Marine Reserves as Tools for Fishery Management and Biodiversity Conservation: Natural Experiments in the Central Philippines, 1974-2000

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Summary

The coral reef fishery of the Philippines is briefly reviewed. Philippine coral reefs (area, 25 million ha) provided about 10-15% of the marine capture fishery in the past. But they have been over-fished, blasted, poisoned and mined, resulting in environmental degradation and fishery depletion. To conserve reefs and their associated biodiversity, marine reserves (marine areas protected from all forms of exploitation) have been established. The areas around reserves (fished areas), have been open to fishing by small-scale fishers using non-destructive gears. At Sumilon and Apo Islands, central Philippines, fish catches from fished areas were monitored in 1976-2000, and the fishes in reserves and fished areas were censused underwater in 1983-1993. Fish abundance, biomass and species richness increased in the reserves when protected but decreased when protection ceased. Fish yields in fished areas were high during periods of protection, but were low when protection was withdrawn, indicating export of adult fish from reserves to fished areas.

Introduction

Marine reserves or no-take marine reserves are areas of the marine environment protected from various forms of human or extractive exploitation, especially fishing. In the sense of this definition, the term is synonymous to marine protected areas, marine harvest refuges, and marine sanctuaries. The marine areas outside of reserves are referred to as non-reserves or fished areas, where fishers are allowed to fish using traditional, non-destructive fishing gears but not destructive fishing methods, such as *muro-ami* drive-in nets and cyanide. The ideal size of a marine reserve is about 20% of the total fished area, based on theoretical models on risk of fish stock collapse. The remaining 80%, the non-reserve, is open to fishing by small-scale fishers. The optimum size of marine reserves is subject to debate. Large reserves are preferable, as fishery and conservation benefits are directly proportional to size. For example, if a hectare of reserve exports 100 fish to a fished area, a 100-ha reserve would export 10,000 fish. But in many countries marine space is generally limited, so that reserve size is often the result of a compromise agreed to by stakeholders, resource managers and government. Evidence indicates that both small and large reserves tend to have positive effects on such biological attributes as abundance, biomass and species richness of marine organisms inside reserves. Without going into the details of the procedures used to locate reserves and non-reserves, it is sufficient to state that, as much as possible, a reserve site should be representative of the general area and its location the result of an agreement among the stakeholders. The boundaries of a reserve should be easily identifiable by markers such as buoys. The scientific monitoring of a reserve, including underwater fish and coral census, fish yield determination, and biodiversity assessment, should follow a methodology in which proper controls are instituted. Members of the communities involved may do the monitoring of the marine species used as food.

In this case study, I discuss the effects of fully protected or no-take marine reserves on (1) abundance, biomass, and species richness of reef fishes; (2) fish yields in areas adjacent to reserves; and (3) marine biodiversity. Results of natural experiments conducted by my colleague, Dr. Garry R. Russ, and myself on two coral reef marine reserves in the central Philippines over a period of 26 years (1974-2000) provide the basis for this study. These two marine reserves are the Sumilon and Apo Marine Reserves (Figure 1 and 2). Sumilon Reserve was studied from 1974 to the present, and Apo Reserve from 1980 to the present. They were established primarily as management tools in response to the dwindling fish catches of fishers and the degradation of the nation's marine environment so evident by the early 1970s.

The data used in this paper are (1) catch-per-unit-effort (CPUE) and fish yield data gathered in 15 separate years between 1976 and 2000 (Alcala and Luchavez 1981, White and Savina 1987, Bellwood 1988 and Maypa *et al*. in manuscript) and (2) underwater fish census data collected over a 10 year period (1983-1993). The methods used to estimate CPUE and fish yield are given in details in Alcala (1981), Alcala and Russ (1990) and in the papers cited above. The method used in underwater visual census is that developed by the Great Barrier Reef Marine Park Authority described in Russ (1989) and Russ and Alcala (1989). The experimental and control sites are shown in Figure 2.

Coral Reef Fishery and its Exploitation in the Philippines

Coral reefs provide humankind with many resources and natural services. Fishes are one of these resources. Smith (1978) estimated the fisheries potential of the world's coral reefs at six million metric tons per year, which is about 7% of the 1990 world marine capture fisheries. The actual yield in 1983, which was 0.48 million metric tons (Longhurst and Pauly 1987), was short of this potential (Russ 1991). Philippine coral reefs estimated at 2.5 million hectares, mostly found in the Sulu Sea, Sulu Archipelago and Palawan in the south and southwest (Gomez *et al*. 1994), account for about 10-15% of the total marine fishery production, according to Carpenter (1977) and Murdy and Ferraris (1980). Its actual share in the total catch may be more than this. Traditionally, coastal dwellers, many of whom are poor, comprising more than half of the 74 million Filipinos, have depended on coral reefs and associated shallow-water ecosystems for their fish protein.

The fishes found on coral reefs are classified into two major categories, *reef species* and *reef-associated species*, according to Choat and Bellwood's (1991) classification in terms of ecological characteristics, habitat associations, distributions, taxonomic characteristics, and structural features. The reef fishes are composed of the Chaetodontidae (butterflyfishes), Pomacanthidae (angelfishes), the Acanthuridae (surgeonfishes, unicornfishes), Siganidae (rabbitfishes), Zanclidae (moorish idols), the Scaridae (parrotfishes), Pomacentridae (damselfishes, anemonefishes, humbugs, pullers), and Labridae (wrasses). The major reef-associated species include predators on mobile invertebrates: the Muraenidae (moray eels), Holocentridae (squirrel and soldierfishes), Apogonidae (cardinalfishes), Haemulidae (sweetlips), Lethrinidae (emperors), Lutjanidae (snappers), Mullidae (goatfishes), Serranidae (rockcods, groupers, basslets), Other reef-associated fishes are Kyphosidae (drummers), Gobiidae (gobies), Blenniidae (blennies), the fish-eating pelagic Carangidae (jacks and trevallies), the piscivore and planktivore Scombridae (tunas and mackerels), the Sphyraenidae (barracudas) and Belonidae (needlefishes). The Caesionidae (fusiliers) are classified as reef-associated by Choat and Bellwood but I consider them reef species. Sharks, skates and rays (all cartilaginous fishes) are often associated with reefs.

Coral reef fishers have used a variety of traditional fishing gears, which are, on the whole (fish traps excepted), not destructive to the coral reef environment. These gears are fish traps, hook and line, set gill nets, and spears. However, blast fishing, a destructive method of fishing on coral reefs, started in the late 1930s. Blast fishers used dynamite originally but later used homemade bombs constructed from gunpowder or potassium and sodium nitrates as the main ingredients (Alcala and Gomez 1987, Thomas 1999). Blast fishing intensified in the late 1940s after World War II, continuing through the 1950s and the 1960s. Its incidence was reduced in the 1970s during martial law, but it again intensified in the 1980s and early 1990s. Its incidence decreased in the late 1990s, due to the implementation of fishery laws by local government units and probably the depletion of schooling target fishes on reefs (Alcala in manuscript). However, it still persists at the present time in some parts of the country. The use of explosives was not limited to reefs. Trawlers used explosives in the 1950s (Thomas, 1999), causing depletion of trawling grounds. Blast fishing depleted reef fisheries and transformed large reef areas into unproductive coral rubble (Alcala and Gomez 1987, Ansula and McAllister 1992, McManus *et al.* 1997).

Poison, usually cyanides, has been used to catch reef fishes for the live reef food fish and aquarium fish trade (Pet-Soede 1996, Rubec 1988, Rubec *et al.* 2000, Barber and Pratt 1997, Anonymous 1997, Mous *et al*. 2000). The target food species are the groupers (*Cromileptes*, *Plectropomus* and *Epinephelus*) and the Napoleon wrasse (*Cheilinus undulatus*). These are exported mostly to Hong Kong. Because of the large demand for these fishes, they have been intensively collected, becoming rare in reefs. Moreover, their high market value has encouraged poaching by foreign fishermen. The use of poisons on coral reefs not only depleted the target species but also destroyed large areas of hard corals (pers obs). Local fishermen have used cyanides in combination with spear fishing while diving with either scuba or hookah compressor, usually with underwater flashlights at night. As a result, many reefs in the central Philippines have been destroyed (pers obs).

Still another fishing method destructive to coral reefs is the *muro-ami*, a drive-in net designed for fishing in coral reefs introduced into the country by Okinawan fishers shortly before World War II (Carpenter and Alcala 1977 Gomez, Alcala and Yap 1987). Ten to 150 swimmers each use a scare line attached to an oval rock weighing four to five kg. The swimmers repeatedly drop the rocks on hard corals as they move towards the bag net. This procedure creates noise and disturbance at the sea bottom, driving schooling and bottom-dwelling fish towards the bag-net, and also breaks branching and other delicate hard corals. Because of complaints about the destructive effects of the use of rocks, the Bureau of

Fisheries and Aquatic Resources (BFAR) banned their use in the early 1990s and replaced them with air bubbles from scuba tanks (Thomas 1999). The modified *muro-ami* fishing technique was allowed to continue operating. However, reports indicate that *muro-ami* operators still use rocks when they can. The old procedure is preferred apparently because it is effective in scaring reef fishes to the nets (D. Inocencio pers. comm.), as indicated by the large production of *muro-ami* ranging from 1,485 mt in 1949 to 2,110 mt in 1955 (Thomas 1999). The catches from this gear increased dramatically during the period 1960-1975, with a range of 9,362- 26,475 mt. During this period, the peaks in the number of *muro-ami* vessels were inversely related to the fishery production, suggesting large fishing efforts in over-fished reef areas (Carpenter and Alcala 1977). The modified Danish seine, a fishing gear banned in Denmark, but used widely in the Philippines, operates much like the *muro-ami* and could potentially destroy coral reefs (J. Palma pers. comm.).

Trends and Summary of Fishery Status

Russ (1991) reviewed fish yields from coral reefs worldwide and concluded that sustainable yields of 10-20 mt/km^2/yr are feasible. Wide variations in reef fish yields have been reported in the literature (Russ 1991). These variations are mainly due to the intensity of the exploitation and the different methodologies employed by investigators. Also, yields would be higher if herbivores and planktivores are largely represented in the catch. One of the highest yields (36.9 mt/km^2/yr) was reported from Sumilon Island in 1983-84 (Alcala 1988, Alcala and Russ 1990) can be explained by the high proportion of the plankton-feeding caesionids in the catch. It would appear that in small intensively fished reefs with good live coral (at least 50%), yields of 15-20 mt/km^2/yr can be expected in a fishery exemplified by Apo, which consists of planktivores, herbivores and carnivores. Our recent data (Maypa *et al.* in manuscript) indicate that a yield of about 20 mt/km^2/yr has been sustained at Apo Island during the past 20 years, as a result of protection of the fish sanctuary since 1982. A couple of degraded Philippine reefs have been found to have lower fish yields of about 3-5 mt/km^2/yr (Alcala and Gomez 1985, Luchavez 1996).

As early as the late 1970s, most Philippine coral reefs had sustained much damage from the three human-induced causes described above and from natural causes. About 70% of the 632 coral reef sites surveyed in the late 1970s had less than 50% live coral cover (Gomez *et al.* 1981). About the same proportion (70%) of 742 reef areas surveyed in the 1980s had 50% and less live coral (Gomez *et al.* 1994). Degraded reefs with much reduced fish abundance and low species richness were observed throughout the country. The exceptions were the protected reefs, which make up about 4% of the total reef area (Alcala in press).

Philippine capture fisheries as a whole had declined by the late 1970s. Trawl grounds showed signs of depletion as early as 1949 (Thomas 1999). The fisheries of reefs and other shallow-water marine environments have been on the decline since the late 1970s (Smith *et al.* 1980, Thomas 1999), although the BFAR (1997, as cited in Anonymous 1999) seems to show that municipal fisheries have declined only since 1991. Intense commercial fishing with drift gill nets, purse seines, ring nets, Danish seines, and beach seines may have contributed to fishery depletion in certain areas of the country. Commercial fisheries have probably already exceeded the limits of sustainable yield, as evidenced by the leveling off of growth in catch and the decreases in some stocks (Dalzell and Corpuz 1990, Dalzell *et al.* 1997 and BFAR 1997, as cited in Anonymous 1999). Even Yap *et al.* (1995), who advocate increased fishing intensity, admit the depleted status of shallow-water fisheries. However, all of these conclusions are not consistent with the fisheries statistics for 1993-1997 (Bureau of Agricultural Statistics, Department of Agriculture). During this 5-year period, the commercial marine production appears to have increased from 824,356 mt in 1993 to 859,328 mt in 1994, 893,232 mt in 1995, 879,073 mt in 1996 and 884,651 mt in 1997. A BFAR official explained the increasing trend as due to the inclusion of commercial catch from international waters. In the same report, the municipal marine production in 1993 (as expected) decreased from 803,000 mt to an average of about 760,000 mt annually during the succeeding four years. Unfortunately, the production statistics does not include the fishing effort, and so it is not possible to determine actual trends.

Management History, Successes and Failures

The two no-take marine reserves covered in this review are the Sumilon Marine Reserve and the Apo Island Marine Reserve, established by the Silliman University Marine Laboratory in 1974 and 1982, respectively (Alcala 1981, MCDP 1986, White and Savina 1986, Savina and White 1987, Russ and Alcala 1999). The main objectives for creating these reserves were to allow the build-up of fish abundance and biomass in order to export fish to the areas outside reserves and to protect biodiversity. The two reserves are located in the 13,700-km^2 Bohol Strait and Bohol (formerly Mindanao) Sea, which is connected to the Pacific Ocean on the northeast and to the Sulu Sea in the southwest (Figure 1). In this body of seawater, there are at least seven marine reserves (Figure 1). Sumilon Island is about three kilometers from Cebu Island. Apo Island is about 8 km off the coast of mainland Negros, and is only 30-45 minutes by motorized boat from the village of Malatapay, the nearest point on Negros. The land area of Sumilon is 23 hectares with a 50-ha coral reef, while Apo is 70 hectares with a 106-ha coral reef. Sumilon is a low, flat coralline island; Apo is a high island, its top about 200 meters, with a small flat area near the shoreline built up by coral sand. Finally, they differ in the number of residents. Sumilon in the 1970s and 1980s had only one resident, but later was occupied by a couple of watchmen and at times by tourists. Fishers from the island of Cebu fish on the island. Apo, in contrast, is home to 700 residents. The following discussion on the management history of these two reserves is based on Alcala (1981, 1988), White and Savina (1986), Savina and White (1987), Alcala and Russ (1990), Russ and Alcala (1999) and Alcala (in press).

Sumilon Marine Reserve

The Sumilon Marine Reserve (area 12.5 ha or 25% of the total reef area, Figure 2) was protected and managed by the Silliman Marine Laboratory from April 1974 to 1984. It was established under Resolution 30, Series of 1974 of the Municipal Council of the town of Oslob, Cebu province after one year of negotiation with the then Oslob Mayor Jose Tumulak. This resolution authorized Silliman University, represented by the Marine Laboratory, to establish a marine park for biological studies and research and to regulate fishing and gathering of marine products. The objectives of the marine reserve were not included in the Resolution, but were clearly stated in another document. They were:

1) to eliminate fishing and gathering within the marine reserve,

2) to protect the habitat of fish in the reserve,

3) to allow build up of fish biomass in the reserve,

4) to increase the fish yield at the island by the export of adult fish from the reserve to the fished area, and

5) to encourage tourism.

Shortly after the approval of the Resolution, the Silliman Marine Laboratory implemented a research program on the island and assigned an experienced fisherman to serve as caretaker. His duties included the enforcement of the no-fishing rule in the reserve, the prevention of destructive fishing methods in the fished area, the dissemination of information about the reserve among fishermen, and the monitoring of the fish catch. The reserve was protected for 10 years from 1974 to 1984, although a few violations occurred in the early 1980s. All of the five objectives were met during this period of protection. The island also served as a natural laboratory for students and researchers from academic and research institutions in the country and abroad and recreation area for local and foreign visitors and tourists.

Teams consisting of biologists and social workers from the Marine Laboratory conducted an environmental awareness and educational campaign on Sumilon Island and in the towns of Oslob and Santander on the Cebu mainland in 1973-1976. The caretaker spent most of his time monitoring the fish catch of fishermen beginning in 1976. He recorded the kinds of fish caught and their quantities (numbers and weights), and the fish gears used by fishermen almost everyday for almost 12 months of the year during the next 10 years. Data on underwater fish censuses and live coral cover have been collected every year since 1983.

In February 1980, two new mayors of the towns of Santander and Oslob, Cebu province, who were not known for any commitment to marine conservation, were elected. These mayors had the political support of the governor of Cebu province. They were not interested in the protection of the reserve and even encouraged the fishermen to fish in the sanctuary. These violations, although committed occasionally and intermittently, increased in frequency with time, causing damage to fisheries and biodiversity. This prompted the Marine Laboratory to review the future management of the reserve. A survey commissioned by the Marine Laboratory to assess fishermen's attitudes towards the reserve came up with negative perceptions of the role and functions of the reserve. It became evident that the past educational effort at explaining the benefits of protection on fish yield had not been effectively communicated to the fishermen. The influence of local politics and its adverse effect on the management of the reserve were simply not anticipated. Neither was the need to fully apply the social process of community organizing (already adopted by Silliman University at that time) to coastal communities on Cebu deemed of much importance. Confronted with the violations and the negative attitude of most of the fishermen, we decided, in 1984, to ask the Bureau of Fisheries and Aquatic Resources (BFAR) to assume the legal responsibility for the reserve and for the Silliman Marine Laboratory to continue its research activities. In response, BFAR issued Fisheries Administrative Order No. 128 series of 1980. This issuance caused resentment among the residents and local government officials of the two towns. They argued that the control of Sumilon should not be under a national agency but under the local government of Oslob. In retrospect, there was basis for the complaint, for which the Local Government Code of 1991 was the remedy. This law gave local government units the authority to manage and protect their natural resources.

The next three years saw the heavy fishing of the reserve and the non-reserve by the local fishermen. This devastated the large numbers of fish and the large fish biomass built up in the reserve during the past 10 years of protection. Not only was the fish standing stock wiped out, but the high cover of live coral in the reserve was also reduced to rubble. The other marine species that constituted the high biodiversity of the reserve disappeared, detracting from the beauty for which this underwater park was known throughout the world. These included sea cucumbers, orange-red sea fans, black coral colonies, large bivalve molluscs, and multi-colored, attractive small fishes. The Sumilon reserve ceased to be attractive to tourists.

The succeeding years from 1987 to the present have been characterized by an unstable period of management of the reserve under the control of the mayor of Oslob, to whom BFAR, because of its inability to assert its legal authority to manage under FAO 128, presumably gave an authority to manage. During this period, the reserve was at times protected and at other times open to fishing, giving the impression of confused decision-making. In 1987-1992, the municipal councils of Santander and Oslob banned fishing in the reserve. This was apparently done to attract tourists. We suspect this decision was influenced by the success of the nearby fully protected Apo Marine Reserve in attracting tourists. But in January 1992, fishing resumed first in the non-reserve but later also in the reserve. Fishing in the reserve was observed in 1995, 1997, 1998, and 1999-2001. The only positive observation in 1997 was the increase in live coral cover and the recovery of caesionids. There was no caretaker in December 1994, but there was one on duty in December 1997, and in 1999-2001. The caretaker, as observed during our visits on the island, allowed fishing in the sanctuary. A tourist resort intended for Japanese tourists from Cebu City, two hours away by car, was built on the island. It initially attracted some tourists, but up to this time this venture failed to attract the tourists expected to bring in large amounts of money. There were no tourists on the island during our visits in 1999-2001, and the resort buildings were in a state of disrepair. The reasons are not clear. It is speculated that the unattractiveness of the reserve and the non-reserve due to lack of protection, as well as the lack of freshwater on the island, are some of the reasons. The status of Sumilon is in contrast to that of Apo Island, which a fully protected marine reserve earning income from tourism for the benefit of their communities. The latest information is that the resort on Sumilon has been sold to a consortium based in Cebu City. I met the head of this consortium sometime in 2000, and he told me that he was waiting for a government permit to operate. He also assured me that the marine reserve on the island will be protected under his management. I have just learned that this consortium has not yet submitted its management plan to the Department of Environment and Natural Resources as of February 2001. So it appears that full protection of the marine reserve may not be forthcoming in the next several months.

The management objectives of Sumilon Island have only been partly achieved during its 26-year history. But the benefits of the protective management have since been eliminated. Sumilon provided some of the best early examples of build-up of fish abundance and fish biomass and increase of fish yield to local fishers following the establishment of the no-take marine reserve. A tourist resort has also been established on the island. But all these benefits from the reserve do not appear to be a long-term success. However, the "Sumilon Model" has positively influenced marine resource policy. This influence and the scientific findings and conclusions from the Sumilon experiment will be discussed in the succeeding sections of this paper.

Apo Marine Reserve

This marine reserve was managed by the Marine Management Committee of the Apo Island community from the early 1980s to 1994. Beginning in 1994, the Protected Area Management Board (PAMB) under the Department of Environment and Natural Resources (DENR) took over the management.

Silliman University conducted studies on land vertebrates on Apo in the 1950s and 1960s. The Marine Laboratory started a marine conservation education campaign on the island in the 1970s. The first study on fish yield on the island was made in 1980 (Alcala and Luchavez 1981). In the same year, the Marine Laboratory began to set up a no-take marine reserve on the island patterned after that of Sumilon Island. By that time it had become clear that the fish yield from the Sumilon non-reserve increased, a fact we attributed to the presence of a reserve. Our effort was met with mixed reactions: some favorable, others opposed. Those who opposed were operators of the destructive fishing technique, *muro-ami*. Apo was much easier to work in, compared with Sumilon, because all of the 500-600 residents lived in a closely-knit community, facilitating communication. Despite some objections, the community agreed to setting aside a 0.45 km long section of the island at the southwest side containing about 10% of the total reef area of 106 hectares as no-take marine fish sanctuary (= reserve) in 1982 (Figure 2). The establishment of the fish sanctuary was covered with an agreement between the municipality of Dauin, to which Apo Island belongs politically, and Silliman University (Russ and Alcala 1999, Alcala in press). A grant from The Asia Foundation in 1984 resulted in the formation of the Marine Conservation Development Committee (MCDP), in which three academic units at Silliman University, the Marine Laboratory, the Biology Department and the Department of Social Work, were represented. Two social workers served as resident community organizers on the island to organize the Apo community to strengthen their commitment to conservation and to build their capacity to protect and manage the reserve (see Alcala in press, for a description of community organizing). Although protection of the marine reserve by the local community and the local governments of Apo village and Dauin town began in 1982, the municipal ordinance, the legal basis for protection, was not passed by the Dauin municipal council until November 3, 1986. This legislation now comes under the Local Government Code of 1991 and the Philippine Fisheries Code of 1998, both of which give local governments the right to manage their coastal and marine resources found within a distance of 15 km from shore. Between 1984 and 1986, the management plan for the sanctuary was formulated by the community with the assistance of the community organizers.

The main points of the management plan in the words of the Apo community were:

1) Ban all fishing methods destructive to the coral reef habitat within the reserve area (i.e., the entire reef to 500 m off the island). The fishing methods specifically banned were

dynamite fishing, muro-ami drive-in net fishing with weighted scare lines, spear fishing with scuba, fishing with strong poisons such as cyanide and gill nets with very small mesh.

2) Ban extractive practices and anchoring in the sanctuary.

3) Allow traditional fishing (bamboo traps, gill nets, hook and line, spear) outside the sanctuary.

4) The reserve to be managed by the Marine Management Committee with enforcement from the Philippine Constabulary and scientific advice from Silliman University. At the present time, the Philippine National Police has replaced the Philippine Constabulary.

The objectives of the management plan in the words of the community were as follows:

1) to prevent fishing around the island by non-residents,

2) to prevent the use of fishing methods destructive to the coral reef habitat,

3) to protect the coral habitat of fish,

4) to prevent fishing and gathering within the no-take sanctuary,

5) to provide an undisturbed breeding site for fish in the sanctuary,

6) to allow build up of fish biomass in the sanctuary,

7) to increase local fish yield by export of fish (both adult and larval) from the sanctuary to local fishing grounds,

8) and to encourage tourism.

The reserve is strictly a no-take reserve and fishing is restricted to the non-reserve. The MCDP withdrew from the island after the establishment of the marine reserve. The Apo Marine Management Committee managed the reserve (=sanctuary) from 1985 to mid-1994. However, The Silliman Marine Laboratory, and later also the Silliman University-Angelo King Center for Research and Environmental Management (SUAKCREM), continued overseeing the project during the next succeeding years. It assisted the community in various ways, such as helping to obtain grants for building an information center, preventing construction of incompatible structures on the island, facilitating the assignment of policemen to help enforce the rules and regulations of the reserve, giving advice on the use of coral reef resources and helping in the preparation of project proposals.

The community organizing work on the island in the early 1980s was very successful in convincing the whole community to conserve and protect their marine resources. Subsequent surveys and observations on the island in the 1990s, which revealed a high degree of compliance with the sanctuary rules and regulations by all members of the community, confirm this. When asked about the effects of the sanctuary on their fish catch, most of the fishermen responded positively, claiming that their catch doubled because of the presence of the fish sanctuary. The community also expressed confidence in the capability of the Marine Management Committee to manage the reserve. Even small children understood the objectives of the sanctuary. The reserve has attracted tourists, many of them scuba divers, since the late 1980s. The effect of full protection was evident in the large numbers and large biomass of fish, their lack of fear of divers and the healthy condition of fish and corals in the sanctuary and the non-sanctuary.

In the 1990s, two resorts with dive shops were built to serve the diving needs of tourists, mostly foreigners. Earnings from tourism have been estimated at $126,000 annually (Vogt, 1997), and divers' fees are estimated to be about $35,000 a year (Records of DENR, Dumaguete City). Income from tourism appears substantial for a small island with 106 ha of coral reef. An important question is, how much of this income filters down to the common people? In addition to the income from tourism, the community receives benefits in terms of the fish catch of about 20 mt/year (unpubl. manuscript).

In 1994, Apo Marine Reserve became part of the National Integrated Protected Area System (NIPAS) of the country under the DENR. Instead of the local Marine Management Committee, it now has a Protected Area Management Board (PAMB), chaired by the regional director of the DENR, to manage it (Alcala in press). The PAMB is composed of representatives from national, provincial, municipal and local levels. The local people's organizations and the barangay (village) captain are members of the Board. With the PAMB, the community has expressed its dissatisfaction with the new arrangement, because 25% of the earnings (entrance fees) of the sanctuary (last year about $35,000) goes to the national government. Furthermore, it feels less free to decide on what to do with its share of 75% for its development projects. And finally, it is unhappy about the delay in the release of its share by the government treasury. The DENR should eliminate this red tape in the release of the community's share of the income. The University has continued to exercise its important role as adviser to the community to help ensure the sustainability of the marine reserve. Recently, its suggestion to reduce the number of divers in the sanctuary in order to prevent such high levels of disturbances to the fish populations was followed by the community.

There is no question that all objectives of the Apo Island Marine Reserve have been met fully. Apo Island stands as a classic example of a highly successful community-based coral reef fishery resource project. This success is due to the collaborative partnership among a non-government organization (an academic research laboratory), an organized local community (Apo people's organization), and local government units (Apo barangay and Dauin town). A social process, community organizing, and an information campaign on marine conservation by social workers and scientists made this cooperation possible. The community and the local governments were empowered to co-manage their own marine resources. The Apo Marine Reserve case history was an improvement over that of Sumilon Marine Reserve in that there was full involvement of the Apo local community in all of the discussions leading to the reserve establishment. As a result of this process, they developed a sense of "ownership" of the project, which was essential for its success. Apo Marine Reserve, perhaps more than Sumilon Marine Reserve, has emerged as the model for marine resource management for the country and even for the world (Russ and Alcala 1999). Like the

Sumilon Reserve, it has influenced coastal resource conservation and management policy. The effects of Apo Marine Reserve will be discussed in the succeeding sections of the paper.

Importance of Biodiversity in the Fishery

Diversity seems directly correlated with stability of communities (e.g., Odum 1971). Although the cause and effect relationships between biodiversity and stability are still being debated, it seems that stability of species populations in a community increases with the number of trophic links between species and the energy flow in the food webs (MacArthur 1955, as cited in Pianka 1974). Pauly *et al.* (1998) stressed the importance of biodiversity, as represented by the various components of marine food webs, in attaining sustainable fisheries. Perez and Mendoza (1998) mentioned ecological, genetic, nutritional, and biomedical reasons for preserving marine biodiversity. Fisheries management depends, so much, on a better understanding of ecosystems, and must move from a consideration of single species to a broader view of aquatic ecosystems (e.g., Vakily *et al.* 1997, Smith 1999). Species diversity or richness appears dependent on habitat complexity or habitat heterogeneity (Roughgarden 1979, Donaldson 1996). Coral variables (diversity, species richness, and percentage live coral cover) are correlated with the richness and diversity of fish assemblages (Chabanet *et al.* 1997). The stabilizing role of biodiversity in the coral reef communities of Sumilon and Apo seems evident from the high fish yields of these islands. This stability, however, may also be related, through recruitment, to the oceanographic features of, and the movements of propagules in, the study area, being connected to both the Pacific Ocean and the Sulu Sea (Figure 1).

As already discussed above, fishing in the non-reserves of Sumilon and Apo was non-selective, that is, fishing was not concentrated on certain species. The ranking of the families in the catch was similar to that in the fish community in the reserves. Thus, the diversity of species in the fishery was maintained.

The coral reef habitat on Sumilon and Apo has been monitored since 1983 (Table 1). The reserve sites appeared to have higher percentage of live coral cover compared to the non-reserves at both islands during the 10-year observation period. Apo reserve and non-reserve had higher percentages of live coral cover than their corresponding sites at Sumilon. Data from limited number of samples taken by the Silliman Marine Laboratory at shallow and deeper parts of the reef from 1995 to 2001 indicated that the percentage of hard coral cover at Sumilon reserve ranged from 16 to 58%. Live hard coral cover at Apo reserve had remained moderately high at 52-54% but variable at the non-reserve at 2-47%. The coral organisms were maintained in both protected reserves and fished non-reserves, more so at Apo than at Sumilon. This is important as hard coral serves as the main structure of coral reefs and certain fish groups, such as scarids and chaetodontids, depend for food and cover directly on living coral (e.g. Choat and Bellwood 1991, Adrim *et al.* 1991, Gochfeld 1991).

Effects of Fishing on Biodiversity

Family composition of fish catch in non-reserves

Reef fishery is a multi-species fishery. The combined total number of fish families taken by fishers at Apo and Sumilon was 34, with about 125 species (unpubl. data). In addition, there were two families of crustaceans and two families of cephalopods. About 14 fish families contribute substantially to the fish catch at these islands. These are the Acanthuridae, Siganidae, Scaridae, Labridae, Haemulidae, Lethrinidae, Lutjanidae, Mullidae, Serranidae, Carangidae, Scombridae, Sphyraenidae, Belonidae and Caesionidae. Other fish families, such as Pomacentridae, Pomacanthidae, Chaetodontidae, Muraenidae, contribute an insignificant proportion of the fish harvested, although they are also caught and consumed. Invertebrates harvested from reefs are locally consumed, except for lobsters which are sold at high prices.

Out of the 14 families, nine comprised 90% or more of the fish catch of traditional gears from the vicinity of no-take marine reserves in the central Philippines (Figure 1) in 24 years. The relative proportions of these fish families varied somewhat. On Sumilon Island, Caesionidae, Acanthuridae, Carangidae, Belonidae, and Labridae, in this order, made up 94.71% of the annual fish catch in 12 months in 1983-84 (Alcala 1981, Alcala and Russ 1990). On Apo Island, the Carangidae, Acanthuridae, Caesionidae, Lutjanidae and Scombridae comprised 94.58% of the 12-month fish yield in 1999-2000 (Maypa *et al.*, in manuscript). This has been the pattern during the past 20 years, as shown by four studies of fish yield on this island since 1980-81 (Alcala and Luchavez 1981, Bellwood 1988, White and Savina 1987, Maypa *et al.* in manuscript). The picture for Selinog and Aliguay is not much different from that for Apo in that Carangidae, Acanthuridae, Lutjanidae, Lethrinidae, and Caesionidae accounted for 90 % of the total catch for 12 months in 2000 (unpubl. data). On the island of Pamilacan situated farther northeast in the Bohol (Mindanao) Sea, Carangidae, Acanthuridae, Caesionidae, Scaridae and Lutjanidae contributed 89% of the total annual catch in 1985-86 (White and Savina 1997). It would be of interest to compare our observations with those in other areas outside of the Bohol (Mindanao) Sea.

Intensity of fishing in non- reserves

The percentage yield or catch of the reef fishery of the major reef fish families, summarized in Table 2, are based on one study at Sumilon in 1983-84 (Alcala and Russ 1990) and three studies at Apo (Alcala and Luchavez 1981, White and Savina 1987 and Bellwood 1988) and are discussed in Russ and Alcala 1998a and 1998b. The fishery yields at the two islands are dominated, in terms of biomass, by the Caesionidae (14-70%), Acanthuridae (14-29%) and Carangidae (9-40%). Fishing intensities measured as the percentage of standing stock removed annually by fishing ranged from 20-30% for Caesionidae, 10-20% for Acanthuridae, and 7-100% for the large predators Serranidae, Lutjanidae, Lethrinidae and Carangidae. Fishing intensities on Scaridae and Labridae ranged from 3-5%; all other families constituted a small percentage of the catch (Table 2). On each island the general ranking of families in terms of their contribution to community biomass was similar to the ranking of families in the catch (Russ and Alcala 1998b). The fishery was in general non-selective. It was estimated that the fishing intensity, in terms of percentage of biomass removed for all species per year, was 15% for Sumilon and 25% for Apo (Russ and Alcala 1998a). Under this level of fishing, the total community biomass was affected but not density, significantly. Species richness was not affected, except at Sumilon Reserve.

Life history and fishing intensity are generally good predictors of the differential rates of declines and recovery of abundance in response to fishing. In our study (Russ and Alcala 1998a, 1998b), the large predators had vulnerable life histories. When subjected to high fishing intensity, they declined significantly in density. When protected they increased significantly but slowly. The Caesionidae, with a life history that is resilient to fishing, also declined rapidly when intensely fished. The Acanthuridae were fished intensively and had a life history of intermediate vulnerability but showed weak responses to fishing pressure. For the Chaetodontidae, the effect of fishing conformed to expectations on one island but not on the other. The Scaridae, Labridae, Mullidae, and Pomacentridae displayed weak responses to fishing.

Effects of fishing and protection on fish abundance, biomass and species richness

The effects of fishing and protection on the fish communities (about 200 species in 19 families) within and outside of the reserve borders have been studied through underwater visual censuses over ten years, 1983-1993 (Russ and Alcala 1996a, 1996b, 1998a, 1998b). About 41 of these species belong to the four “large carnivore” families Serranidae, Lutjanidae, Lethrinidae and Carangidae (Table 3, five species not included). The effect of fishing on the density and biomass of the large carnivores, Serranidae, Lutjanidae and Lethrinidae, in the Sumilon Reserve is shown in Figure 3. At Sumilon the density (no/1000 m^2) and the biomass (kg/1000 m^2) were high in 1983 during the period of protection starting from 1974. Density decreased significantly twice when fishing occurred and increased slowly when protection was restored. The biomass was also negatively affected by fishing and tended to recover slowly during the period of protection. Species richness at Sumilon declined by 70% from 1983 to 1985, increased by a factor of 2.4 from 1985 to 1990 (although non-significant) when protected, and decreased by 68% between 1983 and 1993 when not protected (Figure 4). At the Sumilon non-reserve, the species richness of large carnivores increased from 1985 to 1992, but decreased in 1993. At Apo, species richness increased from 1983 to 1993 by a factor of 5.7. No significant changes occurred in the intensely fished Apo non-reserve during the 10-year period of protection of the reserve.

The effects of fishing and protection of the reserves at Sumilon and Apo on the caesionids, an intensely fished planktivorous group, are of interest (Figure 5). At Sumilon Reserve, the pattern resembles that of the carnivores in Figure 4, declining significantly by 60% between 1983 and 1985 as a result of fishing, but increasing by a factor of 2.3 (almost significant) between 1985 and 1990 following restoration of protection. The density declined by 44% between 1990 and 1993 as a result of fishing. The density in the non-reserves of Sumilon and Apo did not show significant changes. The density in the Apo reserve continued to increase from 1983 through 1991, but decreased in 1992 and 1993 in spite of the continuous protection. This is probably due to failure of recruitment. Species richness of caesionids increased significantly at Sumilon non-reserve from 1988 to 1990 and at Apo reserve from

1990 to 1993. No significant changes in species richness occurred at Sumilon reserve or Apo non-reserve during the study period.

The relationships between density and biomass of large predators and years of protection for the Sumilon and Apo marine reserves are shown in Figures 6 and 7. Mean density plotted against years of protection was a straight line (Figure 6). Mean biomass plotted against years of protection was curvilinear (Figure 7). Density of large predators in the Apo non-reserve was significantly lower than that in the Apo reserve, showing clearly the influence of protection on the build-up of biomass. It is to be noted that the biomass of top predators was still increasing after 9-11 years of protection. Using conservative carrying capacity estimates, the best-fit logistic population growth model asymptote at 20-25 years for Sumilon reserve and 40-45 years for Apo reserve (Russ and Alcala submitted manuscript). The management implication is that a few generations of reserve protectors (such as those found in communities) are required to ensure the attainment of the carrying capacity of these reserves, indicating the usefulness of community-based management approaches (Alcala in press).

The significant increases in density, biomass and species richness in no-take marine reserves compared to adjacent non-reserves have been documented by a number of workers (e.g., Roberts and Polunin 1991, Watson and Ormond 1994, McClanahan *et al.* 1996, Wantiez *et al.* 1997, and Johnson *et al.* 1999).

Effects of no-take marine reserves on areas outside reserves

This section of the paper will deal with fisheries enhancement of areas outside reserves through the export or spillover of adults and juveniles from reserves. Improved fish catches in areas near reserves are an important socioeconomic benefit of reserves. As discussed above, protection results in a build-up of numbers and biomass of fish in the reserve, and fish move out to the non-reserve or fished area where they are caught by fishers. The spillover has been demonstrated by our studies at Sumilon and Apo reserves (Alcala and Russ 1990, Russ and Alcala 1996a). At Sumilon, there was a steady increase of fish yield from traps during the period of protection from 1973-74 to 1983-84 (from 9.7 to 16.8 mt/km^2/yr) (Figure 8). When protection was completely stopped in 1984-85, the yield from traps declined to 11.2 mt in 1985/86. The CPUE (catch/man/trip) by the three main fishing gears (hook and line, gill net and trap), before and after breakdown of protection, are presented in Figure 9. The total yield of 36.9 mt/km^2/yr in 1983-84 from the whole non-reserve plummeted to 19.87 mt/km^2/yr in 1985/86. The decline in total yield was 57% for hand lines, 58% for gill nets and 33% for traps. The mean CPUE for all three gears decreased from 2 kg/man/trip during the period of protection, one year before protection ceased, to 1 kg/man/trip 18 months after cessation of protective management (Figure 10). The only reasonable explanation for these findings is that adult fish moved out of the reserve to the fished area when abundance was high during the period of protection.

This spillover of adult fish from the reserve to the non-reserve occurred in another study site on Apo Island (Russ and Alcala 1996a), as shown by the larger densities of fish in the non-reserve closest to the reserve (Figure 11). An analysis of fish yields from Apo non-reserve indicates that this spillover effect has probably helped maintain the fishery production at about 20 mt/km^2/yr during the past 20 years (unpubl data). Reports from Japan and Florida, USA have also documented the spillover effect for snow crabs, lobsters and shrimps. The study by G.E. Davis on spiny lobsters in Florida in 1977 was the first documentation in scientific literature of the effects of reserves on fishery harvest. Recently, Johnson, Funicelli and Bohnsack (1999) demonstrated the export of sport fish from protected areas to fished areas through tagging studies.

The finding from Sumilon Island that fishers catch more fish from 75% of the reef area during the period of protection than from 100% of the area when there is no protection appears contrary to common sense. Two British fishery scientists, R.J.H. Beverton and S.J. Holt, in 1957, provided a theoretical explanation: at high levels of fishing mortality, closing an area to fishing as a regulatory measure can enhance yield per recruit. A simulation of the Beverton and Holt explanation for the observed large fisheries yield caused by random movements at Sumilon indicated that only 10% of the enhanced yield could be attributed to the theory, based on the findings of Russ, Alcala and Cabanban (1993). It is possible that other mechanisms, such as active migration of fish from the reserve to the fished area, contributed to the large fish yield. Another reason appears to be the large contribution of fish low on the food chain (the planktivorous caesionids) to the fish yield.

The length of time required for a healthy coral reef to build up its fish population, in order to export adult biomass to adjacent fished areas, appears to vary, depending on the life history of the fish species. For small, rapidly growing planktivores such as caesionids (fusiliers), a timeframe of four to five years would appear to be sufficient, but for large carnivorous species at the top of food webs, such as serranids, carangids, lethrinids and lutjanids, a timeframe of 10 years or more may be required.

Integration of Biodiversity in Fisheries Management

On the two islands, biodiversity conservation has been integrated in fisheries management. All marine species in the two no-take reserves were protected from fishing during the periods of active management, and only non-extractive activities such as photographing and diving, were allowed. The Apo Marine Reserve has served as an effective refuge for fish, marine turtles and invertebrates since 1982. Even Sumilon, during its erratic protection after 1984, could have contributed positively to biodiversity conservation, as there is evidence that certain fishery species (e.g. *Panulirus argus* in the Caribbean) may exist in greater abundance in partially protected reefs than in unprotected ones (Arias-Gonzalez *et al*. 1999). Several no-take marine reserves near Apo, along the coast of southeastern coast of Negros Oriental, have also shown increased abundance and biomass of fish and invertebrates four or five years after their establishment. Unfortunately, these reserves have not been regularly monitored (C. Cimafranca pers. comm.).

At Sumilon and Apo, about 200 species of fish have been observed in underwater census. Of these about 125 are eaten, of which about 40 contribute to the biomass of the catch. The rest of the species do not significantly to the total catch. Their importance lies in the overall functioning of the coral reef community (Russ and Alcala 1998b). All of them contribute to the high aesthetic quality of the reefs, attracting tourists who bring in income to the community. As already mentioned, the Apo community has financially benefited from tourism. The case of Sumilon has been an unfortunate one. The marine reserve was so devastated by the heavy fishing a couple of years after 1984 that the corals and attractive invertebrates, such the gorgonians, black corals and giant clams, disappeared. Consequently, the island never developed into a tourist attraction after 1984.

Non-Target Biodiversity Concerns

Non-target species have been included in the conservation effort on the two islands. Aside from fishes, these species include three groups. One of these species is the whale shark, a plankton-feeder frequently observed in or near the marine reserves. Some foreigners, particularly Taiwanese nationals, have been buying whale shark meat at fantastic prices. This has served as incentive for local fishermen to kill this gentle shark. Fortunately, local conservation groups have been waging a campaign against the slaughter of this species (Alcala 2000). Communities protecting marine reserves make use of this species for recreational purposes rather than for food.

Two species of marine turtles, the green turtle and the hawksbill, have been found on coral reefs at the two islands. They occasionally nest on the sandy beaches and are protected on Apo. Drift gill nets probably kill turtles as part of the by-catch. Fortunately, this fishing gear is banned on Apo. At least four species of sea snakes, three of *Laticauda* and one of *Emydocephalus* are found in or in the vicinity of the protected areas (Alcala 2000). The former species climb onto rocks on seashores to lay eggs, the latter bears its young alive in water. *Laticauda* feeds on eels and *Emydocephalus* on fish eggs. Sea snakes, although not target species, are highly dependent on the coral reef environment, and are now studied as a possible indicator species for reef health. Part of the education of island communities, that are organized to protect the reserves, deals with the conservation of marine reptiles.

The third group of non-target species is the marine mammal group. Dolar (1999) reported 14 species of dolphins and whales in the Bohol (Mindanao) Sea, and some of the dolphins are caught as by-catch in drift gill nets in the vicinity of our study islands. She reported that 2,259 dolphins (clearly beyond sustainable level) were caught and butchered in the eastern Sulu Sea in 1994-95. A program of dolphin and whale watching for tourists has been in operation for sometime. This has raised the level of awareness about the importance of dolphins and whales. Fishers at Apo abandoned the use of these nets a few years ago, so these cetaceans are no longer caught in the vicinity of the island. However, well over 200 drift gill nets, varying from one to three kilometers long, currently operate in the Bohol (Mindanao) Sea and the eastern Sulu Sea, and so these marine mammals still form part of the by-catch (Alcala in press). Marine mammal conservation is an on-going concern.

Examples of Best Practice

The first example of best practice is the establishment of no-take marine reserves as a management tool for the rapidly dwindling fishery resources in the Philippines. It is argued (Russ 1996) that, given the overexploitation of coral reef fisheries in many countries, networks of marine reserves may be the only option available to us to maintain spawning stock biomass needed to sustain reef fisheries.

The second example of best practice is the full participation of local communities and local government units, along with the academe and non-government agencies, in the protection and management of coral reef fisheries exemplified by the Apo Island case. In this mode of management, the national government provides a general legal and policy framework for management, leaving the implementation to local governments and local communities. The community-based management approach in empowering and building the capacity of stakeholders and resource users to manage their resources has been effective in the Philippines (e.g. Alcala 1998) and Pacific island countries (Reti 2001). Management of fisheries by a centralized government agency which dictates to the resource users how to manage their fishery resources never worked in the Philippines, simply because of its non-participatory nature. This is illustrated by the failure of government to establish coral reef sanctuaries through top-to-bottom management schemes in the 1980s. The existence of a few hundred marine reserves established by local government units, non-government organizations and local communities, some of which are apparently working even though they have not been scientifically monitored, attests to the success of the community-based approaches in coastal resource management (Alcala 1998). To be sure, the community approaches are very effective in simple situations, such as cases of fishery management without the complications of non-compatible and competing resource uses (Alcala in press), but are nevertheless superior to top-to-bottom approaches.

The third example of best practices from our own projects is the decision of the Apo fishing community to stop the use of traps and drift gill nets some years ago to reduce fishing pressure. Traps, if not well set on the sea bottom could physically damage coral and/or decrease the amount of light available to the coral. The drift nets could be non-selective as a fishing gear, catching non-target species, such as dolphins and turtles. The elimination of these gears did not reduce the total yield from the non-reserve, which was about 20 tons a year. The major reason why fishers abandoned these two gears was the excellent health of the biodiversity, which promoted tourism and earned income for the community.

The fourth example of best practice is the large amount of learning by communities about marine conservation and community-based management. What the older generations did and practiced to protect the coral reef was "caught" by the younger generations. The Apo community has become a model learning site for the communities on nearby islands in the Bohol (Mindanao) Sea. One result has been the reduction of time needed for the community organizers to convince a community on a nearby island (Selinog Island) to accept the idea of marine reserve from 2-3 years to one year (Alcala, in press).

Results and Lessons Learned

The first result of our studies is the demonstration that marine reserves at Sumilon and Apo export adult fish biomass to adjacent areas after a varying period of protection. Recent data (Maypa *et al.* unpublished) indicates that this biomass export probably maintained the high fish yield of about 20 mt/km^2/yr on Apo island during the past 20 years.

The second result is that abundance, biomass and species richness of fishes increased when the marine reserves were protected, but these biological attributes decreased when protection was lifted.

The third result is that the biomass of predatory target fish was still rising exponentially after 9-18 years of protection. This implies that the carrying capacity of the reserves takes decades to level off and implying further that protection must be long-term in order that full benefits may be derived from marine reserves (Russ and Alcala, submitted manuscript).

The fourth result is that fish families responded differently to intense fishing (Russ and Alcala 1998b). The density and biomass of large carnivores were affected strongly by fishing and tended to recover slowly when protected. The plankton feeding species also declined with fishing but tended to bounce back when protected. However, under heavy fishing, they also declined rapidly.

The fifth result is that the density of carnivores increased with the number of years of protection in a straight-line fashion, but the relationship of biomass to years of protection was curvilinear.

The five lessons learned from our experience in marine fishery management and marine biodiversity conservation are as follows:

1) Marine reserves appear to be the most viable fishery management tool for developing nations because of their simplicity and the relative ease with which they can be established. However, given the situation obtaining in these nations, marine reserves are necessary but not sufficient for conservation and are likely to be most effective if local government units and local communities are fully involved in their management and protection. Community-based management of marine resources, therefore, appears to be the most suitable approach to ensure sustainable fisheries and biodiversity conservation in countries like the Philippines.

2) Marine reserves, or more appropriately networks of marine reserves, are one of the best tools for the protection of marine biodiversity. For example, a network of marine reserves in the Bohol Sea is necessary for long-term sustainability of the fishery resources, considering the likelihood of propagules moving in the northeast-southeast direction from the Pacific Ocean (see Figure 1).

3) There is a need for linking the stakeholder community to government agencies and non-government organizations working on management of coral reef resources. Such linkages have been of immense value in accessing livelihood and training opportunities for the community.

4) Politics has a role in the management and protection of marine resources, and political issues must be faced early in the initiation of projects.

5) Large carnivores in marine reserves attain their maximum biomass only after a long time, up to 45 years of continuous protection. This calls for a sustained, long-term effort at protection on the part of the managers of fishery resources.

Guidelines, Policies, Programs, Legislation Resulting from Experience

Before the 1970s, marine parks were established for conservation purposes. In 1987 (Alcala 1988) there were only 19 parks and reserves in the Philippines, including the reserves or fish sanctuaries at Apo Island, Balicasag Island and Pamilacan Island, all in the central Philippines. In late 1980s fish sanctuaries were established on Luzon (San Salvador Island, Zambales) and in the province of Misamis Occidental, northern Mindanao. During the 1990s, the number of marine reserves or marine protected areas proliferated. The DENR under my direction established the Coastal Environment Program in 1993. More than 100 marine protected area sites throughout the country were identified. Only a few of these sites were successful, but two especially stood out from the rest, one in Sorsogon, Bicol and another in Pujada Bay, Davao Gulf. A workshop in 1997 inventoried more than 400 marine protected areas in the Philippines (Pajaro *et al.* 1999). Aliño *et al.* (submitted manuscript) has added 100 more to make the current total about 500, but stated that only 10-15% of this number is functional. Some of these non-working reserves are actively protected by community organizations and/or local government units and lack only a regular monitoring program. Examples are the more than 20 marine reserves in Negros Oriental initiated by the governor's office. While it is true that only a few reserves are working reserves, the large number reflects the interest and commitment of many conservation organizations to the cause of resource protection.

It is reasonable to attribute the establishment of the many reserves in the country to the success of the Sumilon and Apo reserves (Alcala in press). Sumilon was especially well known in the country and abroad for fish export from the no-take marine reserve to the fished area during the first 10 years of its existence. Apo Marine Reserve became a model community-based coastal resource management project, and many visitors have observed the workings of the sanctuary. The International Coral Reef Initiative held its first international meeting at Apo Island in May 1995, and the reserve received a wide publicity. A Jamaican friend who attended the meeting told me that he established a protected area after that visit. The Philippine Council for Marine and Aquatic Research and Development recognized the two reserves through a cash award to the Silliman Marine Laboratory in 1998. The United States Agency for International Development designated the Laboratory as Center of Excellence in Coastal Resource Management for the work done on these two reserves in 1995. Several papers on these reserves published in refereed journals almost certainly influenced resource policy.

The Philippine Congress, recognizing the value of marine reserves and the role of communities in fisheries conservation, has included marine reserves and community participation in recent legislation, the Agriculture and Fisheries Modernization Act of 1997 (R.A. 8435) and the Philippine Fisheries Code of 1998 (R.A. 8550). Section 80 of the Code discusses the process of setting up fisheries reserves by local government units and Section 81 deals with the establishment of fish refuges and fish sanctuaries.

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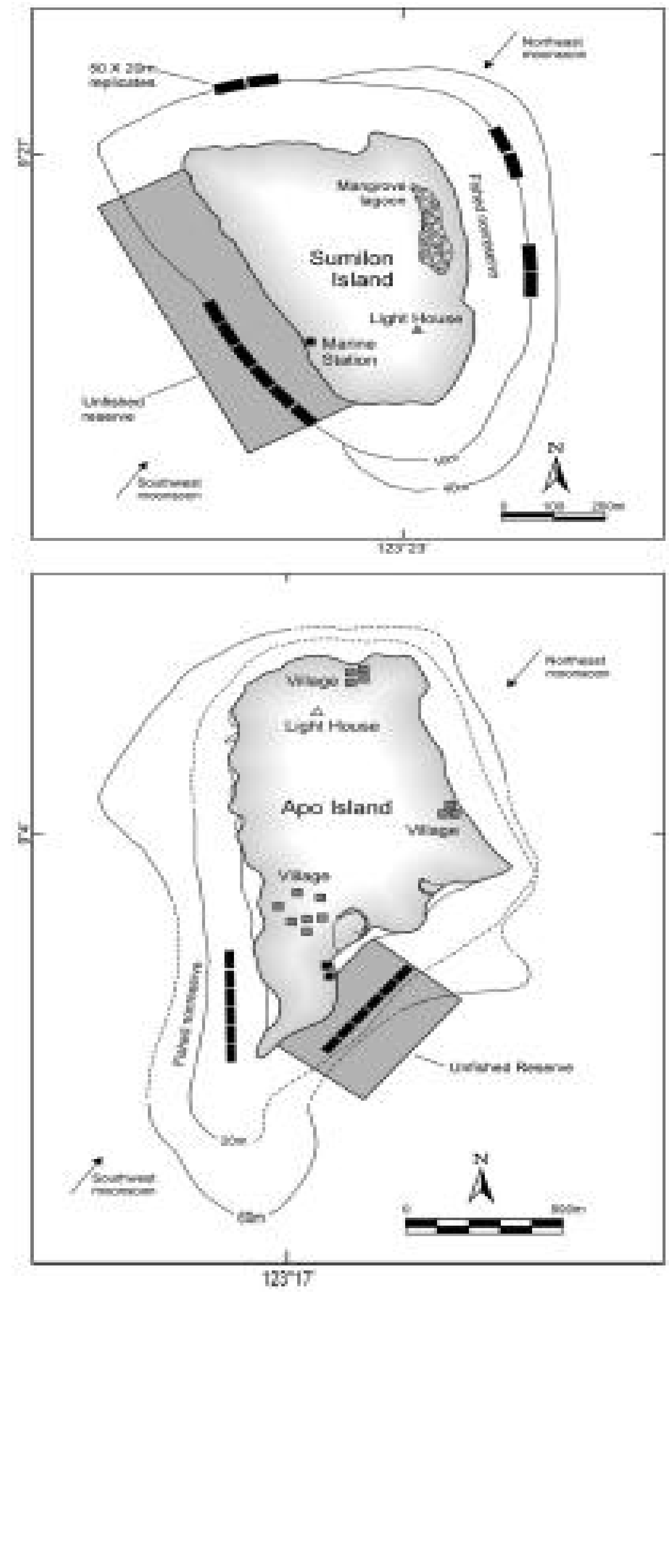
Figures and Tables

Figure 1. Location of the marine reserves, Sumilon and Apo.[1]

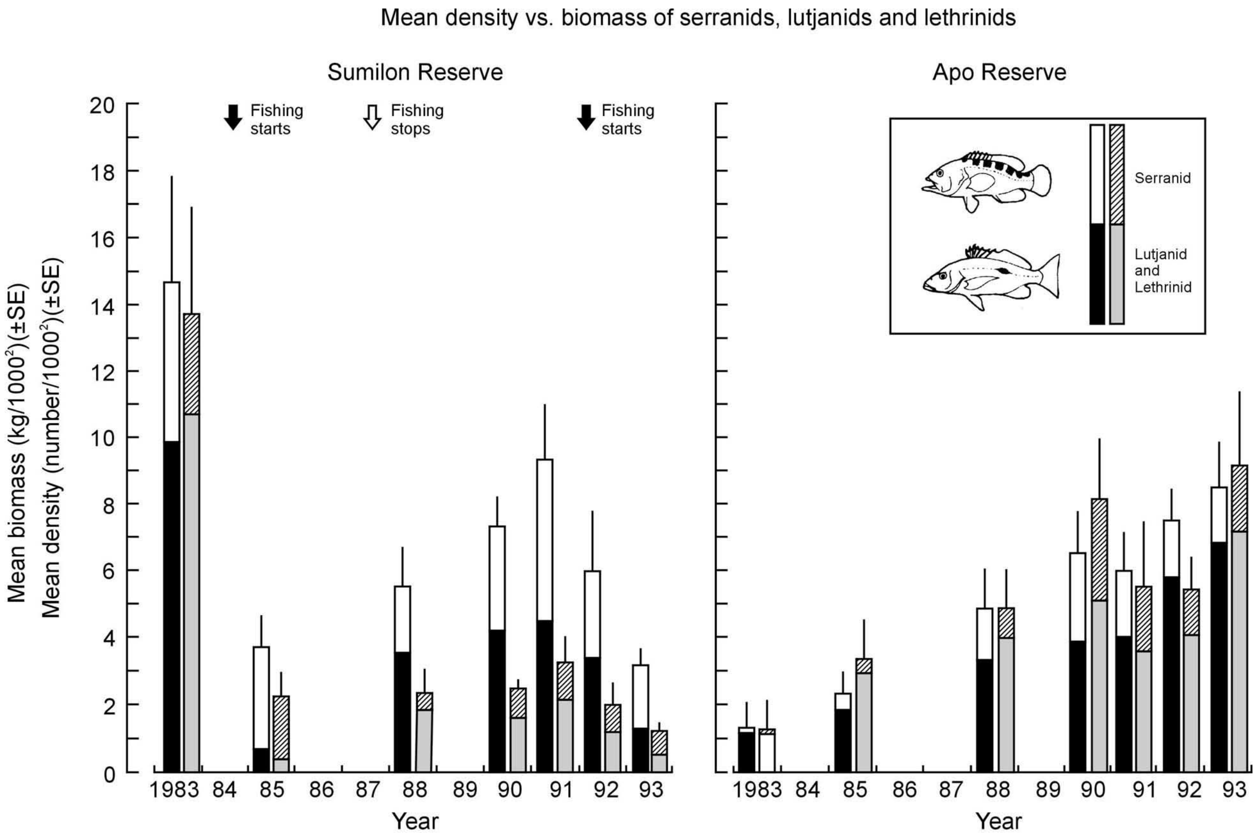
[1] Five other marine reserves are located at Aliguay, Selinog, Balicasag, Pamilacan and Mantigue Islands in the Bohol (Mindanao) Sea. Note: Bohol Sea is connected to Pacific Ocean on the northeast and Sulu Sea on the southwest.

Figure 2. The study areas: A. Sumilon Island, B. Apo Island.[2]



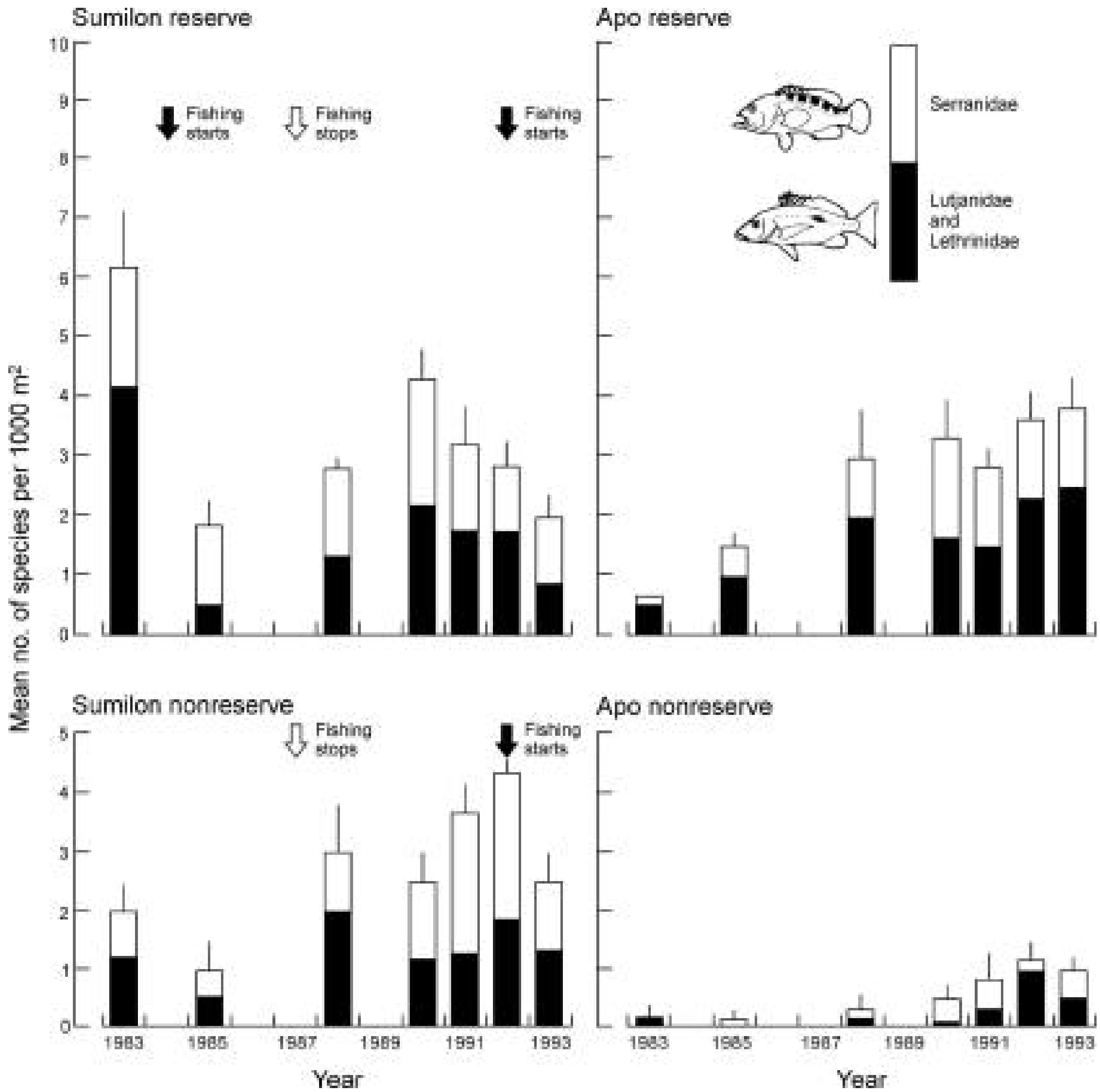
[2] Source: Fig. 1, Russ and Alcala 1999

Figure 3. Mean number (left columns at each time) and mean biomass (right columns) of large predatory reef fish (Sub-F. Epinephelinae, F. Lutjanidae and F. Lethrinidae) per 1000 m^2 in the Sumilon and Apo reserves from 1983-1993.[3]



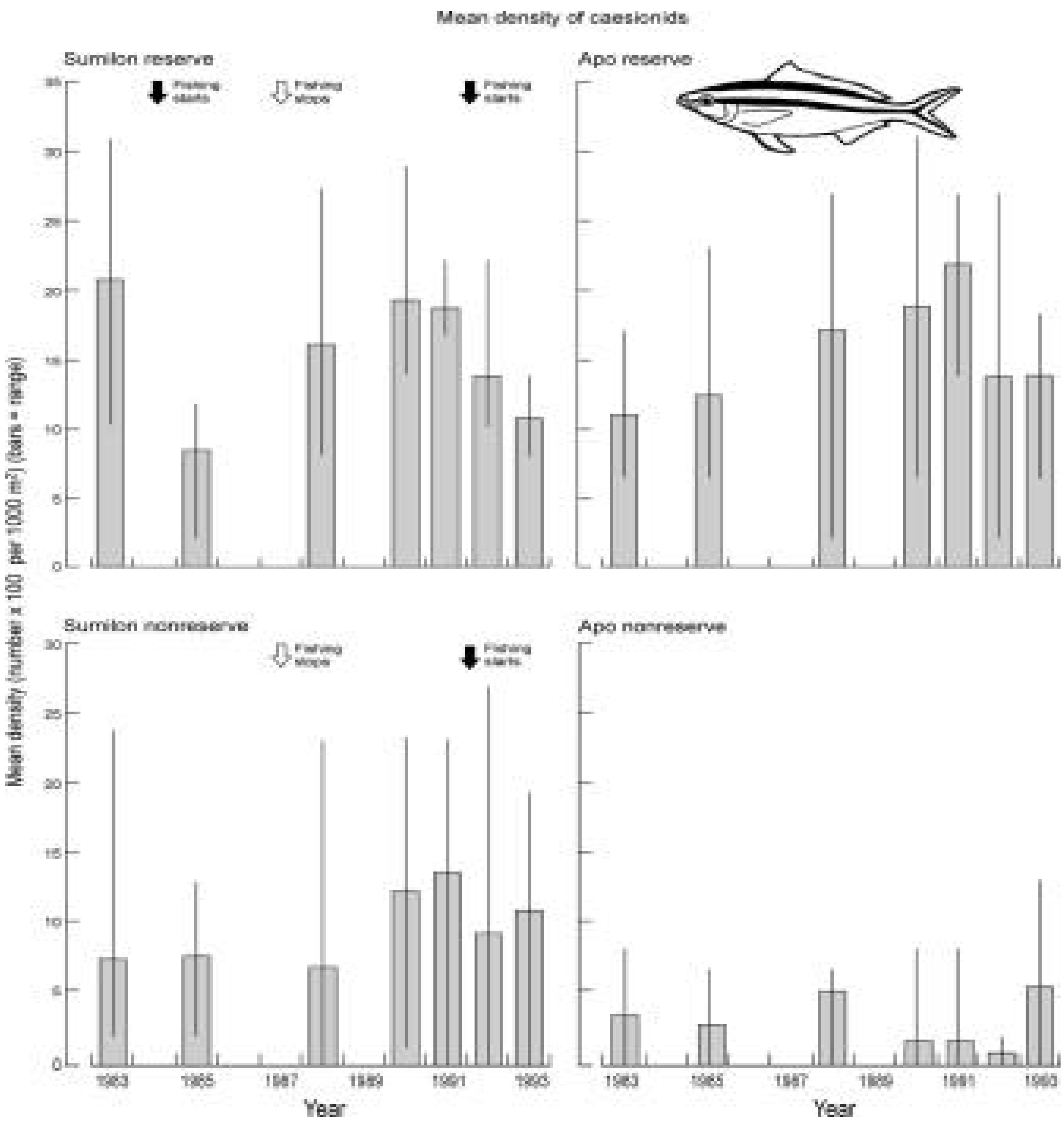
[3] Density estimated by visual census each December for seven years. Censuses were made from 2-17 m depth on the reef slope. The reserve had been protected from fishing for almost 10 years in 1983. Solid arrows indicate when fishing in the reserve began (1984, 1992) and the open arrow indicates when fishing ceased (1987). Source: Fig. 5, Russ and Alcala 1999.

Figure 4. Mean (±SE) number of species of large predatory reef fish (Families Serranidae (Epinephelinae), Lutjanidae and Lethrinidae as a group) per 1000 m^2 at four sites at the seven sampling times.[4]



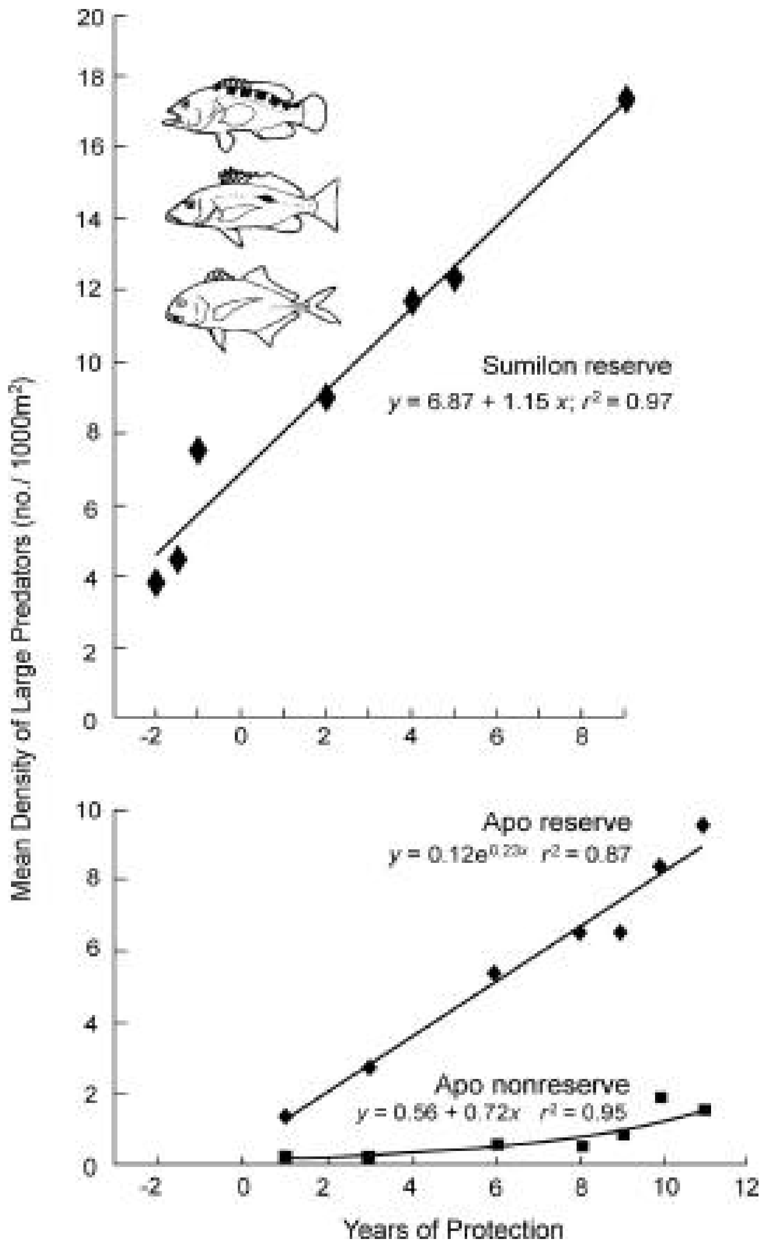
[4] Shaded arrows indicate when fishing began and the un-shaded arrows indicate when fishing stopped at the two Sumilon sites. Source: Fig. 1, Russ and Alcala 1998b.

Figure 5. Mean (bar, range) density (number/1000 m^2) of caesionids at four sites at the seven sampling times.[5]



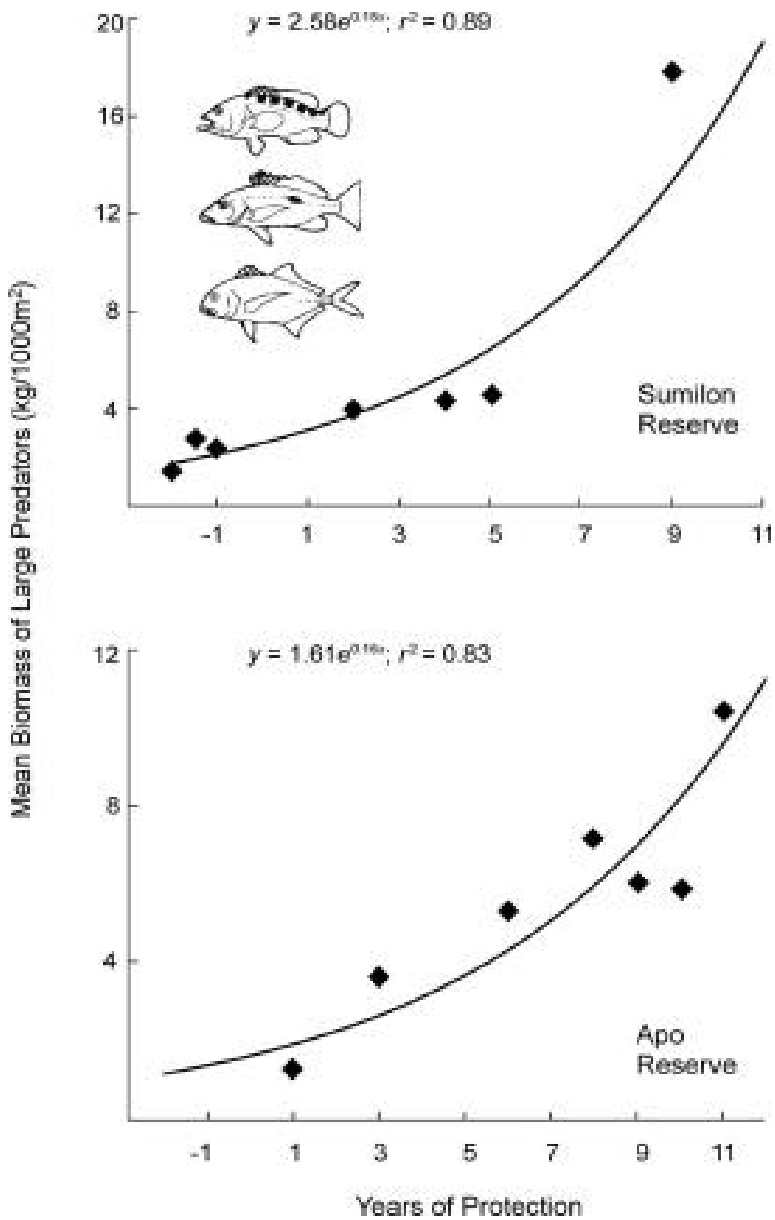
[5] Remainder of legend as for Fig. 4. Source: Fig. 2, Russ and Alcala 1998b.

Figure 6. Change in mean density of large predatory reef fish [Families Serranidae (Epinephelinae), Lutjanidae, Lethrinidae, and Carangidae as a group] and years of marine reserve protection at Sumilon and Apo Islands.[6]



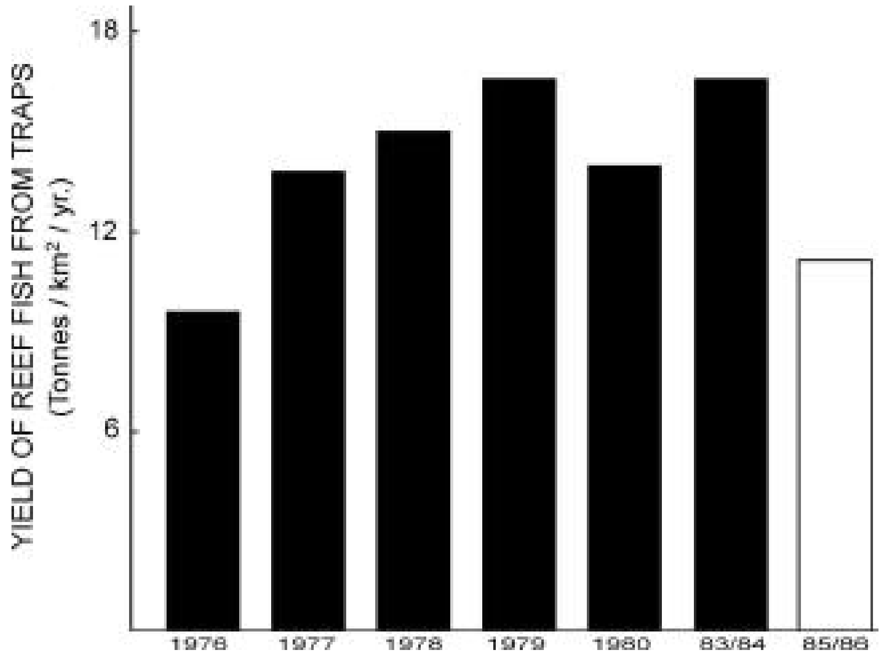
[6] Negative years of protection indicate years open to fishing. Source: Fig. 4, Russ and Alcala 1996b and Fig. 5, Russ and Alcala 1996a.

Figure 7. Relationship between mean biomass of large predatory reef fish [families Serranidae (Epinephelinae), Lutjanidae, Lethrinidae, and Carangidae as a group] and years of marine reserve protection at Sumilon and Apo Islands.[7]



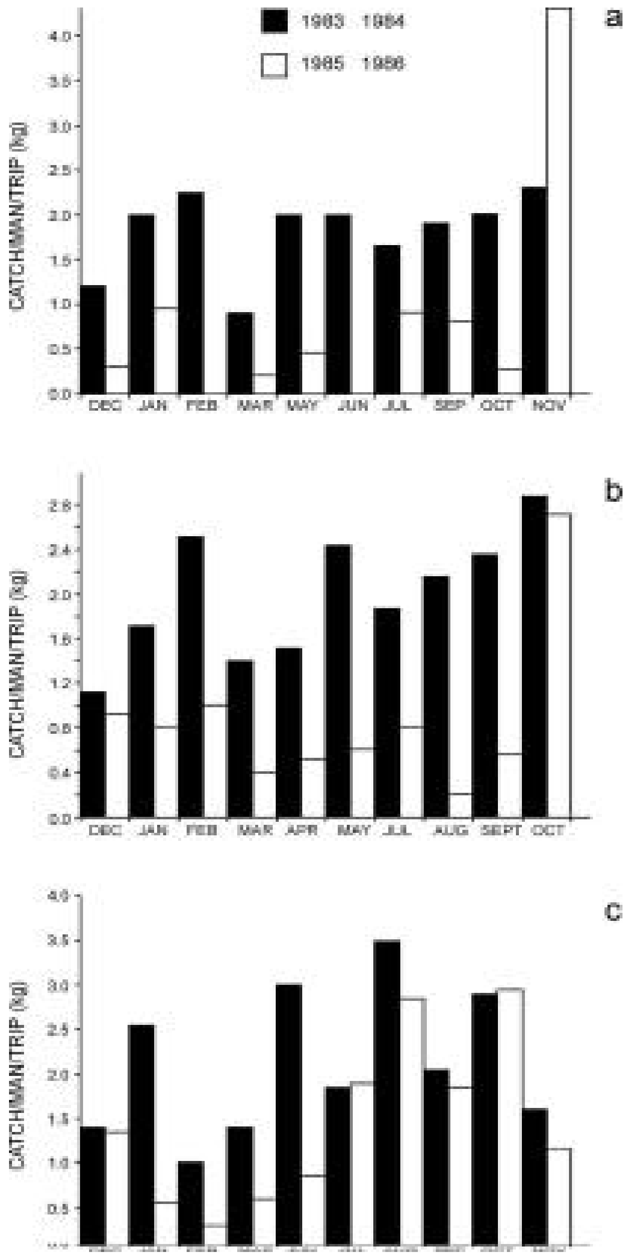
[7] Negative years of protection indicate years open to fishing. Source: Fig. 7, Russ and Alcala 1996b.

Figure 8. Yield of reef fishes (metric tonnes/km^2/year) taken in traps from Sumilon Island in six separate years during the period of protection (1974 to 1984) and yield from traps measured 18 months after protective management broke down (1985/1986).[8]



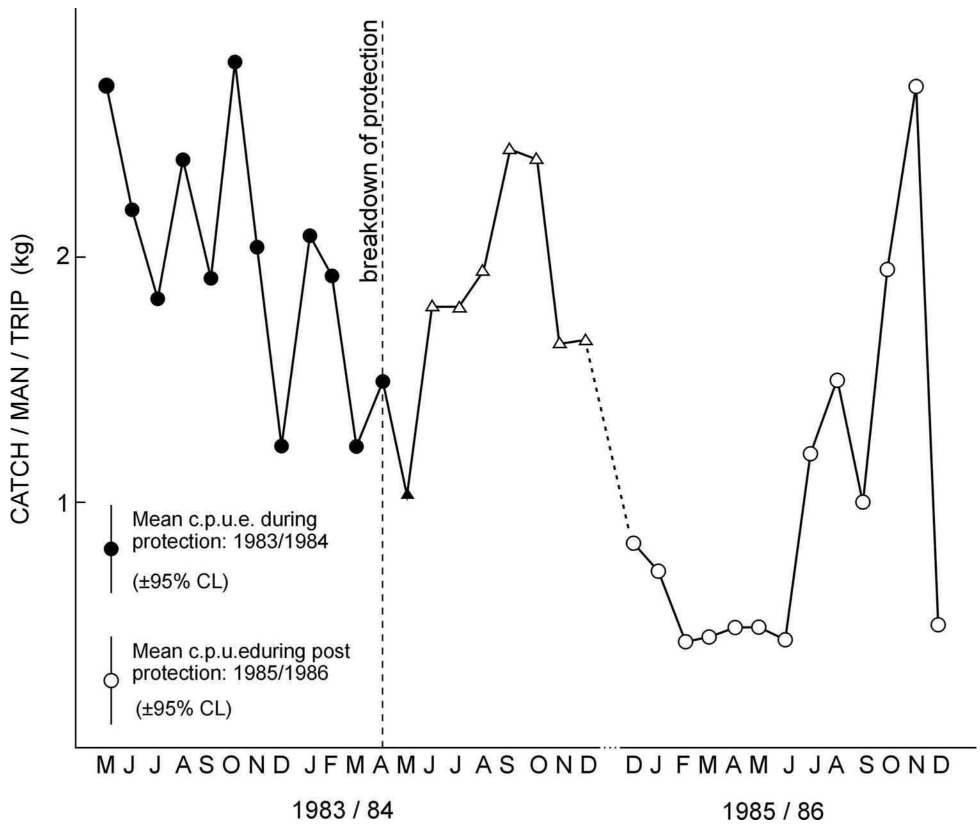
[8] The yield from traps (approximately 45% of the total yield) from the whole island in 1985/1986 was significantly less than the average yield from the non-reserve area (75% of the reef) measured over six separate years during the period of protection (one sample *t*-test, $t_5 = 3.05$, $p < 0.05$). Source: Fig. 4, Alcala and Russ 1990.

Figure 9. Catch per unit effort (CPUE) at Sumilon Island reef before (dark bars) and after (white bars) protective management broke down for (a) hook and line; (b) gill nets; and (c) traps.[9]



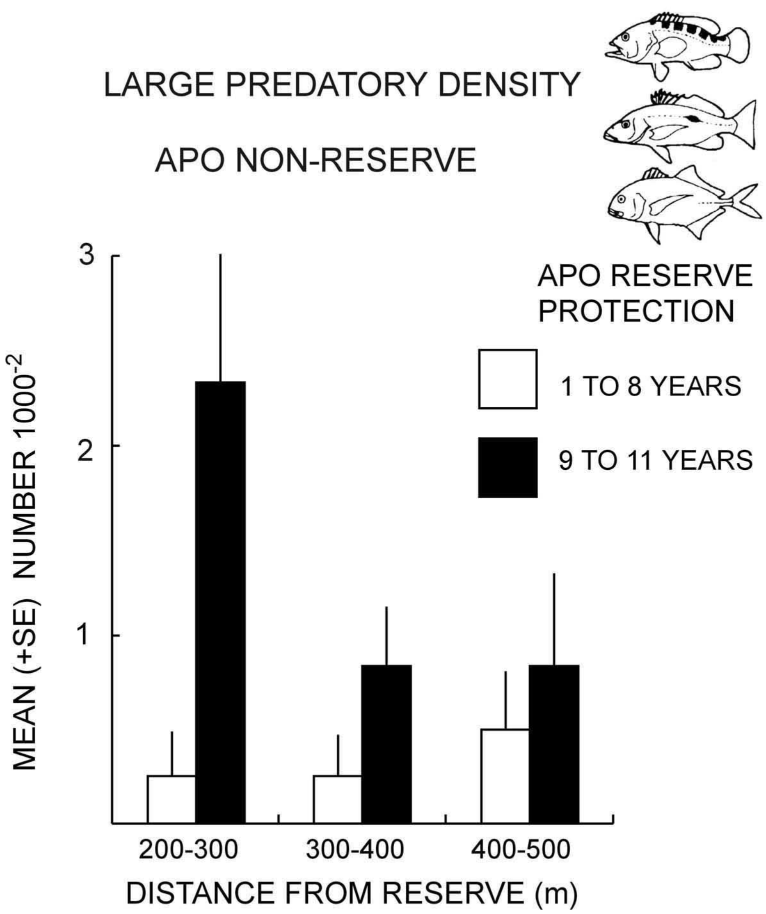
[9] White bars represent CPUE 18 months after protection broke down (December 1985 to November 1986). Dark bars represent CPUE data for the final 12 months of protection (May 1983 to April 1984). The monthly data collected during protection are matched with the corresponding months after protection broke down. CPUE declined significantly by 57%, 58%, and 33% for hook and line, gill net, and traps respectively. These three gears accounted for approximately 98.5% of the total yield in 1983/1984 and 1985/1986. Source: Fig. 3, Alcala and Russ 1990.

Figure 10. Monthly catch per unit effort (CPUE) at Sumilon Island.[10]



[10] Closed circles are CPUE for the final 12 months of protection of the reserve (May 1983 to April 1984). Open triangles are CPUE for 8 months immediately following breakdown of the reserve (May 1984 to December 1984). Open circles are CPUE for the 12-month period beginning 18 months after breakdown of the reserve. Mean CPUE was significantly higher during protection (closed circles) than well after breakdown of protection (open circles). Data shown by triangles were not used in calculation of either mean. Source: Fig. 2, Alcala and Russ 1990.

Figure 11. Mean (+SE) density of large predatory fish [Serranidae (Epinephelinae), Lutjanidae, Lethrinidae and Carangidae as a group] at different distances from the reserve boundary during the first 8 yr of reserve protection (4 sampling periods pooled) and the last 3 yr of reserve protection (3 sampling periods pooled).[11]



[11] Source: Fig. 3, Russ and Alcala 1996a

Table 1. Mean % live coral cover on the shallow reef slopes at all four study sites at the beginning (1983) and end (1993) of the study and mean % live coral cover of the shallow reef slope for seven separate years at the Sumilon Reserve, the only site to show any visually obvious changes in coral cover during the study.[12]

	Sumilon reserve		**Sumilon non-reserve**		**Apo reserve**		**Apo non-reserve**	
Year	1983	1993	1983	1993	1983	1993	1983	1993
Mean	51.0	55.8	27.2	32.5	67.8	68.5	49.8	40.3
Standard error	(5.2)	(4.4)	(0.7)	(3.6)	(4.1)	(5.1)	(124)	(5.7)

	Sumilon Reserve						
Year	1983	1985	1986	1990	1991	1992	1993
Mean	51.0	30.2	30.0	32.3	31.3	43.8	55.8
Standard error	(5.2)	(6.2)	(3.4)	(4.1)	(4.2)	(4.7)	(4.4)

[12] No significant differences of live coral cover were detected at any of the sites in 1993 compared with 1983. Source: Table 1, Russ and Alcala 1998a. Data for 1983 and 1985 from White (1984). Data for 1986 from L. Alcala, unpublished. All other data derived from 6 (9 at Sumilon Reserve) 20 m line intercept transects taken on the shallow reef slopes (4 to 7 m, Sumilon Reserve, 9 to 12 m all other sites). Details of change in coral cover at Sumilon reserve are seven in the description of study sites.

Table 2. Percentage yield of major reef fish families for Sumilon (SNR) and Apo (ANR) Island non-reserve areas.[13]

Taxon	% Yield from SNR	Intensity of fishery (SNR) (% removed/year)	% Yield from ANR	Intensity of fishery (ANR) (% removed/year)
Caesionidae	69.5%	32.5%	13.6%	20.0%
Acanthuridae	14.4%	9.7%	29.3%	20.3%
Carangidae	8.9%	High?	40.5%	High?
Lut. & Leth.	0.3%	6.9%	4.7%	High
Serranidae	0.4%	20.4%	0.5%	100%?
Labridae	3.2%	6.6%	0.2%	2.6%
Scaridae	2.4%	6.5%	4.1%	11.2%
Chaetodontidae	< 0.05%	3.0%	< 0.05%	0.6%
Mullidae	< 0.05%	1.6%	0.2%	4.5%
Haemulidae	< 0.05%	54.1%	< 0.05%	9.5%
Siganidae	< 0.05%	78.8%	< 0.05%	51.6%
Pomacentridae	< 0.05%	0.04%	0.7%	0.6%
Anthiinae	< 0.05%	0.07%	< 0.05%	0.5%

[13] The intensity of fishing (approximate % of standing stock removed annually by the fishery) on each family is estimated. Source: Table 1, Russ and Alcala 1998b.

Table 3. Taxa of reef fish, grouped by family, that make up the category “large predators”, together with an indication of any sites where the taxon attained a density equal to or greater than one of three arbitrary densities at sometime during the study.[14]

Family	Species	Sites
Serranidae (Epinephelinae)	Anyperodon leucogrammicus	
	Atheloperca rogaa	AR
	Cephalopholis argus	**AR, <u>SNR</u>**
	C. boenack	
	C. cyanostigma	
	C. leopardus	
	C. miniatus	**SNR**, SR
	C. sexmaculatus	AR, SNR, **<u>SR</u>**
	C. urodelus	
	C. spp.	
	Epinephelus caeruleopunctatus	
	E. fuscoguttatus	
	E. ongus	SNR
	E. spp.	
	Plectropomus laevis	
	P. leopardus	
	P. oligocanthus	
	Variola albimarginata	
	V. louti	
Lutjanidae	*Aphareus furcatus*	
	Lutjanus bohar	SR
	L. decussates	**SNR, <u>SR</u>**
	L. fulviflamma/ehrenbergi	**<u>SR</u>**
	L fulvus	SR
	L. gibbus	
	L. monostigma	AR
	L. rivulatus	
	L. russelli	
	L. spp.	
	Macolor macularis/niger	**ANR, <u>AR</u>, SNR, SR**
Lethrinidae	*Lethrinus erythracanthus*	SR
	L. erythropterus	
	L.. harak	SR
	L. obsoletus	
	L. spp.	SNR
	Monotaxis grandoculis	AR, **SR**
Carangidae	"Carangids"	**AR, SNR, <u>SR</u>**

[14] ANR, Apo non-reserve; AR, Apo reserve; SNR, Sumilon non-reserve; SR, Sumilon reserve. Bold underline indicates a mean density of ≥ 2 fish/1000 m^2; bold indicates a mean of ≥ 1 fish/1000 m^2; standard type indicates a mean of ≥ 0.5 fish/10000 m^2. Source: Table 1, Russ and Alcala 1996b.