R&D Priorities – Marine Protected Areas

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Abstract / Summary

This paper briefly identifies areas of particular MPA relevance for definition of objectives and management strategies and for performance evaluation and monitoring of management strategies and biodiversity outcomes against objectives.

On the expectation that there are substantial overlaps of MPA marine science research needs and those addressed in discovery, ecosystems. services and functions papers, this paper provides a brief introduction to areas of research important for better understanding of biodiversity structure, processes and linkages relevant to MPA design and management. While these issues are priorities for MPAs design and management many are covered in the papers on ecosystem values, discovery and ecosystems.

Background

Marine Protected Areas (MPAs) are a management tool with primacy of biodiversity conservation objectives. The IUCN defines a protected area as "*A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values*." Nevertheless MPAs are created in a range of contexts and there is considerable professional, community and policy confusion over the roles and specific objectives of individual MPAs. There is also substantial overlap in the knowledge and research requirements for their creation and management and those for other human uses and impacts affecting marine space.

While their primary objective is conservation of biodiversity and ecosystem processes. MPAs have different management regimes and terminologies globally and in different parts of Australia. These range from areas with a single management regime for strict conservation to areas zoned to include areas where multiple-uses are allowed and regulated under other legislation. For the purposes of this paper the term MPA is used to refer to IUCN Category I and II areas managed for non-extractive activities – as scientific baseline/reference areas and public access non-extractive use.

Australia has a high global reputation for MPA creation and management .There are groups of highly competent biophysical scientists in universities, museums, government agencies in all states, CSIRO AIMS and GBRMPA have substantial capacity nationally. MPA agencies in all states have significant monitoring programs. The establishment of the national network of representative marine reserves in Commonwealth waters is mostly completed and it is reasonable to expect that the spatial marine conservation focus for the Australian

Government will be on better understanding what we are protecting and evaluating the effectiveness of management measures. Thus a focus for review of the South-east Commonwealth Marine Reserves Network Management Plan 2013-23, is expected to address the adequacy of the zoning for meeting the network objectives. The Department of Environment's National Environment Science Program Marine Biodiversity Research Hub may be seen as a core source of funding for MPA studies in its primary focus is on research findings to meet Commonwealth priorities, particularly addressing decision making needs for management of CMRs and Commonwealth waters more generally

Relevance

The Commonwealth, States and Territories have established MPAs to address objectives of marine biodiversity and ecosystem process conservation, research, education and nature based recreation. Many of these have been established on the basis of existing information derived from geomorphology and relatively limited species and community data extrapolated through surrogacy. Most face challenges of establishing and sustaining monitoring and performance evaluation for adaptive management.

MPAs, biodiversity and ecosystem service conservation are important considerations in the context of design of viable "blue economy" marine development in marine jurisdictions. While the primary research clients are government agencies marine industries and NGOs are clients and funders of MPA and biodiversity conservation research.

Science Needs

The design and management of MPAs involves substantial assumptions and extrapolations of limited understandings of marine ecosystems, their linkages and services, of the range of values they provide and of their resilience to individual, multiple and cumulative impacts. Virtually any robust research that increases such understandings should contribute to MPA management. Given the constraints of length of this paper, a broad scope of science needs shared by many MPA managers is presented in the point summary list below. Some of these are discussed more substantially in the perspective section that follows.

- Roles of area based and other tools for marine bioregion/biodiversity protection
    - Integrated ecosystem based management mosaic and on/off reserve management
    - Integrated ocean and coastal management for near shore areas, which suffer from poor land management practices.
    - Baseline reference areas - free from direct human impact
    - Sanctuaries
        - Larval recruitment/ dispersal significance
        - genetic linkages
    - The role of MPAs in a well-managed fishery
        - Added protection for slow growing sessiles
        - Reference points
- Critical lifecycle sites of economic/charismatic species
    - Benthic habitat of fish and visible invertebrates

    - Feed sites for central place based foragers, migrators
    - Locations of high ecosystem process function – sink/source, nutrient cycling,
- Greater understanding of MPAs, the blue economy, health and well-being-
    - how marine biodiversity conserved through MPAs may contribute to society's better health and well- being
        - eg bio-pharmacologically active compounds for medicinal purposes)
    - the ecosystem services that these areas provide as part of a blue economy
        - eg. protected areas of seagrass for carbon sequestration purposes)
    - scenic, cultural and spiritual values and their multiple social benefits
    - the roles and relationships of IUCN MPA categories within ecosystem based management and blue economy strategies

- Improving the science of the size of MPAs
    - Multi-directional biodiversity connections within and between water column and seabed
    - Strengths and vulnerabilities of marine multiple linkage food webs/chains
    - MPAs and conservation of estuarine and shallow shelf endemism.
        - Linkage role in protecting "key ecological features" in offshore areas
    - Adult range, lifecycle scale and connectivity of species within communities
    - Networking of NTMPAs and water column dynamics
    - The roles of infaunal and epibenthic micro and soft-bodied fauna in foodchains
        - Detritus based and demersal food web roles and linkages
    - The linkages of climate and current change and benthic communities
        - South East Australia and elsewhere
        - Flow on effects to species using or dependent on benthic and watercolumn communities
    - The role of 'no-take' MPAs in building ecological resilience to climate change
        - impacts on species and functional richness
        - impacts on food webs and trophic cascades
        - resistance to tropical and subtropical invasives and vagrants
        - less pronounced increases in the community-averaged temperature affinity
        - Evaluating the effectiveness of MPAs and assessing their performance

- Defining measurable criteria for assessing performance against MPA
    - Establishing key evaluation questions and evaluation tools, which will assist in adaptive management.
    - Effective reporting of MPA performance and outlooks.
    - Science engagement, community knowledge and implementation of MPAs

- Strategies for effective communication and information availability for communities
    - Biophysical state and trend monitoring
    - Activity and impact and trend monitoring
    - Cross boundary dependencies and impacts

- Engaging communities, community knowledge, data collection, knowledge sharing,
    - Communicating difficult concepts
        - Land and sea third dimension - water column as linking primary production habitat
        - Marine ecosystem services – beneath the surface of the seascape
        - Ground truthing “plenty more fish” and “just a drop in the ocean”
        - Better informing governance and legal processes for MPAs
- Understanding legislative and socio-cultural constraints and opportunities
- Understanding social networks
- Understanding dependencies, aspirations, social and cultural linkages
- Understanding drivers of conflicting albeit reasonable objectives
- Using social methodologies to inform decision support modelling

Perspective

Surrogacy and MPA design - Many MPAs and marine reserves have been proclaimed on the basis of habitat level surrogates with relatively limited inventory of species level biodiversity. [Ward et al 1999 and more recent]. Research to expand and refine biological understanding of regionalisations and connectivities is an urgent priority for MPA management.

Australia’s Integrated Marine and Coastal Regionalisation of Australia (IMCRA 4.0) (Commonwealth of Australia, 2006), developed for National Representative System of Marine Protected Area (NRSMPA) purposes, was based on substantial seabed and sub-seabed geomorphology description, made possible by swathe mapping. Bioregions were described largely on the basis of patterns of bottom dwelling fish communities and limited biological and seabed sampling of large fauna such as seabed sponges and echinoderms. Depth-related biomes were derived from distribution of demersal fish species. Very little sampling and analysis of microfauna or benthic epi-fauna and in-fauna was possible and much of the material that was collected in IMCRA and surveys remains unidentified or unsorted (Kenchington and Hutchings 2012).

There are significant gaps as taxonomic capacity as recruits from the 1970s retire. This is of particular concern in the light of Poore et al (2014) who have reported on analysis of 135 grab samples from the West Australian shelf in which 94.6% of crustacean species were undescribed and 72% of the polychaetes new to the Australian fauna.

While IMCRA 4.0 provided an informed regionalisation and enabled the planning of the Commonwealth Marine Reserve Network and State systems of Marine Protected Areas, the narrow vertebrate and macrofauna basis for the regionalisation is a matter of concern. The IMCRA 4.0 report (Commonwealth of Australia, 2006) identified the need for data to enable further revisions in ecosystem understanding and ecosystem surrogates, data coverage; and conceptual classification models. It is assumed that these issues are addressed in the papers on Discovery and Ecosystems However, the effective application of CAR principles for MPAs design purposes is a topic that requires further research, development and evaluation.

Linkages and constraints to the Protected Area functions. Understanding of cross boundary impacts on the effectiveness of MPAs is an area of research that requires greater attention. The effectiveness of area based management of marine ecosystems is severely constrained by internal and cross boundary linkages with and through the primary productive, active transport water column. Research to better understand the nature and scales of linkages is important for better understanding of MPA functions, values, opportunities, constraints and complementary marine management tools.

The concept of a protected area, in the sense of an island of naturalness sectorally managed for primacy of biodiversity conservation, surrounded by areas independently sectorally managed for other uses, has limited application in the marine context. It transfers reasonably to protection of communities of sessile or site associated species with no, or very limited planktonic larval distribution even though most such species depend on the water column and its primary productivity.

For most other species and communities, larval or adult distributional ranges present complex issues of cross boundary ecological roles and dynamic linkage through mass transport of the third dimension active, primary productive, habitat` of the water column. This may be addressed where it is possible to create, enforce and monitor very large no-take MPAs or effective networks of no take zones in multiple use MPAs or integrated management regimes. Even for very large networked protected areas, the nature and scales of nutrient, biological and pollutant linkages are such that interaction of on-reserve and off-reserve management is typically a substantial factor in the effectiveness of MPAs. (GBRMPA 2009, 2014),

.Complementary marine management tools that address cross-boundary issues of MPAs within a broader integrated management context are very important for effective MPA networks. The objectives of the various components of integrated ecosystem based management are addressed by tools that may conflict with, be irrelevant in relation to, or have complementary overlap with biodiversity conservation. (Rice et al 2012, Kenchington, Vestergaard and Garcia, 2014). For spatial management of marine biodiversity conservation within in ecosystem based management it is important to develop robust understanding of the objectives, constraints and opportunities for integrating conservation and other management priorities and tools applied within or outside MPAs..].

Surveillance and Monitoring– A crucial area of marine research concerns development and application of cost effective technologies and long term consistent programs for monitoring and surveillance. Robust evaluation questions are a very important step in any design for monitoring, enforcement and evaluation of MPAs to address the biodiversity and human activity objectives of the MPA in question.

Although MPAs have been in place since the 1970s few have been effectively monitored for biodiversity outcomes or with explicit objectives to inform understanding of the effects and impacts of MPAs (eg Edgar et al. 2009). Where consistent long-term MPA monitoring in areas with reasonable MPA compliance is being undertaken, it is providing clear measures of ocean ecosystem benefits and services (ie Tasmania (Edgar et al. 2009) and the Great Barrier Reef (McCook et al. 2010).

Meaningful monitoring of MPA effectiveness requires effective surveillance of the extent of compliance with conditions of use and entry, particularly and challengingly with respect to recreational fishing. The costs of surveillance of human activities in MPAs are a major constraint to MPA management. They are even greater when the purpose is collect evidence that can reasonably be expected to secure a conviction.

Because the condition of many nearshore MPAs depends on the quality of catchment land and freshwater management it is also important that MPA monitoring programs include or are integrated with broader coastal monitoring.

Social and Cultural Issues. On-reserve or off-reserve, conservation of marine biodiversity is achieved by influencing what people do, or do not do. Human behaviours flow from culture and attitudes influenced by experience, knowledge sharing and education. Socio-economic and cultural research to develop and share knowledge of values, understandings, aspirations, dependencies and attitudes towards marine ecosystems is crucial for supporting planning and management of MPAs.

In the Northern Territory, Indigenous Territorians represent more than 30% of the NT 's total population and own around 85% of the coastline, including intertidal lands and waters to the low water mark, under inalienable Aboriginal freehold tenure granted under the *Aboriginal Land Rights Act (NT) 1976* (Ganter 1996). For many parts of northern Australia, Aboriginal people are major custodians of the coastal and marine ecosystems and biodiversity. Culture, systems of traditional law and knowledge in the sea remain strong over most of the coastline and have major influence over contemporary Aboriginal use, occupation and aspirations in the marine and coastal zone. While engagement with Aboriginal people with interests in and rights to be involved in coastal and marine management planning provides challenges for science-based MPA but also provides opportunities and obligations (Ganter 1996, Smyth & O'Leary 2007). Participatory, cooperative and community-based approaches are required, and should take account of and incorporate Indigenous customary knowledge, values, management aspirations as well as opportunities for economic development.

In other settled and accessible areas, concepts of the seas and their resources as public commons and deep cultural views of "plenty more fish in the seas"; of the sea as a last frontier with limitless capacity to accept and remediate human wastes; and of the social importance of recreational fishing and marine recreation are inescapable considerations in marine biodiversity conservation planning and management.

Even for coastal people and seafarers with substantial and frequent contact with the marine environment, appreciation of the conservation issues is constrained by the invisibility and alien nature of most life and processes beneath the water surface. A crucial scientific issue is to achieve more effective communication and sharing and development of scientific and community knowledges of marine systems to develop and share better understanding of their benefits, opportunities and vulnerabilities.

Economic and Ecosystem Valuations: Explicitly or otherwise the establishment of networks of MPAs depends upon or is greatly assisted by ecosystem services valuations. Development of a more coherent framework for such valuations is an important area of biophysical and socio-economic research for MPA design, and ongoing management.

A range of techniques with inherent assumptions and models has developed to address valuation of marine activities and opportunities. Such valuations are complicated by the flow and separation of costs and benefits within and beyond a protected area.

In South Australia, an economic assessment of the ecosystem services value of proposed Sanctuary Zones in South Australia's MPA Network ($22.80 million/year in total, or $20.69 million/year for the newly proposed sanctuary zones in the MPAs) (Hoisington 2012), were vital in securing political and public support. The commitment to, and establishment of a National System of Marine Protected Areas (or NRSMPA) (ANZECC 1998, 1999) and also, efforts by the Commonwealth to undertake ecosystem-based, bioregional, integrated ocean planning, provide excellent opportunities for using existing (and new) spatial datasets (on ocean values and human uses) to inform future valuation of Australia's ocean ecosystem services.

Climate Change & Resilience: In addition to biodiversity and ecosystem benefits, recent studies suggest that MPAs can also promote resilience to climate variability, by supporting intact trophic webs and large-bodied individuals and also enabling alteration of community responses to long-term climate change by offering habitat for range-shifting species. As such, 'no-take' MPAs can buffer fluctuations in biodiversity and also, provide resistance to the initial stages of tropicalization (Bates et al. 2013).

Multiple Data Streams and MPA Network Modelling: Decision support and modelling systems have evolved with MPAs and are evolving with increasing data availability and modelling capacity. This is an important active area of research for MPA design and management. Of particular promise is the increasing ability to integrate social and economic considerations into scenario models.

Over the past 2 decades, MPA network planning by both, Commonwealth and State jurisdictions (eg. McNeill 1994, Wescott 2006, Fernandes et al. 2009, Kirkman 2013), have been informed by large-scale surveys, habitat mapping and inventories (eg. Edyvane 1999, Banks & Skilleter 2002, Jordan et al. 2005, Shortis et al. 2007, Harris et al. 2008). Increasingly, MPA identification and gap analysis incorporates multiple data streams (geophysical, biological, socio-economic), and modelling of ecosystem processes (eg. Harris et al. 2008, Game et al. 2009, Monk et al. 2011). They are also increasingly informed by systematic conservation planning and decision-support tools that explicitly consider cost considerations (eg. Stewart & Possingham 2005, Watts et al. 2009, Ban et al. 2011, Barr & Possingham. 2013). With the unprecedented availability of ocean data (through national initiatives such as IMOS and the AODN) and modelling approaches and tools, there is a critical need to explore and design optimal methodologies and protocols to assist MPA network planning – particularly for ecosystems dependent on ecosystem surrogates (ie. pelagic, deepwater). Recent modelling studies for the Commonwealth's MPAs network (Barr & Possingham 2013) show the potential of such approaches to refine and validate MPA network planning.

4. Realisation

Infrastructure perspective and Science Capability – CSIRO and AIMS have substantial capacity nationally. There are groups and teams of highly competent biophysical scientists in universities, government agencies and museums in all states and territories..
MPA management is a multidisciplinary activity. The ability to establish and sustain transdisciplinary programs of biophysical, social, information and engineering sciences with

effective community engagement and knowledge sharing.is an important challenge and opportunity for MPA and biodiversity conservation management.

There is substantial technological capacity for development or conversion of surveillance and remote monitoring systems in universities, CSIRO and the Defence Science and Technology Organisation.

Funding – Potential sources of funding,include:

- National Environmental Science Program
- FRDC and possibly a component of the $100M election commitment to RDCs for enhanced primary industry productivity
- State Govts. with their various recreational fishing and boating licence reallocation systems
- Private sector and NGOs

Conclusions

We suggest it is now timely for trandisciplinary R&D to focus on design consolidation and evaluation of a network of MPAs within an effective framework for sustainable integrated ecosystem based management mosaic for management of ALL Australian waters and marine ecosystems. This framework should incorporate integrated ocean and coastal management principles in order to better integrate with land management practices.

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