Case Studies

Case studies

A. Saba Marine Park, Netherlands Antilles

No-take restrictions protect tourism asset

The volcanic island of Saba lies in the eastern Caribbean and rises precipitously to 900m. It covers only 11km^2 and has a low population of approximately 1,800 residents. Both factors are significant in enabling Saba to have a marine park which surrounds the entire island and a no-take fishing zone which is almost 100% effective! The marine park is operated by a non-governmental organization and has the distinction of being the world's first self-funding marine park. Plans for the park began in 1984 in response to the island government's request for help in managing its marine resources. It took just under three years to develop a fully zoned management plan and raise funds to establish the park. During that time there was intense consultation with the island's fishers to alleviate their concerns about why the park was being set up and how it would affect them. By the time the park was opened it had gained almost universal support and that popularity has never faltered. What is it that has made the Saba Marine Park so successful?

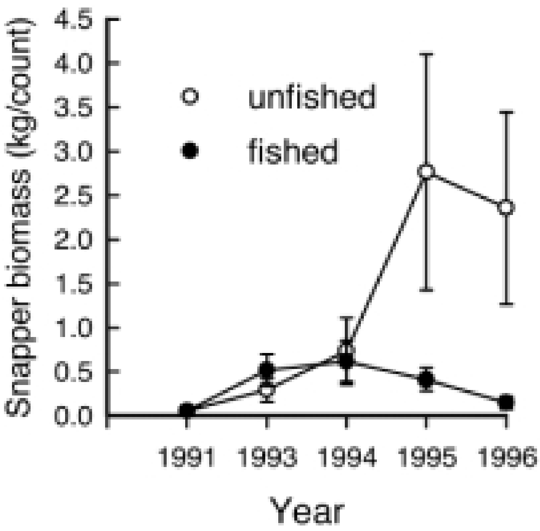


Figure 17: ***There was a steep initial increase in biomass of snappers in the fully-protected zones of the Saba Marine Park following protection, followed by a leveling off (perhaps a consequence of several major storms that passed nearby in 1995). Even though the reefs of Saba are only lightly fished, the fully-protected zones offer important protection to the most vulnerable species, like snappers. Roberts and Hawkins, unpublished data.***

The principal objective of the marine park was to maintain a healthy marine environment to attract tourists and boost the island's economy. Right from the start local people wanted to follow the route of ecotourism, where tourists would benefit the island but not begin to take it over or degrade the environment. In Saba these ideals of ecotourism have been realized. Some of the key reasons are that the island has no real sandy beaches and no access for cruise ship tourism. People visit Saba to dive or hike and because the landscapes both below and above water are so spectacular they are prepared to pay a high price to do so. The mass tourism that miles of white sand beaches tend to attract has not been a significant problem and there has been little pressure for greater development on the island. In fact, most locals feel they are doing pretty well with things as they are and don't need too much change in their lives. This sort of attitude is all part of the charm and appeal of Saba.

The island's fishers have a similar attitude towards catching fish. Although there are several commercial boats, modern intensive fishing has never developed on the island. In fact, for some time before the marine park was established, fishing had become a predominantly part-time activity. Most of it is for open water fish caught by trolling with hook and line, well offshore of the coral reefs. Nowadays there is very little net or trap fishing, although in former times the Sabans relied heavily on these methods. Today reef species are mostly targeted by a small number of spearfishers. Only locals are allowed to do this and they must dive using a snorkel. No-one is allowed to do any type of fishing in the no-take area (although, initially, fishing from the shore with hook and line was permitted, few used the opportunity). Hence, because fishing pressure in Saba was low when the marine park was established the primary objective was to protect tourism assets rather than offer a means of salvation for fishers. Nevertheless, no-take zones were an integral part of the management plan. They were set up to enhance the numbers and size of fish on the reefs, primarily for the benefit of divers. Any advantages to the fishers would be an additional bonus.

The relationship between divers and the marine park is mutually beneficial. The park provides mooring buoys for dive boats and protects the underwater environment which the divers have come to enjoy. It provides regular slide shows at hotels and on live-aboard boats to tell people about the park and how they should behave to conserve the reefs. Meanwhile divers help fund the park through user fees which are automatically added to their dive costs and collected for the park by the diving centres. Other money for the park comes from yacht mooring fees and a "Friends of Saba Marine Park" foundation which is supported by past visitors to the island. Park wardens make daily patrols to collect mooring fees from yachts and enforce no-take regulations. Very few violations have ever been committed by locals over the park's entire history.

Saba is a tiny island but is much loved by tourists seeking out beautiful natural environments above and below water.

Fish and coral communities at 14 sites within the marine park have been regularly monitored since 1991. Even though the fishing pressure on Saba was, and has remained light since then, there has been a rapid build up of fish biomass inside no-take zones. This rise has been most striking in two families which are particularly vulnerable to over-fishing, the snappers and groupers. Figure 17 reveals an exponential increase in the biomass of snappers following protection, although numbers fell slightly in 1996, probably as a result of three hurricanes which passed by the island between the 1995 and 1996 surveys. A second effect on the fish communities has been an increase in biodiversity in both no-take and fishing areas, due to increases in the abundances of fish throughout the whole marine park. Tourism development on Saba has led to an easing of fishing pressure in areas outside the no-take zones too.

Results from monitoring of coral communities show that, despite a 42% increase in the number of dives made in the park between 1988 and 1994 coral cover in the park held steady, unlike many parts of the Caribbean where it declined during this period. Furthermore overall levels of diver damage appear to be declining. This suggests that the marine park's efforts at diver education and the practice of all boats having to use mooring buoys rather than drop anchors is promoting reef conservation. However, one serious problem on Saba that threatens some of the near shore reefs, is sedimentation. Over-grazing by goats is causing high levels of sediment run-off throughout the island, while dust released from a rock crushing plant was causing localized damage to reefs nearby (until the plant closed following a hurricane in 1999). Unfortunately, the marine park's jurisdiction ends at the high water line and as yet it has been unable to properly address land-based problems. Ultimately, the success of the park will depend on controlling land-based activities as well as those in the sea.

Key lessons:

- Reserves run by NGOs can be highly successful.
- Income from tourists can provide much of the running costs for a marine park.
- Zoning of activities has minimized conflict and promoted a healthy marine environment.
- It is important to link management of the land and sea.

References: Roberts, C.M. and J.P. Hawkins, unpublished data; van't Hof 1991; Polunin & Roberts 1993; Web site: www.sabapark.com/

B. Hol Chan Marine Reserve, Belize

Success of pilot reserve stimulates development of a national reserve network

The Hol Chan Marine Reserve is situated approximately 4km south of San Pedro, a small but prosperous tourist town on Ambergris Caye, an island in the northern section of Belize's barrier reef. It was established in 1987 in response to a growing concern for the area's marine environment. Overfishing had seriously depleted valuable conch and lobster fisheries, and caused the disappearance of several species of large, easily caught fish. Mangroves were being cleared for development and increasing numbers of tourists were starting to have visible impacts on the reef, for example by breaking corals and collecting marine curios.

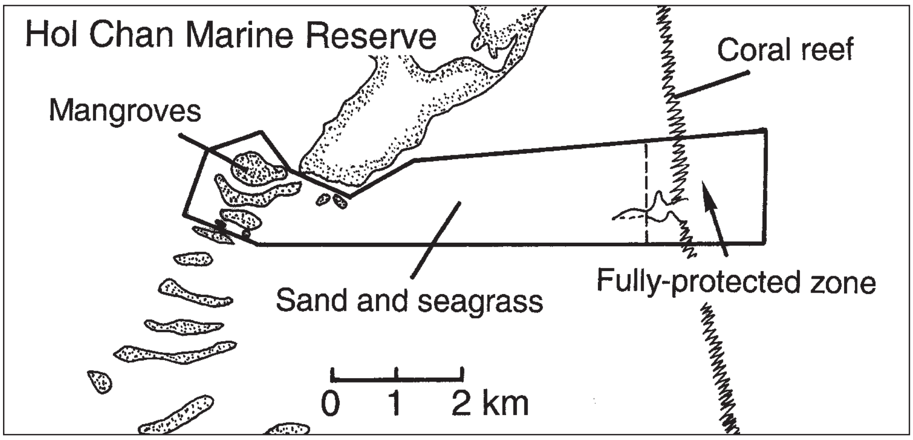


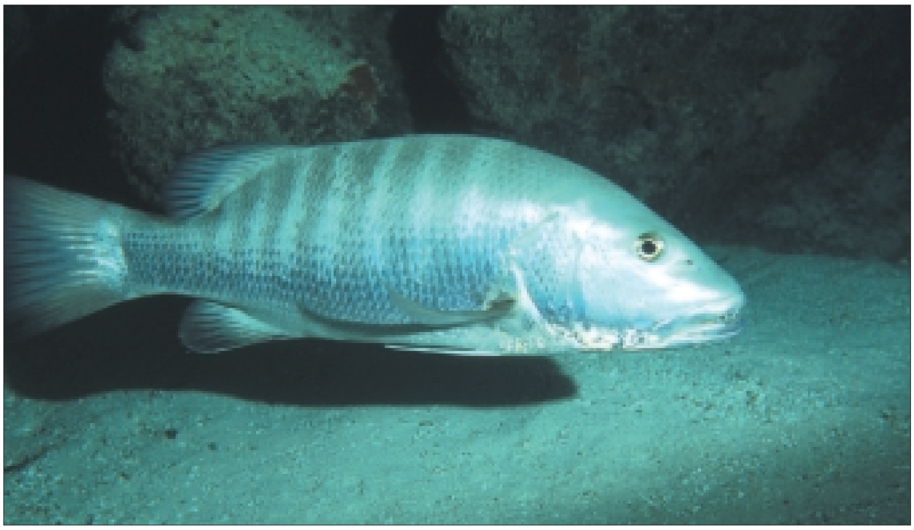
***Figure 18:* The Hol Chan Marine Reserve was one of the first in Belize to benefit from a fully-protected zone. However, only the coral reef and a small area of seagrass are encompassed by the fully-protected zone. The extensive mangroves, sand flats and seagrass beds in the remainder of the reserve receive less protection.**

The marine reserve was set up to encompass coral reef, seagrass and mangrove habitats and was zoned for different uses (Figure 18). Fishing activities are restricted throughout the reserve, but only banned in Zone A, a small fully-protected area of 2.6km^2. The fully-protected zone is centred around a channel that connects the lagoon with the outer reef. Even before it was protected, this channel was an excellent place for fish and because of this had become a key attraction for tourists. Although the channel was also a good spot for fishing it was felt to be more valuable as a tourist asset, and deserving of full protection.

'Walls' of fish can now be found inside the fully-protected zone. In the channel itself, fish schools are so dense that they literally obscure the reef. Build-up of fish biomass was exceptionally fast, partly due to immigration of large animals like groupers to the site. Four years after protection began the total biomass of commercially important, reef-associated fish was 50% greater at the edges of the fully-protected zone than in surrounding fished areas. In the central channel it was six to ten times higher! On average, 25% of reef fish species had significantly higher abundance, size or biomass in the fully-protected zone. Several species once favoured by fishermen were not present in fishing grounds but were found in the fully-protected zone. They included the gray snapper *(Lutjanus griseus),* black margate *(Anisotremus surinamensis),* and saucereye porgy *(Calamus calamus).* All but one commercially important species of fish was bigger in the fully-protected zone than in fishing grounds.

Densities of conch and lobster are also higher inside the fully-protected zone. For these species in particular, people 'fish the line'. That is, they fish close to reserve boundaries to get better catches. Spillover occurs when individuals from more closely packed populations in the reserve emigrate into the less densely-packed fishing grounds.

The Hol Chan marine reserve has overall been a great success. In addition to protecting marine life, it now attracts over 35,000 visitors a year. Many local people have given up fishing to take tourists snorkeling and scuba diving and this has further reduced pressure on reef fisheries. However, it has increased the need to protect the reef from tourists. Because the reserve is small there are problems caused by overcrowding and too many boats in the water. Damage is especially noticeable in the Hol Chan channel which is the most popular place of all. Here many corals have been broken and abraded by tourists. It is thought that a localized outbreak of black band disease, which occurred in the reserve in the early 1990s, might have been due to corals damaged by tourists becoming more susceptible to infection.



A large cubera snapper* (Lutjanus cyanopterus) *in the central part of the Hol Chan Marine Reserve, in Belize.

Efforts are now being made to educate tourists on how not to damage the reef, and several other reserves with fully-protected zones have been established to help divert tourist pressure away from Hol Chan. This is important because tiny fully-protected zones, within larger marine reserves where fishing is allowed, still mean that the greater part of the sea is essentially unprotected. A national network of fully-protected areas that is currently being developed in Belize should provide widespread benefits of the sort that the Hol Chan reserve has already achieved.

Key lessons:

- Recovery of fish and invertebrate communities from over-fishing can be extremely rapid where areas of high quality habitat are made into fully-protected reserves.
- Fully-protected zones can swiftly become tourism assets. This provides lucrative opportunities for fishers to cater for tourists.
- If fully-protected zones are very small, they may become overused by tourists, leading to habitat damage.
- It is important to have fully-protected zones representing all the different habitats included within marine reserves.

References: Polunin & Roberts 1993; Roberts & Polunin 1993b, 1994; Carter & Sedberry 1997.

C. Edmonds Underwater Park, Washington State, USA

Artificial habitats and voluntary protection have spectacular effects on marine life

The Edmonds Underwater Park hugs a small section of the shore in Puget Sound near Seattle on the west coast of the USA. It covers just 6.8 hectares of seabed and 3.3 hectares of intertidal, and on one side is bounded by a ferry terminal. The park was established in 1970 to provide a safe, high quality site for recreational scuba diving. When first established it covered only 75m of shoreline to the north of the ferry terminal, but in 1998 the boundary was extended northwards so the park now encompasses 550m of shore.

The Edmonds Underwater Park is remarkable in many ways. It is one of the longest-standing no-take marine reserves in the world. The site was first designated under a City of Edmonds local law that prohibited removal of any marine life from the park. Remarkably, that law was never enforced by the City. Instead, protection has been maintained voluntarily, and has become self-enforcing over time. A group of volunteer Park Stewards, have provided the first line of protection, and through their efforts, people have developed a protection ethic for the site. Compliance with no fishing regulations is maintained through peer pressure, even as fish stocks have built up over time. Locals simply feel it would be anti-social to catch fish in the reserve. Recognizing the park's success, protection has recently been reinforced by passage of a state law to back up the city's no-fishing regulations.

The Edmonds Underwater Park is intensively used for recreation. Although it is near the city of Seattle in Puget Sound, abuts a busy ferry terminal, and the 'habitat' within it consists mainly of human junk, the reserve supports spectacular populations of fish not seen in unprotected parts of the Sound.

Perhaps most surprising of all, the Edmonds Underwater Park consists almost entirely of artificial 'habitat'. The site was originally a dry dock that eventually fell into disrepair and began to attract divers. It was this dock that formed the kernel of the original, smaller area of the park. However, from 1972 onwards, additional features (human junk!) have been added and trails established to connect them. The 'habitat' now consists of all kinds of debris strewn accross the sandy bottom, from the ruins of an old mill to vehicles, sunken boats and cable. Despite this, the park

sustains much greater densities of rockfish and lingcod than fished habitats in Puget Sound. For example, after 25 years of protection, Palsson and Pacunski (1995) estimated that densities of copper rockfish *(Sebastes caurinus)* ranged between 9 and 25 times greater in the park than at fished sites. Average sizes of these fish are also higher in the park. Such differences are revealing. They show just how great the impact of fishing has been on populations of exploited fish in Puget Sound. The scale of those impacts is brought into sharp relief by the fact that artificial habitats close to areas of extensive boat traffic and coastal development have outshone natural habitats. A park consisting of artificial habitats can hardly be considered an accurate baseline against which to measure human impacts on the sea. Populations on undisturbed natural habitats might reach even greater levels.

The greater abundance and size of fish in the park provide a boost to their reproductive output. Palsson and Pacunski (1995) calculated that lingcod *(Ophiodon elongatus)* in the reserve produced 20 times more offspring than those in fished populations, while copper rockfish produced 100 times more. Such differences are striking and, even though the park is small, they are regionally significant. This tiny scrap of protected area produce as many young copper rockfish as 50km of fished shoreline in Puget Sound! There is also tantalizing evidence for a local effect of recruitment enhancement in adjacent fishing grounds by the reserve. A survey by Ray Buckley found that recruitment of these species was much greater in areas to the north and south of the underwater park than at other sites examined in the Sound. Either, habitats nearby are forming a sink for recruitment, or perhaps more likely, they are benefitting from reproduction by fish in the park.

Edmonds Underwater Park has proven far more valuable than just a means of keeping scuba divers happy. Scientists have used the opportunity to study the effects of protection from fishing, and their findings provide a deeper understanding of human impacts on the sea and how marine reserves can help reverse them. Although the park is tiny, its spectacular underwater life now attracts some 40,000 visitors a year. Despite such high levels of use, the artificiality of its habitats, its close proximity to Seattle and the adjacent ferry terminal, the reserve works well! It gives us a much needed insight into what could be achieved if protection were offered to larger areas containing more natural habitat.

Key lessons:

- Reserves can work without statutory law enforcement if there is strong community support and education.
- Reserves that are protected from fishing can work well in unpromising places.
- Pilot reserves can teach us much about the extent of human impact on the marine environment.

References: Palsson & Pacunski 1995; Murray 1998.

D. Soufrière Marine Management Area, St. Lucia

Participatory management leads to rapid benefits from no-take reserve network

The Caribbean island of St. Lucia is renowned as a tropical paradise and the town of Soufrière, with its seven thousand inhabitants, lies in a prime location on the south-west coast. Its magnificent coastal scenery, sandy beaches and beautiful coral reefs attract thousands of tourists every year. However, in contrast to the growing prosperity of the tourism industry, life for the fishers of Soufrière was becoming increasingly difficult. Decades of population growth had led to intensifying fishing effort and dwindling catches. By the mid-1980s, a fisher might have to work all day to secure a handful of undersized fish that would have been dumped over the side twenty years before.

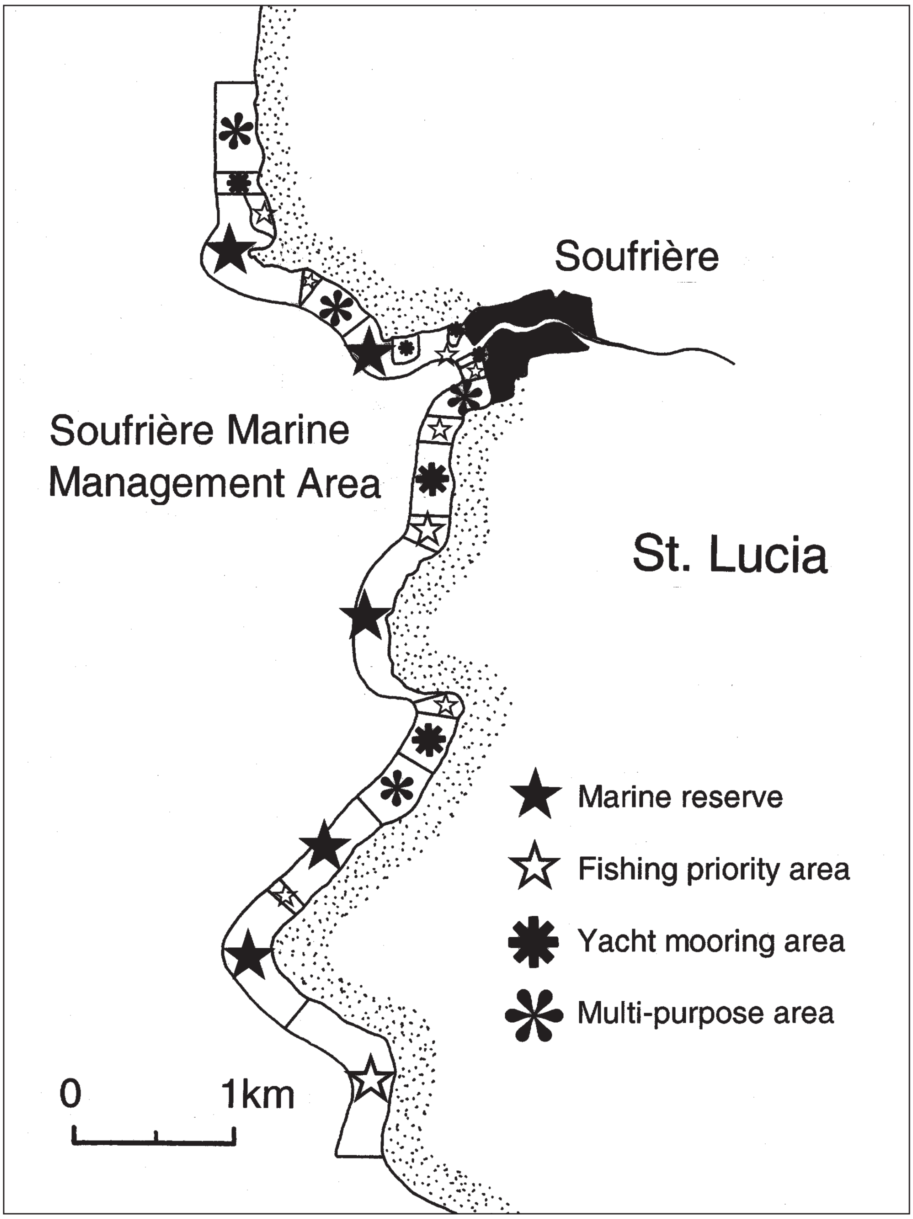


Figure 19. ***Zonation map of the Soufrière Marine Management Area, St. Lucia.***

Around this time, the St. Lucian government moved to establish a country-wide system of 19 marine reserves to protect marine habitats from impacts such as overfishing. However they failed to properly consult the fishers over their plans or to adequately fund this initiative. Unsurprisingly, this first scheme was doomed to failure and the reserves were ignored.

View across the bay of Soufrière and the Pitons in St. Lucia. This area forms the centre of the 11km long Soufrière Marine Management Area.

By the early 1990s, life had become even worse for the fishers of Soufrière. Their catches were still declining and they felt their attempts to fish were being hindered by an ever increasing number of tourists. Seine fishers complained that yachts were getting in the way of them hauling their nets, while trap fishers accused divers of deliberately damaging their gear. The time was ripe for change and, seizing the opportunity, the Department of Fisheries spearheaded a process of participatory community management for the seas around Soufrière. All local stakeholders including fishers, diving operators, hoteliers and representatives of the yachting community, were brought together to air their views and work out their problems. After three years of effort, the end result was a comprehensively zoned management plan for 11km of Soufrière's coastline: the Soufrière Marine Management Area (SMMA).

The management plan for the SMMA was implemented in 1995 and has two key objectives: (1) to rebuild fish stocks and restore fishery productivity, and (2) to separate conflicting activities. At the heart of this plan is a series of four no-take zones interspersed between fishing areas (Figure 19). The reserves cover roughly

35% of the area of coral reef habitat in the SMMA. By promoting the build up of fish stocks, the reserves were expected to contribute to fisheries, create a spectacular attraction for divers, and reduce conflict by separating tourism from fishing. People are still allowed to dive and fish outside marine reserves in ‘multiple use areas’ but fishers also have their own ‘fishing priority areas’, where they are the primary users. For yachters there are three designated areas for mooring, equipped with mooring buoys.

Healthy populations of herbivorous fish, like this stoplight parrotfish* (Sparisoma viride), *in Soufrière’s fully-protected zones help prevent algae from overgrowing the reef.

To be successful, measures such as these require a combination of strong management and community support. The SMMA is a non-governmental organization responsible for enforcing the management plan. It has a staff of seven people including four park wardens who make daily patrols by boat. Part of the running costs of the SMMA come from user fees paid by divers and yachters. Anyone found violating the no-fishing regulations can be fined or have their gear confiscated. In practice, continuous education and positive reinforcement have proved far more effective than punishment for maintaining no-take zones. However, not everything worked to plan. The trap fishers, who were formerly the main users of the no-take zones, felt they had not been properly represented in the negotiations leading to establishment of the SMMA. Some continued to fish in these zones, putting the whole system in jeopardy. In the end, a compromise was reached which allowed a few of the oldest fishers, people who had no alternative employment opportunities, to fish in part of one of the no-take zones. In addition, they were given one year’s compensation of US$150 per month not to fish in the no-take zones. This helped tide them over the difficult period where they had lost fishing grounds but stocks in reserves had not yet built up sufficiently to improve catches in fishing areas. The compensation was very popular and eliminated almost all illegal fishing.

One of the most important factors in maintaining support for no-take zones has been to keep fishers and other stakeholders informed about how they are performing. Results of annual surveys of fish and corals collected by a team from the University of York in England show reserves are working very well indeed. After only three years of protection, the biomass of commercially important fish in no-take areas has tripled compared to what it was before the SMMA was established. Most importantly, it has doubled in adjacent fishing areas. In fact the fishermen have obviously noticed an effect from the reserves because the most popular fishing sites have begun to shift toward the boundaries of the no-take zones. Even in the no-take zone where some trap fishing was later allowed, the biomass was still higher than in sites with no protection. This is an important finding since it shows that even partial protection can still produce some benefits.

The increase in biomass has also been reflected in more bigger fish within protected areas, and no-take zones are becoming increasingly popular with divers and snorkelers. Protection from fishing has also benefited biodiversity, with a 20% increase throughout the entire management area in the number of fish species observed per count in annual censuses. This is a result of increased fish abundance, not the return of species that had been eliminated by fishing. Soufrière still lacks the large groupers and snappers that are common on unfished reefs elsewhere in the Caribbean. Hopefully they will eventually return if adequate protection is maintained.

One of the most immediate successes of Soufrière's management plan has been the reduced conflict between tourists and fishers. After all the long negotiations between the different users, a mutual respect for each other's territory has now been established. In fact, many people now have interests in both fishing and tourism as more fishers take advantage of the economic opportunities offered by tourism. Some turn their hands to construction and fish only part time while others turned their boats into water taxis and gave up fishing as a livelihood. However, fishing is in the blood in St. Lucia and many a tourist is kept waiting while their water taxi driver helps friends haul in a seine net in exchange for a small share of the catch!

Key lessons:

- Community participation is vital if no-take zones are to be effective. It is essential at the outset of the management plan to identify and include all the different stakeholders.
- If no-take zones cover a sufficiently large proportion of the area, are interspersed with fishing areas, and there is good compliance with no-take regulations, the benefits of marine reserves can build up very rapidly.

References: George 1996; Roberts, C.M. & J.P. Hawkins, unpublished data.
Web site: www.smma.org.lc/

E. Anse Chastanet, St. Lucia

Even tiny reserves can provide benefits if well protected

In the mid 1980s, the government of St. Lucia attempted to create an island-wide network of marine reserves to protect the country's coastal resources. On the whole, this proved unsuccessful due to a lack of funding and insufficient consultation with local users. More details about the initiative and its subsequent accomplishments are provided in the Soufrière Marine Management Area (SMMA) case study. Here we look in detail at one particular no-take area near the town of Soufrière on the west coast, the Anse Chastanet Reserve. This reserve was one of those designated as part of the government's original network, and was later incorporated into the SMMA in 1995.

In the original network design, the Anse Chastanet Reserve encompassed 12 hectares, and surrounded a headland which sheltered a beach backed by the luxury Anse Chastanet Hotel. This reserve would have remained a 'paper park', like most of the others, except that in 1992 the hotel instigated protection of a small area of reef used by its guests for snorkelling and diving. This area covered only 150 x 175m (2.6 hectares) and was marked off by buoyed ropes. Although it was much smaller than the government had intended, the fact that any protection existed at all was entirely due to efforts by the hotel. The buoyed off area provided a safe haven for swimming, snorkelling and diver training and also kept the fishers out. If fishers did try to use the area they were asked to leave by hotel staff and, together with the fact that so many dive boats and water taxis operated in the area, most fishers were persuaded that it wasn't worth the trouble to fish there. Hence, by the time the Soufrière Marine Management Area was set up in 1995, there had already been a *de facto* no-take zone operating at Anse Chastanet for three years.

View over the Anse Chastanet marine reserve, which lies within the Soufrière Marine Management Area. This picture encompasses most of the area that was protected by the Anse Chastanet hotel from 1992 to 1995, prior to the implementation of the Soufrière Marine Management Area.

Despite the reserve's tiny size, benefits from cessation of fishing accumulated rapidly. By 1995, biomass of commercially important fish species was more than double that present in adjacent areas of similar habitat (Figure 20). In particular the biomass of predatory snappers (Lutjanidae), a group highly vulnerable to the effects of over-fishing, was very high there. For both predators and herbivores alike, the reason the biomass was much greater inside the reserve than out was primarily because fish in the reserve were significantly larger than those outside. The abundance of fish was only significantly greater in the reserve for two families: parrotfish (Scaridae) and snappers.

One particularly telling feature of this reserve was that even species that had the capacity to be highly mobile benefitted from protection at Anse Chastanet. Three large species, the mutton snapper *(Lutjanus analis)*, and the Spanish grunt and Black Margate *(Haemulon macrostomum and Anisotremus surinamensis)* were found nowhere else along the Soufrière coast but were present within this tiny reserve. These species are easily caught by fishers but have managed to persist with the help of only a small, well-protected no-take zone.

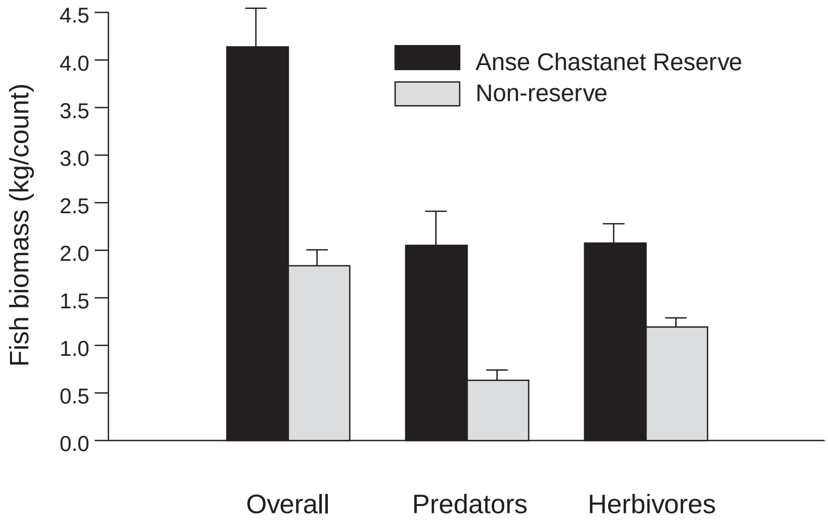


***Figure 20:* Differences in biomass of commercially important fishes between the Anse Chastanet reefs and similar adjacent fished reefs, after three years of effective protection in 1995.**

The Anse Chastanet reserve also shows the vulnerability of small protected areas. In 1996, after the full reserve system of the SMMA had been in operation for one year, the biomass of fish actually fell by 20% in the Anse Chastanet reserve. This was caused by "protest fishing" shortly after the SMMA was established and was done by those who opposed the idea of no-take zones. Some started setting their nets inside the reserve, others began fishing at night with hook and line, and one individual spear fisherman repeatedly violated the law. The protest didn't last long and was confined to only a few fishers, but it had an impact.

By 1998 the social problems underlying opposition to the SMMA had been more or less resolved, and for nearly two years virtually full protection was re-established at the Anse Chastanet Reserve. During this time fish biomass recovered to a level higher than the peak reached in 1995 (Figure 21). Turtle Reef, a patch reef within the reserve, now supported the largest and most spectacular schools of snappers in St. Lucia. This shows that even if no-take compliance does break down, benefits can be recovered once protection is reinstated. How quickly this happens obviously depends on how bad violations were, how long they went on for and what state the fish stocks were in before the problems started. In the case of Anse Chastanet the poaching was sufficiently light and short-lived, and stocks good enough for recovery to be very rapid.

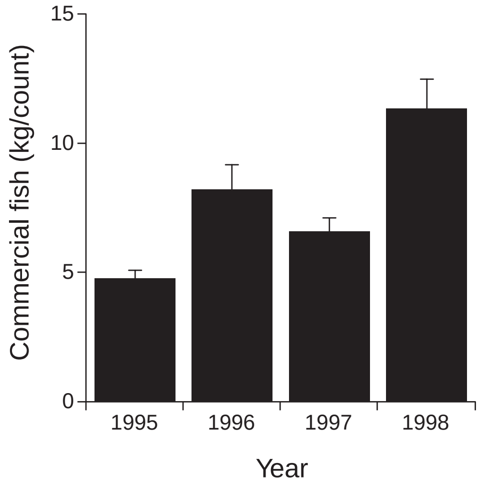


***Figure 21:* Changes in biomass of commercially important fishes inside the Anse Chastanet reserve over time. Biomass fell in the year after the creation of the Soufrière Marine Management Area due to protest fishing. However, protection was reinstated in late 1996 and has continued since then.**

Key lessons:

- Even a very small marine reserve can show rapid benefits when protected from fishing.
- Small reserves can protect surprisingly large and mobile species.
- Local initiatives, for example by hotels, can help protect marine habitats.
- Small reserves are especially vulnerable to poaching.

Reference: Roberts & Hawkins 1997. Web site: www.smma.org.lc/

F. De Hoop Marine Protected Area, South Africa

Reserve that links land and sea provides many benefits

De Hoop lies in the warm temperate zone of the Western Cape Province and is the most southerly marine reserve on the African continental shelf. It was proclaimed a marine protected area in January 1985. The reserve measures 50 km along the shore and extends three nautical miles seaward. The intertidal area comprises sandy beaches, wave-cut sandstone platforms and rocky headlands. Vast quantities of sand are continuously shifted from the land to the sea and vice versa, covering and uncovering reefs over periods varying from days to years. The sub-tidal habitat includes low profile sandstone reefs and soft sediment.

All habitats adjacent to the reserve are heavily exploited. The target fisheries include: (1) inter-tidal shellfish collection by subsistence and recreational fishers (targets at least six species), (2) beach seine fishery (targets mullet), (3) recreational shore-angling (targeting 30 species of fish), (4) squid fishery (targets spawning aggregations of *Loligo* species), (5) inshore trawl fishery (targets hake, horse mackerel, kingklip, and sole plus substantial by-catch), (6) line fishery (targets 17 fish species), (7) longline (targets hake), and (8) pelagic purse-seine (targets pilchards). The De Hoop reserve therefore provides valuable protection for over 60 directly exploited species.

De Hoop is Africa's most southerly marine protected area, encompassing rocky and sandy inter-tidal, subtidal sandstone reefs and soft-bottom environments. It is backed by an adjacent terrestrial protected area. Photograph by Colin Attwood.

For the past 14 years, scientists have studied how fish stocks in the surf zone of the reserve respond to protection and if it improves fishing in the adjacent areas. Since it is impossible to conduct dive surveys in the surf zone, abundance has been measured as catch per unit effort (CPUE). A research team also tagged and released fish to study their growth and movement patterns in relation to the reserve. There is good evidence that eight species of fish, most of them bream (Sparidae), have recovered well within De Hoop. Their CPUE was considerably greater in the protected area than in similar habitats outside (Figure 22), and the difference suggests that the total number of commercially important fish in De Hoop is at least ten times higher than in fishing grounds. Mean fish size and age is also greater in the reserve, although for some vulnerable species even small fish are uncommon in the fishing grounds. Any large fish of these species present in fishing grounds may have moved there from the reserve.

The tagging study demonstrates that fish leave De Hoop to move into fishing grounds. Some fish species show great site-fidelity but populations of others, such as galjoen *(Dichistius capensis)* and some bream, contain individuals that will migrate long distances. Other species undergo predictable migrations between spawning grounds and feeding areas. The De Hoop reserve is well placed to protect many species of juvenile fish which stay there to feed until they reach maturity. Examples among bream include white steenbras *(Lithognathus lithognathus)*, red steenbras *(Petrus rupestris)*, musselcracker *(Sparadon durbanensis)* and poenskop *(Cymatoceps nasutus)*. South Africa has over 40 species of bream, most of them endemic, and several such as the white steenbras are seriously over-exploited. Fully-protected marine reserves are vital to protect the diversity of this particular family.

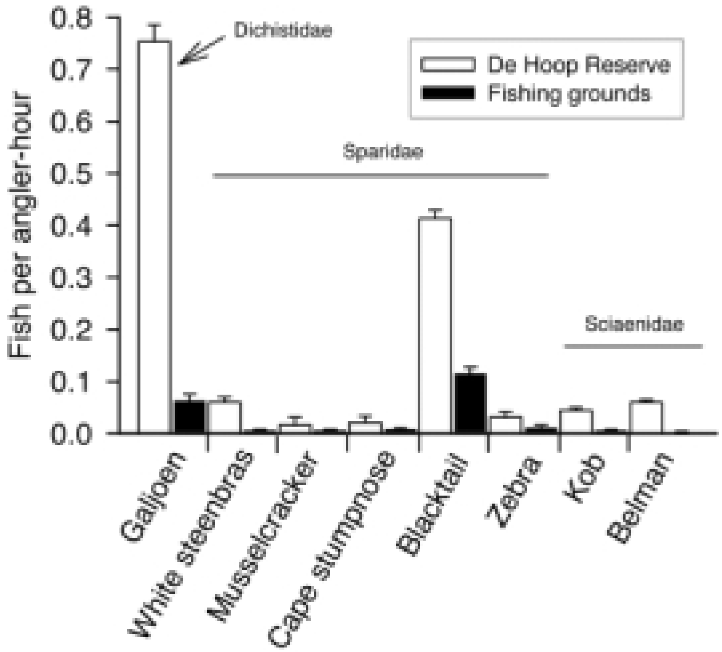


Figure 22: ***Catch per unit of fishing effort, a measure of fish abundance, of eight fish species was considerably greater in the De Hoop Marine Reserve than in similar habitats nearby that remained open to fishing. The samples were collected over a period spanning between 8 and 13 years of protection in the reserve. Samples inside the reserve were from experimental fishing by researchers, while those in unprotected areas came from analysis of recreational anglers catches. Colin Attwood, unpublished data; reproduced with permission.***

In a comparison of the reef topography, sea bed and fish communities of De Hoop with an unprotected area over a period of 8 years, it emerged that protection from fishing was more important in determining fish abundance, than any other biological, geological or physical factor studied.

To help fishers appreciate how well marine reserves can function, 'guest' anglers have been taken out on field surveys, to see for themselves how effective protection can be. This has had enormous impact, causing them to change their attitudes and become supportive of marine protected areas.

The De Hoop reserve also helps mitigate other problems threatening the coast. For example it is a monitoring site for plastic litter that is increasing throughout the region, and which mainly originates from fishing and shipping industries. It provides a buffer against coastal development which is proceeding rapidly in the area due to its popularity for recreation. In fact De Hoop is the seaward extension of a terrestrial reserve against which it abuts (in combination protecting an area of 50 x 15 km). The land reserve protects highly diverse but threatened vegetation, and includes remains of archaeological interest.

De Hoop is widely used for education and approximately 70 schools visit the reserve to learn about terrestrial and marine conservation. It is also one of the best shore-based whale-watching sites in the world, where people can observe the 200 or so southern right whales *(Eubalaena australis)* that return to mate and calve there every year. With so much to offer eco-tourists, De Hoop has become a popular attraction. It provides an excellent example of how terrestrial and marine conservation can be integrated.

Key lessons:

- Reserves are highly effective in protecting stocks of commercially important fish in South Africa, including endemic species.
- Fully protected marine reserves provide vital refuges for overexploited species.
- Species which don't normally move far will spillover to fishing grounds.
- Taking anglers out on research trips helps them to understand the effects of their activities and spread the message about reserve effectiveness through the fishing community.
- Adjacent marine and terrestrial reserves can complement each other to provide more effective biodiversity conservation.

References: Bennett & Attwood 1991; Attwood & Bennett 1994.

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G. Barangay Lomboy and Cahayag fish sanctuary, Pangangan Island, Philippines

Unforeseen circumstances undermine reserve effectiveness

From 1960 to the 1980's coral reefs of Calape Bay in the Philippines were fished with dynamite. Every day there would be about twenty blasts with each one killing around 200 kilograms of fish. Local residents of the barangay Lomboy did their fishing with hook and line, not dynamite, but tolerated the practice because there were plenty of fish and the dynamiters left shares of their catches for the community. However, by the late 1980's locals were seeing their catches fall dramatically. Previously a hook and line fisher could expect to land about 15 kilos of fish a day, but that went down to two or three kilos or even nothing at all. People were beginning to realise the damaging consequences of blasting a reef with dynamite.

In early 1991 a group of conservationists visited Calape Bay and suggested a community-based fish sanctuary could help rectify some of the problems that dynamiting had caused. The Lomboy village head, Benjamin Cuadrasal, thought this was a good idea and tried to set one up in his barangay. However, he was met with considerable opposition, as most people did not appreciate the potential improvements a marine reserve would bring. They could not see beyond the problem of lost fishing area and were afraid a sanctuary would further reduce their catches. As elections were approaching, the village head did not pursue the idea.

Lomboy fishers construct a guardhouse for their marine sanctuary. Close surveillance is important to help prevent poaching. Photograph by Stuart Green.

It was not until several years later that government representatives from the Department of Environment and Natural Resources (DENR) started a coastal environment program (CEP) to set up marine reserves. The re-elected village head helped them run a series of community workshops and take people to provinces where fish sanctuaries were already in operation. These visits were incredibly successful in helping people understand the benefits a sanctuary could provide. In March 1995 the Lomboy-Cahayag Fish Sanctuary was established with the full support of local people. It covered 8.6 hectares and was located in a place that village elders remembered as a fish spawning ground.

Initially all went well and the sanctuary flourished. However, in 1996 an outsider set up two large fish corrals alongside the sanctuary boundary where he began to catch large amounts of fish. These corrals were not illegal and the owner refused to take them away. Locals could only watch as he continued to catch large quantities of fish, probably originating from their reserve. After one and a half years of bitter legal fighting the law was eventually amended to include a buffer zone around the sanctuary. Only certain types of fishing were to be allowed within this area, and these did not include maintaining a fish corral!

In 1997 a group was established to assess social and biological effects of the fish sanctuary. Results showed that between 1997 and 1998 hard coral cover increased from 7% to 17% inside the sanctuary whereas it decreased from 30% to 18% outside. There was also a marked decrease in sand from 48% to 9% inside the sanctuary and an increase in rock cover from 29% to 45% outside. However, there were few food fish in the sanctuary, some wrasse, parrotfish, eeltail catfish and fusiliers, but the community was dominated by damselfishes and fairy basslets.

When the community were told about these findings, it came to light that certain individuals had been fishing in the sanctuary. This had started during the corral problem, when despondency had caused people to be less vigilant about guarding the sanctuary. It had also tempted others to fish illegally at night. People justified this behaviour on the grounds that an outsider was already stealing their fish. As a result of these revelations a sanctuary management committee was formed. The committee aimed to increase vigilance against illegal fishing and promote support and raise funds for the sanctuary.

After the management committee was set up, the sanctuary began to show considerable improvements. Fish stocks increased in abundance and diversity and there are now more large individuals around (Uychiaoco et al. 1999). The community has learned not to take the sanctuary for granted and to tackle problems as they arise. It has become a "showcase" for communities interested in setting up their own sanctuary and a further three have been established in the area.

Key lessons:

- Communities must have a thorough understanding about the purpose of a marine reserve.
- Local leaders can help persuade people about reserve benefits, but their effectiveness will be constrained by political climates.
- Creating fish sanctuaries is not the end to a problem - they are the start of a never-ending, full time job.
- Thorough planning is essential prior to implementing a protected area.
- Local communities require regular feedback on the effectiveness of a reserve.

References: Uychiaoco et al. 1999.

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H. The Galápagos Marine Reserve, Ecuador

From management conflicts to community-based management

The unique biology and historical importance of the Galápagos Islands attract tourists from all over the world. They provide important revenue for Ecuador and are a source of great national pride. The Galápagos National Park was created in 1959, and the archipelago was designated as one of the first natural World Heritage Sites by the United Nations Educational, Scientific and Cultural Organization (UNESCO). A marine reserve was declared in 1986, but this had no management plan and received no protection.

The stark beauty of the Galapagos islands. If Charles Darwin had been able to scuba dive he would have found a spectacular and unique underwater biota just as impressive as that he described from land!

In 1992 a management plan was developed, but locals were not involved and it was never implemented. Part of the problem in getting management established was due to the fact that two different government agencies had responsibility for the marine reserve. Bureaucratic conflicts delayed progress in protection and over-exploitation increased during the 1980s. In particular, intensive and highly lucrative fisheries developed for shark fins and sea cucumbers which threatened to cause local extinctions and reduce marine biodiversity. Both fisheries were new to the Galápagos, but developed rapidly in response to huge demand from Asian markets.

In 1996 a participatory management approach was initiated which gave local stakeholders the opportunity to help develop a management agenda for the Galápagos Marine Reserve. At the same time a "Special Law" was devised to provide a legal basis for these agreements. In January 1998, through the Galápagos Special Law, the Ecuadorian parliament approved a series of important protective measures for the islands. The new law placed the marine reserve under the jurisdiction of the National Parks Service, and extended its limits to 40 nautical miles from the archipelago's baseline (a line joining the outermost points of the outer islands). Industrial fishing by mainland and foreign fleets was banned, and only locals could fish within the newly designated 140,000km^2 reserve. The law also required that 50 percent of revenue generated from tourists be invested in local biodiversity conservation.

The Galápagos Marine Reserve will now be zoned into areas permitting different activities. Examples of the categories to be used include "scientific use only", "no fishing but tourism and recreation allowed", and "fishing, tourism and recreation allowed". A new participatory management body will decide how much area should be included in each type of zone and where to put them. Following this, zones will be set up for an experimental two year period, with the possibility of extension to four years, while their effects on wildlife and people are evaluated. Following review of these outcomes and possible amendments to the scheme, the zoning is expected to be made permanent.

The zoning scheme provides a great deal of flexibility in the level of protection and type of management that can be applied. For example, staff at the Charles Darwin Research Station and Galápagos National Park Service have proposed a zoning scheme that will represent all habitats and biogeographic regions of the archipelago in the two categories of no-take zone. Their scheme would protect 36% of the total length of the coastline, up to a distance of two miles offshore, from fishing.

The way these zones are distributed will ensure that fishery benefits are spread around the entire archipelago. This should offer the prospect of recovery for overexploited stocks such as the Bacalao (*Mycteroperca olfax*, a large grouper) and sea cucumbers. Theoretical studies of reserves suggest that a closure of 36% will produce a high level of long-term benefit to fisheries. In the Galápagos, a large closure is particularly important because the islands are isolated and subject to extreme environmental variability. Both these factors call for a precautionary approach to management and the no-take zones will help provide resilience against environmental fluctuations. However, the proposed zoning scheme does not offer an equivalent level of protection to offshore areas, leaving important habitats unrepresented in zones giving the highest level of protection.

The design of a monitoring programme is still being developed, as are the measures by which success or failure will be judged. However, at present there are plans to assess reserve effectiveness after only two years of closure, with a mind to re-opening some if they fail to perform. Experience of establishing and monitoring reserves elsewhere in the world indicates that few biological effects can be convincingly demonstrated in only two years of protection. Although it is likely that fish populations will increase within no-take zones, it is very unlikely that catches will improve over such a short time. Furthermore, the zoning scheme is intended to

Fisheries are very species-specific in the Galapagos. Bacalao* (Mycteroperca olfax) *are highly sought after and becoming rarer, while yellow-tailed surgeonfish* (Prionurus laticlavius) *are not targeted and still extremely abundant.

secure the long-term sustainability of fisheries and conservation of biodiversity in the Galápagos and measures of short-term effects on ecosystems and society are unlikely to reflect the eventual benefits of such a scheme.

The zoning scheme also has one other problem: a lack of staff and resources to implement protection. This means that enforcement will be limited and much effort will be needed in community education to build compliance and support. However, the small population of the Galápagos and the significant advances in participatory management make this a realistic goal.

Key lessons

- If protection is to be effective, management agencies must have clear jurisdiction over resources.
- Management must have the flexibility to address unforeseen threats such as the development of new fisheries.
- Building consensus takes a real commitment of time and resources but as trust grows, diverse stakeholders can achieve complex tasks such as formulating management plans.

References: World Wildlife Fund 1998; Roberts 1999; Heylings & Cruz in press.

Further Information: Fundacion Natura and WWF produce an annual "Galápagos Report", available in Spanish and English, providing detailed assessments of the status of the islands' marine and terrestrial biodiversity. Visit the website of the Charles Darwin Research Station at www.polaris.net/sui/jpinson/pml/root.html, the Galápagos Coalition at www.law.emory.edu/PI/GALAPAGOS/ and the Galápagos Conservation Trust at www.law.emory.edu/PI/GALAPAGOS/TrustConservation.htm

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I. The Mombasa Marine National Park, Kenya

Fully-protected marine park restores ecosystem health and fisheries

The Mombasa Marine National Park covers 10km^2 and was set up in Kenya in 1987. Despite legislation, it took several years for the park to become functional. Fishers remained in the area until 1991, and poaching continued to be a problem until 1992 when night-time patrols finally brought it under control. Hence, although

Kenyan fisher in a traditional dhow. In the area to the south of the Mombasa Marine National Park, only traditional fishing methods are permitted. Photograph by Tim McClanahan.

fishing pressure began to decline from about 1989 onwards, it was not until 1992 that the park became truly protected from fishing. When the marine park became fully-protected from fishing, restrictions were also implemented in the area immediately to the south, called the Mombasa Marine Reserve. Here fishing is limited to traditional techniques, with only traps, gill nets, and handlines allowed. However, once again the new regulations were slow to take hold and were not properly adhered to until 1994. Figure 23 shows a map of the area.

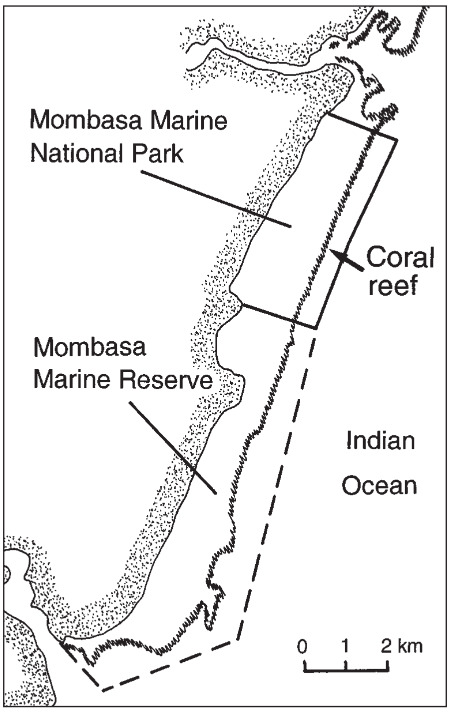

Figure 23:* *Map of the Mombasa Marine National Park in Kenya.

Between January 1991 and December 1994 the number of fishers using the Mombasa Marine Reserve fell by 68%, because they preferred to go elsewhere, or stop fishing altogether rather than crowd into the reserve. The number of fishers per unit area remained almost the same because 63% of their fishing area had been incorporated into the fully-protected park. As a consequence of this lost fishing ground, the catch of bottom-living fish fell by 35%. However, this drop was much less than the percentage decrease in fishing area because the over-all catch per unit effort (CPUE) increased by 110%, from 20kg/person/month to 43kg/person/month. The increase for coral reef fishes alone was 74%.

Over time these initial increases in CPUE were not maintained, because in 1994 bans on the more effective fishing gears like spear guns were enforced. However, over time, as stocks improve CPUE for the remaining gears should increase to a level higher than before the park was protected.

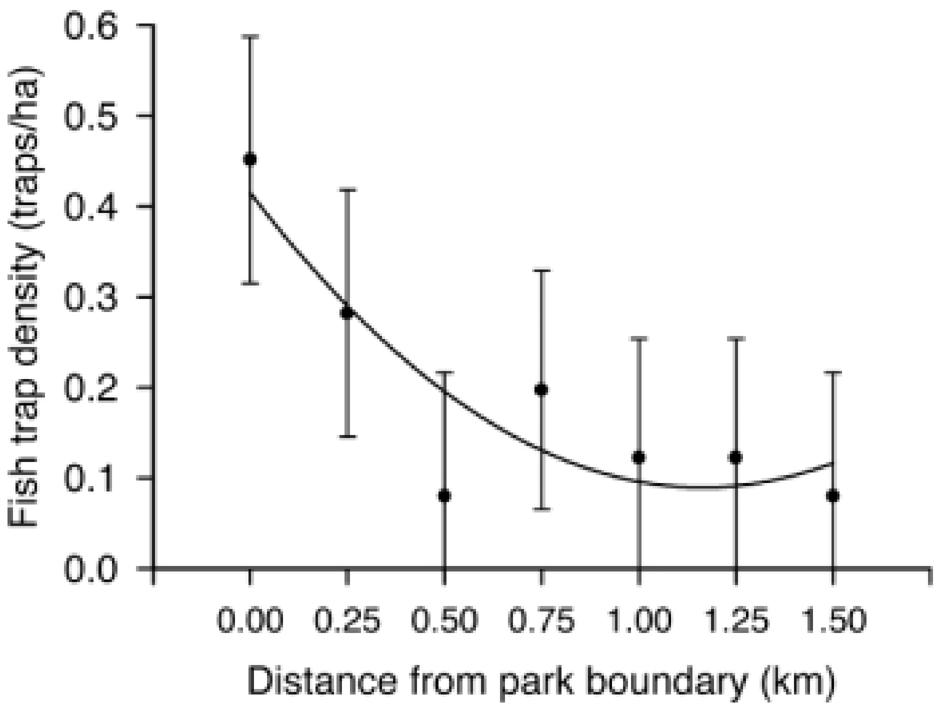

Figure 24: ***Since the creation of the Mombasa Marine National Park, catch per unit effort of fish traps has increased. The highest catches are now obtained close to the reserve boundary, suggesting spillover from reserve to fishing grounds. Redrawn from McClanahan & Kaunda-Arara (1996).***

In 1994, three years after full protection, fish biomass within the marine park was estimated to be approximately1600 kg/ha compared to only 300 kg/ha in fishing areas. Fishing areas lacked large sized fish in all families. At first glance, this differential suggests that fishers are not benefitting from the fully-protected zone, whereas in fact they are. At park boundaries CPUE in 1993 was 25% higher than elsewhere in the fishing grounds. Consequently, fishers are targeting these areas with higher densities of traps (Figure 24), and prime fishing spots close to the park boundary are restricted to the most senior fishers. Although densities of fish are not increasing in fishing grounds, the fact that CPUE is greater approaching reserve boundaries suggests that catches are being supplemented by spillover from the fully-protected zone. This spillover of fish does not penetrate far into fishing grounds because it is captured close to the boundary.

The benefits of marine protection in Kenya do not end with increased CPUE for fishers. Tim McClanahan, a scientist who has spent years studying African coral reefs, has concluded that fully-protected reserves are vitally important in preventing the destruction of Kenya's coral reefs by grazing sea urchins. In areas of high fishing pressure, populations of sea urchins are many times higher than in fully-protected zones. This is because intensive fishing removes key predators of sea urchins such as triggerfish and emperors. Without them sea urchin numbers can explode, leading to intensive grazing on the reef. Their scraping mouthparts erode the reef and reduce coral cover. At such grazing intensities the very framework of the reef begins to erode. Degraded reefs support fewer fish than healthy ones. Furthermore, high densities of urchins can also out-compete fish herbivores for food and so reduce the number of these fish that the reef can support. Hence, because of its indirect effect on sea urchins, intensive fishing has not only removed target species but led to processes which have further reduced the amount of fish to catch. Areas closed to fishing help restore a healthier ecosystem state and improve catches.

Key lessons:

- It is often necessary to patrol reserves at night to control illegal fishing.
- Catches are enhanced close to the boundaries of no-take zones through spillover.
- Closing areas to fishing protects against unforeseen, harmful effects of over-exploitation on marine ecosystems, and can help restore areas where such effects have occurred.

References: McClanahan 1994; McClanahan & Kaunda-Arara 1996.

J. The Leigh Marine Reserve, New Zealand

Pioneering reserve reveals the benefits of protection from fishing

The Leigh Marine Reserve is situated on the rocky coast of New Zealand's north island. It is a small reserve, covering 5.2km^2, and extends 800m from the shore. It was one of the world's first reserves to be closed to fishing and was protected in 1977 after more than a decade of community effort. The initiative was taken by scientists working in the Leigh Marine Laboratory. They had become concerned that spearfishers and people collecting along the shoreline and shallow sub-tidal habitats were having too great an impact on the ecology of the area. As well as threatening the environment, they felt these activities compromised their ability to do good science.

In 1965 the scientists from Leigh began a tireless campaign to gather support for a fully-protected marine reserve, targeting schools, diving clubs and the general public. Local divers were easily persuaded as they too felt that marine life was rapidly disappearing. Other support came more slowly and cautiously, with 17 official objections raised before protective legislation was finally passed. Concerns included (1) doubts about the scientists' integrity, (2) an unwillingness to believe that over-exploitation was actually happening, and (3) suspicions that local people would be unable to use the reserve for recreation. Twelve years of effort in community education could not completely take away all these niggling doubts and insecurities. It was not until the reserve had been up and running for a number of years that almost universal approval was achieved.

Setting up the Leigh reserve had been a contentious issue. However, once the legislation was finally passed, many people began to lose interest in it. Because it had primarily been established for scientific research, they felt it now had little to do with them. After a few years, scientists began recording changes in populations of commercially-important species within the reserve and this soon interested a lot of people. For example, the density and size of rock lobster *(Jasus edwardsii)* were increasing rapidly, while populations of snapper *(Pagrus auratus)* and red moki *(Cheilodactylus spectabilis)* were also doing well. By the mid 1980s, scientists concluded that the Leigh reserve was helping replenish fishing grounds for rock lobsters. Fishers started to preferentially set their traps along the reserve boundary, feeling this was the place they would get the best catches. They also began to report illegal poaching. This was a sure sign that people recognized the benefits of the reserve and would not tolerate others jeopardizing them.

Throughout the 1980s an increasing number of people began to visit the Leigh reserve. In the summer of 1984 it attracted around 14,000 tourists. By 1994 that number had risen to 100,000. As tourism grew, amenities such as dive shops, cafes, camp grounds, glass bottom boat operations and a marine education centre also developed. People were attracted to the reserve by stories of abundant, easily approachable marine life and went there to dive, snorkel and swim. However, because there is only one access point to the reserve, this spot often becomes over-crowded. It is also a place where people liked to feed fish. At the moment, scientists are not too worried that visitor use is threatening marine life or their research because tourists are highly concentrated into one specific area comprising about 5% of the reserve. However they do feel that tourists are affecting the behaviour of certain species of fish.

The Leigh Marine Reserve has become an inspiration to people worldwide. The experience at Leigh, and the campaigning efforts of one of its founders, Bill Ballantine, have made the scientific community and public aware of how important reserves are.

Key lessons:

- Even an extensive public education campaign cannot allay all misgivings about a fully- protected reserve.
- Support for a fully-protected reserve will increase once it is operational and people can discover their fears were unfounded.
- When fully-protected reserves start showing positive results, local fishers help police them voluntarily.
- Abundant, easily approachable marine life attracts visitors to reserves which boosts the local economy.

References: Walls 1998; Ballantine 1991; Babcock et al. 1999.

K. Marine Reserves in Tasmania, Australia: Governor Island, Maria Island, Tinderbox and Ninepin Point

Reserves reveal how fishing has transformed marine ecosystems of southern Australia

In late 1991, four fully-protected marine reserves were declared on the east and south-east coast of Tasmania, Australia. The largest, at Maria Island, covers 7km of coast. This reserve includes many marine habitats typical of the east coast and was established to conserve a broad range of biodiversity. Ninepin is smaller, only 1km long, and was designed to protect a single, unusual habitat. The two other reserves, Tinderbox and Governor Island are 2km and 1km long respectively, and were declared to promote recreation. Although the reserves were set up to fulfill a variety of objectives, a common expectation was that each would restore populations of overexploited species such as rock lobsters *(Jasus edwardsii)*, black-lip abalone *(Haliotis rubra)* and large fish.

Six years of protection have brought several changes to Maria Island Reserve. The number of fish species increased by 5%, whereas in nearby unprotected areas it fell by 23%. Most of the new species were large and had suffered badly from overfishing. They included the bastard trumpeter *(Latridopsis forsteri)*, ling *(Genypterus tigerinus)* and draughtboard shark *(Cephaloscyllium laticeps)*. Diversity of mobile invertebrates and algae also increased at Maria Island by 25% and 11% respectively, whilst falling by 7% and 5% in fishing grounds. However, there were no changes in the number of species for any of these three groups at Governor Island or Ninepin Point, while at Tinderbox, only the number of large fish species increased.

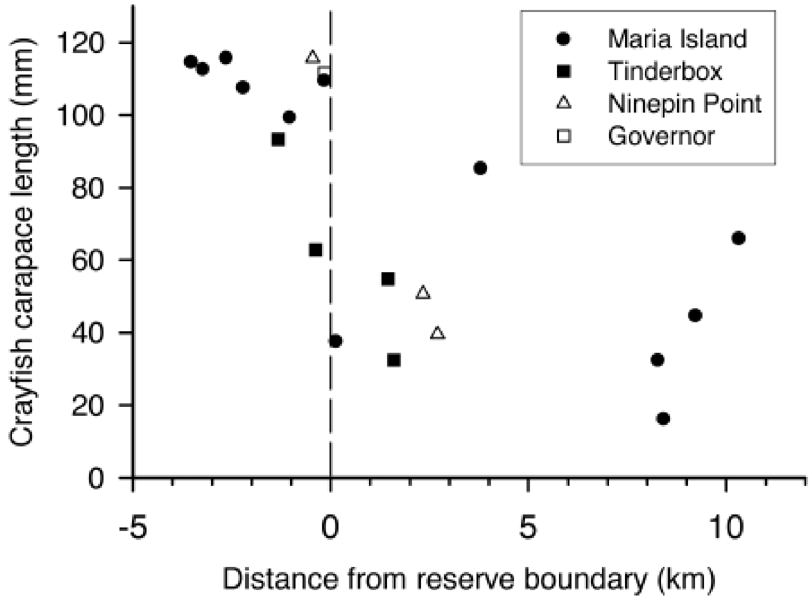

Figure 25: ***Differences in size of rock lobsters*** **(Jasus edwardsii)** ***inside four Tasmanian reserves and with increasing distance away from them. Five years of protection from fishing has led to marked increases in size of lobsters within reserves.***

The most striking outcome of protection in Tasmania has been the build-up of large fish, (> 33cm). In the Maria Island Reserve, these increased from an average of 2.6 to 9.2 per 500m^2, a rise of over 240% in 6 years. Outside the reserve densities remained more or less constant at 1 per 500m^2. The same pattern was found at Tinderbox where large fish increased by 300%. At Ninepin the trend was upheld if long-fin pike *(Dinolestes lewini)* were considered reef-associated rather than pelagic. These pike were very abundant in this reserve, but rare in all of the others. However, at Governor Island there was no accumulation of large fish.

The species showing the greatest recovery was the bastard trumpeter at Maria Island. This species is virtually absent from unprotected areas, but following a large recruitment in 1994/1995, numbers in reserves showed an incredible 100 fold increase. This species is thought to spawn on deep offshore reefs, which if true, will result in a mass movement of fish outside the reserve when the young reach sexual maturity. It appears that as juveniles they do not move far, otherwise there would have been more dispersal outside the Maria Island Reserve. However, tagging studies suggest that some individuals will travel as far as 140km. In South Africa it has been shown that amongst galjoen *(Dichistius capensis)*, some individuals will disperse over great distances, while the majority of the population move little (Attwood & Bennett1994).

Rock lobsters also showed significant responses to protection. In Maria Island their numbers increased by 260% over 6 years compared to only 12% outside the reserve. They also grew in size. When the reserve was set up, carapaces of the biggest lobsters measured about 110mm, the minimum legal size in the fishery. After six years protection, some lobsters had carapaces measuring 200mm, whilst in fishing areas the biggest were still around 110mm. As a consequence of increased size, lobsters at Maria Island produced ten times more eggs than exploited stocks. The other reserves also contained much larger lobsters than fished areas (Figure 25), and at Tinderbox their abundance rose by 100%.

Size of black-lip abalone also increased in reserves. At Maria Island these grew from an average of 128 to 136mm but outside fell from 125 to118mm. It was only in reserves that any individual grew bigger than 160mm. However, the number of juvenile abalone did decline at Maria Island between 1992 and 1997, perhaps due to competition with larger abalone, or perhaps because of predation from the extra numbers of rock lobsters and large fish. Surprisingly, marine reserves did not enhance densities of the sea urchin *(Heliocidaris erythrogramma)*, which are exploited throughout the area.

It is unclear why several species did not grow big at Governor Island and Ninepin Point in the way they did at Maria Island and Tinderbox. Maria Island may have offered more effective protection because parts of it were surrounded by large stretches of sand which might have deterred fish movements. Another explanation is that the large number of nets and lobster pots set close to the reserve boundaries at Governor Island and Ninepin Point made protection less effective for mobile species in these very small reserves. The fact that rock lobsters were able to increase in size in all reserves suggests that this species does not move very far. In Tasmania, any lobster that wanders out of a reserve is highly likely to end its journey on a dinner plate!

Key lessons:

- The densities and sizes of commercially important species are limited by fishing on Tasmanian reefs.
- Reserves provide an important refuge for severely overexploited species.
- Monitoring the effects of protection provides a valuable insight into ecosystem health. Without reserves the true state of overfishing on Tasmania's reefs would not have been realized.

Reference: Edgar & Barrett 1999.

L. Sumilon Island Reserve, Philippines

Reserve benefits to fisheries are vulnerable to local politics

Sumilon Island is a small coralline island in the central Philippines. There is no local community on the island, but it is used by about 100 small-scale fishers from the neighbouring islands of Oslob, Santander and southern Cebu. In 1974, biologists from Silliman University on the island of Negros, persuaded the municipal council of Oslob to declare one of the world's first marine reserves on Sumilon. By local government decree, a quarter of the island's coral reef was totally protected from fishing. Whilst these official negotiations were taking place, local fishers were also being educated about how the proposed reserve would benefit them, although it later emerged that many people had been unclear about the purpose of the reserve. Nevertheless, enough people respected the closure to fishing for benefits from the reserve to start to filter through. By the late 1970s most fishers believed that their yields had improved as a result of the marine reserve.

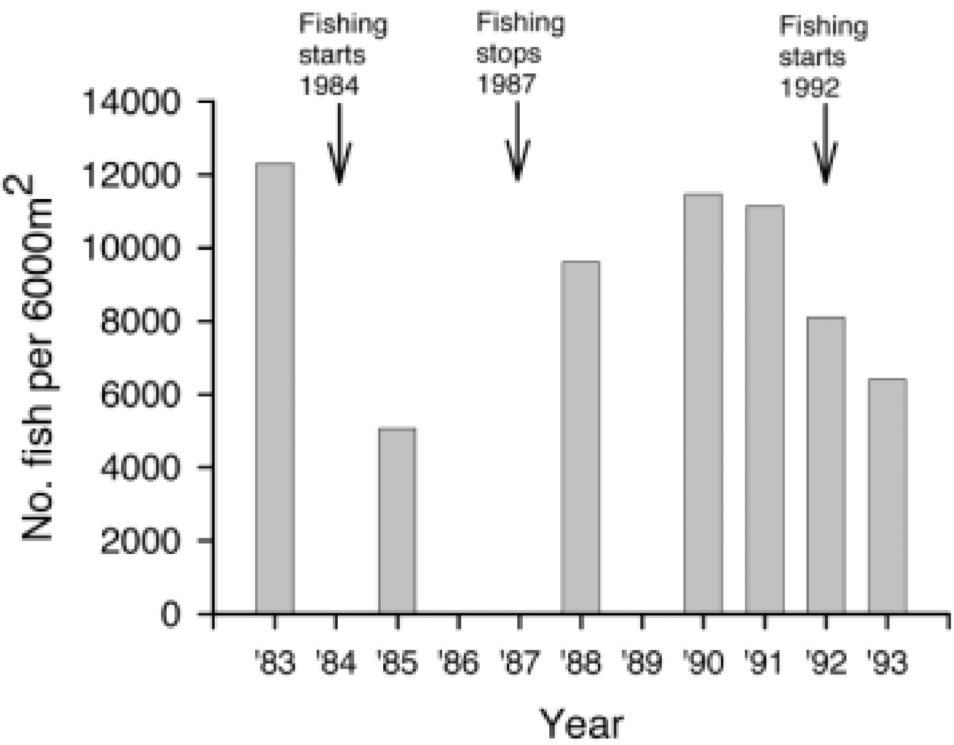

Figure 26: ***Patterns of decline and recovery for the most important family in the Sumilon fishery, the fusiliers (Caesionidae). The abundance of these short lived (2-5years), fast growing species, closely tracked patterns of illegal fishing in the marine reserve. Redrawn from Russ & Alcala (1994).***

Unfortunately, problems began in 1980 following the election of new mayors in Oslob and Santander islands. They opposed the reserve, and as a result several serious fishing violations were allowed to take place. In response, Silliman University appealed for help to the national government, who instigated protection under national law. The University was given powers to manage the reserve, and to do research there. However, resentment brewed amongst local officials at this interference in their area and fishing violations continued to escalate over the next five years. Between 1984 and1985 protection broke down completely and the reserve became heavily fished. As if this wasn't bad enough, destructive techniques such as "muro-ami" (drive net fishing) and dynamite fishing were instigated.

By 1987 the situation began to improve. Santander and Oslob councils wanted to develop a tourist resort on Sumilon Island and as a result decided to issue a local ban on all fishing there. This was upheld for four years until the resort was completed. In 1992 all restrictions were lifted from the former fishing area, while hook and line fishing became legal in the old reserve. With the return of fishers to the area, and insufficient enforcement to protect the marine reserve, it was not long before illegal fishing resumed. Violations included establishment of a fish corral (where fish are driven into a large, fixed position trap), widespread use of small bamboo fish traps, and spear fishing, some possibly by scuba diving tourists.

Throughout this turbulent period, scientists visually estimated the biomass and density of fish species within the Sumilon reserve. In addition, they collected quantitative data on yields and catch per unit effort for seven years between 1976 and 1983. This latter information showed that when the reserve was functional, total catches and catch per unit effort were around 50% higher than when it broke down, despite the extra area which became available for fishing. This suggests that the reserve had been enhancing adjacent fisheries, although falls in catches may have

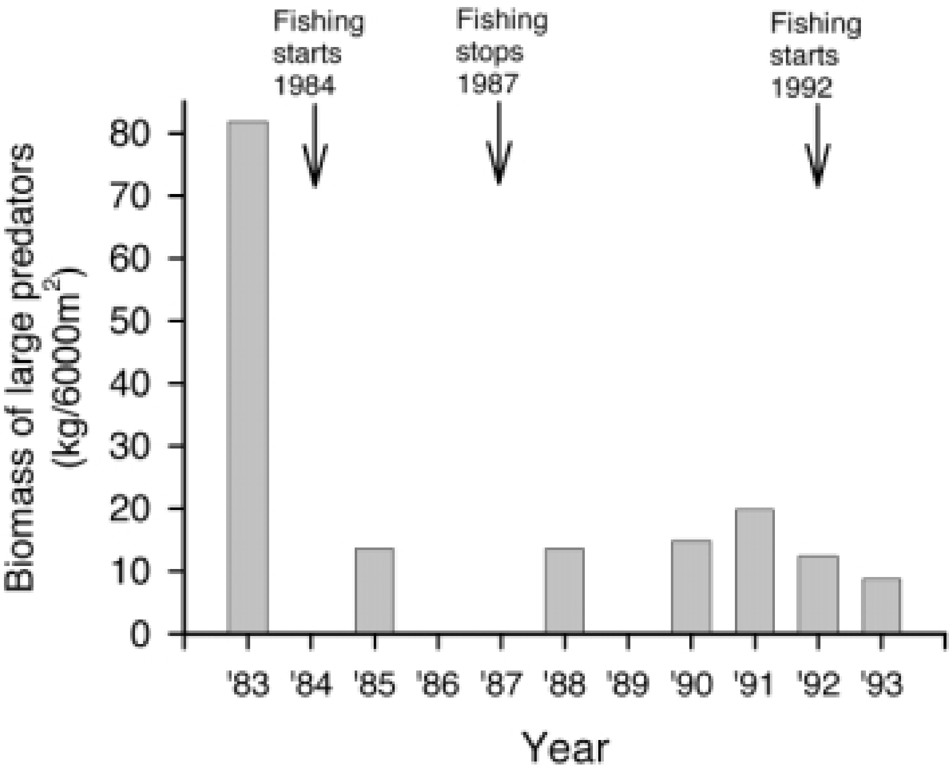

***Figure 27:* Patterns of decline and recovery for large predatory fishes at Sumilon, the snappers (Lutjanidae), groupers (Serranidae) and emperors (Lethrinidae). These species respond more slowly to protection and are very easily depleted by illegal fishing. Redrawn from Russ & Alcala (1994).**

resulted from destructive fishing methods undermining productivity of the reef.

Results from the underwater surveys made between 1976 and 1986 showed strong patterns of recovery and decline for the most important family in the fishery, the fusiliers. These are short lived (2-5years), fast growing species, and their abundance closely tracked patterns of illegal fishing in the marine reserve (Figure 26). When reserves were being respected fusiliers were abundant, but shortly after fishing resumed their populations crashed. Between 1983 and 1993, the same pattern was found for groupers, snappers and emperors, which are much less abundant, but highly prized by fishers. These are big, long-lived (5-20 years), slow growing species, and their rates of recovery were much slower than those of the fusiliers (Figure 27). This meant that even though populations were able to recover after the illegal fishing bout of 1984 -1987 stopped, their numbers and biomass were dramatically down over what they had been during the protected period. When the next bout of poaching started in 1992, populations of these fishes dropped to their lowest levels.

The Sumilon reserve was one of the first to show the great importance of protecting areas of the sea from fishing. The roller-coaster ride of protection implemented, taken away, implemented again and so on, has proved enormously frustrating for all the people who have worked so hard to protect the reserve. However, it has proved a bonus for understanding of how effective reserves are, how fast they provide benefits, and how fast these can be lost. The evidence is clear - reserves can offer rapid results but these are fragile gains that are easily eroded if protection lapses.

Key lessons:

- Benefits from protection are rapid.
- Illegal fishing erodes the long-term gains provided by marine reserves.
- Benefits to fishers from re-opening marine reserves are extremely short-lived.
- Large, slow-growing, long-lived species are more vulnerable to exploitation than small, fast-growing, short-lived species. Vulnerable species are the ones most at risk from poaching.
- Political upheaval poses a threat to marine reserves.
- Community support is more important than protection by local or national law.

References: Alcala 1988; Russ & Alcala 1994.

M. Dry Tortugas Ecological Reserve, Proposal B, Florida Keys National Marine Sanctuary, USA

Setting up a new fully-protected zone in the Florida Keys - making the right compromises

The management plan for the US Florida Keys National Marine Sanctuary is the size of a large telephone directory and just as dense. It provides what is probably one of the world's most detailed blueprints for managing a large marine ecosystem. Over the years this management plan has been responsible for much contention, drawn out battles, and even personal threats. However, people in the Keys are now working together to set up the Dry Tortugas Ecological Reserve.

The Sanctuary is managed by the National Oceanic and Atmospheric Administration (NOAA) and protects America's only barrier coral reef, plus vast seagrass meadows, and innumerable mangrove fringed islands. It was established in 1990 and covers 2,800 square nautical miles surrounding the Florida Keys, and extending to the southernmost tip of the United States.

Early zoning schemes proposed to set aside approximately 20% of the Sanctuary in five fully-protected marine reserves. However concerted political action reduced this proposal to three reserves and finally to one, leaving only half a percent of the Sanctuary fully-protected from fishing. The original proposal included a reserve in the Tortugas but the boundary, which encompassed around 100 square miles, was hotly contested. Consequently the reserve was dropped from the management plan, although marked out for reconsideration in the future. Billy Causey, the superintendent of the Sanctuary described this as leaving the sanctuary with "unfinished business."

Sport fishing is a major money spinner in the Florida Keys, but good catches depend on there being good replenishment of exploited populations. The Dry Tortugas are ideally placed, being upstream of most reefs in the Keys, to supply young fish to support these fisheries. Creation of a fully-protected, ecological reserve will ensure high levels of reproduction by fish within it and is expected to help sustain sport and commercial fisheries.

Second time around, NOAA developed a truly comprehensive approach towards setting up a Tortugas reserve. They carried out detailed scientific research and made a thorough socio-economic study of the area. In addition Billy Causey's team launched the project 'Tortugas 2000' which was designed to raise public interest and steer people towards creating a workable reserve. As a result, a participatory group was established containing commercial and recreational fishers, divers, conservationists and other interested stakeholders. They were responsible for presenting the Sanctuary's Advisory Council with revised recommendations for the reserve.

The shallow banks of the Tortugas provide an ideal spot for a fully-protected marine reserve. They are remote and relatively undisturbed, with high water quality and a rich diversity of marine life. Being upstream of all other reefs in the Keys, they are perfectly placed to benefit Florida's fisheries by exporting the eggs and larvae of commercially important animals that are resident in the reserve.

In April 1999, the Tortugas working group started making provisional proposals for the reserve's boundary. They took into consideration many different criteria. The reserve needed to provide fisheries benefits and protect important fish spawning aggregation sites. It needed to be easy to locate and straightforward to patrol. Commercial fishers wanted to retain access to key fishing grounds, and divers wanted to ensure that the best dive spots were included in the fully-protected area.

With all these different priorities, building consensus around a single proposal was not easy. A key element of success was that during initial meetings the group discussed people's interests without putting lines on a map. By getting to know each other well, and working through their differences together first, the group learnt to co-operate with goodwill and humour. By the time proposals started being drawn up, people had confidence that their views and interests would be properly considered.

Many different proposals emerged, but eventually one began to gain the support of both conservationists and fishers. Some people felt it left too much unprotected, while others thought it reached too far beyond existing Sanctuary boundaries, but this plan received the kind of consensus previously unknown in the Sanctuary. Voters that had seemed destined to object to any kind of reserve approved it, and the proposal was carried forward with unanimous support. Getting consensus depended on making the proposal realistic for everybody. For example, keeping access to king mackerel grounds over a relatively small area won the support of recreational fishers. At 186 square nautical miles, the newly proposed reserve was nearly twice the size of the one put forward in 1990.

There is still a long way to go before the Tortugas reserve is formally established. However with fishers and conservationists committed to backing the proposal it should just be a matter of passing through the legislative process. In the end neither conservationists nor commercial fishers got exactly what they might have liked. One member of the group noted that no-one was completely happy but everyone could live with the decision. People involved in formulating the proposal were clearly surprised but delighted at the level of consensus, and it was felt that NOAA had learnt a lot from their earlier attempts at setting up the reserve.

Key lessons:

- All stakeholders need to be involved in the planning process from the beginning.
- It is essential to gain the trust and support of local communities and all stakeholders. This takes time but the value of support is priceless.
- Establishing a protected area involves compromises - usually from everybody.

Further information: For further information on the Dry Tortugas Ecological Reserve, or to find out about other aspects of management in the Florida Keys National Marine Sanctuary, visit their website at www.nos.noaa.gov/nmsp/fknms or contact the Sanctuary's science co-ordinator directly: Ben Haskell, Science Co-ordinator, Florida Keys National Marine Sanctuary, Marathon, Florida 33050, USA. Tel: +1 305 743-2437, Fax: +1 305 743 2357, Email: bhaskell@noaa.gov.

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Glossary

Analysis of complementarity: a process by which sets of reserve locations are chosen that optimize the number of species or habitats protected, while minimizing some function such as the cost of protection (often expressed as the total area of reserves required). The analyses can be undertaken in many ways, but usually involves first selecting sites with the most species, or the greatest number of geographically restricted species. The next site selected is the one that adds the most new (i.e. unrepresented) species. The selection process continues until all species, or some target fraction of them, are represented.

Allee effect: a reduction in fitness at low population densities, often measured as the numbers of offspring that are produced or survive. For example, many marine species reproduce by releasing eggs and sperm into the water where they are fertilized externally. The rate of fertilization is greatly reduced as the distance between reproductive partners increases. For animals that have low mobility, such as clams that are attached to the sea bed, reductions in population density can prevent effective reproduction long before all the individuals have been removed. Strong Allee effects render populations vulnerable to extinction when their densities have been reduced to low levels, for example by fishing. They also hinder the recovery of populations from low densities.

Biodiversity: the variety of life. Biodiversity is manifested at many different levels, from genetic variation within populations, to different races of species, to the variety of different species present, the habitats they create and occupy, and the land and seascapes that they help shape.

By-catch: species caught unintentionally while fishers are in pursuit of other **target species.**

Connectivity: the movement of organisms from place to place (e.g. among reserves) through dispersal or migration.

Directional selection: the tendency for the genetic structure of a population to be channeled in a particular direction by a selective force such as fishing. Fishing tends to reduce the abundance of the largest and boldest fish in a population preferentially. This often leads to a shift towards shorter-lived, earlier reproducing fish that may be less able to persist in the face of long-term environmental fluctuations.

Economic yield: net economic benefit from an exploited resource, such as a fish population.

Ecosystem: the complete biological community in an area, together with its physical environment. Ecosystem boundaries are usually vaguely defined since virtually no ecosystem is completely isolated from others.

Ecosystem processes: processes that take place within ecosystems that are mediated by biological action, such as breakdown of organic matter, production of oxygen, or growth of coral reefs.

Ecosystem services: ecosystem processes or properties that are useful to humanity. For example filtration of water, production of fish, protection of coastal areas from storms or breakdown of pollutants.

Eutrophication: addition of excess nutrients can lead to changes in marine ecosystems that together are called eutrophication. They include excess growth of planktonic (drifting, open water) algae and seaweeds, reduced light penetration through seawater, low oxygen or anoxic conditions at the sea bed due to breakdown of dead organic matter, red tides (blooms of toxic planktonic organisms), mass mortalities of fish or shellfish, among other effects.

Fecundity: the level of reproductive output from an organism.

Fish: throughout this book we frequently use the term ‘fish’ in the sense used by fishery managers, meaning any organism that is exploited, whether it is a fish, mollusc, crustacean or whatever.

Fishing-the-line: the tendency of fishers to fish very close to the boundaries of successful marine reserves.

Fully-protected marine reserve: an area of the sea that is protected from all fishing, extractive or harmful human uses. Many people react negatively to the term **no-take reserve**, believing that it means 'no-people reserve'. Furthermore, no-take reserves may not limit other non-consumptive human activities to non-damaging levels. Hence, the broader term fully-protected reserve is used here. The term is not perfect, as to some people it may imply protected from all uses. However, it should be interpreted as meaning fully-protected from extractive uses (= no-take) and from harm by other uses. Thus, a fully-protected reserve is one where there is no fishing, and no extractive use (e.g. mining, dredging or curio collection). However, non-consumptive uses such as swimming, scuba diving, snorkelling, recreational boating, passage of shipping etc. are permitted up to levels which do not harm the environment.

Habitat: the place where organisms live. Ecologists usually use the word to describe distinct associations between species and their environment, such as hydro-thermal vents, upwelling areas, sandy beaches, kelp forests or rocky shores.

Harvest refugium: an area of the sea that is closed to fishing for one or more target species. Such an area may be permanent or temporary.

Infilling: the creation of new land by dumping of fill material into the sea. Areas that are infilled are generally shallow and are often highly productive marine habitats like mud-flats, coral reefs or seagrass beds.

Marine protected area (MPA): The World Conservation Union (IUCN) defines marine protected areas as "any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical or cultural features, which has been reserved by law, or other effective means, to protect part of all of the enclosed environment". An MPA can be zoned to support multiple uses, including zones providing full-protection. Some authors have argued that the possession of at least one fully-protected zone should be a minimum standard for MPAs.

Maximum sustainable yield: There is a hump-backed relationship between the amount of fish caught and the amount of fishing effort. Low and high levels of fishing effort attract small catches, while maximum catches can be obtained from intermediate fishing intensities. The maximum sustainable yield point marks the highest level of catch that can be obtained and has been a traditional target for fishery managers. However, managing fisheries for this level of catch risks overexploiting them in the long run.

Metapopulation: a population that consists of a series of physically separate sub-populations that are linked by dispersal. Metapopulations persist as a result of a balance between extinctions of sub-populations and recolonization of habitat patches (and hence re-establishment of sub-populations).

Network: see **Reserve Network**.

No-take marine reserve: an area of the sea that is closed to all forms of fishing and other extractive uses. No-take reserves are distinguished from fully-protected reserves in that they may not have any other forms of management to limit non-consumptive human uses to non-damaging levels.

Non-target species: species that are not the intended targets of exploitation by fishers.

Open access: free-for-all fishing. Fisheries are open access where there are no legal constraints to prevent people from fishing. The decision of whether or not to fish, and for what, lies entirely with the individual.

Overcapacity: too much fishing power present to catch the available fish efficiently.

Participatory management: stakeholders and managers working together to develop, and often to implement, management.

Recruitment: For fishery scientists, the moment of recruitment to a fish stock is the time that fish first become vulnerable to capture by fishers. However, in this book we adopt a broader use of the term, taking it to mean the replenishment of populations by new reproduction.

Recruitment overfishing: the exploitation of a fish population to the point where there are too few reproductively active fish present to assure the population can replace itself.

Reserve network: a group of reserves which is designed to meet objectives that single reserves cannot achieve on their own. Networks of reserves are linked by dispersal of marine organisms and by ocean currents.

Reserve system: the totality of a series of reserve networks that in combination meet objectives of fully-representing all marine species and habitats, and replicating them in different reserves (wherever possible).

Sectoral management: the pursuit of management objectives by different agencies independently of one another, or with only limited interaction or coordination. Such management approaches often lead to competition, conflict, confusion among users and the perception of protection rather than the reality.

Services: see **Ecosystem Services.**

Spawning stock: the amount of reproductively active fish present in a population (often expressed in terms of biomass).

Spawning potential ratio: this is the ratio between the amount (usually measured as weight) of reproductively active fish in an exploited population, compared to an unexploited population. Lower values of spawning potential ratio (< 35-40%) indicate a heavily exploited stock whose reproductive output has been significantly reduced by fishing.

Spillover: export of organisms from a reserve into fishing grounds.

Stakeholders: anybody having an interest in the region where a reserve is being proposed. In the past, stakeholders were only considered to be users of an area. However, it is now recognized that all interested parties should be involved in discussion and planning for reserves, including those who do not necessarily use the area directly.

Stock-recruitment relationship: the relationship between the number of reproductively active fish in a population (the stock) and the number of offspring that they produce which eventually reach a size where they can be caught (recruitment). Such relationships are often highly variable and so difficult to estimate.

Target species: a species that is the intended target of fishing operations.

Yield per recruit model: a model which examines the weight of fish caught for every individual that is recruited to a fishery. A higher yield per recruit can often be obtained by allowing fish to live longer and grow larger before capturing them. Fully-protected reserves, by reducing the number of juvenile fish that are caught as by-catch in other fisheries, can increase yield per recruit, especially of migratory species.

Zoning: the spatial separation of different uses and mixes of uses within an MPA.

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