

# Adaptive management in fisheries: assessment benchmarks

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The place of adaptive management (the 'adaptive approach') within the development of fishery industry paradigms has been briefly discussed in an earlier chapter. The purpose of the present discussion is to provide a brief overview of the logic of adaptive management, to identify the essential elements of the approach as applied to practical fishery management, and to formulate testable benchmarks by which an agency program can be judged.

It is immediately necessary to distinguish between (a) passive adaptive management – sometimes called the 'monitor and modify approach', or the 'quality assurance approach', and (b) active adaptive management. Active adaptive management is most applicable to the management of natural resources where small scale experimentation is either impractical or impossible. In this situation knowledge about the way the target ecosystem operates can be gained only by: (a) deduction from prior knowledge of the ecosystem's components, or (b) experience with similar ecosystems elsewhere, or (c) by using opportunities provided by optional management strategies in a conscious attempt to gain information critical to long-term management goals. This latter approach is active adaptive management – or as it will be referred to below – simply 'adaptive management'.

Adaptive management in fisheries rests on a combination of three elements: the principle of quality assurance, coupled with mathematical modelling (particularly to investigate the effects of errors, uncertainties, and alternative management strategies), together with an intent to seek information from thoughtful management programs. Adaptive management is management which consciously and thoughtfully seeks to learn from experience.

The principle of quality assurance, now familiar to many people through the International Standards Organisation ISO 9000 and ISO 14000 series of standards, states that agreed outcomes (quality) are achieved through a cyclic process which sets goals, monitors the achievement of these goals, and reviews both goals and operating procedures in the light of the results. Figure 1. portrays the process:

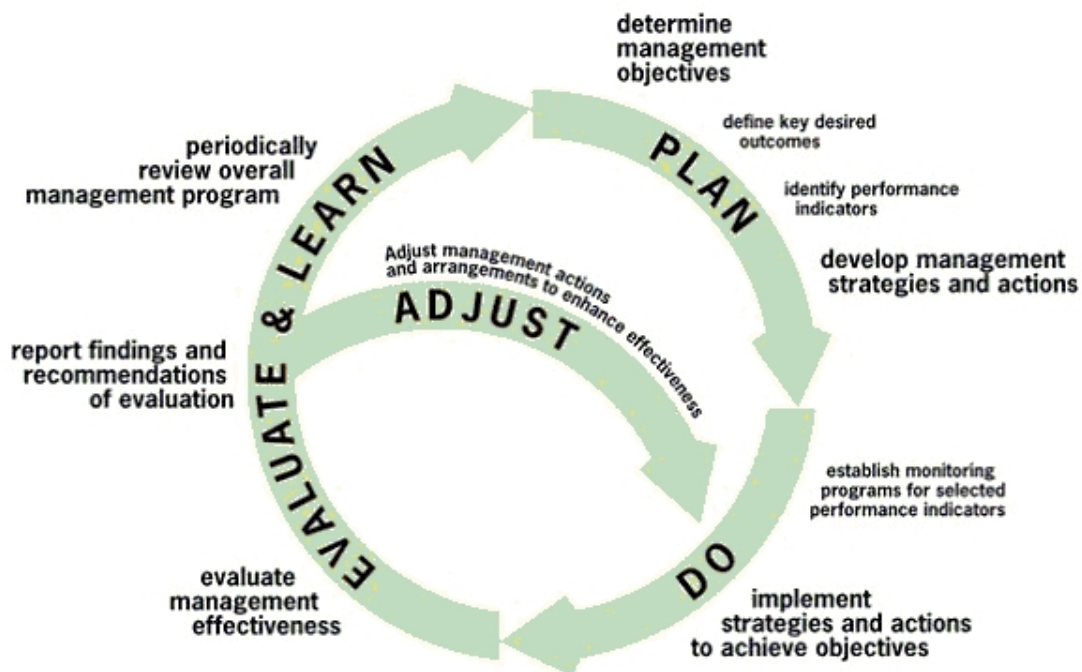


Figure 1: The QMS/EMS planning cycle. source: Jones (2005)

The ISO 9000 (Quality Management System QMS) and ISO 14000 (Environmental Management System EMS) standards in practical use describe the system, organizational structure, procedures and resources that companies use to control processes and activities in order to produce a product or service of consistent quality. The EMS standard extends the essential logic of the QMS standard to a company's environmental performance, so as (in theory) to minimize the impact of the company's activities and products on the environment. The QMS standard incorporates the principle of continual improvement – which states that, as the cycle progresses over time, opportunities will arise (and should be taken) which will enable improvement in the 'quality' of the company's goods and services. A third important principle, underpinning the EMS standard, is that of 'producer responsibility' – a company should take responsibility for the environmental impacts of its products over their life cycle (often long after they have left the direct control of the company).

While the application of the quality assurance approach to, say, the manufacture of a small physical object (like a plastic drink container) is relatively straight-forward, this is not the case when applying the approach to the management of natural resources, such as forestry or fisheries. The extension of adaptive management to natural resources was pioneered by Crawford Holling, Carl Walters and Ray Hilborn in the 1970s.

To a large extent natural ecosystems are, and are likely to remain in the foreseeable future, highly unpredictable (see the earlier chapter on uncertainty). This is less the case with forestry, where small area trials can be conducted which will allow experimentation with key parameters, and the investigation of the effects of management options which may be widely applicable. However capture fisheries, in general, do not lend themselves to such experiments.

While the study of fish biology and ocean ecology has provided much insight into the possible ways in which large scale ecosystems might respond to fishing pressures, the very substantial uncertainties which remain preclude accurate predictions. In this context adaptive management seeks to gather information which will be useful in informing future management decisions.

As computers became faster and more accessible in the later decades of the twentieth century, fisheries management turned increasingly to quantitative models in an attempt to predict the response of marine ecosystems to alternative harvesting policies. However, as Walters observed: ...“model building has not been particularly successful, and it keeps drawing attention to key uncertainties which are not being resolved through normal techniques of scientific investigation” (Walters 1986:vii). In opening his (now classic) book on the *'Adaptive management of renewable resources'* Walters sets out his view on the essential rationale for adaptive management (Walters 1986:vii):

[A] basic issue becomes whether to use management policies which deliberately enhance the [management] experience. Such policies would represent a radical departure from traditional prescriptions about how to deal with uncertainty... My basic theme is that management should be viewed as an adaptive process: we learn about the potentials of natural populations to sustain harvesting mainly through experience with management itself, rather than through basic research or the development of general ecological theory.

My major conclusion is that actively adaptive, probing, deliberately experimental policies should indeed be a basic part of renewable resource management. The design of such policies involves three essential ingredients:

- mathematical modeling to pinpoint uncertainties and generate alternative hypotheses;
- statistical analysis to determine how uncertainties are likely to propagate over time in relation to policy choices; and
- formal optimization combined with game playing to seek better probing choices.

Walter expands these ingredients when he writes about four basic issues involved in the *application* of adaptive management, which are (Walters 1986:8):

1. bounding of management problems in terms of explicit and hidden objectives, practical constraints on actions, and the breadth of factors considered in policy analysis;
2. representation of existing understanding of managed systems in terms of explicit models of dynamic behaviour, that spell out assumptions and predictions clearly enough so that errors can be detected and used as a basis for further learning;
3. representation of uncertainty and its propagation through time in relation to management actions, using statistical measures and imaginative identification of alternative hypotheses (models) that are consistent with experience but might point towards opportunities for improved productivity [here Walters appears to mean management performance]; and
4. design of balanced policies that provide for continuing resource production while simultaneously probing for better understanding and untested opportunity.

Walter also made important recommendations on the place of models within the general adaptive approach. In particular, he recommended thinking carefully at the start of the exercise about what products the analysis should produce:

It has been taken for granted by too many analysts that the ultimate goal should be detailed and quantitative predictions about the future of the system. But in practice such predictions are seldom examined very carefully or taken seriously by the actors involved in decision making. .... [T]he key product should usually be a small set of strong (robust) qualitative arguments and conclusions that can be understood and debated by actors without quantitative skill. Each step in the analysis (and each proposal for data gathering) should be first examined in terms of its likely contribution to qualitative arguments (Walters 1986:36).

The application of adaptive management to natural resource management should, according to Walters & Holling (1990:2063) involve the statement of an explicit hypothesis (or hypotheses). The authors also observe that the best policy "is to make a fairly dramatic and informative experimental disturbance; minor experiments are not favoured because they erode average performance without significantly improving learning rates (Walters & Holling 1990:2063).

The detection of small effects is extremely difficult in the highly variable ocean environment: Peterman (1990) has emphasised that managers must consider the size of detectable effects when evaluating alternate hypotheses. Peterman's discussion underlines the importance of the use of power analysis in statistical tests, in combination with the more commonly used likelihoods (see the earlier discussion in the chapter on uncertainties).

Over the years adaptive management techniques, under the definition used by its early founders, has been widely accepted as an important element in effective natural resource management – if frequent references to the need for the approach in scientific literature can be used as a measure of acceptance<sup>1</sup>. Provision for adaptive management has, for example, been formally included in major north American forest plans (Stankey et al. 2005). However academic support has often been echoed by lip-service endorsement within management agencies, and even associated research institutions. The practical implementation, and indeed the assessment of the technique against more traditional approaches, has met with resistance. Writing a decade after publication of his seminal book on the subject, Walters (1997:1) wrote: "Research and management stakeholders have shown deplorable self-interest, seeing adaptive policy development as a threat to existing research programs and management regimes, rather than as an opportunity for improvement." An application where adaptive management has been used with at least some success is the artificial flooding of the Grand Canyon (Walters et al. 2000).

**Adaptive management in the OMP and MSE approaches:**

The growing popularity of the Operational Management Procedure (OMP) approach, as well as the very similar Management Strategy Evaluation (MSE) approach over the last decade (Butterworth 2007, Smith et al. 2007, Butterworth & Punt 2001, Smith et al. 1999) rests substantially on the ability of these approaches to incorporate both adaptive and precautionary principles. The approaches, however, are defined more by their use of a suite of models, and the specific inclusion of fisher behaviour and fisher participation, than they are by precaution or adaption – these factors must be consciously included in the use of the MSE/OMP approaches in determining harvest requirements. Smith et al. 1999:971 describe 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. 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.

Smith et al. make a distinction between MSE and the similar OMP approach:

While virtually identical in methods and philosophy, [MSE] 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.

**Adaptive management benchmarks:**

If the proposed survey of agency management is to include an examination of the application of adaptive management, benchmarks for adaptive management must be formulated. The following benchmarks rest almost entirely on the work of Walters discussed above:

A management program will be deemed to incorporate passive adaptive management if:

- a) individual fisheries are subject to periodic public review against stated objectives, indicators and performance targets; and
- b) the performance of the management agency itself is subject to independent periodic review against stated objectives, indicators and performance targets.

A management program will be deemed to incorporate active adaptive management if:

- c) it uses mathematical modelling to pinpoint uncertainties and generate alternative hypotheses;
- d) the assumptions behind the models are clearly set out and evaluated;
- e) the reports incorporating the use of adaptive management set out the bounding of management problems in terms of explicit and hidden objectives, and practical constraints on actions;
- f) the use of adaptive management specifically explores key uncertainties and their propagation through time in relation to management actions, using statistical measures and imaginative identification of alternative hypotheses;
- g) there are changes in management controls, designed to test clearly stated hypotheses, which are sufficiently large to reasonably produce detectable effects; the size of these effects must be estimated in advance, and sufficiently powerful field surveys undertaken, and statistically examined to deduce the probabilities of both Type I and Type II errors (Peterman 1990).

- h) formal organizational requirements are established for evaluating and reporting the results of the experimental management strategies, both to managers and stakeholders.

Benchmark a) is similar to EBFM Benchmark 1) (see discussion in the separate EBFM section) so this benchmark will not be used in the proposed agency evaluation. Benchmark f) will not be used as it overlaps to some extent with Benchmarks d), e) and g). The remaining six benchmarks will be used.

**Benchmark summary:**

The above discussion has, on the basis of a literature review, identified the main elements of adaptive management, and the ecosystem and precautionary approaches, as they apply to fisheries. For each of these three approaches, six benchmarks are identified, as follows:

**The precautionary approach:**

- A1 Management strategies and plans contain clear objectives, indicators and performance targets relating to the protection of: target stocks, populations of dependent and associated species, and habitat.
- A2 Fishery management plans use pre-agreed decision rules based partly on limit reference points equivalent to, or more conservative than, both target stock MSY and bycatch population MSY for the most vulnerable species of bycatch.
- A3 Undesirable outcomes which could result from excessive fishing pressures are identified, and monitoring programs are in place with sufficient power to rapidly detect these changes should they occur.
- A4 The risks to ecosystem health and integrity are assessed for each major fishery, and additional caution applied to management programs for high-risk fisheries
- A5 Independent peer review is used as quality assurance for major management policies, strategies and plans.
- A6 Management procedures provide for rapid response in the light of unexpected declines in target stocks, bycatch populations, or habitat value. Such provisions provide for fisher compensation where necessary.

**The ecosystem approach:**

- B1 There is formal periodic assessment of the impacts of particular fisheries against agreed objectives, including ecosystem-based objectives.
- B2 There is monitoring and reporting of agreed ecosystem indicators based on stated ecosystem objectives.
- B3 There is a substantial program in mapping, protecting and monitoring critical and vulnerable habitats, funded by the fishery agency or responsible government.
- B4 There are effective programs in place to monitor and maintain old-growth age structure in specific fisheries.
- B5 The agency has a substantial program to account for evolutionary change caused by fishing.
- B6 There are effective programs in place to maintain the spatial extent of all major sub-populations (both target and bycatch) affected by specific fisheries, and maintain and monitor population genetic diversity.

**Adaptive management:**

- C1 The performance of the fishery management agency itself is subject to independent periodic review against stated objectives, and quantifiable indicators and performance targets.
- C2 The management program uses mathematical modelling to pinpoint uncertainties

and generate alternative hypotheses.

- C3 The assumptions behind the models are clearly set out and evaluated.
- C4 Reports incorporating the use of adaptive management set out the bounding of management problems in terms of explicit and hidden objectives, and practical constraints on actions.
- C5 There are changes in management controls, designed to test clearly stated hypotheses, which are sufficiently large to reasonably produce detectable effects; the size of these effects is estimated in advance, and sufficiently powerful field surveys undertaken, and statistically examined to deduce the probabilities of both Type I and Type II errors.
- C6 Formal organizational requirements are established for evaluating and reporting the results of the experimental management strategies, both to managers and stakeholders.

**Each benchmark will be scored as follows:**

- 0 – no evidence of policy or implementation;
- 1 – policy in place; no substantive implementation at this stage;
- 2 – policy in place; evidence of partial implementation;
- 3 – policy in place; evidence of substantial implementation.

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**Endnotes:**

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<sup>1</sup> Johnson (1999) found 65 papers that used 'adaptive management' in their title, abstract or keywords in the Cambridge Scientific Abstracts for the period 1997-98. That search, repeated for the period 2006-07, yielded 243 papers. It would appear that adaptive management has not lost its popularity within the subject matter of scientific journals. However a search for "evaluation of adaptive management" for the period 1978-2008 yielded only two publications – Parkinson (1990) and Walters et al. (2000).