Why a management procedure approach? Some positives and negatives

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Butterworth, D. S. 2007. Why a management procedure approach? Some positives and negatives. – ICES Journal of Marine Science, 64: 613–617.

The origin of the management procedure (MP) approach (sometimes termed management strategy evaluation), with its simulation testing of feedback-control algorithms as a necessary and structured basis for dealing with the inevitable uncertainties associated with fisheries assessments, is briefly reviewed. Also discussed are the advantages that overcome some of the difficulties of the "traditional" approach of coupling an annual "best" assessment to some harvest control rule, such as a failure to consider longer-term trade-offs properly. The MP approach does, however, also have disadvantages, such as the length of time typically required for its development and an argued inflexibility after implementation. Solutions that have been developed to overcome some of these difficulties are discussed.

Keywords: assessment, management procedure, operating model, precautionary approach, risk, simulation testing, trade-offs, uncertainty.

Received 30 June 2006; accepted 3 January 2007; advance access publication 1 March 2007.

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Introduction

This topic is most readily addressed by comparing the management procedure (MP) approach with what might be termed the "traditional" approach (TA) to the provision of scientific recommendations for management measures [such as total allowable catches (TACs) or allowable effort levels] for fishing marine resources.

Typically, the TA involves developing a "best assessment" of the resource, i.e. a mathematical evaluation that integrates all available data for and understanding of the resource to provide estimates of, in particular, past and present resource abundance and productivity. This is then augmented in some manner to translate these results into, say, a TAC recommendation, e.g. by the application of a reference-point-based harvest control rule or consideration of resource trends predicted under future alternative constant-catch scenarios. In many cases, this process is repeated as frequently as annually.

An MP is formally a formula to provide, say, a TAC recommendation, where the inputs to the formula (essentially resource monitoring data) have been pre-specified. To that extent, it seems no different from the TA. However, the core difference is that this formula has been tested by simulation to confirm that it can be expected to get reasonably close to concurrently achieving appropriate trade-offs among the mutually conflicting objectives of maximizing catches, minimizing interannual catch variability in the interests of industrial stability, and minimizing the risk of substantial depletion of the population that could put future use of the resource in jeopardy. Importantly, though, it must also be shown to be able to achieve this even if the current best assessment of the resource is in error (at least to a degree that is within the bounds of plausibility). Therefore, it is by design compatible with the precautionary approach (PA), by making appropriate allowance for scientific uncertainties. Crucially, it relies on the mechanism of feedback control to adjust for inevitable errors in current perceptions about the resource (the "uncertainties").

The MP approach was first developed by the Scientific Committee of the International Whaling Commission (IWC) during the late 1980s. In 1974, the "New Management Procedure" (NMP) had been adopted as a basis to provide advice on catch limits (IWC, 1976; Punt and Donovan, 2007), a typical example of the TA. However, a decade later, the approach was seen to have failed for two main reasons: (i) the NMP proved unable to meet its intended role of facilitating scientific agreement on catch-limit recommendations, because debate simply moved from what might be an appropriate catch-control law to arguments about parameter (such as maximum sustainable yield (MSY)) values, when implementing that law for a particular case, and (ii) even if agreement could have been reached about the best estimates of those parameters, arguments then developed about how the inevitable scientific uncertainty about those values should be taken into account. The process of developing the IWC "Revised Management Procedure" (RMP) (IWC, 1989; Kirkwood, 1992), initiated by the pioneering work of de la Mare (1986) and with its eventual product accepted by the IWC Scientific Committee in 1991 (IWC, 1992), deliberately focused on resolving these two problems and did so by the process set out above, which is now taken to define an MP.

At about that same time, the desirability of adopting a PA in the management of renewable natural resources was gaining general acceptance, following broad statements to this end adopted by UNCED in Rio de Janeiro in 1992, but it was unclear how to put the PA into effect operationally. The FAO (1995) Technical Consultation on the Precautionary Approach to Capture Fisheries, held in Lysekil, was organized to address this very

point. The report of that meeting implicitly endorsed the MP approach developed by IWC by expressing the need for "management plans" involving "decision rules" to be developed, in conjunction with a directive that "a management plan should not be accepted until it has been shown to perform effectively in terms of its ability to avoid undesirable outcomes". Note that the evaluation of such "performance" necessarily implies some simulation testing.

After summarizing major difficulties (primarily in implementation) with the TA in fisheries management, the main advantages of the MP approach are listed below, emphasizing how they resolve those TA problems. However, the MP approach introduces some new difficulties, and I conclude by explaining those and suggesting how they can be addressed. The presentation is framed in terms of providing advice on TACs, but the comments made would apply similarly to management under effort limitation.

Difficulties with the TA

Variability in "best assessments" from year to year, and hence in associated TAC recommendations

This type of variability can arise for three reasons: new data becoming available, primarily from resource-monitoring sources such as surveys and commercial catch per unit effort (cpue); modified methods to refine such data for inputs into stock assessment (e.g. standardization through generalized linear modelling of cpue series); and (supposed) improvements to the assessment methodology. As a consequence, the recommended TAC can vary independently of the true population dynamic processes, for example, as a result of estimation error in the first case or even change in the opposite direction to trends in resource indices in the other two cases.

Inability to consider longer-term trade-offs properly

An evaluation of the trade-off between long-term catches and risk to the resource is fundamental to sound fisheries management. However, risk can be properly evaluated only based on simulating repeated application of a decision rule because, except for short-lived species, no immediate threat to the resource arises from taking catches somewhat in excess of sustainable levels. The common TA of making catch projections based on a best assessment (even if taking account of estimation error and uncertainty about future recruitment) can overestimate risk appreciably, because the management responses that would follow given future resource monitoring data are not considered. For example, if these provided firm evidence of deteriorating stock status, a recommendation to reduce the TAC would undoubtedly follow and adjust the risk downwards.

Lengthy haggling

Even in nominally objective scientific gatherings, discussions during the process of selecting a singular TAC recommendation can become wastefully protracted through attempts (perhaps linked to interest-group agendas) to squeeze agreement to small changes (up or down). These may be based on argued improvements that would arise from minor modifications to data choices or methods used. Generally, however, such changes reflect only noise, rather than improved detection of resource trends from noisy data, and they add no real value to the advice generated.

What if the "best assessment" is wrong?

The TA does not include any formal basis to make proper allowance for uncertainties, which means that the best assessment at any particular time could be considerably in error. Simple approaches to address such uncertainties, such as basing decisions on the most conservative assessment alone (see critique in Butterworth *et al.*, 1996) or on a lower 95% confidence bound on an estimated TAC, can be wasteful of the resource by setting catches much lower than is needed to avoid real risks of unintended depletion of the population.

Default decisions of "no change"

In the numerous instances of assessment uncertainty that occur in practice, management agencies frequently fall back on the default decision of no change as the easiest path to take. In international fora, where change requires a consensus among participating parties, this problem is particularly acute. The ensuant procrastination usually results in whatever action is eventually taken as being too little, too late.

Advantages of the MP approach

Less time spent haggling to little long-term benefit

The flaw in the IWC's NMP was that it stopped with the specification of the catch-control law. A true MP also needs pre-specification of the data to be used, together with a pre-specified estimation method. The latter transforms the input data into the information required for the computation of a TAC in accordance with the control law. This pre-specification (i.e. before any implementation) of both the formule used and their inputs eliminates room to discuss and modify these each year, which can save considerable time. A classic example of this benefit has been provided by the experiences of the South African Rock Lobster Scientific Working Group when converting from a TA to an MP approach: the total of 40 meetings needed in the previous year to finalize the TAC recommendation was reduced to only four in 1997 when an MP was first implemented for the fishery for *Jasus lalandii*.

Haggling time saved can be put to better use

An important byproduct of the MP development process is the identification of those scientific uncertainties that cause the greatest difficulties in meeting risk-related performance criteria. This in turn clarifies the focus areas for longer-term research to help resolve such uncertainties, and perhaps thereby allow for enhanced harvests with the same perceived risk. Reducing haggling time, and the pressure to address short-term issues, creates the opportunity to focus more on longer-term research efforts designed to resolve these more important uncertainties in assessments.

Proper evaluation of risk

Using medium-term projections, the simulation testing framework provides the appropriate basis for an evaluation of risk. Importantly, it generates new resource-monitoring data for each new year, then re-applies the MP formula, so that allowance is made for feedback effects primarily using the updated trend information to self-correct (at least to some extent) for earlier errors made in TAC recommendations.

Providing a sound basis to put limits on interannual TAC variability

Orderly industrial development requires fairly steady TACs. Under the TA, it is impossible to judge what externally imposed constraint on the extent to which the TAC can be allowed to vary from year to year might be set without jeopardizing resource status. In contrast, evaluation of the implications of alternative levels for such constraints is readily achieved through the MP-testing framework. For the short-lived pelagic species dominating the South African purse-seine fishery, the capability to address this desirable feature for management of the fishery in an objective way has proved particularly advantageous, with industry showing particular interest in plots showing the trade-off between bigger catches and lesser TAC stability. This trade-off arises because, if limitations are set on the rate at which a TAC may be reduced, the TAC cannot be allowed to increase to too high a level either; otherwise, it may become impossible to reduce the TAC fast enough to counter drops in abundance arising, perhaps, from some years of environmentally driven poor recruitment.

Consistency with the PA

As the MP simulation testing framework includes not only the best assessment, but also robustness tests to reflect the scientific uncertainties of this assessment, consistency with the PA is ensured.

Providing a framework for interactions with stakeholders, particularly regarding objectives

The MP approach enforces consideration of the long-term as well as the short-term developments. Because many of the objectives of sound management pertain to the former, this prompts clearer thinking among stakeholders. Moreover, the process of scientists neutrally reporting the range of trade-offs available, from within which it is for stakeholders to make the choice, facilitates enhanced interactions among all players. This in turn promotes those players' buy-in to the MP selected and to the TAC recommendations, which it subsequently provides.

Providing a default

Some haggling may nevertheless be unavoidable, particularly in international settings where member states tend to accord primary priority to maintaining their recent catches. In national situations, the state, which ultimately decides the TAC, is distinct from the potential beneficiaries of that decision (the fishing companies), so the decision may reflect broader objectives than the typical emphasis on shorter-term priorities of such companies. However, in international settings, the states become the beneficiaries while still remaining the decision-makers, which in turn creates additional pressure for a no change decision as the only one that can achieve consensus. An important role for an MP in this situation is to output a "default" TAC calculation as the fallback position, to replace the current no change default that may expose the harvested population to undue risk.

Disadvantages of the MP approach and how they can be addressed

Lengthy development time

The development and review of an MP for a fishery requires more time (at least a number of months) than TA assessments to arrive at a TAC recommendation (typically in 1 or 2 weeks in scientific committees of regional organizations). However, once the MP is in place, non-productive scientific and political haggling time in later years is greatly diminished. Experience has emphasized the importance of avoiding "backtracking" during the extended development/review process, i.e. once a certain stage of the process has been reached, such as specification of the set of models of resource dynamics for simulation testing, the next stage must be undertaken without allowing new hypotheses or information to be placed on the table to take the process back towards its beginning in a potentially infinite loop. As elaborated in Punt and Donovan (2007), the IWC (2005a) set down a schedule to complete the development or review process for selecting which variant of its RMP to apply to a specific species and region over five meetings within a 2-y time frame. This was not to abort new insights developed after such deadlines; rather the place for their consideration was accepted to be the next MP review. Reviews are planned at intervals of 5 y in the IWC framework, but for shorter-lived species, shorter intervals may prove more appropriate.

An overly rigid framework

Decision-makers sometimes desire flexibility to have the "wriggle" room required by the political process, which may have to take heed of the socio-economic realities of the moment. This can be addressed by designing MPs which output a range of TAC options, rather than a single number. The simplest version of such an approach is a "block quota" awarded for a number of years, with a specified maximum amount (somewhat higher than the annual average for the period) that can be taken each year if the block quota is not exceeded over the full period. However, such extensions require that the MP evaluation process include a model of how the choice within the available range is to be made each year. Necessary robustness to possible choices that lead to more negative impacts on the population introduces a cost to such flexibility. This is likely by way of either lower future TACs on average or higher interannual TAC variability, if the perceived risk is to be kept unchanged. As discussed below, the MP review process also provides a mechanism that allows participants to address argued needs for flexibility.

Trusting an autopilot?

An MP is analogous to an autopilot, with the associated advantages. However, this does not mean that the aircraft should be left without a pilot. The pilot must remain on board to look out for unexpected major course deviations that may not have been factored into the design, including appreciable changes in scientific perceptions concerning the resource. Therefore, the MP under consideration for southern bluefin tuna (*Thunnus maccoyii*) includes provisions for updated assessments at regular intervals to ensure that the resource has not moved outside the range over which the MP was designed to operate (CCSBT, 2005). Similar provisions are being adopted for South African fisheries managed under MPs (MCM, 2006). If compelling evidence becomes available, planned reviews at wider time intervals can be brought forward.

Such reviews also provide the opportunity to assess whether the objectives originally chosen, and which the control parameters of the selected MP were "tuned" to achieve, remain appropriate under possibly changed socio-economic circumstances. Importantly, though, decisions to change objectives, or to bring reviews forward, must first ensure that the rationale offered is indeed compelling. Otherwise, such mechanisms can degenerate into surrogates to

tinker with outputs each year in a manner that frustrates the advantages that the MP approach seeks to achieve—genuinely appreciable changes in scientific perceptions about a resource are typically not annual events.

Non-availability of, or "poor", data inputs

Care needs to be taken in designing MPs that the future monitoring data assumed to become available for input to the TAC-computing algorithm are indeed likely to eventuate. Nevertheless, the design process needs to consider the possibility that such data either are occasionally not collected or are deemed inadequate for use (e.g. because a small sample size raises questions of whether such data are representative). Simple ways of dealing with occasional gaps in data (e.g. use the same value as for the previous year) need to be pre-specified, with their adequate performance confirmed in robustness trials. If such gaps develop more regularly, however, it may become necessary to consider bringing the regular MP review forward (see provisions in MCM, 2006). Another possible mechanism to consider would be an appropriate adaptation of the IWC RMP, which stipulates a period over which a TAC is phased down to zero, if an abundance survey anticipated in the testing process within a certain period fails to materialize (IWC, 1994). This provides an incentive to encourage continuation of the necessary resource monitoring.

Reference case selection

Evaluation of the achievement of specified quantitative objectives, such as resource recovery by a certain amount within a specified time frame, is dependent on, and can be quite sensitive to, the choice of the "reference case" operating model (or plausibility-weighted "reference set" of such models over which performance statistics are integrated; Plagányi *et al.*, 2007; Rademeyer *et al.*, 2007) that is used for such computations in the testing and tuning process. In other words, the MP approach does not fully escape, in its fullest sense, the difficulties of selecting a best assessment. Naturally, the TA has exactly this same problem, but the MP approach has the advantage of having tested for the adequacy of feedback to correct for any errors, which can to some extent compensate for a poor initial choice of a reference case.

A related problem can arise if such a quantitative, risk-related objective is framed in terms of the probability of not having abundance decrease below a certain level. Even if it is agreed that "low" plausibility scenarios be excluded from consideration (IWC, 2004), arguments can ensue about whether or not certain hypotheses are sufficiently plausible to merit retention, particularly if they are perceived to influence the conclusion as to whether the objective is met. Hypotheses about more complex stock structure in particular tend to raise difficulties because of Type II error problems: the absence of significant evidence from, for example, genetic data to support such hypotheses is not necessarily sufficient to classify them as implausible. Punt and Donovan (2007) outline an innovative "research-conditional" approach adopted by the IWC Scientific Committee to address this problem (Donovan and Hammond, 2004; IWC, 2005b).

Conclusion

The MP approach can solve most, though not all, of the problems of the traditional "best assessment + control rule" approach. Although it does introduce additional difficulties, these can largely be resolved by operating in accordance with sound protocols (IWC, 2005a; MCM, 2006). The greatest advantages are probably: (i) a sound basis to limit the extent of future TAC variations without compromising resource status and (ii) the proper way of addressing concerns about scientific uncertainty through simulation testing to ensure that feedback secures reasonably robust performance across a range of plausible alternative resource dynamics.

As an afterthought, three decades ago, the major issue in global fisheries management was the collapse of several large fisheries for small pelagic species (e.g. Peruvian anchoveta, *Engraulis ringens*; Namibian sardine, *Sardinops sagax*), primarily as a result of overexploitation to which the management response had come too late. The primary lesson from these events was summarized by Alec MacCall in a speech around 1980 (subsequently reflected in MacCall, 1996) as: "agree beforehand what remedial action to take if negative signals are forthcoming from the resource, rather than risk socio-economic arguments being advanced to delay action in tandem with wishful thinking that the situation will rectify itself." MacCall's invocation is no more than the theme underlying the MP approach: all stakeholders (industry, conservationists, scientists, and managers) need to agree the rules before a fisheries management game is played.

Acknowledgements

The thoughts expressed here follow from rewarding interactions about Management Procedures over a considerable period with many colleagues, particularly in South Africa and on the Scientific Committees of the IWC and the Commission for the Conservation of Southern Bluefin Tuna. Although too numerous to list individually, I must nevertheless mention Geoff Kirkwood and Kjartan Magnusson in the light of their sad passing shortly before the ICES Symposium at which this paper was presented. Beth Fulton is thanked for her comments on an earlier version of the paper.

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doi:10.1093/icesjms/fsm003