6 July 2011

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SUBMISSION
TO THE SELECT COMMITTEE ON MARINE PARKS IN SOUTH AUSTRALIA

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SUMMARY
The marine environment is in great danger, both in Australia and around the world. Section One below lists the five main threats. Of these threats, the most significant are fishing and increasing atmospheric carbon dioxide. In many parts of the world, and in some parts of Australia, marine ecosystems, or significant components of these ecosystems, have collapsed, and collapses like these are increasing in frequency and severity worldwide. Section Two below outlines this disturbing situation.

A huge body of scientific evidence is available to guide the design and management of marine parks (Terms of Reference part (a)). Section Three below lists a small sample of the peer-reviewed literature relevant to the design and management of marine protected areas. At a general level, international law also offers policy guidance on the design and management of marine protected areas. As a nation signatory to the international Convention on Biological Diversity 1992 Australia has endorsed a formal agreement to develop networks of marine protected areas, having sanctuary (or no-take zones) at their core. The details of this agreement are contained in the CBD Jakarta Mandate. Section Four of this submission takes an overview of the literature supporting the design and management of marine protected areas, and includes a discussion of key policy issues – relevant to scales from international to local. Section Five below includes an indication of the support given to marine protected areas by Australian scientists.

This submission does not discuss Terms of Reference (b), (c) or (d).

With regard to Terms of Reference (e), I am aware that there have been moves in NSW, particularly sponsored by the NSW branch of the Shooters Party, to limit or reduce the extent of no-take sanctuary zones. However the general trend world-wide has been to expand sanctuary zones not to limit them. Member states of the European Union have been expanding no-take zones under an EU Directive dating back about a decade. The USA, particularly under the leadership of George Bush, designated huge expansions of no-take marine protected areas in Alaska and in the USA’s Pacific Ocean jurisdictions. Pacific nations, including Fiji, Palau and the states of Micronesia (as examples) have hugely increased no-take zones in recent years. South Africa too has added large additions to its no-take zones.

Terms of Reference (f) considers the correct balance of general marine park areas to no-take sanctuary zones. Section Six of this submission reviews scientific literature on this subject, and concludes that, as far as the conservation of marine biodiversity is concerned, a huge increase on no-take zones is required, both in Australia and overseas. Most of the studies reviewed conclude that sanctuary zones occupying 20% to 50% of marine habitats
are required to stem the current erosion of biodiversity values. As far as support for the
fishing industry (both commercial and recreational) studies find that no-take zones can
provide protection for critical spawning, nursery and feeding areas, thus providing fished
populations with buffers against both fishing mortality and environmental variations. The
result is more stable and reliable fisheries from year to year. However if these effects are
considered alone (ie not considering other biodiversity values) current science suggests that
fishery benefits can be gained from carefully placed sanctuary zones occupying around 10% to
20% of habitats.

Given the very serious threats facing marine ecosystems, I strongly support the model
provided by Queensland’s Great Barrier Reef Marine Park, where around 33% of the park is
designated as no-take zones. I recommend that common ecosystem types which are not
under significant threats be protected at a rate of at least 20% of the total area under that
habitat type in the jurisdiction under discussion. However, where ecosystem types are rare
or under threat, much greater protection is needed, up to 100% where very rare or highly
endangered ecosystem types are concerned. It should be noted, as an example, that coral
ecosystems are highly threatened by both fishing and climate change, where the latter threat
will become increasingly severe over coming years. Yet only around 10% of coral habitats off
the Queensland coast (including offshore and in the Gulf of Carpentaria) are protected in no-
take zones. This situation is entirely inadequate.

I wish to conclude with two points about the management of fisheries in Australia. It is
sometimes said that Australian fisheries management is so good that further protection of
the marine environment from fishing impacts is unnecessary. This is certainly not the case.

My first point concerns the way Australian governments, both State and Commonwealth,
define “overfishing”. Fifty years ago it seemed logical to define overfishing solely on the
basis of the health of the stock being fished – in other words taking no regard of the effects
of fishing the stock on the marine environment broadly. Consequently the practice grew up
where fisheries management agencies would define overfishing relative to the stock’s
maximum sustainable yield (MSY). Unfortunately, this approach is still in use, even though
during the last 50 years Australia has made important commitments to protect marine
ecosystems (eg: through the Convention on Biological Diversity process, and at a general
level through the Law of the Sea).

In my view a logical modern definition of overfishing is 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. This definition would take into account damage caused by fishing to the surrounding ecosystem, and a fishery
would be defined as ‘overfished’ if significant damage had occurred, irrespective of the
health of the fish stock in question. Technically, this definition is a good deal more sensitive
than the old-fashioned definition, so it is likely that most major Australian fisheries would be
defined as overfished using this definition – and this sadly reflects the reality. At present
fishing levels are usually so high that ecosystem damage is evident, and so high that the
long term futures of the fisheries themselves are at risk. Management against this new
definition would have the added advantage of protecting important fish stocks by imposing
lower fishing mortality, thus providing a buffer against unpredictable natural variations –
which over the years have seen many important fish stocks collapse (eg the recent collapse
of the Western Rock Lobster fishery in WA).

My second point relates to the way that two modern management techniques, the ecosystem
approach and the precautionary approach, are applied by Australian fisheries management
agencies. I spent four years (2005 to 2009) conducting in-depth reviews of several important
Australian fisheries. This is a difficult and time-consuming task, given the amount of
managerial and scientific literature which must be considered. The conclusion I reached, set
out in detail in my book Overfishing Under Regulation, is that, at least in the fisheries I
studied, these modern approaches are not competently applied, in spite of policy assurances
to the contrary. In some cases important information was excluded from public reports,
apparently to create the impression that the approaches were being successfully applied.
This can only be described as dishonest, and reflects badly on the caliber of senior management within the agencies.

It seems likely that my findings apply broadly across fisheries management in Australia. The existence of organisational cultures within fisheries agencies which condone incompetence and encourage dishonest reporting could go a long way to explaining the poor track record of the agencies, even assessed by old-fashioned criteria. Here I refer to the ability of the agencies to manage fisheries for sustained harvest levels over periods of decades.

To recapitulate:
1. There is a huge body of scientific evidence supporting the creation of very large marine protected area networks, centred around core sanctuary zones. The creation of such networks has been a central part of international efforts to protect marine biodiversity for many years.
2. The value of sanctuary zones has been clearly documented in the scientific literature, and the Australian science community strongly supports the expansion of no-takes zones (see Sections 4 and 5 of this submission).
3. Internationally, there are many programs, begun over the last decade and continuing, to support a massive expansion of no-take zones and networks built around such zones. These programs rest on important international agreements, such as the Jakarta Mandate, which guides the implementation of the international Convention on Biological Diversity 1992.
4. No-take zones are essential to protect marine biodiversity values against fishing effects. Worldwide, fishing at the present time represents the greatest threat to marine biodiversity, although the threats posed as a result of increasing atmospheric carbon dioxide will become dominant in the near future.
5. Substantial no-take zones, strategically placed over key spawning, nursery and feeding areas, can boost and stabilize fisheries.
6. Blanket no-take area targets relating to large marine jurisdictions are of little value. Area targets should be set for all major habitat types. Common types under little threat should be protected with no-take areas covering at least 20% of the total area under that habitat type. Uncommon or highly threatened habitats should be protected at greater levels, with 100% protection for extremely rare or highly threatened habitat types. Examples of such rare and vulnerable habitats can be found on seamounts and steep deep canyons crossing the continental slope.
7. At present fisheries in Australia are assessed against a definition of overfishing which takes no account of the damage the fishery causes to impacted ecosystems. This unfortunately reflects the real priorities of Australian fisheries management agencies – priorities which are in urgent need of change.
8. All Australian fisheries agencies have made policy commitments to apply both the precautionary approach and the ecosystem approach to fisheries management. In-depth study of the application of these approaches however reveals reluctance to apply the approaches in practice, and dishonesty in reporting fishery outcomes. In many cases fishing represents the greatest danger to Australian marine ecosystems at a local and sometimes regional level.

Further contact:
I would be pleased to talk with the Committee in person if the Committee could fund a one-way budget airfare to Adelaide. I would pay the return flight. Alternatively I could address the committee through a telephone link. My number is 0422 926 515.
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Section One:
Threats to marine environments.

1.1 Introduction:

In broad terms, 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 the effects of 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. The destructive impacts of fishing stem chiefly from overharvesting, habitat destruction, and bycatch. Over the coming 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.

Overharvesting is probably as old as human civilization. There is evidence that ancient humans hunted many terrestrial animals to extinction (eg: Alroy 2001). Historically, fishing has rarely been sustainable (Pauly et al. 2002). On the global scene, modern fishing activities constitute the most important threat to marine biodiversity (Hiddink et al. 2008, Helfman 2007:8; MEA Millennium Ecosystem Assessment 2005a:67, 2005b:8, 2005c:12; Crowder & Norse 2005:183; Kappel 2005:275; Myers & Worm 2003; Pauly et al. 2002; Reynolds et al. 2002; Jackson et al. 2001; Leidy & Moyle 1998 - noting contrary views from Gray 1997). Of all recently documented marine extinctions, the most common cause has been excessive harvesting activities (Malakoff 1997, Carlton et al. 1999, VanBlaricom et al. 2000).

Fisheries in the deep sea have "undoubtedly had the greatest ecological impact to date" of all known threats (Thiel & Koslow 2001:9). Fishing was identified as the main threat to marine ecosystems in the northwest Atlantic over the period 1963-2000 (Link et al. 2002). The fisheries of the Bering Sea have long been recognised as among the world’s best managed (Aron et al. 1993); however Greenwald (2006) in a study of the region’s vertebrates, identified commercial fishing as the most important threat, followed by climate change, habitat degradation, ecological effects and pollution.

Historically, the impacts of fishing activities, even when regulated by governments, have in many cases caused major, often irretrievable damage to marine ecosystems (Jackson et al. 2001, Ludwig et al. 1993). The benthic ecosystems of large areas of the ocean seabed have
been destroyed or damaged (Watling & Norse 1998, Watling 2005). The genetic effects of fishing may be substantial, yet are commonly ignored (Law & Stokes 2005). The failure of managers to learn from past mistakes appears to be a notable feature of the history of fisheries management (Mullon et al. 2005) in what Agardy (2000) has called the "global, serial mismanagement of commercial fisheries".

"In many sea areas, the weight of fish available to be harvested is calculated to be less than one tenth or even one one-hundredth of what it was before the introduction of industrial fishing." (MEA 2005c:16)

On the Australian scene, 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.

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) may well be considerably higher than a level of fishing intensity which meets criteria designed to protect marine biodiversity (Jennings 2007). 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.

Amongst fishery scientists (and to lesser extent fishery managers) it is widely believed that "governance, and not science, remains the weakest link in the [fisheries] management chain" (Browman & Stergiou 2004:270). To a large extent fisheries managers, like bankers, do not learn the lessons of the past, they simply repeat them.

The core impacts of climate change are caused by:

- an increase in the temperature of ocean waters - causing, for example, coral bleaching (Veron 2008);
- the increase in the acidity of ocean waters, causing a rising aragonite saturation horizon, particularly in the North Pacific and Southern Ocean - with resulting impacts on organisms using calcium carbonate body structures (Turley et al. 2006), and
- a reduction in ocean overturning circulation, risking, for example, impacts on deep ocean oxygen content (Koslow 2007).

Important reviews of pollution in the marine environment are provided by:

- noise – Cummings (2007); Firestone & Jarvis (2007); NRC (2005); Koslow (2007)
- radioactive waste – Koslow (2007)
- armaments – Koslow (2007)
- heavy metals – Islam & Tanaka (2004); Hutchings & Haynes (2005)
- discarded fishing gear – Matsuoka et al. (2005); Brown & Macfadyen (2007)
- endocrine disruptors – Lintelmann et al. (2003); Porte et al. (2006)
- info-disruptors – Lurling & Scheffer (2007)
- other hazardous materials – Islam & Tanaka (2004); Koslow (2007).
Important papers on marine and estuarine habitat damage include:

- impacts of bottom trawling – Koslow (2007), Gray et al. (2006), Jones (1992), NRC (2002), Gianni (2004);
- coral ecosystems – Aronson & Precht (2006), Pandolfi et al. (2003), Gariney et al. (2003), Hughes et al. (2003), McClanahan (2002), Jackson et al. (2001), McManus (1997);
- mangroves – Duke et al. (2007), Alongi (2002), Valiela et al. (2001); Ellison & Farnsworth (1996);
- seagrasses – Orth et al. (2006), Duarte (2002);

For a general introduction to the problem of alien species, see Mooney & Hobs (2000), McNeely (2001), and Mack et al. (2000). General references on marine issues include Hewitt & Campbell (2007), Streftaris & Zenetos (2006), Carlton & Rutz (2005), Bax et al. (2003), and Rutz et al. (1997).

1.2 Threats and controls:

Over the last thirty years, broad controls have been proposed or developed relating to the five major threats. Controls can be categorised with threats (Table 2.1 below). Many nations have commendable statutes and policies; however implementation failures are widespread.

<table>
<thead>
<tr>
<th>Threats</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overfishing and bycatch</td>
<td>Restricted entry to fishery, catch quotas, limits or requirements on gear, limits on fishing seasons, limits on fishing areas, no-take areas, prohibitions on dumping or discarding gear. Attempts to reduce or eliminate government subsidies contributing to fishing over-capacity. Control by flag States of high seas fishing particularly in regard to compliance with international and regional fishing agreements. Market-based fishery accreditation systems such as that of the Marine Stewardship Council. Government control programs based on minimising ecosystem effects. Surveillance and compliance programs including VMŚ and remote surveillance (video surveillance, and electronic catch recording and tracking, for example).</td>
</tr>
<tr>
<td>Habitat damage</td>
<td>Limits on gear, limits on fishing areas, no-take areas. Fixed mooring systems in sensitive (eg coral) environments. Surveillance and compliance programs. Land-based zoning schemes combined with project assessment and approval provisions aimed at minimising the loss of coastal habitat resulting from land-based developments. Special protection for high conservation value estuaries. Zoning of key migration rivers to exclude dams, weirs and other impediments to fish passage. Protection of the catchment of high conservation value estuaries and rivers to maintain natural water flows and water quality.</td>
</tr>
</tbody>
</table>
### Threats

<table>
<thead>
<tr>
<th>Threats</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate change</td>
<td>International agreements, such as those focussed on greenhouse gases or chlorofluorocarbons or (eg: the Kyoto Protocol, Montreal Protocol) - and the implementation programs which follow, including incentives, prohibitions and market-based schemes aimed at reducing greenhouse gas emissions.</td>
</tr>
<tr>
<td>Pollution</td>
<td>Controls focussed on fixed point sources, mobile point sources and diffuse terrestrial sources – including dumping and emissions to air and water. Controls on marine noise. Controls focused on specific pollutants, such as plastics or highly toxic or radio-active substances. Integrated coastal and river basin planning, including objectives to limit the passage of nutrients and other pollutants to the marine environment. Surveillance and compliance programs.</td>
</tr>
<tr>
<td>Alien organisms</td>
<td>Controls on ballast water and hull fouling based on risk minimisation rather than prevention. Import prohibitions relating to aquaculture stocks. Infestation monitoring and removal programs. Surveillance and compliance programs.</td>
</tr>
</tbody>
</table>

Good general references covering threats and management options are Koslow (2007) and Norse & Crowder (2005).

### 1.3 Three core management concepts of modern marine management

Any overview of threat control programs would be incomplete without mentioning the evolution of three core concepts which have been endorsed (at least in principle) by most national marine conservation policy frameworks, and (at least in the case of protected area networks) many practical control programs:

- ecosystem-based fishery management (EBM);
- the precautionary principle (PP) and the closely-related precautionary approach (PA); and
- the strategic development of networks of marine protected areas (MPAs).

Active adaptive management, although the subject of much academic discussion for over 20 years, has yet to appear in operational fisheries management programs in any substantial way (see Chapter 9).

Several fishery experts made comments during the nineteenth century to the effect that the resources of the ocean were so vast as to defy any possible damage from human activities. These views, although proved incorrect more than a century ago, still linger on, particularly in fisher cultures. Within government fishery agencies and academic circles, the need to take into account the effects of fishing for particular species on marine ecosystems has been accepted for several decades. Promotion of ecosystem-based management was a core feature of the FAO Code of Conduct for Responsible Fisheries 1995. Although the concept is now embedded in key international and national law, fishery agencies have generally been slow to incorporate EBM in fishery controls, often citing the need for more research as the primary reason for the delay.

The precautionary principle, and its ‘softer’ version the precautionary approach, appeared in international discussions some decades ago, and have been accepted, like EBM, into international and national law. Article 174 of the Treaty establishing the European Community requires, inter-alia, that Community policy on the environment be based on the
precautionary principle. The principle was one of the core environmental principles contained in the Rio Declaration 1992 (UN Conference on Environment and Development) as well as the earlier World Charter for Nature 1982. A generic definition of the principle may be stated as follows:

Where the possibility exists of serious or irreversible harm, lack of scientific certainty should not preclude cautious action by decision-makers to prevent such harm. Decision-makers needs to anticipate the possibility of ecological damage, rather than react to it as it occurs.

Like EBM, use of the precautionary principle in practical control strategies has lagged behind its adoption in policy, not only in the EU but around the world. This remains the case, in spite of the prominence given to the principle on the FAO Code of Conduct.

Marine protected areas were largely unknown in an era when it was generally considered that the oceans needed no protection. However, as the damage to the marine environment became more widely understood, marine protected area programs have featured in international agreements as well as national conservation programs. The FAO Code of Conduct stresses the need to protect critical habitat in aquatic environments, for example.

One of the most widely quoted international statements calling for the acceleration of marine protected area programs around the world is that from the World Summit on Sustainable Development (WSSD) (Johannesburg 2002). The marine section of the WSSD Key Outcomes Statement provides basic benchmarks for the development of marine protected areas as well as other key issues of marine governance:

Encourage the application by 2010 of the ecosystem approach for the sustainable development of the oceans.

On an urgent basis and where possible by 2015, maintain or restore depleted fish stocks to levels that can produce the maximum sustainable yield.

Put into effect the FAO international plans of action by the agreed dates:
• for the management of fishing capacity by 2005; and
• to prevent, deter and eliminate illegal, unreported and unregulated fishing by 2004.

Develop and facilitate the use of diverse approaches and tools, including the ecosystem approach, the elimination of destructive fishing practices, the establishment of marine protected areas consistent with international law and based on scientific information, including representative networks by 2012.

Establish by 2004 a regular process under the United Nations for global reporting and assessment of the state of the marine environment.

Eliminate subsidies that contribute to illegal, unreported and unregulated fishing, and to over-capacity.

The same statement also contains a commitment: “Achieve by 2010 a significant reduction in the current rate of loss of biological diversity.”

Two years later the 2004 Conference of the Parties to the Convention on Biodiversity 1992 agreed to a goal of: “at least 10% of each of the world’s marine and coastal ecological regions effectively conserved” (by 2012) (UNEP 2005:44).

1.4 Protection of representative marine ecosystems:
Attention needs to be given to the use of the word “representative” in the WSSD text above. Requirements to provide adequate and comprehensive protection for representative
examples of all major types of ecosystems date back many years. Clear requirements for action are contained in:

- the 1982 World Charter for Nature (a resolution of the UN General Assembly); and
- the 1992 United Nations international Convention on Biological Diversity;

Principle 2 of the Stockholm Declaration 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.”

The 1982 World Charter for Nature states: “Principle 3: All areas of the earth, both land and sea, shall be subject to these principles of conservation; special protection shall be given to unique areas, to representative samples of all the different types of ecosystems, and to the habitat of rare or endangered species.”

An examination of the wording of both the Charter and the Declaration reveals that they place wide obligations, not only on governments, but on all agencies of governments as well as individuals. These instruments are however soft law, and as such carry no explicit reporting requirements or sanctions for non-compliance.

1.5 Summary
The oceans of the world are being severely damaged. Five major threats continue to undermine biodiversity values across the marine realm. According to a United Nations advisory committee (GESAMP 2001):

The state of the world’s seas and oceans is deteriorating. Most of the problems identified decades ago have not been resolved, and many are worsening. New threats keep emerging. The traditional uses of the seas and coasts – and the benefits that humanity gets from them – have been widely undermined.

Damage identified in 2001 has generally worsened. Since the 2001 report was written, a major new threat has emerged: ocean acidification. The international goal of ‘at least 10% of the world’s ecological regions effectively protected’ by 2010 will almost certainly not be met (Wood 2005).

It is generally believed that the major failings of national programs to protect marine biodiversity rest on failures of governance rather than failures of science. The three core governance concepts discussed above are crucial to all serious attempts to address marine conservation issues in a strategic way. However, in general, attempts to apply them have often been poorly resourced, badly planned and ineffectually implemented.

The primary ingredient missing from national programs across the globe is political commitment to address the issues in the face of short-sighted resistance from vested interests, such as polluters, fishers and coastal developers. This failure in turn rests on widespread ignorance of the severity of the issues amongst the general community in all nations, rich and poor alike.

In many cases, the degradation which is occurring now cannot be reversed within the timescale of a human life. Decisive and intelligent action by politicians and community leaders is urgent. Such action must be underpinned by programs aimed at developing an increased awareness of the issues amongst the general population.
Section Two:  
The marine environment in crisis: ethics, fisheries, and the role of marine protected areas.

A system of conservation based solely on economic self-interest is hopelessly lopsided. It tends to ignore, and thus eventually to eliminate, many elements in the … community that lack commercial value, but are (as far as we know) essential to its healthy functioning. It assumes, falsely I think, that the economic parts of the biotic clock will function without the uneconomic parts.”

Aldo Leopold 1948

Learning to coexist with the rest of nature presents us with a huge challenge, requiring not only technical solutions but more importantly a profound shift in our own attitudes and philosophy.

Nik Lopoukhine, Chair of the World Commission on Protected Areas (Dudley et al. 2005:2)

2.1 Introduction

The planet’s biodiversity is in decline, and marine ecosystems are in urgent need of protection. Fishing (in its many manifestations) is currently the single most important threat to marine biodiversity – from a global perspective (Chapter 2). In the coming decades the destruction caused by fishing will almost certainly be overshadowed by ocean acidification.

The creation of marine protected areas is usually justified in terms of utilitarian needs relating to the conservation of biodiversity or the protection and enhancement of fish stocks. Could such reserves also be justified in terms of ethics? In spite of the general absence of discussion of ethics within areas of marine science or fisheries management, a substantial and long-standing literature exists from which an ethical basis for the establishment of protected areas could be drawn. This chapter briefly reviews some of the landmarks within this literature, and without apology for an explicit ethical position – recommends increased discussion and use of ethical arguments within the marine community. Far from harvesting other life forms in a sustainable way, humans are gradually but inexorably killing the wild living inhabitants of our planet, and destroying the places in which they live. It can be argued that the time to adopt a new ethical position has already passed with some talk but almost no action.

Many factors affect human behaviour, and to a large extent the remaining chapters of this thesis consider the reaction of fishery scientists and managers to knowledge about fish populations and the ecosystems in which they reside. However, the cultures in which people work are also important determinants of action, and this chapter explores ethical questions which permeate, or are excluded from, organizational cultures. This chapter argues that humans need to accord a right to ‘peaceful coexistence’ to at least a fair proportion of the other living residents of the planet – an approach which in fact aligns with the scientific recommendations of many conservation biologists. I argue that the matter is now so urgent that it requires the attention of every marine scientist.

Australia has declared its entire Exclusive Economic Zone (EEZ) as a whale sanctuary, and has proposed the creation of a South Pacific Whale Sanctuary at meetings of the International Whaling Commission (IWC). Australia’s international stance on whaling rests partly on two government-funded investigations: the Frost Inquiry (Frost 1978) and the National Task Force on Whaling (NTFW 1997) – both relying partly on ethical arguments to support their anti-whaling recommendations. These ethical arguments related to the perceived ‘special nature’ of whales and other cetaceans: their intelligence, their family behaviours, their ability to communicate, and their occasional voluntary contacts with humans. Both inquiries drew the conclusion that we should accord these animals greater rights than other sentient animals – essentially a ‘right to life and a right to a peaceful home.”
However, while the Australian government supported the recommendations of both inquiries, it appears noticeably reluctant to engage in any direct discussions of an ethical nature.

The Australian Government and Australian scientists have criticised Japan’s scientific whaling program (Gales et al. 2005). Interviewed in a Australian Broadcasting Commission (ABC) ‘Four Corners’ program screened in July 2005, a Japanese government spokesman asked a very reasonable question: “Australians eat cows, pigs and sheep. Why shouldn’t we eat whales?” Although this question was tangential to the immediate discussion, I found it interesting that it remained without discussion or reply, although it lies at the heart of the Japanese position. An ethical position underlies the Australian point of view, yet Australians seem reluctant to talk about it. In discussing the issue later with a colleague (a marine scientist) I asked: “have you ever heard a marine scientist talk about environmental ethics?” The reply was negative.

In this chapter I examine the reluctance of marine scientists to involve themselves with questions of ethics. I suggest that many marine scientists may be ignorant of the extensive environmental ethics literature, or see it as irrelevant. I argue that, while this is entirely understandable, it is now counter-productive. It is not un-scientific to adopt an explicitly ethical position, and I argue that discussion of ethics within the community involved in the management of marine resources should be strongly promoted until it seeps through to the level of the general community and thus to political decision-making.

2.2 Justifying marine protection

Terrestrial scientists do have a track record, if somewhat uneven, in using ethical arguments to justify the creation of protected areas – with Aldo Leopold being one of the most celebrated (more below). A well known example from more recent times is the controversial judgement of Justice Douglas (US Supreme Court) who argued that the moral rights of nature should be given legal recognition – based partly on the arguments of terrestrial ecologists (see Stone 1996). Jim Chen, a prominent academic US lawyer, continues to press such arguments (Chen 2005) again based on the findings of terrestrial biologists.

As a fairly typical example of a marine scientist arguing for the creation of marine protected areas, Professor Terry Hughes argued that a substantial proportion (30% or more) of coral reef ecosystems need to be protected from harvesting pressures in order to ensure ecosystem stability. According to Hughes (2004) (my emphasis): “Our final recommendation, the most challenging, is for the creation of institutional frameworks that align the marketplace and economic self-interest with environmental conservation. The ultimate aim is to secure future options for social and economic development” (my emphasis). It should be noted, however, that Professor Hughes on other occasions has adopted an explicitly ethical position in arguing for the need for major change in reef management around the world (Hughes et al. 2002) – unlike most other marine scientists who generally avoid taking ethics into public discussions.

The reliance on utilitarian arguments is of course not restricted to discussions of marine protected areas. Alfred Duda and Kenneth Sherman, in calling for urgent changes to existing fishery management strategies, state (my emphasis): “Fragmentation amongst institutions, international agencies and disciplines, lack of cooperation among nations sharing marine ecosystems, and weak national policies, legislation and enforcement all contribute to the need for a new imperative for adopting ecosystem-based approaches to managing human activities in these systems in order to avoid serious social and economic disruption” (Duda & Sherman 2002).

Verity et al. 2002, in a review of both the status of pelagic ecosystems and the scientific and political paradigms underpinning resource exploitation, conclude that “use of resources for the benefit of humanity” is the prime driver. In spite of finding the paradigms of resource exploitation unsustainable, Verity et al., in recommending paradigm changes, do not attempt to expand this narrow ethic (2002:226).
Sissenwine and Mace (2001) in defining ‘responsible fisheries’ state: “…we believe ‘responsible’ means sustainable production of human benefits, distributed fairly, without causing unacceptable changes in marine ecosystems.”

In their review of marine pollution, Islam & Tanaka (2004) stated: “Effective and sustainable management of coastal and marine environments should be initiated... to ensure .. the best possible utilization of resources for the broader interest and benefit of mankind.”

The FAO published a report Ethical issues in fisheries in 2005. The words “deep ecology” and “humanism” are not mentioned in the entire document, which revolves almost completely around the ethics of distributing fishery benefits between existing and future human populations (FAO 2005a). While these are important issues, they are not the subject of this chapter.

All these human-focused views are expressed by eminent and well-respected scientists, and their reliance on utilitarian motives, and their avoidance of any discussion of ethical motives is typical of the approach of marine scientists generally. Almost certainly each of these scientists speaks from an underlying ethical position; however this is seldom or never articulated.

There are, thankfully, exceptions. Unusual papers by Balon (2000) and de Leeuw (1996) take a strongly ethical position in opposing recreational fishing - based partially on arguments of unnecessary cruelty and the trivial destruction of life.

Coward et al. (2000) discuss fisheries ethics at length, focussing on “four kinds of justice: distributive, productive, restorative and creative.” Of these, the most relevant to the present discussion is “restorative justice” which refers to a need to restore degraded ecosystems, both for the benefits of the plants and animals which live in the ecosystem, and the humans which depend on the ecosystem for food and livelihood. In conclusion, they suggest: “Recognizing that we have the right to use our environment as a necessary resource... we must also recognize the concurrent responsibility not to abuse that right by taking more than we need, or more than the ecosystem can sustain…” Their recommendations include promotion of the precautionary principle, and promotion of marine protected area development.

Another important exception (directly relevant to the subject of this chapter) is a paper by Bohnsack (2003), while the well-respected American philosopher Callicott has specifically addressed the ethics of marine resource use (Callicott 1991, 1992). After examining the role of shifting baselines in undermining public expectations of what constitutes a healthy marine environment, Bohnsack concludes: “marine reserves not only protect marine resources but can help restore human expectations and provide a basis for new conservation ethics by providing a window on the past and a vision for the future.” These thoughts are echoed by Safina (2005) in an eloquent plea to extend Leopold’s land ethic to the ocean.

2.3 Environmental ethics and the development of an ecological conscience

Many religions contain concepts of care which extend beyond responsibilities to other humans. As Bohnsack (2003) points out, indigenous people in many parts of the world have strong beliefs that man is a part of, and not dominant over, nature. Traditional belief systems in many parts of Oceania, for example, have emphasised cultural and social controls and taboos on fishing, with strict and enforced codes of conduct (Johannes 1984). Buddhism combines a core ‘ecological’ concept, the ‘inter-connectedness of all things’ with an admonition to avoid causing suffering to any sentient being (BDK 1966). Hill (2000:161) has argued that Judeo-Christian teaching contains the concept that “nature serves something beyond human purposes, and as such it must be respected and honoured”. The recently-developed Bahai’i faith advocates responsibilities relating to maintaining the health of the planet, while Pantheism is more explicit in it’s ‘unity of all life’ teaching (refer www.comparative-religion.com). More contemporary authors such as Birch (1965, 1975,
1993) argue for the recognition of intrinsic values in nature, rather than its purely instrumental value to mankind.

These concepts have appeared in popular western literature for well over 100 years (see for example Tolstoy 1903), without significant influence on government or corporate decision-making, which are pervaded (globally) by John Stuart Mill’s anthropocentric ‘enlightened self-interest’ (Mills 1863). Callicott traced the roots of the now widely held ‘resource conservation’ ethic, which essentially aims at “the greatest good for the greatest number for the longest time” (Callicott 1991:25). Bohnsack (2003) provides an excellent summary of Callicott’s detailed chronology of schools of resource ethics.

In a classic essay “The historical roots of our ecologic crisis” Lynn White (1967) argues that modern technology and its application, the immediate cause for the twentieth century’s environmental problems, emerged from an anthropocentric culture of thought which rests in large part on Judaism. The particular passage cited is the ‘dominion’ passage of the Book of Genesis 1:26,28):

Then God said "Let us make man in our image, in our likeness, and let them rule over the fish of the sea and the birds of the air, over the livestock, over all the earth, and over all the creatures that move along the ground": So God created man in his own image, in the image of God he created him: male and female he created them. God blessed them and said to them, "Be fruitful and increase in number; fill the earth and subdue it. Rule over the fish of the sea and the birds of the air and over every living creature that moves along the ground."

White’s essay continues to create discussion and controversy. Many support his basic contention (eg: McKibben 1989). Christian writers (eg: Birch 1993, Hill 2000) inheriting in part a Judaic foundation, have argued for the expansion of Christian philosophy to encompass strong environmental stewardship ethics. However, such arguments appear to have limited sway over the bulk of the Christian churches or their leaders. Consider, for example, the Christian ‘Cornwall Declaration on Environmental Stewardship’ 2000, which criticises “unfounded and undue concerns [including] fears of destructive manmade global warming, overpopulation, and rampant species loss”. The evidence suggests that these three issues are in fact three of the most important facing the immediate future of our planet (MEA 2005, Novacek & Cleland 2001). On July 14, 2008, the Catholic Archbishop of Sydney, Cardinal Pell, appeared on the ABC TV Seven O’clock News, calling on people in countries where the birth rate was slowing to “have more babies”. It is also noticeable that modern Buddhist leaders, in spite of the inherent environmental concepts within their philosophy, do not speak strongly for comprehensive environmental stewardship concepts (see for example The Dalai Lama 1995 and other works by the same author). For a detailed discussion of various religious positions on the environment, see Nash (1990).

Henry James Thoreau, John Muir and Aldo Leopold (referred to by Callicott 2003 as “the three giants of American environmental philosophy) all advocated a reverence for nature, and argued the need to set aside large areas away from human impact (wilderness areas) in order to preserve intrinsic natural values.

2.4 Aldo Leopold’s “land ethic”

Of the writings of these three, Aldo Leopold’s ‘Land ethic’ (Leopold 1948) has made perhaps the most lasting impression, and continues to be extensively quoted. I consider his views to be powerful and coherent, and warrant examination in more detail.

Suppose no law prevented you from killing your neighbour and taking his land – would you do it? Hopefully not. Suppose your ‘neighbour’ belonged to a different racial or cultural group, and lived in another land. Would you kill him and take his land? Would you enslave him? Again, hopefully not. Yet that is exactly what our forefathers did – and what they did seemed ‘right’ within the moral framework of the time. In certain parts of the modern world, slavery still continues (www.antislavery.org). These questions are not far-fetched. If you
discovered an uncharted island, populated only by a forest and its animals, would you take possession, clear the land, kill the animals, build a house and plant crops? Maybe you would. If everyone else acted in the same way, where would it end? With increasing human domination of the planet’s ecosystems (MEA 2005; Vitousek et al. 1997) that end is now in sight.

I agree with Balint’s view (2003:14): “Scientists often do not recognize, or hesitate to raise relevant ethical issues when participating in environmental policy debates, relying instead on scientific theories, models, and data.”

As Balint also points out, Leopold urges humanity to undergo a change of heart towards the environment and extend society’s ethical structure to include the natural world. Leopold reminds us that slavery, including the killing of slaves as property, was once considered normal and right. Leopold equates movement towards a “land ethic” with previous cultural changes that led, for example, to abolishing slavery and recognizing the rights of women. In contrast to anthropocentric utilitarian views of nature, in which morally right acts are those that protect or increase human well-being, Leopold offers the following recommendation:

...quit thinking about decent land-use as solely an economic problem. Examine each question in terms of what is ethically and esthetically right, as well as what is economically expedient. A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise (Leopold 1948:240 – my emphasis).

In a rare paper focused directly on fishery ethics, Callicott (1991:25) called Leopold’s words (quoted above) “the golden rule of the land ethic”.

Leopold wrote, “There is as yet no ethic dealing with man’s relation to the land and to the animals and plants which grow upon it … The land-relation is still strictly economic, entailing privileges but not obligations.” Movement toward such an ethic, he suggested, is “…an evolutionary possibility and an ecological necessity …Individual thinkers since the days of Ezekiel and Isaiah have asserted that the despoliation of land is not only inexpedient but wrong. Society, however, has not yet affirmed their belief. I regard the present conservation movement as the embryo of such an affirmation.” (Leopold 1948:218)

Apart from the immediate issue of technological capability, the planet’s environmental crisis stems from the way humans act as if they own the planet – dubbed by Ehrenfeld (1981) the “arrogance of humanism”. Balint concludes (2003:22) “Leopold argued that the unlimited prerogative to own nature – defined to include ‘soils, waters, plants, and animals, or collectively: the land’ – that humans have bestowed upon themselves should be replaced by a constrained set of rights and an expanded set of responsibilities founded on principles of membership and citizenship in – rather than domination and exploitation of – the community of nature.”

*It is this concept of mankind as part of a ‘community of nature’ which provides the essential basis for the ethic we now so badly need.*

It is one thing to catch a fish and eat it, but it is another to over-fish that species to extinction, and yet another to destroy the place where that species lives. Do humans have the right to do all three?

**2.5 Contemporary environmental ethics**

Why are contemporary biologists and ecologists generally unwilling to engage in discussions of ethics? There are, of course, exceptions. According to Balint (2003:21): “Michael Soule has listed the postulate “Biodiversity has intrinsic value,” as one of four key tenets in the field of conservation biology, which he helped found, giving the idea that all life has intrinsic value the status of a first principle.”
Like White, David Ehrenfeld, in his critique of humanism (1981) argues that management of the planet's resources is almost universally founded on the idea that the features and objects of the natural world were created primarily for the benefit of humanity, and that it is the responsibility of humanity to accept this gift and accept stewardship of the natural world. Stanley (1995) in applying Ehrenfeld's arguments to ecosystem-based management, finds ample evidence that humanity's belief that effective ecosystem management is both possible and necessary lacks a strong factual basis – the history of such management being paved with failures. Stanley suggests that such failures will continue without a change in underlying ethics: “Humanity must begin to view itself as part of nature rather than the master of nature. It must reject the belief that nature is ours to use and control” (Stanley 1995).

Arne Naess and George Sessions are often seen as the founding fathers of ‘deep ecology’ – an ecology explicitly based on ethics which acknowledge the intrinsic value of non-human life forms. According to Naess & Rothenburg (1989:c1) “The inability of the science of ecology to denounce such processes as the washing away of the soil of rainforests suggests that we need another approach which involves the inescapable role of announcing values, not only ‘facts’.” Deep ecology is based on a ‘deep’ consideration of the values behind human use and abuse of the natural environment.

James Lovelock proposed the ‘Gaia hypothesis’ which sees the entire planet as resembling a single organism in the inter-connection of its biological components: “the self-regulation of climate and chemical composition is a process that emerges from the tightly coupled evolution of rocks, air, and ocean - in addition to that of organisms. Such interlocking self-regulation, while rarely optimal - consider the cold and hot places of the earth, the wet and the dry - nevertheless keeps the Earth a fit place for life” (Lovelock 1995). The ethical extension of this concept involves care of the planet as a living organism – with, Lovelock argues, reverence, humility and caution.

These ethical positions are broadly termed “biocentric”. Those opposing the extension of such ethics to the management and protection of planetary ecosystems are apt to highlight extreme versions as manifestly unworkable. For example, according to Hill (2000:161):

The effort to move beyond an anthropocentric to a biocentric view neither fits with our moral sensibilities nor yields useful policy prescriptions. First of all, the various attempts to derive a biocentric theology have been stymied in determining agreed-upon stopping points for the rights of nature. Although early efforts concentrated on the concept of sentience, philosophers and theologians have been unable to present a workable definition of what sentience includes. Edward Abbey, a leading deep ecologist, has said, “unless the need were urgent, I could no more sink the blade of an axe into the tissues of a living tree than I could drive it into the flesh of a fellow human.” Rene Dubos, a prominent bacteriologist, believes that just as people and wolves should coexist, so should people and germs. Philosopher Paul Taylor argues, “The killing of a wildflower, then, when taken in and of itself, is just as much a wrong, other-things-being-equal, as the killing of a human.” But even granting rights to living creatures does not solve the problem, since several leading figures in the environmental movement now argue, in the words of Michael J. Cohen, that “rocks and mountains, sand, clouds, wind, and rain, all are alive. Nothing is dead...”

Most environmental philosophers, however, take more defensible, moderate positions. Stone (1987, 1996) in addressing questions relating to the standing of those without voices, argues for increasing weight to be placed on intrinsic biological values in reducing further erosion of natural ecosystems, as well as the need (Stone 1995) to develop institutional protection for the rights of future generations of humans. Chen (2005) argues within a traditional but precautionary ethical framework for the development of stronger legal mechanisms to protect global biodiversity. The modern philosopher Peter Singer (1993) echoes the earlier approach by Passmore’s (1974) in grounding his ethical framework largely on enlightened self-interest informed by long-term and precautionary ecological science, with a generally accepted need to reduce suffering of sentient beings”. Such views are anything but radical.
2.6 Ethics in international instruments and government policy

With a few environmental philosophers expressing apparently extreme views, perhaps the reluctance of marine scientists and managers to adopt explicit ethical positions is in some way understandable. The university courses in marine biology that I am familiar with contain little or no formal exposure to issues of environmental ethics – which seem generally left within social science faculties. Keeping up with current science, past graduation, is a demanding task, and practising scientists mostly have little time to explore ethical issues. Where a scientist holds an ethical position (as many, even most perhaps do) it will often seem more useful to couch arguments about ecosystem protection in terms which are clearly understandable within the utilitarian framework of politics and economics. I argue, however, that this approach is now unnecessarily conservative. We can, in fact, look to international agreements and documents to legitimise an explicit ethical position.

The World Charter for Nature 1982 (a resolution of the United Nations General Assembly) was supported by the Australian Government in its development through the UNGA. Although hortatory and without compliance provisions, and thus non-binding, the Charter nevertheless represents an important commitment. Commitment obligations apply not only to government agencies, but, through article 24, to corporations and individuals.

In the preamble, the Charter notes that “civilization is rooted in nature… and living in harmony with nature gives man the best opportunities for the development of his creativity, and for rest and relaxation”. Importantly, the Charter also notes “Every form of life is unique, warranting respect regardless of its worth to man, and, to accord other organisms such recognition, man must be guided by a moral code of action”.

Foreshadowing the Convention on Biological Diversity which was to develop a decade later, Article 1 of the Charter requires that “Nature shall be respected, and its essential processes shall not be impaired”. Article 2 focuses on the protection of genetic diversity, and article 3 requires that “all areas of the earth, both land and sea, shall be subject to these principles of conservation; special protection shall be given to unique areas, to representative samples of all the different types of ecosystems, and to the habitat of rare or endangered species.” Article 10, perhaps particularly relevant to fishery management, states in part: “Living resources shall not be utilized in excess of their natural capacity for regeneration”. I suggest that flagrant violation of these principles has become such common practice that we now think of these transgressions as ‘normal’.

The Earth Charter was developed to extend the World Charter for Nature by adding social objectives, including the eradication of poverty and the universal adoption of democracy. The Earth Charter was developed over many years following a 1987 initiative of the United Nations. An Earth Charter Commission was formed in 1997 with help from influential UN figures and funds from the Dutch Government. After many years and much consultation, the Charter was endorsed by the Commission in 2000, and was put to the 2002 World Summit on Sustainable Development in Johannesburg - with a view to it being endorsed by the United Nations General Assembly.

The Earth Charter is important, as it embodies an explicit ethic of respect for the planet. The preamble states: “The protection of Earth’s vitality, diversity and beauty is a sacred trust”. Both Taylor (1999) and Bosselmann (2004) consider the Charter to be of considerable significance in regard to its long-term ability to influence both international law, and environmental law in general. According to Bosselmann (2004): “Among its ground-breaking principles are ecologically defined concepts of sustainability, justice, rights and duties.”

Article 1 advocated the recognition “that all beings are interdependent, and every form of life has value regardless of its worth to human beings”, and article 15 requires that “all living beings” be treated with respect and consideration. Many fishery practices flagrantly violate these requirements – consider, for example, the habitat damage routinely caused by trawling operations (Appendix 4) or the incidental kill caused by prawn fisheries (Chapter 11).
Although it is a conservative document, shying away from important issues such as the need to reduce the human population of the planet, and the need to reform democratic governance, the Earth Charter has nevertheless failed – so far – to get widespread government endorsement. It has, however, considerable support amongst the global community (including the scientific community) within many nations, and remains open for public endorsement. Over three thousand organisations worldwide have endorsed the Charter, including UNESCO and the World Conservation Union (IUCN) (www.earthcharter.org).

Writing shortly before the UN Johannesburg summit, Callicott had high hopes for the Earth Charter: “The prospective adoption of the Earth Charter by the General Assembly of the United Nations may have an impact on governmental environmental policy and performance similar to the impact on governmental social policy and behaviour of the adoption by the same body in 1948 of the Universal Declaration of Human Rights.” (Callicott 2002). It is to be hoped that Callicott’s expectations in this regard will ultimately be fulfilled – however for this to happen there will need to be a growing awareness, particularly within agencies which provide direct advice to politicians, of the need to articulate the policy implications of ethical positions.

Australia’s National Strategy for the Conservation of Australia’s Biological Diversity (DEH 1996:2) underwent wide agency consultation prior to publication, and, in its final form, was endorsed by the Australian (Commonwealth) Government, all State and Territory Governments, and by Local Government’s peak body. In it we find an articulate ethical statement:

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 which 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.

This clear expression (in a widely-endorsed government policy document) of the beginnings of a ‘land ethic’ provided Australian scientists with an opportunity to build discussion and use of deeper ethical positions, yet almost nothing has happened, and nearly a decade has passed, since this statement was published.

2.7 Oceans in crisis

Global trends:
Driven by the demands of an expanding human population combined with increasing per capita resource consumption, global ecological assets and processes are being seriously eroded. As the Millennium Ecosystem Assessment puts it: “Human activities have taken the planet to the edge of a massive wave of species extinctions” (MEA 2005c:3). Outside protected areas (IUCN categories I-VI) which cover about 12% of the terrestrial areas and about 1.4% of the marine realm (www.unep-wcmc.org) humans have already affected almost all terrestrial and freshwater habitats (Cracraft & Grifo 1999, Wilson 2002). About half of all natural terrestrial ecosystems have been destroyed or severely damaged, with this percentage escalating (Vitousek et al. 1997). Most of the remaining terrestrial natural habitat is significantly degraded (MEA 2005a, 2005b), and major degradation is occurring inside many protected areas, particularly in underdeveloped countries (Carey et al. 2000).

About one-quarter of the Earth’s ‘modern’ bird species have already been driven to extinction (Vitousek et al. 1997), with notable marine species such as albatrosses currently on extinction trajectories (Baker et al. 2002, Dulvy et al. 2003). Of the planet’s vertebrates, amphibians are the most threatened, followed by freshwater fishes (Helfman 2007). Helfman estimates one quarter to one third of all freshwater fish species are threatened. Marine fishes are the least endangered, with possibly 5% threatened (Leidy & Moyle 1998).
Considerable uncertainty surrounds estimates of threatened terrestrial plants, as poor data exists for the tropical regions where the bulk of plant species reside. Estimates by Pitman and Jorgensen (2002) suggest that "as many as half of the world's plant species may qualify as threatened with extinction under the IUCN classification scheme". Recent anthropogenic changes to the earth's atmosphere may not produce smooth changes in the earth's major ecosystems or the processes which underpin climate itself (such as the global thermohaline circulation – Koslow 2007). The resilience of the planet is being undermined; abrupt changes could occur and could prove to be both damaging and effectively irreversible (Steffen 2004).

The oceans as well as the planet’s terrestrial areas are being severely damaged. According to a United Nations advisory committee (GESAMP 2001):

> The state of the world's seas and oceans is deteriorating. Most of the problems identified decades ago have not been resolved, and many are worsening. New threats keep emerging. The traditional uses of the seas and coasts – and the benefits that humanity gets from them – have been widely undermined.

After two intensive workshops examining global fisheries, the FAO editors concluded:

> Over the last 15 years, the marine fishery resources of the world have been increasingly subjected to overexploitation, detrimental fishing practices, and environmental degradation. The phenomenon now affects a majority of fisheries worldwide, with very severe consequences in terms of resource unsustainability, massive economic waste, increasing social cost and food insecurity (Swan & Greboval 2003:1).

The workshops found that "poor governance" – including importantly a lack of political and managerial will – was the "major cause for the inability to achieve sustainable fisheries" (Swan & Greboval 2003:2).

Winter & Hughes (1997:22) characterised loss of biodiversity as "one of the four greatest risks to natural ecology and human well-being".

**Overfishing**

Overfishing is one of the greatest threats to the marine environment (GESAMP 2001:1) – and fishing overall is the greatest threat when attendant effects of habitat damage, overfishing, IUU fishing and bycatch are taken into account (Dulvy 2003, MEA 2005).

Overfishing, far from being a modern phenomenon, has been occurring in certain regions for a considerable time. Overfishing has been the rule rather than the exception, even in artisanal fisheries. As Jackson (2001) points out: "Untold millions of large fishes, sharks, sea turtles and manatees were removed from the Caribbean in the 17th to 19th centuries. Recent collapses of reef corals and seagrasses are due ultimately to the losses of these large consumers as much as to more recent changes in climate, eutrophication, or outbreaks of disease." According to Pauly et al. 2002: "Fisheries have rarely been ‘sustainable’. Rather, fishing has induced serial depletions, long masked by improved technology, geographic expansion and exploitation of previously spurned species lower in the food web".

Populations of ocean fishes have been hugely reduced over the last two centuries. Historical evidence suggests that earlier stocks may have been an order of magnitude greater than stocks in the last half-century (Steele and Schumacher 2000) – which themselves have now often been reduced by another order of magnitude (see below). The last few decades have witnessed accelerating inroads into marine habitats, which in many instances are now broadly approaching ecological collapse. Many coastal ecosystems have already passed the point of collapse when compared with their pristine state – some well past, like the Black Sea (Daskalov 2002, Daskalov et al. 2007) and the Baltic Sea (Osterblom et al. 2007). The dramatic decline of coastal fisheries is the signal we see (Jackson et al. 2001) – masked to some extent by shifting baselines (Pauly 1995) where each generation of fisheries scientists forgets (or never learns) about the state of the oceans before their own lifetimes.
According to Jackson (2001): “Ecological extinction caused by overfishing precedes all other pervasive human disturbance to coastal ecosystems, including pollution, degradation of water quality, and anthropogenic climate change”. Duda & Sherman (2002) express similar concerns: “Continued over-fishing in the face of scientific warnings, fishing down food webs, destruction of habitat, and accelerated pollution loading – especially nitrogen export – have resulted in significant degradation to coastal and marine ecosystems of both rich and poor nations.”

Subsidization of national fishing fleets continues, in spite of warnings by scientists (eg: Pauly 1995) and the FAO (www.fao.org) that excessive fishing pressures are the primary cause of fisheries collapse. Global fishing fleets are two or three times the size necessary to harvest the approximate reported annual global catch of around 90 million tonnes. Many fisheries have “staggering levels of discarded bycatch” which, when combined with unreported, unregulated and illegal fishing, pushes the true global annual catch to around 150 million tonnes (Pauly & Christensen 1995). These figures, although a decade old, are still roughly accurate if Chinese reports of fishing take are excluded. This estimate does not include ‘ghost fishing’ – the take by lost or abandoned fishing gear. While difficult to estimate, ghost fishing may be causing significant damage. The plastics used in many nets, once removed from the effects of UV radiation in sunlight, last virtually indefinitely.

Many marine animals have suffered dramatic declines due to over-fishing. Roman & Palumbi (2003) estimate that “pre-whaling populations [of fin and humpback whales in the northern Atlantic] [were] 6 to 20 times higher than present-day population estimates”. Jennings and Blanchard (2004) in their study applying macro-ecological theory to the North Sea, suggest that the current biomass of large fishes is over 97% lower than it had been in the absence of fisheries exploitation.

Dayton et al. (1998) describing the kelp forest communities of western USA, state: “…fisheries have had huge effects on the abundances, size-frequencies, and/or spatial distributions of sheephead, kelp bass, rays, flatfish, rock fish, spiny lobsters and red sea urchins. Now even sea cucumbers, crabs and small snails are subject to unregulated fishing. …most of the megafauna have been removed with very little documentation or historical understanding of what the natural community was like.”

Studies by Myers and Worm (2003) have estimated “that large predatory fish biomass today is only about 10% of pre-industrial levels”. This decline may have caused serious damage to ocean ecosystems, and species extinction is a real possibility (Malakoff 1997). Baum and Myers (2004) estimate that oceanic whitetip and silky sharks, formerly the most commonly caught shark species in the Gulf of Mexico, “have declined by over 99% and 90% respectively”. Grey nurse sharks were the second most commonly caught shark on Australia’s eastern seaboard in the early 1900s (Roughley 1951); today their total population is estimated at 400 individuals and is continuing to decline (Otway et al. 2004). Worm et al. (2005) confirms the generality of declines in large predators across the world’s oceans.

As Botsford et al. (1997) point out, it is abundantly clear that, at a global level, “[fishery] management has failed to achieve a principal goal, sustainability”.

**Habitat damage**

In spite of the admonitions of many international agreements and national policies aimed at the protection of habitats and ecosystems, trawling continues to cause massive damage to fragile benthic communities (Dayton 1998, Koslow et al. 2000, NRC 2002, Koslow 2007). The advent of recent technologies in navigation, sonar and deep fishing gear have permitted damaging fishing of the deep sea (Roberts 2002). Due to very slow recovery times in deep sea ecosystems, damage already caused by deep sea trawling is likely to take many hundreds of years to repair, if full recovery is possible at all.

Vulnerable coastal habitats, such as mangrove, salt marsh, seagrass, and coral reefs have been seriously – in many cases irrevocably – damaged by human activities through pollution,
alteration of tidal flows, and deliberate damage (e.g. from blast fishing or mining operations – Oakley 2000).

**Coral, global warming and biogeochemistry**

Coral reef ecosystems have been declining globally for many decades (Wilkinson 2004, Pandolfi et al. 2003, Jackson 1997). Average coral cover in the Caribbean region has declined from about 50% to 10% in the last 30 years (Gardner et al. 2003), and similar declines are common in heavily fished reef ecosystems globally. Even given these dramatic declines, for coral ecosystems the worse is yet to come.

The concentration of carbon dioxide in the Earth’s atmosphere has increased by about 30% since the beginning of the industrial revolution (Vitousek et al. 1997) with a continued massive increase effectively unavoidable over the coming decades. Carbon dioxide levels are now higher than any time in the last 400,000 years, and possibly the last 50 million years (Koslow 2007, Veron 2008).

According to the Royal Society (2005) many marine organisms dependent on calcium carbonate structures, including corals, are unlikely to survive increases in ocean acidity predicted at the close of the next century, if global emission rates of carbon dioxide continue along current trajectories. Coral reefs are already degrading under the effects of overfishing, increasing sea surface temperatures, and nutrient-laden runoff from the agricultural and urban development of nearby coasts (Bellwood et al. 2004, Hughes et al. 2003). According to Pandolfi et al. (2003): “[Coral] reefs will not survive without immediate protection from human exploitation over large spatial scales”. Veron (2008) is even more pessimistic.

**Pollution**

Excessive anthropogenic nitrogen inputs to coastal marine ecosystems are causing ‘dead zones’ (oxygen-depleted zones) of substantial size. Moffat (1998) reported a zone “the size of the State of New Jersey, expanding westward from the coast of Louisiana into Texas waters”. Since then other similar zones have been identified (Diaz & Rosenberg 2008). As mentioned above, shallow coral ecosystems are readily damaged by nutrients (Harrison & Ward 2001) sediment, and pesticides in runoff from adjacent agricultural land (Hutchins et al. 2005). Trace metal pollution may also be important; copper for example has been found to inhibit coral spawning even at very low concentrations (Reichelt-Brushett & Harrison 2005). Pollution from plastic litter has reached epidemic proportions (Islam & Tanaka 2004). Ingested plastics accumulate in the guts of some marine animals, causing starvation. Most plastics do not degrade once removed from UV radiation, making the problem of plastic accumulation particularly severe in marine environments.

According to Islam & Tanaka (2004): “Coastal and marine pollution has already caused major changes in the structure and function of phytoplankton, zooplankton, benthic and fish communities over large areas... Most of the world’s important fisheries have now been damaged to varying extents...”.

**Trophic cascades: catastrophic shifts in ecosystems**

The Millennium Ecosystem Assessment biodiversity synthesis (2005a:25) highlights damage which can occur to ecosystems by removing species which supply local services critical to key ecosystem processes, such as grazing in coral reefs, or pollination in terrestrial ecosystems. Examples of damaging trophic cascades in the marine environment listed in MEA include overharvesting of Californian sea otters, Alaskan sea lions, Kenyan trigger fish, and Caribbean reef fish (MEA 2005a:27).

2.8 Conclusion

Human activities are undermining the biological fabric of planet Earth. Critical problems identified decades ago by the international community have not been addressed in any
effective way, and are worsening. “Business as usual” – resting on existing anthropocentric cultures within science, government and the community at large – is not working.

As Callicott (1991:27) argued more than ten years ago: “The public conservation agencies [read: fishery management agencies] are still ruled by the 19th century Resource Conservation Ethic, but as Aldo Leopold realized some 40 years ago, the Resource Conservation Ethic is based upon an obsolete pre-ecological scientific paradigm. Since the Land Ethic is distilled from contemporary evolutionary and ecological theory it should, therefore, be the new guiding principle of present and future conservation policy.”

The single most important issue the world faces today is the need to develop an ecocentric ethic of planetary stewardship, based on notions of participation in the community of nature rather than domination of it – as advocated by Leopold (1948). Such ethics need to be underpinned by a reverence for the beauty and complexity of our “water planet” and its diversity of life forms. Without this ethic, the forces behind our industrial-consumer society are pushing global resource consumption to higher and higher levels, eroding the essential life support systems of the planet. The expansion of ‘human habitats’ is now so pervasive that it is quite simply destroying the homes of other inhabitants of our planet on a massive scale.

Much is at stake. The human onslaught on the marine environment has, until the last few decades, been concentrated in estuaries and coastal oceans – through overfishing, habitat damage, pollution and the introduction of invasive species. This has, however, changed dramatically in recent times. While coastal marine areas continue to suffer, massive damage is now being inflicted over oceanic environments, primarily by industrial over-fishing (Gianni 2004).

As Ludwig et al. (1993:17) argued: “There are currently many plans for sustainable use or sustainable development that are founded upon scientific information and consensus. Such ideas reflect ignorance of the history of resource exploitation and misunderstanding of the possibility of achieving scientific consensus concerning resources and the environment. Although there is considerable variation in detail, there is remarkable consistency in the history of resource exploitation: resources are inevitably over-exploited, often to the point of collapse or extinction.” In the decade since Ludwig wrote, evidence is still accumulating that over-exploitation of marine resources remains the rule rather than the exception (Koslow 2007; Kieves 2005; Verity et al. 2002; Wilson 2002).

A voluminous and long-standing literature on environmental ethics exists, but is seldom referred to by marine scientists. While little of this discussion has permeated international and national policies, a few notable documents, such as the UN World Charter for Nature 1982, the Earth Charter, and Australia’s national biodiversity strategy (Commonwealth of Australia 1996) do contain statements reinforcing the idea of respect and reverence for nature. But where is this concept being expressed? What part should it play in strategies and programs to protect natural ecosystems which continue to be exploited and degraded by the incremental expansion of human activities?

Over the thousands of years of human civilization, it is only recently that a ‘right to life’ has become a universally accepted part of the way humans treat each other – along with rights to property and ownership of land. At present we humans accord the rest of the living world scant rights. Fish, for example, are not even accorded the right to a humane death, nor have we provided a right to an undisturbed home: no-take reserves (as of 2004) amount to only a miniscule proportion of the marine realm. Humans, like other predators, have always eaten plants and animals; however humans are now destroying both species and ecosystems.

A few nations are, at present, moving along a path which would accord a ‘right to life’ to whales and other cetaceans (Commonwealth of Australia 2002, 2004). However this extension of rights is hotly debated by other nations, and international agreement (even in the long-term) seems unlikely (Danaher 2002, Molenaar 2003).
Given the pressing need to put ethics into action to protect the planet’s ecosystems, a search for a right to life for particular species – resting as it does on highly controversial arguments – is a path which we have no time to explore. However, I believe scientists and the community generally need to extend the concepts of respect for and community with nature (concepts which have at least some wide general acceptance) to rights of peaceful coexistence. This concept, in practice, means setting aside large parts of the planet where human impacts are kept to a minimum, and consumptive harvesting does not occur.

There is scope to do this in the marine realm – if we are willing to pay for it. At present only 1.5% of the oceans have protective management regimes (meeting the IUCN protected area criteria I-VI), and only 0.18% of the ocean is protected to the criteria I level (no-take zones). 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. Many scientists support such a target purely on ecosystem management grounds (www.onlyoneplanet.com.au). As Pimm et al. (2001) have said: “Enforceable protection of remaining natural ecosystems is an overarching recommendation”.

Providing refuges for at least a substantial part of marine biota is an idea that finds support amongst many conservation biologists. Browman & Stergiou (2004:270) ask “…why is it so difficult to recognize the inherent rights that marine fauna have to a safe haven?”. The fact of the matter is that the establishment of marine protected areas will place short-term costs on those who have traditional (or formal) rights to harvest from the sea. These rights must be recognised and compensation must be paid.

Victoria (Australia) established no-take areas over 5.3% of its coastal seas (to 3 nm) in 2002. The program of establishing these protected areas nearly failed due to intense political pressure applied by fishers incensed by the government’s lack of compensation provisions. The State government was at first unwilling to formalise a compensation program for fear of excessive costs – which no-one had bothered to estimate in any detail. Three years later, the lesson from the Victorian program is that compensation costs need not be high: claims have in fact amounted to only half a million dollars (Phillips 2005), much less than many had predicted, and trifling in the circumstances.

There is a desperate need to protect marine environments. While utilitarian arguments must continue to be used, I believe it is now essential that scientists and policy-makers enter into ethical debate. Our species is gradually but inexorably killing the other wild living inhabitants of our planet, and destroying the places in which they live. The time to adopt a new ethical position has already passed with some talk but no action. The matter is now so urgent that it demands the attention of every marine scientist. In Callicott’s words: “we … must rise to the challenge of our time” – requiring an explicit change of the underlying ethics of our use of marine ecosystems (Callicott 1991:27).

My conclusion is that biological scientists are amongst the few residents of the Earth who can appreciate the gravity of the changes which are taking place. We need to speak for the planet, and we need to use ethical as well as scientific arguments to do so. The ‘right to peaceful coexistence’ is a concept in need of urgent and widespread discussion. We need to discuss “the arrogance of humanism” and the ethics of resource use on a planet whose ecosystems are in crisis. Marine protected areas need to be developed for many reasons, one of which is to provide peaceful and secure homes to other living residents of this planet, in addition to their role in safeguarding the integrity of ecosystem processes we barely understand.
Section Three:  
A sample of peer-reviewed scientific papers relevant to the design and management of MPAs.


resources’, *Marine Ecology Progress Series* 300: 241-96.


Buton, C, JF & Bradshaw, M (2006) Regional impact assessment for the marine protected areas proposed for the south-east region, Tasmanian Aquaculture and Fisheries Institute, Hobart.


Caddy, JF & Seijo, JC (2005) ‘This is more difficult than we thought! The responsibility of scientists, managers and stakeholders to mitigate the unsustainability of marine fisheries’, *Philosophical Transactions of the Royal Society* 360(1453): 59-75.


Haltuch, MA, Punt, AE & Dorn, MW (2008) 'Evaluating alternative estimators of fishery management
Hastings, A & Botsford, LW (2003) 'Comparing designs of...
Harrington, JM, Myers, RA & Rosenberg, AA (2005) 'Wasted bycatch species, and implications for monitoring...'
planning outcomes: an example from the Great Barrier Reef Marine Park\textsuperscript{a}, paper presented to IMAP\textsuperscript{b} Conference, Geelong, October 21-28.


IUCN (2004) 'Ten-year high seas marine protected area strategy: summary version as agreed by the marine theme participants at the fifth IUCN World Parks Congress, September 2003; World Conservation Union IUCN, Gland Switzerland.


Jennings, S (2005) 'Indicators to support an ecosystem approach to fisheries', Fish and Fisheries 6(3): 212.


Johnson, CN (2005) 'What can the data on late survival of Australian megafauna tell us about the cause of their extinction?', Quaternary Science Reviews 24(20-21): 2167-72.


Kappel, CV (2005) 'Losing pieces of the puzzle: threats to marine, estuarine, and diadromous species'.

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Laurenson, LJ, Ursworth, P, Penn, J & Lenanton, RCJ (1993) 'The impact of trawling for saucer scallops and western king prawns on the benthic communities in coastal waters off southwestern Australia', Department of Fisheries Western Australia, Perth.


Lucieer, VL & Pederson, H (2008) 'Linking morphometric characterisation of rocky reef with fine scale lobster movement', ISPRS Journal of


Murray, MS (2008) ‘Zoocarchaeology and ARCTIC MARINE MAMMAL BIOGEOGRAPHY,'


Steffe, AS, Murphy, JJ, Chapman, DJ, Tarlinton, BE, Gordon, GMA & Grinberg, A (1996) An assessment of the impact of offshore recreational fishing in New South Wales waters on the management of commercial fisheries, NSW Fisheries Research Institute, Cronulla NSW.


Australia: making the most of patchy data', *Fisheries Bulletin* 103(1): 169-82.


Section Four:
An overview of the science relating to marine protected areas.

The Australian Marine Science Association’s *Position Paper on Marine Protected Areas 2008* provides a good overview of the science: (subsections renumbered):

4.1 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*. “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. 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.

4.2 Position statement

4.2.1 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.

4.2.2 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.

4.2.3 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 is a vital tool for the study of long-term MPA effects, and such ongoing studies must be adequately funded.

4.2.4 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.

4.2.5 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 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).

4.2.6 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.

4.2.7 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.

4.2.8 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\(^{xvii}\) 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\(^{xviii}\), 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 \(a, c, f, h, q, x, y\) 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.

4.2.9 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.

4.2.10 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 evidence-based decision making.

4.2.11 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.

4.2.12 AMSA has been disappointed\(^{xix}\) 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.\(^{xx}\)

4.2.13 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.

4.2.14 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.

4.2.15 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.

4.2.16 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.

4.2.17 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.

4.3 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 (SPRPNRSA 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);


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.

### 4.3.1 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 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*. 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.

### 4.3.2 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.

4.3.3 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);

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 Technical 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 database listed 200 MPAs in Australian waters covering approximately 648,000 km² or ~ 5.7% of Australia’s marine jurisdiction, excluding the Australian Antarctic Territory. The MPAGlobal website, checked in September 2008, listed 359 Australian MPAs, of which 310 were reserves, and 81 were no-take.

### 4.3.4 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\textsuperscript{xix}.

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)\textsuperscript{xx}

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, 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.

4.3.5 Marine protected area networks

4.3.5.1 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.

4.3.5.2 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.
4.3.5.3 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).

4.3.5.4 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. 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.

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 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 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 rogersii 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)xxxvi. 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 longline 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” (68%) for all fish species combined, but from 195 to 0.6 kg hour” (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
cauised 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.
4.3.5.5 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 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. Paddock & 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).

4.3.5.5 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, 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 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\textsuperscript{xix}. 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. \textit{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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Section Five:
Scientific support for the establishment of networks of marine protected areas around core sanctuary zones.

Over 150 highly qualified scientists supported the following public letter:

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Monday 16th August 2010

The Hon Julia Gillard
Prime Minister
Parliament House
Canberra ACT 2600

The Hon Tony Abbott
Leader of the Opposition
Parliament House
Canberra ACT 2600

OPEN LETTER TO THE PRIME MINISTER AND LEADER OF THE OPPOSITION
SCIENCE SUPPORTING MARINE PROTECTED AREAS

Dear Ms Gillard and Mr Abbott

Recently articles have appeared in State and national press suggesting that there is little or no scientific evidence to support the creation of systems of marine protected areas. This is false. In this letter we briefly discuss the scientific evidence that shows marine protected areas have very positive impacts on biodiversity, and in many cases fisheries as well. Some reserve systems also produce substantial economic benefits through tourism, as well as providing important educational, inspirational and research opportunities.

Here we use the definition of marine protected areas of the Australian Marine Science Association (AMSA): areas of the ocean or coastal seas, securely reserved and effectively protected from at least some threats. In the discussion below, we look briefly at threats to the marine environment, the history of marine protected areas, the development of networks of MPAs in Australia (against a background of bioregional planning), and their importance to Australia in an uncertain future.

The marine environment faces five general threats: climate change and ocean acidification resulting from rising CO₂ levels, overfishing, habitat damage, pollution, and the effects of alien organisms. On the global scene, modern fishing activities constitute the most important threat to marine biodiversity at the present time, although this will change in the near future as rising CO₂ levels affect ocean chemistry, temperatures and sea levels.

Fishing activities in Australia have had damaging effects on biodiversity. Well known examples include the orange roughy where populations (and their fragile coral habitats) have been massively reduced by commercial fishing, and the east coast grey nurse shark, where historic recreational fishing pressures combined with commercial bycatch could result in the regional extinction of this species. While area protection clearly cannot be effective against all threats (eg: ocean acidification) it can provide protection from important threats such as fishing and habitat damage.

Protected areas have been used in some parts of the world for hundreds, perhaps thousands of years. Protected areas established by tribal law in Oceania were put in place purely to protect fisheries, for example by the protection of spawning, nursery and feeding
In 1972, the nations of the world pledged to protect representative examples of major terrestrial, marine and freshwater ecosystems through the United Nations Conference on the Human Environment Stockholm Declaration. The protection of such areas is of immense scientific value, in many instances offering the only 'natural' benchmark by which we can judge the effects of human interventions. Australia’s commitment to this program of protecting representative ecosystems was re-affirmed in 1982, through the United Nations General Assembly World Charter for Nature, and again in 1992, when Australia supported the international Convention on Biological Diversity. This latter document (the CBD) led, through an extended program of scientific and stakeholder consultations, to a commitment (set out in the CBD Jakarta Mandate) to develop global and national networks of marine protected areas. Hundreds of scientists from around 180 nations contributed to the development of this program, which continues across the world today. Australian scientists and politicians have played (and continue to play) a world leading role in this program.

Most Australian States had already begun programs of marine spatial protection when the Commonwealth Government took the role of coordinating and supporting the development of networks of marine protected areas in the early 1990s, and by introducing marine bioregional planning in the late 1990s (bioregions contain repeating patterns of similar ecosystems, providing a key spatial framework within which protected area networks can be designed and implemented). These efforts were unanimously applauded by scientists around the world, and in large part established Australia as a major international player in areas of marine science and conservation. Senator Robert Hill played an important role in establishing a national program strongly based on science – which up until the present time has had bipartisan support for nearly two decades.

Australia is a world leader in marine conservation planning, although implementation outside the Great Barrier Reef is patchy. The current planning for marine protected area systems in federal waters has been carried out by the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA) with world class tools and principles, and some outcomes are of a high standard. Indeed the successful rezoning of the Great Barrier Reef is considered to be a global model of best scientific practice.

Scientific studies have confirmed several ‘common sense’ outcomes. Where areas are effectively protected (and that does mean that compliance measures must be in force) harvested species (fish, for example) tend to be older, larger and more abundant. In a few cases statistically significant evidence of a beneficial effect of marine reserves cannot be found largely because of inadequate data, or insufficient time for effects to clearly manifest, not because there are actually no effects. This is particularly important because, unlike many land dwelling vertebrates, larger females tend to be more effective breeders (often much more effective). Again, not unexpectedly, benefits appear over time, sometimes slowly. Some of the oldest marine protected areas are still showing the effects of ‘recovery’ from harvesting and other pressures. Protected areas can also ameliorate coral disease by promoting ecological resilience. While the benefits for marine biodiversity flowing from no-take areas have been well established, arguments continue (and will continue) about the use of marine protected areas for fishery enhancement purposes. It is noteworthy, in this context, that some MPAs have strong support by fishermen – an example being the shallow seagrass areas of the Gulf of Carpentaria set aside specifically to protect prawn nursery areas. In many instances, protected areas can be specifically targeted to protect the spawning, nursery and feeding areas of commercial species.

If we recognise that some parts of the ocean need to be protected from humans (just like the land) then the benefit of marine protected areas for biodiversity conservation is not a matter of dispute. Over the last few years, there have been hundreds of peer-reviewed scientific articles confirming the beneficial effects of marine protected areas, supplemented by several recent in-depth reviews (see the reference list below for a listing of some of these). In addition, there have been several major scientific consensus statements, again confirming the scientific basis, and the conservation value, of marine protected areas.

Australia has committed, through international agreements, to ‘effectively protect’ at least 10% of its oceans and coastal seas, and the target date for this commitment is imminent.
The Australian Marine Science Association has called for Australian governments to protect at least 10% of State and Commonwealth marine waters in no-take (sanctuary) zones, with rare or vulnerable ecosystems protected at higher levels\textsuperscript{vii}. Such targets need to be applied at the ecosystem level rather than broadly across marine jurisdictions, noting that many scientists believe much higher levels of protection are necessary to protect marine biodiversity in the long term\textsuperscript{vii}. We endorse AMSA’s viewpoint, and call on you take account of important responsibilities to protect Australia’s biodiversity in making long-term decisions on Australia’s program of establishing marine protected areas, or the bioregional planning framework in which the program sits.

**In summary:**

- networks of marine protected areas play a vital role in protecting marine ecosystems, certainly just as important as protected areas, such as national parks, in the terrestrial environment;
- systems of protected areas have many benefits, not least of which are the economic benefits flowing from tourism;
- protected areas are not a ‘cure-all’ for problems of marine conservation; they must be put in place alongside other effective measures aimed at protecting biodiversity across Australia’s entire marine jurisdiction, and here implementation of the ecosystem approach and the precautionary principle in fisheries management is essential;
- the establishment of MPAs in Australia fulfils important and long-standing international obligations, and Australia (at present) has an enviable reputation amongst the global community for the strength of its science and the effectiveness of its conservation programs;
- the establishment of protected area networks, particularly in Australia, rests on a strong scientific foundation, and here marine bioregional planning provides an essential scientific and planning framework;
- once established, governments have an obligation to provide funds for effective enforcement of agreed protective measures; particularly in relatively remote areas, history has shown that enforcement is essential for compliance\textsuperscript{viii}; and
- Australia’s program of the establishment of networks of marine protected areas has, until now, enjoyed bipartisan support across both State and Commonwealth jurisdictions – long-sighted support which will be even more important in an increasingly uncertain future.

**Government actions needed:**

1) Recognize the importance of MPAs in mitigating major threats to marine biodiversity. Set area protection targets ensuring at least 10% of all ecosystem types have no-take protection, with vulnerable, rare and iconic ecosystems, and special and unique habitats, protected at higher levels;

2) Increase funding for marine bioregional planning, while providing additional ongoing funding for enforcement, monitoring, and public education and awareness programs;

3) Provide a vision for managing the diversity of threats to Australian marine habitats through MPAs and other management tools – particularly implementation of the ecosystem and precautionary approaches in fisheries management, combined with urgent greenhouse gas reductions.

We wish to close with a quote from a document endorsed by the Council of Australian Governments in 1996 – Australia’s national biodiversity strategy:

> 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 which 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.\textsuperscript{ix}

--ooOoo--

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Section Six: The balance between sanctuary zones, other protected zones, and overall marine habitats.

6.1 Overview of this section:
Currently around 1.2% of the global marine realm is classified by the IUCN as protected area, with no-take areas accounting for only around 0.2%. Such areas are created mainly to protect marine biodiversity or to assist the sustainability of fisheries. 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 (and somewhat vague) target set by the Conference of the Parties to the Convention on Biological Diversity in 2004 (see below). 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.

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.

The purpose of this paper is to provide further background for a continuing discussion of area targets (“dangerous targets”) for MPA networks, by listing and briefly commenting on all major papers published since 2000 dealing with no-take area network size. Some key references on size in relation to planning individual no-take areas, and the spacing of areas within a network, are also included in the discussion.

The literature reviewed below reveals a general consensus amongst marine scientists (summarized in Table 1) that a massive increase in no-take areas will be necessary if agreed international conservation goals are to be met.

6.2 Terminology
Protected areas, as defined by the World Conservation Union (IUCN 1994) are areas of land or water “especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means”. Close examination of the logic underpinning the IUCN definition reveals three key elements. The area should be under defined management (i.e. an agreed management plan should exist). Secondly, actual management arrangements should effectively reduce at least one major threat to the area’s values (i.e. value and condition should be monitored and reported over time). Thirdly the area should have secure tenure (preferably through statute). In summary, protected areas are areas where (a) management regimes are in place designed to protect the natural ecosystems and features (ie ‘values’) within an area against threats, and (b) those management regimes are effective and secure.

The full IUCN definition lists six different categories of protected area, with category one having the highest, and category six the lowest level of protection. Category 1 are strict no-take areas. Category 2 (wilderness areas) are also highly protected, but do allow indigenous harvesting. Within this paper the term ‘no-take area’ means an area where no harvesting occurs. Such an area will meet the IUCN protected area category 1a and 1b definition (IUCN 1994). Within this paper the term ‘marine protected area’ is used to encompass all IUCN categories (1-6), while the term ‘reserve’ is used to encompass IUCN categories 1-4 (where conservation is a primary goal).

6.3 International commitments to MPAs and NTAs:
According to the Convention on Biological Diversity 1992, the conservation of biodiversity requires two fundamental strategies: the establishment of protected areas, together with the
sympathetic\textsuperscript{lxv} management of exploited ecosystems outside those areas (CBD articles 7 and 8).

Marine protected areas were un-known in an era when it was generally considered that the oceans needed no protection\textsuperscript{lxvi}. However, as the damage to the marine environment has become more widely understood, marine protected area programs have featured in international agreements as well as national conservation programs. One of the most widely quoted international statements calling for the acceleration of marine protected area programs around the world is that from the World Summit on Sustainable Development (WSSD Johannesburg 2002). The marine section of the WSSD Key Outcomes Statement provides basic benchmarks for the development of marine protected areas as well as other key issues:

Encourage the application by 2010 of the ecosystem approach for the sustainable development of the oceans. On an urgent basis and where possible by 2015, maintain or restore depleted fish stocks to levels that can produce the maximum sustainable yield.

Put into effect the FAO international plans of action by the agreed dates:
- for the management of fishing capacity by 2005; and
- to prevent, deter and eliminate illegal, unreported and unregulated fishing by 2004.

Develop and facilitate the use of diverse approaches and tools, including the ecosystem approach, the elimination of destructive fishing practices, the establishment of marine protected areas consistent with international law and based on scientific information, including representative networks by 2012.

Establish by 2004 a regular process under the United Nations for global reporting and assessment of the state of the marine environment. Eliminate subsidies that contribute to illegal, unreported and unregulated fishing and to over-capacity.

The same statement also contains a commitment: “Achieve by 2010 a significant reduction in the current rate of loss of biological diversity.”

Worldwide, the most important threat to marine biodiversity, generally speaking, is fishing (MEA 2005) – including the effects of overfishing, bycatch, habitat damage, ecosystem effects, and ghost fishing\textsuperscript{lxvii}. While fishing constitutes the major global threat, climate change, pollution, and the effects of alien organisms also present major (and in some cases intractable) problems. The exclusion or reduction of fishing activities – and the control of other threatening processes – through networks of marine protected areas is recognised worldwide (through the Johannesburg statement) as essential to national marine protection programs.

While no-take area targets have not been set so far by international agreements, the World Parks Congress (2003) recommended the establishment of national networks of marine no-take areas (NTAs) covering 20-30% of habitats by 2012. Greenpeace International have called for a similar area target of 40% (2006:26).

A few scientists, however, are not only opposed to the use of no-take area targets, but question the widespread use of marine protected areas, particularly as fishery management tools. The fishery benefits of no-take areas remain subject to debate. Shipp (2003) for example argued that most commercial fish stocks are too mobile to obtain protection from NTAs, although his views have few supporters amongst marine scientists. In spite of ongoing failures in fishery management, Steele & Beet (2003) suggested that controlling fishing impacts may generally be more effective at protecting marine biodiversity than MPA protection. Jones (2006) stressed the need for participatory democracy within MPA governance arrangements, and Sale et al. (2005) identified critical information needs for effective MPA functioning. There is, however, amongst the differing views of marine scientists a general consensus (consolidated through the CBD’s Jakarta Mandate) that MPA networks are essential to any national marine conservation program. With respect to the fishery benefits of MPAs, most “agree that MPAs will complement other management tools” (Browman & Stergiou (2004)).
According to Jake Rice: “We have largely emerged from the “polarized period” when
discussion of MPAs was too often a non-dialogue between believers (who often verged on
the fanatic in their enthusiasm) and non-believers (who had a comparable share of

The science underpinning MPA design suffers from some of the same problems as the
science underpinning fisheries models. In spite of such concerns, the worldwide acceptance
of marine protected areas as vital conservation tools is now well consolidated, at least at the
levels of academic science and international law (if not national politics)\textsuperscript{lviii}.

6.4 Protection of representative marine ecosystems:
Attention needs to be given to the use of the word “representative” in the WSSD text above.
Requirements to provide adequate and comprehensive protection for representative
examples of all major types of ecosystems date back many years. Clear requirements for
action are contained in:

- the 1992 international Convention on Biological Diversity (United Nations)
- the 1982 World Charter for Nature (a resolution of the UN General Assembly), and
  Environment.

The 1982 World Charter for Nature states: “Principle 3: All areas of the earth, both land and
sea, shall be subject to these principles of conservation; special protection shall be given to
unique areas, to representative samples of all the different types of ecosystems, and to the
habitat of rare or endangered species.”

Principle 2 of the Stockholm Declaration 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.”

An examination of the wording of both the Charter and the Declaration reveals that they
place wide obligations, not only on governments, but on all agencies of governments as well
as individuals.

National governments have, however, been slow to action these important commitments.
Australia’s representative area program on the Great Barrier Reef, for example, although in
planning for many years, was not initiated until 2002 – thirty years behind the Stockholm
Declaration.

6.5 Targets and logic:
Within a terrestrial framework, Pressey et al. (2003, 2004) stressed the need for the
development (and size) of protected area networks to follow a logical approach based on
defined goals and ecological criteria, arguing that the effectiveness of conservation efforts
are reduced by “focussing conservation efforts on landscapes with least extractive value”
(Pressey 2004:1044). The real objective of such programs is not the establishment of
reserve networks of a specific size, but the protection of biodiversity. Pressey points out that
targets framed in general terms can be met by the inclusion of the least productive (least
fished) areas, which may also be of little value for the protection of biodiversity. He also
argues that specific rare, highly vulnerable ecosystems may require high levels of protection.
Following Pressey’s logic could well result in reserve network designs with NTAs
considerably in excess of 30% in some cases – depending on the core objectives –
particularly if a precautionary approach (incorporating redundancy) was to be adopted in
regard to naturally rare, vulnerable ecosystems within the region of interest.

Using similar arguments, the Ecological Society for Australia (ESA 2001) stressed the need
for area targets to rest on broad policy goals (relating to the conservation of biodiversity)
through evolving scientific understanding – suggesting that reserve networks may need to
shrink or expand or change shape and location as knowledge of ecosystem values and processes changes over time.

Fernandes et al. (2005) point out that, while a broad area target may be a useful first step, the identification and design of possible NTA sites needs to be based on more detailed goals and principles incorporating a variety of ‘input’ targets. For example, in the GBR Representative Area Program, the Scientific Steering Committee set 20% as a minimum required habitat target. While this remained a primary goal, the establishment of NTAs was substantially based on 11 ‘biophysical operational principles’ (BOPs) supported by decision rules. Principle Eight was: “Represent all habitats: represent a minimum of each community type and physical environment type in the overall network”. One decision rule supporting this BOP was “capture about 50% of all high-priority dugong habitat”. Other rules for different habitats set targets (for common habitats under relatively low threat) as low as 5%. The decision rule targets set minimum figures, not desirable figures. The overall outcome of the program saw NTAs within the Great Barrier Reef Marine Park increase from 4.5% to 33% of the park’s area. This result is entirely consistent with the input targets and BOPs, and is a result which saw most BOPs and most design targets met or closely approached.

Pressey et al. (2004) use a variable target which is worthy of further discussion, if not widespread use. Here the target is given by a simple formula which takes into account the rarity and vulnerability of the ecosystem in question:

\[
\text{Target } \% = 10\% + (10\% \times NR) + (20\% \times V)
\]

Here NR is the natural rarity of the ecosystem, and V is the vulnerability, both indices scaled from 0 to 1. The outcome is that naturally common ecosystems under no threat will be subject to a target of 10% of their naturally occurring area protected. Highly vulnerable and naturally rare ecosystems will accrue a target of 40%.

**6.6 MPAs and no-take areas: recent history**

We live in a world where community perceptions, folklore and ethics are lagging behind the reality of increasing human domination of the planet’s ecosystems – and the science of conservation biology. Only a century ago the oceans were perceived by most as so vast as to defy human degradation. The idea of setting aside protected marine areas would have made little sense. Today marine scientists at least are only too aware of the degradation which has occurred and which in many cases is escalating in intensity.

In Australia and New Zealand, marine protected areas were still almost unknown four decades ago. Although they often receive considerable community support where they have been established for many years (the Leigh Marine Reserve in New Zealand, for example) community perceptions (and thus the perceptions of politicians) is that protected areas are the exception rather than the rule. No-take areas are perceived as occupying minor fractions of the seascape. It is here that there is divergence between the ideas of the community and the ideas of many of the scientists whose work is reviewed in this paper.

The modern era of marine protected area management dates from Resolution 15 of the First World Conference on National Parks (Adams 1962). Since then marine protected areas have been created around the world, and their effects over time have been studied and reported (eg: Lubchenco et al. 2003, Murray et al. 1999). An extensive literature exists on the effects of MPAs. Marine protected areas serve five main functions, not all of which necessarily apply simultaneously:

(a) to protect biodiversity;
(b) to enhance fishery production outside NTA boundaries;
(c) to protect cultural, recreational, spiritual, educational and scientific values;
(d) to provide benchmarks against which the modification of the planet under human hands can be measured and assessed, and, last but not least;
(e) to protect from disturbance the homes of other living inhabitants of the planet.
Sufficient evidence has accumulated on the benefits of marine protected areas to allow the publication in 2001 of a definitive scientists’ consensus statement, affirming the use of protected areas as an essential tool for the conservation and management of marine biodiversity (AAAS 2001).

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. Walter’s views are reinforced by Russ & Zeller (2003).

One of the reasons why many MPA practitioners advocate large no-take areas so strongly is that the history of fishery management over the last century is marked by a variety of failures which have regularly led to fishery collapse and/or major ecosystem change (Jackson et al. 2001). Although well known and the subject of agreements and guidelines, these failures are in many cases still not effectively addressed, and include compliance enforcement, failure to regulate new fisheries or new technology, inappropriate single-species modelling, massive bycatch, illegal fishing, fishing down the food web, lack of precaution in the face of uncertainty, and perhaps most importantly massive damage to benthic habitats by bottom trawling. Many conservation biologists have simply lost faith in the ability of fishery managers to apply the sympathetic management called for by the Convention on Biological Diversity. The models which scientists use to support NTA targets often assume, with a good deal of justification, that organisms living outside NTAs have no effective protection.

This cultural divide between fishery managers and conservation biologists has the potential to be enormously destructive – and could lead to a situation where the need to protect biodiversity at varying levels across the entire marine realm is all-but abandoned (instead of intensified) leaving biodiversity conservation the sole responsibility of marine reserve managers. Such a situation would be disastrous, with severe ramifications for the essential oceanic processes on which marine biodiversity ultimately depends.

Marine habitat should be protected everywhere, and we should not expect to harvest fish populations at maximum sustainable yield. With the planet’s human population expected to continue its increase for most of this century – with consequently increasing demands for food, precaution demands less intensive harvesting over the marine realm generally if the health of ocean ecosystems is to be maintained. Friedlander and DeMartini (2002) have shown, for example, that lightly fished areas in Hawaii supported far more fish than some small no-take areas surrounded by high exploitation.

6.7 Protecting biodiversity
Generally speaking, protected areas are the most important single tool available for the protection of biodiversity (ESA 2001). Their development on land preceded their development in the seas, with freshwater protected areas lagging further behind (Nevill & Phillips 2004). As already mentioned, the Convention on Biological Diversity 1992 (CBD) rests on the idea that the conservation of biodiversity, including aquatic biodiversity, requires the protection of representative examples of all major ecosystem types, coupled with the sympathetic management of ecosystems outside those protected areas. These twin concepts underpin, in theory at least, all biodiversity protection programs. The need to protect the processes on which biodiversity depends (broadly relating to flows of energy, nutrients, and information) form a vital part of protection strategies both within and beyond reserves.
Many misunderstandings rest on over-simplifications of the meaning of the key elements of conservation strategies. As far as biodiversity protection goes, protected areas must be seen as one element amongst the many protective mechanisms used to conserve biodiversity in the wider landscape (seascape). It is not a question of protecting a few areas together with unfettered exploitation of the rest of the planet – this has never been seriously proposed. It is a question of applying a mix of appropriate tools to a given situation to achieve a range of defined conservation, social and economic goals. Ray (2004) refers to a century-old debate between protagonists of the ‘preservationist’ and ‘wise use’ approaches in forest management. Expressed in these over-simple terms, such a debate can never be resolved. As Ray points out: “we must be reminded of the 30-year old ‘biosphere reserve’ concept, which calls for large-scale multiple-use planning and zoning, motivated by a no-take area at its core”.

NTAs created largely for ethical reasons – to provide habitat for some of the non-human inhabitants of this planet – are rare, and at this point in time may be restricted to whale sanctuaries created over the last decade in various locations. Australia’s support for the Southern Ocean Whale Sanctuary was based partly on the recommendations of a public inquiry (Frost 1978) which used ethical arguments to justify its recommendations. In my view, the ethical basis for establishing protected areas needs much more public discussion, both within Australia and internationally.

The size of NTA networks, and the size of individual NTAs are important issues – unfortunately. In an ideal world, size targets would not exist. The size and shape of NTAs, and the overall size of NTA networks, should ideally be driven by the core objectives underlying the establishment of MPA systems, such as the protection of biodiversity, and the protection of processes underpinning that biodiversity (Cowling et al. 1999, Margules and Pressey 2000; Pressey et al. 2003, 2004 – these are all terrestrial references xx). In some cases, the objectives of establishing NTAs focus on the enhancement of adjacent fisheries, rather than the protection of natural values such as biodiversity. However we do not live in an ideal world, but a world where the protection of ocean biodiversity has, historically, been hugely misunderstood and under-resourced. As the Millennium Ecosystem Assessment reports: “Human activities have taken the planet to the edge of a massive wave of species extinctions” (MEA 2005:3). We live in a world where the gap between the biodiversity targets set in international agreements, and the actions necessary to achieve those targets, is enormous. In this context, size targets should be an important part of strategic programs for marine biodiversity conservation.

6.8 Conference of the Parties to the Convention on Biological Diversity
At the sixth meeting of the CBD CoP, in decision VI/26 (UNEP 2002) the Parties adopted the Strategic Plan for the Convention on Biological Diversity. In its mission statement, Parties committed themselves to more effective and coherent implementation of the objectives of the Convention, “to achieve by 2010 a significant reduction of the current rate of biodiversity loss at global, regional and national levels as a contribution to poverty alleviation and to the benefit of all life on earth”.

This target was subsequently endorsed by the Johannesburg World Summit on Sustainable Development (WSSD) (United Nations 2002a:33). The Summit’s ‘key outcomes’ statement committed participating nations to: “achieve by 2010 a significant reduction in the current rate of loss of biological diversity” – notably omitting the final section of the CBD statement which, importantly, contains an explicit validation of the ‘intrinsic value’ concept.

The WSSD outcomes statement also contained a commitment with regard to ‘oceans and fisheries’ which included the development of MPA networks:

Develop and facilitate the use of diverse approaches and tools, including the ecosystem approach, the elimination of destructive fishing practices, and the establishment of marine protected areas consistent with international law and based on scientific information, including representative networks by 2012 (United Nations 2002b:3, my emphasis).
Although most nations are committed to the establishment of representative protected area networks, no global statistics on representation of marine ecosystems with protected area networks are available, largely as the collection of this information, in the marine realm, has only recently been addressed by nations themselves.

At the seventh meeting of the CBD CoP, 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, 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, and based on scientific information – thus providing a slight expansion of the 2002 WSSD commitment.

Notably the 10% target does not mention protected areas, or provide a target timeframe. It could, however, be argued that, read in conjunction with the above WSSD commitments, a specific target for the development of MPA networks covering at least 10% of ecoregions by 2012 is implied. In decision VII/5 Annex I (UNEP 2004) the Parties requested that: “the Subsidiary Body on Scientific Technical and Technological Advice (SBSTTA) at its tenth or eleventh meeting further refine the proposal for the integration of outcome-oriented targets into the programme of work on marine and coastal biodiversity…”.

This recommendation provided the SBSTTA (an organ of the UNEP CBD program) with the opportunity to expand the implicit meaning and time-frames of the target, especially given the 2003 recommendations of the World Parks Congress; however in its tenth meeting (2005) it did not do so. In it’s ‘application of the VII/30 targets to the CBD programme of work on marine and coastal biodiversity’ it chose to simply repeat the original general target within the marine context: “At least 10% of each of the world’s marine and coastal ecological regions effectively conserved” (UNEP 2005:44).

Leaving the original CoP target expressed in these general terms, without specific measurable goals (relating, for example, to the establishment of no-take area networks - or more generally protected area networks - within defined timeframes) means that the target cannot be effectively monitored and reported – the different meanings which can be attributed to the phrase “effectively conserved” are simply too broad, and the timeframe too vague.

6.9 Targets in current use
According to AHTEG (2003:16), the Bahamas, the Galapagos Islands and Guam have set no-take area (‘reserve’ in the AHTEG’s language) targets “of 20% for the primary network”. At this stage I have no further information on targets from these nations.

California is in the process of establishing an MPA network covering about 18% of State waters (to 3 nm). See Appendix Two below.

*Australia*:
As discussed in the analysis below, the Australian (Commonwealth) Government has adopted a conservation goal of the protection of 30% of remaining natural terrestrial ecosystems; however this cannot be construed as a accountable target as most responsibility for protecting terrestrial ecosystems lies with Australia’s State governments. These governments have not endorsed the Commonwealth target. The Australian Government has not developed a similar goal or target for the marine realm.

The Great Barrier Reef Marine Park Authority (GBRMPA) commenced a consultation process in 2002 to underpin the establishment of no-take protection of a comprehensive selection of representative examples of the marine ecosystems making up the Great Barrier Reef. This program was named the Representative Areas Program (RAP). The program’s Scientific Steering Committee recommended the protection of: “at least 20% of the area [of each bioregion]” SSC 2002:4. The committee stated: “…the SSC expects that around 25-30% of the Great Barrier Reef Marine Park will be protected … in no-take areas…” SCC 2002:5.
Prior to the commencement of the RAP, only one political party had endorsed a target: “The Australian Democrats… [support] the expansion of highly protected areas to cover at least 50% of the Marine Park ….” (Democrats election platform, October 2001). The Democrats are a minority party.

The SSC recommendations were subsequently accepted by the GBRMPA, and later endorsed by both the Australian and Queensland State governments. The final plan reserved 33% of the 348,700 km² park within no-take zones. Displaced fishers are being provided with financial assistance as part of a major program of fishery structural adjustment in the region.

**South Africa:**
The South African government has set a target of at least 10% of each ecosystem type to be reserved within protected areas:

*The Government is committed to the establishment of a comprehensive, representative system of protected areas and will build on current initiatives. In collaboration with interested and affected parties, the Government will [e]stablish a national co-operative programme to strengthen efforts to identify terrestrial, aquatic, and marine and coastal areas that support landscapes, ecosystems, habitats, populations, and species which contribute or could contribute to South Africa’s system of representative protected areas. It will aim to achieve at least a 10 percent representation of each habitat and ecosystem type within each biome (DEATSA 1998:46).*

According to WWF-South Africa, around 540 km of South Africa’s 3000 km coastline is currently reserved within protected areas (18% by length)(WWFSA 2004). The proportion in no-take areas was not reported.

The document *A Bioregional approach to South Africa’s protected areas* was released in May 2001 by the Minister of Environmental Affairs and Tourism. This document establishes the objective of maximizing benefits of South Africa’s natural heritage for all South Africans, both now and in the future, through establishing a comprehensive and representative system of protected areas covering South African biological diversity. It sets a goal of increasing the terrestrial protected area estate from the current 6% of South Africa’s land surface to 8% and the marine protected area from 5% to 20% by 2010 (DEATSA 2003:13).

The Minister for Environmental Affairs and Tourism, Marthinus van Schalkwyk, as reported by a DEATSA press release (DEATSA 2004) stated:

*These [four] new marine protected areas will bring South Africa much closer to achieving the targets set at the World Summit on Sustainable Development and the World Parks Congress for the protection of coastal waters (20% of national water). In future our efforts will also be directed at conserving substantial components of the continental shelf, extending into our economic exclusion zone.*


**New Zealand:**
The *New Zealand Biodiversity Strategy* states (Government of New Zealand 2000:67):

*Objective 3.6 Protecting marine habitats and ecosystems:*

Protect a full range of natural marine habitats and ecosystems to effectively conserve marine biodiversity, using a range of appropriate mechanisms, including legal protection.

*Actions:*
a) Develop and implement a strategy for establishing a network of areas that protect marine biodiversity, including marine reserves, world heritage sites, and other coastal and marine management tools such as mataitai and taiapure areas, marine area closures, seasonal closures and area closures to certain fishing methods.

b) Achieve a target of protecting 10 percent of New Zealand’s marine environment by 2010 in view of establishing a network of representative protected marine areas.

The New Zealand Government published a Draft Marine Protected Area Policy Statement in 2004 which suggested that the 10 percent target should be seen as a minimum standard. Although this emphasis was removed in the final policy statement (Government of New Zealand 2005) the commitment to the 10 percent target remains. It is noteworthy that, unlike other similar targets, the 10 percent applies not to the protection of representative ecosystems, but to the marine realm overall (although development of a representative network is also a specific target). Such an area target is difficult to justify on scientific grounds (Pressey 2004) and is open to the creation of biologically ineffective ‘paper parks’.

Brazil:
This section contributed by Patricia von Baumgarten, DEH South Australia.
The Brazilian Government released a draft National Plan for Protected Areas for public consultation in January 2006 (MMA 2006, available in Portuguese only on www.mma.gov.br/forum). The plan defines objectives, targets and strategies for the establishment of a comprehensive system of ecologically representative and effectively managed protected areas, which will integrate terrestrial and marine landscapes, by the year 2015. The Plan includes specific objectives for marine areas. Although it specifies that the final percentage of total protection to be given for each ecosystem will depend on further research on the representativeness of specific ecosystems, the Plan proposes a minimum target of 10% fully protected for each major ecosystem type.

The Plan includes sixteen objectives for coastal and marine areas that provide direct guidance for: system planning, site selection, establishment of participative decision making, establishment of the system, its monitoring and evaluation, institutional capacity building, and equality of opportunity for sharing benefits.

Fiji:
According to a briefing paper from WWF (WWF-Fiji 2005) Fiji’s Minister for Foreign Affairs, Kaliopate Tavola, issued a statement in January 2005 which read in part:

By 2020 at least 30% of Fiji’s inshore and offshore marine areas will have come under a comprehensive, ecologically representative network of marine protected areas, which will be effectively managed and financed.

According to a news column in MPA News vol.7 no.5 November 2005:
“Local chiefs of Fiji’s Great Sea Reef have established five marine protected areas with permanent no-take (tabu) zones as a step towards meeting the nation’s commitment to build a MPA network protecting 30% of Fijian waters by 2020.”

Micronesia:
According to MPA News April 2006, government leaders in the Micronesia region have pledged to protect 30% of their nearshore marine ecosystems by 2020. Termed “The Micronesia Challenge”, the commitment is being led by Palau, the Federated States of Micronesia, the Marshall Islands, and the US territories of Guam and Northern Marianas Islands. It was formally announced at the Eighth Conference of the Parties to the Convention on Biological Diversity (CBD), held in Curitiba, Brazil, in March 2006. The pledge also includes a commitment to protect 20% of their terrestrial ecosystems by 2020. Palau President H.E. Tommy Remengesau said his nation intends in the intervening years to be the first in the world to achieve, and surpass, having at least 10% of each of its ecological regions effectively conserved.
Also at the CBD meeting, the Caribbean island nation of Grenada pledged to put 25% of its nearshore marine resources under effective conservation by 2020.

Table 6.1: Summary: national MPA/NTA targets:

<table>
<thead>
<tr>
<th>Nation</th>
<th>Type</th>
<th>Target</th>
<th>Timeline</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bahamas</td>
<td>NTA</td>
<td>20%</td>
<td></td>
<td>AHTEG (2003:16); this is a secondary reference and ideally should not be quoted. Can we get more information?</td>
</tr>
<tr>
<td>Brazil</td>
<td>NTA</td>
<td>10%</td>
<td>10% 2015</td>
<td>MMA 2006</td>
</tr>
<tr>
<td>Fiji</td>
<td>MPA</td>
<td>30%</td>
<td>30% 2020</td>
<td>WWF-Fiji 2005</td>
</tr>
<tr>
<td>Galapagos Is</td>
<td>NTA</td>
<td>20%</td>
<td></td>
<td>AHTEG (2003:16); this is a secondary reference and ideally should not be quoted. Can we get more information?</td>
</tr>
<tr>
<td>Guam</td>
<td>NTA</td>
<td>20%</td>
<td></td>
<td>AHTEG (2003:16); this is a secondary reference and ideally should not be quoted. Can we get more information?</td>
</tr>
<tr>
<td>Micronesia</td>
<td>MPA</td>
<td>30%</td>
<td>30% 2020</td>
<td>MPA News April 2006</td>
</tr>
<tr>
<td>New Zealand</td>
<td>MPA</td>
<td>10%</td>
<td>10% 2010</td>
<td>Government of New Zealand 2000:67</td>
</tr>
<tr>
<td>South Africa</td>
<td>MPA</td>
<td>&gt;10%</td>
<td>8% 2010</td>
<td>DEATSA 1998:46</td>
</tr>
</tbody>
</table>

6.10 Network size and reserve size

The borders of NTAs should, ideally, derive from the purpose and mechanism of the NTA – eg: what is to be protected, how that protection is to be achieved, and what security such protection should have. Protected areas are essentially about the control of threats. If there were no threats, or no threats relevant to area management (or no such threats likely) then there would be no need for MPAs, or protective NTAs (setting aside for the moment other goals like the establishment of scientific benchmark sites). However, harvesting activities in the marine environment, generally speaking, do pose threats to ecosystems – largely from the direct removal of organisms and from damage to habitat by gear. Historically, these threats have often resulted in gross changes to ecosystems and sometimes to the extinction of species. The greater the harvesting pressures on the local or regional environment, the greater the threat, and thus the more need there is for MPAs, and particularly protective NTAs. The larger the desired scope of protection, and the greater the need for that protection to be secure in the long-term, generally speaking, the larger the NTA network will need to be to achieve those goals.

On an individual basis, the size and shape of an NTA is directly related to edge effects which may threaten values within the NTA. In over-simplistic terms, the larger the NTA, and the more the shape of the NTA resembles a circle, the lower the edge effects will be – as a result of simple geometrics (Walters 2000). However, the design of NTAs as fisheries management tools may involve the enhancement, rather than the minimisation, of edge effects. Edge effects are, of course, only one of many issues relevant to size and shape. Ease of policing is another obvious consideration: fishers (and ‘police’) need to be able to identify boundaries – hopefully with ease and accuracy. Small NTAs may protect sedentary species, but are unlikely to protect important processes on which their survival ultimately depends. Halpern et al. 2006 relate the spacing of reserves within a network to larval dispersal distances (see Table and endnotes).

We do not live in an ideal world, where MPA network objectives and targets can precisely define NTA boundaries, and thus the size of both individual NTAs and NTA networks. Even if the science was that good, the history of MPA creation has shown that stakeholders would still argue over larger goals and timing. Habitats and micro-habitats may be poorly understood, categorised and mapped. Trophic and dispersion effects within the ecosystem may be poorly understood, and may be difficult to model. In the surrounding seas, fishing pressures may be difficult to control, and their direct and indirect effects may be poorly
understood – with significant differences between short and long term effects. Uncertainties relating to long term climatic or oceanographic changes may be significant. Natural variability in ecosystem parameters may be high, temporarily masking anthropogenic effects. Catastrophes may degrade or even destroy local ecosystems. The need for redundancy within a NTA network must be considered.

We must bear in mind that, so far, national networks of marine NTAs do not live up to either the commitments contained in the Convention on Biological Diversity 1992 (especially in regard to the creation of fully representative networks) nor do they line up with the science behind accepted MPA goals – as illustrated by a perusal of the papers reviewed below. In this context, size targets are important, and, in my view, the establishment of large protected area networks should remain a core objective of nation-state marine strategies – as should the sympathetic management of biodiversity across the entire sea-scpe. While Agardy et al. may be right to highlight the dangers and difficulties of using size targets, the simple and urgent message from current MPA literature is, as Jake Rice $^{109}$ (2003) has said: “we need MPAs to be large and we need them soon” $^{109}$. 
Table 6.2: NTA network size targets
Percentages refer generally to coverage within major ecosystem or habitat type, however see footnote below.

<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>NTA TARGET</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agardy et al. 2003</td>
<td>not specified</td>
<td>The authors warn against the universal application of a single (20%) target for NTAs.</td>
</tr>
<tr>
<td>Airame et al. 2003</td>
<td>30-50%</td>
<td>A recommendation from scientists to a community-based panel of stakeholders.</td>
</tr>
<tr>
<td>Allison et al. 2003</td>
<td>not specified</td>
<td>The author’s arguments and methods require a planning authority to specify an initial area target, which is then expanded by an insurance factor to meet possible catastrophes.</td>
</tr>
<tr>
<td>Ardon 2003</td>
<td>10-50%</td>
<td>Review of earlier studies.</td>
</tr>
<tr>
<td>Beger et al. 2003</td>
<td>at least 20%</td>
<td>Examined reserve selection options to protect corals and reef fishes.</td>
</tr>
<tr>
<td>Bellwood et al. 2004</td>
<td>not specified</td>
<td>Authors describe a USA coral reef protection goal of 20% NTAs by 2012 as “too little too late”.</td>
</tr>
<tr>
<td>Bohnsack et al. 2000</td>
<td>20-30%</td>
<td>Recommend at least 20-30% NTA.</td>
</tr>
<tr>
<td>Botsford et al. 2003</td>
<td>&gt;35%</td>
<td>Not a recommendation: a theoretical (modelled) maximum based on species survival assumptions.</td>
</tr>
<tr>
<td>Fogarty et al. 2000</td>
<td>35-75%</td>
<td>Not a recommendation. Fogarty et al. review a number of studies which suggest a range of 35% to 75% of an area should be protected to optimise fishery yield outside the reserves. As quoted by AHTEG 2003.</td>
</tr>
<tr>
<td>Gell and Roberts 2003b</td>
<td>20-40%</td>
<td>Not a recommendation: authors present evidence suggesting these sizes work best for some (mostly local) fisheries enhancements.</td>
</tr>
<tr>
<td>Gladstone (in press)</td>
<td>&gt;30%</td>
<td>Modelling of coastal reef fish communities finds that a 30% MPA target will cover 75% of surveyed species.</td>
</tr>
<tr>
<td>Halpern 2003</td>
<td>not specified</td>
<td>Author reviews studies on the related issue of reserve size and MPA performance, and finds size is important (larger is more effective).</td>
</tr>
<tr>
<td>Halpern et al. 2006</td>
<td>not specified</td>
<td>Authors review modelling approaches accounting for uncertainty in effective dispersal, within a framework of variable persistence. A ‘rule of thumb’ for reserve spacing of around 25 km is suggested.</td>
</tr>
<tr>
<td>Hughes et al. 2003</td>
<td>&gt;30%</td>
<td>Not a recommendation: authors present evidence from ecological modelling studies – greater than 30% reef NTAs needed to protect coral ecosystems.</td>
</tr>
<tr>
<td>Leslie et al. 2003</td>
<td>20% +</td>
<td>Not a recommendation: figure selected for illustrative purposes (model demonstration).</td>
</tr>
<tr>
<td>AUTHOR</td>
<td>NTA TARGET</td>
<td>COMMENTS</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Lockwood et al. 2002</td>
<td>not specified</td>
<td>Authors model population persistence inside coastal reserves assuming zero populations outside reserves. To ensure persistence “[the] upper limit for the minimum fraction of coastline held in reserve is about 40%.”</td>
</tr>
<tr>
<td>Mangel 2000</td>
<td>~5-50%</td>
<td>Modelling analysis of reserves as a fishery enhancement tool depends on selecting a time horizon, fishing pressure and a probability of ecological extinction of the population(^{xcii}).</td>
</tr>
<tr>
<td>McClanahan &amp; Mangi 2000</td>
<td>not specified</td>
<td>“Our field survey, combined with previous modelling studies, based on adult emigration rates from marine reserves, suggests that tropical fisheries dominated by rabbitfish, emperors and surgeonfish should be enhanced by closed areas of around 10 to 15% of the total area” – also adding that a larger area may be calculated if larval export is important.</td>
</tr>
<tr>
<td>National Research Council 2001</td>
<td>20-50%</td>
<td>Figures from a literature review(^{xciv}) relating to enhancement of fisheries effects.</td>
</tr>
<tr>
<td>Palumbi 2004</td>
<td>not specified</td>
<td>Author reviews information on the scale of marine neighbourhoods, and discusses the relevance of MPA size and spacing(^{xcv}).</td>
</tr>
<tr>
<td>Pandolfi et al. 2003</td>
<td>not specified</td>
<td>The authors talk about a need for “massive protection” and “protection at large spatial scales” (coral reefs).</td>
</tr>
<tr>
<td>Pew Fellows 2005</td>
<td>10-50%</td>
<td>“Place no less than 10% and as much as 50% of each ecosystem in no-take zones, according to identified needs and management options in a particular ecosystem”</td>
</tr>
<tr>
<td>Ray 2004</td>
<td>Implicitly supports (high) targets</td>
<td>Ray’s paper is a critique of Agardy et al. suggesting that (a) MPAs in general need much more attention, and (b) to argue about the rights or wrongs of particular views on targets is counter-productive.</td>
</tr>
<tr>
<td>RCEP 2004</td>
<td>&gt;30%</td>
<td>Authors call for the urgent creation of massive NTAs to allow marine habitat / ecosystem recovery(^{xcvi}).</td>
</tr>
<tr>
<td>Roberts et al. 2003ab</td>
<td>&gt;20%</td>
<td>Not a recommendation; authors provide a comprehensive review of NTA design methods and parameters.</td>
</tr>
<tr>
<td>Rodwell &amp; Roberts 2004</td>
<td>20 – 40%</td>
<td>Fishery models indicate that: “reserve coverage of between 20% and 40% prevent stock collapse in most cases.”</td>
</tr>
<tr>
<td>Shanks et al. 2003</td>
<td>NTA size &amp; spacing</td>
<td>Authors deal only with size and spacing using analysis and modelling of dispersal data(^{xcvii}).</td>
</tr>
<tr>
<td>Sala et al. 2002</td>
<td>40%</td>
<td>Gulf or California rocky reef habitat(^{xcviii}).</td>
</tr>
<tr>
<td>Sale et al. 2005</td>
<td>20 – 35%</td>
<td>Not recommendations – paper includes brief review(^{xcix}).</td>
</tr>
<tr>
<td>AUTHOR</td>
<td>NTA TARGET</td>
<td>COMMENTS</td>
</tr>
<tr>
<td>------------------------</td>
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<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>UNEP 2004</td>
<td>&gt;10%</td>
<td>Not a NTA, or even a MPA target. CBD CoP VII/30 annex II (see discussion above): “at least 10% of each of the world’s ecological regions effectively conserved”.</td>
</tr>
<tr>
<td>Walters 2000</td>
<td>NTA size</td>
<td>No recommendations on habitat targets. The paper deals with the relative benefits of a few large vs. many small NTAs. For mobile species, many tiny fragmented NTAs are likely to have negligible benefits.</td>
</tr>
<tr>
<td>Watson et al. 2000</td>
<td>20%</td>
<td>Paper models fisheries impacts of MPAs using Ecopath. “Within the range of exchange rates simulated, the maximum increases in catch and overall biomass levels were reached when 20% of the system was protected.”</td>
</tr>
<tr>
<td>Worm et al. 2006</td>
<td>23%?</td>
<td>Check this</td>
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<tr>
<td>World Parks Congress 2003</td>
<td>20-30%</td>
<td>WPC recommendation 5.22 to be considered by the UN General Assembly.</td>
</tr>
</tbody>
</table>

6.11 Acknowledgements:
Thanks to Dr Trevor Ward and Professor Richard Kenchington for helpful comments and assistance with references, and Ms Patricia von Baumgarten (Department of Environment and Heritage, South Australia) for the section on Brazilian MPA targets.

6.12 References:
Note that not all cited references are reviewed: some are referenced in endnotes.


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**Section 6 Appendix 1**

The ESA considers that:

* Explicit, quantitative targets are essential for planning and managing protected areas and off-reserve protection mechanisms.

* Quantitative targets should be the subject of ongoing debate and refinement. The primary concern of this debate should be the scientific interpretation of broad goals stated in policy, not the political and economic constraints on targets. New data and new understanding will require continuing refinement of targets.

* Targets should concern not only elements of biodiversity pattern but the spatial and temporal aspects of natural processes, including population sizes, movements, metapopulation dynamics, disturbance regimes, ecological refugia, adjustments to climate change, and diversification.

* Refinement of conservation targets will largely depend on research into spatial surrogates for biodiversity pattern and process and the effects of alteration of habitats outside protected areas.

* Appropriate scales for formulating targets will vary, but targets expressed as percentages of regions or subregions are essentially meaningless unless they are tied to, and preceded by, targets for habitats at the finest available scale of mapping. Targets for regions, subregions or jurisdictions should emerge from targets at finer scales.

* Targets for protected areas should be complemented by ceilings for loss of habitat with the balance comprising multiple-use under appropriate forms of off-reserve management.

* Protection targets should not be constrained by areas of extant habitats but should, where necessary, indicate the need for restoration to extend and link fragments of habitat and improve their condition.

* Constraints on the rates of expansion of protected areas within regions require individual targets to be prioritised so that early protection is given to those biodiversity features that are most irreplaceable and most vulnerable to threatening processes.
In August 2006, the Fish and Game Commission of the US state of California unanimously approved a proposal to designate a network of marine protected areas along the state’s central coast, encompassing 18% of Central California’s coastal waters. Totaling 204 square miles (528 km2), the proposed network of MPAs will now undergo environmental and regulatory review before taking effect, which could occur in early 2007, say officials. The proposed network consists of 29 MPAs each extending seaward from the coast for three nautical miles, the outer boundary of state waters. Approximately 94 square miles (243 km2) of the network would be no-take marine reserves, while the remainder would allow limited recreational or commercial fishing.

The proposed network is the first product of California’s seven-year process so far to build a state-wide system of marine reserves in its waters. The California state legislature passed the Marine Life Protection Act (MLPA) in 1999 with a goal of redesigning and strengthening the state’s fragmented system of MPAs (MPA News 1:3). But the MLPA-based process to plan and designate a marine reserve network got bogged down in stakeholder opposition (MPA News 3:9) and budget shortfalls (MPA News 5:7). California Governor Arnold Schwarzenegger revived the process in 2004 with funding contributed by private foundations, appointing a special task force of experts to spearhead the planning. In a statement following the Commission’s approval of the proposed network, Schwarzenegger said, “[This] milestone makes California a national leader in ocean management and is proof of what can be done when all those involved - the fishing industry, environmentalists, and others - work together.”

Fishing groups, however, have expressed disappointment with the proposed network. United Anglers of Southern California (UASC), which represents nearly 50,000 recreational fishermen, said in a press statement that although the proposed network was “not the worst possible outcome” (there had been larger reserve packages on the table for consideration), the reserves would have an unnecessarily large impact on sport boat operators who depend on access to areas now slated for closure. UASC Fisheries Specialist Bob Osborn specified that the proposed network focused disproportionately on rocky reef habitats, thereby limiting anglers’ opportunities to catch rockfish, a popular target. Zeke Grader, executive director of the Pacific Coast Federation of Fishermen's Associations, said that despite no-take regulations, the proposed reserves would still be vulnerable to the threat of coastal pollution and runoff from the region’s major cities and farming areas, and called for stricter controls on these impacts.

The Commission’s proposed network provided less protection than several environmental groups would have liked, but these organizations applauded the step forward. “This is a solid start toward restoring our ocean and implementing ecosystem-based management,” said Kaitlin Gaffney of The Ocean Conservancy. “Although we believe that a higher level of protection is warranted, the Commission action does protect important central coast habitats like kelp forests, nearshore reefs, and submarine canyons, consistent with science guidelines on preferred size [of reserves] and protection levels.”

In January 2007, the California Department of Fish and Game is expected to begin meetings with stakeholders about possible marine reserves in the Southern California region.

For links to more information:
The proposed network for Central California, including maps and regulations: http://www.dfg.ca.gov/mrd/mlpa/commissiondocs.html
Response from The Ocean Conservancy: http://www.oceanconservancy.org/site/News2?abbr=issues_&page=NewsArticle&id=8731.
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i Ghost fishing refers to the continued effects of lost and abandoned fishing gear.

ii VMS refers to Vessel Monitoring Systems – compulsory fitting of satellite tracking and reporting devices.

iii The precautionary principle appears in one of its many variations in the World Charter For Nature 1982, a resolution of the UN General Assembly, and was more formally endorsed in the Rio Declaration 1992 (United Nations Conference on Environment and Development).

iv While the Australian position at the IWC’s Scientific Committee must rest on scientific arguments (see IWC 2001) arguments supporting whale sanctuaries on the government’s website (www.deh.gov.au) also avoid addressing ethical issues directly. In successfully arguing for the creation of the Southern Ocean Whale Sanctuary, and in unsuccessfully arguing for the creation of the South Pacific Whale Sanctuary, Australia has been constrained by the mandate of the IWC to argue in terms of rebuilding whale stocks (Gales, pers. comm. 2005). The mandate of the International Whaling Commission, as the name suggests, revolves around the central concept of sustainable harvesting. The IWC is not the International Whale Protection Commission, as the Japanese IWC delegation have correctly pointed out. So – although the Australian position on whale conservation appears to be underpinned by a wider ethic of protection of species for their own sake, the actual arguments used to establish protective measures are in fact based on traditional harvesting paradigms. See Government of Australia 2002, 2004.

v Comment by Scoresby Shepherd 12/1/06: Passmore at a philosophic level set out to show that the modern West leaves more options open than most societies. He said: “Its traditions, intellectual, political, and moral, are complex, diversified and fruitfully discordant. That gives it the capacity to grow, to change. It is inventive, not only technologically, but politically, administratively, intellectually.” However, later in a perceptive historical analysis of the prospect of moral improvement of man, gives little reason to hope that man is likely to be any less greedy in the future than he is now, or will ever be more ready to revive well known ethics, or embrace new ones.

vi Singer later extended these arguments to more controversial ground when he claimed: “The only ethical approach to Australia’s wild animals is one that gives their interests equal consideration alongside human interests.” Singer (1996).

vii The first sentence of the Convention on Biological Diversity 1992 explicitly recognises the “intrinsic value of biological diversity”. The importance of intrinsic values was reinforced a decade later by the Strategic Plan of the CBD Conference of the Parties (CoP). Decision VII/5 of the CoP in 2004 explicitly incorporates intrinsic values into its statement on the goals of marine no-take areas: “The key purpose of these areas would be to provide for intrinsic values...” as well as anthropocentric values. (Annex I Appendix 3 paragraph 10). In my view, marine scientists need to make use of these international commitments to the protection of intrinsic values in discussions at all levels, from grass-roots stakeholders to the highest political level.

viii According to Bosselmann: “I would argue that the state-centred model of governance is on its way out to be replaced by a multi-layered system with civil society at its core. The Earth Charter is the founding document for this.” Pers. comm. 11 May 2006.

ix IUU: illegal, unregulated and unreported.

x Used here, the term ‘order of magnitude’ means approximately a factor of ten.

xi FAO: the United Nations Food and Agriculture Organization, based in Rome.

xii It should be noted, however, that compensation costs for fishers in the Great Barrier Reef, displaced by the expansion of representative areas in 2004, were underestimated. Clearly estimating compensation costs needs to be undertaken with care.

xiii 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).

xiv Note that the word ‘reserve’ is often used in marine literature to mean a fully protected or
no-take area.

xv Such monitoring should take place across a sufficient spatial scale.

xvi 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.

xvii 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 principles 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).

xviii 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
endorsement of the Convention on Biological Diversity 1992 implies that the latter level is the
critical level by which overfishing should be measured.

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

xx The area of the SE Marine Planning Region is 1,192,500 km², (Harris 2007) or 1,632,402
km² including Macquarie Island, of which 226,458 km² are covered by Commonwealth MPAs.
Of these, 96,435 km² 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 km² (pers.comm. Barbara Musso
16/10/08; see also Edgar et al. 2008:972).

xii 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.

xxii IMCRA: interim marine and coastal regionalisation of Australia (IMCRA Technical Group
1998).

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

Australia’s marine jurisdiction, including Antarctic zones, is around 16 million km². Without Antarctic areas it is around 11.4 million km².

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

In this paper “reserves” includes IUCN categories I-IV.

Here “no-take” MPAs includes IUCN categories Ia and Ib.

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).

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.

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

Up-to-date information on global MPAs was hard to locate in 2008. The IUCN published an 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 consolidated 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 km² Kiribati Phoenix Islands MPA (announced March 2006) and the 360,000 km² 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 km²). 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.

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).

In particular goals relating to the slowing of biodiversity loss, such as those incorporated in the Johannesburg Declaration 2002 ‘key outcomes’ statement.
In the marine context, substitute “habitat” for “land”.

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

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.

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

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

In 2006-07 tourism to the Great Barrier Reef contributed $A5.117 billion to the Australian economy:


See Pogonoski et al. (2002) and Ponder et al. (2002).

Nevill (2009)

Otway et al. (2004).


There were some problems with the outcomes from the South East Bioregion process – see Nevill & Ward (2009).


Edgar & Stuart-Smith (2009)

Raymundo et al. (2009).

Lists of references may be obtained from Dr Jon Nevill jon.nevill@onlyoneplanet.com.

Some of the many scientists’ consensus statements on the subject of marine protected areas may be obtained from http://www.onlyoneplanet.com/marine.htm or by contacting Dr Jon Nevill.


Systematic conservation planning attempts to maximise the conservation benefits of reserve networks within a number of key constraints, including providing for other uses of the sea. One of the most important of these constraints are regional area targets, and choosing these targets involves tradeoffs and judgements (see comments in AMSA 2008b). Many papers, reports and a number of workshops have examined the question of protected area targets in the marine environment (Nevill 2007). In the context of this letter, we follow the recommendation in AMSA (2008b) (see discussion above) by recommending a minimum of 10% of every major ecosystem protected in sanctuary zones, and rare, vulnerable or iconic ecosystems, and special or unique habitats, protected at higher levels. These sanctuary zones should lie within larger networks of multi-use zones, some having a buffer function: this is a core concept within the Convention on Biological Diversity Jakarta Mandate. According to AMSA (2008b): “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 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 Great Barrier Reef Marine Park of 33% is more likely to achieve substantial and sustained biodiversity benefits”.

Returning to the issue of area targets, it is noteworthy that several of the papers discussed in Nevill (2007) assume that, outside the reserve network, biodiversity is not well protected if at all, and these papers often recommend area targets in the range 20-40%. Our recommending an area target of “at least 10%” in this letter, is based partly on an optimistic assumption that all of Australia’s marine jurisdiction, outside the reserve network, is reasonably well protected, particularly by fisheries controls applying the precautionary and ecosystem approaches. While Australia has led the world in developing science to support the application of these approaches, actual implementation in some cases has lagged badly behind the science (Nevill 2009) particularly with respect to recreational and mixed fisheries. There is considerable room for improvement, and the science developed by Australian scientists is providing the tools for such progress.

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\[\text{iviii}\] See Ayling & Choat (2008).
\[\text{lx}\] The World Database on Protected Areas (WDPA) (\text{www.unep-wcmc.org} accessed 18/1/06) contains 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. The ‘total’ percentage is based on summing the global areas under categories I-VI, and includes the 184,000 km² Kiribati Phoenix Islands MPA (announced March 2006) and the 360,000 km² Northwestern 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 km²). 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 PAs has not been included in the calculation of 0.18% NTAs.

\[\text{lxii}\] According to Evans & Russ 2004: “Adjacent fisheries may benefit from no-take marine reserves due to spillover (net export) of adult individuals (Russ and Alcala, 1996; McClanahan and Mangi, 2000; Roberts et al., 2001; Galal et al., 2002) and net export of propagules via larval dispersal (Stoner and Ray, 1996; Roberts, 1997; Gell and Roberts, 2002). See Evans & Russ for citations.

\[\text{lxiii}\] 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).

\[\text{lxiv}\] In particular goals relating to the slowing of biodiversity loss, such as those incorporated in the Johannesburg Declaration ‘key outcomes’ statement – see discussion.

\[\text{lxv}\] The word ‘area’ implies defined and constant boundaries over time. The word ‘protected’ implies conscious protection. Conscious protection from what? Threats to an area’s values. This implies that a management plan exist which identifies both threats and values. ‘Protected’ also implies effective protection – which implies the existence of monitoring and reporting programs.

\[\text{lxvi}\] Semantically, the word “sympathetic” is not used in the CBD, although the logic is explicit. A concise statement capturing the two core concepts may be found in Principle Eight of the National Strategy for the Conservation of Australia’s Biological Diversity (Commonwealth of Australia 1996) which 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 production systems."

This era came to an end at the close of the 19th century. The World Protected Area Database’s first MPA entry is dated 1888.

Ghost fishing refers to the continued effects of lost and abandoned fishing gear.

The acceptance by the scientific community of the importance of MPAs as conservation tools is illustrated by several major scientific consensus statements, such as those published by the Marine Conservation Biology Institute in 1998, and the American Association for the Advancement of Science in 2001 (both available at http://www.ids.org.au/~cnevill/marine.htm).

Such as the FAO Code of Conduct for Responsible Fisheries 1995.

An example of an important ecological process under threat globally relates to ocean chemistry. Aquatic organisms which create calcareous structures, such as coral, depend on complex chemical reactions to extract calcium carbonate from surrounding water (calcium here listed as a nutrient). Increasing levels of atmospheric carbon dioxide are increasing aquatic acidity, placing in jeopardy this essential process. Clearly protected areas will do little in some cases to protect essential ecological processes.

Here water is defined as a nutrient for the purposes of terrestrial ecosystems.

Processes of information flow include larvae dispersal and pollination, for example.

The ethical arguments of the Frost Report where echoed in the findings of a more recent inquiry (NTFW 1997). However the arguments Australia used in the International Whaling Commission were based purely on scientific grounds: that the sanctuary would assist in rebuilding depleted stocks (Commonwealth of Australia 2002, 2004)

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Stellar’s Sea Cow (Anderson 1995) and the Caribbean Monk Seal are amongst the best known.

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Rice adds: “…we also need to be prepared to act without full information and full consensus when the decision system is receptive, and to make some mistakes due to incomplete knowledge. What matters then is that we admit the mistakes later when more information becomes available, and do our best to correct them.”

The percentages listed below are not recommended on a strictly equivalent basis. Some (eg DEH 2001) apply to specify ecological communities, while others apply to a total area under jurisdiction (like the New Zealand target). The former (more common) approach follows a specific rationale concerned with the protection of biodiversity through the protection of representative examples of habitat (see Appendix 1).

The authors also make the important point that MPA system design should go hand in hand with measures aimed at sympathetic management of the remaining matrix.

“After consideration of both conservation goals and the risk from human threats and natural catastrophes, scientists recommended reserving an area of 30-50% of all representative habitats in each biogeographic region”. Page S170.

“A variety of marine reserve sizes ranging from 10% to 50% have been suggested as being efficacious as a conservation and/or fisheries management tool (MRWG 2001, NRC 2000, Roberts & Hawkins 2000, Ballantine 1997, Carr & Reed 1993), with an emphasis on larger reserves coming from the more recent literature. Furthermore, it has been found that larger reserves often have beneficial effects disproportionate to their size (Halpern 2003)”.

Beger et al. found that over 80% area protection would be required to protect 100% of both coral and fish species at their Kimbe Bay study site. Their recommendation of 20% coverage was based on protecting just under 80% of all surveyed species.

The authors present modelling analysis suggesting that, based on larvae dispersal and survival assumptions, together with assumptions about reserve size and distribution, 35% of
coastal habitat would need to be reserved if no survival occurred in the remaining areas (the remaining 65%).

Rodrigues and Gaston 2001 examine the application of complementarity-based network design methods for identifying a minimum reserve network area to contain all species of identified terrestrial taxa. They found that the minimum area depends (in part) on type of taxa, regional endemism, and the size of the selection unit used in the design. At this level of generality their findings are likely to apply to marine ecosystems. Assuming every terrestrial plant needs to be represented at least once within a reserve network, a selection unit size of 12,000 km$^2$ leads to a reservation requirement of 74% of the global land area, while a selection unit size of 270 km$^2$ leads to a reservation requirement of 10% of the global land area. As the authors state, it is most unlikely that such small reserves would protect the processes which underpin biodiversity persistence, let alone evolution. There is however a major difference between terrestrial conservation and marine conservation. Mankind has succeeded in not only modifying most pristine terrestrial habitats, but in destroying them and replacing them with highly modified and simplified ecosystems, where only highly adaptable organisms continue to survive. The analysis of Rodrigues and Gaston assumes that the greater part of terrestrial biota need protected areas to survive – a reasonable assumption. While global marine ecosystems have been pushed into ecological crisis, it may be that, if harvesting impacts can be sufficiently reduced, most marine ecosystems can continue to function as ‘homes’ for resident biodiversity. If this is the case, the need for strictly-protected no-take areas may be somewhat reduced. It is important to note, however, that the processes which underpin marine biodiversity often operate at regional and global scales, and the means for their comprehensive protection is at present well outside the scope of current science. Under these circumstances, a precautionary approach to marine protected area network design is appropriate. If we are to adequately protect marine biodiversity, we must now err on the side of creating reserves which are too large rather than too small.

Gladstone concludes: “...the upper range of currently promoted targets for MPA establishment (i.e. 30%) should be regarded as a minimum for biodiversity conservation.” Halpern 2003 concludes: “The most important lesson provided by this review is that marine reserves, regardless of their size, and with few exceptions, lead to increases in density, biomass, individual size, and diversity in all functional groups. The diversity of communities and the mean size of the organisms within a reserve are between 20% and 30% higher relative to unprotected areas. The density of organisms is roughly double in reserves, while the biomass of organisms is nearly triple. These results are robust despite the many potential sources of error in the individual studies included in this review. Equally important is that while small reserves show positive effects, we cannot and should not rely solely on small reserves to provide conservation and fishery services. Proportional increases occur at all reserve sizes, but absolute increases in numbers and diversity are often the main concern. To supply fisheries adequately and to sustain viable populations of diverse groups of organisms, it is likely that at least some large reserves will be needed.”

Halpern et al. 2006 argue: “unless we are fairly certain about our estimate of dispersal distance, reserves should be spaced around 25 km from each other.” They note: “Botsford et al. 2001 developed a similar rule of thumb using a different approach to modelling dispersal distance.” Halpern’s findings are supported by Cowen et al. 2006, who report: “typical larval dispersal distances of ecologically relevant magnitudes are on the scale of only 10 to 100 kilometers for a variety of reef fish species.”

Pandolfi et al. 2003:933 “Ecological modelling studies indicate that, depending on the level of exploitation outside NTAs, at least 30% of the world’s coral reefs should be NTAs to ensure long-term protection and maximum sustainable yield of exploited stocks”.

The percentages listed below are not recommended on a strictly equivalent basis. Some (eg DEH 2001) apply to specify ecological communities, while others apply to a total area under jurisdiction (like the New Zealand target). The former (more common) approach follows a specific rationale concerned with the protection of biodiversity through the protection of representative examples of habitat (see Appendix 1).

The upper 50% figure derives from selecting a high fishing pressure outside the NTA network, a planning time horizon of 100 years, and an acceptable probability of population extinction of 1%. Assuming lower fishing pressures, a shorter time horizon, and an increased acceptable risk of extinction will all produce a smaller NTA network size target.
For fisheries, the benefit of a reserve does not increase directly with size. The maximum benefit of no-take reserves for fisheries, in terms of sustainability and yield, occurs when the reserve is large enough to export sufficient larvae and adults, and small enough to minimize the initial economic impact to fisheries (see review in Guenette et al. 1998). Data from harvested populations indicate that species differ greatly in the degree to which they can be reduced below normal carrying capacity before they are not self-sustainable in the long term (e.g., Mace and Sissenwine 1993, Hilborn, personal communication). If reserves are designed for fisheries enhancement and sustainability, the vast majority of studies done to date indicate that protecting 20% to 50% of fishing grounds will minimize the risk of fisheries collapse and maximize long term sustainable catches (NRC 2001, Table 1).”

Palumbi concludes: “[Available studies] suggest adult neighbourhood sizes for many demersal fish and invertebrates as small as kilometers and up to 10 to 100 km. Larval dispersal may be shorter than previously suspected: neighbourhood sizes of 10 to 100 km for invertebrates and 50 to 200 km for fish are common in current compilations. How can small reserves protect such species? One conceptual framework is to set reserve size based on adult neighbourhood sizes of highly fished species and determine spacing of a reserve network based on larval neighbourhoods. The multispecies nature of fisheries demands that network designs accommodate different life histories and take into account the way local human communities use marine resources.”

Recommendation 8.96.

“We suggest that reserves be designed large enough to contain the short-distance dispersing propagules and be spaced far enough apart that long-distance dispersing propagules released from one reserve can settle in adjacent reserves. A reserve 4-6 km in diameter should be large enough to contain the larvae of short-distance dispersers, and reserves spaced 10-20 km apart should be close enough to capture propagules released from adjacent reserves.”

“We describe a means of establishing marine reserve networks by using optimization algorithms and multiple levels of information on biodiversity, ecological processes (spawning, recruitment, and larval connectivity), and socio-economic factors in the Gulf of California. A network covering 40% of rocky reef habitat can fulfill many conservation goals while reducing social conflict.”

According to Sale et al. (Box 1) “Protecting 20% of the area [available habitat type] has become a commonly cited target. This arbitrary target relies on the assumption that protecting 20% of the area protects 20% of the original spawning stock, and on the argument that protecting 20% of the stock would prevent recruitment overfishing. More recent models suggest that >35% of the total area needs to be in no-take reserves to prevent recruitment overfishing of sedentary species, such as sea urchins or many reef fishes, and area requirements differ among species with differing biology.”

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According to Walters: “The message is simple: for relatively mobile species, single large MPAs can be much more effective than many small ones”.

Therefore, PARTICIPANTS in the Marine Cross-Cutting Theme at the Vth World Parks Congress, in Durban, South Africa (8-17 September 2003): CALL on the international community as a whole to:

Establish by 2012 a global system of effectively managed, representative networks of marine and coastal protected areas, consistent with international law and based on scientific information, that: (a) greatly increases the marine and coastal area managed in marine protected areas by 2012; these networks should be extensive and include strictly protected areas that amount to at least 20-30% of each habitat, and contribute to a global target for healthy and productive oceans;” The full text of the recommendation is available from www.iucn.org.