

Adaptive management and its role in managing Great Barrier Reef water quality

J. Bennett^{a,b,*}, P. Lawrence^{a,c}, R. Johnstone^{a,d}, R. Shaw^a

^a CRC for Coastal Zone Estuary and Waterway Management, 80 Meiers Road, Indooroopilly, Qld 4068, Australia

^b Queensland Environmental Protection Agency, Qld 4002, Australia

^c Queensland Department of Natural Resources and Mines, Natural Resources Sciences, Qld 4068, Australia

^d University of Queensland, Qld 4067, Australia

Abstract

Adaptive management is the pathway to effective conservation, use and management of Australia's coastal catchments and waterways. While the concepts of adaptive management are not new, applications involving both assessment and management responses are indeed limited at the national and regional scales. This paper outlines the components of a systematic framework for linking scientific knowledge, existing tools, planning approaches and participatory processes to achieve healthy regional partnerships between community, industry, government agencies and science providers to overcome institutional barriers and uncoordinated monitoring. The framework developed by the Coastal CRC (www.coastal.crc.org.au/amf/amf_index.htm) is hierarchical in the way it displays information to allow associated frameworks to be integrated, and represents a construct in which processes, information, decision tools and outcomes are brought together in a structured and transparent way for adaptive catchment and coastal management. This paper proposes how an adaptive management approach could be used to benefit the implementation of the Reef Water Quality Protection Plan (RWQPP).

© 2004 Elsevier Ltd. All rights reserved.

Keywords: Adaptive management; Systems approach; Natural resource planning; Reef Water Quality Protection Plan

1. Introduction

Adaptive management can be defined as “a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs” (Holling, 1978). The concept is aimed at increasing our understanding of systems as a whole through active participation and learning, evolving experimentation, reviewing and responding (Walters, 1986). The focus is on action and learning, not in preparing to learn (Lee, 1999). Adaptive management

is seen as the preferred choice of changed management and policy development when the risk of trial-and-error methods is too high and decisions cannot be postponed while further data are collected given the long timeframes for ecosystem responses. Further objectives and actions, including new scientific research, are then based on improved understanding from the outcomes of monitoring and review. The adaptive management process therefore assists decision makers to make informed choices on coastal and catchment management actions particularly where integrated knowledge is required. An adaptive management approach is the pathway to effective conservation, use and management of Australia's coastal waterways.

Most natural resource planning and management decisions, however, are surrounded by uncertainty.

* Corresponding author. Address: CRC for Coastal Zone Estuary and Waterway Management, 80 Meiers Road, Indooroopilly, Qld 4068, Australia.

E-mail address: john.bennett@epa.qld.gov.au (J. Bennett).

The difficulties of dealing with uncertainty and complexity arise for a number of reasons including: the time constraints to undertake detailed investigations; existing data and information are disconnected in time, space and function; knowledge required to fully understand a planning issue cannot be assembled from the available pieces of disjointed information; or the ecosystem interactions cannot be predicted accurately and will be significantly altered by episodic events. Marshall (1995, p.147) comments on this notion of disconnectedness between the sources and application of information better than most: “If you don’t synthesise knowledge, scientific journals become spare-parts catalogues for machines that are never built. Until isolated and separated pieces of information are assimilated by the human mind, we will continue to rattle around aimlessly”.

While accepting that a significant portion of environmental science was conducted using reductionist methods, the challenge is to commence holistic, systems investigations of the way that people interact with their biological and physical environment. The information and learning creates a broader understanding of sustainability and integrating science. An adaptive management approach is ideally suited to linking environmental, social and economic systems, and bringing about a fundamental change in the vision of the catchments in which we live. Folke et al. (2002) promote the concept of *resilience*, urging us to detach ourselves from a singular goal of increasing production capacity and reorient towards *adaptive capacity* as the primary goal in which ecology and society are restored to a balance. Notwithstanding these benefits, adaptive management is time consuming, as causal responses are revealed and understood (Walters and Holling, 1990), resource intensive and most likely to involve some elements of conflict between participants.

The Great Barrier Reef World Heritage Area is a nationally and internationally significant area off the coast of Queensland with outstanding natural, social and economic values. In 2003, the Australian and Queensland governments jointly released the Reef Water Quality Protection Plan (Australian Government and Queensland Government, 2003). Benzaken (in press) outline a number of converging factors that led to the development of the RWQPP, including the political situation at the time, the scientific consensus on the causes of declining water quality (i.e. increased sediment and nutrients loads to the Great Barrier Reef lagoon, linked with international examples of reef degradation and causes), the value of marine based tourism to the reef and the inadequacy of existing management responses. The RWQPP harnessed existing science information and knowledge to establish a basis for cooperative and participatory management approach by community, industry and government agencies to ensure the national icon of the Great Barrier Reef re-

mained sustainable through the balance and integration of economic, social, environmental and institutional considerations. The plan (outlined in Section 3) is underpinned by the principles of a precautionary approach, and identifies the necessary actions, mechanisms and partnerships to build on existing Government policies and industry and community initiatives that will reverse the decline in the quality of water entering the Reef.

The primary focus of this paper is to advance the concepts of a systematic adaptive framework for linking participatory processes, existing tools and planning approaches to achieve community and government partnerships and address the issues of institutional dysfunctionality, uncoordinated management and monitoring, uncertainty in decision making and sub-optimal investments. An Adaptive Management Framework developed by the Coastal CRC is designed to overcome many barriers that have plagued traditional efforts to reach long term collaboration and consensus by taking up the concept of “learning by doing”. To support the concepts, a case study based around the recently signed Reef Water Quality Protection Plan demonstrates the utility of this Adaptive Management Framework, particularly when there are multiple objectives under constraints of time and resources. The current processes and regional arrangements in operation within the Reef region are examined to show how implementation of the RWQPP could benefit from an adaptive management approach.

2. An Adaptive Management Framework

2.1. Development of the framework

An Adaptive Management Framework, developed by the CRC for Coastal Zone Estuary and Waterway Management (Coastal CRC), evolved from six frameworks that supported improved decision making in coastal areas. These frameworks are:

- (i) National Water Quality Management Strategy (NWQMS) and Queensland activities in implementing the NWQMS (Bennett et al., 2002, Appendix D3);
- (ii) Decision Environment (Lawrence et al., 2001);
- (iii) Framework for integrating coastal science into planning (Low Choy, 2003);
- (iv) Framework for integrating research and management (Ockie Bosch, pers comm.);
- (v) Management Strategy Evaluation (Smith et al., 1999); and
- (vi) Integrated monitoring program using LogFrame (Ron Johnstone, pers comm.).

Individually, these frameworks can be guides to improve catchment partnerships in developing and implementing their integrated natural resource management plans. By combining their strengths into an adaptive framework for developing and evaluating management actions, there is a greater opportunity for resource management plans to be implemented and supported in the longer term. The Coastal CRC Adaptive Management Framework (hereafter referred to as AMF) recognises that the NWQMS (ARMCANZ and ANZECC, 1994) underpins the National Action Plan for Salinity and Water Quality (www.nrm.gov.au) and Natural Heritage Trust programs (www.nht.gov.au) and specifically incorporates the concepts in integrated regional natural resource management plans, including targets and performance indicators as measures of effectiveness. Basing the AMF on the NWQMS framework ensures a greater degree of consistency for the development and implementation of resource management plans at the catchment and regional scales, as well as the ability to transfer processes associated with integrating and exchanging knowledge. Importantly, the links between the NWQMS and the AMF mean the community is less confused by a ‘forest of frameworks’ and, at the same time, improves the likelihood of efficient and effective participation by all stakeholders.

2.2. Components

The AMF comprises six basic components (Fig. 1). Each component represents a focused activity with clear outputs, and provides a logical step in the broad framework. The individual components are linked through an on-going, evolving process of actions and responses. A brief description of each component follows.

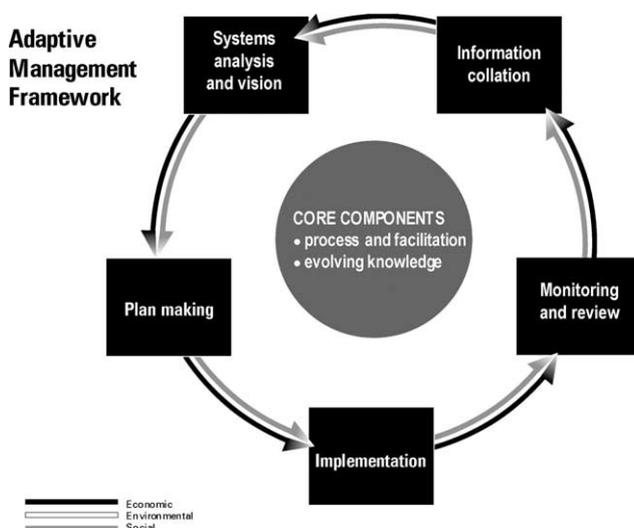


Fig. 1. Schematic of the Coastal CRC's Adaptive Management Framework <www.coastal.crc.org.au/amf/amf_index.htm>.

Core components are a prerequisite for the iterative planning and management cycle and comprise agreed stakeholder interactive processes for building healthy regional arrangements amongst community, industry and government sectors within the catchment. This core component recognises the principles of trust, negotiation, conflict resolution and an evolving maturity in facilitated decision making processes. In addition, there are actions for developing and implementing an evolving knowledge system and community stewardship.

Information collation, in which information from stakeholders and on-going research is pooled, commences the AMF cycle. This dynamic integration of information serves several associated functions, including: defining a broader context of the issue or planning opportunity; refining the understanding of the natural and social systems and their interactions; identifying knowledge links and gaps; developing better communication between scientists, managers and other resource stakeholders; and scoping options for management solutions. Pooling and communicating information so that it is accessible and understood by all partners is a key step towards building trust.

Systems analysis and vision focuses on identifying the institutional context and the stakeholders gaining a broad understanding of the catchment systems in order to define their vision and aspirations for the catchment. A number of participatory processes and engagement tools may be used, including adaptive environmental assessment and management (AEAM) and techniques defined in the Coastal CRC's Citizen Science Toolbox (see www.coastal.crc.org.au/toolkit). These aspirational statements of environmental values should be consistent with the institutional context including current legislation, and the corporate and strategic plans, policies and guidelines of industry, catchment coordinating bodies and government agencies. Stakeholders are encouraged to share their perceptions of the problems, the causes and feasible solutions from their own experiences and based on the best available science. Tools such as influence diagrams and causal-loop systems models are ideally suited for this purpose to identify interactions and impacts through constructing a ‘mudmap’ of community systems thinking (see Gill, 1998). This phase of the AMF also challenges government agencies to identify and resolve barriers and impediments that prevent institutions from embracing adaptive management. An agreed multi-sector registry of environmental values and aspirational goals is the output from this phase of the AMF.

Plan making is where resource management goals and targets are established and potential social, economic and ecological impacts are evaluated to negotiate and define a preferred strategy. A range of impact assessment techniques are utilised during this phase of the framework so that data and information are

transformed into usable knowledge that lead to strategic positioning and potential solutions. These techniques typically include simulation modelling, multiple objective decision support systems, visualisation of catchment scenarios and social and economic impact assessment techniques. In addition, deliberative qualitative methods, such as a citizens’ jury, can play a strategic role in understanding impacts and choosing a preferred course of action (Robinson et al., 2002). The outcomes from this step of the AMF are agreed goals, targets and management actions that are developed from a synthesised information and knowledge base. An important element is identifying and dealing with uncertainties and how they will impact on the decisions made and implementation proposals. As these uncertainties are understood and reduced, changes in management actions may be required. By incorporating known uncertainties in the plan, actions to deal with them can be anticipated.

Implementation of the agreed necessary actions and assignment of responsibilities follows the plan making. The implementation step includes: agreeing to institutional changes and improved governance for initiating changes to management actions, based on stakeholders’ expectations and responsibilities; the establishment or reinterpretation of relevant legislation, policies, guidelines, codes of practice, licences, and permits; and the allocation of resources, funds, expertise, priorities, timeframes, milestones, performance measures and reporting requirements to ensure the actions in the preferred strategy are implemented.

Monitoring and reviewing the effects of the plan against the agreed environmental values, management goals and targets is essential following the decision to implement the strategy. This may involve spatial and temporal evaluation using an integrated monitoring program, and assessment against agreed performance-based targets for management actions and water quality to ensure the community’s expectations for environmental values are being satisfied. The information is continuously pooled to update the shared knowledge base and informed decision making position of the partners.

Outcomes from the monitoring and reviewing are reported, according to processes agreed by the stakeholders, and are subsequently used to determine whether any updating of systems understanding, revision of environmental values, goals or targets and intervention of management actions is warranted. Importantly, these actions must ensure that the health of the catchment and its waterways is progressing towards the goals and aspirations established at the commencement of the adaptive management process and account for unforeseen impacts of decisions based on imperfect knowledge that may require monitoring and adjustment.

3. Application of the AMF to the Reef Water Quality Protection Plan

The Reef Water Quality Protection Plan represents one of the most ambitious and challenging initiatives

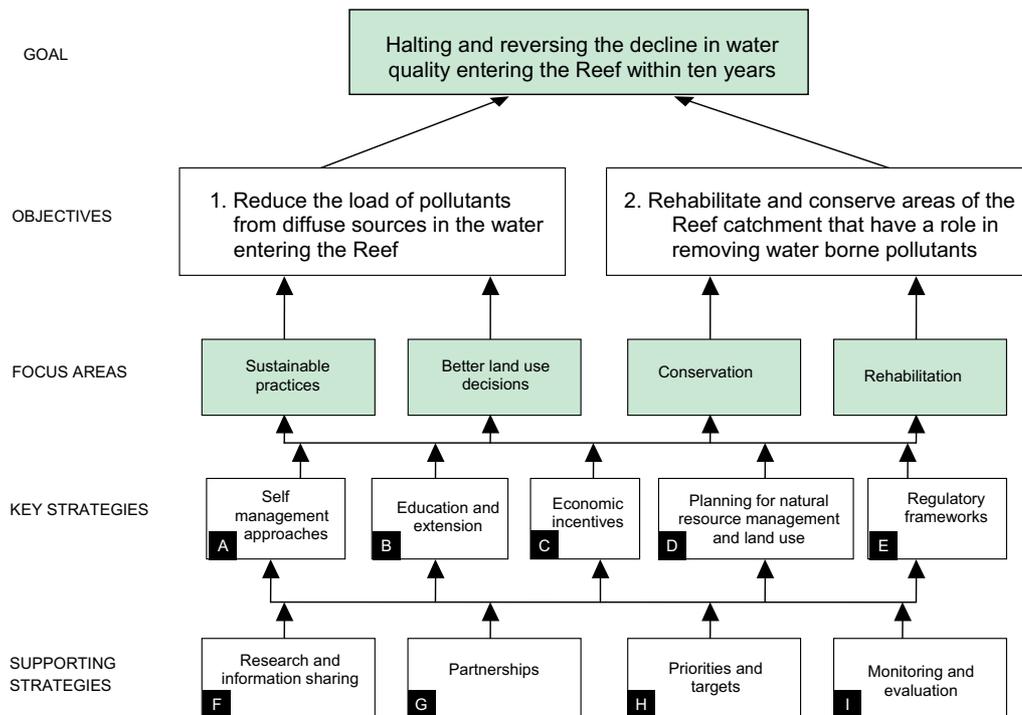


Fig. 2. Reef Water Quality Protection Plan goal, objectives, focus areas and strategies.

Table 1
Alignment of the Adaptive Management Framework to the RWQPP activities

AMF component	Relevant activities related to the Reef Water Quality Protection Plan
Core components	<ul style="list-style-type: none"> • Formal structure for implementation of RWQPP • Strategy G of RWQPP advocates partnerships with regional NRM bodies, local governments, indigenous people and research organisations • Range of communication products advocated and currently available • “Healthy Waterways” programs supported
Data collation	<ul style="list-style-type: none"> • Range of information systems currently in place or being developed • Strategy F of RWQPP outlines actions for research and information sharing
System analysis & vision	<ul style="list-style-type: none"> • Vision: halting and reversing the decline in water quality entering the Reef within 10 years • Institutional environment: Integrated regional NRM Plans (non-statutory/Incentives for priority actions), as well as statutory planning processes e.g. <i>Coastal Protection and Management Act</i>, <i>Environmental Protection Act</i>, <i>Water Act</i>, <i>Integrated Planning Act</i> • Scientists present their understandings graphically in conceptual models of river, estuary, groundwater and lagoon pressures, components and processes
Plan making	<ul style="list-style-type: none"> • Pressures defined (runoff from rural & urban areas, point sources) • Initial targets set by GBRMPA. Regional NRM plans to develop aspirational, resource condition and management action targets • Catchment models & risk assessments used to assess priorities & impacts of alternative management strategies • Social and economic impacts mainly assessed by Industry Commission Report, risk assessment workshops and consultation with key stakeholder groups
Implementation	<ul style="list-style-type: none"> • Implementation strategies <ul style="list-style-type: none"> – Strategy A: Self-management approaches – Strategy B: Education and extension – Strategy C: Economic incentives – Strategy D: Planning for natural resource management and land use – Strategy E: Regulatory frameworks – Strategy F: Research and information sharing – Strategy G: Partnerships – Strategy H: Priorities and targets – Strategy I: Monitoring and evaluation • Implementation plans being developed by Australian and Queensland governments
Monitoring & Review	<ul style="list-style-type: none"> • Strategy I of RWQPP outlines actions for Monitoring and Evaluation, including: <ul style="list-style-type: none"> – Analyse effectiveness of implementation actions – Evaluate success of the RWQPP against established targets – Opportunity to initiate improvements

undertaken in Australia with its goal to halt and reverse the decline in water quality in the Great Barrier Reef region. It aims to achieve its goal through partnerships between industry, community and government sectors. Fig. 2 shows the goal, objectives, focus areas and strategies of the RWQPP.

Detailed actions, roles and responsibilities are included in the plan and various management teams and consultative processes have been established to implement and review progress of the plan. The AMF provides a mechanism to show how the components of the plan fit together and leads to true adaptive management for sustainability with all parties agreeing to the processes and practices adopted as they move through the adaptive management cycle together. Table 1 provides a summary of current activities related to the RWQPP and demonstrates the alignment and application of the AMF for improved water quality planning and management. More details are provided on this

AMF case study at: www.coastal.crc.org.au/amf/amf_index.htm.

4. Concluding remarks

With the National Action Plan for Salinity and Water Quality and the extension of the Natural Heritage Trust program (both of which will provide funding to the RWQPP) redefining the way in which coastal and catchment resource management and planning is undertaken within Australia, there is a need for holistic approaches that facilitate the development of partnerships and integrate environmental, social and economic considerations. The Adaptive Management Framework utilises a number of other structured approaches, including the NWQMS, to suggest an improved way for industry, community and government sectors to participate, develop, implement and review coastal resource

management plans. On reflection, there is a close alignment between many components of the Reef Water Quality Protection Plan and the Adaptive Management Framework. This suggests that synergies from collaborations and the achievement of the goals from the Reef Plan can be achieved by organisations and science providers framing their roles and contributions using the construct of the AMF.

At the core of the AMF is the recognition that agreed solutions come from an evolving learning-based model in which the acquisition and sharing of knowledge is used to continuously review and evaluate the implemented management actions. Other steps in the AMF include: the establishment of healthy regional institutional arrangements; processes and tools for systems analysis and understanding; defining an agreed set of values, goals and objectives/targets for the catchment and its waterways; using all available sources of information and experiences to identify a preferred management strategy that considers a balanced approach to ecological, social and economic requirements; plan implementation; and monitoring, reporting and an adaptive cycle of review and responsiveness. In practice, the AMF provides an initial guide for multi-sectoral catchment planning groups to establish and maintain constructive dialogue and processes that work towards improving capacity as well as achieving environmental outcomes. To support these groups, an interactive web-based application of the Adaptive Management Framework is now available which describes actions and examples of the individual components being applied for effective and efficient resource planning (www.coastal.crc.org.au/amf/amf_index.htm).

Acknowledgments

We thank our colleagues: Donna Barchiesi, Ockie Bosch, Rob Fearon, John Fien, Don Kerr, Neil Lazarow, Darryl Low Choy, Francis Pantus, Tim Smith, Andy Steven, Jan Tilden, Rodger Tomlinson, Lynne Turner, Stephen Fisher and Jess Wallwork for their participation in open discussion workshops and willingness to develop an integrated framework which led to the AMF becoming more than just a concept.

References

Australian Government and Queensland Government, 2003. Reef Water Quality Protection Plan: for catchments adjacent to the

- Great Barrier Reef World Heritage Area, Available from: www.thepremier.qld.gov.au.
- Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) and the Australian and New Zealand Environment and Conservation Council (ANZECC), 1994. National Water Quality Management Strategy, Policies And Principles-A Reference Document. Canberra, Australia, 37pp.
- Bennett, J., Sanders, N., Moulton, D., Phillips, N., Lukacs, G., Walker, K., Redfern, F., 2002. Guidelines for Protecting Australian Waterways, Land & Water Australia, Canberra, 194pp.
- Benzaken, D., Morris, S., Young, L., in press. From catchment to reef: a case study of integrating catchment, coastal and oceans management. In: Proceedings of the United Nations Environment Programme Hilltop 2 Oceans Partnership Conference. 11–14 May 2004, Cairns, Australia.
- Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C.S., Walker, B., Bengtsson, J., Berkes, F., Colding, J., Danell, K., Falkenmark, M., Gordon, L., Kasperson, R., Kautsky, N., Kinzig, A., Levin, S., Maler, K., Moberg, F., Ohlsson, L., Olsson, P., Ostrom, E., Reid, W., Rockstrom, J., Sventin, H., Svendin, U., 2002. Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations. Scientific Background Paper on Resilience for the process of The World Summit on Sustainable Development on behalf of The Environmental Advisory Council to the Swedish Government. Available from: www.resalliance.org.
- Gill, R., 1998. Malpas Dam Community Catchment Planning, Natural Heritage Trust Malpas Dam Community Catchment Planning Project, Combined Stakeholder Workshop, Thalgarah, 19 June, 1998. Available from: <http://members.optusnet.com.au/~roderic/MalpasDam/Malpas.html>.
- Holling, C.S., 1978. Adaptive Environmental Assessments and Management. John Wiley and Sons, London.
- Lawrence, P.A., Robinson, J., Eisner, R., 2001. A decision environment: going beyond a decision framework to improve the effectiveness of decision making in natural resource management. In: Proceedings of the International Congress for Modelling and Simulation, Canberra 10–13 December 2001, pp. 1613–1618.
- Lee, K.N., 1999. Appraising adaptive management. Conservation Ecology 3 (2), 3, Available from: <http://www.consecol.org/vol3/iss2/art3>.
- Low Choy, D.C., 2003. Cooperative Planning and Management for Regional Landscapes, Ph.D. thesis, The University of Queensland, St Lucia, Australia.
- Marshall, A., 1995. In: Gunderson, L.H., Holling, C.S., Light, S.S. (Eds.), Barriers and Bridges to Renewal of Ecosystems and Institutions. Columbia University Press, New York, USA.
- Robinson, J., Clouston, B., Suh, J., 2002. Estimating consumer preferences for water quality improvements using a citizens' jury and choice modelling: a case study on the Bremer River catchment, South East Queensland. CRC for Coastal Zone, Estuary and Waterway Management Working Paper.
- Smith, A.D.M., Sainsbury, K.J., Stevens, R.A., 1999. Implementing effective fisheries management systems—management strategy evaluation and the Australian partnership approach. ICES Journal of Marine Science 56, 967–979.
- Walters, C.J., 1986. Adaptive Management of Renewable Resources. McMillan, New York, USA.
- Walters, C.J., Holling, C.S., 1990. Large-scale management experiments and learning by doing. Ecology 71, 2060–2068.