GENERIC INFORMATION REQUIREMENTS FOR THE MANAGEMENT OF MARINE CONSERVATION RESERVES IN WESTERN AUSTRALIA

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June 1998

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INTRODUCTION

In December 1992 Australia, along with 152 other nations, signed the *Convention on Biological Diversity* which committed Australia to protect and maintain the biodiversity of its lands and waters. In November 1994, Western Australia, along with all other states and territories of Australia, agreed to implement the *National Strategy for Ecologically Sustainable Development* which committed Western Australia to ensure that development delivered economic prosperity to the community without compromising the ecological integrity of the natural environment. Both the *Convention on Biological Diversity* and the *National Strategy for Ecologically Sustainable Development* are centred around the dual objectives of bio-diversity conservation and ecologically sustainable human usage of the natural environment. The development of comprehensive, representative systems of terrestrial and marine conservation reserves is accepted, worldwide, as a major mechanism to achieve these objectives.

In June 1994, the Government of Western Australia released a report produced by the Marine Parks and Reserves Selection Working Group, entitled *A Representative Marine Reserve System for Western Australia* (CALM, 1994), in which 70 areas were identified as worthy of consideration for marine conservation reserve status under the CALM Act. Later that year the Government released a policy statement entitled *New Horizons in Marine Management* which stated that "…*the central thrust of the [Government's] conservation effort would be though the creation of a statewide system of marine conservation reserves under the CALM Act*". Currently there are seven marine conservation reserves in Western Australia: Hamelin Pool Marine Nature Reserve in Shark Bay and six marine parks: Rowley Shoals, Ningaloo, Shark Bay, Marmion, Shoalwater Islands and Swan Estuary marine parks.

A comprehensive scientific understanding of the functioning of natural systems and the implications of human usage on these systems is necessary for the effective long-term management of marine conservation reserves. Natural systems are usually very complex and the resources to acquire the information necessary to develop an adequate scientific understanding are rarely ever available. As such, research and monitoring activities have to be carefully prioritized in relation to management objectives and available funds allocated judiciously to achieve the maximum benefit. Gathering information on natural systems and human usage will lead to better management if there is an established framework to guide the collection and use of this information.

This paper outlines the generic information requirements considered by CALM to be necessary for the effective management of marine conservation reserves in Western Australia and provides the rationale used to identify and prioritize these requirements. Generic priorities are identified and a summary is given in bold at the end of each section.

The paper also provides the framework for the development of specific strategic research and monitoring programs for individual marine conservation reserves in Western Australia. In addition, it has the benefit of providing a clear indication of CALM's broad marine research and monitoring priorities to other State Government agencies in Western Australia as well as to local universities and to Commonwealth marine research organisations such as the CSIRO, AGSO and AIMS. In doing so it will, hopefully, facilitate the development of strategic alliances and collaborative projects where responsibilities and/or interests overlap.

INFORMATION REQUIREMENTS

Information requirements for the management of marine conservation reserves in Western Australia falls into the following broad categories:

- VALUES
- MANAGEMENT OBJECTIVES
- CHARACTERISATION
- THREATENING PROCESSES
- MONITORING PROGRAMS

Values

The values of marine conservation reserves reflect both the implicit ecological attributes and the explicit 'cultural' values placed on the system by the broad community. In this context the ecological values are defined in terms of the physical, chemical, geological and biological characteristics of an area. The 'cultural' values relate to the social, economic, and scientific values. As many human uses depend on the maintenance of healthy ecosystems and not vice versa, ecological values are, intrinsically, of greater importance than 'cultural' values and this natural priority should be reflected in management priorities.

Ecological values

Ecological values include physical, chemical, geological and biological components. Spatial scales range from local, regional and national to international scales. Temporal scales range from seconds to evolutionary time scales. Biological components include species, populations, communities and ecosystems.

Criteria to assess ecological values (adapted from Kelleher & Kenchington 1992) should include:

- ***Uniqueness***: Contains unique species, populations, communities or ecosystems. Global uniqueness would afford an area an ecological/conservation value of international significance (e.g.. stromatolites in Hamelin Pool Marine Nature Reserve).
- ***Representativeness***: Representativeness is the degree to which the area in question represents a species, population, community or ecosystem type within a particular marine bioregion. Physiographic features and ecological processes or other natural characteristics can also contribute to the representativeness of an area.
- ***Dependency***: Ecological processes are highly dependent on biotically structured systems. Examples include coral reefs, kelp 'forests', mangrove 'forests' and seagrass meadows. These areas may contain nursery or juvenile areas or contain feeding, breeding or rest areas for migratory marine fish, reptiles, birds or mammals or maybe a source of larvae for downstream ecosystems.
- ***Diversity***: The area has a high variety of physical, chemical, geological and biological (e.g.. species, populations, communities and ecosystems) characteristics.
- ***Productivity***: The species, populations, communities or ecosystems of an area have a high natural biological productivity.
- ***Naturalness***: The area has a high degree of naturalness (i.e. it is not disturbed or degraded by anthropogenic activities).
- ***Integrity***: The area is a biologically functional unit (i.e. an effective, self-sustaining ecological entity).
- ***Vulnerability***: The area is highly susceptible to degradation by natural events or anthropogenic activities. For example, biotic communities may have a low tolerance to changes in environmental conditions, or may exist close to the limits of their tolerance, which can be defined by water temperature, salinity, turbidity or depth. Similarly marine ecosystems adjacent to large coastal populations are particularly vulnerable to anthropogenic activities.

Cultural values

'Cultural' values include the entire range of human uses of the natural environment, in the broadest sense, and include social, economic and scientific components.

- ***Social significance***: The area has existing or potential value to the local, indigenous, regional, national or international communities because of its heritage, historical, cultural, traditional, aesthetic, educational or recreational qualities.
- ***Economic significance***: The area has existing or potential economic value. For example, the area supports important commercial activities such as fisheries, aquaculture and nature-based tourism, is a food source and/or a source of income for indigenous communities, or is a nursery area or replenishment area for economically important species.
- ***Scientific significance***: The area has particular significance for scientific study at local, regional, national and international scales.

International and national values

Sites with national or international value include those with the potential to be listed on the World or a National Heritage List, declared as a Biosphere Reserve, included on a list of areas of international or national importance, or is the subject of international or national conservation agreements (such as the RAMSAR convention).

Priority should be given to ranking the values of each existing marine conservation reserve using the ecological and cultural criteria outlined above.

Management objectives

Management objectives represent the explicit goals of a management program and specifically address the maintenance of the relevant values described above. These include ecological objectives relating to the maintenance of biodiversity and ecological integrity (i.e. ecosystem structure and function) and 'cultural' objectives relating to the maintenance of educational, scientific, cultural/heritage, economic and recreational values. In this context *biodiversity* is considered at three levels: genetic diversity, species diversity and ecosystem diversity. *Ecosystem integrity* is defined as "…the ability to support and maintain a balanced, integrative, adaptive community of organisms having a species composition, diversity and functional organisation comparable to that of natural habitat of the region" (Karr 1991).

Management objectives need to be clearly enunciated in scientifically measurable terms so that quantitative performance measures and management targets can be developed and applied spatially. Monitoring programs (see below) can then be formulated to specifically address these targets as an indication of management effectiveness and, where necessary, to trigger appropriate management actions.

Management objectives should be formulated to maintain the values identified above and be defined in scientifically measurable terms so that management effectiveness can be assessed through monitoring programs.

Characterisation

The ecological and 'cultural' values of a marine conservation reserve need to be described in both time and space if these areas are to be managed effectively. A comprehensive description of the natural system being managed, an understanding of the key ecological processes that maintain the system and a knowledge of the extent and cause/s of natural variability, combined with monitoring programs and appropriate management strategies, are necessary to detect and ameliorate undesirable impacts on the marine environment resulting from anthropogenic activities.

Resource Inventory

Resource inventories tell us what is present in an area, providing information both on natural systems and human usage, which is required for management. Resource inventories should provide a detailed description of the various ecological and 'cultural' values of the area in question. Comprehensive surveys of marine ecosystems are invariably expensive and, as such, selected components of the environment are usually progressively described.

Survey priorities should be considered in the light of existing scientific knowledge, with a review of all existing information on ecological and cultural resources in the area in question forming the basis for further resource inventory work. An important component of establishing a resource inventory is the creation of a GIS-linked database and the development of biologically and spatially accurate maps to clearly and effectively communicate the information on a system to researchers, managers and the community.

Research priorities should be based on the ecological and cultural significance of the marine resources, vulnerability to existing and future threats and recovery potential.

Baselines and natural variability

An essential element in effectively managing the human impacts on natural systems is the development of quantitative baselines of the various physical, chemical, geological and biological components of the system and measurement of how these baselines vary in time and space, producing a picture of how the system is changing. Without this information it is difficult to understand the significance of the short-term effects, or the long-term implications, of human activities on natural systems. Baseline information often focuses on key representative sites, this may result in reduced spatial coverage but enables recording on an extended time scale. Baselines of both natural attributes and human usage are needed for management.

Research priorities should be based on the ecological and cultural significance of the

marine resources, vulnerability to existing and future threats and recovery potential, focusing on key indicators of threatening processes.

Key ecological processes

Key ecological processes are the natural processes related to the growth, feeding and reproduction of key species, populations and communities within an ecosystem. An understanding of these key processes is essential for the effective management of marine systems. An understanding of key processes which relate to vulnerable systems or to threats which are manageable are of particular importance. An understanding of how marine ecosystems function also provides greater flexibility in management response to unknown threats than would be the case if this understanding was limited, potentially presenting different options for managing a threat.

Research priorities should be based on existing scientific understanding of the relative ecological importance of ecosystem processes.

Human Use

Human usage of the marine environment reflects the range of 'cultural' values held by the community. The community has certain expectations concerning usage of the marine environment. An understanding of the community attitudes to the natural and social environment and the impacts of human usage on the environment as well as the interaction between different uses, is essential for effective management of marine systems. Comprehensive socio-economic databases of both uses and attitudes are required to establish appropriate management objectives and to identify the anthropogenic activities that constitute a significant risk to the values of an area.

Research priorities should focus on developing the socio-economic databases that are relevant to formulating management objectives and identifying key threatening processes.

Threatening processes

Threatening processes are those processes that threaten the values outlined above. These can be natural physical and biological processes or those associated with anthropogenic activities. For the purposes of this paper they are defined here as anthropogenic activities that impact on a regional-scale or less (i.e. management has some degree of control) and have, or potentially have, an undesirable impact on one or more of the values outlined above. Examples include the nutrient enrichment, oil or waste discharge, anchor or diver damage to coral reefs and over-fishing .

Broadscale natural events, such as damage to coral reefs by physical processes like cyclonic waves, or by biological processes like Crown-of-Thorns starfish predation, are considered natural cyclic events and are, therefore, not considered here to be a threatening process. Similarly, anthropogenic processes operating at greater than regional scales, such as the 'Greenhouse Effect', are not considered to be threatening processes, for the purposes of this paper, as 'management' of this type of 'threat' requires co-ordinated global-scale action to be effective. Broadscale events resulting from anthropogenic and physical processes can, however, greatly affect regional systems and observations of resultant changes to natural systems should be routinely monitored (see *Surveillance monitoring* section), thereby keeping a watch on the changes caused by these processes and events.

A comprehensive database of human usage and, at least, a conceptual understanding of the links and synergies between usage and the deleterious effects on one or more value/s is required to identify existing and/or potential 'threats'. The significance of an existing or potential threat will relate to the ecological or 'cultural' importance of the threatened value/s, the spatial and temporal scales of the threat, the vulnerability of the value/s to the threat and the ability to 'regain' the value/s once the threat is removed.

Research priorities should focus on developing a comprehensive risk assessment framework for management as this will identify existing and potential key threatening processes. The major components of this risk assessment frameworks are a comprehensive inventory of the key values of the natural system in question, the temporal and spatial patterns of human usage (including attitudinal information) of, and impacts upon, these values and a comprehensive understanding of the physical oceanography.

Priority should be given to ranking the threatening processes of all existing marine conservation reserves.

Monitoring programs

Monitoring provides ongoing information about interactions between the natural system, human use, management strategies, threats and values. Monitoring trends in key indicators to address changes in the natural system, human uses and threats is an essential component of the management of natural systems. Monitoring provides an assessment of the effectiveness of management in meeting objectives by providing status reports against agreed management targets, detecting undesirable trends and, if necessary, providing the trigger for remedial action.

Monitoring differs from other types of information gathering in that it is based on an on-going collection of information about key elements and processes in the natural, anthropogenic and management systems. The focus for monitoring is determined by the assessment of all other types of information collected to determine potential pressure points where surveillance is necessary. Monitoring tells managers whether they are achieving their objectives and what to do if they are not. In the case of broadscale natural or anthropogenic influences, monitoring may show that no action is the appropriate management response.

The design of monitoring programs should reconcile the spatial and temporal scales of the values under threat with the spatial and temporal scales of the identified threatening process/es. Monitoring parameters should also be clearly linked to a specific threat-value pathway and be sufficiently 'early' in this pathway to allow effective implementation of remedial action. Similarly, monitoring programs should be designed to ensure the minimum detectable difference of the monitoring parameter/s (i.e. the 'sensitivity' of the monitoring program in detecting change) is reconciled with the timescales of human-induced change and remedial action.

Both surveillance and compliance monitoring programs are necessary in the management of marine conservation reserves. Surveillance monitoring is generally broadscale and provides an overall status check on natural systems. Compliance monitoring is used to help ensure specific anthropogenic (usually commercial) activities do not have unacceptable impacts.

Surveillance monitoring

Surveillance monitoring programs are generally broadscale and temporally constrained and are used to provide regular (e.g. annual) overall status reports on the health of natural systems. Surveillance monitoring programs are generally undertaken or coordinated by management agencies. As well as providing an assessment of natural or anthropogenic system-wide influences on ecosystem 'condition', surveillance monitoring programs provide the spatial perspective necessary to interpret the results of local-scale compliance monitoring programs. The nature, extent and frequency of surveillance monitoring programs will reflect the nature, extent and frequency of natural (e.g. storm and predation events) and anthropogenic (e.g. dispersed recreational usage) influences and effects.

Compliance monitoring

Compliance monitoring programs are generally spatially and temporally constrained and are used to help ensure specific anthropogenic (usually commercial) activities do not have unacceptable impacts on the natural environment. The nature, extent and frequency of compliance monitoring programs will reflect the nature, extent and frequency of the potentially detrimental influences (e.g. waste inputs) associated with the anthropogenic activities. In Western Australian marine conservation reserves, compliance monitoring programs are usually part of conditional approvals granted by the EPA for commercial/industrial activities, in consultation with CALM, under the environmental impact assessment process or as part of CALM license requirements of commercial operators in the existing marine conservation reserve system.

Monitoring priorities should address ecosystem components that reflect their ecological and cultural significance, their vulnerability to existing threats and their recovery potential.

Research priorities should focus on key threat-value pathways with the intention of identifying key monitoring parameters and developing methodologies that ensure that the minimum

detectable difference of the monitoring parameter is reconciled with the timescales of human-induced change and remedial action.

SUMMARY OF PRIORITIES FOR ACTION

The following summary outlines the priority actions necessary for the management of all existing marine conservation reserves in Western Australia.

First Order Priorities

- **Prioritize the values using the ecological and cultural criteria outlined above.**
- **Develop comprehensive databases of human usage (including attitudinal information).**
- **Develop, at appropriate scales, biologically and spatially accurate digital maps of the major marine habitats and other major marine resources.**
- **Develop an appropriate level of understanding of the physical oceanography.**
- **Develop an understanding of the links between human usage and values and an understanding of the effects of human usages on the natural environment.**
- **Prioritize threatening processes.**
- **Formulate management objectives in scientifically measurable terms.**
- **Implement comprehensive surveillance monitoring programs.**
- **Ensure the objectives of existing compliance monitoring programs are reconciled with reserve management objectives.**

Second order priorities

- **Quantitatively describe the major taxa within representative areas of each major habitat. Where quantitative data is not available qualitative data such as presence/absence data may be adequate.**
- **Quantitatively describe, in space and time, the physical, chemical and geological environment of (in order of priority) the major primary producers, rare or endangered species and important commercial and recreational species.**
- **Quantitatively describe, in space and time, the variability in species composition and abundance of (in order of priority) the major primary producers, rare or endangered species and important commercial and recreational species.**
- **Develop an understanding of the maintenance processes (i.e. growth, feeding, reproduction and recruitment) for (in order of priority) major primary producers, rare or endangered species and important commercial and recreational species.**

ACKNOWLEDGMENTS

Drs Charles Jacobi and Neil Loneragan of CSIRO, Dr Jim Penn of Fisheries WA, Dr Iva Stejskal of Apache Energy and Brad Barton of CALM provided constructive criticisms of the draft report.

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