LINKAGES BETWEEN STOCK ASSESSMENT AND MANAGEMENT

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Introduction

The most important aspects of the links between stock assessment and fisheries management relate to communication: the way that fisheries scientists answer questions. Asking questions, giving answers, and interpreting the answer are usually not as simple as we would like.The reasons for poor communication are many, but a common attribute of poor communicators is that they are also poor listeners and do not hear the question properly. Consequently, the answers are likely to be incomplete. Although fisheries scientists are often guilty of answering the wrong questions, a more common criticism by fisheries managers is that the answers contain so much uncertainty that they are unhelpful. On the other hand, it is also true that fisheries managers often have objectives that are not precisely specified and hence, difficult to address from a scientific perspective.A separate, and common problem for fisheries scientists is that the uncertainty built into stock assessment reports is interpreted as excessive caution, or in other words, conservative bias.

The first choice of title for this paper was "Just answer the question", meaning that many fisheries scientists often fail to answer the questions being asked. Recently, concerted attempts are being made to answer the questions posed by fisheries managers and industry through the use of risk assessment. The aim is to find new ways to express the uncertainty in stock assessments, while coming closer to answering the important questions such as estimating the robustness of particular management options. Here I discuss, from a Commonwealth fisheries perspective, the links between stock assessment research and management under the following headings

- The advisers
- Giving the advice
- How good is the advice?
- How is it received and used?

The Advisers

The majority of fisheries scientists in Australia are employed by governments and naturally see the government, rather than the industry, as their major client. This bias in service delivery is often reinforced by poor communication between scientists and fishers. It is also reinforced by the fact that it is government fisheries managers who ask the most questions of scientists. In many fisheries the industry has limited opportunity to talk to scientists, and individual fishermen rarely seek out scientists and ask them to tackle specific problems.

The exception is the link between logbook collectors and fishermen, but such collectors are relatively few given the size of Australia and the number of fishermen. Given the low level of funding for this activity, it is clearly not regarded as important by most fisheries managers. The high value in terms of enhancing communication is probably not well recognised. Apart

from the human contact aspect, the results of fisheries monitoring programs, such as aggregate catch and effort statistics, would be of considerable interest to the fishing masters and industry in general.

Fisheries scientists in Australia are adjusting to what, for them, is a new phenomenon: the industry scientist. Although government scientists are nervous about the *modus operandi* of non-government scientists, it is very useful to have a technically competent person who is trusted by industry and who communicates well with them.

Contrary to what fishermen may think, this nervousness does not stem from a fear of being shown to be wrong. Rather, it comes mainly from the fact that the reports of industry scientists are generally not subject to normal peer group review mechanisms. In addition, there is concern about the strong pressures brought to bear on industry-employed scientists to pursue only those hypotheses that suit the client. In other words, industry scientists are accountable to their employers, rather than to other scientists and the public. This may be risky for them in a professional sense. At the same time, it should be said that government scientists can be equally biased if proper review mechanisms are not established.

If there is a threat to the industry scientist, it is the temptation to be selective in testing only those hypotheses that are favourable to industry in the short term. Another threat may be to give only half the answer to their clients' questions like "Can those government scientists prove that this stock will not recover?" or "Are those government scientists being too conservative on this stock assessment?"

As an aside, it was from an industry-employed scientist that I first heard the expressions "government scientist" and "industry scientist". These distinctions reinforce the implication that the science will somehow be different when done by one group or another.

There are real benefits from having industry regard themselves as "owning" a scientist but there are real dangers also. The input of scientists employed by industry could be very valuable given that industry will "own" (ie believe) the result, provided their advice is reviewed in the same way that other scientific work is reviewed. Industry will have far greater ownership of the results and be more likely to support management action stemming from those results.

One thing that all scientists have in common with both the industry and fisheries managers is that they all regularly make large, often unstated, assumptions about either the fish stocks, the fishing practices, the data quality or the reasoning behind management objectives: and sometimes all of these at once. Simplifying assumptions are often made to make a problem tractable or to allow a complex message to be communicated more easily. However the assumptions need to be stated and the process for giving advice should make them as clear as possible.

Giving the advice: the process

It has been stressed repeatedly in the Workshop that scientific advice has to be (of course) honest, as relevant and complete as possible, and timely. Scientific advice on a fisheries issue should also include some feedback to the manager on the questions being asked: this is usually disguised and put under the heading "Implications for research" in stock assessment reports.

For example, in those fisheries where the scientists and managers are not one and the same, how many managers implement an immediate review of their fisheries monitoring program when the scientists report that no assessment is possible owing to lack of data? It is normally left to the scientists to take the initiative when fisheries data are poor. This problem is caused by poor communication and lack of

understanding by all parties — researchers, managers and industry.

The process of giving scientific advice to managers ought to be easy but many scientists spend too little time negotiating with those asking the questions (industry and managers) about what questions they should be trying to answer.

The links between scientists, industry and managers should be simple but the connections seem to break down frequently. Why is this? Probably because in fact the real links are much more complicated than we like to admit and the fish stocks and the fishing industry do not stand still while the scientists try to catch up.

This complexity of linkages in the real world (Figure 1) has a major significance for modellers aiming to simulate this process. Management Strategy Evaluation, reported on by Tony Smith (CSIRO) in this Session, attempts to simulate this complex set of interactions and describes the robustness of management options using a model of this system.

New arrangements for communication under AFMA

The Australian Fisheries Management Authority (AFMA) has proposed that scientific research and reporting of results should include close consultation with industry and managers. AFMA is aiming to develop a "standard" approach to all of the fisheries it manages (Table 1). This includes establishment of a Management Advisory Committee (a MAC), with each MAC being served by a research subcommittee and stock assessment group (SAG).

It is intended that the stock assessment groups be open rather than closed, and should incorporate economic and fishing industry expertise as far as possible.

The arrangements for delivery of scientific advice in Commonwealth-managed fisheries varies across fisheries. In the South East Fishery, the Stock Assessment Group met for the first time in August 1993. The report will be reviewed by the Demersal and Pelagic Fish Research Group (a subcommittee of the Standing Committee on Fisheries and Aquaculture). After the review, the report will be considered by the Total Allowable Catch Subcommittee of SETMAC (see Table 1). SETMAC provides advice to AFMA on the suggested TACs (Total Allowable Catches) for the 16 species for which Individual Transferable Quotas are set.

In the case of SBTMAC, the stock assessment group is not formally defined, but the bulk of the work is done by the CSIRO Pelagic Program with some support from the Bureau of Resource Sciences. The work of this group is reported to an international meeting of scientists from Australia, New Zealand and Japan which then submits a report to a meeting of fisheries managers from the same trilateral group.

In future the demand will increase from the Management Advisory Committees for bioeconomic analyses (or even socio-economic studies) rather than single species reports.

In spite of the common structure proposed by AFMA, the arrangements for provision of research in aid of management vary across each Commonwealth-managed fishery. The process is a mixture of historical accidents and depends in part on the history of involvement and expertise of particular agencies and individual scientists. The research done in aid of Commonwealth fisheries is funded from a variety of sources (Table 2).

AFMA and the fishing industry contribute directly to some of the research done in support of Commonwealth-managed fisheries, but the bulk of work is done using Commonwealth funding appropriated to agencies that have responsibilities extending to areas beyond the immediate problems of Commonwealth fisheries management. Consequently, circumstances arise when the research providers (eg CSIRO and BRS) are unable to address immediate priorities of AFMA.

This arrangement creates a tension in setting priorities that is obvious each time there is a short term research problem in AFMA-managed fisheries. However, there is a second, less obvious tension in this system. AFMA is responsible for collecting monitoring data (eg catch and effort statistics) for the fisheries it manages yet it relies heavily on other agencies to analyse those data where they are suitable for fish stock assessment. AFMA, in some cases, uses the same information for management purposes (eg calculation of quota allocations) that scientists are expected to use for stock assessment. In this case, the data are often highly unreliable because some members of industry submit erroneous information in the hope of a more favourable quota allocation.

Another problem occurs when AFMA itself does not need the monitoring information for direct management purposes and so the incentive to pay for monitoring is low. In this case the resources allocated to monitoring are often inadequate to ensure data reliability is high. Compounding this problem, AFMA did not inherit a long-standing database for many of its fisheries because the Commonwealth role in fisheries management expanded only in the late 1970s following the declaration of the Australian Fishing Zone.

How good is the advice?

Assessing (and improving) the usefulness of the advice

Establishing objectives and performance criteria for fisheries management is a necessary first step in evaluating the usefulness of scientific advice. Scientific advice cannot be given in a vacuum and this is the step of establishing the question being asked.

Assuming there was agreement on the questions being asked and answered, one could measure the value of a research project by whether it reduced the uncertainty inherent in the information available prior to delivery of the advice.

The cost of reducing uncertainty in scientific advice will steadily, or exponentially, increase with the amount of reduction sought. In other words there is a law of diminishing returns. Knowing when to stop spending on particular research programs is decided by industry, fisheries managers and central government (which protects the interests of the wider community).

However, it is clear that the industry itself is often not well placed to be objective in assessing research advice. This is particularly true when the stock is assessed as overfished. In other words, there may be occasions when there is an incentive for the industry to suggest that further research is not needed because it may lead to results that will be used by managers as evidence that catch levels should be reduced.

Sometimes it is difficult to obtain a consensus view on the merits of particular research work because the industry is fragmented. The Southern Shark fishery is a case in point, where different sectors of industry profit from different segments of the stock of two species: the school shark (*Galeorhinus galeus*) and the gummy shark (*Mustelus antarcticus*). Each sector of the industry has a different view not only of the stock, but also of the scientific advice. For example, the eastern Bass Strait fishermen who target mainly gummy shark are not particularly concerned that the school shark in eastern Bass Strait is relatively depleted (and has been so for about 30 years). Understandably, the eastern Bass Strait fishermen are more interested in the catch rate and stock assessment of the gummy shark and have less interest in the concerns of school shark fishers farther west and the fisheries managers who are charged with conserving both the school shark and the gummy shark.

In the case of southern shark and southern bluefin tuna (SBT), the amount spent on research has increased significantly in recent years - mainly because of a perceived need by fisher-

ies managers to reduce the uncertainty before taking management action. SBT is a high value species ($90 m for Australian industry in 1992-93) while southern shark is a very fragmented and spatially variable fishery. In both cases gaining widespread industry acceptance of scientific evidence on stock status is an extremely difficult task.

How is scientific advice received and used?

How useful is the precautionary principle?

The precautionary principle gained currency through environmental circles, and was heavily promoted at the World Environment Conference in Rio de Janeiro. In fisheries, it is widely used in forums such as FAO and the UN in discussions of "responsible" fishing practices for highly migratory stocks on the high seas. There was recently a debate in the New Scientist on whether the precautionary principle is a useful scientific concept or too vague to be applied in resource management.

Fisheries scientists are often accused by industry of applying the precautionary principle uncritically. In fact, stock assessments often do carry a high degree of uncertainty but are generally not deliberately biased towards a cautious management approach (ie an approach that favours the conservation of a resource).

Rather than engage in this debate, it is more productive to find more rigorous ways to express the uncertainty in stock assessments. Chris Francis (NZ) described in this Workshop how the aim is to make probabilistic, but quantitative, statements about the effects of various amounts of fishing on a particular stock.

Key indicators, management objectives and acceptance of advice

The concept of key indicators of stock status were discussed earlier in the Workshop. They are becoming increasingly popular in resource management, having been applied recently to the Commonwealth Environmental Protection Agency's State of The Environment Reports and the Bureau of Resource Sciences' indicators of sustainable agriculture. What are the best indicators? Fisheries scientists sometimes make the mistake of designing their sampling programs to fit a budget rather than first establishing what needs to be measured to obtain a useful result and then establishing later whether the benefits warrant the costs. However, when considering scientific advice to fisheries managers, one key indicator that is not usually put "up front" is: "Will the industry believe it?" In other words, one of the main issues in explaining stock status to the fishing industry is to find indicators that can be communicated readily.

Unfortunately any management plan based on scientific advice that is totally rejected by industry is not likely to succeed because of the high costs of enforcement. This issue is at the heart of why fisheries management often fails to meet its objectives, and brings us back to the main point of the Session which is about delivery of effective scientific advice to management.

Ecological bottom lines: the pros and cons of biological reference points

Biological reference points have been proposed as a key indicator for fisheries management, yet their strengths and weaknesses have not been widely debated in the Australian fisheries context.

Recently AFMA (Barry Kauffmann and Bruce Phillips, personal communication) outlined a possible approach to formalising the nature of advice to management through increased use of biological reference points. They drew a strong distinction between biological reference points, such as the size of the stock in relation to virgin biomass, and economic reference points such as $F_{0.1}$.

The argument put in favour of reference points is that industry should have the major

input into setting management objectives and designing management plans, except when some key reference point was approached or exceeded. Then stock conservation would over-ride all other priorities and rebuilding of the stock would become paramount.

However, the consequences, and the dynamics of how this would operate in practice need to be considered. If the normal forces operate, it seems possible that the ecological bottom line would become a target for those fishermen who don't have the long term resource status as a high priority. The "tragedy of the commons" applies even when only a minority of resource users break the rules and seek short term gain at the expense of long term sustainability.

It seems likely that the model proposed by AFMA would work only if some account is taken of the errors in estimates of the parameters defined in the reference point, for example, the uncertainty of the size of the biomass relative to the virgin levels. Perhaps a safety margin can be built into the ecological bottom line. If such safety margins lead to lower quota levels then the fishing industry should be made aware of the need to gain accurate fisheries data in order to reduce uncertainties in the stock assessments.

Conclusion

Strengthening the link between fisheries assessments (the scientists) and the management process

Given the shortage of funds for research, and the difficulties faced by scientists, managers and the industry in pursuing their separate goals, there is a need to strike the balance between the following:

- monitoring: collaborate with industry and managers to find the cheapest way to gather what David Smith (Vic FRI) earlier called the "non-negotiables", in order to build a useful time series of data;
- "this year's assessment": make sure that the current state of knowledge is properly documented, reviewed and published in some form;
- long term work: collect data and initiate research targeted at longer term (issues such as effects of environmental variation are not amenable to quick workshops and 6 month projects);
- translation/communication: at present AFMA is proposing annual workshops for each fishery. However the interaction between scientists, industry and managers is like an ecosystem: and the process has successional stages. Early in the process there is little trust by industry in stock assessments and scientific advice in general. As this trust increases, meetings with different formats may be appropriate (noting the recent switch to small working groups in the northern prawn fishery reported by Ian Somers, CSIRO, in this Workshop). Whatever the stage of succession, some form of direct and frequent interaction between industry and scientists seems to be essential to build and maintain effective communication.

Immediate needs

Speaking only for the Commonwealth-managed fisheries, there is an urgent need for

- improvements in fisheries monitoring and data management;
- more detailed studies of the commercially important species; and
- further work on how to express uncertainty in useful forms, especially when detailed quantitative models are not available.

Table 1. Main Commonwealth managed fisheries (as at August 1993).

Fishery	Management Committee	Research Committee
Commonwealth-managed		
northern prawn	NORMAC	✔
south east fishery	SETMAC	✔
southern bluefin tuna	SBTMAC	✔
east coast tuna	ECTUNAMAC	✔
east coast purse seine	-	-
Great Australian Bight trawl fishery	GABMAC	-
northern fish trawl	-	-
western deepwater trawl	*	-
north west slope trawl	*	-
Joint authority		
Torres Strait (Qld, PNG)	TSFMAC	✔
south west shark (WA)	**	-
pearl (WA, NT)	**	-
Status quo (no Offshore Constitutional Settlement)		
southern shark	SSFMAC	✔

* Consultation between scientists, industry and managers does occur but no formal Management Committee exists

** The consultative committees are organised by State departments

Table 2. Sources of research funding, and major clients.

Funding source	Major client(s)
Fishing industry funds directly (through MAC's or direct to consultants);	Industry and AFMA
Fisheries Research and Development Corporation (FRDC) funds (majority C'wealth funds; with some industry contributions);	Industry
CSIRO Division of Fisheries (C'wealth funds);	Various, but including AFMA (and industry indirectly)
Bureau of Resource Sciences (C'wealth funds);	Minister responsible for fisheries, DPIE, AFMA (and industry indi rectly)
Fisheries Resources Research Funds (C'wealth funds);	DPIE and AFMA (and industry indi rectly)
State fisheries agencies undertaking work that is of interest to C'wealth fisheries also; (State funds, FRDC and FRRF).	State governments and state-managed industry

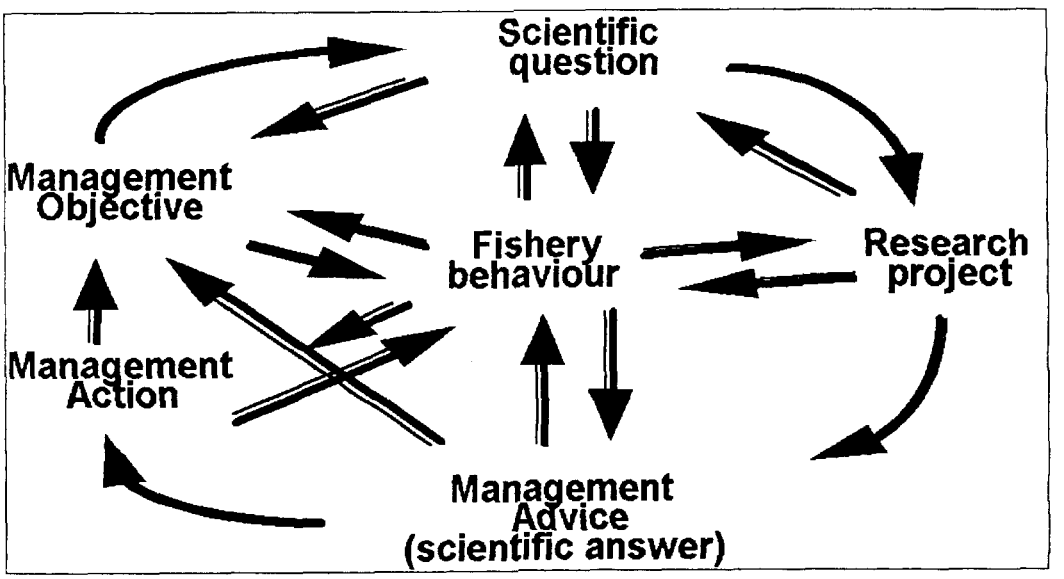

Figure 1. Complex links between scientists, managers and industry affecting communication.