

Science shows marine park benefits

Marine parks are internationally recognised as an effective tool to manage and conserve marine resources and biodiversity.

Because marine parks will introduce some changes to how South Australian waters can be used, it's important to know what benefits can be gained from protecting sections of our marine parks as no-take marine reserves (sanctuary zones) where extractive activities are prohibited.

Multiple-use marine parks 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.

There have been many scientific studies on the effects of sanctuary zones. The positive benefits are significant and include:

- Increases in the abundance, individual sizes, diversity and overall biomass of sea life.
- Increased ability of local marine life to reproduce.
- Spill-over of larvae and/or adults into unprotected areas, and;
- Improvements in ecosystems and habitats (i.e. healthy natural balances restored).

The protection of habitats can result in benefits to a range of species and the associated ecosystem, some of which are documented below.

Whether these benefits can be achieved is largely dependent on reducing the level of activities which have negative impacts on the ecosystem. These activities include fishing, mining, pollution, urban stormwater run off, marine pests etc.

Scientific studies of ecological improvements

One of the main objectives of sanctuary zones is to manage the activities that impact on ecosystems and habitats.

The removal of animals, damage to the benthic (sea-floor) habitats, and land-based impacts (such as storm-water runoff etc.) can all have flow-on effects within an ecosystem. By protecting whole ecosystems, sanctuary zones will allow these areas to return to near natural and more ecologically balanced states. Examples of habitat and ecosystem recovery include:

Australia

- No-take reserves on the Great Barrier Reef appear to benefit overall ecosystem health and resilience: outbreaks of the coral-eating crown-of-thorns starfish appear less frequent on no-take reefs, which consequently have higher abundance of coral.

The crown of thorns' frequency of outbreaks was found to be seven times higher on fished reefs compared to protected reefs (McCook *et al.*, 2010). The exact reason for this is unclear, but it appears that the protection of fish and other animals has significantly helped this ecosystem return to a more balanced state.

- At the Maria Island Reserve in Tasmania, the establishment of sanctuary zones resulted in an increase in large predators such as rock lobster and large fishes and a decrease in urchins and abalone, which graze on algae (Edgar *et al.*, 2009). The cover of the kelp *Ecklonia radiata* also substantially changed through time since protection, with a significant increase in its cover within the sanctuary zones (Barrett *et al.*, 2009).

This increase in kelp is thought to be the result of a decrease in algae consuming invertebrates such as the urchins and abalone, as is the case in New Zealand.

United States

- The Georges Bank reserve in the Gulf of Maine, USA, is enabling benthic habitats to recover. Protection from trawling has led to significant increases in the abundance, biomass, species diversity and production of benthic animals, such as echinoderms, hydroids and sea fans.

These effects are likely to be enhancing production of commercial species such as haddock and flounders, leading to long-term sustained benefits (National Research Council, 2002).

New Zealand

- The Leigh reserve in New Zealand has shifted from being unnaturally dominated by sea urchins to being more naturally dominated by macroalgae. This is a result of an increased abundance of sea urchin predators, namely the spiny lobster (*Jasus edwardsii*) and snapper (*Pagrus auratus*) due to the protection offered within the reserve boundary. Also, lower densities of the limpet *Cellana stellifera* and higher densities of the gastropod *Cookia sulcata* have been found at reserve sites and are thought to be a result of the change in reef habitat structure, representing an additional indirect effect of increased urchin predators (Shears & Babcock, 2003).

Africa

- The protection of coral reefs in five Marine Protected Areas (MPAs) in East Africa has resulted in an increase in the red-lined triggerfish (*Balistapus undulatus*), a key predator which in turn has resulted in a decline of sea urchin populations (McClanahan, 2000). "Studies on the East African reefs has shown that fishing of key predators such as the red-lined triggerfish results in proliferation of sea urchin

populations, which reduces coral abundance and diversity.

Consequently, many of the heavily fished reefs of East Africa are dominated by sea urchins and algal turf, while many unfished reefs are dominated by hard corals, coralline algae and a high diversity of grazing and predatory fishes" (McClanahan & Arthur, 2001).

Overview studies of ecological improvements

There are a number of documented examples of the recovery of exploited marine species and habitats in no-take marine reserves. It is difficult to predict the response, but in general terms, the overall effectiveness of marine reserves at restoring ecosystems improves over time (Edgar *et al.*, 2009).

Although some reserves may quickly improve, most reserves require more than a decade to yield substantial benefits. A number of studies have indicated a period of 10-25 years is required for the full benefits of sanctuary zones to develop. This is in part due to the flow-on effects (trophic cascades) that take place when one element in a food web is removed.

"Fishing generates a series of trophic cascades in reef ecosystems, population densities of large predators catastrophically decline, densities of grazing invertebrates increase, and algal communities change, with additional ripples through the food web as habitats transform. Once fishing ceases, each of these trophic steps adds time lags of many years before the ecosystem can be considered fully recovered" (Edgar *et al.*, 2009).

Increases in abundance, size, diversity and overall biomass

Other studies have measured the effects of sanctuary zones on fish species in particular. They provide further evidence that protected marine reserves help fish grow to greater sizes and in greater numbers when under natural conditions. Examples from Australia and around the world include:

Australia

- Aldinga Reef Aquatic Reserve (South Australia) showed an increase in abundance of fish greater than 45cm and increased biomass of fish inside the reserve compared to outside (Edgar *et al.*, 2009).
- Monitoring of the Great Barrier Reef Marine Park has revealed a two-fold increase in both numbers and size of fish, in particular coral trout, red emperor and redthroat emperor on many of the no-take reefs (McCook *et al.* 2010).
- The Tinderbox Marine Reserve in Tasmania showed a 10-fold increase in the abundance of large fish and a doubling of species diversity of large fish in no-take areas compared to fished areas (Barrett *et al.*, 2007). Lobster abundance increased two-fold within the reserve, while fished sites remained constant (Barrett *et al.*, 2009).
- At the Maria Island reserve in Tasmania, southern rock lobster (*Jasus edwardsii*) abundance increased by 250%, with increasing numbers of legal-sized lobsters being largely responsible for this increase. Lobsters within the reserve were significantly larger compared with fished sites (Barrett *et al.*, 2009).
- The no-take reserves around Palm Island and the Whitsunday Islands off Queensland were shown to contain 3.6 and 2.3 times respectively the abundance of coral trout compared to fished zones. The biomass of coral trout was approximately four times higher in protected areas. There were significantly higher numbers of legal sized coral trout within protected areas compared to fished areas (Evans & Russ, 2004).
- Within the Moreton Bay Marine Park, mud crabs (*Scylla serrata*) are higher in abundance and larger in average size within the no-take areas compared to outside. This pattern is consistent for several other targeted species within the marine park (Pillans *et al.*, 2003).

- Targeted fish species in the Houtman Abrolhos Islands reserves in Western Australia have been found to be larger inside the reserves than areas open to fishing. Targeted species on average were found to be 48mm larger inside MPAs than in areas open to fishing (Watson *et al.*, 2009).

United States

- A study in southern California, USA, in which five reserves were compared to fished areas, showed that fishes normally targeted by recreational and commercial fishers consistently exhibited increases in abundance (of 150%), size (30%), biomass (440%) and egg production (730%) inside reserves (Tetreault & Ambrose, 2007).
- In the Everglades National Park in Florida, USA, (established 1985) the modal size of grey snapper *Lutjanus griseus* was 25–30 cm compared with 15–20 cm in fished areas (Faunce *et al.*, 2002 cited in Gell and Roberts, 2003).
- The most dramatic effect for the Georges Bank reserve in the Gulf of Maine, USA has been on scallops *Placopecten magellanicus*, which, before the closures, had been heavily depleted. After five years of protection, abundance of legal-sized scallops reached 9–14 times those in fished areas (Murawski, et al., 2000 cited in Gell & Roberts, 2003).

In the Florida Keys, abundance of yellowtail snapper *Ocyurus chrysurus* increased by more than 15 times in the fully protected Sanctuary Preservation Areas over four years (Bohnsack and Ault, 2002 cited in Gell and Roberts, 2003).

Africa

- The biomass of fish was found to 3.5 times greater within protected East African reefs than those open to fishing (McClanahan *et al.*, 1999).

New Caledonia

- A study conducted on five islands in the southwest lagoon of New Caledonia found species diversity, abundance and biomass of fish on the protected reefs increased by 67%, 160% and 246%, respectively (Wantiez *et al.*, 1997).

Mediterranean Sea

- Fish assemblages found in seagrass beds in the Tabarca Island Marine Reserve in the south-western Mediterranean Sea were found to have 96.5% higher abundance compared to unprotected areas. Biomass and number of species inside the reserve were also found to be higher compared to unprotected areas. Larger sizes were also detected in the reserve for all recorded fish species (Valle & Bayle-Sempere, 2009).
- Six Mediterranean marine protected areas (two near France and four near Spain) have been found to have higher fish species diversity, abundance and biomass inside the reserves compared to adjacent fished areas (Harmelin-Vivien *et al.*, 2008).
- The effects of marine reserve protection was studied on the spiny lobster (*Palinurus elephas*) in a central western Mediterranean area. It was found that the mean abundance within the reserve was 7.5 times greater than that of the unprotected area. Lobster size within the reserve also showed a progressive increase of adults and juveniles (Follesa *et al.*, 2008).

Philippines

- Russ and Alcalá (1996) reported a sevenfold increase of larger predatory reef fish after coral reefs were protected for 11 years at Apo Island in the Philippines.

Overview studies

- Lester *et al.* (2009) conducted a global analysis on the biological effects of marine reserves,

which utilised data from the studies cited elsewhere in this document. They found the biomass of organisms within reserves increased by 166% and abundance by 61%. Individual size and species richness increased by 21% and 15%, respectively.

- Halpern (2003) conducted a review which found marine reserves were associated with higher invertebrate abundance, biomass and size.

Spill-over of larvae and/or adult marine species into unprotected areas

Spill-over refers to the movement of adults or juveniles (including larvae or spores) from no-take zones into adjacent fished areas. Such movements can lead to increased abundance adjacent to the no-take zones, and thus can improve fishing in these areas.

It is important to note that while this is a possible benefit of sanctuary zones, and one often keenly anticipated by fishers, it is not the core purpose for which they are created.

While there are limited studies of spill-over in Australian waters, some international examples include:

United States

- In the Georges Bank reserve in the Gulf of Maine, USA, fishers have reported improvements in catches. One Cape Cod fisherman reported that he now travels less than half the distance and catches nearly twice as much cod as he did before the closures (Gell and Roberts, 2003).
- Satellite monitoring in the Georges Bank reserve showed scallop-fishing vessels clustering around the edge of the closed areas. Areas of high fishing effort corresponded with the places that biophysical models showed would have received most scallop larvae exported from closed areas. Those models showed that, with a 40-day larval duration, currents can take larvae from closed areas to large regions of the bank as well as back into closed areas

to replenish protected stocks (Lewis, 1999 cited in Gell & Roberts, 2003).

- The Merritt Island National Wildlife Refuge at Cape Canaveral, Florida, USA contains two areas (totalling 40 km²) that have been closed to human access and fishing since 1962 for the security of the nearby Kennedy Space Centre.

Within a 200km stretch of coast around the reserves (just 13% of the Florida coast), in 1996 anglers caught 62% of record-breaking black drum and 54% of record-breaking red drum. Since the mid-1980s most Florida records for both these species have been recorded close to the refuge. Captures of record fish around the refuge indicate that spill-over is occurring (Bohnsack cited in Gell and Roberts, 2003).

Spain

- In the Columbretes Islands Marine Reserve the spill-over into the adjacent fishing area was 2065 lobsters per year. Although the *number* of lobsters spilling over annually did not quite make up for the loss of fishing grounds, it did in terms of *weight* because the mean size of the lobsters moving out from the reserve was larger than that of those outside (Goni *et al.*, 2010).

Kenya

- The biomass, mean size of fish and the number of fish species caught was greater on the managed side of the Mombasa Marine Park in Kenya, compared to the unmanaged side of the park. The increase in size etc. declined as distance from the park edge increased (McClanahan & Mangi, 2000).

Philippines

- A study at the Apo Island marine reserve in the Philippines found that after 11 years of protection there was significantly higher densities of large predatory fish immediately adjacent the reserve and up to 300m from the reserve edge compared to the first couple of years of protection (Russ & Alcala, 1996).

Hook and line catch per unit of effort at the island was 50% higher during 1998-2001 than during 1981-1986 (pre-reserve and early phases of reserve protection) (Russ *et al.*, 2004).

- It has been found in Florida and St Lucia, USA that after five years, the catch per unit of effort of fish traps increased by 46-90% in fishing grounds around a network of reserves (Roberts *et al.*, 2001).

Are these studies relevant to South Australia?

Clearly, marine sanctuaries create a range of beneficial effects but how relevant are studies from other parts of the world to South Australia? Many examples of the effects of marine reserves are from tropical

areas, or countries that lack sophisticated fisheries management and may allow illegal, unethical or destructive fishing practices. Can we be confident that marine sanctuaries will produce benefits in South Australia's cool, temperate waters, where our local fisheries are already well managed?

Lester *et al* (2009) compared the effects of temperate and tropical marine sanctuaries and found that effects in temperate waters were at least as strong as in tropical waters.

In fact, they found a 446% mean increase in biomass within marine sanctuaries. However, this study incorporated some examples from countries with relatively poor fisheries management practices.

To reduce the effect of poor fisheries management on the study, Fairweather *et al.* (2009) examined a subset of the Lester *et al* (2009) dataset that came from countries with temperate waters and efficient fisheries management, of the kind found in New Zealand, Canada and Australia.

The researchers found an even stronger effect than Lester *et al* (2009), with a mean biomass increase of 975% in sanctuaries.

Thus it can be concluded that international experiences of the effects of marine sanctuaries are relevant in South Australia.

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