



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

Prepared on behalf of the Marine Parks Authority Research Committee

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.

Marine parks complement other management strategies (e.g. seasonal closures, bag limits, size limits), and assist in ensuring that harvested species, by-catch and habitats are protected in specific areas. They also complement other wildlife management actions for marine mammals and seabirds, and catchment management activities that address land-based impacts on the marine environment.

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. This document highlights some of the key threats to some marine species and their habitats and examines key benefits of marine protected areas in addressing these threats.

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 coastal development, pollution, agriculture, recreational and commercial fishing, 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.¹ 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.

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. For example, the Healthy Rivers Commission estimated that around 30% of coastal lakes are 'moderately' or 'severely' affected by human pressures.² Increased nutrient levels and turbidity from 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.³ 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 such things 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 benthic 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.⁴ Some of the best documented examples are from shellfish fisheries, particularly abalone where the catch has declined in many places around the world.^{5,6,7} 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 being at moderate to high risk of becoming overfished; many of which are sharks species reflecting their slow growth, low recruitment and long life span. Fishing may have contributed to the significant declines in population numbers of species now listed as threatened in NSW, such as the grey nurse shark (*Carcharias taurus*).⁸

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.⁹ The large extent of these areas may indicate a considerable loss of overall marine productivity.

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 extinctions 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 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 systems within a marine protected areas. 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 threatening processes. The protection of species and their habitat can result in benefits to a range of species and habitats, some of which are documented below.

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

The complete banning 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 sanctuary zones have been based on comparing the abundance and composition of flora and fauna 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 flora and fauna.

Some examples from around the world that document the benefits of sanctuary zones are:

- In the De Hoop sanctuary, a surf beach on the southern coast South Africa, the numbers of 6 surf-zone fish species increased by between 30 and 500% compared to fished beaches.^{10, 11}
- The numbers of four heavily targeted fish (3 Sparids and 1 Dichistid) in sanctuary zones of the Tsitsikamma National Park in South Africa were between 5 and 21 times greater than in areas open to fishing.¹²
- Exploited species of coral reef fish, such as coral snappers (Lutjanidae) and parrot fish (Scaridae) were ten times more abundant in two Kenyan sanctuaries than on fished reefs. Also, the total diversity of fish species was double in the sanctuary.¹³
- At the Sagay Marine Park in the Philippines, the number of donkey’s ear abalone (*Haliotis asinina*) increased by 500% compared to fished sites.¹⁴
- Numbers of groupers (Serranidae) from sanctuary zones in Cuba and the Dominican Republic were 6 times greater than in areas open to fishing.¹⁵
- At the Leigh and Tawharanui sanctuaries in New Zealand, adult snapper (>27 cm fork length) were 14 times more abundant than in nearby fished areas. In the sanctuary, adult snapper were also much bigger (most >40 cm fork length) than those from fished areas, where most snapper were close to, or smaller than the legal size of 27 cm fork length.¹⁶
- 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 there were 73% more emperors (Lethrinidae) in sanctuaries than in recreational fishing zones. Other species of commonly targeted fish such as coral snappers, wrasse (Labridae), rockcods (Serrandidae) and sweetlips (Haemulidae) were also significantly more abundant in the sanctuary zones.¹⁷
- At the Poor Knight Islands in New Zealand, the total biomass of snapper increased by around 800% following the declaration of a ‘no take’ marine reserve.¹⁸
- At the Maria Island Marine Reserve in Tasmania, fish numbers increased by around 240% following protection. In particular, southern rock lobster (*Jasus edwardsii*) 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.^{19, 20}
- Four sanctuary zones around the Palm and Whitsunday islands in Qld were shown to contain around 4 to 6 times the abundance of coral trout (*Plectropomus* spp) compared to similar fished areas.²¹
- 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.²²
- Preliminary results from the Jervis Bay Marine Park show that sanctuary zones can have a positive effect.²³ Two exploited fish species, red morwong (*Cheilodactylus fuscus*) and bream (*Acanthopagrus australis*) have increased populations in the sanctuary zones. Also, recent re-sighting of several grey nurse sharks within a sanctuary area at Jervis Bay Marine Park²³ is an

encouraging sign and may indicate that general protection from fishing will allow for some recovery for this endangered species.

- 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.

‘Spillover’ of fish from sanctuaries into areas open to fishing

‘Spillover’ refers to the movement of adults and juveniles from sanctuary zones into neighbouring areas, and the extent to which this occurs is dependant on the size and habitat configuration of the zone and the mobility of the species. Such movements can lead to improved catches adjacent to the sanctuary zones, and often fishers change their attitude over time regarding marine parks as they experience improved fishing in these areas. For example:

- Around sanctuary zones in the Red Sea, fishers reported a 75% increase in catches of coral snappers, emperors and groupers.²⁴
- 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.²⁵
- 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.²⁵
- Adjacent to a sanctuary zone around part of Apo Island (Philippines) catches of surgeonfish (*Naso vlamingii*) increased by 30%. Surveys of large predatory fish, such as rockcods and jacks (Carangidae), showed a 230% increase in numbers immediately adjacent to the reserve (200 to 300 m), and an increase of 75% at distances up to 500 m. Local fishers also reported improved catches.^{26, 27}
- 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.²⁸
- 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.²²

Sanctuaries lead to improvements in ecosystems and habitats

- Studies of a sanctuary zone in New Zealand found that once the numbers and average sizes of snapper and rock lobsters had recovered, these large predators began controlling the local sea urchin (*Evechinus chloroticus*), which had eaten extensive areas of kelp (predominantly *Ecklonia radiata*) resulting in barren areas. This resulted in a decrease in urchin density and a reduction in barrens to 14% of the reserve, compared to 40% in unprotected areas. The primary production of the marine reserve was estimated to be over 50 times greater than it was before protection from fishing.²⁹
- Similar predator/urchin/habitat results have been demonstrated in Californian and Tasmanian sanctuaries.^{30, 20}
- There are 6 times more urchins outside sanctuaries in Kenya than inside. This is thought to be because the numbers and average size of red-lined trigger fish (*Balistapus undulatus*), which when eat large urchins, have recovered in the sanctuary zone.^{13, 31}
- Along the rocky shores of Chile, the mussel *Perumytilus purpuratus* dominates the seabed. However, in sanctuary zones the mussels are uncommon and there are many species that inhabit the shorelines resulting from the recovery of the loco, the predatory snail which eats, among other things, mussels, but is usually heavily targeted by commercial and recreational fishers.³²

Improved reproductive potential of key species in sanctuary zones

One of the key benefits of sanctuary zones is to provide a refuge area for large mature animals. For most marine animals, the protection of the large mature males and females is important as egg and sperm production increases exponentially with size.

Increases in abundance within sanctuary zones resulting from increases in egg production 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.

Overall, there are numerous documented examples of the recovery of marine species and habitats in sanctuaries. 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 parks are based on these type of species. The same could be said for many of the conservation goals that are specific to individual parks and specific habitats within them (e.g. urchin barrens, seagrass loss, impacts from bottom trawling etc) where the response following protection may be site-specific, but in most cases is towards better habitat condition and greater ecosystem 'health'. In some cases the connectivity of sanctuary zones is important in maximising benefits to many species.

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 scheme, 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, which is mainly driven by the longevity and recruitment patterns 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 conventional bottom 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 coastal development is also an important part of marine park planning and management.

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.³³

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 degree to which the size, boundaries and location of the parks are adequate to maintain biodiversity, ecological patterns and processes,

particularly in relation to the ability to manage impacting activities; and representativeness is the extent to which the parks reflect the range of biological diversity within ecosystems and habitats.

These ecological criteria were examined at a broad scale in the bioregional assessments in NSW that resulted in the identification of areas with important biodiversity values.^{34,35} Recent mapping of estuarine and marine areas in NSW marine parks subsequently have 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.³⁶ This principle is being applied in NSW marine parks.

Other important design considerations for marine parks include:

- consideration of the marine park location and 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 ecological 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 licences to minimise displacement of commercial fishing from sanctuaries to other areas.

Examples of the application of 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.⁸
- Studies of some fish species inhabiting rocky reefs in NSW suggest that sanctuary zones of between 2 and 6 km long would be optimal for many temperate species. For example, the average home range of a commonly targeted reef fish (red morwong) is around 1800 sq/m.^{37,38} This estimate the minimum area of suitable habitat required in a sanctuary zone for it to provide some protection for this species.
- 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 instance, kingfish are known to form breeding aggregations around seamounts, and when aggregated species are often vulnerable to high catch rates. Such aggregation sites make ideal sanctuary zones as they can protect key locations for many species.³⁹ Like fish, anglers are also not evenly spread, rather they are typically observed to repeatedly use areas of less than 500 m². This is particularly true for anglers targeting pelagic fish.⁴⁰
- Placing sanctuary zones boundaries on sand adjacent to rocky reefs is recommended to maximize protection to many reef species that move over the entire reef. For instance, a movement study of six Tasmanian reef fish on a very small (1ha) isolated reef indicated that while they moved around the reef, they tended not to move off onto the adjacent sand areas.⁴¹
- Studies of beach species suggests that to effectively provide protection, whole beaches need to be included in single sanctuaries due to movement along the beach.^{10,11}

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.

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 management of marine resources. A network of such areas is considered by many of the world's leading marine scientists to be necessary for the long-term conservation of marine biodiversity and to assist the management of sustainable fisheries.⁴² 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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7. Further reading of NSW MPA documents (available at www.mpa.nsw.gov.au)

1. Developing a Representative System of Marine Protected Areas in NSW: An Overview
2. Strategic Framework for the Evaluation and Monitoring of Marine Parks in NSW
3. NSW Marine Parks Authority Strategic Research Plan