Asian Fisheries Science **15** (2002):177-192
ISSN: 0116-6514
https://doi.org/10.33997/j.afs.2002.15.2.009

Asian Fisheries Society, Manila, Philippines

Status of Philippine Coral Reef Fisheries

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Abstract

Coral reefs have traditionally supplied coastal human populations with fishery products. Reef fisheries constitute about 20% of the total marine production (1.64 million mt) in the Philippines, as of the late 1990s. Based on the total area of coral reefs, which is 25,000 km^2, and the average fish yield of good reefs, estimated at 15 $mt \cdot km^2 \cdot yr$, the potential annual production of Philippine coral reefs would be about 350,000 mt. Since only 30% remains in good condition and 70% is in degraded condition, this estimated annual production have been reduced to about 177,500 mt as of the 1990s. Coral reef fisheries in the central Philippines comprise about 125 reef and reef-associated species distributed in 14 families. Aside from being over-fished, the Philippine coral reefs have been damaged by the use of destructive fishing methods. The high intensity of fishing (up to 50% of fish standing stock removed by fishing annually) has resulted in the depletion of fishery species. Protection of reefs occurs at a slow rate, indicating a need to increase efforts at establishing marine reserves and restoring degraded reefs to stabilize or enhance fish yields.

Introduction

Coral reefs provide mankind with many products and natural services, but only a few of these goods and services have been properly valued economically (Moberg and Folke 1999). In the Philippines, the most important coral reef products are fish and other marine animal species serving as food. Traditionally, coastal dwellers comprising more than half of the total population of the country have depended on coral reefs and other shallow-water ecosystems for their fish protein. Over the last two decades, coral reefs have provided income to coastal communities through tourism. Another important contribution of coral reefs requiring proper valuation is coastal protection from erosion.

Coral reefs in the Philippines, like those in other parts of the world, are among the most productive marine habitats. Our observations on pristine coral reefs in the central Philippines 60 years ago have left the impression that these tropical ecosystems have no rivals in the marine world in terms of diversity of animal species. Unfortunately, no scientific assessments of species richness and standing stock of reef and reef-associated species were made at that time, only taxonomic accounts are available (Nemenzo 1981). When more intensive reef studies started in the 1970s, most Philippine reefs had already been damaged (Gomez et al. 1981, 1994; Alcala et al. 1987), making it impossible to state unequivocally the actual conditions of our coral reefs at the turn of the 20th century. However, it can be reasonably assumed that most reefs of the Philippines at that time compared favorably with the present pristine or lightly disturbed reefs in the Indo-West Pacific region, such as those in the Great Barrier Reef as described by Wallace (1999) and Veron (2000). Recollections of our senior citizens born at the turn of the 20th century agree with this assumption (Alcala 2001).

This paper discusses the present status of coral reef finfish fisheries in the Philippines and the important role of marine reserves in the conservation of the country's coral reefs. The review was undertaken due to the importance of coral reefs and their fisheries in providing food security for the people. This paper can also serve as a baseline against which changes in the future may be compared.

Trends in marine capture fisheries

Philippine marine capture fisheries may have begun to decline decades ago (see Jackson et al. 2001 for worldwide trends). Trawl grounds showed signs of depletion as early as 1949 (Thomas 1999). Intense commercial fishing using drift gill nets, purse seines, ring nets, Danish seines, and beach seines may have contributed to fishery depletion in many areas of the country. Commercial fisheries have probably exceeded the limits of sustainable yield, as evidenced by the leveling off of growth in catch and the decreases in some stocks (Dalzell et al. 1987; Dalzell and Corpuz 1990 and BFAR 1997, as cited in Anonymous 1999). Exports of live reef food fish that showed an increasing trend until 1993 and remained steady at 1100 tons until 1996, have fallen by 50% (Bentley 1999). However, all of these assessments are not consistent with the fisheries statistics for 1993-1997 (BFAR undated), which shows an increasing trend. During this 5-year period, commercial marine production was reported to have increased from 824,356 mt in 1993, to 859,328 mt in 1994, to 893,232 mt in 1995, to 879,073 mt in 1996, and to 884,651 mt in 1997 (the average production during the last four years (1994-1997) was calculated to be 879,071 mt. A Bureau of Fisheries and Aquatic Resources (BFAR) official explained the increasing trend as due to the inclusion of commercial catch from international waters.

Fisheries of reefs and other shallow-water marine environments have also been reported to be declining since the late 1970s (Smith et al. 1980, Thomas 1999). For example, the dugong fishery had declined due to over-fishing as early as the 1920s. The decline of reef fisheries is difficult to demonstrate because production of reefs has been lumped together with that of other shallow-water ecosystems and recorded as municipal fisheries production. However, BFAR (1997, as cited in Anonymous 1999) seems to imply that municipal fisheries have declined only since 1991. This does not make sense because intense fishing in shallow coastal areas has been known to occur since the earlier decades. In fact, fishing gears such as beach seines and small mesh-size gill nets have been banned by some local government units (LGUs) from operating in many coastal areas in the central Philippines in response to declines in the catch of sustenance fishers (pers obs). Even Yap et al. (1995), who advocated increased fishing intensity, admit the depleted status of shallow-water fisheries. As expected, published official statistics from the Bureau of Agricultural Statistics, Department of Agriculture (BAS,DA) show that the municipal marine production decreased from 854,687 mt in 1992 and 803,000 mt in 1993 to an average of about 760,000 mt annually during the succeeding four years (BAS, DA). Adding the mean commercial production and the mean municipal production during the four-year period (1994 to 1997) gives a total marine production of 1.64 million mt. This figure is questionable because it does not differ from the 1.66 million mt total marine production in 1992, when in fact, evidence points to a reduced production in 1997.

Causes of decline of reef fisheries

Over-fishing has been identified as the major cause of the recent collapse of the coastal ecosystems (Jackson et al. 2001). For coral reefs, natives of the western Pacific may have begun fishing 35,000 to 40,000 years ago (Jackson et al. 2001). The main reasons for the decline of reef fisheries in the Philippines are well known: the physical destruction of coral reefs mainly by human-induced stresses and overexploitation of fish and other marine species (Yap and Gomez 1985, Gomez et al. 1994). Since it is not possible to treat the effects of these two causes separately, they are also treated together in the following discussion. However, the tendency to overexploit coral reef resources beyond sustainable levels and the use of reef-destructive fishing methods has as its roots the two major social problems: poverty and overpopulation. These factors have in turn strongly influenced the implementation of fishery and conservation laws. Many cases involving violations of these laws have been ignored, not pursued, or dismissed on the lame excuse that violators are poor or they do little damage with insignificant effects. A small amount of damage inflicted by a single fisherman repeated through time and over space can result in a significantly large proportion of damaged reefs (Gomez et al. 1994). Poverty and overpopulation are better treated separately and have been discussed in some papers dealing with coastal resources (see Pauly and Chua 1988).

Reef fishers have used a variety of traditional fishing gears. Some are not destructive to the coral reef environment (e.g. hook and line), others damage the fragile coral species (e.g. fish traps, set gill nets); still others are very destructive to coral reefs.

Blast fishing, one of the destructive methods of fishing on coral reefs, started in the late 1930s. Originally, blast fishers used dynamite but later on employed homemade bombs using 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 and continued until the 1960s. Its incidence was reduced in the 1970s during martial law, but again intensified in the 1980s and early 1990s. Its incidence decreased again in the late 1990s, probably due to more efforts by LGUs at implementing fishery laws and the depletion of schooling target fishes on reefs (Alcala in press). However, it still persists in some parts of the country to date.

The use of explosives has not been limited to reefs. Trawlers used explosives in the 1950s (Thomas 1999) and probably contributed to the fishery depletion of trawling grounds. Blast fishing has depleted reef fisheries and transformed large reef areas into unproductive coral rubble (Alcala and Gomez 1987, Ansula and McAllister 1992, McManus et al. 1997).

Another fishing method destructive to coral reefs is the *muro-ami*, a drive-in net designed for fishing on coral reefs introduced into the country by Okinawan fishers shortly before World War II (Carpenter and Alcala 1977, Alcala et al. 1987). While *muro-ami* is a commercial gear, a smaller version of it used to be common in the inland waters of the central Philippines. In *muro-ami,* each of the 10 to 150 swimmers use a scare line attached to an oval rock weighing 4 to 5 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, but in the process, it breaks branching and other delicate hard corals. Due to complaints about the destructive effects of rocks, BFAR banned their use in the early 1990s and replaced them with air bubbles from scuba tanks (Thomas 1999); but strips of white plastic material attached to the scare line to create visual scare effects used in earlier operations were retained. This modified *muro-ami* fishing gear was allowed to operate. However, reports that *muro-ami* operators still use small rocks (which they claim do not damage fragile corals) as well as large-sized rocks have reached the author. The old procedure is preferred apparently because it is more effective in driving 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). Catches from this gear dramatically increased during the period 1960 to 1975, ranging from 9,362 to 26,475 mt (Thomas 1999); large catches from the South China Sea have been reported this year (C. Batal pers comm). What we know about the destructive effect of this gear on fragile coral species makes it very likely that it has contributed greatly to fishery depletion on coral reefs. During that period (1960-1975), 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).

Poisons, including various local species of plants (e.g.*Derris*) and chemicals like cyanides and bleaching agents, have been used to kill or stun reef fishes (pers obs). Cyanides have been used to capture high-value fishes for the live reef food fish and aquarium fish trade (e.g.Rubec 1988, Barber and Pratt 1997, Anonymous 1997, Bentley 1999). The target food species are the groupers (*Cromileptes, Plectropomus* and *Epinephelus*) and the Napoleon wrasse (*Cheilinus undulatus*). Owing to the large demand for these fishes in the live food fish trade, they have been intensively collected for both local consumption and exportation. The result has been depletion of their stocks and much reduced volume of exports (Bentley 1999). 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 contributed to the destruction of large areas of hard corals (pers obs). Local fishermen have combined cyanides and spear fishing while diving with either scuba or hookah compressor, usually with underwater flashlights at night. As a result, many reefs in the Philippines have been destroyed and over-exploited.

The causes of reef destruction discussed above are all directly man-induced. Coral reefs have also been destroyed by excessive sedimentation brought about by human activities (logging and forest conversion to agricultural farms) in the uplands. Accelerated erosion of deforested uplands have increased the sediment loads of rivers, which in turn have smothered large areas of fringing reefs as well as nearby offshore reefs (Gomez et al. 1994, Alcala pers obs).

Composition of reef fisheries in the central Philippines

There is a lack of information on family and species composition of reef catch. Our information pertains only to our study reefs in central Philippines (Alcala 2001, Maypa et al. 2002). Our recollection of the catch composition of *muro-ami* fishing from the Sulu Sea in 1984 indicates that there may be differences in the composition of catches between central Philippines and the Sulu Sea. For example, sharks and allies, lobsters and the fish families, Siganidae, Serranidae and Lutjanidae, are either absent or under-represented in the catch from the Bohol (Mindanao) Sea in the central Philippines. Species of siganids and lutjanids are usually caught from coral reefs in areas near mangroves, where they spend a part of their life history. Little mangrove exists in our study areas.

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. Of the 20-odd families of major reef and reef-associated families, 14 fish families contribute substantially to the fish catch on 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, and Muraenidae contributed little to the fish harvest. Invertebrates (crustaceans and cephalopods) were also harvested from reefs but were consumed locally, except for lobsters, which were sold outside the islands at high prices. The total number of finfish species observed at Sumilon and Apo was about 200, of which about 125 were used for food (unpublished data).

Of the 14 families of finfish, nine comprised 90% or more of the fish catch of traditional gears from the vicinity of no-take marine reserves in the central Philippines during the past 25 years. On Sumilon Island, Caesionidae, Acanthuridae, Carangidae, Belonidae, and Labridae, in this order, made up

94.71% of the annual fishery catch in 12 months in 1983-84 (Alcala 1981, Alcala and Russ 1990). On Apo Island, the Carangidae, Acanthuridae, Caesionidae, Cephalopoda, Scaridae, Lethrinide, Lutjanidae and Serranidae (Epinephelinae) have comprised the greater bulk of the annual fish catches during the past 21 years (Alcala and Luchavez 1981, Bellwood 1988, White and Savina 1987, Maypa et al. 2002). Table 1 shows the family composition of the fisheries at Apo in 2001 and in the three other nearby islands in the Bohol (Mindanao) Sea, Selinog, Aliguay and Pamilacan, is shown. A cluster analysis of the data in table 1 (Fig. 1) shows that Apo stands distinctly apart from the three other islands and that Selinog and Aliguay are more similar to each other than to Pamilacan in terms of family distributions of their fish catches.

Table 1. Catch composition of reef and reef-associated fisheries at 4 islands in the Bohol (Mindanao) Sea.

Family	Apo Is.± (2001)		Aliguay Is.* (1999/2000)		Selinog Is.* (1999/2000)		Pamilacan Is.± (1985/1986)	
(major genus/genera)	% total yield	Rank	% total sample	Rank	% total sample	Rank	% total yield	Rank
Carangidae(*Caranx,Elagatis*)	46.64	1	37.82	1	30.25	1	21	1
Acanthuridae(*Naso,Acanthurus*)	24.53	2	7.52	3	8.42	5	13+	3
Scaridae (*Scarus*)	6.68	3	NR		NR		12	5
Caesionidae (*Caesio*)	3.95	4	5.38	6	3.64	6	7	6
Lutjanidae (*Lutjanus*)	2.33	5	6.67	5	9.70	4	13	4
Cephalopoda (*Octopus*)	1.48	6	16.04	2	12.69	2	17	2
Lethrinidae (*Lethrinus*)	0.21	7	7.07	4	11.67	3	3	8
Serranidae (*Epinephelus*)	NR		4.02	8	2.78	9	2	9
Balistidae	NR		4.93	7	2.90	7	N	
Dasyatidae	NR		2.62	9	NR		NR	
Muraenidae	NR		NR		2.79	8	NR	
Sphyraenidae	NR		NR		NR		4	7

± Published data (Maypa et. al. 2002 for Apo; White & Savina 1986 for Pamilacan)
* Unpublished data at SUAKCREM

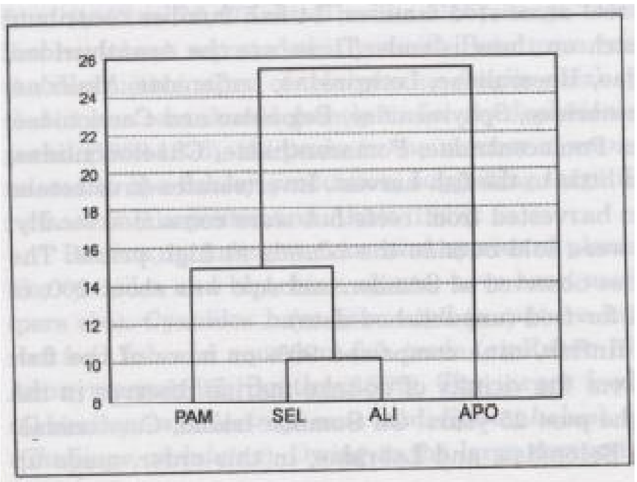

Fig. 1. Tree diagram for fish catches of Apo, Aliguay, Selinog and Pamilacan Islands using default options.

Intensity of fishing on coral reefs

With regard to the intensity of fishing, measured as the percentage of standing stock removed annually by fishing, there is little documentation available. But it appears that it is very intensive in many areas of the Philippines. For example, anecdotal reports indicate that *muro-ami* fishing is so efficient in removing fish that small-scale fishers fail to catch fish from fished reefs a week after its operations. Another report states that 50% or more of the fish standing stock on some reefs is removed annually by sustenance fishers. Many Philippine reefs are so over-fished that only small sized fishes are caught from them. This exploitation rate is obviously unsustainable.

Our data from the central Philippines indicate a highly variable fishing intensity: some species are more heavily fished than others. Fishing intensities at Sumilon and Apo non-reserves in central Philippines ranged from 20 to 30% for Caesionidae, 10 to 20% for Acanthuridae, and 7 to 100% for the large predators Serranidae, Lutjanidae, Lethrinidae and Carangidae. Fishing intensities on Scaridae and Labridae ranged from 3 to 5% (Russ and Alcala 1998a). All other families constituted a very small percentage of the catch. On both islands the general ranking of families in terms of their contribution to community biomass was similar to the ranking of families in the catch. 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 1998b).

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 were found to exhibit vulnerable life histories. When subjected to high fishing intensity, they declined rapidly in density and biomass. When protected they increased significantly but slowly, requiring a few decades to recover. Even the planktivorous caesionids, with a life history that is resilient to fishing and persistent in the face of intense fishing pressure, also declined rapidly when intensely fished.

Fishery yield of Philippine coral reefs

Smith (1978) estimated the fisheries potential of the world's coral reefs at six million metric tons annually, about 7% of the 1990 world marine capture fisheries. The actual yield of 0.48 million mt (Longhurst and Pauly 1987) was short of this potential (Russ 1991). Russ (1991) reviewed fish yields from coral reefs worldwide and concluded that sustainable yields of 10 to 20 $mt \cdot km^2 \cdot yr$ are possible.

The fishery yield of Philippine coral reefs is difficult to estimate primarily because catches from various shallow-water habitats such as coral reefs, mangroves, sea grass beds, and soft-bottom communities have all been reported together in the catch statistics by BFAR and the BAS, DA under the two categories of commercial and municipal fisheries. Catches of vessels of more than three gross tons are considered commercial and those of vessels three and less than three gross tons are municipal (sustenance and artisanal). In these reports fishery production from reefs is included in the municipal fisheries category. The exception is catch of the *muro-ami* fishing, which uses large fishing vessels and is therefore considered commercial fisheries.

Yield estimates from Philippine coral reefs have been based on non-pristine reefs in central Philippines with varying coral cover (Alcala 1980, 1981, Alcala and Luchavez 1981, Alcala and Gomez 1985, White and Savina 1987, Bellwood 1988, Alcala and Russ 1990, Luchavez 1996, Maypa et al. 2002). Variations in estimates are mainly due to the intensity of exploitation and the different methods employed by investigators. Fish yields should ideally include only reef and reef-associated fish species (see Choat and Bellwood 1991, for definitions), but sometimes fish yield reports include off-reef (wide-ranging) species as well. Yields would also depend on composition of the catch, high if herbivores and planktivores predominate. One of the highest yields (36.9 $mt \cdot km^2 \cdot yr$) was reported from Sumilon Island in 1983-84 (Alcala 1988, Alcala and Russ 1990). This may be due to the high proportion (60 to 65%) of the planktivorous caesionids in the catch. Reef yields may in part depend on mangroves, since it is known that mangroves serve to nurse some fish species and export organic matter to adjacent reefs (e.g. Robertson et al. 1988) and these two communities exchange fish species as well. It would appear that in small intensively fished reefs with good live coral (50% and above), yields of 15 to 20 $mt \cdot km^2 \cdot yr$ can be expected. This is true for the reef fishery of Apo Island, which consists of a mixture of herbivores, planktivores, and carnivores (Maypa et al. 2002). A sustainable yield of 15 to 20 $mt \cdot km^2 \cdot yr$ of reef and reef-associated fish has been maintained during the past 20 years at Apo Island (Maypa et al. 2002). The Apo Island marine sanctuary, fully protected by the community since 1982, has had direct influence on this sustainable fish yield (Maypa et al. 2002). Alcala (1980, 1981) considered a yield of 15 $mt \cdot km^2 \cdot yr$ of Sumilon reef as sustainable. A couple of degraded Philippine reefs in the Panay Gulf and the Bohol (Mindanao) Sea have been found to have much lower fish yields of about 4 to 5 $mt \cdot km^2 \cdot yr$ (Alcala and Gomez 1985, Luchavez 1996, unpublished data at SUAKCREM).

How much fish can be produced by Philippine coral reefs? The potential yield may be estimated based on available information on reef area and average annual fish yield. The total area of Philippine coral reefs is about 25,000 km^2 with most reefs located in the southern and southwestern Philippines (UP, Marine Science Institute data). Assuming an area of 25,000 km^2 and 15 $mt \cdot km^2 \cdot yr$ as the average sustainable yield of good reefs, the probable potential annual yield of Philippine coral reefs would be about 350,000 metric tons. This fishery production is no longer true at this time because of the widespread degradation of these marine habitats (Gomez et al. 1994) and associated mangroves (Primavera 2000).

The fishery production from coral reefs at the present time may be estimated indirectly with the use of published data on fish yields and assumptions (as discussed above) as well as reef status (Gomez et al. 1994). The majority (70%) of the 742 Philippine reefs surveyed in the 1970s and 1980s had live coral cover of 50% and less (Gomez et al. 1994). If we assume (although this may not be totally justified) that these figures reflect the proportions of relatively less productive and more productive reef areas, we might be able to show the extent of loss of fishery production from the potential yield of 350,000 mt. To do this we shall assume that reef areas with less than 50% live coral cover yield about 4 mt·km^2·yr (Alcala 1980, Alcala and Gomez 1985) and that those areas with live coral cover of 50% and more yield on the average 15 mt·km^2·yr. The total annual fishery production at the present time is estimated at 182,500 mt (0.7 x 25,000 x 4 + 0.3 x 25,000 x 15). This production is about 11% of the total marine production of 1.64 million mt in 1993-97, indicating a substantial reduction of 48% from the estimated potential yield of 350,000 mt a year as of the decade of the 1990s. The potential loss of 167,500 (350,000 minus 182,500) tons, valued at US $167,500 x 1000 (US $1,000·ton, based on Barut et al. 1997), is consistent with anecdotal reports of low fish yields from reefs throughout the country during the last decade.

The total marine fishery production in 1964 was 541,000 mt (Thomas 1999). The percentage contribution of coral reef fishes to this production is not known. What we can be sure of is that coral reefs were then in much better condition. Assuming a potential annual yield from coral reefs of 350,000 mt, and assuming further that this potential was realized, the percentage of coral reef fishery contribution to the reported total marine production of 1.64 million mt (BAS, DA) in 1994-1997 would be about 23%. This is the case if the published fishery figures are accurate. This estimate happens to agree with an earlier report which placed the contribution of West Sabah coral reefs at about 18 to 25% (Mathias and Langham 1978). Carpenter (1977) and Murdy and Ferraris (1980) gave the contribution of coral reef fishery in the Philippines as 10 to 15% of the total marine capture fisheries without specifying the basis for their estimate. Their value would appear to be an underestimate. Intuitively, based on field observations on the intensive use of reefs by coastal populations, an estimate of ca 20 to 25% as the contribution of coral reef fisheries to marine production seems reasonable.

Biodiversity and coral reef fisheries

The importance of marine biodiversity is now being stressed both for its own sake and for the sustainability of fisheries. Biodiversity, for example, provides recreational and livelihood opportunities through tourism for coastal dwellers. A couple of examples in the central Philippines may be cited. A 106-ha protected coral reef on Apo Island earns about US $160,000 (including $35,000 from diving fees) and an additional $20,000 from fisheries (a total of $180,000) every year since the 1990s (Alcala 2001, Vogt 1997, pers obs). A smaller protected island nearby, Balicasag, earns a gross income of $100,000-$120,000 from tourism. Proceeds from dolphin and whale watching off Bais City, Negros Oriental amount to $50,000 annually (pers obs). For practical reasons, marine biodiversity should be conserved. There is now an urgent reason for biodiversity conservation as some species have suffered local extinctions. In the central Philippines for example, at least four invertebrate species are extinct or near extinct locally (Alcala, 2001). These are *Nautilus pompilius*, *Cypraea* sp., *Conus* sp., and *Placuna placenta*. The first species (a chambered nautilus) has disappeared from Tañon Strait since the late 1980s. The next two species (a cowry and a cone) have been virtually fished off Aliguay Island in the Bohol (Mindanao) Sea. The fourth species, an oyster, is almost gone in certain coastal areas in southwestern Negros and is now the object of conservation. There are probably other macro-invertebrate species that are threatened with extinction in Philippine seas as a result of intense collection. The BFAR should now take steps to determine the conservation status of these species and stop or regulate the exploitation of the highly threatened ones.

Our general understanding is that the stability of species populations in a community increases with the number of trophic links between species and the energy flow in the food webs, based on theoretical and empirical studies of MacArthur (1955). The present consensus of opinion emphasizes the need “for a minimum number of species to maintain the stability of ecosystem processes in changing environments,” and that this minimum is a large number (Loreau et al. 2001). My management view emphasizes the role of ecosystem stability and “the harvesting of nature’s excess production with as little fluctuation as possible” (Holling 1973). Pauly et al. (1998) stressed the important role of biodiversity, as components of marine food webs, in attaining sustainable fisheries. There are several reasons for preserving biodiversity, and Perez and Mendoza (1998) mentioned ecological, genetic, nutritional, and biomedical reasons. Fisheries management depends so much on a better understanding of ecosystems, and must move from an emphasis on single species to a broader consideration of the various trophic levels and their interactions involving many species in aquatic ecosystems (e.g.,Vakily et al. 1997, Smith 1999, Micheli et al. 2001). Species diversity or richness appears dependent on habitat complexity or habitat heterogeneity (e.g.,Roughgarden 1979, Donaldson 1996). Coral variables (diversity, species richness, and percentage live coral cover) are correlated with the richness and diversity of fish assemblages (e.g.,Chabanet et al. 1997, Friedlander 2001).

The stable fish yields at Apo Island during the past 20 years (Maypa et al. 2002) appear to be related to the protection of biodiversity in general. This stability 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 (Fig.2).

Our findings tend to confirm the importance of biodiversity in fisheries. The diversity of species in the fishery was maintained in the reserves. The ranking of the fish families in the fishery catch at the Apo and Sumilon non-reserves tended to be similar to that in the fish community in the reserves. The Sumilon and Apo marine reserves appeared to have higher percentage of live coral cover compared to the non-reserves at both islands during the 10-year observation period from 1983-1993. The 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 showed 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 to 54% but variable at the non-reserve at 2 to 47%. The maintenance of a high percentage of living hard coral cover is important as reef and reef-associated fishes depend for food and/or cover directly or indirectly on living coral (e.g. Choat and Bellwood 1991, Adrim et al. 1991, Gochfeld 1991).

Present efforts at protection and management of coral reef resources

No-take marine reserves, despite few demonstrations of actual benefits in terms of fish biomass export (Alcala and Russ 1990, Roberts and Polunin 1991, Russ and Alcala 1996) from them, are now recognized as one of the best options for managing coastal and marine resources. Russ (1996) argues that given the status of coral reef fisheries in the Philippines, the only viable management option would be to establish no-take marine reserves to protect the spawning stock biomass, in effect serving as an "insurance policy" for fisheries. Marine reserves may be considered precautionary measures against possible total collapse of fisheries. They are relatively easy to set up, are generally acceptable to small scale fishers, and offer other benefits to local communities, such as income from tourism. The idea of marine reserves appears to have attracted the attention of many organizations and government units in the Philippines. Since the establishment of the first working reserve in 1974 (Alcala 2001), it is estimated that about 500 small no-take marine reserve systems have been established throughout the country, although only a few (about 10%) are fully functional (Pajaro et al. 1999, Aliño et al. unpubl manuscript). However, there is a need to demonstrate to the primary stakeholders the beneficial effects of these marine reserves as fishery management tools. In order to do this, marine reserves should be monitored.

Experience in coastal resource management in the central Philippines shows that, with few exceptions, marine reserves can function maximally only with full protection and full involvement and "ownership" of local fisher communities (the

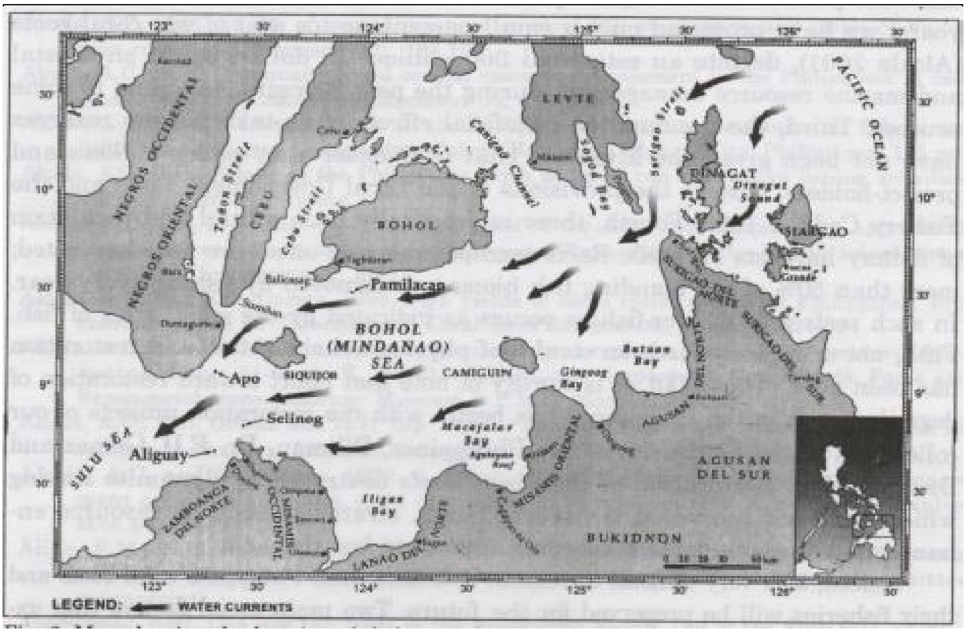

Fig. 2. Map showing the location of th four study islands in the Bohol (Mindanao) Sea.

primary stakeholders) and LGUs (Alcala and Russ 1990, Alcala 1998, Russ and Alcala 1999, Alcala 2001). The usefulness of this tripartite local partnership in bringing about success in protective management of coral reefs, especially those near human communities, has been shown in an increasing number of cases (Alcala 2001, Ferrer et al. 1996). Such partnerships allow for networking for management purposes and tend to ensure intergenerational sustainability of management by organized communities.

Coral reefs that are relatively inaccessible have been managed using a different mode. The Tubbataha Reefs National Marine Park is an example. In this case a government council and an international NGO (WWF) cooperate to provide a strong and effective enforcement mechanism. This is different from community-based management where communities and LGUs take the responsibility for law enforcement and sometimes have difficulties in implementation.

Is sustainable coral reef fisheries an attainable goal?

Finally, it may be asked whether the goal of sustainable coral reef fisheries is attainable. This question has been recently posed by Helen Yap (1999), who proposed that in order to maintain the integrity of coral reefs as ecosystems, certain interventions such as marine reserve establishment, control on harvests, and enhanced natural productivity are needed. In a later paper (Yap 2000) she added reef restoration. I fully agree with her.

It seems that much effort is still needed to ensure the protection and management of coral reefs and their fisheries during the succeeding decades for the following reasons: First, degradation of coral reefs and associated shallow-water ecosystems such as mangroves (Primavera 2000) is still going on in many areas of the country. Second, reefs are not protected rapidly enough as to offset the present rate of degradation of these fishery habitats. Over the past 25 years, we have protected only a small percentage (ca 4%) of our coral reefs (Alcala 2001), despite an estimated 300 million US dollars spent on coastal and marine resource management during the past 20 years, according to some sources. Third, the documented beneficial effects of no-take marine reserves have not been given the attention that they deserve by policy-makers and project-holders, despite the provisions of the Local Government Code and the Fishery Code of 1998. Fourth, there is practically little control and regulation of fishery harvests on reefs. Reefs (except protected ones) are over-harvested; more than 50% of the standing fish biomass is removed by fishing every year. In such reefs growth over-fishing occurs as indicated by the small sizes of fish. Fifth, not enough research on coral reef physical rehabilitation and restoration has been done (Yap 2000). It is worthy of note that effort toward restoration of degraded reefs in the Philippines has begun with the restoration projects of our colleagues at the University of the Philippines, Diliman, Dr. E.D. Gomez and Dr. H.T. Yap. Restoration of the many reefs destroyed by dynamite fishing which have not recovered is needed. Sixth, strategies such as resource enhancement through captive breeding remain to be tried.

Indeed, it is very difficult to remain optimistic that Philippine coral reefs and their fisheries will be preserved for the future. Two main social factors that exacerbate the problem of reef protection and management have influenced this view. These are runaway population growth and poverty. The present rate of growth will result in the doubling of the population every 30 years. Government has not been able to address these issues adequately, and the future prospects remain dim. Most coastal resource management projects treat the population issue as a "hot potato" and choose to ignore it. Unless government at all levels exercise strong political will and other sectors of society fully cooperate, coral reef ecosystems will continue to deteriorate in the coming years.

Acknowledgments

We are indebted to Dr. Helen Yap for reviewing an earlier draft. We thank the Pew Trusts for our Fellowship in Marine Conservation. The World Fisheries Trust, Victoria, Canada headed by Dr. Brian Harvey provided financial support to ACA for the preparation of an earlier draft for which we are grateful. Jasper Leif Maypa prepared the illustrations.

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Manuscript received 10 May 2002; Accepted 20 June 2002