EFFECTIVENESS OF FISH SANCTUARIES IN THE MABINI MARINE RESERVE, PHILIPPINES, AFTER A DECADE OF PROTECTION

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ABSTRACT

Three marine no-take zones (fish sanctuaries) were established by municipal ordinance in Mabini, Balayan Bay, Southern Luzon in the northern Philippines in 1991. Eleven years later Reef Check surveys were carried out by Coral Cay Conservation volunteers in order to assess reef fish populations and hard coral cover both inside and outside the no-take zones. Results indicated that within the Mabini reserve on the southwest Calumpan peninsula, hard coral cover compared favorably with the rest of the Philippines and Indo-Pacific region, especially in shallow (<10m) water where the coral cover in places was high (>50% in Cathedral and Arthur's Rock sanctuaries). Sanctuaries generally had higher hard coral cover than non-sanctuary areas, especially in shallow (5m) waters.

In the Mabini reserve both predatory commercial fish families such as groupers (*Serranidae)* and herbivorous parrotfish (*Scaridae*) were low in abundance both inside and outside the sanctuaries at shallow and medium depths. The very small number of these reef fish indicates that the no-take areas are currently having little direct effect on increasing the abundance of commercially important reef fish species relative to surrounding unprotected reefs. Patterns of increased fish diversity could be seen inside sanctuaries, with individual parrotfish, bumphead parrotfish (*Bolbometopon muricatum*), and *Scombridae* all recorded on one or two dives in the sanctuaries at medium depths. It appears that hard coral cover had a positive influence on fish abundance in the whole Mabini reserve.

Sanctuaries also had a positive impact on reef fish diversity at medium depths compared to areas outside the sanctuaries, but had limited influence on diversity at shallow depths. Fish feeding by dive operators within Cathedral sanctuary may increase the diversity and abundance of smaller site-attached species found at this popular dive site (e.g. butterflyfish). Results indicate that the fish sanctuaries may be too small and have too much surrounding fishing pressure and encroachment to have a significant positive effect on the biomass of more valuable commercial fish species in the area. However, our data imply that sanctuaries are showing some success in establishing greater fish family and species diversity.

Introduction and Background to the Area

Fish sanctuaries (also known as 'no-take zones') are fundamental to the development of marine conservation initiatives, as they can conserve and increase fish stocks both in tropical artisinal and temperate industrial fisheries (Gell and Roberts, 2003; Roberts and Hawkins, 2000). There can be considerable advantage in developing effective reserves at a small local scale as they encourage communities to drive management and policing of the reserve themselves (Ledesma *et al.,* 1998). However, problems associated with incursions into fish sanctuaries by fishermen can occur if education of local communities and enforcement is poor (Gilman, 1997; Alder, 1996; Erdmann *et al.*, 2003). Realistically, many marine reserves in the Philippines are failing to protect fish stocks, even after having achieved statutory status (Christie *et al.*, 2002; Pajaro *et al.*, 1999; Russ and Alcala, 1994).

Effective fish sanctuaries can provide spill over of adults when the carrying capacity of commercial fish populations within the sanctuary boundary is reached (McClanahan and Mangi, 2000). Fishermen on the edge of the sanctuary can then legally harvest these fish. Another beneficial effect of sanctuaries is that larvae from fish and shellfish within sanctuaries can also spill over into unprotected areas, and 'seed' reefs which may have had poor previous recruitment (Tawake *et al.*, 2001; Gell and Roberts, 2003; White *et al.*, 2002). Therefore, there can be long-term advantages in the use of protected areas, as has occurred in community-based reserves in the Philippines in the past, such as Apo Island (Russ and Alcala, 1996) and to a lesser extent, Sumilon Island (Alcala, 1981).

Anilao (named because of the main fishing village commonly associated with the Mabini-Tingloy dive area) is the most famous and historically rich of the Philippine dive areas (Fig. 1). Only three hours by road from the capital city, it began to emerge in the 1970s as one of the most popular dive areas for Manila residents, with around 400 dives carried out in the area during peak weekend periods (Trono, pers. comm.). Since the fall in foreign tourist numbers from the west, mainly Korean, Japanese and Filipino tourists have continued to dive in the region. It has also been an important fishing area for both artisinal local fishermen and a tuna fishery working from larger vessels (White *et al.*, 2001).

Between the late 1970s and 1980s, considerable efforts were made by the National Environment Protection Council to create marine parks around Sombrero Island, Sepoc, and Layag-Layag in Mabini-Tingloy municipal waters. These initiatives were unsuccessful and the areas remain accessible for all stakeholders and resource users to this day. The Haribon Foundation introduced a community-based conservation project along the shores of San Teodoro and Bagalangit barangays in Mabini in 1990 (White *et al.*, 2001; White and Vogt, 2000), which led to the creation of the first fish sanctuaries by municipal (Mabini) ordinance in 1991 in the areas of Cathedral Rock, Arthur's Reef, and Twin Rocks (Fig. 2). All these sanctuaries lie on the southwesterly facing the coast of the Calumpan peninsula within the Mabini reserve. During the mid 1990s, the Sulu Fund for Marine Conservation Foundation Inc., now known as the Coastal Conservation and Education Fund (CCEF), funded by Earthwatch, began a series of surveys in the Mabini sanctuaries and reefs surrounding the Anilao dive area. These surveys have continued throughout the 1990s with the most recent survey completed in 2001 (White *et al.*, 2001).

In 1997, WWF-Philippines (KKP - Kabang Kalikasan ng Pilipinas) became actively involved and promoted the area as one of its key sites within the Sulu-Sulawesi Marine Eco-Region program. Work initiated by WWF, The Center for Empowerment and Resource Development, and the Sulu Fund for Marine Conservation Foundation led to the inception of The Mabini-Tingloy Coastal Area Development Council in 1997 (White and Vogt, 2000).

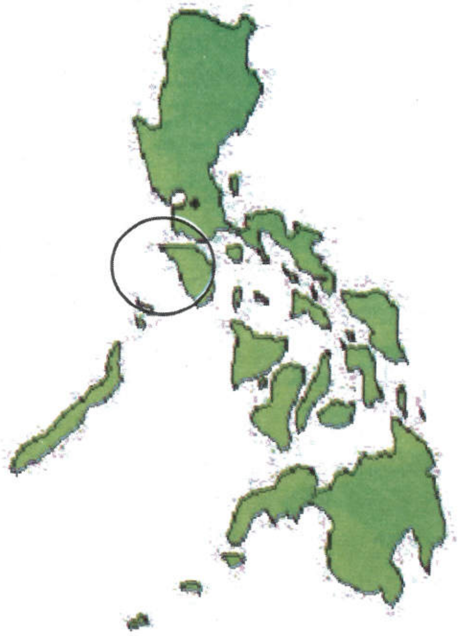
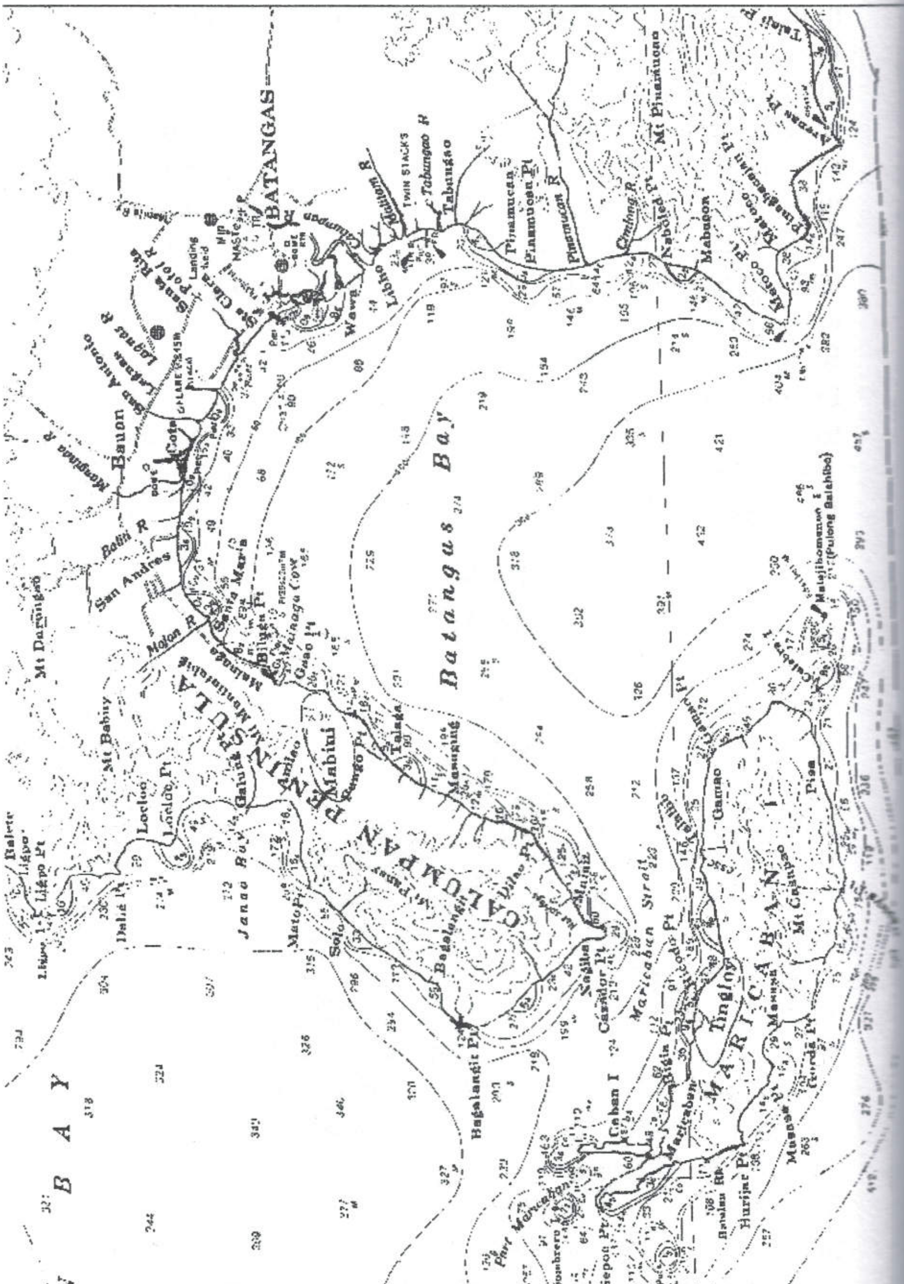


Figure 1. Location of the Anilao area (Mabini and Tingloy municipalities) in southern Luzon, Philippines. (For an enlarged view, see next page.)


BATANGAS
Batangas Bay
CALUMPAN PENINSULA
MARICABAN I
Maricaban Strait
Mabini
Tingloy

This legislative council was formed in order to discuss trans-boundary issues related to conservation in the waters of Batangas and Balayan Bays and around the island of Maricaban (Tingloy municipality). WWF also initiated a resort-owners' NGO known as 'The Friends of Balayan Bay' in 2000 so that divers and resort stakeholders could have a single voice concerning environmental issues. In September 2001, NGOs, Governmental Organizations, local businesses, as well as oil and shipping companies of the area signed an MOU agreeing to support efforts to protect the environment in the Batangas region.

The area has therefore seen considerable investment in both community-based and legislative initiatives to introduce marine environmental conservation practices to aid the protection of local coral reef resources. This culminated in WWF working with another Philippine-based NGO, the Philippine Reef and Rainforest Conservation Foundation Inc., and the invitation of the UK-based not-for-profit NGO, Coral Cay Conservation (CCC), into the Mabini-Tingloy region. CCC was invited to conduct a baseline assessment of the coral reefs for the purposes of habitat mapping (Solandt *et al.*, 2002; Trono *et al.*, 2003) and a rapid quantitative assessment of reef health using the internationally recognized Reef Check survey methodology (Hodgson, 2001). Between January and June 2001, CCC carried out more than 300 dives involving over 70 personnel (Solandt *et al.*, 2002; 2003).

This study focuses on data collected from the Reef Check dives undertaken in the Mabini reserve and concentrates on reef fish populations at shallow (5m) and medium (10m) depths inside and outside the three fish sanctuaries of Cathedral Rock, Arthur's Reef, and Twin Rocks. The primary aim of the study was to establish whether the sanctuary designation had any significant effect on reef fish populations and benthic communities inside and outside the sanctuaries.

Methods and materials

The Reef Check methodology was designed in 1997 in order to allow volunteers to gather reliable data on the status of coral reef health, (www.reefcheck.org). The method was designed to be easily replicable both temporally and spatially so that a database of information can be built up from a number of locations. Six years of data have been collected which has allowed a global spatio-temporal comparison of reef health (Hodgson and Liebeler, 2002; Hodgson, 2001).

For the diving surveys undertaken in this study, the standard Reef Check protocol was modified to collect more detailed information at a greater taxonomic resolution and hence provide a more comprehensive assessment of reef health. Such modifications are possible because CCC volunteers receive more intensive training than regular Reef Check divers (Solandt, *et al.,* 2002; Mumby *et al.*, 1995).

The survey protocol utilized two transects at depths of approximately five and ten meters as this is where the greatest coral reef diversity and benthic cover occurs on the majority of fringing coral reefs (Fig. 2). Along each depth contour, a 100m transect was deployed parallel to the reef slope. Each 100m transect consisted of four 20m replicate transects separated by 5m spaces (Fig. 3). Further details on the methodology can be found in the Reef Check survey manual (Hodgson *et al.*, 2003).

Data were recorded from three fish sanctuaries (Cathedral Rock, Arthur's Reef, and Twin Rock). Data were pooled from four other dive sites within the Mabini reserve but outside the fish sanctuaries at the two same depth bands to represent control (fished) sites.

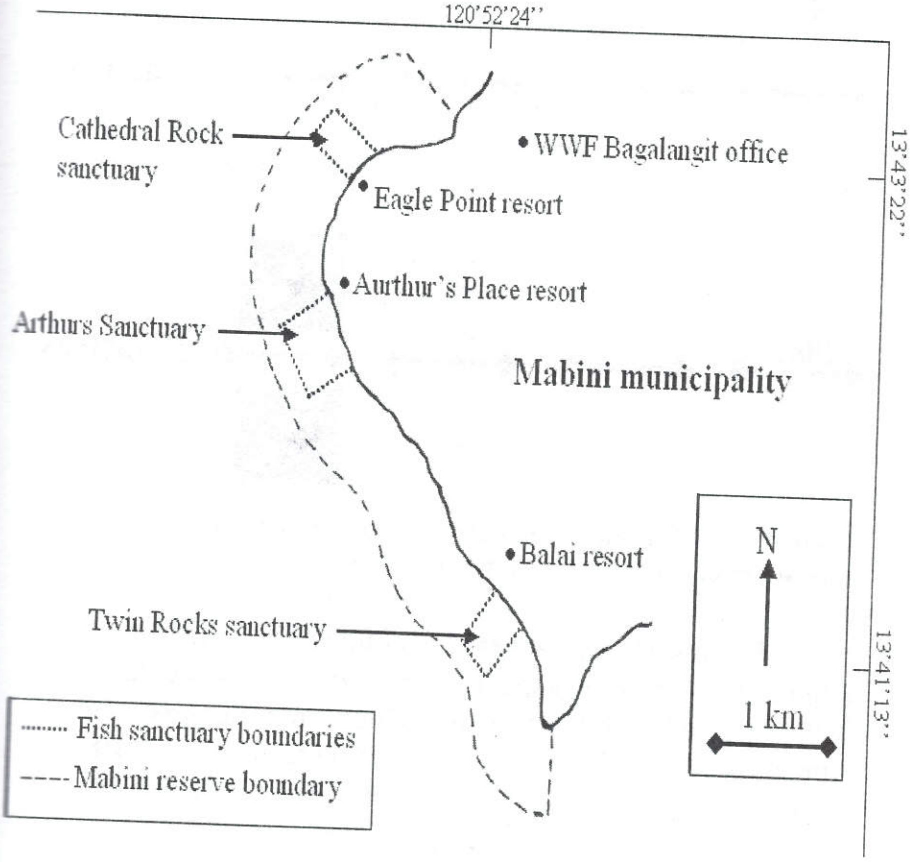


Figure 2. Location of the three fish sanctuaries within the Mabini reserve.

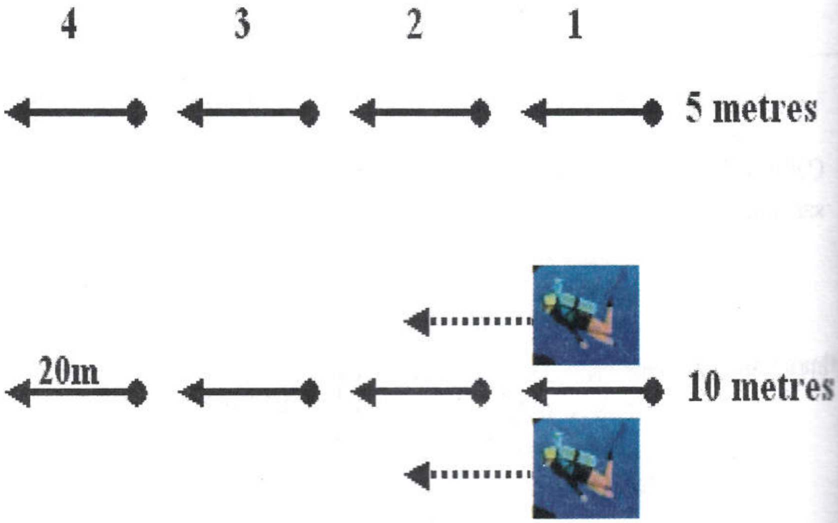


Figure 3. Schematic diagram showing the position of the transect lines at two depth bands during a Reef Check survey.

The presence and absence of commercially important fish families and target species were recorded, particularly those targeted by fisherfolk and aquarium collectors (see Appendix 1). Fish were counted if they were present in each $5m^3$ block of water (up to 5m above the transect line and 2.5m either side) giving each replicate an area of 20 x 5 x 5m = $500m^3$. The divers assigned to fish surveys waited for three minutes before each 5 meter section of a 20m transect to allow reef fish to resume normal behavior. They then swam slowly along the 5m section recording all targeted reef fish along the way. The process was then repeated for subsequent 5 meter blocks. See www.reefcheck.org and Hodgson *et al.* (2003) for the full methodology of replicate transect design.

Following fish surveys, the four 20m long transects at each dive site were point sampled to determine the substratum types and benthic community of the reef. For these surveys, the diver recorded the benthic cover or substratum at 50 cm point intervals along each transect. Reef Check categories recorded were hard coral, soft coral, recently killed coral, dead coral, fleshy seaweed, sponge, rock, rubble, sand, silt/clay, and 'others.' In addition, the surveyors recorded hard coral life-forms following the protocol in English *et al.*, (1997) and a number of target coral, algae, invertebrate and fish species developed by Coral Cay Conservation. All data were transferred to specially-designed recording forms immediately after dives, and checked thoroughly by the scientific staff on site.

For coral cover information, data were pooled from three sanctuary areas and compared to data pooled from all control (non-sanctuary) sites at the two specified depth bands.

Statistical analysis

Reef fish populations were compared between sanctuary (on an individual basis) and non-sanctuary (control) areas within the Mabini reserve. Non-parametric ranked (Kruskal-Wallis) tests were used to compare fish counts between the four different reserve areas: Cathedral Rock, Arthur's, Twin Rocks, and non-sanctuary (control) areas. Tests were performed separately on shallow (5m), and deep (10m) reef fish populations (Fig. 5 and 6).

Multivariate analysis

In order to describe the various fish assemblages present both inside and outside the fish sanctuaries, data were analyzed with multivariate statistics using PRIMER software (Clark and Warwick, 1994). Multivariate analysis can be used to cluster the site records into several groups, which represent distinct fish populations (assuming the fish populations remain within the study sites). Firstly, the similarity between fish assemblages at each site record was measured quantitatively using the Bray-Curtis Similarity Coefficient without transformation (Bray and Curtis, 1957). This coefficient has been shown to be a robust measure of ecological distance.

Agglomerative hierarchical cluster analysis with group-average sorting was then used to classify survey replicates into groups. The resulting dendrogram grouped site records together based on biological similarities (Fig. 7). SIMPER (SIMilarity PERcentage) analysis of the data was subsequently used to determine key fish species and families which contributed to each 'cluster' (see Solandt *et al.,* 2001, 2003).

Shannon-Weiner biodiversity indices were calculated for reef fish data at each survey site and then pooled to compare reef fish diversities inside and outside sanctuary areas.

Results

Hard Coral Cover

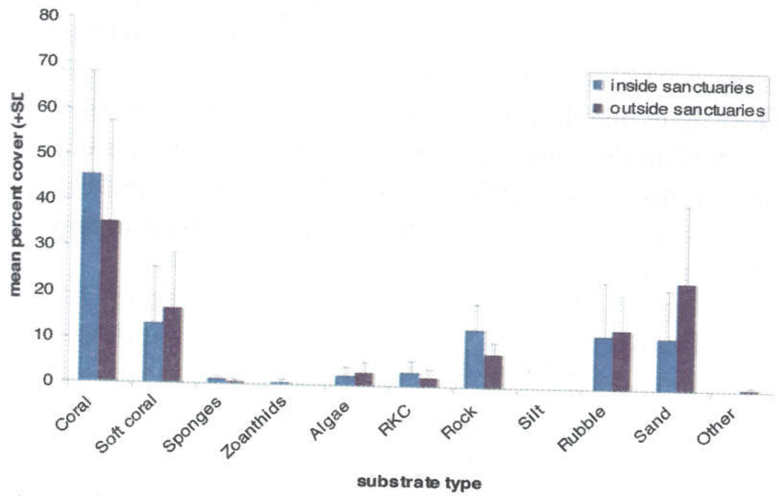
Mean hard coral cover was similar both inside and outside sanctuaries within the Mabini reserve (Fig. 4), although there was slightly greater coral cover at 5m depth inside sanctuaries (45.4% ± 22.6 S.D.) compared to cover outside sanctuaries (35.0% ± 22.3). Both these values compare favorably with average coral cover for previous ReefCheck dives; approximately 35% for Indo-Pacific reefs between 1997 and 2001 (Hodgson and Liebeler, 2002).

There is considerable difference in hard coral cover between depths at all sites in the reserve (both sanctuary and non-sanctuary sites). Coral cover inside sanctuaries at 10m fell to 20.4 ± 16.7%, and outside sanctuaries to 20.0 ± 9.0%. However none of these relationships was significant when compared between depths (paired t-test) or sites (Mann-Whitney test).

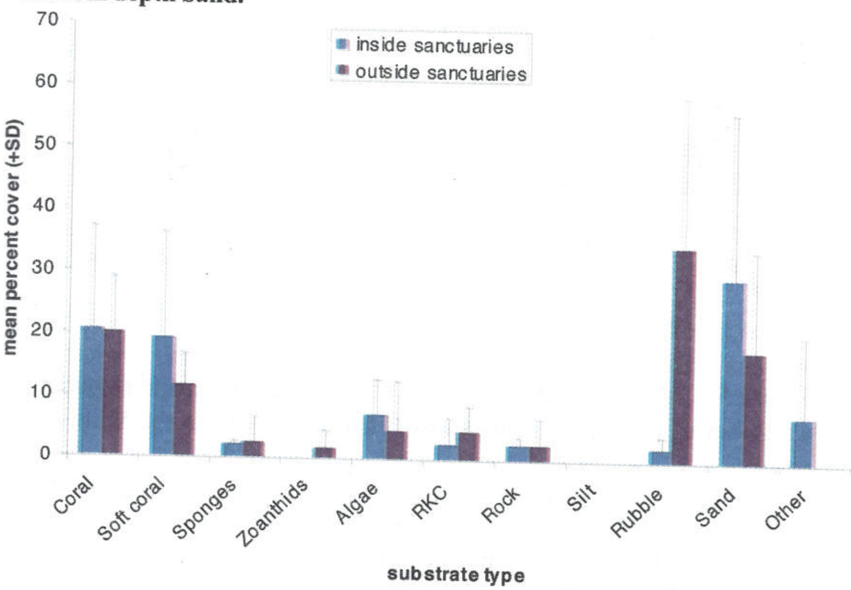
Hard coral cover at medium depths was generally lower than at the shallow reef crest and was apparent at many other survey sites in the Mabini-Tingloy area. Branching and table *Acropora* colonies, digitate *Montipora* and *Pocillopora* forms, and *Acropora palifera* dominated much of the coral cover in shallow water. Deeper (10m) waters of the Mabini reserve were dominated by sand, rubble, macroalgae, and soft coral communities, with rubble considerably higher in non-sanctuary areas (34.6 ± 24.2%) compared to sanctuary areas (2.08% ± 1.91).

Figure 4. Substratum cover inside and outside fish sanctuaries at the 5 (4.a) and 10 metre (4.b) depth bands.

4.a: 5m depth band



4.b: 10m depth band.



Fish Abundance

Butterflyfish (*Chaetodontidae*) were significantly more abundant at shallow (5m) depths at Cathedral Rock than at other sites (ANOVA, $F = 6.49$, $P<0.0067$) (Fig. 5). Another significant difference occurred in the distribution of parrotfish (*Scaridae*), which were absent from 52 non-sanctuary replicates but occurred inside Arthur's Reef sanctuary (0.25 ± 0.46 individuals per $500m^3$, Kruskal-Wallis test, $H = 17$, $P < 0.0007$). This number represents only two fish in eight replicate dives, but these were significant observations as they all occurred inside a sanctuary. The only other reef fish category to show reasonable numbers at shallow depths were the Surgeonfish (*Acanthuridae*), dominated by planktivorous and herbivorous species.

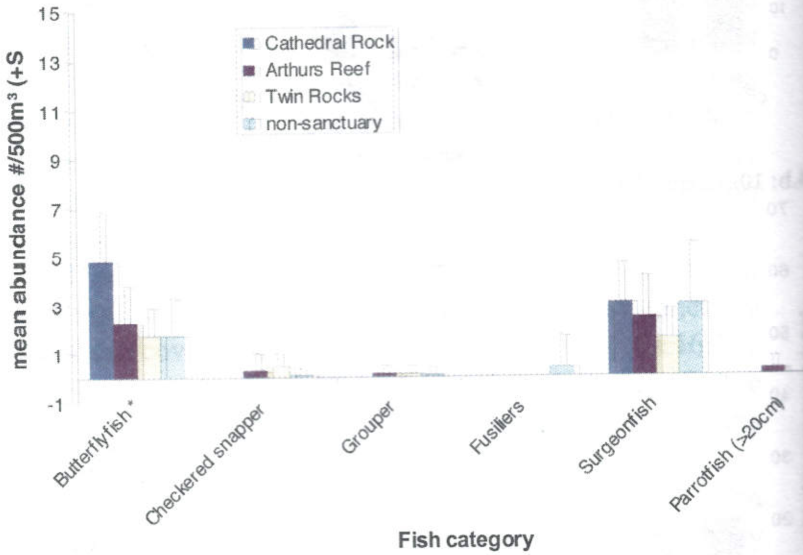


Figure 5. Mean abundance (+SD) of reef fish inside and outside a number of sanctuaries at shallow (5m) depths within the Mabini reserve.

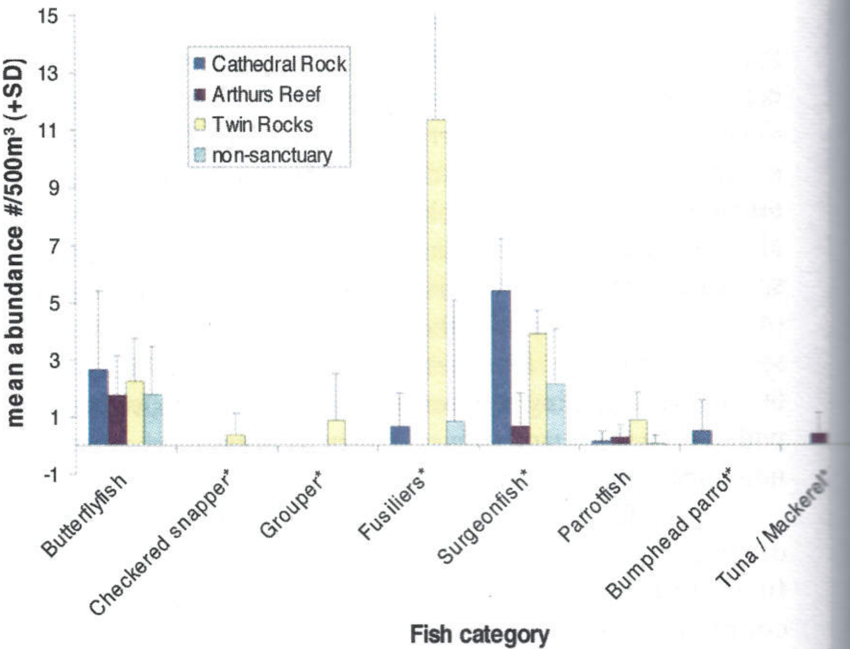
* - designates a significant difference in fish abundance in butterflyfish numbers, with highest abundance of this family at Cathedral Rock (ANOVA, $P<0.05$). All other populations were not significantly different from each other.

A greater diversity of reef fish (families and species) was recorded at medium (10m) rather than at shallow depths (5m), especially within sanctuaries. Checkered snapper (*Lutjanus decussatus*), groupers (Serranidae), fusiliers (*Caesionidae*), surgeonfish, bumphead parrotfish (*Bolbometopon muricatum*), and tuna/mackerel species (*Scombridae*) were all significantly more abundant inside rather than outside sanctuaries (Kruskal-Wallis, $P < 0.05$). Abundances of most of these species, especially the wide-ranging, larger commercial species were very low (between 0.375 and 0.875 fish per $500m^3$), representing between only one and three fish observed within each sanctuary. However, they were totally absent from non-sanctuary areas (41 replicates).

Twin Rocks supported significantly greater numbers of checkered snapper (*Lutjanus decussatus*), grouper, and fusiliers (in one replicate, 60 individual fusiliers were counted) at 10m compared to other sanctuary sites (Fig. 6). Twin Rocks is located a little further away from other reserve areas and at certain times was seen to support large numbers of *Carangidae* which may be feeding on the considerable numbers of planktivorous fish present at this site.

Figure 6. (See next page) Mean abundance (+ SD) of reef fish inside and outside a number of sanctuaries at medium (10m) depths within the Mabini reserve.

* designates a significant difference in fish abundance for Checkered snapper, Grouper, Fusiliers, Surgeonfish, Bumphead Parrotfish and Tuna/ mackerel, between dive sites (K-W test, $P < 0.005$).



Fish population assemblages

Reef fish species and family assemblages were fairly randomly mixed between sites at shallow depths (5m), indicating that there was no significant influence of location on species diversity, or fish trophodynamic assemblages at this depth.

At medium (10m) depths, however, there did appear to be a difference between reef fish recorded inside and outside sanctuaries (pooled data for this analysis) (Fig. 7, next page).

Figure 7. Dendrogram of percent similarity (cluster analysis) in reef fish populations between survey dives. Five population 'clusters' (assemblages) fall out of the analysis. Those surveys from within fish sanctuaries are marked by a black dot '•' beside the code of that dive.

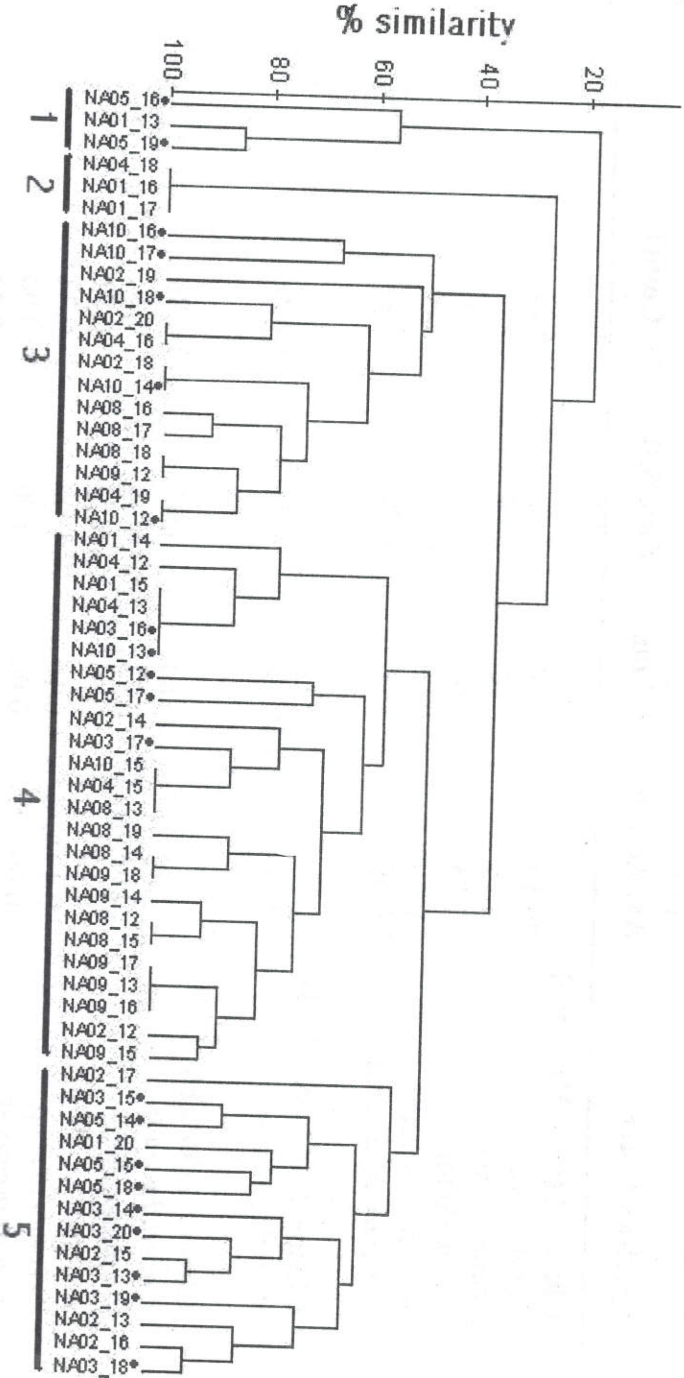

% similarity
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Table 1. Analysis of SIMPER of clusters 1-5 in Figure 6. Simper shows the percentage contribution of the most important species to define each cluster. **FS** - is the percent of survey dives from Fish Sanctuary areas in that cluster. (*N* is the total number of replicates in that cluster).

Species/Cluster	Av. Abund.	Av. Sim.	Sim./S.D.	% Contrib.
Cluster 1 (66% FS, *N* = 3)				
Caesionidae	26.50	27.36	0.87	76.22
Acanthuridae	2.75	6.00	2.79	16.71
Chaetodontidae	1.75	2.54	0.85	7.07
Scaridae (>20cm)	0.50	0.00	0.00	0.00
Lutjanus decussatus	0.50	0.00	0.00	0.00
Cluster 2 (0% FS, *N* = 3)				
Acanthuridae	1.00	100.00	0.00	100.00
Cluster 3 (36% FS, *N* = 14				
Chaetodontidae	2.94	49.84	1.97	91.86
Acanthuridae	0.62	3.73	0.34	6.87
Scaridae (>20cm)	0.19	0.50	0.16	0.92
Scrombridae sp.	0.19	0.19	0.09	0.34
Plectropomus sp.	0.06	0.00	0.00	0.00
Epinephelus sp.	0.06	0.00	0.00	0.00

Table 1. (Continued)

Species/Cluster	Av. Abund.	Av. Sim.	Sim./S.D.	% Contrib.
Acanthuridae	2.59	46.63	2.61	69.80
Chaetodontidae	1.64	19.96	1.07	29.87
Scaridae (>20cm)	0.23	0.22	0.11	0.33
Caesionidae	0.05	0.00	0.00	0.00
Lutjanus decussatus	0.05	0.00	0.00	0.00
Cluster 5 (66% FS, *N* = 14)				
Acanthuridae	5.71	48.32	4.20	75.81
Chaetodontidae	2.43	10.01	1.02	15.70
Caesionidae	1.64	4.96	0.53	7.78
Scaridae (>20cm)	0.21	0.30	0.18	0.47
Bolbometopon muricatum	0.29	0.15	0.10	0.23
Siganidae sp.	0.14	0.00	0.00	0.00
Lutjanus biguttatus	0.07	0.00	0.00	0.00
Seranidae (all species)	0.21	0.00	0.00	0.00

Reef fish assemblages within sanctuaries generally consisted of two assemblage types ('clusters'); assemblages dominated by fusiliers (Table 1, cluster 1) and those assemblages dominated by surgeonfish and butterflyfish but with a wide diversity of other species (Table 1, cluster 5). The dendrogram indicates that these two assemblages are clearly defined by the cluster analysis (Fig. 7) and that they are both dominated by surveys from inside sanctuaries (66% of both groups are made up of sanctuary replicate surveys).

The analysis also reveals that most of the reef fish populations in sanctuaries at 10meters depth are either characterized by large numbers of fusiliers, or by populations dominated by surgeonfish and butterflyfish with a suite of other less abundant families such as parrotfish, grouper, and wrasse. The factor that distinguishes cluster 5 (which contains most of the sanctuary dives) from other clusters is the increased diversity of the less abundant species recorded.

Fish species diversity inside and outside sanctuaries

Shannon-Weiner diversity indices were calculated using PRIMER for 5m and 10m sanctuary and non-sanctuary fish populations from the original data set. There was no significant difference in diversity between sanctuary and non-sanctuary populations at shallow depths (Mann-Whitney on pooled Shannon-Weiner diversity indices, $P>0.05$). However, sanctuaries contained greater diversity of reef fish (Shannon-Weiner index: 0.744 ± 0.42) than in non-sanctuary areas (0.41 ± 0.34) at the 10m depth band (Mann-Whitney, $P< 0.0012$).

Discussion

The results reported here indicate that patterns of hard coral cover, reef fish abundance, and reef fish diversity were slightly greater inside than outside the sanctuaries.

Some of the three Mabini sanctuaries were originally chosen because they were established dive sites with interesting benthic topography, high coral diversity and health, and better than average fish numbers. Indeed, the shallow sites at Cathedral Rock and Arthur's Reef have good coral cover, often exceeding 50% in places, which are dominated by branching, tabulate, digitate, and submassive forms of the *Acropora* family. Higher coral cover has previously been shown to support greater abundance and diversity of site-attached fish species (Roberts and Ormond, 1987) and may have resulted in higher *Chaetodontid* abundance in some of the sanctuary areas reported in this study. Indeed, the abundance of small site-attached species at sites such as Cathedral Rock may be more attributable to the degree of habitat availability rather than as a result of hand-feeding by sport divers. The evidence of greater diversity recorded within cluster 5 (Fig. 7), comprising a high proportion of replicates from sanctuary areas, could have been as a result of both these factors.

Coral reefs of Mabini have seen considerable historical investment of resources in community- based coastal resource management in the past 10-20 years (Solandt *et al.*, 2003; White *et al.*, 2001; White and Vogt, 2000). This background of education and awareness-raising in coastal communities of coral reef conservation issues will no doubt provide a stronger chance of long term resource protection in Mabini than for many other Philippine reefs. Unfortunately, there is only limited evidence from the data that sanctuaries are having a positive effect on building up the biomass of commercial fish families and species, although some patterns did emerge from the deeper sites. The presence of higher species diversity within the deeper sanctuary areas bodes well for the future. Many of the extra species found in deeper sanctuary waters were commercial species, including groupers, bumphead parrotfish and other parrotfish species, all of which can attain considerable biomass. However, increased size of reef fish individuals or populations usually results in an increase in the required home range of a species. Unfortunately, the largest sanctuary in the Mabini reserve (Arthur's Reef) is only approximately 300m x 100m, which is probably too small to effectively protect any population of larger predatory species from fishing pressure, unless encroachment into the sanctuaries is completely eliminated. Even if the fishermen were to fish many of the reefs at the edge of these boundaries, it would be likely that at some time or other, larger members of the *Serranidae*, *Lethrinidae*, *Lutjanidae*, *Carangidae*, and *Sphyrenidae* would be caught by hook and line, spear or net fishing at the edge of the reserve boundary. Many of the larger species in these families need areas of up to one square kilometer in order to maintain a feeding 'home range' and therefore be immune from effects of fishing by local fishermen at the boundary-line of the sanctuary.

As a result, it appears that the sizes of the sanctuaries within the Mabini reserve may be too small to support anything other than the smaller planktivore, herbivore, and corallivore species such as *Caesionidae*, *Acanthuridae*, and *Chaetodontidae* in reasonable numbers. All of these trophic groups can be supported in larger numbers within smaller areas than the larger carnivores. Kramer and Chapman (1999) showed that the larger the area of a reserve (fish sanctuary), the lesser the significance of effect of fishing the boundary line, as many fish would still be entrained within the sanctuary. By inference, one can assume that the larger the area of the reserve (for the same fishery), the lesser the impact of fishing the boundary line.

The size of the reserve becomes less important if one has carefully considered matching the life history and home range of the species to the size of the sanctuary and, more significantly, if one can be sure of complete compliance by local communities to the closed area (Halpern, 2003). As an illustration, CPUE of the hook and line fishery around the 0.74 km^2 Apo Island reserve increased ten-fold over twenty years of protection, from 0.13-0.17 kg per person/hour in 1981 to 1-2 kg per person/hour in 1997-2001 (Maypa *et al.*, 2002). It may be that if total fishing effort in the Mabini reserve was reduced, allied with complete compliance of the boundaries of the sanctuaries, the abundance and biomass of larger commercial fish species within the sanctuaries would increase.

Recommendations

Fishermen in the Mabini-Tingloy area stand to benefit in the long term if there was complete compliance with the boundaries of the marine reserve and if a network of marine protected areas was established in the region. Part of the recommendations of the recent CCC survey of Tingloy and Mabini (Solandt *et. al.*, 2003) suggested allocating the north-western tip of Tingloy Island for MPA and fish-sanctuary status as a result of the high diversity of habitats (100% coral cover on reef flats; sheer coral walls; large 'backreef' *Porites* mounds; spur and groove formations), and its potential for supporting high fish biomass within them. The sanctuaries and reserves of Mabini are a good starting point for an overall conservation strategy for the area. However, by including other sanctuaries from slightly further afield in the management plan and with greater compliance from local populations to areas closed to fishing, we may see a positive effect on reef fish populations based on the result of networking marine protected areas (Roberts *et al.*, 2001).

The above recommendation and a number of others by Solandt *et al.* (2003) are in close agreement with those suggested by another recent study in the region (White *et al.*, 2001). As well as increasing the number of MPAs, both the above reports state that local environmental awareness and education programs should be implemented to increase understanding and ultimately compliance with any marine conservation regulations, either currently in place or implemented in the future. There is also a need for a local sense of stewardship of the marine environment so that fishing communities and other stakeholders act to maintain and enhance the resources that are provided by the coral reef ecosystem.

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APPENDIX I

The following table lists all the reef fish categories recorded by CCC divers during Reef Check surveys in the Anilao region in 2002. A combination of families and particular target species were recorded. All reef fish within a particular family were recorded to species if known.

Reef Fish Categories	Family	Species
Butterflyfish	*Chaetodontidae*	
Sweetlips	*Haemulidae*	
Snappers	*Lutjanidae*	
Two-spot	"	*Lutjanus biguttatus*
Checkered	"	*Lutjanus decussatus*
Black-and-white	"	*Macolor macularis*
'Bluelined'	"	*Lutjanus kasmira*
Paddletail	"	*Lutjanus gibbus*
Groupers (<30cm TL)	*Serranidae*	
Groupers (>30cm TL)	"	
Barramundi Cod	"	*Chromileptes altivelis*
Flagtail	"	*Cephalopholis urodeta*
Peacock	"	*Cephalopholis argus*
Lyretail	"	*Variola louti*
'Honeycomb'	"	*Epinephelus merra*
	"	*(E. hexagonatus, E. quoyanus*
Humphead wrasse	*Labridae*	*Chelinus undulatus*
Bumphead parrot	*Scaridae*	*Bolbometopon muricatum*
Parrotfish (>20 cm TL	*Scaridae*	
Tuna / Mackerel	*Scombridae*	
Fusiliers	*Caesionidae*	
Surgeonfish	*Acanthuridae*	
Rabbitfish	*Siganidae*	
Barracuda	*Syphrenidae*	
Jacks / Trevally	*Carangidae*	
Moray eel	*Muraenidae*	