams Phil Stewart Neil Klaer	Peter Ward Gina Newton	Kathy Colgan
Australian Bureau of Agricultural and Resource Economics		
Sean Pascoe	Mark Nayar	Sean Pascoe Mark Nayar
Australian Institute of Marine Science		
Mike Cappo	-	-
Antarctic Division		
-	Dick Williams	-
Melbourne University		
Rob Day	-	Rob Day
Private consultants		
Neil Loneragan	Jeremy Prince	Neil Loneragan Jeremy Prince

ATTACHMENT III

SUMMARY OF CONSULTANCY ACTIVITIES

IST INTRODUCTORY COURSE - GYMPIE

This course was organised by Dr J Glaister and staff of the Southern Fisheries Research Centre of the Queensland Department of Primary Industries and Energy. A video of the course was made and a copy is enclosed.

The Workshop was held at the Forestry Training Centre at Gympie and a total of thirty delegates from State and Federal fisheries research institutes in Queensland, New South Wales, Australian Capital Territory participated.

The first day saw an exploration of some of the basic rationale of modelling and Walters' SIMCON Structure was explained as a vehicle. Population processes and models were then examined in detail.

Biomass dynamics models (Deriso-Schnute) were examined on day two. The simplicity (!) of Deriso's elegant model was demonstrated and some of the assumptions examined. Walters and Hilborn demonstrated a time series data management programme (GENEST) that additionally was adaptable to auxiliary data management, model fitting and confidence interval estimation. Northern Territory barramundi catch-effort data analyses illustrated the programme.

The third day commenced with an examination of fishermen behaviour - the fact that fishermen know of fish aggregations and concentrate on them, causing violations of many assumptions commonly made in stock assessment with catch-effort data. Hilborn made use of this problem in examining DEPLETE, a model useful in this area. Laboratory sessions with the microcomputers focused on this area. Examples included southern bluefin tuna and barramundi.

Recruitment questions were discussed at some length with the pros and cons of the various traditional recruitment models (and their assumptions) being closely scrutinised. The stock-recruitment relationship, problems in fitting a relationship (the errors in variables problem) and the general representativeness of samples, were discussed.

The common problems associated with length-frequency data analysis were discussed on day four, particularly with regard to feedback policy design. There was much interest generated in defining a constant, "safe" exploitation rate. Catch at age and virtual population analyses were also contrasted. Walters presented a concise description of the model building process. Bounding the problem, structuring the calculations by

"working outwards" and the process of recursion were developed in detail. The programme SIMCON was used to demonstrate this procedure.

The final day was devoted to adaptive management, the most recent school of thought on fisheries management and a thesis developed in a book recently published by Walters. The principal idea being that knowledge about a system is gained by experimental manipulation of the system and resultant feedback. Examples suggested included abalone, banana prawns, southern bluefin tuna and trawl fisheries. The costs and benefits of the approach were examined and the Western Canadian Experimental Management Project cited as an example of simulating future learning.

Delegates agreed it was a particularly worthwhile workshop and an educational experience.

CONSULTANCY - QUEENSLAND

Drs Walters and Hilborn held discussions with representatives from the Department of Primary Industries, Queensland Fish Management Authority and Queensland Commercial Fishermens Organisation at the QFMA office in Brisbane. They spoke at length on fisheries management in British Columbia and the South Pacific concentrating on practical management tools and their effectiveness. Dr Walters outlined the experimental strategy to be implemented in managing the Canadian west coast deepwater trawl fishery and the expected benefits of such an innovative approach. Dr Hilborn gave a precis of his work in Noumea particularly in the area of fleet dynamics and the conflict of fishermens' behaviour with the assumptions in many fisheries models.

The next day discussions were held between the consultants and officers from the DPI Fisheries Research Branch and Fish Management Branch, followed by an afternoon examining the proposed studies into the effects of fishing on the Great Barrier Reef particularly strategies for sampling, and identifying those effects.

CONSULTANCY - MARINE SCIENCE LABORATORIES, QUEENSCLIFF

During their visit to the Marine Science Laboratories, Professor Walters and Dr Hilborn discussed a wide range of topics in 1-2 hour sessions on major Victorian fisheries. These included:

Southern shark fishery - the suitability of CPUE as a measure of abundance in schooling species such as sharks.

Native flat oyster - a range of growth models, particularly predictive models which

might incorporate variables for temperature.

South eastern trawl fishery - orange roughy was the major species covered and the review of data and subsequent discussion formed the basis for modelling at the advanced workshop in Sydney.

Abalone - spatial and movement models.

In addition, a range of planning and management issues relevant to Victorian fisheries were discussed.

Professor Walters presented a seminar titled "Adaptive Environmental Assessment and Management (AEAM)".

CONSULTANCY - DEPARTMENT OF SEA FISHERIES, HOBART

The consultants spent one day talking to staff at the Taroona laboratory on issues concerning the state's fisheries including priorities for research. In the case of abalone, it was recommended that catch and effort trends, and stock-recruitment relationships should be investigated for isolated abalone populations rather than on a fishery-wide basis. Advice was given on research for the jack mackerel fishery and emphasis placed on comprehensive aging of sampled fish. Discussions also included the Tasmanian rock lobster and orange roughy stocks.

2ND INTRODUCTORY COURSE, HOBART

The second introductory course on Fish Stock Assessment was given by Professor Walters and Drs Hilborn and Deriso at the CSIRO Marine Laboratories in Hobart from 26 April to 30 April 1988. It was attended by 38 fisheries scientists from Tasmania, Victoria, South Australia, Western Australia and the ACT. Ms S Wayte was responsible for organising the CSIRO-based course in Hobart.

After a description of the types of fisheries stocks, and the kinds of data needed for stock assessment, the participants were introduced to the modelling process using the program SIMCON on IBM-PC compatible microcomputers. For many people, this course was their first encounter with computer modelling. The consultants pitched all their lectures and tutorials at a level appropriate to the skills and knowledge of the participants. The course covered models and data, stock-recruitment relationships, virtual population analysis, catch at age analysis and fisheries management strategies, using a combination of lectures and tutorials on the computers. As well, evening sessions were held on

topics such as 'Multispecies Fisheries' and 'Priorities for Stock Assessment in the Early Stages of a Fishery'.

All participants enjoyed the course tremendously, and learned a lot about approaches to solving the problems of fisheries stock assessment.

CONSULTANCY - SOUTH AUSTRALIA

Professor Walters and Drs Hilborn and Deriso visited the Department of Fisheries in Adelaide on 2 and 3 May, to provide consulting services. They carried out strategic assessments of research in a number of key fisheries including abalone, Western King prawn, southern rock lobster and the marine scale fishery.

They provided valuable advice with regard to the South Australian marine scale fishery where competition between sectors is likely to become a major concern in coming years. Based on their experience with similar developments elsewhere, they advised strategies to minimise conflict. They also suggested that a long term age sampling programme be instituted in the fishery. Mr N. Carrick, Senior Research Officer (prawns), discussed the depletion experiments he carried out on the Spencer Gulf prawn stock. Dr Sluczanowski, the Acting Research Manager, discussed the strategic overview of the Department's research programme and some of the consultants' recommendations have been implemented since their visit. The Department regarded the exercise as extremely valuable.

CONSULTANCY - WESTERN AUSTRALIA

Dr Walters presented a seminar on adaptive management strategies to staff from the Waterman Laboratories, CSIRO and universities. The remainder of the consultants' stay was spent gaining familiarity with Western Australian fisheries and providing advice on the assessment and management of selected fisheries, particularly the Shark Bay snapper and western rock lobster.

The Shark Bay snapper fishery catch/effort data were employed in a number of simulations aimed at determining the present status of the stock. No management recommendations could be given due to data limitations and the nature of the fishery, which concentrated on schools of spawning fish. It was recommended that examination of age structure of the stock and systematic surveys of the complete range of the stock would give a more reliable indicator of abundance.

An overview of the western rock lobster fishery was presented to the consultants and their views sought on the trends in historical data. A simulation was developed to

explore the possibility that catch rates might not accurately reflect abundance, but the conclusion from the simulation was that the catch rates were satisfactory.
They considered the hypothesis that the population was not as productive as currently thought. A model based on this hypothesis fitted the available data equally as well as those assuming higher recruitment and mortality rates. It was considered likely that gear efficiency had increased over time, adding a further complicating factor to the model and that the exploitation rate calculated from tagging studies could be too high. Concern was expressed that puerulus sampling should be extended, especially to those areas at the fringe of the population distribution in order to detect any downturn in recruitment. Further, there might be considerable merit in undertaking direct experimental work to produce good estimates of the abundance of spawning stock and population in deep water.

ADVANCED STOCK ASSESSMENT WORKSHOP, MACQUARIE UNIVERSITY

Mr D Reid organised the course held at Macquarie University, in consultation with Professor Gilmour of the Centre for Environmental and Urban Studies. The workshop covered the following topics:

Catch-at-age models
Size-age dynamics
Catch rates and spatial structure
Survey design
Filtering and adaptive estimation
Analysis of tagging data
Environmental factors in stock-recruitment
Generalised depletion estimators.

The course sessions ran from 8.30 till about 6.30 daily, with 2 additional night sessions of about 2 hours. There were some problems with the network of microcomputers, some of which arrived just prior to the course. This caused disruption to the amount of time that course participants could spend on computers, and also limited the scope of what could be done.

The specific fisheries considered during the workshop were Orange Roughy in the Great Australian Bight, scallop fisheries, abalone (depletion process model) and the Great Barrier Reef commercial fishery/recreational fishery.

The lecture material for the course was very well documented, and was well received by participants. There was a very substantial amount of advanced material covered by the 3 instructors, and the problem with the computing facilities was the only hitch in the

running of the workshop.

ABALONE WORKSHOP

A workshop to discuss the problems of managing and providing research information for abalone fisheries was organised by Dr P. Sluczanowski of the South Australian Department of Fisheries. Professor Walters, and Drs Hilborn and Deriso conducted the workshop in Sydney on 16 and 17 May 1988. It was attended by nineteen Australian scientists and fisheries managers involved in abalone including representatives from all relevant State fisheries departments and the University of Melbourne.

On the first day, representatives from New South Wales, Tasmania, Victoria, South Australia and Western Australia described their abalone fisheries, the biology of their stocks and relevant research. They also outlined proposed future directions and major concerns. The consultants then led the development of models, capturing the most important aspects of abalone stock dynamics. The work resulted in substantial progress over what had been previously achieved.

The modelling work confirmed a number of features unique to stocks such as abalone. The most important of these is that abalone stocks are not as productive as many other species. A consequence of this is that taking catch in excess of the sustainable yield will result in a continual long term decrease in abundance of the stock which becomes increasingly difficult to halt, requires increasingly severe management measures and requires increasingly long periods to recover. Recovery periods of over-exploited stock will be measured in decades rather than years.

The workshop identified those areas of research which would most benefit future management of the stocks. The lack of a reliable density sampling methodology is one of the most serious shortcomings, especially because catch rates cannot be used, as they are in most fisheries, as an indicator of stock abundance. Research is needed to compare the effectiveness of alternative sampling techniques. Experiments to determine whether the adult stock from one area can provide recruitment to an adjacent (perhaps overfished) one are also important.

At the conclusion of the workshop, all participants agreed that there had been substantial interchange of valuable information as well as progress towards understanding the dynamics of abalone stocks. It is becoming increasingly plain that managing abalone fisheries is very difficult and it appears that only long term studies can improve the situation. Unfortunately, this may be too late for some stocks.

CONSULTANCY- FISHERIES RESEARCH INSTITUTE, CRONULLA

The consultancy at the Fisheries Research Institute covered discussions of: gemfish data (K. Rowling); some detailed analyses of Tiger flathead, Eastern rock lobster and King prawn data (S. Montgomery); and general discussions of the work on spanner crabs (S. Kennelly).

CONSULTANCY - CANBERRA

The Canberra consultancy was conducted at the end of Prof. Walters and Dr Hilborn's Australian visit and much of the discussion at the Bureau of Rural Resources involved assessment of the courses and consultancies conducted. Possible alternative schemes for fish stock assessment education in Australia were investigated.

The conduct of the forthcoming Great Australian Bight multi-vessel survey was discussed. The consultants stressed the value of regular resource surveys, independent of commercial fishing, to estimate absolute stock abundance.

Other topics explored included the use of tagging studies in fish stock assessments, the effects of delaying effort-reduction measures on recovery imes of slow-growing species and the possible use of transponders in vessels to obtain accurate fishing position information. Prof. Walters delivered an address entitled " Experimental Management in Relation to the Study of Fish Population Dynamics.

ATTACHMENT IV

Final Report

Short courses and consultancies on stock assessment problems

Prepared for Department of Primary Industries and Energy

by

Carl Walters

University of British Columbia, Vancouver, B.C. Canada

Ray Hilborn

University of Washington, Seattle, Washington U.S.A.

Rick Deriso

International Pacific Halibut Commission, Seattle, Wash. U.S.A.

May 21, 1988

Summary

This report summarizes the views of the authors concerning key stock assessment weaknesses in some major fisheries, on needs for future development of stock assessment research and the state of affairs in education of Australian fisheries scientists on the use of quantitative methods in stock assessment. These views are based on our many discussions with assessment biologists from all states over the period 8 April-21 May, 1988, and on our previous consultancy in 1986.

We feel that there has been very substantial improvement in general computer and quantitative literacy among Australian biologists, particularly since 1986. Far more biologists

are not only using packaged microcomputer software, but also developing their own programs for statistical analyses and simulations. Along with increased use of computers and assessment models has come a much more careful and skeptical attitude about the validity of various stock assessment recipes and estimates.

In most states the key problem now in stock assessment is not ignorance of what tools to use, but rather lack of adequate data (or worse, availability of apparently good but actually very misleading data). In particular, there are serious gaps and flaws in the catch-effort data series that are being used to assess abundance trends in most fisheries. Inadequate attention is being paid to the behavior of fishermen in regard to the impact of that behavior on catch-effort patterns. Also there has been inadequate routine sampling of catch for age composition for many species, so that it is now impossible to apply some of the most powerful stock assessment methods for "reconstructing" historical patterns of stock size, recruitment, and exploitation rates.

Key stock assessment needs in Australia now include (1) the development of better systematic survey fishing schemes, in cooperation with commercial fishermen, to provide information on how the spatial distributions of stocks are being impacted by fishing (ie, are some stocks declining by disappearance from much of their range); (2) acceptance by Commonwealth and State agencies that routine collection of catch and effort statistics and age composition should be funded in all major fisheries on an ongoing basis, (3) the development of experimental management programs to provide direct, planned comparisons of the impacts of alternative management regimes; (4) development of much better programs to estimate catches, efforts, and catch distributions of recreational fisheries that are coming into progressively greater conflict with commercial fisheries; and (5) development of facilities to collect much larger age composition samples from the commercial and recreational catch of a variety of species around Australia, on a routine and continuing basis.

There is a continuing need for education in stock assessment concepts and methods. The major need is for post-graduate education in quantitative fisheries, something totally lacking in the Australian university system. While foreign experts may be brought in for short term projects such as this consultancy, this can in no way substitute for good university training in fisheries statistics and population dynamics. A concerted effort is needed to establish several university faculty positions to provide training in these areas, and it appears that such an initiative must come from outside of the universities.

There remains a short term need for in-service training in stock assessment methods. However, we are not convinced that continued short courses like we have been doing since 1983 (broad subject coverage, general audiences) will best serve this need. We think that the training emphasis should now focus mainly on techniques for model building to provide more realistic models specifically tailored to the peculiarities of individual stocks. This type of training is best accomplished through workshops that focus on specific case problems, and expose general modelling techniques by showing how they are applied in several cases. A series of workshops rather than short courses would also provide the side benefit of first-cut working models for the case stocks, which could then be refined over time by the workshop participants.

Status and Needs Regarding Stock Assessment Education

We were pleasantly surprised to discover that practically all participants at the Gympie and Sydney courses, and most at Hobart, had acquired at least rudimentary experience in microcomputer operating procedures and programming. Most were able to use our packaged

software with ease, and to follow our demonstrations on programming and model building well enough to detect and comment on various programming mistakes as we made them.

We were also surprised to see that extensive use has been made of several programs introduced in the 1986 courses, particularly the CATANAL program for catch-at-age analysis and the SCHNUTE (now GENEST) program for fitting catch-effort time series data to delay-difference population models. These programs have not given particularly credible results (population parameter estimates) in most cases, due to their stringent data requirements, but trying to use them has stimulated efforts to improve data gathering and experimentally evaluate various assumptions underlying them.

There was one substantial disappointment regarding assessment education. In the 1986 courses we developed a number of simulation models for specific fisheries (prawns, barramundi, bluefin tuna, abalone), expecting that these models would be further developed and that the modelling techniques would be applied to a variety of other fisheries. On this visit we found that there is still considerable enthusiasm for such modelling, and we found repeated reference in various reports to plans for model development. However, we did not encounter a single instance where the modelling had actually been done, even where only a modest investment of time and effort would be needed.

It is critically important for Australian scientists to develop skill at modelling specific situations. Too many Australian fish stocks do not fit any classical model for spatial distribution, changing vulnerability to fishing over time and age, and allocation of harvest among gear types. For example, elaborate and expensive tagging experiments have been done on several species in order to estimate harvest and migration rates. The results of these experiments have often been analyzed by simple classical techniques such as catch curves that ignore most of the information in the data and give misleading estimates due to hidden assumptions in the classical derivations. Case-specific modelling would help to both design such experiments to be more effective, and to extract much more information from the results.

Most Australian scientists involved in stock assessment have quite adequate training in the mathematical relationships and programming techniques needed to do better modelling. What they lack is confidence in knowing when to apply these techniques, and experience in organizing component equations and techniques into new models.

The development of further confidence and experience will not be accomplished through courses that emphasize lectures and demonstrations as we have done in the past. If we are to be of further assistance, it should be through a series of case workshops where the onus for model development and programming is placed on the workshop participants (Adaptive Environmental Assessment Workshop format), with our instruction being limited to organizational advice, assistance with specific programming and modelling techniques, help to avoid various pitfalls (troubleshooting), and assistance in interpreting the results. The aim of such workshops should be not only educational, but also to provide initial models for which there is a commitment to further development in terms of specific responsibilities, timetables, etc.

Good candidate cases for training/model development workshops over the next two years include: (1) impacts of trawl and recreational fishing in the Great Barrier Reef; (2) comparative population dynamics and effects of regulation on rock lobster stocks throughout Australia; (3) development of recreational and commercial fishing conflicts with barramundi, snappers, and Australian salmon; and (4) comparative population dynamics and responses to exploitation of northern and southern shark stocks.

Key Assessment Difficulties

In examining data from around the country, we repeatedly encountered similar information gaps and difficulties in interpreting observed patterns. These gaps and difficulties relate primarily to the use of commercial catch and effort information to indicate trends in stock size and productivity, to the lack of systematic sampling of catches for age composition, and to lack of information on recreational fishing impacts.

Interpretation of Commercial Catch Rates

General trends in abundance and productivity are usually assessed from commercial catch per effort (cpue) statistics. We encountered a number of instances (sharks, abalone, orange roughy, schooling species taken by seining) where cpue is likely to remain high even after substantial stock decline, due to progressive concentration of fishing effort on remaining fish concentrations. We also saw instances where cpue may drop very rapidly within each fishing season or among years even if the total stock is lightly exploited, due to rapid depletion of local fish concentrations that do not reform quickly (lobsters, prawns, perhaps orange roughy). There is no way to detect either of these biases without detailed information on the spatial distribution of fishing effort relative to the concentration patterns of the stocks. Persistent high cpues could lead to overfishing before decline is detected, while rapid cpue drops could be misinterpreted as overfishing when in fact there is considerable room for further development.

Cpue data from recreational and hook-and-line commercial fisheries are particularly difficult to interpret, because of effort targeting and switching of targeted effort among species. For example in some South Australian data we even saw hook-and-line cpue increases following rapid seasonal depletion by net fishing, apparently due to poorer fishermen going elsewhere and leaving only the best fishermens' results reflected in the catch rate statistics.

There have been some efforts to supplement commercial cpue data with abundance surveys deliberately designed to provide a more systematic picture of changes in spatial distributions (most notably for Spencer Gulf prawns, orange roughy). However, the survey grids have been hopelessly coarse (especially for orange roughy) except in cases where the commercial fishermen have been co-opted to substantially increase the amount of survey fishing effort.

Routine Collection of Catch and Effort Statistics

While there are a number of fisheries where routine collection of catch and effort data has been well maintained, there are a surprising number where either catch data has only recently begun to be collected, or even worse, where existing catch data collection systems have broken down for a number of years. A number of current catch data systems are funded only on a short term basis (FIRTA for instance), and the state governments have been unwilling to commit to an ongoing catch data system. Catch data (combined with age composition mentioned below) is simply the most basic fishery statistic and must be recognized as such. In addition to collection of the data, the agencies must commit the necessary resources to computerize the data and make it available to biologists and managers.

The Commonwealth logbook program is a good example of a catch and effort collection system that is essential to the long term management of the stock, but which appears to have not

received the priority it should have. In 1986 many people promised us that they would soon be able to examine the spatial pattern of catch rates from the logbook program, but in 1988 we saw little availability of this data within the state fisheries agencies. We did see, however, that BRS was developing some spatial mapping routines for the Commonwealth logbook data, and we were shown spatial maps of yellowfin tuna catch, cpue, and effort.

Collection of Routine Age Composition Samples

Annual estimates of the age composition of commercial catches can eventually be used to backcalculate stock sizes and exploitation rates (virtual population analysis), and these stock size estimates can in turn be used to validate other estimation methods (surveys, depletion experiments). Hence composition sampling is critical for long term understanding and management, especially in those fisheries where abundance trends cannot be inferred from cpue data (hook-and-line, seine, trap fisheries).

We found that routine ageing is not being done in many cases even where good ageing methods are available, apparently because either (1) the use of age information is not understood, or (2) fear of bias when the data are used incorrectly (catch curves, etc), or (3) difficulties in economically obtaining and processing representative age samples, or (4) mistaken belief that age composition can be inferred from cheaper length composition sampling coupled with age-length keys (in fact age composition estimates obtained this way are usually grossly misleading, especially about recruitment trends and exploitation rates. The S.E. trawl gem fish data are a typical example, where due to staff limitations only 4 years of age composition data have been collected. Such fisheries should have annual age composition taken as a routine matter of fisheries management.

Assessment of Recreational Fishing Impacts

Recreational fisheries are developing rapidly for a wide variety of species, ranging from lobsters and prawns to barramundi and snappers. In a few cases recreational catches may now exceed commercial catches. The general experience in such settings around the world is that recreational fishing wins out over commercial fishing in political battles over allocation, with the battles characterized by arguments over comparative economic values and by wholesale use of misinformation (pretense that recreational impacts are small because each fisherman takes little, blaming commercial fishermen for indirect impacts such as habitat damage, etc.). Defusing the misinformation can consume a great deal of valuable research and management time.

A key step toward sensible recreational/commercial joint management and allocation is to obtain good estimates of recreational catch and effort, through creel surveys, licensing programs for recreational fishing, and mail surveys. There has been a tendency to put off this step across Australia because it is expensive and controversial. However, without it the future expenses and troubles will likely be even larger.

The analysis of tradeoffs between recreational and commercial fishing requires case specific models, which can trace through the impacts of differential exploitation rates on different age classes and areas. Classical assessment models do not provide the needed flexibility. There appears to have been little effort to develop appropriate models for Australian situations, beyond what we initiated on barramundi as an example in the 1986 courses.

Recommendations

There are substantial opportunities in Australia for improved stock assessment and management. Our main recommendations have to do with information gathering rather than modelling and statistical analysis of existing data.

1. Improved logbook systems and analysis of spatial patterns

Existing logbooks for most fisheries do not record fishing locations with sufficient accuracy to permit analysis of changes in spatial distributions of catch rates and proper spatial averaging of these rates so as to correct for effects of aggregation on apparent trends in relative abundance. Even where the logbook data are sufficiently detailed, good data management systems for catch rate mapping and averaging are not available or consistently used. Wherever possible, fishermen should be required to log accurate bearings for each shot or set (with the records to be kept confidential), and statistical programs developed to permit mapping and averaging of these data. Most importantly the logbook systems that are now in place must be recognized as the basic element in a fishery management system and should receive rock solid core funding on a permanent basis. State and Commonwealth agencies should commit themselves to collection of catch data as part of accepting the responsibility for management of the resource.

2. Systematic and cooperative survey systems

Even very detailed logbooks will not fill some important gaps in information about spatial distributions. The experience in North America and Europe is that catch and age data provide an adequate basis for retrospective description of what happened in a fishery, but real time management of fisheries requires surveys. The gaps in logbook data should be filled wherever possible through systematic survey fishing (grids of sets or hauls), preferably conducted by the fishermen through cooperative management arrangements such as Neil Carrick uses with the Spencer Gulf prawn fishery.

A variety of inducements can be offered to fishermen to cooperate in systematic surveys. These inducements include promises of less restrictive catch limits when abundance trends are better monitored, access for cooperating fishermen to closed areas or seasons, and amendments to individual quotas or limits. The traditional inducement of direct charter fees should be avoided wherever possible; it is unnecessarily expensive and generally results in much smaller samples than can be obtained by having a number of cooperating vessels.

3. Development of a routine fish aging facility/service

Age composition sampling is one of the most informative types of data that can be collected for fisheries management and will require samples of around 1000 fish per year for each fish stock. There are dozens of stocks around Australia for which this sampling would not be economical if it meant adding staff and equipment to existing laboratories. Also there is considerable duplication of effort on aging among laboratories.

We recommend establishing a single routine aging center that can process at least 20,000 samples (otoliths, scales, etc) per year, staffed with experienced aging technicians from around the country and equipped with key devices such as a scanning electron microscope. This center might house scientific staff to do basic research on aging methods, but its primary function would be to provide consistent aging on large routine samples. If FIRTA could provide seed money for the physical facility and core staff, state agency users could provide sustained funding on a per-sample basis.

4. Large scale management experiments

Many impacts of fishing and changes in regulatory policies will not be revealed by existing monitoring programs, at least in the foreseeable future. Examples include impacts of trawling on Great Barrier Reef fishes, effects of reproductive refuges on recruitment to scallop stocks, longer term impacts of erosion of population age structure on recruitment rates for longer lived stocks such as snapper, and relative importance of environmental "cycles" (El nino, etc) as opposed to fishing in causing recruitment changes.

We recommend the use of large scale, planned management experiments to provide direct, empirical comparisons of areas that are subject to differential impacts. A key to the success of such experiments will be to develop much better systematic monitoring programs than are usually used in fisheries assessment. Cooperative survey arrangements (point 2 above) involving commercial fishermen offer one way to expand the monitoring at minimum direct cost to management agencies.

5. Research on the behavior of fishermen

The interpretation of cpue data and prediction of impacts of changing regulations in multispecies fisheries depend heavily on understanding how fishermen where to fish and how long to fish, and on the factors that limit their catch rates while fishing (handling time, etc).

Studies on fisherman behavior are urgently needed in a number of fisheries, especially where detailed logbooks, surveys, and fish aging are not practical as means to calibrate or validate abundance trend information based on cpue. Behavior studies should be done in conjunction with, or accompanied by, depletion experiments in designs such as Paul McShane has used in his Victoria abalone study.

6. Comparative studies of recruitment variation

Recruitment declines or cycles have been observed in a number of important Australian fisheries, and there has been controversy about whether the cause is environmental change or recruitment overfishing. Where deliberate management experiments are impractical, some insight can be obtained about environmental effects by comparing variation among stocks of the same species and by examining patterns of variation among species that are subject to the same general environmental changes (Eg among species whose larvae and juveniles are affected by the Lewen current).

We recommend a series of workshops to bring together long term abundance and recruitment data, in standardized formats for comparison, for at least the following cases: (1) prawn stocks all around Australia; (2) snappers; (3) fishes using the Lewen current; and (4) fishes taken in the southeast trawl fishery.

7. Recreational fisheries monitoring

Recreational fishing will likely continue to grow, especially in more remote areas as access improves and areas near population centers are overfished. Stocks that can withstand either commercial or recreational fishing will be hard put to sustain both, and severe political conflicts will develop.

We recommend a concerted program to develop and test creel census (cpue, effort) methods for widely dispersed marine sport fisheries. It is also worth considering a nationwide mail survey program to obtain rough estimates of fishing efforts, regional movements of sport fishermen, and total catches (though such mail surveys are prone to severe bias).

8. Continued training in stock assessment and modelling

The top priority in stock assessment training is to develop a graduate program in quantitative fisheries management within Australia. Some mechanism should be found to recruit several university faculty who have experience in fisheries management and statistics and would be able to provide post-graduate training in these areas and conduct research programs in the area of fisheries management, hopefully in conjunction with State or Commonwealth agencies.

As noted in the first section, we believe that the key in-service training need now is to develop Australian experience and expertise in modelling techniques, so as to permit timely analyses of local fisheries without resorting to models developed elsewhere, for other purposes. This need is particularly acute in relation to the analysis of recreational/commercial fishing tradeoffs and conflicts, and in relation to the design of large scale management experiments.

We recommend continuing support for training meetings, but in the form of modelling workshops focussed on specific fisheries problems rather than survey short courses. An opportunity to begin such a workshop sequence will be September 1989, when Walters is planning to start a sabbatical leave of at least six months in Australia. At that time, it would be relatively inexpensive to hold a workshop on Great Barrier Reef fishing impacts in conjunction with the Australian Fisheries Society meeting in Townsville.