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Implementing effective fisheries-management systems – management strategy evaluation and the Australian partnership approach

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Fisheries management is characterized by multiple and conflicting objectives, multiple stakeholders with divergent interests and high levels of uncertainty about the dynamics of the resources being managed. This conjunction of issues can result in high levels of contention and poor outcomes in the management process. Management strategy evaluation (MSE) can assist in the resolution of these issues. MSE involves assessing the consequences of a range of management options and laying bare the trade-offs in performance across a range of management objectives. Key steps in the approach involve turning broad objectives into specific and quantifiable performance indicators, identifying and incorporating key uncertainties in the evaluation, and communicating the results effectively to client groups and decision-makers. At a technical level, the framework facilitates dealing with multiple objectives and uncertainties in prediction. At the implementation level, it fails if it cannot accommodate effective stakeholder participation and acceptance. MSE shares many features with approaches such as adaptive management and development of management procedures. The principles for implementing the MSE approach are reviewed and practical aspects of its implementation under the Australian Fisheries Management Authority (AFMA) partnership model to fisheries management are discussed. The model stresses stakeholder involvement in all key areas of fisheries management, from stock assessment and setting research priorities, to enforcement and decision-making. Stakeholder involvement, including industry, science, and conservation, extends from membership of the AFMA Board, through Management Advisory Committees to Fisheries Assessment Groups. The benefits and limitations of the AFMA partnership approach are reviewed, both for MSE, and, in a wider sense, in the development of an effective fisheries management system.

Key words: fisheries-management systems, management strategy evaluation, partnership approach.

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Introduction

Fisheries management and fisheries-management agencies are under challenge worldwide. The apparently increasing public perception that fisheries management has failed is driven by a variety of factors. There has been international media focus on spectacular examples of fisheries collapse (such as northern cod), as well as general evidence of overfishing and overcapacity (Garcia and Newton, 1997; Mace, 1997). There has also been public concern and media attention on issues such as dumping of by-catch, and impacts of fishing on the marine environment and particularly on marine mammals and birds. Apart from general public concern with performance, fisheries-management agencies have also had to deal with challenges from the fishing industry on a range of issues, not the least being acceptance of restrictive measures to protect

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stocks, and challenges to the scientific basis for such restrictions.

One of the responses to these concerns, and particularly to the challenge from the fishing industry itself, has been a move to involve industry and other stakeholders much more in the management process. This approach has been called co-management (Jentoft, 1989; Symes, 1996) and has seen different expression in different countries and jurisdictions.

The role of science in supporting fisheries management is also under challenge, and the form of scientific advice is changing. In the past, uncertainty about scientific advice has tended to be understated, or even hidden, and the advice itself has tended to be prescriptive. Wider acceptance of the precautionary approach now allows scientists to be more open about uncertainty, while the introduction of ideas from areas such as decision analysis and the "management" sciences has resulted in a greater tendency for advice to be descriptive rather than prescriptive.

Evolution of the types of scientific assessments and the forms of management advice in fisheries has led to the development of an approach which in Australia has been called management strategy evaluation (MSE; Smith, 1993a, 1994). The MSE approach is described more fully later on, but is similar in method and philosophy to the development of management procedures in the International Whaling Commission (e.g. Kirkwood, 1997). Both deal explicitly with uncertainty, seek to identify trade-offs among management objectives, and evaluate the consequences of alternative strategies or decision options, rather than seeking to find "optimal" solutions.

The literature on the technical aspects of management procedures and MSE is now fairly extensive (Butterworth *et al.*, 1997; Cooke, 1999). However, the general approach is of relatively recent origin, and there are few papers which describe the practical experience, and the problems and issues which arise, in implementation. Butterworth and Bergh (1993) and De Oliveira *et al.* (1998) describe aspects of implementing management procedures in South Africa. Cochrane *et al.* (1998) describe the process and lessons from implementing a management procedure in the South African pelagic fishery, including quite a detailed description of the players in the process, and the practical difficulties encountered.

We describe and evaluate the experience in developing the MSE approach within the Australian Fisheries Management Authority (AFMA) fisheries assessment process. The AFMA partnership model for fisheries management is described in some detail. The MSE approach is also described and contrasted with preceding and existing approaches to fisheries assessment. There is no attempt to describe the technical aspects, which are well covered elsewhere. The focus is rather on the implementation of MSE within the AFMA partnership model, on the role and responses of the various key players in the process, and on the lessons that have been learned along the way.

The AFMA partnership model

The Australian Fisheries Management Authority is responsible for the day-to-day management of fisheries that come under the jurisdiction of the Australian Federal Government, which manages about 25% by value of Australian fisheries. The remainder are managed by State and Territory Governments. (For the remainder of this paper, the expression "federal" fisheries refers to fisheries managed by the AFMA.)

The AFMA was established under the Fisheries Administration Act of 1991 as a statutory authority responsible for ensuring the sustainable and efficient use of federal fishery resources. The AFMA manages those resources under the same Fisheries Management Act 1991, which includes five specific legislative objectives:

- Implementing efficient and cost-effective management on behalf of the Commonwealth ("Commonwealth" here refers to the Commonwealth of Australia)
- Ensuring 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, in particular the need to have regard to the impact of fishing activities on non-target species and the marine environment
- Maximizing economic efficiency in the exploitation of fisheries resources
- Ensuring accountability to the fishing industry and to the Australian community in the Authority's management of fisheries resources
- Achieving government targets in relation to the recovery of the costs of the Authority.

The AFMA model and legislation places a strong emphasis on a partnership approach among fisheries managers, scientists, and relevant stakeholders. This partnership involves close consultation, raising awareness of fisheries resource management issues, and a direct input into, and responsibility for, the decision-making process. The underlying rationale is that the achievement of sustainable fisheries is very much linked to the level of trust and confidence that exists between industry, managers, scientists, and stakeholders generally. Whereas sound legislation and policy are essential, there is no substitute for building sound and positive relationships between all those involved.

Since its inception in 1992, the AFMA has emphasized the importance of all stakeholders taking ownership of decisions and greater responsibility for the well-being of individual fisheries. The AFMA experience

is that a partnership approach does work, and that stakeholder advice and input to the consideration of management issues costs relatively little, yet remains crucial to the development and implementation of practical, cost-effective, and sensible fisheries-management outcomes for all federal fisheries.

The decision to use a statutory authority for the management of federal fisheries arose partly from the success of previous arrangements in the northern prawn and southern bluefin tuna fisheries, where industry made a significant and important contribution to management decisions. It also arose from a growing belief that implementing day-to-day fisheries management through a departmental/ministerial structure was neither cost-effective nor efficient. Previous experience had exposed frustrating delays or lags in decision-making occasioned by intense political lobbying by all parties associated with difficult decisions (managers, scientists, politicians, advocacy groups, lawyers, stakeholders, and conservationists).

The Australian Government's 1989 fisheries policy statement *New Directions for Commonwealth (Australian) Fisheries Management in the 1990s*, stated that "The structure of a statutory authority would enable the Government to effect its responsibilities in a flexible, open, and less bureaucratic way. It would also allow greater community and industry participation in determining the appropriate management programs for Commonwealth fisheries than has been the case in the past".

The AFMA Board

Under the Fisheries Administration Act 1991, the AFMA is a body corporate with a Board consisting of a Chairperson, Government Director, Managing Director, and five nominated directors. Importantly, no more than two directors can be currently engaged in fishing or fish processing. Directors, other than the Managing Director, are appointed by the Minister responsible for federal fisheries management. The five nominated directors are recommended by a Selection Committee established under the Act on the basis of expertise in fishing operations, fish processing, natural resource management, fisheries science, marine ecology, and business management. The Selection Committee comprises members from the government, fishing industry, and environment/conservation interests. It includes a presiding member selected and appointed by the Minister, two members determined by the Minister, one of whom has knowledge of environmental conservation issues, two members nominated by the Australian Seafood Industry Council (ASIC; the peak commercial industry body), and a member nominated by the Australian Ministerial Council on Forestry, Fisheries, and Aquaculture.

The Board is responsible for the overall operations of the AFMA, setting policy direction for staff, the establishment and operation of Management Advisory Committees (MACs) and Consultative Committees (CCs), ensuring adequate resources, and approving and monitoring annual budgets. In addition, the Board is responsible for setting catch targets, biological reference points, total allowable catches, and for determining statutory management plans prior to forwarding to the Minister for ministerial acceptance and tabling in the national Parliament. In setting total allowable catches, the Board must be satisfied that the levels accord with the AFMA's objectives and are supported by the available data.

Accountability

While not involved in AFMA's day-to-day operations, the Minister responsible for fisheries oversees its activities through key accountability provisions of the legislation. These provisions require approval of the AFMA Corporate Plan and Annual Operational Plan by the Minister. AFMA must also submit an Annual Report to the Minister and the national Parliament.

The AFMA is also required to provide a copy of the Annual Report to ASIC, and the Chairman and Managing Director are required to report on its performance to the ASIC executive. Additionally, the AFMA holds an annual public meeting to consult with industry, other stakeholders, and the general public. The Auditor-General audits the AFMA's financial statements annually. Further, the Minister must also formally accept each statutory management plan before it comes into effect, and be satisfied that adequate consultation has taken place and account taken of any representations. The legislation also provides the Minister with a general reserve power of direction.

The AFMA considers that its key accountability requirements safeguard the organization against any concerns that the model will lead to Australian fisheries being managed by commercial fishers for their own exclusive benefit, to the detriment of the wider community. These accountability requirements are supported by the following checks and balances:

- The structure of the Board provides that no more than two of its eight members can come from the fishing industry. Other members have a range of expertise that makes them well equipped to see the commercial sector as one part of a wider picture.
- The overall philosophy provided in the legislation and in the 1989 fisheries policy statement is reflected in the focus of AFMA staff.
- Both the Australian Bureau of Agricultural and Resource Economics and the Bureau of Rural Sciences have an independent role in regularly assessing the performance of the AFMA.

- The AFMA has an increasingly close working relationship with Environment Australia, the Federal Government agency responsible for environmental policy and management.

Fishing industry involvement

The commercial fishing industry plays an important but not overriding role within the model. Experience suggests that industry can and does take its responsibilities in the process seriously. Industry is required to pay 100% of attributable management costs, and is therefore entitled to a say in management decisions. The legislation increases the strength of access rights in fisheries, which is a further incentive to responsible industry involvement. Fishers have an overriding interest in ensuring that fisheries are managed on a sustainable basis, given their reliance on resources for their livelihood and life style.

The model is based on the premise that the most successfully managed fisheries, in terms of both sustainability and economic returns, are those that utilize the skill, knowledge, and expertise of stakeholders in the fisheries-management process. This approach stands in contrast to fisheries management centred in government departments, which can be hampered by:

- overriding political imperatives
- a lack of understanding of commercial realities and the day-to-day environment in which industry in particular operates, leading to
- an overly bureaucratic decision-making process based on enormous distrust, if not outright hostility, between fishers, scientists and fisheries managers.

How the partnership works

The partnership model includes establishing and operating Management Advisory Committees (MACs) or Consultative Committees (CCs) for each federally managed fishery. The Fisheries Administration Act 1991 states that the AFMA:

> ''must try, as far as practicable, to ensure that the membership of a management advisory committee includes an appropriate number of members engaged in, or with experience in, the industry in the fishery in relation to which the management advisory committee is established.''

Under the Act, a MAC consists of a chairperson, the AFMA manager for that fishery and up to seven other members appointed following consultation. Typically, these seven comprise a research member, a member representing State or Territory governments, four industry members, and a conservation member. The configuration of CCs may vary between fisheries but is generally similar but without the limitations on membership. CCs tend to be used for ''minor'' or developing fisheries. These two types of committees play a central role in helping the AFMA meet its objectives by acting as key liaison bodies between AFMA and those with an interest in a particular fishery. They also provide advice to AFMA on fisheries-management policies for that fishery, and assist in the development of cost-efficient management arrangements.

Although consultation with industry and other interest groups can often be time-consuming, the experience suggests that it is the key to gaining broader acceptance and ownership of management decisions. Involving industry and other stakeholders in the decision-making process brings with it certain obligations and responsibilities, and the AFMA has made a concerted effort to inform all members on MACs and CCs of the importance of their role.

Specifically, committee members must be able to satisfy the following:

- They must act in the best interests of the fishery as a whole, rather than as an advocate for any particular organization or interest group. They must also be prepared to observe confidentiality and to exercise tact and discretion when dealing with sensitive issues.
- They must be able to put views clearly and concisely and be prepared to negotiate to achieve acceptable compromises where necessary.
- Industry members must have industry's confidence and authority to undertake their membership functions.
- They must avoid pursuing personal agendas, but participate in discussion in an objective and impartial manner.

The AFMA has developed a specific code of practice for MAC and CC members and requires each member to sign their acceptance of this code formally.

Involvement of industry in the decision-making structure through the MACs/CCs has brought with it significant industry responsibility and accountability. Industry has accepted this responsibility well and in most fisheries the process is now well and truly settled. A most important benefit has been far more informed discussion and acceptance of management arrangements, research priorities, and stock assessments. Overall, the process has been able to make significant progress towards overcoming the previous underlying mistrust between fishers and fisheries managers and researchers, and factional differences within the fishing industry.

The State Government member is responsible for providing input to management decisions and for providing a consultative link with adjacent States on specific fishery issues, particularly where the jurisdictional arrangements are divided between the Commonwealth and the States. The State Government member will normally be a Director of Fisheries or experienced

Table 1. Composition of a "typical" AFMA fishery assessment group, the Eastern Gemfish Assessment Group.

Chair (government scientist)
AFMA manager
Stock assessment scientist
Fisheries biologist
Industry scientist
Economist
Trawl industry members (2)
Non-trawl industry member
Processing industry member
Conservation member
Secretary (AFMA)

senior officer and is appointed on a 1-year rotational basis with the agreement of all relevant States.

The research member is selected on the basis of his/her knowledge of a particular fishery. The Board requires research members to be persons of seniority and standing in the research community, and most are also actively involved in current research in the fishery. The research member not only provides scientific input to the deliberations but is also the conduit between fishers and the research community. Most MACs/CCs have their own research subcommittees, which are usually chaired by the research member, with a majority of members coming from the scientific community.

The AFMA member is normally the manager of the respective fishery, and is responsible for participating in discussion on a corporate basis, contributing fisheries management expertise to the deliberations, providing an understanding of relevant Government policy, and for ensuring that the committee is aware of, and understands, Board policy and the AFMA's obligations under its governing legislation.

In managing federal fisheries, the AFMA, MACs, and CCs strive to achieve a balance between resource use and conservation. In doing so they also draw upon scientific advice provided by Fisheries Assessment Groups (FAGs), which consist of representatives from scientific, economic, industry, and management fields (see typical example in Table 1). FAGs are responsible for producing annual assessments of the major stocks fished. The flow of stock assessment advice from FAGs to the AFMA Board is shown in Figure 1.

During its early years of operation, the AFMA placed considerable emphasis on developing sound relations with its major immediate stakeholder, the commercial fishing industry, in order to build industry confidence in the consultative/advisory process and in the application of fisheries management. Since 1994, the focus has shifted to meeting the needs of an expanded range of stakeholders and the membership of its MACs and CCs has broadened to ensure that environmental/conservation and recreational fishing interests are included in the consultation process. To this end, a number of committees now include either a member from the environment/conservation, charter boat, or recreational fishing sectors or have permanent observers from these interest groups where appropriate.

The MSE approach

Management strategy evaluation (MSE) involves assessing the consequences of a range of management strategies or options and presenting the results in a way that lays bare the trade-offs in performance across a range of management objectives (Smith 1993a, 1994). A key feature of the approach is that it does not seek to prescribe an optimal strategy or decision. Rather, it seeks to provide decision-makers with information on which to base management choices, given a set of (usually conflicting) objectives. The decision-makers are free to apply their own weightings and risk preferences to alternative objectives.

Conceived in these broad terms, MSE is closely related to a whole set of approaches stemming from various branches of decision analysis (Raiffa, 1968). Its antecedents in fisheries assessment and management include adaptive assessment and management (Walters and Hilborn, 1976; Walters, 1986; Hilborn and Walters, 1992), development of management procedures (Butterworth and Punt, 1999), and risk assessment (Francis, 1992; Francis and Shotton, 1997). Although mainly applied to fisheries assessment and management, MSE and related approaches have potentially much wider application in renewable resource and environmental management. These approaches are similar in concept to some aspects of the International Standards Organization (ISO) standards for environmental management (Tibor and Feldman, 1996).

Within fisheries assessment and management, the MSE approach is most closely related to the development and evaluation of management procedures. While virtually identical in methods and philosophy, it is slightly wider in scope, embracing evaluations that do not necessarily deal explicitly with feedback harvest strategies. Also, its purpose is not necessarily to develop an agreed management procedure, but to provide an objective basis for short- or long-term decision-making. The key ingredients include:

- specifying clear management objectives
- developing quantifiable performance measures for each objective
- identifying alternative management strategies or decision options
- evaluating (using quantitative performance measures) the performance of each strategy or option against the range of objectives, taking suitable account of uncertainty
- communicating the results to decision-makers.

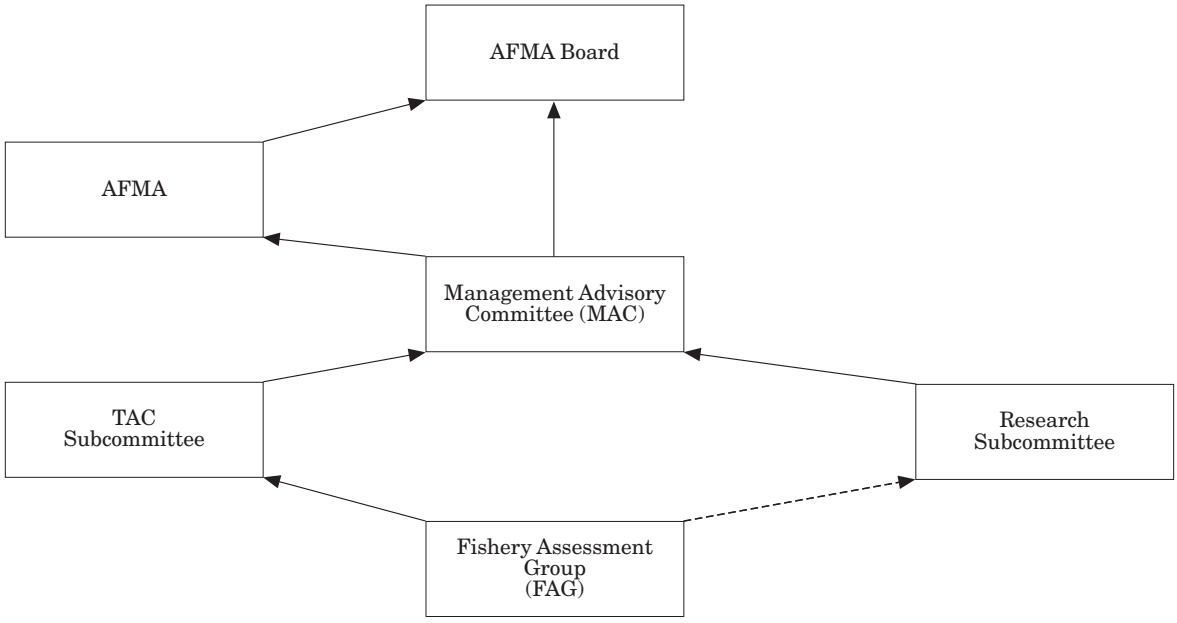

Figure 1. Flow of assessment advice from a Fishery Assessment Group to the AFMA Board.

The evaluation is done using Monte Carlo simulation methods to test the alternative strategies against underlying operating models of the system. Uncertainty is taken into account by developing a plausible range of operating models reflecting the (known) uncertainties about the system. Categories of uncertainty which need to be considered include structural and parameter uncertainty in the models, errors in data and observation systems, estimation uncertainty, and management implementation uncertainty (Smith, 1993a; Francis and Shotton, 1997). The MSE approach is feasible even under relatively high levels of uncertainty; for example, in managing newly discovered resources (e.g. Smith, 1993b). However, the analyses themselves tend to be complex and highly computer-intensive, particularly where feedback management strategies are being evaluated.

Experience in implementing MSE

Defined in the general way described above, the basic MSE approach is widely used in fisheries assessment and management around the world. For example, management procedures have now been evaluated in a number of countries and international commissions (Butterworth and Punt, 1999) and formally adopted in some. In others, feedback harvest strategies have been evaluated, and there are numerous examples of assessments that pick up some, but not always all, of the basic elements of the MSE approach.

This section describes some of the experience to date in implementing MSE within the AFMA stock assessment process (not all assessment groups have explicitly adopted the approach; those that have include the fisheries for southern bluefin tuna, southern shark, eastern gemfish, orange roughy, and eastern tuna and billfish; see also Butterworth and Punt, 1999). Aspects of the process are dealt with by looking in turn at the role and reactions of each of the main players involved in the fishery assessment groups (see Table 1), as well as the involvement of decision-makers outside those groups. A specific group of scientists with quantitative stock assessment skills called "MSE analysts" are singled out because of their key role in guiding the introduction of MSE into the assessment process.

Managers

Attempts to introduce MSE to the fishery assessment and management process prior to the establishment of AFMA met with considerable resistance, although the response from individual managers varied considerably. Some managers saw the approach as a threat to their role and autonomy. This perception stemmed from related concerns, some of which may still in part be current:

- The approach requires that objectives be made explicit and measurable. Development of explicit performance indicators leads to the notion of auditable management performance, by which managers (and management agencies) may be evaluated.
- Making decision rules explicit seems to remove the scope of action for managers. Many managers prefer the "informal" approach that maintains maximum

flexibility, both to respond to emerging issues and to trade-off across conflicting interests and objectives, without having to be explicit about it.
- The approach has arisen from, and has largely been driven by, the scientific community. Moreover, it involves methods, such as modelling, which may be unfamiliar or about which there may be considerable scepticism. It even claims to model parts of the management process itself! The term "management strategy evaluation" seems pretentious and over-inflated. It does not deal with all (or even most) aspects of a manager's job.
- The approach is new and has yet to demonstrate proven benefits. In addition, the process involved can be time-consuming and does not lend itself to the quick answers managers are often looking for.
- Some managers were used to expecting a "single answer" from scientists (e.g. an estimate of MSY). Evaluating the consequences of alternative decisions, and expressing the answer in terms of probability distributions, rather than providing a single optimal answer, was initially confusing and sometimes unwelcome.
- The approach itself, and the methods it uses, is complicated and difficult to understand.

Despite such initial concerns, many managers have come to embrace the concepts of MSE and the approach it entails. There are several features which certainly fit well with emerging approaches to fisheries assessment and management within the AFMA model.
- There is a strong move towards a formal approach to "management by objectives". Increasingly, management plans require that objectives be explicitly stated, that performance indicators be developed, and that strategies be identified to achieve stated objectives. Management agencies are now subject to independent audit of their performance against legislative and other objectives. MSE can help provide evidence that key legislative objectives are being met.
- The approach fits well with the partnership model already adopted by AFMA and increasingly by other jurisdictions in Australia.
- There is much better acceptance of the need to deal formally with uncertainties. Widespread adoption of the tenets of the precautionary approach has served to reinforce this.

Industry

Industry response to MSE itself is a little difficult to judge, because their exposure to it has occurred at the same time as the development of the partnership model, about which they have been in general very positive. The industry response has also been influenced by the development of clearer property rights and the other changes that this has entailed.

The industry response to the partnership approach in the assessment process is best illustrated by a specific example. The Eastern Gemfish Assessment Group (EGAG) has probably gone furthest of all the AFMA assessment groups in developing a formal evaluation of management procedures, but the process is not yet complete and a formal strategy is yet to be endorsed (see Punt and Smith, 1999). Eastern gemfish are a targeted component of a multi-species trawl fishery in south-eastern Australia. The species was brought under quota management in 1988 and ITQs were introduced in 1989. There is good evidence of recruitment failure from about 1987, but this was strongly disputed by industry. There were successive reductions in quota from 1990 until a zero TAC was set in 1993. Because it was part of a multi-species fishery, by-catch arrangements (trip limits) were in place from 1993 to 1996, but there is evidence for deliberate targeting and large discarding (including on the steps of the Federal parliament!) during that period. When EGAG was established in 1996, gemfish was arguably the most contentious fishery in Australia from the point of view of industry/science/management conflict. The following comments on the industry involvement in and contribution to the assessment process are largely drawn from the EGAG experience:
- A major initial success in generating wider credibility and acceptance of the assessment among industry was the development of an industry vessel survey of relative abundance. This has been a major boost to industry ownership of the process.
- Industry participants have made a major contribution to the current assessment, by identifying uncertainties about catches in the early development of the fishery. This is one of the important sources of uncertainty in the current assessment (Smith and Punt, 1998) and went unrecognized in previous assessments.
- Industry members have also provided insights to scientists about the important role of environmental variability in influencing fish behaviour and catch rates.

There have also been a number of problems and challenges for industry members in their involvement:
- They have had to get used to the "rules of the game", in particular to the fact that the assessment group is not concerned with several management issues that are of vital concern to them (such as allocation).
- The technical aspects of the (Bayesian) assessment are very difficult to follow. However, several industry members developed quite a good appreciation of the way in which the various types of data drive the assessment outcomes, and this has helped focus attention on research priorities and design of sampling programmes.
- There is growing frustration at the inability of the "government" scientists to make direct use of

industry information and views on the importance of environmental factors in the formal assessments. This leads to scepticism about the types of models that are used. Fundamentally, the problem is that the industry view of the resource is of an entity driven much more by environmental variation than by the effects of fishing, reflecting their own experience. Although industry members welcome being part of the process, there is a risk to that process if they feel that their ideas and experience are not being properly heeded.

- They face a difficult task in selling the assessment "on the wharf" to those not involved in the process, particularly when the assessment is pessimistic.
- There are concerns with highlighting uncertainties in the assessment, owing to suspicion about the management response, in particular the application of the precautionary approach.
- Events external to the assessment group can threaten any goodwill generated within the process. There have been two events that have come close to derailing the process, but both of those arose from decisions and processes outside of EGAG. The first was an intervention by the federal environmental management agency that sought to apply overriding environmental assessment legislation to decisions about gemfish management. The second involved quota allocation issues between sectors.

A key element of industry acceptance of the process has been the involvement of an industry-funded scientist in the assessment group. His involvement has been important on a number of fronts:

- He helped establish and run the industry monitoring and survey programme which reduced the scepticism about "government data".
- He has helped articulate industry views about environmental influences on fish behaviour, and set about collecting data to test these views.
- He has helped interpret scientific debate and concepts in ways which industry could more easily understand.
- He has provided industry members with some reassurance that the technical aspects of the assessment (the "flute music") were not being used to pull the wool over their eyes.

Although there is at times robust debate within EGAG about use and interpretations of data, modelling methods and assumptions, and other technical aspects of the assessment, industry members have generally embraced the process in a spirit of cooperation and goodwill. Moreover, they have persisted in supporting the process in the face of recent pessimistic outcomes of the stock assessment and, consequently, severe management restrictions. The process has resulted in agreed assessments, and despite a return to zero targeted quota after only 1 year of reopening the targeted fishery, there has been virtually no discarding and much lower incidental catches than in the period of closures preceding EGAG.

Conservation agencies and groups

As in many other countries, there has been increasing interaction in Australia between resource and environmental management agencies in recent years. Areas of interaction include issues about multiple use, marine protected areas, and endangered and threatened species. Increasingly, environmental agencies and groups are taking direct interest in issues of by-catch and even target species management. The AFMA has an environmental management section that deals with many of these issues, but it also has environmental and conservation representation on many MACs and assessment groups. Representation most often involves non-governmental organizations (NGOs). Direct dealings with government environmental management agencies tend to occur in relation to specific legislative and management issues, such as marine parks and threatened species. However, government environmental management agencies occasionally involve themselves directly in stock management issues using overriding legislative powers. For example, this occurred in the case of gemfish management noted above, principally because there had been a previous (unsuccessful) attempt to nominate gemfish as a threatened species.

In all these areas, environmental agencies and groups tend to bring a different perspective to the process. Almost without exception, they are unfamiliar with the methods employed in fishery assessment, and tend to be very sceptical of them. There is a strong perception that fisheries management has almost universally failed, and that assessment methods are equally suspect. For endangered species issues, there is also strong resistance to the notion of "sustainable yield", and therefore resistance to modelling and MSE approaches being applied to these issues. Environmental managers are generally much less familiar with developing and using feedback management strategies than are fisheries managers.

Having said all that, the representation of conservation members has proven to be both useful and productive. In general, they have been well accepted by industry representatives, have provided constructive (although limited) input, have taken some of the heat off scientists (who otherwise tend to be seen by industry as "green"), and have "played by the rules" of the process. A constraint for some NGOs is the cost of providing the resources needed to support the process and consistency of representation. Individually, some representatives have indicated a real interest in, and even some guarded support for, the stock assessment process that has been implemented. From the AFMA's point of view, their involvement is very useful in maintaining wider public support for the assessment and management process.

Fisheries scientists

Scientific input to stock assessment and MSE remains a key requirement for an effective management system. However, under the AFMA model the role of the scientist in the process has changed considerably. Many of the biologists involved have been involved in previous systems where stock assessment groups comprised only scientists. These groups deliberately excluded both industry and managers, and their advice was provided directly to managers and management agencies. Scientists were sometimes called upon to present their results to industry, but there was no process for real industry input into the technical aspects of the assessments. The form of advice was also very different, with far less focus on uncertainty, and a tendency to provide "the answer" (e.g. a recommended catch level or management action) rather than an evaluation of alternative options and their consequences.

Most scientists have adapted well to the new processes. Although in some ways they have ceded some power and autonomy, most feel that the more open process has many benefits. These include:

- Dealing directly with industry and gaining useful information and insights about the stocks and their environments
- Having much better industry support for stock assessment outcomes
- Involvement of conservation members taking some of the pressure off scientists to be "advocates for the stocks"
- The opportunity to discuss and evaluate alternative harvest strategies
- The opportunity to discuss (and help interpret) management objectives
- Better targeted research with opportunity for direct industry support and involvement.

Remaining concerns include:

- The extended time involved in meetings and in the overall process
- In some cases, concerns about undue industry influence on assessments and research priorities
- Concerns about ownership of data, intellectual property, and publications.

While biologists have a long history of involvement in stock assessment and in evaluating harvest strategies, economists have become involved in fisheries assessment groups more recently. Resource economists tend to bring a quantitative approach to fisheries assessment, but often based on a different perspective from, and using different methods than, biologists and stock assessment modellers. Many economists use optimization methods to address resource management problems, in contrast to the comparative approach of MSE that seeks to highlight trade-offs and identify risks, but not prescribe optimal solutions. However, some economists are embracing MSE, and are also making substantial contributions in areas such as fleet dynamic modelling, and in evaluating costs and benefits of research (McDonald *et al.*, 1997). In general, though, the integration of biological and economic analyses has not progressed very far, and the focus of fisheries assessment and MSE still tends to be biological rather than economic.

MSE analysts

Despite the broadening of the process to include a much wider set of stakeholders, much of the "business" of the assessment groups still centres on quantitative stock assessment and evaluation of harvest strategies. Many of these groups are chaired by scientists with quantitative stock assessment skills, and the MSE approach is increasingly being adopted. This raises a number of challenging issues for the MSE analyst in leading and to some extent directing the process.

The first task in establishing an assessment group is to agree a common purpose and understanding of the role of the group. In the case of the AFMA, it is quite clear that their role is stock assessment and evaluation of the consequences of alternative strategies and decisions, but clearly not to formulate specific management recommendations. However, they do have a role in assessing and advising on research priorities. Inevitably, specific management issues arise, particularly allocation and access issues which are of key concern to industry, and some latitude and discretion is required in allowing limited debate on these. It is important that such issues do not detract from the primary purpose of the assessment group, or intrude on the advice produced.

Having established some of the "ground rules" for the process, the next task is to "sell" the MSE approach and methods. In doing so, it is important to bear in mind the backgrounds and motivations of the people involved, including some of the reservations and reactions listed in previous sections. Special care is required to communicate the concepts in a clear and simple fashion. Some of the concepts (such as performance indicators, reference points, and decision rules) and methods (such as Monte Carlo simulation, parameter estimation, and risk assessment) are difficult to understand, and it is better to proceed slowly than rush into a highly technical analysis which leaves behind most of the participants. For example, even in a "simple" stock assessment, it is useful to focus first on the information (which is something people can relate to) and then on simple descriptions about stock dynamics, focusing on alternative hypotheses rather than mathematical detail.

Once the basic approach is established and accepted (but this in itself is iterative, subject to change, and requires frequent attention), the more technical elements can be dealt with. Most of the elements and methods are

well reviewed elsewhere, and only some of the ''process'' issues will be briefly reviewed here.

A key step in the process is to turn objectives into performance measures. Usually, broad objectives are specified in legislation. For example, two of the AFMA legislative objectives are to pursue ecologically sustainable development and economic efficiency. For each fishery and stock, these broad objectives need to be translated into measurable operational objectives, and then to specific performance measures which can be used to evaluate the performance of alternative strategies against the objectives. The Board and MACs play an important role in clarifying and approving objectives and performance measures.

In practice, some progress has been made in identifying and agreeing biological reference points for stock management, a useful starting point in defining stock conservation or ''risk'' performance measures. In Australia, target and limit reference points have tended to be based on biomass rather than on fishing mortality rates. Default limit reference points have tended to be set as a proportion of virgin biomass (typically 20% of B_0). In some cases, generally where there is a more ''mature'' stock assessment available, the biomass in a specific year is used as a reference point (e.g. for southern bluefin tuna, school shark, and eastern gemfish). Choosing a reference point is only one element in defining a ''risk'' performance measure. Others include the time period (for stock projections) over which risk is measured, the way in which time is integrated, and the way in which distributions of outcomes are summarized. Currently, these choices are left pretty much to the MSE analyst, although debate about the details is becoming more frequent and informed in particular assessment groups.

If there is some progress and agreement on development of conservation performance measures, much less can be said about economic and social measures. This partly reflects the lack of integration noted above in the biological and economic inputs to the assessment process. Economic data (price, costs) are collected for many fisheries, and economic analyses are undertaken. These are not currently used in MSE analyses, and it is not clear what role the economic indicators (such as profitability and rates of return on capital) play in the decision-making process. Surrogates used follow the IWC approach and are typically measures such as average or cumulative catch, and some measure of interannual variation in catch. There has been no attempt so far to consider social objectives or indicators, although arguably ignoring real but hidden objectives in this area can undermine the process of agreeing harvest strategies.

Identifying harvest strategies (and particularly decision rules in feedback harvest strategies) is a step in the process to which all participants can and do contribute. It is also an iterative process, with refinements and new options dependent on examining and thinking about the results of previous analyses. One of the challenges is to deal with decision rules at the right level of detail. It is easy in such discussions to get buried in too much detail concerning the practical implementation of management arrangements and monitoring strategies. This is particularly the case where the assessment group is also responsible for coordinating the latter.

There is a large literature on the technical aspects of modelling methods, data analysis, and methods for dealing with uncertainties. In the context of the assessment group process, the technical details are much less important than:

- thorough examination and discussion of the data;
- discussion of broad assumptions and plausible hypotheses and scenarios;
- discussion of methods for selecting or weighting alternative scenarios and selection of ''base case'' scenarios.

Scientists and MSE analysts need to be open to consideration of non-standard hypotheses and non-standard data and need to find ways of translating these into the formal process of quantitative assessments and evaluation, wherever possible. This has proven to be one of the major challenges in implementing MSE in the context of open and participatory assessment groups. Scientists tend to have their own standards, rather like lawyers, on ''admissibility of evidence''. This can and does come as an affront to many industry participants, who are often keen observers of the systems they are exploiting, but don't always have the ''data'' to back up personal or collective observations. Assessment groups need to pay particular attention to efforts to collect such data. Many of the industry observations relate to relationships between environmental conditions and fish availability. Fortunately, remote-sensing and other technologies are providing more ready access to such data. However, the methods for incorporating them in ''standard'' analyses remain fairly primitive.

No matter what efforts are made to incorporate the widest range of data and assumptions into analyses, something is always missed, and real uncertainty is almost always underestimated. MSE analysts (or whoever is leading the process) need to be critically aware of this, lest next year's data and analyses prove so different that they undermine credibility in the whole process. It is always better to understate than overstate confidence in the assessment.

Decision-makers

The ultimate decision-maker within the AFMA management system is the Board (Fig. 1). For fisheries managed on quotas, each fishery or stock assessment group prepares an annual assessment report. This report includes an indication of the current level of the stock

relative to any reference points, and where possible an evaluation of alternative future harvest scenarios (catch levels for stocks managed using quotas). It may also include recommendations on monitoring arrangements, including the need for any allocation of quota for research purposes. The Chair of the assessment group presents a summary of the assessment report at a meeting of the TAC subcommittee. This committee discusses the report and makes recommendations on management arrangements for the following year, including quota levels and/or any by-catch arrangements. These recommendations are discussed at the relevant Management Advisory Committee, and are passed on (possibly in amended form) to the Board for approval. The Board decides on quotas and any supplementary arrangements.

There are, therefore, at least three steps and three different groups of people involved in the consideration of the assessment advice and the decision-making process. Although there is management, industry, and scientific representation at each of these levels, the individuals involved vary, and there may be no overlap between membership of a fishery assessment group and any subsequent level in the decision-making process. This means that there is also an issue of understanding the approach, communication of advice and "ownership" of the process between the assessment group and other levels in the process. Some of these issues also arise in communicating and interacting with agencies and groups outside the fisheries-management process, particularly environmental agencies.

This potential communication gap points to the need for advocates of the MSE approach to explain the concepts and methods at all levels in the system. Some progress has been made in this respect (e.g. use of in-house workshops for managers, which have been very well received), but much more needs to be done. There is clearly a need for multi-way interaction and discussion about such issues as the development of operational objectives and performance measures, identification of management options (including decision rules), and understanding of uncertainty and risk. Shared understanding of concepts, methods, and terminology will prevent unnecessary confusion and the temptation to make *ad hoc* changes to recommendations and agreements forged at particular levels within the process. Mechanisms to foster this shared understanding are still under development.

Discussion

There would appear to be several preconditions for success in developing agreed harvest strategies through the MSE process, several of which are quite general to effective fisheries management systems. First, an effective and stable management and regulatory framework needs to be in place. Having clear objectives within that framework, and a commitment to monitoring performance against them, is another necessary condition. A long-term perspective by the fishing industry would seem to be a prerequisite for developing agreed harvest strategies, which implies some relatively secure level of resource access. There also needs to be wide ownership of the outcomes, which implies effective stakeholder participation in the process. Finally, a reasonable level of certainty in the "political" process overlaying the fishery management process is required, such that agreements reached in an open process with wide stakeholder participation are not regularly overruled by political intervention.

More specific lessons have been learned in applying MSE within AFMA. The first lesson is that establishing and maintaining credibility and trust is essential for the process to work at all. This means that progress is at times slower than would be desirable, but the outcomes are more secure. From a more "technical" point of view, the experience suggests a need for scientists to find more creative ways of embracing alternative hypotheses and data, including fishermen's perceptions and experience. There is also a clear need to find better ways of communicating concepts, approaches, and results, both within and outside the assessment process.

How well is the assessment process working? First, it has generally resulted in agreed assessments. More importantly, it has proved a very useful vehicle for adopting the MSE approach. This has had benefits, not only in developing and agreeing longer-term harvest strategies, but also in providing a much better focus on strategic and tactical research needs. Perhaps the weakest area at the moment is in the effective integration of biological and economic analyses and models. The "real" test of success can perhaps best be seen in the agreement on assessments and adoption of agreed harvest strategies in the previously highly contentious fisheries, such as eastern gemfish and southern shark.

It is more difficult to assess how well the partnership approach is working more generally. However, one positive indication comes from the fact that there has not been a single case in the AFMA's 6 years of existence in which the fisheries minister has used reserve powers to overrule Board decisions on management plans or total allowable catches.

There have been two major external reviews or audits of the AFMA's performance to date. The first was by the Australian National Audit Office (ANAO, 1996). This entailed a fairly comprehensive audit of the performance in meeting each of its legislative objectives. In evaluating the objective related to ecologically sustainable development, the report stated: "In the day-to-day decision-making undertaken by AFMA and the MACs,

the balance is weighted towards maintaining viable levels of industry activity as opposed to conservative or risk-averse decision-making''. The report led to a subsequent inquiry by the Australian Federal parliament which, while acknowledging some of these criticisms, endorsed the partnership approach. Specifically, the parliamentary report stated: ''The ANAO highlighted the dilemma of AFMA's decision making process being captured by industry. The committee recognizes the risks, but believes industry involvement is essential and is undoubtedly an improvement on the previous management approach'' (Commonwealth of Australia, 1997).

One of the responses by the AFMA following these two reviews was to strengthen the conservation and environmental representation on MACs and FAGs. More recently, the peak fishing industry body has also endorsed the partnership approach (ASIC, 1998). Their report stated: ''Perhaps the most satisfactory outcome has been the public recognition of the vibrant co-operative arrangement between the industry, scientists, conservationists and fisheries regulators. The fishing industry calls this the co-management model and is, for all its warts, fiercely protective of it.''

The AFMA partnership model and the application of the MSE approach within it have developed hand-in-hand over the past 6 years and both are still evolving. Many other aspects of fisheries management have changed over the same period, including the introduction of stronger access rights and cost recovery. For these reasons it is difficult to assess the relative role of the partnership and MSE approaches in any overall success of the AFMA model. However, as noted above, the two approaches tend to complement and strengthen each other. One of the possible costs associated with both is the additional time and effort involved in reaching agreement, and the possibility of delays. The clear advantage is a greater commitment to act once strategies are agreed.

Another question that can be asked, but not clearly answered, is the extent to which any success of the AFMA model is due to its status as a statutory authority, outside of existing government departmental structures. Within Australia there are six state and territory fishery management agencies, of which only one is a statutory authority. However, all jurisdictions have developed their own processes for stakeholder involvement and participation, most within a departmental structure. Evaluating the success of those processes and the outcomes for effective fisheries management would involve a comparative analysis (e.g. Sutinen, 1999) that is well beyond the scope of this paper.

One of the priorities for MSE is to broaden its scope and application beyond the relatively narrow confines of target species harvest strategies. This will also entail gaining wider acceptance of the AFMA model in the wider community.

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