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TITLE OF PROPOSAL/PROJECT: Course and consultancy in fish stock assessment techniques

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REPORT ON WALTERS-HILBORN AUSTRALIAN STOCK ASSESSMENT CONSULTANCY

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INTRODUCTION

This report summarizes impressions gained by the authors about Australian fish stock assessment capabilities and problems during a five-week consultancy in April-May 1986. Our comments are in four areas: (1) the training of Australian stock assessment biologists--here we were much impressed with the awareness of staff in all centres visited; (2) development of data bases on major fisheries--here we are concerned that there are serious gaps in data on the early development of most fisheries, and there has been too much willingness to rely on traditional and often misleading statistics; (3) uncertainties in some major fisheries--data for stocks such as the southern bluefin tuna are consistent with some very divergent alternative hypotheses about status and future potential; (4) data gathering and management needs for the future--there is a need to gather more data on the spatial patterns of abundance of key stocks, and to engage in deliberate management experiments on spatially structured stocks such as abalone.

AUSTRALIAN TRAINING IN STOCK ASSESSMENT

At every centre visited, we encountered good people trying hard to make sense of limited data. We felt that most of them have a good intuitive grasp of population dynamics and many have the mathematical and statistical backgrounds needed to make use of recent advances in techniques for stock reconstruction and production parameter estimation. We were pleasantly surprised to find a number of people who were already familiar with and using these advances, indicating that keeping up with the recent literature is not as serious a problem as we have found in other places such as the US and Canada where people often ignore recent literature in favour of "tried and true" methods.

We were also pleasantly surprised to find most biologists quite familiar with the need for economic regulation (licence limitation, vessel quotas, etc), and to have a good grasp of the strengths and weaknesses of various regulatory measures that have been tried. We found many biologists willing to step beyond the bounds of their disciplinary training and to gather behavioural data on fishermen's response patterns just as though they were natural predators.

The only potentially serious weakness we often saw was a tendency to accept existing methods and elaborate equations uncritically, and to apply them as "gospel" in situations where basic assumptions are obviously violated. We hope that the stock assessment courses have helped to foster a more critical attitude, and more particularly an insistence by Australian scientists that every statistical methodology be carefully tested using methods such as Monte Carlo simulation.

DEVELOPMENT OF DATA BASES FOR STOCK ASSESSMENT

We were repeatedly surprised to hear Australian scientists complain about the lack of data and short history of experience with most Australian fisheries, as though the situation in Australia were unique. In fact, the data base is as good (and as poor) for some key fisheries as would be found anywhere in the world. We saw the same problems that have plagued fisheries assessments everywhere: (1) lack of good data on pre-fishery stock sizes and responses to early fishery development; (2) difficulties in interpretation of relative abundance trends as evidenced by catch/effort data, due to nonrandomness in fishing patterns and changing fishing technology; (3) lack of sufficient contrast in historical stock sizes to permit estimation of stock-recruitment relationships; and (4) difficulties in finding good ageing techniques and in the interpretation of growth and mortality patterns from length composition data.

The DPI and other logbook programs will likely provide better information in the future on spatial patterns of fishing effort and relative abundance, which will permit better estimation of abundance trends from catch/effort statistics. However, it is important not to use historical, spatially aggregated catch/effort data as an indication of stock trends. In some cases, such as abalone and sharks, the available catch/effort data probably underestimate rates of stock decline; in other cases, such as South Australia rock lobster, the catch/effort statistics indicate more dramatic declines than have probably occurred.

For many major fisheries, too much reliance has been placed on the gathering and use of length frequency statistics as indices of mortality patterns. In fact length frequency data generally underestimate the impacts of fishing, due to variablility in growth rates, compensatory changes in average growth rates, and invariance of length distributions to fishing mortality changes in heavily fished stocks where recruitment rates are proportional to parental stock sizes (ie. recruitment overfished stocks). In view of these problems, existing techniques for length frequency analysis (age-length keys, ELEFAN, etc.) are likely to give grossly misleading results about total mortality rates and recruitment trends.

Australia appears to have a few unique management situations involving small fishing fleets and good cooperation between fishermen and management biologists. In such situations the fishermen can act partly as survey samplers of abundance patterns, leading to much more precise stock assessments than are possible in the more typical circumstance where fishermen view data gathering as economically threatening. We were particularly impressed with the Spencer Gulf prawn fishery as a model for cooperation between management and industry, and urge other biologists to heed the example set there.

UNCERTAINTIES IN SOME MAJOR FISHERIES

During the consultancy we examined data from a wide variety of fisheries, and did independent stock assessments on as many of them as possible. In some cases our conclusions were quite different than had previously been reached, indicating that the available data are consistent with a variety of hypotheses concerning stock trends and potential productivity. This section summarizes a few examples of these hypotheses, illustrating problems with data bases and with existing assessment techniques. Our motivation in presenting the following examples is not to criticize other workers, but instead to emphasize the need for better data gathering and methods of analysis.

Northern Territory Barramundi

Catch/effort data indicate that commercial fishing has rapidly depleted the stocks from some rivers, with catch per effort now stabilized at levels set by economic factors such as accessibility. Though accurate sport fishing statistics are not available, it appears that sport fishing is growing rapidly in the more accessible rivers, and that this activity is beginning to impact on recruitment rates of older fish to the commercial fishery. Tagging data indicate that the sport exploitation rate has not yet been significant, but it is possible that mortalities after tagging have been high; this would cause the tagging experiments to underestimate exploitation rates.

So while some data indicate that the fishery is stable with sport harvests only a long-term concern, it is in fact possible that there is a significant and rapidly growing impact of sport fishing, which will soon force substantial allocation (sport vs commercial) decisions and possibly a rapid shift in commercial fishing pressure onto less accessible river systems. If the latter hypothesis is true, there may be a "panic" reaction to develop hatchery-based production supplementation, and such a policy would exaggerate the decline of wild stocks by permitting or encouraging continued high fishing pressure.

Prawn Fisheries

Recruitment rates in most prawn populations worldwide are extremely variable, and this has led to the suggestion that spawning stock is not an important determinant of recruitment so that recruitment overfishing should not be a major management concern. However, there are disturbing hints of recruitment overfishing in cases such as the Exmouth stock, and indications of eroding stock structure (smaller and fewer aggregations) in cases such as the Gulf of Carpenteria banana prawns. Some historical data that appear to argue against recruitment overfishing may in fact be misleading due to errors-in-variables and time series regression effects when plotting recruitment estimates against estimates of parental spawning abundance.

Much emphasis in prawn stock assessment has been placed on estimation of growth and mortality patterns, so as to suggest the best yield per recruit management strategy in terms of timing of harvest relative to the growth schedule. That is a laudible emphasis, but should be accompanied with equal concern for the possibility that recruitment declines have (and will) be masked in the short term by variablity due to environmental factors.

Southern Shark Fisheries

Catch/effort statistics indicate that Gummy and School shark stocks have declined markedly in recent years, but are not yet severely overfished. Life history (survival, fecundity) estimates suggest that sustainable exploitation rates are quite low, and that recoveries after severe overfishing would be very slow. Effort reductions have been proposed in order to stabilize stock sizes at current levels, presuming that the stocks are not already severely overfished.

However, it is quite possible that the catch/effort statistics represent a "successive mining" situation in which CPUE remains high until the overall stock is severely depleted, due to ability by the fishermen to find and exploit fish concentrations until such concentrations have practically vanished. Thus an alternative hypothesis about sharks is that the stocks are already depleted, and catches will soon fall. The only ways to test this hypothesis are either to wait for the collapse, or to look in detail at historical patterns of change in the spatial distribution of catches and efforts.

Tasmanian Abalone

As for the southern shark fisheries, catch/effort statistics for the Tasmanian Abalone would suggest that the "stock" (probably many distinct small populations) declined at first, but is now relatively stable at near an optimum level for sustained production. In this case there is more information available about the spatial pattern of fishery development.

It appears that the fishery first concentrated on accessible, safe diving areas, then progressively moved into more difficult diving areas as the easy areas were depleted and when there were economic incentives to dive in riskier areas. Thus the catch/effort data are consistent with the hypothesis that stock size has continued to decline over the whole development of the fishery, so that sustainable yields are substantially lower than recent historical catches. Fortunately this hypothesis can be tested by economically modest management experiments on local populations, involving reductions and increases in local fishing pressure and monitoring of abundance changes. Such experiments could be done very cheaply if commercial fishermen can be co-opted to do the monitoring as well as the changes in exploitation.

Southern Bluefin Tuna

This tuna is perhaps Australia's most difficult fishery management problem. As a long-lived, late-maturing species, the bluefin should be particularly susceptible to overfishing. If the fishery does collapse there will be a long recovery period. Adult stock size has continued to decline throughout the history of the Japanese longline fishery, and this decline has been exaggerated by the Australian fishery on immature (1-6 yr old) fish.

Virtual population analyses by CSIRO have suggested that the juvenile recruitment rate (age 1-3 stock size) has remained high in spite of the decline in adult stock size, implying that management should concentrate on the allocation of catches between the Australian and Japanese fisheries. However, when we did virtual population analyses on the same data, we found that recruitment has apparently been declining since well before the Australian fishery reached its peak; based on this analysis we would predict sharp declines in juvenile recruitment to the

Australian fishery in the next few years, followed likely by a collapse of the Japanese fishery. Thus VPA gives two very different hypotheses about the history and future of the stock. The difference between the CSIRO and our analysis is in assumptions about so-called "terminal exploitation rates", ie. harvest rates for young fish in recent years; as far as we can tell, the alternative assumptions cannot be tested with any data now available on the fishery.

Scallops

It seemed to be a routine in the fishery centres that we visited to first bring out data on apparently well-managed fisheries such as rock lobster and abalone, then end with comments about how the fun was over and it was now time to look at the horrible situation with scallops. It appears that the scallop fisheries first develop by taking an accumulated stock consisting of several age classes, then have to rely on annual recruitments after the accumulated stock has been depleted. As is typical of most marine organisms, the recruitment rates have turned out to be highly variable and there is no mixing of ages at recruitment (in contrast to abalone or lobster where individuals reach the size limits at varying ages) to smooth out the year to year variations. Thus the scallop fisheries now appear to be very erratic, and to be supported by recruits produced by residual spawning stocks that are not aggregated enough to be economically fishable. The presence of such residual stocks implies that recruitment rates will appear to be independent of stock size over the range of residual stock sizes observed in recent years.

One simple hypothesis is that recruitment rates are now as high as they have ever been, and that erratic fluctuations will be an unavoidable factor in future scallop fisheries. However, age compositions and recruitment rates were not measured during the early development of the fisheries, and it is possible that they would be higher and more stable if a larger, mixed-age spawning stock were maintained. The only way to test this alternative hypothesis would be to reduce exploitation rates on a fairly closed stock such as Port Phillip Bay, then see if catches eventually move to a higher, more stable level.

MANAGEMENT AND RESEARCH RECOMMENDATIONS

As the above examples indicate, we repeatedly encountered two basic types of uncertainties about Australian fisheries: (1) historical trends and responses to management masked by inadequate catch/effort and or age composition data; and (2) recruitment relationships not apparent in the range of data available. We have five basic recommendations for data gathering and joint research-management programs to help reduce these uncertainties.

(1) ANALYSIS OF SPATIAL PATTERNS IN CATCH AND EFFORT

Wherever shot logbooks have been kept, there is a need to examine historical spatial patterns of fishing pressure and catch per effort in detail, so as to ascertain whether the spatial distribution of fish is being eroded over time by the fishing process. This analysis will require development of spatial data mapping systems compatible with existing computer data bases containing logbook information. A key research and judgemental issue is what to assume about abundance in areas receiving no or little fishing pressure.

(2) INSTITUTE SYSTEMATIC FISHING AS PART OF LICENCE REQUIREMENTS

Analysis of spatial abundance changes in (1) above will doubtless reveal gross gaps involving areas not fished regularly. Ultimately, this problem can only be resolved by having a sampling grid where the commercial fishery and/or government survey vessels conduct regular abundance surveys. Considering the very large "sampling power" available in most commercial fishing fleets, it would be more economical to have fishermen do regular surveys than to use government vessels. The resulting data on spatial patterns and trends in abundance would pay back the industry by providing early warnings of biological dangers, hence reducing the need to use conservative regulations so as to be sure of avoiding such dangers in the face of poor abundance data.

(3) DEVELOPMENT OF FACILITIES FOR AGEING LARGE SAMPLES OF FISH

In many fisheries it has been hoped that length-frequency changes will provide adequate assessments of changing mortality rates. This hope is not justified, and large (several thousand fish) age composition samples should be taken for major species on an annual basis. Ageing technology (otolith break-and-burn methods, vertebral sections, etc.) is available, but is costly to use with small and fragmentary samples. A single central facility with proper equipment and skilled technicians could handle most of Australia's routine needs.

(4) MANAGEMENT EXPERIMENTS ON SPATIALLY STRUCTURED STOCKS

Many species such as abalone, scallops, barramundi, and prawns consist of a number of reproductively isolated subpopulations. Where there is concern about the sustainability of production or about the effects of regulatory changes (such as lower size limits in Victoria abalone--possibly a $20 million gain in fishery value), the subpopulations should be treated as a series of experimental replicates, with varied regulatory treatments and some controls for environmental effects. Such experimental management will not only resolve uncertainties much faster than time-series management, it will do so at much lower economic risk. The basic concept is to determine production limits through local, highly visible demonstrations of success and failure, rather than to have such demonstrations occur anyway over long time periods on large scales.

(5) SEEKING INDUSTRY AND POLITICAL HELP IN FORMULATING POLICIES FOR DEALING WITH MAJOR UNCERTAINTIES IN THE LARGE FISHERIES

Australian fisheries scientists have largely followed a world-wide tradition that we find deplorable, namely to pretend understanding and certainty from assessments that are in fact not defensible. This is supposedly "necessary" to maintain "professional credibility." Unfortunately, the pretense of certainty never works in the long run, and may actually delay action in cases where the risks are large and error recovery times are very long. Decisions about how to deal with the risks noted above for major stocks such as tuna and sharks are not properly the domain of biologists and scientific stock assessment in the first place; the role of stock assessment should be to precisely define what these risks are and options for dealing with them, and to devise ways to present alternative scenarios and policies clearly to political decision makers.