Australian Marine Sciences Association
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Position paper on marine protected areas

1. Preamble:

Australia is at the forefront of marine conservation internationally, both in terms of legislation enacted to protect the marine environment, and in terms of the spatial extent of proclaimed marine reserves. The Australian (Commonwealth) Government, and all State and Territory Governments, are committed to the development of a national system of representative marine protected areas (NRSMPA) by 2012 (ANZECC 1999).

AMSA is Australia's largest professional association of marine scientists with over 900 members nationally. The AMSA mission is to advance marine science in Australia. AMSA's objectives are to:

- promote, develop and assist in the study of all branches of marine science in Australia;
- provide for the exchange of information and ideas between those concerned with marine science; and
- engage in public debate where we have specialist knowledge.

Marine scientists are not only participants in the NRSMPA through delivering scientific information and advice to assist with the development and evaluation of the protected area network, they are also a key stakeholder group since they use the marine environment for research. AMSA wishes to emphasise the importance of this dual role for marine scientists, because a special effort by governments is needed to include them as stakeholders in the NRSMPA process.

Marine protected areas are *areas of the ocean or coastal seas, securely reserved and effectively protected from at least some threats*[1]. "Effective protection" focuses on identified values, and a management plan (and budget) should be in place. The level of protection, and the intent of protection can both vary. The Great Barrier Reef Marine Park (GBRMP) in Queensland is an example of a large protected area (345,000 km^2) which contains extensive multiple-use areas (covering 66.6% of the marine park) where a variety of fishing activities are allowed, as well as core areas (covering 33.4% of the marine park) which are protected from all extractive activities. In addition, approximately 45% of the multiple use areas are closed to the most ecologically damaging form of fishing – bottom trawling.

The most widely accepted definitions of protected areas are those recommended by the World Conservation Union, or IUCN (Dudley 2008). In their original form they are discussed in an Australian context in IUCN Australia (2000). IUCN categories Ia and Ib are strict no-take areas or sanctuaries, with the categories grading to category VI, incorporating "traditional natural resource management" (Dudley 2008:22). In this paper the word 'reserve' is taken to include protected areas in the first four categories, whose purpose is primarily nature conservation[2]. Areas protected from all harvesting are referred to here as "no-take areas".

Marine reserves must not be seen as a substitute for well-managed fisheries – we need both. The use of marine protected areas to protect biodiversity values is well documented, and MPAs have been accepted at the international level as essential marine conservation tools for nearly three decades. Statements suggesting that the biodiversity conservation benefits of no-take marine protected areas have not been demonstrated are incorrect and misguided – as are statements suggesting fishing activities do not present significant threats to marine ecosystems. Moreover, long-established marine reserves, such as major reserves in tropical Queensland and Western Australia, or the Leigh (Goat Island) and Poor Knights reserves in New Zealand, are important tourist attractions, and produce substantial economic benefits for local and regional communities.

There are two parts to this document (apart from the preamble). The position statement is the first part, and is intended to be a clear statement of AMSA's position on marine protected areas – with recommendations. The second part of the paper provides both background and rationale supporting the statement, and is referenced to scientific and policy literature.

2. Position statement

2.1 AMSA endorses the government's national representative system of marine protected areas (NRSMPA) program, and encourages its timely completion. This should be done for both present and future generations of Australians, as well as to provide undisturbed habitat for at least a proportion of the plants and animals with which we share this planet. AMSA also identifies (below) key areas where further government efforts are urgently needed to maximise the benefits of the NRSMPA to all Australians.

2.2 When an MPA is declared, AMSA believes there should be clearly articulated aims for the MPA, and that the specific MPA be planned for, and managed accordingly.

2.3 Australia's marine biota are poorly studied and in spite of efforts such as the global census of marine life, there are few comprehensive data sets that can be used for MPA design and performance measurement purposes. AMSA encourages governments to invest in taxonomic support and training, ecological modelling studies and especially building national and regional biological data sets, including habitat mapping, to support MPA design, performance measurement and evidence-based decision making. Baseline monitoring before, or at the time of MPA creation[3] is a vital tool for the study of long-term MPA effects, and such ongoing studies must be adequately funded.

2.4 Similarly, the physical aspects of Australia's marine environment are poorly studied. For example, modern multibeam sonar bathymetry data have been collected (at mid-2008) over less than 10% of Australia's EEZ (and over less than 1% of the continental shelf). AMSA encourages governments to invest in building better marine environmental data sets to support all forms of marine management.

2.5 In establishing and expanding networks of marine protected areas, consultation with all stakeholders is vital, combined with adequate education, information and awareness programs. Stakeholders should be able to provide a variety of inputs including both baseline information on ecosystem[4] values and usage, as well as the expression of preferences for reservation options. The selection of options, however, must be framed within Australia's national and international commitments to the protection of biodiversity, and must be based on the best scientific evidence available. Where evidence is inadequate, a precautionary stance must be taken, in line with Australia's commitment to the precautionary principle (Government of Australia 1992).

2.6 Where declaration of MPAs removes substantial and valuable legal entitlements, and where stakeholders suffer significant financial hardship as the result of reserve proclamation, adequate compensation should be paid.

2.7 Networks of marine protected areas must be adequately resourced from the start to ensure they are properly maintained and managed, and to protect them from illegal harvesting and other threats. Well-designed scientific monitoring programmes should be part of their management. It is important to document ecosystem changes following protection to provide information to managers and the wider community on their performance. Such baseline information will also help improve our ability to manage the wider marine environment in a productive and sustainable way.

2.8 AMSA believes that MPAs are vital for the conservation of Australia's marine environment and threatened species. AMSA recommends the following:

a) Given national commitments set out within the NRSMPA strategy, we urge all Australian governments to establish networks of marine protected areas, with the objective of comprehensive, adequate and representative protection of Australia's marine biodiversity assets. National or State marine reserve area targets are only useful in the absence of systematic regional conservation plans. Where detailed planning has not been undertaken, a goal should aim to protect all major marine ecosystems, with a minimum target of 10% of all habitat types under full no-take protection[5] by 2012. Rare and vulnerable ecosystems or communities should be provided with greater protection – up to 100% where an isolated ecosystem or habitat type is endangered. Such no-take reserves should lie within larger multi-use protected areas, designed to provide limited harvesting opportunities which will not prejudice biodiversity assets, especially those within the core no-take zones. A figure of 10% under no-take protection would slow but not prevent loss of biodiversity: the current no-take level in the GBRMP of 33% is more likely to achieve substantial and sustained biodiversity benefits.

b) To be effective, MPA designation should be accompanied by a net reduction in fishing effort for affected fisheries which are at or near full exploitation[6], and AMSA endorses Commonwealth and State use of structural adjustment and industry buyout packages where appropriate (eg: Government of Australia 2004).

c) Although MPAs are an essential tool for marine conservation, AMSA emphasises that MPAs must be complemented by effective management strategies across the marine environment, including (urgently) climate change impact programs, well-managed fisheries, control of spread of invasive species, and control of pollutants, especially nutrients and sediments.

d) AMSA stresses the importance of MPA planning principles set out in several important government documents, especially documents *a,c,f,h,q,s,x & y* listed under the 'guidelines' heading in section 3 below. Several of these documents stress the role and importance of stakeholder consultation, which should take place within a framework of alternative approaches constrained by the essential goals and objectives of the NRSMPA.

2.9 There are (and will continue to be) costs in establishing the NRSMPA, and it is proper that efforts should be taken to minimise these costs. However these costs are predominantly short-term, and should not overshadow the long-term benefits accruing from an effective national MPA network. It is essential that alternative options put to stakeholders do not compromise the fundamental goals, and essential design principles of the network.

2.10 Australia's marine environment has been impacted by a range of human activities. AMSA considers that the cumulative impact of multiple stressors on the marine environment constitutes a key knowledge gap not adequately addressed by existing scientific programmes. A quantitative assessment of cumulative human impacts is required to underpin comprehensive evidence-based decision making.

2.11 While most attention has focussed on the ecological and fisheries values of MPAs, it is also possible that in future MPAs could be created to protect sites of geological or physical oceanographic significance. AMSA encourages consideration of these values.

2.12 AMSA has been disappointed[7] by the small portions of MPAs zoned as totally protected (no-take) particularly on the continental shelf. Only 0.75% of the South East Region shelf is protected by Commonwealth no-take MPAs, noting that about 6% of the SE Region is shelf (on average around 22% of Australia's EEZ is continental shelf). The shelf contains important habitats not found elsewhere. AMSA encourages the inclusion of more shelf areas within existing and future MPA networks, and increased use of full (no-take) protection as the main tool to achieve high-quality conservation outcomes.[8]

2.13 AMSA encourages improved coordination between Commonwealth and State-Territory governments in the design of the NRSMPAs. There is a risk that poor coordination will result in inadequate protection of some ecosystems, particularly those situated near jurisdictional boundaries. Without coordination the placement of MPAs is unlikely to be optimised in terms of cost or effectiveness.

2.14 Systematic network design must be based on biological complementarity, and must consider issues of connectivity, efficiency, uncertainty, replication and effectiveness on a regional basis. Issues relating to rare or endangered species, habitats or ecosystems must be considered, as well as critical habitat, and migratory pathways.

2.15 Good fisheries management is essential to the protection of marine biodiversity. AMSA supports improved fisheries management in conjunction with the development of MPA networks. Of particular importance is the wide application of the ecosystem and precautionary approaches to the management of both commercial and recreational fisheries. AMSA also notes that Australia is committed to the phase-out of all destructive fishing practices by 2012.

2.16 It is unfortunate that Australia lacks an up-to-date consolidated reporting mechanism on protected areas. The collaborative Australian protected area database (CAPAD), maintained by the Commonwealth (at mid-2008) lacked comprehensive information on State marine protected areas past 2004. Further, the database lacks reporting on the extent of protection of marine habitat, ecosystem, geomorphic province, or even bioregion. These are important gaps and should be addressed by the Commonwealth Government as a matter of urgency.

2.17 Marine protected areas assist in maintaining healthy ecosystems. Important ecosystem services supplied by the marine environment include the supply of seafood, passive and active recreational opportunities, dilution and assimilation of wastes (including greenhouse gases), the regulation of coastal climate, and vessel passage – almost all depending heavily on healthy marine ecosystems.

3. Supporting material: protecting marine biodiversity

The following sections provide summary information on:

- important principles and guidelines relating to marine protected areas;
- Australia's marine biodiversity values,
- threats to marine biodiversity values,
- national and State commitments to protect marine biodiversity values,
- general management strategies for protecting marine biodiversity values, and
- the specific role of MPA networks in protecting those and associated values (eg fisheries, scientific and recreational values).

Biodiversity is one of the key conservation values that marine protected areas aim to protect. Other conservation values vary between particular regions and may include key ecological features (eg. upwelling zones), threatened-endangered-protected species (TEPS), geomorphological features having conservation interest (eg. submarine canyons, seamounts, reefs, banks), iconic features (eg. Perth Canyon, Macquarie Island), archaeological or cultural features (eg. historic shipwrecks), and rare or vulnerable marine ecosystems (RVMEs).

Guideline documents

A variety of documents have been published in recent years which seek to provide advice to governments, scientists and stakeholders in respect to the establishment and management of marine reserve networks. Among the most important (from an Australian viewpoint) are (in chronological order – italics mark documents of special note):

a) *Goals and principles for the establishment of the National Representative System of Marine Protected Areas in Commonwealth waters* (Government of Australia 2008) – noting that these represent a revision of the goals originally stated in Government of Australia (1998);

b) Establishing marine protected area networks: Making it happen: Full technical version (Laffoley et al. 2008);

c) *Guidance on achieving comprehensiveness, adequacy and representativeness in the Commonwealth waters component of the National Representative System of Marine Protected Areas* (SPRPNRSMPA 2006);

d) Establishing representative no-take areas in the Great Barrier Reef: large-scale implementation of theory on marine protected areas (Fernandes et al. 2005);

e) The international legal regime of the high seas and the seabed beyond the limits of national jurisdiction and options for cooperation for the establishment of marine protected areas (MPAs) in marine areas beyond the limits of national jurisdiction (Kimball 2005);

f) *Marine protected areas and displaced fishing: a policy statement* (Government of Australia 2004);

g) Designing marine reserves for fishery management (Meester et al. 2004);

h) *Technical advice on the establishment and management of national systems of marine and coastal protected areas* (SCBD 2004);

i) Marine protected areas as a central element of ecosystem-based management: defining their circulation, size and location (Bowman & Sergio 2004);

j) Incorporating marine protected areas into integrated coastal and ocean management: principles and guidelines (Ehler et al. 2004);

k) Reserve selection in regions with poor biological data (Gaston & Rodrigues 2003);

l) *Towards a strategy for high seas marine protected areas: proceedings of the IUCN, WCPA and WWF Experts Workshop on High Seas MPAs, January 2003* (Gjerde & Breide 2003);

m) *Principles for the design of marine reserves* (Botsford et al. 2003);

n) A user's guide to identifying candidate areas for a regional representative system of marine protected areas: south-east marine region (Government of Australia 2003);

o) Population models for marine reserve design: a retrospective and prospective synthesis (Gerber et al. 2003);

p) *Application of ecological criteria in selecting marine reserves and developing reserve networks* (Roberts et al. 2003);

q) *Biophysical Operational Principles* (Great Barrier Reef RAP) (SSC 2002);

r) Marine protected areas: tools for sustaining ocean ecosystems (NRC 2001);

s) *Australian IUCN reserve management principles for Commonwealth marine protected areas*: Schedule 8 of the EPBC Regulations 2000 (Government of Australia 2000);

t) Fully-protected marine reserves: a guide (Roberts & Hawkins 2000);

u) Marine and coastal protected areas: a guide for planners and managers (Salm et al. 2000);

v) Selecting marine reserves using habitats and species assemblages as surrogates for biological diversity (Ward et al. 1999);

w) *Guidelines for marine protected areas* (Kelleher 1999);

x) Australia's Oceans Policy 1998: *Policy guidance for oceans planning and management (Government of Australia* 1998).

y) *Guidelines for establishing the national representative system of marine protected areas* (ANZECC 1998);

z) Guidelines for establishing marine protected areas (Kelleher & Kenchington 1991)

In 1995 the Jakarta Mandate of the *Convention on Biological Diversity 1992* (CBD) established a program within the CBD Secretariat specifically to pursue the protection of marine and coastal biodiversity. Each year the CBD Conference of Parties (CoP) considers this program, and issues a decision statement. These statements are important documents, and Australia (as a strong supporter of the CBD) is committed to their implementation within Commonwealth and State programs[9].

3.1 Australia's marine biodiversity:

Australia's Exclusive Economic Zone (EEZ) obtains its legal validity from our ratification of the United Nations *Convention on the Law of the Sea* in 1994. Australia's EEZ is the world's third largest, with a total area of 11.38 million km^2 (excluding the EEZ attached to Australia's Antarctic Territory). The oceans surrounding Australia are mostly oligotrophic and relatively unproductive. However, the biodiversity of Australia's EEZ is amongst the highest in the world.

Australia's marine flora and fauna encompass a very broad range of latitudes and include tropical, temperate and sub-Antarctic bioregions. These bioregions contain ecosystems which are:

- highly endemic, particularly in the southern temperate zone;
- highly diverse and less damaged when compared to many other places in the world; and
- still poorly documented.

Australia's marine biota also belong to three oceanic systems, including assemblages from the Indo-West Pacific marine fauna, which is of high taxonomic and evolutionary significance, the Indian Ocean, and those of the Southern Ocean (polar) seas.

Given the lack of available information on marine biodiversity, the design of MPAs to date has been substantially based on IMCRA[10] bioregions, with the aim of having representative portions of each bioregion contained within the MPA network for each planning region. Zoning will need to be re-visited in future decades as more information comes to light.

Australian seas are home to marine biodiversity of great international significance. These are assets of great environmental, economic and moral importance, to us and to future generations.

All Australian States endorsed the *National Strategy for the Conservation of Australia's Biological Diversity* 1996[11]. This strategy includes an important paragraph acknowledging the intrinsic value of our biodiversity:

> There is in the community a view that the conservation of biological diversity also has an ethical basis. We share the Earth with many other life forms that warrant our respect, whether or not they are of benefit to us. Earth belongs to the future as well as the present: no single species or generation can claim it as its own.

We have a moral duty to provide undisturbed habitat for at least a proportion of the plants and animals with which we share this planet.

3.2 Threats to marine biodiversity:

Broadly speaking, the living inhabitants of the marine realm face five major threats:

- *climate change*: changes to oceanic temperatures, acidity, patterns of water movement (including currents, eddies and fronts), storminess and sea level, largely caused by *increasing atmospheric carbon dioxide*, as well as impacts from damage to the ozone layer;

- *overfishing* with attendant bycatch problems, both from commercial fishing, recreational fishing, illegal unregulated or unreported fishing (IUU), and ghost fishing;
- *habitat damage* largely caused by fishing gear, especially bottom trawling, but also including effects often associated with coastal development: destruction of coral reefs, mangroves, natural freshwater flows (and passage), coastal foreshores, coastal wetlands and sometimes entire estuaries – which all support coastal marine ecosystems;
- *pollution* (in-sea and land-based, diffuse and point source) including nutrients, sediments, plastic litter, noise, hazardous and radioactive substances; discarded fishing gear, microbial pollution, and trace chemicals such as carcinogens, endocrine-disruptors, and info-disruptors; and
- ecosystem alterations caused by the introduction of *alien organisms*, especially those transported by vessel ballast water and hull fouling.

Amongst these five major threats to marine biodiversity, fishing has, until the present time, been the most damaging on a global scale (Millennium Ecosystem Assessment 2005a:67, 2005b:8, 2005c:12, 2006). The destructive impacts of fishing stem chiefly from overharvesting, habitat destruction, and bycatch. Over the 21st century the threats posed by increasing atmospheric greenhouse gases pose huge dangers to the marine environment (Veron 2008, Koslow 2007, Turley et al. 2006). At smaller scales, other threats (particularly pollution and habitat damage) are dominant at different localities. Coral reef, mangrove, estuarine, seagrass, mud-flat, and sponge-field habitats have been (and are being) extensively damaged. River passage, essential for anadromous and diadromous species, has been impaired or destroyed around the globe.

In Australia, fishing activities appear to be the primary threat to fishes (Pogonoski et al. 2002) and the second most important threat to marine invertebrates (Ponder et al. 2002) after habitat degradation.

3.3 Commitments to protect marine biodiversity:

Australia, and Australian States, have made many strong commitments to protect marine biodiversity.

Principle 2 of the Stockholm Declaration (UN Conference on the Human Environment 1972) states: “The natural resources of the earth, including the air, water, land, flora and fauna and *especially representative samples of natural ecosystems*, must be safeguarded for the benefit of present and future generations through careful planning or management, as appropriate” (emphasis added).

The emphasised section provides, essentially, a commitment to the development of protected area networks focused in large part on the conservation of representative examples of major natural ecosystems. An examination of the wording of the Declaration reveals that it places wide obligations, not only on governments, but on all agencies of governments as well as individuals to act so as to achieve the stated objectives.

Australia was one of many nations endorsing the Stockholm Declaration. Australia later endorsed other important international agreements which reaffirmed our nation’s commitment to the development of networks of protected areas – placing particular emphasis on the protection of representative samples of all major ecosystem types:

- the *World Charter for Nature 1982*;
- the *Rio Declaration 1992* (UN Conference on Environment and Development);
- the *Convention on Biological Diversity* (CBD) 1992; and
- the *Johannesburg Declaration* 2002 (UN World Summit on Sustainable Development);

Australia ratified the United Nations *Convention on Biological Diversity* (CBD) in 1993, and in 1999 the Government enacted the *Environment Protection and Biodiversity Conservation Act* (EPBC Act) which promotes the conservation of biodiversity by providing protection for threatened species and ecological communities, migratory birds, marine mammals and other protected species.

A key requirement of the CBD is for all member nations to establish systems of protected areas, and to develop guidelines for the selection, establishment and management of protected areas. Australia's support of the CBD extends to subsequent agreements under the Convention, in particular the *Jakarta Mandate on Marine and Coastal Biological Diversity (1995)* which provides a strong commitment to the development of marine protected area networks incorporating core no-take reserves within larger multi-use MPAs.

At the seventh meeting of the CBD CoP (Conference of Parties), in Decision VII/30 Annex II (UNEP 2004) the Parties adopted a target: "at least 10% of each of the world's ecological regions effectively conserved". Through Decision VII/5:18-19, the parties also agreed to establish (by 2012) and maintain a network of marine and coastal protected areas that are *representative, effectively managed, ecologically based, consistent with international law, based on scientific information, and including a range of levels of protection*.

At the tenth meeting (2005) of the CBD Subsidiary Body on Scientific Technical and Technological Advice (SBSTTA) an 'application of the targets to the CBD programme of works on marine and coastal biodiversity' repeated this target in the marine context: "At least 10% of each of the world's marine and coastal ecological regions effectively conserved" (by 2012) (UNEP 2005:44).

Australia, and all Australian States are committed to the establishment of networks of marine protected areas representing all major marine ecosystems within Australian jurisdiction. This fundamental commitment is spelt out in increasing detail in three major policy statements: (a) the InterGovernmental Agreement on the Environment 1992 (Government of Australia 1992), (b) the National Strategy for the Conservation of Australia's Biological Diversity (Government of Australia 1996) and, most importantly (c) the Strategic Plan of Action for the National Representative System of Marine Protected Areas 1999 (ANZECC TFMPA 1999).

The goal of the National Strategy for the Conservation of Australia's Biological Diversity is "to protect biological diversity and maintain ecological processes and systems". Principle 8 of the strategy states: "Central to the conservation of Australia's biological diversity is the establishment of a comprehensive, representative and adequate system of ecologically viable protected areas integrated with the sympathetic management of all other areas, including agricultural and other resource production systems."

Commonwealth, State and Territory governments are committed to create a national representative system of Marine Protected Areas (NRSMPA) for the conservation of marine ecosystems by 2012. As at 2004 the CAPAD[12] database listed 200 MPAs in Australian waters covering approximately 648,000 km^2 or ~ 5.7% of Australia's marine jurisdiction, excluding the Australian Antarctic Territory[13]. The MPAglobal website[14], checked in September 2008, listed 359 Australian MPAs, of which 310 were reserves[15], and 81 were no-take[16].

3.4 Protection strategies

What practical steps are available to protect marine biodiversity values in line with existing commitments? Where do MPAs lie in this suite of protective strategies?

Each Australian jurisdiction (at the State and Commonwealth levels) has a relatively similar set of tools at their disposal that are used (to varying extents and effectiveness) for the purposes of management and protection of marine biodiversity. Note here that we use, for the sake of convenience, the term "State" to include the Northern Territory. These tools fall into the three general categories of environment protection, natural resource management, and conservation. The main exceptions to this are the Great Barrier Reef World Heritage

Area which is managed under its own Commonwealth Act, and the intertidal areas that are contiguous with aboriginal lands which fall under indigenous management arrangements.

The systems of *environment protection* include controls on point source pollution as well as diffuse broad-scale pollution of watersheds, estuaries, and coastal foreshores/wetlands; controls on development/disturbance, alienation and modification of estuarine, wetland and shallow marine water habitats; and controls on developments of structures to be placed in deeper waters, including aquaculture facilities, oil exploration/production structures, and tidal/wave/wind energy facilities. These forms of environment protection provide a critical framework to reduce and constrain the pressures imposed by human development on the natural systems of the estuaries and coastal waters, and the structure and processes of marine biodiversity.

Natural resource management principally involves the management of wild capture fisheries, both commercial, recreational, and indigenous. Some harvesting of marine vegetation occurs, but this is mostly beach-cast, and has insignificant effects. Virtually no seabed mining, other than drilling for oil and gas, some sand dredging, and mining of seagrass beds in Cockburn Sound WA for calcareous sand, takes place in Australian waters at the present time[17].

The States are almost wholly responsible for the management of recreational and indigenous fisheries, as well as fisheries substantially confined to State waters. The Commonwealth manages fisheries in Australia's Exclusive Economic Zone, off-shore from the three nautical-mile State limit. This includes the larger of the commercial fisheries, some of which overlap State waters. However, there is a complex set of arrangements between the States and the Commonwealth for delegated management of many fisheries that overlap State and national jurisdictions (noting that the State-waters boundary, aka the 3-nm limit, may be many kilometres offshore in some parts of Australia due to coastal contortions or islands)[18].

Each of the jurisdictions imposes spatial and temporal closures for specific gear types as one aspect of their management system (typically in support of other tools such as minimum and maximum size limits, closed seasons, and controls on bycatch) but the forms of space/time closure normally deployed are both focused on production objectives and are easily revoked should a commercial or recreational need arise. The one dominant exception to this is the protection of coastal wetlands habitats such as mangrove and seagrass beds, which are now more or less well protected (physically) under fisheries management systems because of their important role as spawning, nursery and feeding grounds for targeted species. Overall, the natural resource management systems provide little real protection or commitment to the conservation of marine biodiversity, with (amongst other key biodiversity issues) target stocks being routinely fished down to very low levels within fisheries management systems (so-called 'regulatory over-fishing') leading to likely major ecological consequences for species that are dependent on populations of the various target species. In addition, fisheries-related bycatch and habitat damage are real and significant threats.

Marine protected areas almost invariably fall within the *conservation toolkit* in Australia (in other countries they are also used for sustainable fishing purposes). In Australia, MPAs may comprise a number of different zones, from total protection for strict conservation purposes to sustainable use zones where controls on activities are typically minimal (derived from the tools discussed above). To ensure adequate protection of marine biodiversity values, either MPAs with a high level of protection need to be large, or MPA sustainable use zones need to be very large with strict constraints on the type of permitted uses (eg: bans on trawling).

Overall, conservation of Australia's marine biodiversity requires a mix of all the tools and measures discussed above. Both off-reserve and on-reserve tools and constraints need to be applied to cater for the conservation needs of the vast diversity of life-history strategies, feeding, reproduction, migration and recruitment requirements, and to provide for resilience in the face of the broad-scale pressures being applied by changes in ocean conditions.

MPAs may be deployed at a number of spatial scales, providing a number of types/levels of protection. However, where MPAs provide protection for only a small proportion of the ocean habitats, the importance of off-reserve protective measures becomes critical to the overall conservation of marine biodiversity. Where the MPAs are large relative to their local biogeographic region (currently the only examples are the GBR, Ningaloo, and Heard & McDonald Islands) such areas should be zoned to include both substantial no-take areas (the GBR figure of 33% is a good guideline) as well as multi-use areas permitting activities such as low impact tourism, or small scale wilderness fishing activities. Destructive fishing practices should be entirely excluded. Rare or vulnerable biological communities or habitats within such large multi-use MPAs should be fully protected.

Marine protected areas, no matter how well policed or managed, can be degraded by land-based pollutants, such as nutrients, sediments or pesticides. Estuaries can be degraded by inappropriate land filling or drainage, or the effects of polluted or overdrawn aquifers or rivers. Dams across rivers and creeks can block the spawning pathways of fish. Integrated coastal management programs should be developed to manage the effects of coastal development on the marine environment (see "threats" discussed above). Land use planning, water resource legislation, and pollution controls are key tools in developing such integrated programs.

Of the tools available and used in Australia, only MPAs with high levels of protection (such as no-take or no-access zones) can provide effective conservation that takes into account the high levels of uncertainty that surround our present-day knowledge of the structure, the functional relationships, and the ocean and land-based processes that maintain marine ecosystems (Lester & Halpern 2008, Lubchenco et al. 2007). Small MPAs will provide protection for only a very limited suite of species, noting that even small sedentary species may require secure habitats over large geographic ranges to support their meta-populations. Large MPAs (relative to their bioregion) with large areas of high protection provide the least risk that the MPAs will fail to provide adequate protection for both the known diversity of species and those that have yet to be discovered or understood (Lubchenco et al. 2007).

Systematic conservation planning[19], where conservation objectives are expressly articulated, provides the most robust planning and design of MPAs in the face of limited existing knowledge and high levels of risk. See comments under 'History' below.

3.5 Marine protected area networks

3.5.1 Introduction

Like terrestrial parks, MPAs have important recreational, aesthetic and educational benefits, and can protect important cultural sites such as shipwrecks. In some cases tourism generated by MPAs can have substantial local and regional economic benefits.

Overall, the most general values of MPA networks are those relating to biodiversity conservation, fisheries, and as research and management tools. MPA networks can help to protect rare, vulnerable or threatened species or communities. Protection of community diversity within healthy ecosystems should increase the resilience of these ecosystems, and should offer protection against invasive species. Substantial MPA networks should be able to assist marine communities adapt to some aspects of climate change.

Conservation benefits within MPAs are evident through increased habitat heterogeneity at the seascape level, increased abundance of threatened species and habitats, and maintenance of a full range of genotypes. Fisheries can benefit through protection of spawning populations, spillover, increased dispersal of egg and larval propagules, and as insurance against stock collapse. Scientific benefits primarily relate to the use of MPAs as reference areas to assess the scale of human impacts on the environment, and as locations for the collection of data that are unobtainable in fished systems. Nevertheless, MPAs can also involve costs to human society through displaced fishing effort, short-term reductions in catches, and through creating a false sense of security. MPAs do not represent a universal panacea for all threats affecting marine ecosystems, but are an important tool in the marine manager's toolbox. For marine conservation biologists, they are the most important tool.

It has been estimated that a global MPA network covering 20-30% of the seas would cost $5-19 billion per year to maintain (Balmford et al. 2004). However, returns on this investment would be substantial. Such reserves would promote continued delivery of largely unseen marine ecosystem services with an estimated gross value of $4.5-6.7 trillion each year and have the potential to lead to financial gains from both increased catches and tourism (Badalamenti et al. 2002, Balmford et al. 2004). Marine ecosystem services include the supply of seafood, passive and active recreational opportunities, dilution and assimilation of wastes (including greenhouse gases) and vessel passage – almost all of which depend entirely on healthy marine ecosystems.

On a local scale, the implementation of MPAs can have major social, cultural and economic impacts on communities, which vary considerably according to site and wider social factors within industrialized, developing, or underdeveloped nations (Badalamenti et al. 2002). Careful consideration of socio-economic factors is now considered to be an integral and essential part of MPA network planning and implementation.

3.5.2 History

Marine protected areas have been used by traditional cultures, for example around the Pacific, for hundreds if not thousands of years (Johannes 1978). In fifteenth century Europe trawling was banned in Flanders, with a clear ecological rationale. Different types of trawling were banned throughout the sixteenth and seventeenth centuries in other parts of Europe. Trawling in prohibited areas was made a capital offence in France (WHOI 2002:s1). Clearly, potential damage to marine environments by fishing has been widely recognised for a long time.

In the late nineteen century, concerns over damage caused by fishing led to a decade-long experiment starting in 1885 in Scotland, where open and closed areas were implemented in the Firth of Forth in St. Andrews Bay, with the idea of testing the impacts of fishing on these ecosystems. The final conclusion of that study was that there were serious impacts of harvesting on these ecosystems, and that protection was required (WHOI 2002:s1). Since these early days the concept of marine reserves has received much academic and political scrutiny, and MPAs are now accepted worldwide as a essential marine management tool (see above).

The design and implementation of MPAs has also evolved. Historically the designation of marine reserves was carried out on a site-by-site ‘ad hoc’ basis, with location, size and spacing of MPAs primarily based on opportunistic socio-economic factors rather than a systematic consideration of the conservation requirements of marine ecosystems or organisms (Stewart et al. 2003, McNeill 1994). It is now recognized that good taxonomic and ecological data are imperative for the systematic design of comprehensive, adequate and representative networks of MPAs (Margules & Pressey 2000, Roberts et al. 2003), and there has been considerable discussion on the types of data required (Palumbi 2003, Roberts et al. 2003, Parnell et al. 2006, Gladstone 2007). There has also been a steady increase in studies which collect and interpret data in this context, including the application of mathematical algorithms to reserve system design (Possingham et al. 2000, Curley et al. 2002, Griffiths & Wilke 2002, Stewart et al. 2003, Gladstone 2007).

It is now considered that systematic network design must be based on biological complementarity, and must consider issues of connectivity, efficiency, uncertainty, replication and effectiveness (Laffoley et al. 2008, Halpern et al. 2006, Carwardine et al. 2006, Stewart & Possingham 2005, Fernandes et al. 2005, Pillans et al. 2003). Issues relating to rare or endangered species, habitats or ecosystems must also be considered, as well as critical habitat and migratory pathways (Dobbs et al. 2008, Fernandes et al. 2005; Shaugnessy 1999). Consideration of boundary effects and compliance issues is also necessary in the design phase.

3.5.3 Biogeographic issues

A critical step in the NRSMPA was the development of a national bioregionalisation, which divides Australia’s marine environment into unique bioregions, each characterised by endemic species and distinguishing ecological attributes (Government of Australia 2005). The national bioregionalisation complements the Interim Marine and Coastal Regionalisation of Australia (IMCRA V.3.3; Thackway and Cresswell, 1998) management framework by extending the system of bioregions beyond the continental shelf to cover all of Australia's EEZ. The Interim Marine and Coastal Regionalisation of Australia (IMCRA V.4.0; 50), divides the Australian EEZ into 24 separate Provinces that are separated by 17 Transition Zones making a total of 41 different bioregions. The Provinces are characterised by endemic species, as determined from the distribution of demersal fish. The Transition Zones contain overlapping populations that occur in adjacent Provinces. Distributions of fish species were recorded as 'strings' along the 500 m depth contour. For the analyses, the string was partitioned into smaller segments of about one degree latitude length (about 120 km) into which tabulations of species occurrences were maintained. The similarity or difference between adjacent string segments was measured using the Jaccard statistic , which identified boundaries between different provinces (Government of Australia 2005).

Boundaries between Provinces are locally highly complex because they are based on biophysical information from the lower orders of the classification hierarchy (biomes and, in particular, geomorphological units). Biome boundaries include the shelf break and foot of slope whereas geomorphological units are based on an analysis of seabed geomorphic features (Heap & Harris, 2008).

Following the completion of the South East Regional Marine Plan and declaration of 13 new MPAs in that region, the Australian Government has reviewed the goals and principles that will be used to establish MPAs in Commonwealth waters in the remaining planning regions. The 4 goals and 20 guiding principles specify the criteria that will be used to choose MPA locations, design the MPA boundaries and classify the MPAs into different zoning categories (Government of Australia 2008).

3.5.4 Benefits and costs of MPAs for marine conservation

A primary objective of most MPAs declared to date is the conservation of biological diversity. This may be expressed in terms of the conservation of representative ecosystems, or the protection of important ecological processes, rare or vulnerable habitats, or threatened or important species.

Reserve network area targets

The essential purpose of area targets is to identify the approximate extent of reserves necessary to insure the persistence of both a region's biodiversity, and the processes on which that biodiversity depends. While 'scientific' targets can be developed for single species and areas for which extensive information is available, most studies of targets applying to broader measures of biodiversity, such as habitats or ecosystems, rely on a variety of assumptions and surrogates in the absence of detailed information. In this context a broad arbitrary national target has strengths and weaknesses. In the absence of detailed regional studies it can set a minimum benchmark if applied at a sufficiently fine scale (eg habitat type). However there is also the likelihood that a low target will create false expectations about sufficient reserve areas (Rodrigues & Gaston 2001), and the risk that a target applied at too coarse a scale (e.g. state or national waters) will lead to no-take areas that are not representative of marine regions and habitats, and ineffective at promoting the persistence of important processes.

Such national targets are only useful in the absence of detailed conservation planning at the regional level – once this process has begun a national area target should be abandoned (for that region). Defensible regional targets are an essential component of systematic conservation planning (Pressey et al. 2003:101) The Great Barrier Reef Representative Areas Program (Fernandes et al. 2005) is a good example of such a regional planning exercise. According to Pressey et al. (2003:102) "a basic requirement of [regional] targets is that they should not be constrained or revised downward to accommodate perceived limitations on the feasible extent of conservation areas". The areas important for conservation *and* areas important for extractive uses need to be explicitly identified so that trade-offs are transparent to both decision-makers and stakeholders.

As at 2006 around 0.65% of the global marine realm was classified as protected area, with no-take areas accounting for only a small fraction of this[20]. The World Parks Congress 2003 (WPC) recommended the establishment of national networks of marine no-take areas (NTAs) covering 20-30% of habitats by 2012, a recommendation in marked contrast to the general target set by the *Conference of the Parties to the Convention on Biological Diversity* in 2004, which requires (from participating nations) 10% of all bioregions under protection by 2012. Agardy et al. (2003) however argued against the over-zealous application of the WPC target, suggesting that haste leads to poor planning, and that a focus on targets does little to convince sceptical stakeholders including fishers and politicians[21].

However, while the targets proposed by the WPC remain controversial (Ray 2004) the biodiversity crisis affecting the planet leaves little doubt that an urgent expansion of marine no-take areas is necessary if the global loss of biodiversity is to be addressed in an effective way. This reality is the backdrop against which arguments over marine protected area network targets take place. Soule & Sanjayan (1998) make the point that fully protecting 10% of habitats will not stop biodiversity loss – the target is far too small.

Although Soule & Sanjayan focus mainly on the plight of tropical forests, their discussion of the dilution of scientific reserve selection criteria applies strongly in the marine realm, as recently witnessed in Australia with regard to the protection of Commonwealth waters in Australia's southeast region. Here important representative areas, like the Cascade Plateau, were identified in the initial scoping phase, but later excluded from protection apparently on account of their perceived value to fisheries. A tiny proportion of shelf area was protected within no-take zones (Edgar et al. 2008). The trade-offs made between fisheries and conservation values were not described or justified in any government report, providing the lack of transparency which all too often cloaks poor government decision-making.

Some scientists have proposed reversing the current situation – closing most of the seas, with only a small proportion, perhaps ~ 20%, open to intensive fishing (Walters 1998, 2000). According to Walters (2000): "A revolution is underway in thinking about how to design safe and sustainable policies for fisheries harvesting". Fish stocks repeatedly declining in the face of modern management, major ecosystem damage, and an awareness of the degradation of global biodiversity resources call for a new approach. According to Walters: "Sustainable fisheries management may eventually require a reversal of perspective, from thinking about protected areas as exceptional to thinking about fishing areas as exceptional. This perspective is already the norm in a few fisheries, such as commercial salmon and herring net fisheries along the British Columbia coast". Walters points out that, historically, many apparently sustainable fisheries were stabilised by the existence of 'effective' protected areas, and the erosion of these areas through adoption of new technology subsequently resulted in the collapse of the fishery. Russ & Zeller (2003), in their call for ocean zoning, reinforce Walters ideas.

Literature reviewed by Nevill (2007) reveals a general consensus amongst marine scientists that a massive increase in no-take areas will be necessary if agreed international conservation goals[22] are to be met. Many modelling studies included in this review recommended that targets of 20-40% of habitat should be fully protected. A common assumption in these modelling studies is that fish stocks outside no-take zones are seriously over-exploited, and that these areas essentially provide no protection. While fishery scientists often argue that this need not be the case (Grafton et al. 2007, Hilborn 2007) in practice it remains, unfortunately, all too common worldwide (Pauly & Palomares 2005, Pauly 2005).

It should be noted that Australian governments have, at this stage, not set marine reserve area targets. However a number of nations have set targets. According to Nevill (2007), targets (commonly applying to a proportion of marine ecosystems or habitats) used internationally include:

- South Africa – an official government target of 10% under marine reserves (referenced to the international goal) by 2012. A South African biodiversity protection strategy, released in 2001, recommended 20% under protection by 2010; this recommendation does not appear to have been adopted;
- New Zealand – 10% of marine areas under protection within a network of representative marine protected areas – by 2010;
- Brazil – 10% of each major ecosystem under no-take protection by 2015;
- Fiji – 30% within a representative reserve network by 2020;
- the Bahamas, the Galapagos Islands, Guam – targets of 20% under no-take protection;
- Micronesia – 30% within a marine reserve network by 2020;
- Grenada – 25% within a marine reserve network by 2020;

AMSA endorses the following extract from the *Ecological Society of Australia's* Position Statement on Protected Areas (2003):

> Australian governments have produced and endorsed numerous policies and conventions relating to the conservation of biodiversity. These documents promote broad goals such as comprehensiveness, adequacy, representativeness, persistence and sustainability. Planning and management of protected areas require these goals to be translated into quantitative targets for conservation action on the ground. Targets developed for the Regional Forest Agreements remain controversial scientifically and, in any case, have questionable relevance to agricultural and pastoral regions or marine environments. The more recent retention target of 30% of the pre-1750 extent of ecological communities, even where achieved, will result in further loss of biodiversity in many regions.
>
> The ESA considers that quantitative targets for retention and restoration of biodiversity pattern and process should be the subject of ongoing research, debate and improvement. Targets framed as percentages of regions, subregions or jurisdictions, because of their broad scale, are not useful for planning new protected areas or reviewing established ones. Targets are necessary for land[23] types and species at finer scales. Targets should not be constrained by political or economic considerations because meaningful tradeoffs between nature conservation and competing land uses require areas important for both to be identified and compared.

Conservation of ecosystems

Substantial no-take MPAs can increase ecosystem diversity at large geographical scales. The tools available to modern fishers have created the situation where fish and large invertebrates are captured from virtually all open-access coastal areas of the planet plus trawlable seabeds to over 2000 m depth. The removal of large carnivorous species targeted by fishers in turn affects populations of prey species, with consequent flow-on effects throughout the food web (Pauly et al. 1998, 2000; Okey et al. 2004). Creation of an effective MPA thus adds a new ecosystem component to the regional seascape mosaic in the form of a patch that is ecologically structured by the large commercially exploited fishes that are virtually absent elsewhere.

A second conservation benefit of MPAs is that they protect habitats from physical damage caused by fishing gear. Trawls and dredges, in particular, and to a lesser extent anchors, traps and pots, directly damage the seabed (Watling 2005). Scarring by propellers, boat hulls and anchor chains can also degrade shallow seagrass beds and sandbanks. Until recently, impacts of trawls and dredges were largely out-of-sight and overlooked; however, these fishing techniques are now known to affect huge areas of seabed (Jenkins et al. 2001; Hall-Spencer et al. 2002; Thrush & Dayton 2002).

An extreme example of physical damage to seabed habitats relates to the trawl fishery for orange roughy on deepwater seamounts off south-eastern Tasmania. The complex coral matrix that provided habitat for numerous species on all investigated seamounts shallower than 1000 m depth has been found destroyed by trawl chains and nets, with some small seamounts trawled up to 3000 times during the initial 'goldrush' period (Koslow & Gowlett-Holmes 1998; Koslow et al. 2001). Similar destruction has been documented in New Zealand (Clark & O'Driscoll 2003) and has presumably occurred world-wide.

Another impact of fishing excluded from MPAs is the effect of bycatch and bait discards. Populations of some scavenging species increase significantly in fishing grounds as a consequence of the capture and discard from boats of dead unwanted organisms, plus animals killed or wounded by trawls or dredges passing over the seabed (Wassenberg & Hill 1987; Bradshaw et al. 2002).

In theory, MPAs should also assist efforts to safeguard biodiversity through increasing local ecosystem resilience to invasive species and climate change. Human-induced stresses that affect biological communities rarely operate on their own but often act in a synergistic manner, such that the net impact of threats such as fishing plus catchment nutrification, sedimentation, invasive species and climate change is greater than the sum of these threats if acting individually. Modelling studies support this view, indicating that communities with the full complement of species should possess greater stability and resistance to threats such as invasive species than disturbed communities (Case 1990; Stachowicz et al. 1999, 2002; Occhipinti-Ambrogi & Savini 2003) including those affected by intense fishing.

Field studies on this topic are, however, limited; hence general support for theoretical predictions that MPAs increase ecosystem resistance requires more data, particularly on the scale of ecosystem response to threats. Work from the California coast has shown that fished areas are less stable than adjacent marine reserves, since high density populations of urchins are much more susceptible to disease epidemics (Behrens & Lafferty 2004). In another example, populations of the invasive, habitat-modifying sea urchin *Centrostephanus rodgersii* appear to be rapidly expanding through the eastern Tasmanian region as a consequence of warming water temperatures (Crawford et al. 2000); however, the presence of high densities of predatory lobsters has the potential to constrain recruitment and survival within the Maria Island MPA. Thus, the Maria Island MPA is likely to resist sea urchin invasion better than adjacent fished coasts (Buxton et al. 2005). Because of a paucity of sea urchin barrens, this MPA is also likely to better resist invasion by the exotic kelp *Undaria pinnatifida* (Valentine & Johnson 2003; Edgar et al. 2004a).

Highly protected areas do not operate in isolation and external pressures must also be managed. The protected areas will remain as dynamic ecological systems after their change in zoning status. Apart from natural variation, biological populations in highly protected areas can become depleted under the influence of disturbances emanating from outside the zone, whether they are caused by humans (e.g. pollution, global warming) or by nature (a cyclonic storm), or by events whose cause is debateable (crown of thorns starfish)[24]. There should be more than one protected area declared for each major ecosystem type (ie: replication).

Conservation of species

The most obvious conservation benefit of MPAs is the protection of exploited animals, including both targeted and bycatch species. For the majority of exploited species, this benefit translates to increased local abundance inside MPAs relative to outside rather than the persistence of a species that is fished elsewhere to extinction. Increases inside reserves in both fish abundance and biomass are regularly reported (eg: Pande et al. (2008) and discussion elsewhere in this paper). Once populations of targeted fishery species decline below a certain point then continuation of the fishery is no longer economically viable ('commercial extinction'), and that species generally continues to persist at low levels. Nevertheless, extinction of local populations and even species is possible in circumstances where the target is highly valuable and lacks a refuge from hunting, as in the case of Steller's sea cow, or where an animal concentrates in a small area to breed. For this reason, boundaries of MPAs are often delineated to include and protect spawning aggregations of fishes, such as Nassau grouper (Chiappone & Sealey 2000; Sala et al. 2001).

A major conservation benefit of MPAs at the species level relates to bycatch. Exploitation of species caught incidentally during fishing operations does not necessarily decline as their populations decline, providing that the fishery for the main target species remains economically profitable. Thus, populations of albatross caught incidentally in the tuna long-line fishery (Brothers 1991) for example, could decline to extinction, as long as the tuna population persists and fishers actively continue to set baited lines.

Perhaps the most effective use of MPAs to protect bycatch species relates to trawling grounds, where the ratio of target to non-target species killed by fishing can exceed 1:10 (Andrew &.Pepperell 1992). Shark and ray species appear particularly vulnerable to trawl bycatch threats because of very low fecundity, slow growth, and late onset of sexual maturity. During the first 20 years of fishing on the New South Wales continental slope trawl grounds, for example, the catch per unit effort declined from 681 to 216 kg hour^{1} (68%) for all fish species combined, but from 139 to 0.6 kg hour^{1} (99.6%) for slow-growing dogshark *(Centrophorus* spp.) (Graham et al. 2001). Populations of dogshark continue to decline towards extinction because the NSW trawl fishery remains viable for other species.

MPAs will also indirectly benefit some species because of the complexity of food-web interactions. Declaration of the Leigh Marine Reserve (NZ) indirectly benefits *Sargassum* plants, for example, because sea urchin grazing pressure has declined as a consequence of increased numbers of lobsters and other predators within the MPA, which have consumed most local sea urchins (Shears & Babcock 2002). Similarly, predation pressure exerted by abundant lobsters in a South African protected area caused a major ecosystem shift, with resultant higher abundance of some invertebrate species (Barkai & Branch 1988).
On the other hand, some species will decline in population numbers following the declaration of MPAs. In general, for every positive response shown by species to protection from fishing, some prey species will show a negative response, with ripple effects through the ecosystem. As a consequence of summing up negative as well as positive responses, changes in species richness measured at the site scale are rarely predictable, other than the minor increase caused by the addition to fish and invertebrate counts of large exploited species that become common in the seascape, and species greatly affected by fishing-related damage to habitat structures.

The prevalence of indirect effects within MPAs highlights the importance of ecological monitoring programs for assessing MPA effectiveness. As an example, MPAs may not provide the best mechanism to protect critically endangered white abalone *(Haliotis sorenseni)* in California (Tegner 2000) because of increased predation risk from sea otters and other shellfish consumers. Abalone populations declined following declaration of Tasmanian MPAs (Edgar & Barrett 1999) probably as a result of increase in abundance of rock lobsters and other large predators of juvenile abalone.

Protection from the effects of recreational fishing can provide some species with important benefits (Cooke & Cowx 2004). The grey nurse shark, once the second most commonly caught shallow-water shark off Australia's eastern seaboard, is now under serious threat, partly from recreational angling and spearfishing (Nevill 2005).

Conservation of genotypes

When fishing mortality is greater than natural mortality, as occurs for the majority of fished stocks, then fishing exerts a strong evolutionary pressure on populations (Law & Stokes 2005). For example, individuals of fished populations that grow slowly and reach maturity at a relatively small size, particularly if that size is below the minimum legal size of capture, will have a greater chance of spawning and passing their genetic code to the next generation than fast growing individuals. Fishing mortality can cause the mean size of maturity of fished populations to decline significantly within less than four generations (Conover & Munch 2002; Conover et al. 2005).

Because declining growth rate and size at maturity negatively affects fishery production, fishery-induced selection is sometimes counterbalanced by specific management actions, such as maximum as well as minimum size limits, which allow some large spawners to pass on their genes. However, new regulations directed at individual species cannot counteract the full range of selective pressures induced by fishing, such as behavioural adaptations that decrease probability of capture.

Effective no-take MPAs provide the best management tool for conserving genetic diversity because populations within MPAs are not affected by fishing mortality or fishery-induced evolutionary pressures. In most situations, populations within MPAs will be genetically fitter than fished populations because through millennia the population has evolved specific characteristics that maximise long-term survival of the species in the natural environment. Populations consisting of slow-growing individuals as a result of fishing selection, for example, will suffer higher rates of natural mortality than populations of fast-growing individuals because animals take longer to reach spawning size. Populations with reduced size at maturity tend to have lower total egg production than an unfished population where individuals spawn at a large size with many more eggs released per female. Populations where individuals forage less often because they stay longer in crevices to avoid capture by divers will have reduced food consumption rates, growth rates and net egg production.

Maintenance of genetic diversity within a network of MPAs should prove particularly important for the persistence of species in the face of changing environmental conditions, such as during a period of rapid climate change.

Costs of no-take marine protected areas for biodiversity conservation

As well as providing benefits, MPA establishment can negatively affect biodiversity in some circumstances, and managers should try to minimise any such losses. As discussed above, populations of species such as abalone may decline within MPAs as a result of increases in populations of fished predatory species. More importantly, the declaration of MPAs results in changed human behaviour, with potential negative consequences.

The exclusion of fishers from MPAs will, unless action is taken to reduce overall fishing effort, result in displacement of fishing effort and greater fishing pressure within open-access areas outside the MPA network. If the total fishing catch is finely regulated using total allowable quotas, then such displaced effort could potentially cause overfishing and a gradual decline in fish populations within the open-access areas, ultimately resulting in protected 'islands' of high biodiversity that are surrounded by a 'sea' of low fish production (Buxton et al. 2005). Such a scenario is clearly undesirable from a resource management perspective, and also from a conservation perspective for species with little connectivity between the MPAs.

The declaration of MPAs can also concentrate divers and other users of the marine environment into localised areas. Whereas accidental damage to corals and other organisms caused by diver contact may have little environmental impact when spread over a large area, such impacts can be catastrophic when localised along popular dive trails. Clearly, management prescriptions within MPAs must take into account the potential impacts on marine biodiversity of concentrations of 'passive' users. Management planning should also pre-empt any race by fishers to extract as many fish as possible before MPA regulations come into force, and recognise that spawning aggregation and other important sites may be targeted for illegal fishing if locations are advertised within MPAs.

One pervasive threat to biodiversity that accompanies MPA creation is a false sense of security. The general public frequently assume all necessary protection is in place once a MPA network is declared regardless of the size or spread of the reserves, the level of protection, or the level of poaching. Well designed and executed field monitoring studies should indicate whether MPAs are actually working or not.

Scientific and tourism benefits of marine reserves

Marine protected areas generate economic benefits. The tourism economy of Queensland’s Great Barrier Reef Marine Park, including flow-on effects, exceed $5 billion pa. These revenues, of course, include recreational fishing – an important activity within the multi-use park. The Leigh (Goat Island) no-take reserve in New Zealand attracts over 300,000 visitors each year – generating significant benefits to the local economy.

In addition to economic impacts, MPAs provide opportunities and potential benefits for education and recreation. They also generate scientific benefits of importance to fishery and conservation managers, and to the wider community.

The immediate scientific value of effective MPAs is that they act as reference areas for understanding effects of fishing on marine communities (Dayton et al. 2000). Our present understanding of this topic is poor, hence information on the unexpected population changes that almost inevitably occur within MPAs greatly enhances our understanding of ecosystem processes. To date, a general understanding of the effects of fishing has been severely compromised by complexities of interactions between species and by the 'sliding baseline syndrome' – the phenomenon whereby slow incremental changes may amount to massive environmental changes over several human generations but are not noticed because each generation starts with a different, albeit slightly worse, conception of the 'natural' state of the environment (Dayton et al. 1998).

In this context, it is important to recognise that the study of MPAs not only provides information on how fishing affects the environment, but can also alleviate concerns about fishing where this activity has little effect. For example, fisheries for a variety of south-eastern Australian species – including school shark, striped trumpeter, jack mackerel, barracouta, gemfish and warehou – collapsed during the second half of the twentieth century. In some cases the collapse was probably due to overfishing; however, fisheries may also have declined as a consequence of increasing water temperatures, coastal degradation, or a combination of factors. Without MPAs as reference areas, the contributing factors can only be guessed, and fishing possibly blamed in some cases when not a major contributing factor.

An additional scientific benefit of MPAs is that they provide access to subjects that are so rare that they cannot be rigorously studied elsewhere. For example, if large predators have been overfished across the coastal seascape, then without study of protected populations their potential role in the ecosystem cannot be assessed. Similarly, without MPAs it is often impossible to accurately measure basic parameters used for modelling stock dynamics of fished species, such as rates of natural mortality, growth rates of large individuals, and size at maturity for unfished stocks.

MPAs are also useful in providing a controlled environment for scientific experiments, particularly when public access is restricted and experiments can be undertaken without interference. The Leigh (Goat Island) Marine Reserve in New Zealand was originally planned with this scientific aim as its primary goal, although the reserve was subsequently found to also generate many conservation-, fishery- and recreation-related benefits over the long term.

From an ecological perspective, MPAs represent a large-scale manipulative experiment where predation by humans is excluded from particular plots (Walters & Holling 1990). If appropriately monitored, results can provide profound insights into structural connections within food webs at regional, continental and global scales. These spatial scales differ markedly from those traditionally studied in ecological investigations, such as when plant and animal densities are modified at the scale of metres on patches of shore. Processes operating at small scales often differ from those operating at larger scales (Andrew & Choat 1982; Andrew & MacDiarmid 1991; Babcock et al. 1999) so conclusions reached cannot be extrapolated to the more interesting larger domains without validation (Eberhardt & Thomas 1991; Menge 1992). MPAs provide prime opportunities to validate experiments at scales relevant to management intervention.

3.5.5 Significance of no-take MPAs in fisheries management

Most marine protected areas globally are established to conserve biodiversity through the protection of ecosystems, habitats, and species (Roberts et al. 2005). The majority are not declared with fisheries enhancement as a primary goal. While the biodiversity benefits of marine protected area networks are accepted worldwide through (for example) international agreements and the resolutions of the United Nations General Assembly, the fishery benefits of marine reserves are not as well documented, and are more hotly debated.

High levels of uncertainty characterise fisheries management. Uncertainty stems from many factors, including environmental fluctuations over short, medium and long time periods, lack of knowledge of the dynamics of single species, and their role and relationship to the ecosystems which support them, data uncertainties from statistical and sampling bias, and uncertainties in predicting of the activities of fishers. When some of these uncertainties are included in modelling studies, results indicate that the establishment of significant areas under no-take protection can result in increased fish catches in adjacent areas (Grafton et al., 2005; 2006).

Australia's best-known MPA is the Great Barrier Reef Marine Park (GBRMP) in Queensland (Day et al. 2003). In 2004 the GBRMP was rezoned under the Representative Areas Program (RAP), a Commonwealth Government initiative. The objective of RAP was to protect at least 20% of each of 70 bioregions in the GBRMP (Day et al. 2003). While the RAP was not established for fisheries management purposes, which are the responsibility of the Queensland State Government, it increased the no-take (no fishing) zones from 4.5% to 33.4% of the GBRMP, closing an area of approximately 115,000 km^2. At the time this was the largest single spatial closure to fishing in the world. Furthermore, for the first time, many of the no-take zones are now close to the coast, where many people fish, particularly for recreation. Not surprisingly, the public debate over the implementation of RAP centred on fishing, not biodiversity, issues. The debate helped to bring into sharper public focus the potential benefits of no-take zones as fisheries management tools, particularly the potential benefits for reef fisheries.

Many fish stocks worldwide are currently over-exploited by marine capture fisheries (Pauly et al. 2002). To many people no-take reserves represent one potential solution to enhance the long-term sustainability of many of these fisheries. To others they represent a 'fencing off of the seas' attitude, a denial of people's 'rights' to fish. Thus, the use of no-take reserves as fisheries management tools is a highly controversial topic in fisheries science and fisheries management.

The popularity of marine reserves as fisheries management tools, at least in the literature, stems partly from a frequent failure of 'traditional' catch and effort controls to prevent overfishing in many developed nations, and the difficulty in applying such 'traditional' options in many developing nations. It also reflects a growing interest in a more holistic approach to fisheries management, particularly the concept of protecting the habitats and ecosystems on which fish productivity depends. MPAs have attracted a great deal of interest from a remarkably broad cross-section of disciplines, for example conservation, ecology, economics, environmental science, fisheries science, fisheries management, mathematical modelling, and social science. The topic is popular since it offers, simultaneously, conservation and sustainable exploitation, two objectives that many have viewed in the past as often conflicting. It proverbially offers us a chance to have our fish and eat them too.

Expectations of no-take marine protected areas as fisheries management tools

There are seven expectations of the effects of no-take marine reserves on organisms targeted by fisheries (Russ 2002):

Effects inside reserves

- lower fishing mortality
- higher density
- higher mean size/age
- higher biomass
- higher production of propagules (eggs/larvae) per unit area.

Effects outside reserves

- net export of adult (post-settlement) fish (the 'spillover' effect)
- net export of eggs/larvae ('recruitment subsidy').

Good evidence indicates that the abundance and average size of organisms targeted by fisheries increases inside no-take marine reserves. However, to be useful as fisheries management tools, no-take marine reserves need to become net exporters of targeted fish biomass (export of adults and/or propagules) to fished areas or provide other forms of benefit for fisheries management (such as increased profits, or reduced levels of uncertainty). The use of marine reserves as fisheries management tools remains controversial, since clear demonstrations of such export functions and benefits are technically and logistically difficult to demonstrate. However, the potential remains for a wide array of benefits to be secured by fisheries from carefully designed and strategically located MPAs (Ward 2004).

Protection of aggregations, and stock recovery

Marine animals aggregate for a variety of reasons, most commonly to do with spawning, feeding, 'safety in numbers' and migration (Allee 1931). Many such aggregations occur at predictable times and places. Such aggregations are often targeted by fishers, and many important aggregations have been so heavily harvested that they have been effectively eliminated. Populations and sub-populations are sometimes at great risk, and the scale of damage to date suggests that genetic variation within many populations has been lost – however evidence for this is lacking, and the extent of damage may never be assessed (Sadovy 2003).

In Australia, for example, spawning populations of orange roughy have been decimated across its Australian range, with the Cascade Plateaux population the only one remaining above 10% of its virgin biomass (Nevill 2006). Protection of spawning sites, and curtailment of fishing effort was instigated only after populations had crashed. In South Australia, a massive spawning aggregation of giant Australian cuttlefish near Whyalla was almost extirpated before fishing effort was restricted by a temporary reserve.

The protection of critical spawning areas and populations, and nursery habitat is of particular importance. The protection of such areas are important commitments under the Rio Implementation Statement 1992 and the UN FAO Code of Conduct for Responsible Fisheries 1995 – both endorsed by the Australian Government.

With respect to the general issue of recovery of depleted stocks, there is a growing scientific literature which supports the notion that MPAs, and particularly fully-protected (no-take) MPAs, can be effective in promoting the recovery of stressed ecosystems and of depleted fish-stocks (eg. Lindholm et al. 2004; Wooninck and Bertrand, 2004; Bohnsack et al., 2004). Crowder et al. (2000) found in a review of 28 MPAs that most exhibited increased fish density, biomass, average fish size and diversity after the MPA was declared. Similarly, in an analysis of 89 studies of fully-protected reserves, Halpern (2003) showed that, in almost every case, the creation of a reserve promoted increases in abundance, biomass, size and diversity of organisms. Furthermore, these increases appeared to be (contrary to the predictions of modelling studies) independent of the size of the reserve (i.e. small reserves appeared to be as effective as large reserves), suggesting that the biological benefits of declaring reserves are directly proportional to the amount of area protected rather than the size of individual reserves (Roberts et al., 2003). This is an issue which needs further study, as both species/area relationships, as well as our understanding of habitat complexity and the movements and habitat needs of large marine animals, argue that large reserves should be more effective than small reserves in several important respects (Laffoley et al. 2008:58-61; Lubchenco et al. 2007:13-15).

Compelling evidence of the effectiveness of one MPA network comes from recent reports on the status of the George's Banks MPA (Murawski et al. 2004; Fogarty and Murawski 2005) which had been heavily overfished and largely closed to fishing in 1994. The MPA is concluded to have had the following affects over a ten-year period:

- the biomass (total population weight) of a number of commercially important fish species on Georges Bank has sharply increased, due to both an increase in the average size of individuals and, for some species, an increase in the number of young surviving to harvestable size;
- some non-commercial species, such as longhorn sculpin, increased in biomass;
- by 2001, haddock populations rebounded dramatically with a fivefold increase;

- Yellowtail flounder populations have increased by more than 800 percent since the establishment of year-round closures;
- Cod biomass increased by about 50 percent by 2001; and
- Scallop biomass increased 14-fold by 2001, an unintended benefit of the establishment of closed areas to protect groundfish.

Examples of expected effects of no-take marine protected areas

Higher density, average size and biomass

Williamson et al. (2004) demonstrated that no-take zones on inshore coral reefs of the Great Barrier Reef (GBR) increased the density and biomass of coral trout, the major target of the recreational and commercial line fisheries on the GBR, two- to four-fold over a period of around 13 years. Coral trout were, on average, much larger in no-take zones. No-take zoning was the likely cause of these differences between no-take and fished areas, since Williamson et al. (2004) had data on density, biomass and average size before zoning was implemented in 1987. Edgar and Barrett (1999) surveyed reef biota in four Tasmanian no-take marine reserves, and at various control (fished) sites. They also collected data at the time these reserves were established and then monitored the changes over a six-year period. In the largest of these reserves, Maria Island (7 km in length), rock lobsters increased in biomass tenfold, and trumpeter (a reef fish) a hundredfold. The number of fish, densities of larger fish, mean size of blue-throat wrasse and mean size of abalone, increased in this reserve. Such changes were not as obvious in the smaller reserves studied. Similar large increases in abundance of spiny lobster and snapper have been recorded in northern New Zealand no-take reserves over more than two decades (Babcock 2003).

A key question regarding no-take marine reserves is what duration of protection is required for full recovery of abundance of species targeted by fishing. Some authors have suggested that many targeted species may display significant levels of recovery in no-take reserves in just a few years (Halpern & Warner 2002). Other evidence suggests that duration to full recovery of large predatory reef fish in Philippine no-take reserves may take three to four decades (Russ & Alcala 2004; Russ et al. 2005).

Higher propagule production

A key requirement for no-take reserves to become net exporters of propagules (and thus net exporters of potential recruits to fisheries) is that the per unit area production of propagules is substantially higher in reserves well protected in the long term. Since density and average size of targeted species should increase in well-protected reserves, egg production per unit area also should increase. Evidence for this simple expectation remains fairly limited, despite it being reasonable (even obvious). Some of the best evidence for this comes from New Zealand no-take reserves. Snapper *(Pagrus auratus)* egg production was estimated to be 18 times higher inside than outside three New Zealand reserves over three years (Willis et al. 2003a). Kelly et al. (2002) used empirical data to predict that egg production of lobster, *Jasus edwardsii,* would be 4.4 times higher in New Zealand no-take reserves after 25 years of protection. Paddack & Estes (2000) showed that egg production of rockfish were often two to three times higher in no-take compared with fished reefs in California. While these differences in egg production are substantial it is less clear whether they translate into measurable differences in recruitment, either locally or to the wider stock. Further study is needed.

Spillover

Do no-take reserves, well protected in the long term, become net exporters of adult targeted organisms? Some of the best evidence for such export (spillover) comes from studies that have demonstrated increased abundance of targeted fish inside reserves and in adjacent fished areas over time (McClanahan & Mangi 2000; Roberts et al. 2001; Russ et al. 2003; Abesamis & Russ 2005). Many of these studies report the development of gradients (from higher inside reserves to lower outside reserves) of abundance and catch rates. However, not all studies indicate the potential for spillover. Kelly et al. (2002), for example, could not detect any enhanced catch rate of lobsters adjacent to a well-protected marine reserve in New Zealand; however, their results also showed that there was no reduction in catch in the region. This suggests that conservation goals were being achieved without negatively affecting local fisheries.

A substantial literature on movements of marine fish and some invertebrates establishes the strong potential for spillover (Gell & Roberts 2003). Computer modelling studies suggest that if spillover occurs, its contribution to overall fishery yield will likely be modest (Russ 2002). Most models of spillover suggest that such a process will rarely, if ever, compensate for the loss of fishery catch caused by the loss of fishing area required to set up the reserve in the first place.

The key question is what happens to local fishery catch, in both the short and long term, when part of the area is declared no-take? One of the few studies to address this question was that of Alcala et al. (2005) at two small Philippine islands. They demonstrated that closure to fishing of 10-25% of fishing area of these two islands did not reduce total fishery catch at the islands in the long term (two decades), similar to the results for lobsters in New Zealand (Kelly et al. 2002). On the contrary, the experimental evidence suggested that the total catch was sustained, or even enhanced, in the long term. These results are particularly significant, given that municipal (subsistence) fishing is such a major human activity at each island.

Where spillover does occur, although it may have a fairly modest impact on local fish yields, commercial fisheries stand to secure a range of other benefits, including higher monetary returns from fewer but larger individuals, and long term stability of yields (Ward 2004, Grafton et al. 2006, 2004). In addition, the potential also exists for net export of propagules from reserves to fished areas, the 'recruitment subsidy' effect.

Recruitment subsidy

Evidence for recruitment subsidy (net export of propagules from no-take marine reserves) is still extremely limited. The main reasons for this are that propagules (eggs, larvae) are extremely difficult to sample, tag, and track. Marine ecologists still have very limited knowledge of the 'dispersal kernels' of most marine larvae. Furthermore, recruitment of marine organisms is notoriously variable, making both the identification and statistical testing of trends in recruitment difficult.

Some empirical evidence for recruitment subsidy comes from a scallop fishery in the northern hemisphere, although a good deal of disagreement remains about the interpretation of the evidence. The abundance of scallops *(Placopecten magellanicus)* increased substantially following the 1994 closure to fishing of three large areas of the Georges Bank, north-eastern USA (Murawski et al. 2000). Total catch of the scallop fishery increased between 1994 and 1998, despite the reduced fishing area. Fishing effort concentrated outside the boundaries of the closed areas, particularly in places most likely to receive scallop larvae exported from the closed areas (Gell & Roberts 2003). These results suggest that the no-take reserves have had a positive effect on total yield of scallops on the Georges Bank, by exporting propagules to fished areas. Recruitment subsidy from no-take reserves to fished areas is by far the most likely mechanism to sustain, or even enhance, fisheries outside the boundaries of the no-take reserves. While many marine ecologists believe that such an expectation is reasonable, given that marine larvae can often disperse distances much greater than the spatial scale of most no-take marine reserves (Baker et al. 1996), empirical evidence in support of this export process is still rare.

Insurance against management failure and unpredictable stochastic events

A particularly powerful argument in support of establishing no-take marine protected areas or reserves is that they serve as insurance against future fisheries management failure and unpredictable stochastic events (Grafton et al. 2006). The record of 'traditional' fisheries management to maintain spawning stocks of exploited organisms at levels most marine scientists would consider to be sufficient to ensure long-term sustainable harvest is fairly dismal (Pauly et al. 2002).

Many people now argue that the only way to ensure sufficient spawners is to set aside a reasonable proportion of the stock in no-take zones (Grafton et al. 2005). Others argue that the economic and social cost of such an insurance policy is too high. Such arguments have to be weighed against the considerable economic and social hardships that occur if a fishery is so depleted that it is no longer economically viable. Such a debate is one of the trade-offs between short- and long-term costs and benefits, and the ability of 'traditional' fisheries management to maintain enough spawning fish in the water.

Information on important parameters for stock assessment

A clear benefit of no-take reserves, protected properly in the long term, is that they provide scientists with sites for study of unexploited populations, communities, and ecosystems. They are some of the few places where scientists can directly make reasonable estimates of such key parameters as natural mortality rates or growth rates (Buxton et al. 2005). They are also places that show us what natural marine communities and ecosystems actually look like, and how they function. No-take reserves can also provide novel means of independently estimating parameters, such as fishing mortality, that are vital for the effective management of fisheries. For example, by comparing seasonal fluctuations in abundance of New Zealand snapper in reserves and fished areas on coastal reefs it has been estimated that between 70 and 96% of legal-sized snapper are being taken, mostly by recreational fishers (Willis & Millar 2005).

Costs of no-take marine protected areas as fisheries management tools

Displaced effort

An argument against the use of no-take MPAs as fisheries management tools, at least at first sight, is that reserves will simply move fishing effort away from the no-take area and concentrate it in the remaining fished area. If steps are not taken to reduce fishing effort, the short-term cost is likely to be very real, particularly if the fishery is fully exploited or over-exploited. In many cases, the implementation of no-take reserves involves financial compensation to some displaced fishers – and in some cases these costs can be substantial. Recent experience in Victoria has shown that early calculations of compensation were over-estimated, and that in fact actual compensation payouts were easily afforded by the State Government (Phillips 2005). In Queensland, however, the reverse was the case, with compensation payouts following the expansion of no-take areas in the Great Barrier Reef Marine Park exceeding early estimates. However such short-term costs must be weighed up against the longer-term benefits likely to flow from recruitment subsidy, insurance against management failure, and tourism income generated by Australia having some of the best and largest well-protected marine ecosystems in the world. The key point with respect to displaced effort is weighing up short-term costs against long-term gains.

Locked-up resources

Another argument against no-take MPAs as fisheries management tools is that they simply make part of the resource unavailable to the fishery, and thus make that portion of the resource useless to the fishery. Such an argument ignores two things. First, export functions may, in the long term, compensate for initial loss of 'locked-up' resources. Such export functions may even enhance fishery yields, particularly if the resource is already heavily fished. Second, those 'locked-up' resources are possibly one of the best insurance policies we can have against the possibility of future fisheries management failures. These areas also provide refuges for genetic diversity at risk in heavily fished populations (see discussion above).

False sense of security

If no-take MPAs are poorly protected (e.g. poor compliance with no-take regulations) or, due to specific life-history characteristics of some target species, do not develop export functions, they may well create a false sense of security for fisheries managers and the public. The remedy to this problem is to ensure adequate compliance, enforcement and monitoring. If adequate enforcement is not carried out, the inevitable long-term consequence is that most fishers will ignore the rules. Conversely, with adequate enforcement, it is in the interests of honest fishers to comply with the rules and to report illegal fishing. Monitoring is also essential. Appropriate and effective monitoring of reserve performance is necessary to determine if the stated goals of the MPA are being achieved. If MPAs are established partly on the basis of assumptions of fisheries benefits (and this may be advisable in some cases as a precautionary measure) these assumptions should be scrutinized by ongoing monitoring programs.

Uncertainty, and the importance of long time-frames in planning

Fisheries are important, but so are the values of marine biodiversity. Although there is no doubt that a reasonable balance between marine resource exploitation and nature conservation has rarely been achieved across the planet, it is important to start from a position which seeks ways to protect *both* marine biodiversity and fisheries. Marine reserves and fisheries are often seen in a 'win-lose' way, where the establishment of reserve networks is assumed to prejudice the interest of fishers. This simplification may often be incorrect, and fails to acknowledge that in many cases reserves can provide fishery benefits. While it is important that such benefits should not be overstated (Sale et al. 2005) to neglect them ignores important benefits of reserves, especially over long time scales (Grafton et al. 2006).

3.5.5 How effective are Australia's existing MPA networks?

In developing the NRSMPA framework in 1999, all Australian jurisdictions were committed to the creation of MPA networks which would provide comprehensive, adequate and representative protection for Australia's marine ecosystems. The principles on which the NRSMPA strategy was based, as well as planning and management principles incorporated in *Australia's Oceans Policy* 1998 (see the 'guidelines' listed in section 3 above) are sound. Two questions are important: (a) have the principles been properly applied so far in the creation of existing MPA networks, and (b) are the networks meeting their objectives in practice? This section provides an answer to the first question, and outlines an approach for answering the second.

Australia has eight State/Territory jurisdictions[25], who carry very considerable responsibilities for natural resource management. They depend heavily on the Australian (Commonwealth) Government for funds – thus providing the Commonwealth with the leverage needed to encourage States in meeting international obligations.

In examining progress over the last decade, it is clear that the design principles of the NRSMPA have been followed in some cases; in others they have been abandoned. In considering whether protection has been "comprehensive, adequate and representative" there are two key issues: the use of zoning which provides effective protection, and the extent of habitat representation within the regional network.

Queensland is Australia's best example of the development of effective MPA networks. As discussed above, the substantial Great Barrier Reef Marine Park (developed principally by the Commonwealth Government) includes 33% no-take zones, which provide effective protection for representative habitats. The GBRMP occupies a very substantial portion of the continental shelf adjacent to Queensland. Most habitat types within the Park are protected to the 20% level (or better) by no-take zones. At the State level, the Queensland Government has protected most Moreton Bay[26] habitats at 9% or better, with a total of 16% of the Bay in no-take zones. In Western Australia, the large Ningaloo Marine Park protects around 30% of its area in no-take zones. Victoria also provides an example of effective protection of representative habitat, although at a considerably smaller scale, and with less comprehensive coverage of habitat types. Here about 5% of habitat within State jurisdiction is zoned as no-take[27]. Habitat maps are available for the bulk of Victorian marine waters, with high-resolution mapping within MPAs.

On the other hand, the progress made by the Tasmanian Government, as well as the Commonwealth MPAs in the South East Region around Tasmania, provide examples of ineffective protection. In the absence of comprehensive habitat maps for this region, geomorphic province can be used as a coarse biodiversity surrogate – the shelf for example contains important habitats not found elsewhere. Commonwealth MPAs include only 0.75% of the region's shelf in no-take zones. Remaining MPAs are IUCN category VI, providing little effective protection from fishing activities – a key threat in the region. At the State level, the Tasmanian Government's Bruny Bioregion MPA network (announced in 2008) is entirely category VI, and fishing activities continue within the MPA network essentially unrestricted.

This approach provides virtually no protection from one of the most important threats in the bioregion.

In the case of the Commonwealth's South East Region, considering only the area covered by the MPA network creates a misleading impression. MPAs of all zones (in this case almost entirely two categories: IUCN class Ia and VI) cover a substantial proportion of the region: ~5.5%. This seems like a good outcome, until the detail is examined. Coverage of shelf habitats is in fact far from 'adequate'.

Any national assessment must take into account the extent of effective protection, and here no-take MPAs should be used as an indicator. Secondly, the extent of representative habitat protection must be assessed. Future habitat mapping programs will assist greatly in this regard.

The Commonwealth-managed Collaborative Australian Protected Area Database (CAPAD) fails to provide important basic information on Australia's MPA network. Different States have used different reporting formats within the CAPAD framework. Some States list every MPA, while others list only MPAs grouped into State categories (eg: 'marine nature reserve') which are terms which have no national meaning. Some States list the IUCN categories of each MPA (which is useful) while others do not. In terrestrial protected area reporting, some States list the bioregions and subregions within protected areas (which is at least a start in reporting surrogates for representation) however no State reports this information for MPAs. The database is not updated regularly: the most recent marine data in mid-2008 was for 2004. *CAPAD is in urgent need of major improvement*.

All MPAs should be managed (within a dedicated budget) monitored and assessed. Management plans must identify key values to be protected, and establish indicators by which these values can be monitored. Any national or regional assessment of a MPA or a MPA network must be based at least in part on the extent to which identified values are maintained or enhanced over time. Assessments of the effects, and effectiveness, of MPAs at zone, reserve or system level should be placed within a transparent adaptive management framework, allowing progressive improvement of MPA design and implementation.

Assessments must also take into account both the intent of management (the zoning), the extent to which such management is effective (including the extent of compliance enforcement) and the extent to which the combined set of zones within an MPA network contributes to conservation outcomes for species, assemblages and habitats across the region. Where models to assess the different levels of contribution of conservation outcomes delivered by the different management zones are weak, or the data are lacking, it is appropriate to consider the success of a MPA system cautiously, and restrict the assessment and reporting of effectiveness to only the zones of high-protection (eg: no-access or no-take). In the zones of high-protection, given evidence of effective compliance enforcement, assessment and reporting on effectiveness then becomes an issue of measuring and reporting on intrinsic conservation parameters appropriate to the species, assemblages habitats or processes that are intended to be protected.

Compliance cannot be taken for granted. Even in Australia, where fisheries are often perceived to be well-managed, there is ample evidence not only of non-compliance, but of cultures of non-compliance. For example, Poiner et al. (1998:s2) in a study of prawn trawling in the Great Barrier Reef World Heritage Area reported: "there has been a high level of illegal trawling in the Green Zone and evidence that 40 to 50 boats regularly trawl the area. Misreporting of catch has taken place with catches from inside the Green Zone being credited to adjacent open areas." Cultures of non-compliance will arise where absence of enforcement is predictable.

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> We consider it is part of our professional duty as marine biologists to state publicly and frequently the need for a representative, replicated, networked and sustainable system of highly protected marine reserves. We doubt if our grandchildren will accept any excuses if we fail.
>
> Ballantine & Langlois 2008:35

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3.8 Endnotes

[1] The concept of "effective protection" is important. To demonstrate effective protection key values must be identified, managed and tracked over time. This implies that a protected area should have a management plan which identifies key values, and the plan should explain how management will seek to protect these values. Monitoring programs should track the

values over time (through measurable indicators) and the results of monitoring programs should be regularly and publicly reported. Only then will "effective protection" be demonstrated.

The IUCN used a more detailed definition of a marine protected area: "any area of the intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (Kelleher 1999). This was replaced by a general protected area definition: "A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values." (Dudley 2008).

[2] Note that the word 'reserve' is often used in marine literature to mean a fully protected or no-take area.

[3] Such monitoring should take place across a sufficient spatial scale.

[4] Readers unfamiliar with the rather vaguely defined terms referring to spatial units should note that a rough hierarchy exists starting with "large marine ecosystems" (LMEs) which lie within ocean basins (generally along continental margins), to bioregions, subregions, ecosystems, habitats and, at the scale of meters to kilometres, communities. The term 'ecosystem' is also used in different situations independent of scale, according to its strict definition which is an area characterised by coherent trophic and energy pathways, and species interactions.

[5] Noting that an area target of 20% of habitat types was included in the biophysical operating principles used in the Representative Areas Program (2002) of the Great Barrier Reef Marine Park Authority – along with other princples such as replication and inclusion of whole reefs. The 2004 re-zoning saw 32% of the coral reefs in the GBRMP protected in no-take reserves (which accounts for 15% of coral reefs in the NE Marine Planning Region, and about 10% of coral reefs offshore from the Queensland coast). In the terrestrial scene, a protected area target of 15% of pre-European vegetation communities was set as a central conservation goal of Australia's Regional Forest Agreements, to be expanded for rare and/or vulnerable vegetation communities (Mendel & Kirkpatrick 2002).

[6] An important point of definition arises immediately. Overfishing is defined in this discussion as *a level of fishing which puts at risk values endorsed either by the fishery management agency, by the nation in whose waters fishing takes place, or within widely accepted international agreements*. A point of critical importance in this regard is that a level of fishing intensity which successfully meets traditional stock sustainability criteria (for example fishing a stock at maximum sustainable yield) is likely to be considerably higher than a level of fishing intensity which meets maximum economic yield criteria (Grafton et al. 2007) which in turn is likely to be considerably higher than a level designed to protect marine biodiversity (Jennings 2007, Walters et al. 2005, Murawski 2000, May et al. 1979). The wide endorsement of the *Convention on Biological Diversity 1992* implies that the latter level is the critical level by which overfishing should be measured.

[7] See the AMSA submission on the South East Region MPAs: http://www.amsa.asn.au/

[8] The area of the SE Marine Planning Region is 1,192,500 km^2, (Harris 2007) or 1,632,402 km^2 including Macquarie Island, of which 226,458 km^2 are covered by Commonwealth MPAs. Of these, 96,435 km^2 are no-take, with the rest mostly classed as IUCN category VI – multiple use (where nature conservation is not the primary objective). However, almost all of the no-take areas cover slope and deep sea habitats. Commonwealth no-take reserves cover only 0.75% of regional shelf areas, or 692 / 92175 km^2 (pers.comm. Barbara Musso 16/10/08; see also Edgar et al. 2008:972).

[9] The CBD CoP decisions can be accessed at http://www.cbd.int/marine/decisions.shtml. If this link doesn't work, go to the homepage (www.cbd.int) and follow the links: programmes & issues>marine and coastal>programme>decisions.

[10] IMCRA: interim marine and coastal regionalisation of Australia (IMCRA Technical Group 1998).

[11] Government of Australia (1996).

[12] The Commonwealth CAPAD (Collaborative Australian Protected Area Database), accessed in September 2008, contained MPA data current to 2004.

[13] Australia's marine jurisdiction, including Antarctic zones, is around 16 million km^2. Without Antarctic areas it is around 11.4 million km^2

[14] The MPAglobal website is currently (Sept 2008) under development and data may not be accurate.

[15] In this paper "reserves" includes IUCN categories I-IV.

[16] Here "no-take" MPAs includes IUCN categories Ia and Ib.

[17] This neglects a few insignificant mining operations, for example for diamonds in Joseph Bonaparte Gulf (WA), gold in the Gulf of Carpentaria (Qld) and sapphire around Flinders Island (Tas).

[18] States have jurisdiction over 3.6% of Australia's marine jurisdiction comprising 410,677 sq km in coastal waters that are within 3 nautical miles (5.5 km) of the coast. The remaining 10.97 sq km in Commonwealth waters is administered by the Australian Government.

[19] Of particular note in defining systematic conservation planning are the papers by Margules & Pressey (2000) and Pressey et al. (2003).

[20] Up-to-date information on global MPAs was hard to locate in 2008. The IUCN published a estimate in 2008: "as of the end of 2006 only 0.65% of the area of the seas and oceans and 1.6% of the area within exclusive economic zones worldwide is covered by marine protected areas." (World Conservation Congress 2008 statement on marine protected areas).

The World Database on Protected Areas (WDPA) (www.unep-wcmc.org) accessed 19/9/08 did not contain global consolitated data. An estimate of 1.4% of the marine realm within MPAs was obtained from the WDPA when accessed on 18/1/06 - it contained MPA area data to 2003. IUCN categories Ia and Ib were used as identifiers for no-take areas, and adjusted by the 2004 expansion of no-take areas in the Great Barrier Reef Marine Park. This produced a figure of 0.18% of the marine realm within no-take areas. The 'total' percentage is based on summing the global areas under categories I-VI, and includes the 184,000 km^2 Kiribati Phoenix Islands MPA (announced March 2006) and the 360,000 km^2 North-western Hawaiian Islands National Monument (announced 15 June 2006) but does not include the area managed by the Commission for the Conservation of Antarctic Marine Living Resources (35.7 million km$^{2)}$. If it can be assumed that IUU fishing, and fishing by non-Party States has negligible impact on this area, the zone qualifies as a category IV marine protected area. Even taking these two important factors into account, the Convention Area probably qualifies as a category VI protected area. The global area percentage under general MPA management would then increase (dramatically) to 12 %. It should be noted that internal CCAMLR papers at this stage support the 'IV' classification; however CCAMLR has not requested entry to the WDPA. Note that at this stage no information is available on the area under categories Ia and Ib in the Phoenix Islands or NW Hawaiian MPAs, so these new MPAs were not included in the calculation of 0.18% NTAs.

[21] Agardy has major concerns over the possibility of a rapid and poorly planned expansion of marine protected areas. “The desire for quick fixes has led to a proliferation of MPAs – many in areas where they are not needed, executed in a way that does not address the threats at hand, and planned with little consideration of long-term financial and social feasibility.” (Tundi Agardy, *MPA News* October 2005 p.3).

[22] In particular goals relating to the slowing of biodiversity loss, such as those incorporated in the Johannesburg Declaration 2002 ‘key outcomes’ statement.

[23] In the marine context, substitute “habitat” for “land”.

[24] Noting that no-take marine reserves appear less prone to crown-of-thorns attack (Sweatman 2008).

[25] Australia has three ‘territories’. The Australian Capital Territory, under an agreement with the Commonwealth Government, manages the territory at Jervis Bay on the NSW coast. Although all eight State/Territory jurisdictions manage marine environments, this responsibility is insignificant in the case of the ACT. The marine protected area at the south side of Jervis Bay is managed by the Commonwealth Government.

[26] Queensland’s large Moreton Bay lies adjacent to the major city of Brisbane, and receives the outflow of the Brisbane River.

[27] Victoria’s no-take MPA network occupies 53,776 ha, or 5.3% of marine waters under State jurisdiction.