Marine Parks Authority New South Wales

A review of benefits of Marine Protected Areas and related zoning considerations

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Research into ecosystems, habitats and species in the marine park is ongoing, so this document will be updated to incorporate new, relevant information.

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Contents

1. OBJECTIVES OF NSW MARINE PARKS

The NSW Marine Parks Authority (MPA) aims to establish and manage a system of multiple-use marine parks along the NSW coast, the broad objectives of which are to:

- conserve marine biodiversity and maintain ecological processes;
- provide for ecologically-sustainable use, public appreciation, education, understanding and enjoyment of the marine environment.

The primary criteria identified throughout much of the world for establishing Marine Parks are that they contain a comprehensive, adequate and representative sample of marine biological diversity. In the Australian and NSW context, "comprehensiveness" refers to the extent to which the full range of ecosystems and habitats within and across all NSW bioregions are included in the parks; "adequacy" is the capability of the areas to maintain biodiversity and ecological processes into the future; and "representativeness" is the extent to which the parks reflect the full range of biological diversity.[1,2] These broad ecological criteria were examined in the bioregional assessments in NSW that resulted in the identification of specific areas with important biodiversity values.[3,4]

In addition, economic, social and cultural selection criteria are also assessed in the identification of marine parks within specific bioregions. The underlying principle of multiple-use marine parks is that there is continued access and opportunities for users of marine resources, provided biodiversity and cultural values are conserved.

Marine parks complement a range of specific fisheries management tools (e.g. seasonal and area closures, bag limits, size limits, gear restrictions), and assist in ensuring that harvested species, by-catch and habitats are protected in specific areas. They also complement coastal management tools that address land-based impacts on the marine environment, such as pollution, sedimentation and coastal development. Marine parks can also assist in the conservation of marine mammals and reptiles, and seabirds.

Over the last few decades marine parks have been established throughout the world in order to protect species and their habitats from a range of activities that threaten the diversity, productivity and overall 'health' of the marine environment. The document presented here provides results from studies that assess direct and indirect fishing impacts, and evaluates the related benefits of marine park zones to specific species and habitats. It is not presented as a comprehensive literature review or a detailed critique of all issues related to the need for the establishment and overall effectiveness of marine protected areas, but to highlight some of the key issues relating to the threats and benefits to some exploited species and their habitats.. Further details on potential benefits, and costs, of no-take areas are presented within a number of recent Australian reviews.[5,6]

2. THREATS TO MARINE ENVIRONMENTS

Marine environments in most coastal regions of the world have been impacted by a wide range of human uses for many decades. Activities such as commercial and recreational fishing, coastal development, catchment activities, pollution and introduced marine pests contribute to the incremental loss of habitats such as seagrasses, mangroves, macroalgal reefs, and a reduction in the numbers of some species to such an extent that they become threatened or

endangered.[7] The extent and persistence of impacts from these activities on marine biodiversity (usually considered as genetic, species and ecosystem diversity) have considerably decreased the overall ecological condition or 'health' of many coastal regions.

For example, within estuaries in NSW human activity in catchment areas is a major contributor to their deterioration, with approximately 60% of coastal wetlands lost or degraded over the past 200 years. The Healthy Rivers Commission estimated that around 30% of coastal lakes are 'moderately' or 'severely' affected by human pressures.[8] Urban and industrial discharges and catchment usage are the key causes of increased turbidity and nutrient levels that often result in a decline of seagrass habitats and diversity of species in soft-sediment areas.[9] Direct damage can also occur through increased numbers of introduced marine pests, swing-mooring chains, propellers, retrieval of anchors and indirectly through shading from jetty and pontoon construction.

The overall pressures include some fishing activities that can impact, to varying extents, on the structure of estuarine communities and extent of estuarine habitats. Marine waters generally are considered to be in better ecological condition than estuarine waters, although some specific coastal areas, mainly adjacent to coastal towns, are at a greater risk of impacts on habitats and species, due to impacts such as pollution and intense commercial and recreational use. However, the perception that marine areas are in better condition may simply reflect the lack of knowledge about marine biological diversity and the ongoing impacts of some fishing activities such as demersal trawling.

For many harvested marine species, sustained fishing pressure over many decades has resulted in a significant reduction in their size structure, abundance and productivity.[10] Some of the best documented examples are from shellfish fisheries, particularly abalone where the catch has declined in many places around the world.[11,12,13] In addition to the capacity to significantly reduce the natural size structure and composition of fish populations, some fishing methods can have considerable cumulative impacts on non-commercial by-catch species, threatened and protected species and communities, and marine habitats. There are a number of species in NSW identified as having a high to moderate risk of population decline as a result of fishing pressure. Many of these species are sharks, which are particularly vulnerable because of their slow growth, low recruitment and long life span.[14] Fishing has contributed to the significant declines in population numbers of species now listed as endangered, such as the grey nurse shark (*Carcharias taurus*).[15]

More indirect changes to marine habitats can occur due to the removal of target and by-catch species. For example, the development of barren reef areas due to the over-grazing of macroalgae by sea urchins can result, in part, from the reduction in the number of urchin predators due to fishing. Such barren areas are estimated to cover around 50% of shallow rocky reefs along the central and southern NSW coast.[16] The large extent of these areas may indicate a considerable loss of overall marine productivity and has important implications for many species of algae, fishes and invertebrates.

3. BENEFITS OF MARINE PARKS

In recent decades, concerns over the cumulative impacts of human activities resulting in declines in the ecological condition of marine ecosystems, and sizes and abundances of many

species, have led to the use of marine protected areas as a management tool for conserving biodiversity in most of the world's oceans.

Benefits cited in scientific studies that may result from the implementation of marine protected areas like marine parks and their sanctuary zones include:

- increases in the abundance, biomass, diversity and productivity of many organisms;
- reductions in the loss of threatened and vulnerable species;
- helping ecosystems recover from natural and human impacts;
- increased protection of important species and habitats;
- the provision of reference sites for the evaluation of threats to biodiversity; and
- improved engagement and education of the community concerning issues of marine conservation.

The likelihood of significant and measurable improvements in the health of marine ecosystems through the implementation of a marine protected area, however, is strongly related to the following criteria:

- adequate knowledge about the contained biodiversity;
- assessment of the vulnerability of the biodiversity and threatening processes;
- consideration of the location and extent of zone types in relation to the distribution of habitats, ecological processes and management practicality; and
- the capacity to reduce the level of impacting activities.

Given that many activities have direct and indirect impacts on species and habitats, managing or eliminating those activities is an effective way of reducing those impacts on the marine ecosystem, and contributing to the long-term ecological viability of marine ecosystems. Zoning arrangements within multiple-use marine parks such as those set up in NSW attempt to reduce the impacts on marine ecosystems by protecting a proportion of all habitats and their associated species from removal, destructive activities and a range of threatening processes. In terms of indirect impacts such as pollution and siltation, a range of catchment management programs are progressively being implemented to address these issues. The protection of species and their habitat can result in benefits to a range of species and habitats, some of which are documented below.

3.1 Increases in the sizes and numbers of marine fish and invertebrates in sanctuary zones

The complete removal of all fishing is a feature of 'no-take' marine protected areas or 'sanctuary zones' in multiple-use marine parks. Most studies evaluating the benefits of these no-take zones have been based on comparing the abundance and composition of fish and invertebrates inside them to similar places where fishing is still allowed. The majority of the evidence indicates that sanctuary zones result in increases in the abundance and average size of many marine species, particularly those that are heavily exploited.

Some examples from around the world that document some of these changes are:

- The numbers of four targeted fish species (3 Sparids and 1 Dichistid) were between 5 and 21 times greater in sanctuary zones of the Tsitsikamma National Park in South Africa than in areas open to fishing.[17]

- The biomass of fish was found to be 3.5 times greater within protected East African reefs than those fished, with exploited species such as surgeonfish, triggerfish and parrotfish responsible for much of the difference. There were also increases in the numbers of individuals and species of damselfishes and small wrasses in unprotected reefs, which is likely to be an indirect effect of fishing reducing the abundance of predators.[18]
- At the Sagay Marine Reserve in the Philippines, the abundance of donkey's ear abalone (*Haliotis asinina*) was significantly higher on protected reefs than unprotected reefs, with average size also larger.[19]
- The density and biomass of larger grouper species (Pisces: Serranidae) were significantly greater in no-take marine reserve and lightly fished areas than in the more intensively fished areas in the Caribbean region.[20]
- In northern New Zealand marine reserves, snapper (*Pagrus auratus*) above the minimum legal size of 27 cm were estimated to be 14 times more abundant than in nearby fished areas. In one reserve, adult snapper were also consistently larger than those from fished areas, where most snapper were close to, or smaller than the legal size.[21]
- At the Poor Knight Islands in New Zealand, snapper showed significant increases in abundance and biomass relative to fished locations, particularly for large snapper (>27 cm), whose numbers increased rapidly to levels 7.4 times higher in the final survey compared to the initial pre-reserve survey. Total snapper biomass increased by over 800% following the declaration of the 'no take' marine reserve.[22]
- A study at the Ningaloo Marine Park in Western Australia, in which five sanctuary zones were compared to areas where recreational fishing was allowed, but commercial fishing prohibited, found significantly greater biomass, size, and abundance of legal-sized emperors (Lethrinidae) (the most targeted family in the region) in sanctuary zones, but no differences in other families/genera.[23]
- Similar trends were detected in the abundance of the spiny lobster (*Jasus edwardsii*) in New Zealand where legal-sized lobster were 11 times more abundant and biomass 25 times higher in the no-take marine park, while in the marine park where commercial fishing was excluded but recreational fishing allowed there has been no significant change in lobster numbers.[24]
- At the Maria Island Marine Reserve in Tasmania, southern rock lobster (*Jasus edwardsii*) increased by 260%, while the largest lobster observed in the sanctuary steadily increased over the years of surveying from 129 to 200 mm carapace length. Generally, legal-sized lobsters (110 mm males, 105 mm females TL or CL) were common in the sanctuary, but extremely rare in areas open to fishing.[25, 26] There was also evidence of a significant increase in abundance of the trumpeter (*Latridopsis forsteri*), but overall increases in abundance and species richness did not occur at all reserve sites.[27]
- Four sanctuary zones around the Palm and Whitsunday Islands in Queensland were shown to contain around 4 to 6 times the density and abundance of coral trout (*Plectropomus* spp) compared to similar fished areas.[28]
- In terms of estuarine species, within the Solitary Islands Marine Park in NSW there is evidence that the abundance and mean size of mud crabs (*Scylla serrata*) were consistently greater within sanctuary zones compared to the fished areas within the same estuary.[29]
- Within Jervis Bay Marine Park, red morwong (*Cheilodactylus fuscus*) have shown a significant increase in abundance and size distribution in sanctuary zones relative to fished areas.[30] The lack of observed response by other fished species may in part reflect the fact that around 50% of all reef habitat within surveyed sanctuary zones remain as urchin

barrens. Also, recent re-sighting of grey nurse sharks within a sanctuary zone at Jervis Bay Marine Park is an encouraging sign and may indicate that general protection from fishing will allow for some recovery for this endangered species.[30]

- In the Solitary Islands Marine Park, there are preliminary indications that certain demersal fish such as red morwong have greater densities in sanctuary zones, but the patterns are often inconsistent between sites, and more years of monitoring are needed before the significance of the trends can be determined.

One of the key benefits of sanctuary zones is to provide a refuge area for large mature animals. For many marine fish and invertebrates, the protection of the large mature males and females is important as egg and sperm production generally increases exponentially with size. Increases in egg production within sanctuary zones are more likely to occur for species whose larvae remain within the protected habitat, such as abalone whose larvae typically move only small distances. However, while many species have eggs and larvae that drift outside sanctuary zones (e.g. rock lobster), it is difficult to quantify the benefits to the overall populations from this export as these benefits are influenced by many factors, such as levels of egg production, local currents, food availability and predation rates. There are also significant technical challenges in quantifying these export related benefits.

3.2 'Spill over' of fish from sanctuaries into areas open to fishing

'Spillover' refers to the movement of adults and juveniles from no-take zones into neighbouring fished areas, and the extent to which this occurs is dependant on the size of the zones and habitat configuration within them, and the abundance and mobility of the species. Such movements can lead to increased abundance adjacent to no-take zones, and often fishers change their attitude over time regarding marine parks as they experience improved fishing in these areas. For example:

- In the Red Sea mean catch per unit effort of targeted fish species increased by about two-thirds within fished areas adjacent to no-take zones after 5 years of protection.[31]
- Within 5 years of the creation of a network of sanctuary zones around the Caribbean island of St. Lucia, catch by fishers increased between 46 and 90%, depending on the gear they used.[32]
- Since 1985 all new Florida trophy records for black and red drum (*Sciaenops ocellatus* and *Pogonias cromis*) have been won for fish caught adjacent to a sanctuary zone near Cape Canaveral.[32]
- Adjacent to a sanctuary zone around part of Apo Island (Philippines) the biomass of surgeonfish (*Naso vlamingii*) over time increased by a factor of 40 outside but close to the reserve boundaries (200 to 250 m), but not at greater distances (250 to 500 m). Hook-and-line catch per unit effort for surgeonfish was 45 times higher within 200 m of the reserve boundary than for all other fishing grounds combined.[33]
- In the Moreton Bay Marine Park, mud crabs (*Scylla serrata*) were twice as common in sanctuary zones than in fished areas, and were also larger. Tagging work showed that some of these crabs "spilled over" into fished areas.[34]
- Similar movements from sanctuary zones into fished areas were found for mud crabs in the Solitary Islands Marine Park, with fishers often targeting zone boundaries.[29]

3.3 Marine parks can lead to improvements in ecosystems and habitats

A key objective of marine protected areas is to manage activities that impact on the biological diversity, productivity and ecological processes of ecosystems and habitats. Importantly, this includes, but is not limited to, exploited species. Direct impacts from activities such as demersal trawling on the productivity of both non-target species and their associated seabed habitats are well documented[35], although the extent of impacts are influenced by a number of factors, including:

- the type of seabed (reef, sand, mud etc.),
- levels of trawling effort,
- variations in the abundance of bottom flora and fauna, and
- the resilience of species or assemblages.

This can have a flow on effect of changing the composition of fish species that inhabit the area.[36] It is considered that ocean trawling has significant ecological impacts on sessile animals and plants on low-relief rocky reefs and soft sediments. Removal of trawling will considerably reduce the risk (currently assessed to be high) that these ecosystems will be degraded.[14] Other more indirect impacts are often more difficult to quantify, although one example relevant to many NSW coastal reefs relates to the increasing evidence that ecological impacts on kelp dominated reefs can result from the removal of some predator populations. This leads to increased abundance of urchins and loss of macroalgae, resulting in barrens. Specifically:

- Studies in New Zealand found that increased abundance and average sizes of snapper (*Pagrus auratus*) and spiny lobsters (*Jasus edwardsii*) in no-take areas resulted in a decrease in sea urchin (*Evechinus chloroticus*) abundance, which had eaten extensive areas of kelp (predominantly *Ecklonia radiata*) resulting in barren areas.[37] The higher density of predators and tethering experiments have shown that the chance of predation on sea urchins within the no-take areas was around 7 times higher relative to outside.[38] Such interactions have resulted in a reduction in barrens areas to 14% of the marine reserve, compared to 40% in unprotected areas, and an estimated increase in primary production within the reserve of over 50%.[37]
- Similar predator/urchin/habitat results have been demonstrated in Tasmanian and Californian no-take areas.[26, 39]
- Sea urchins were estimated to be six times more abundant outside sanctuaries in East Africa than inside, which is thought to result from the significantly higher numbers of a key urchin predator (red-lined trigger fish - *Balistapus undulatus*) in the sanctuary zone.[18, 40]

Overall, there are numerous documented examples of the recovery of marine species and habitats in marine protected areas. While it is difficult to predict the response of species and individual habitats to protection, in many cases the response is positive. Fast growing, site-attached species (usually those living on rocky reefs) are likely to respond better to protection, and much of the data from tropical marine protected areas are based on these type of species. Highly mobile species are less likely to show benefits, particularly given the lack of information on spatial patterns of movement and aggregation.

While marine parks have a broad biodiversity conservation goal, managing marine parks entails setting more specific conservation goals for the habitats and zones within a park. For example, reduction in urchin barrens, loss of seagrass and impacts of demersal trawling are specific

conservation goals. The response to protection of the area may be site-specific, but in most cases shows an improvement in habitat condition and greater ecosystem 'health'. In some cases the connectivity of sanctuary zones is important in maximising benefits to many species. Research in this area will assist in maximising zoning benefits.

Biological systems are variable and take time to respond following protection. Documenting differences between sanctuary zones and other areas may take many years following the establishment of a zoning plan, and such differences are likely to be species-specific. A number of studies have indicated a period of at least 10 to 25 years is required for the full benefits of sanctuary zones to develop for some reef fishes, invertebrates and macroalgal assemblages, which is mainly driven by the longevity, recruitment patterns and prey interactions of those species. However, because of the complex food web within habitats such as rocky reefs, increases in numbers of some species may also be limited by the availability of food and competition.

While much of the attention is generally focussed on sanctuary zones where no fishing is allowed, significant conservation benefits can also arise from 'habitat protection' zones where specific forms of fishing such as demersal trawling that pose greater environmental risk are excluded, or substituted with modified, sustainable fishing methods. However, in cases where seabed habitat has been disturbed through trawling or dredging activities, recovery may take many years, with changes over time only measurable with well-designed and resourced monitoring programs. In addition, while marine park zoning arrangements currently are not designed to address all the threats to the oceans such as pollution, disease, invasive species, and climate change, they can contribute to an improvement in the overall health of marine ecosystems. Clearly identifying and contributing to the process of reducing threats from activities related to some catchment activities and coastal development is also an important part of marine park planning and management.

4. DESIGN CONSIDERATIONS FOR MARINE PARKS

The primary criteria identified for establishing marine protected areas throughout Australia are that they contain a comprehensive, adequate and representative sample of marine biodiversity.[1,2] These ecological criteria were examined at a bioregional scale in NSW using reserve planning tools to provide a framework for defining marine park boundaries.[3, 4] Recent mapping of estuarine and marine areas in NSW marine parks have subsequently allowed a more detailed assessment of a wide range of seabed habitats. There is increasing evidence that habitats may be effective 'surrogates' for biodiversity, provided that they are appropriately validated and that representative examples of all types of habitats are included in sanctuary zones.[41] Surrogates are components shown or assumed to be related to biological diversity that are more easily measured or mapped than species diversity itself. They are used to infer distributions and measures of biodiversity from the distributions and measures of surrogates. This principle is being applied in NSW marine parks.

Other important design considerations for marine parks [1] include:

- consideration of the marine park location, extent and zoning arrangements in relation to ecological processes (e.g. movement and biology of particular species), distribution of habitats, and practicality of management (e.g. enforcement, education);
- assessment of the vulnerability of the biodiversity and threatening processes;
- the ecologically sustainable use of marine resources for a range of human activities;

- economic, social and cultural selection criteria which are considered in the zoning process; and
- buy-back of sufficient commercial fishing effort to minimise displacement of commercial fishing from sanctuaries and habitat protection zones to other areas.

Some examples of the application of secondary ecological criteria to zone planning are presented below:

- One of the key aggregating species that are protected in NSW marine parks is the grey nurse shark. This is because at present rates of decline due to accidental capture by fishers the species may become locally extinct in the next 50 years.[15] Protection of key sites is an important part of the overall strategy to reduce impacts and promote recovery of the species.
- Studies of fish species inhabiting rocky reefs in NSW suggest that sanctuary zones of around 2 to 6 km long would be optimal to represent the diversity of temperate fish communities.[42] Such a size would adequately protect species such as red morwong whose average home range is around 1800 square metres.[43] There is increasing evidence from new tracking techniques that species such as snapper also show strong site fidelity, with most fish having maximum home ranges around 650 m in diameter, although some seasonally occur over a larger area.[44]
- Species with large ranges can receive protection within sanctuaries during specific life-history stages such as juveniles, or at aggregation sites for spawning and/or feeding. For example, protection of juveniles of many species such as yellowfin bream, tarwhine and snapper is expected within estuarine sanctuary zones, particularly those located over seagrass beds. Little is known about the spatial movement of most mobile species, although many are known to form feeding and/or breeding aggregations around specific seabed features. Protection of some aggregation sites can afford limited protection for some species in places where heavy fishing pressure can significantly reduce their size structure and abundance.[45] Like fish, fishers are also not evenly spread, rather they are typically observed to repeatedly use the same areas. This is particularly true for anglers targeting pelagic fish.[46]
- Minimising the placement of sanctuary zone boundaries across areas of continuous rocky reefs is recommended to maximise protection to many reef species that move over the entire reef.[47]

The benefits of protection in a marine park for a particular species are related to the extent of threats, the spatial arrangements of their habitat (and therefore the spatial arrangement of zones), and their specific life-history patterns (growth, movement, recruitment etc.). Given the wide range of life-history characteristics of estuarine and marine species, responses to protection will be species-specific and it is nearly impossible to identify a zone size and position that is optimal for all species. This has led to the approach of using consolidated rather than fragmented sanctuary zones that span a range of habitats. Further details on guidelines for the selection of marine parks and zoning arrangements in NSW are presented within a number of documents. [1, 48]

5. CONCLUSION

Overall, there is considerable scientific information that indicates that the designation of zones in marine parks that provide protection from impacting activities is an important tool in the long-

term conservation and management of marine biological diversity and ecological processes. A network of such areas is considered by many of the world's leading marine scientists to be a necessary component of the overall strategy to provide for ecologically sustainable use of marine resources.[49] Further, such a network can be expected to provide an important benchmark for the evaluation of threats to marine ecosystems by providing areas against which impacted areas can be compared.

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