Chapter 2
Coral reefs: A highly productive but threatened ecosystem

"There have been people living near coral reefs since prehistoric times, making use of the rich source of food they provide as well as depending upon them for other common necessities such as tools (made from shells) and building materials for their houses."

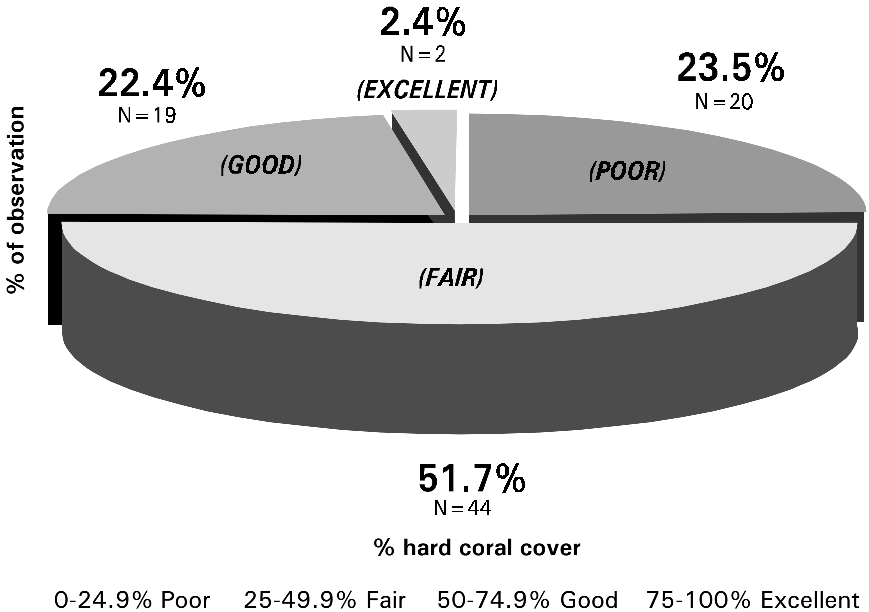
—The Greenpeace Book of Coral Reefs[115]

CORAL REEF EXTENT AND CONDITION

Coral reefs are the coastal ecosystem which provides the most substantial and sustainable source of sustenance to people in the Philippines[3, 53, 117]. The 18,000 km coastline of the Philippines is estimated to have about 27,000 km^2 of coral reef fringing its shores or in offshore areas in the form of submerged reefs or coral atolls. This area is equal to slightly more than 10% of the total land area of the country[53]. It is estimated that more than one million small-scale fishers depend directly on reef fisheries for livelihood[22]. In addition, reef fisheries supply a sizable amount of protein in a country where more than 50% of the animal protein is derived from marine fisheries and aquaculture.

The overall condition of the coral reefs in the country is not good. Most reef areas have been adversely affected by human activities and less than 5% are considered to be in excellent condition (Table 1.2; Figure 2.1). As coral reefs are destroyed, fisheries, tourism, coastal protection and biodiversity values are all lost[91]. The approximate economic losses being incurred from the destruction of coral reefs are presented in detail in this chapter. These losses, expressed in thousands of dollars per year per square kilometer of coral reef, have their greatest impact on local fishing communities and local tourism establishments. Such losses also reflect a general decrease in the recruitment of fish which could have emanated from damaged reef areas if they were still intact.

Figure 2.1. Status of Philippine coral reefs at 14 localities (About 75% of the reefs are in poor and fair categories)[53].



MANY USES OF REEF PRODUCTS AND THEIR VALUES

Fisheries and other reef resources used by people

Coral reefs in the Philippines can supply up to 35 t/km^2/year (the highest reported fish yield from Sumilon Island in 1983) of edible and economically valuable fish and invertebrates assuming that ecologically sound fishing methods are used[3]. This unprecedented production is only one of the direct economic contributions coral reefs make to people. Other contributions include potential diving and snorkeling fees, and other existing tourism and recreation revenues, natural protection provided by reefs to shoreline structures from waves and storms, recruitment of fish and invertebrates to areas downstream from any given reef and unequaled biodiversity which humans want to preserve but have difficulty in assigning a measurable value to[128, 129].

Reef-related fisheries yield an estimated 9-12% of the world's total fishery of 70 million t/year[77, 103] and are probably undervalued because of their subsistence use. The contribution of reef fish to the total fisheries of the Philippines ranges from 8 to 20% (or about 143,200-358,000 t)[2, 24, 78]. The contribution of a reef fishery to some small island fisheries in the Philippines can go as much as 70% of the total fish harvest[2, 3, 98, 99, 126, 127]. The average of documented reef yields for the Philippines is 15.6 t/km²/year as shown in Table 2.1.

Table 2.1. Yield of fishes from coral reef areas in the Philipines (updated from 93).

Location	**Area of reef** (km²)	**Depth used in estimate** (m)	**Yield** (t/km²/year)		**Reference** (numbers refer to those in reference list)
Sumilon Is	0.5	40	9.7	(76)*	(2)
Sumilon Is	0.5	40	14.0	(77)	(2)
Sumilon Is	0.5	40	15.0	(78)	(2)
Sumilon Is	0.5	40	23.7	(79)	(2)
Sumilon Is	0.5	40	19.9	(80)	(2)
Sumilon Is	0.5	40	36.9	(83)	(7)
Sumilon Is	0.5	40	19.9	(85)	(7)
Apo Is	1.5	60	11.4	(80)	(6)
Selinog Is	1.26	30	6.0	(82)	(5)
Hulao-hulao	0.5	15	5.2	(85)	(5)
Apo Is	0.7	20	31.8	(85)	(127)
Pamilacan Is	1.8	20	10.7	(85)	(98)
Apo Is	1.06	60	24.9	(87)	(17)
Bolinao Reef	42.0	RS	2.7	(90)	(72)
Bolinao Reef		RF	12.0	(90)	(72)
San Salvador	3.4	40	7.0	(89)	(28)
San Salvador	3.4	40	14.0	(90)	(28)
Mean for all sites (n=17)			15.6		

*Year of data collection
RS - Reef slope
RF - Reef flat

Coastal people supplement their fish intake by the consumption of many invertebrates such as octopuses, bivalves (giant clams such as *Tridacna* sp. and other clams and oysters), gastropods, shrimps, spiny lobsters, sea urchins and sea cucumbers. In addition, hundreds of thousands of sea turtle eggs are harvested in the Sulu Sea Turtle Islands and other remaining sea turtle rookeries in the country.

Miscellaneous food products from the reef include edible algae, jellyfish and sea anemones. Consumption of these items depends on particular traditional and cultural preferences (Table 2.2).

Coral reefs have traditionally served as sources of building materials. Lime is extracted from Indonesian and Sri Lankan reefs for use in cement and plaster, and tiles have historically been made from massive corals in the Philippines. Sand extracted from reefs and adjacent beaches serves as a fill material and is widely used in cement mixes or to replenish beaches in other areas.

One type of interaction well developed on coral reefs is antibiosis, the production by one organism of substances that are harmful or repulsive to others[55]. Some of these substances are used as essential pharmaceutical and industrial products. Ongoing research is discovering new uses for chemicals found in coral reef invertebrates which will add more pressure for exploitation. Sources range from sea hares to sea fans, anemones and nudibranch animals. Algae also provide a source of agar and carrageenan, the most common products of the seaweed growing industry.

In the late 1960s, international trade in ornamental corals, shells, sea turtles and coral reef fish began to flourish. These items now support large industries and end up mainly as decorative pieces in various parts of the world[114, 115]. In the early 1980s, an average of 3,000 to 4,000 t/year of ornamental shells were exported from the Philippines mostly to the United States. This excluded the mother-of-pearl shell which is a large industry alone[115]. Live fish with a value of some US$32 million were exported from the Philippines in 1996 for aquarium use—a decline from 1995 and previous years[13]. Before coral collection was banned in 1978, the Philippines was exporting an average of 1.8 million m^3 of corals annually[71]. Even

Table 2.2. Coral reef resource products and uses (updated from 116).

Major reef export products of economic importance		
Resource	**Role in reef**	**Product use**
*Stony coral[a]	Primary reef frame builder	Building material, fish tank decoration
*Precious coral[b]	Enhances habitat	Jewelry, decoration
Fish[b]	Link in metabolism	Food, aquarium fish
**Tridacna* clams[b]	Calcification	Shell collection, food
Top shells, *Trochus*	Calcification, food chain	Mother-of-pearl
Oysters[b]	Calcification, food chain	Pearls
Various gastropods[b]	Calcification, food chain	Collection, decoration, crafts
*Sea horses[b]	Food chain	Medicine, aquarium use
Lobsters[b]	Scavenger	Gourmet food
Sea cucumbers	Detritus feeder, sand	"Trepang," food
Sponges[b]	Borer	Toiletry
*Sea turtles[b]	Food chain	Shell, oil, meat, eggs
Sea snakes[b]	Food chain	Skin, crafts
Misc. invertebrates	Varied	Antibiotics, drugs
*Coral sand	Substrate, beaches	Concrete, building
*Ecosystem	Conservation, genetic diversity	Tourism, aesthetic appeal, natural laboratory

Subsistence food products commonly used	
Organism group	**Kind**
Fish[c]	Most large and small ones
Bivalves	Clams, mussels, oysters
Gastropods	Most large and small ones
Cephalopods	Squid, cuttlefish and octopus
Crustaceans	Crab and shrimp
Echinoderms	Sea cucumbers and sea urchins
Coelenterates	Jellyfish and anemones
*Sea turtles	All except hawkbills, eggs
Algae	Many edible varieties

[a]1,830,089 m^3 were exported from the port of Zamboanga in 1976[71].
[b]Seriously depleted on many reefs throughout the Philippines and Southeast Asia.
[c]The most significant contribution of reefs to subsistence food consumption in the Philippines and throughout Southeast Asia.
*Organism regulated by law in some form so that traditional use is no longer allowed or is controlled.

though bans exist on coral and sea turtle collection, these items continue to be harvested as noted by coral drying yards in some islands and reports of community residents. Sea snakes have been exploited primarily for skins and secondarily for meat since the 1930s in the Philippines[88] and are now too rare in numbers to support commercial collection.

A growing industry since about 1990 is the live food fish trade. About 840 t (net weight) were officially exported from the Philippines in 1996[60]. This export depends primarily on Napoleon wrasses and a few species of grouper, rock lobster, stone fish and several others[65]. One 40-kg Napoleon wrasse may sell for as much as US$5,000 in Hong Kong[65]. This industry adds value to reef fish by keeping them alive for sale in restaurants but has earned a bad reputation because of the rampant use of sodium cyanide in the capture of the fish. Since fishers are always under pressure to catch as many fish as possible with a minimum of effort, they use poison. Better economic incentives and law enforcement could perhaps change this scenario.

The international demand for these species is driving overexploitation, and as the price goes up with scarcity, the incentive to catch certain valuable species such as Napoleon wrasses is increased. Much of the exploitation of the various coral reef generated products has led to destruction and local extinction of the organism being collected and often its habitat. Usually the ecological and economic consequences of this blatant overexploitation using destructive techniques goes unnoticed and undocumented. Such practices of course will require both international and local economic and enforcement strategies to curtail.

Tourism uses of coral reefs

The aesthetic appeal, biological richness, clear waters and relative accessibility of coral reefs make them popular recreation areas for local and foreign tourists. In this sense, coral reefs are a valuable resource for the tourism industry. Skin and scuba diving, and underwater photography are common activities on reefs. Diving tourism has increased substantially over the last ten years in the Philippines. Indeed, the tourism promotion strategy for the country by the Department of Tourism rests heavily on the natural attractions of coastal areas. A significant portion of visitors to the Philippines spend part or all of their stay in coastal areas with access to swimming, snorkeling or diving.

It is well accepted that the most popular diving resorts are in those locations where multiple dive sites with good and exceptional quality coral reefs can still be found. Examples include Mabini, Batangas, northern Palawan; the Central Visayas areas of Mactan Island, Cebu; Panglao, Bohol; and Negros Oriental as well as selected areas of Mindanao Island. Tourism is not likely to flourish where the reefs have been destroyed or damaged such as at Hundred Islands National Park in Lingayen Gulf where reef-viewing tourism has declined to almost nothing.

Shoreline protection role in the coastal environment

Fringing and barrier reefs are natural breakwaters which protect low-lying coastal areas from erosion, coastal flooding and other destructive action by the sea. Coral reefs also contribute to terrestrial accretion by providing sand for beaches and low islands through calcification processes[54, 103]. These reef functions naturally protect thousands of coastal villages, low-lying coastal plains and coastal engineering structures, such as roads and bridges, built behind the outer edges of reefs along tropical coasts[67]. If these reef buffers were removed, the equivalent artificial structures for protection would cost billions of dollars.

Biodiversity and other values from reef existence

The diversity of life on a coral reef per unit area is comparable to or greater than that in a tropical rain forest. This high diversity of life among a range of different types of plants and animals creates a rich and productive system which provides many of the useful products we have elaborated above. In addition, reef life interactions have evolved a variety of unique chemical compounds (sometimes toxic) as their defense strategy. Many of these compounds have no terrestrial counterparts[57]. In this regard, the potential for discovery of useful chemicals for medicine and other uses is very high. The existence of this potential highlights the need to maintain healthy and evolving reef systems so that potential future uses are not sacrificed in the present.

Coral reefs are known as good laboratories for ecological science. They provide excellent in-situ classrooms for students at the high school and college levels. Many ecological relationships are easily seen and explained on coral reefs because so much life can be observed at close range. Since many school children in the Philippines have little contact with their natural environment, coral reefs provide an excellent opportunity to expose large numbers of students to one of the most interesting and complex ecosystems in the world. Locales like Olango Island, Cebu, and Batangas, which are accessible from urban areas, can play important roles in educating the youth about marine ecology and conservation.

Aesthetic appeal is a final important resource of coral reefs. Although not easily quantified as other resources associated with the reef system, it is really this aspect which attracts most tourists to view reefs. Most reef visitors as well as some people who never even travel to see a reef will contribute to protection efforts just to know that the aesthetic value of a coral reef is maintained into perpetuity.

WHAT IS LOST AS REEFS ARE DESTROYED?

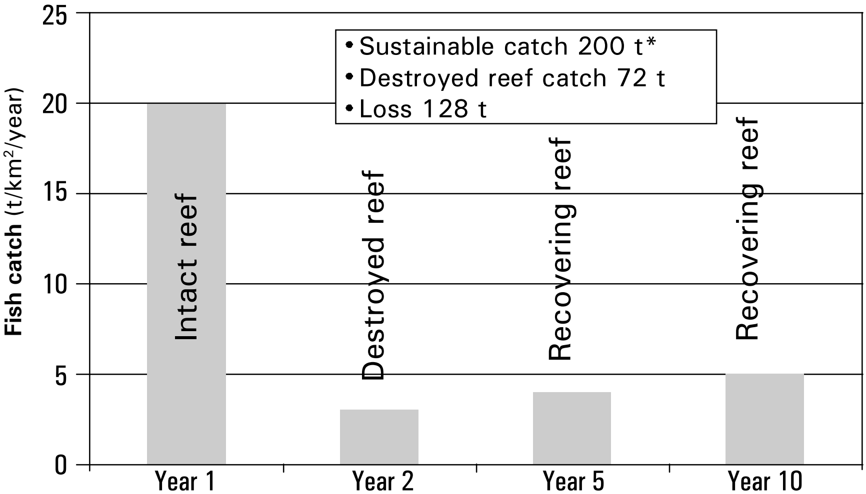
Human activities and their impacts on coral reefs are summarized in Table 2.3. It is noted that there are many destructive activities to reefs and that some, like overharvesting, are not obviously damaging unless we understand the various cause and effect relationships[95]. The purpose of this book is not to analyze the causes of destruction. Rather, the focus is to highlight economic losses from destruction of reefs so that we will have a better sense of what is at stake.

Table 2.3. Human activities and their adverse impacts on coral reefs[117].

Activities	Impacts
Extraction of coral limestone	Reef foundation degradation, habitat destruction
Extraction of coral sand	Turbidity, water flow dynamics, erosion
Explosive fishing techniques	Habitat destruction, loss of productivity and biodiversity
Terrestrial sediments from human activity	Turbidity, smothering
Physically damaging fishing method	Habitat destruction
Reef trampling by humans and anchors	Habitat destruction
Overexploitation of fish and invertebrates	Changes in ecosystem balance, decrease in sustainable yield
Aquarium fish collection	Selective depletion of population
Urban-industrial pollution	Biological degradation
Oil spill	Biological degradation
Oil drilling	Turbidity, habitat destruction
Fish poisoning	Biological degradation, habitat destruction
Spear-fishing	Selective depopulation of fish
Construction	Habitat destruction, turbidity
Tourism	Collecting, minor habitat disturbance
Thermal or salinity changes	Detrimental to coral polyps and invertebrates

Before we look at the economic consequences of coral reef loss, it is useful to consider fish catch alone. Loss in sustainable fish yield from 1 km^2 of healthy coral reef over ten years which has been partially destroyed by blast fishing or use of poison, for example, is approximately 128 t of fish for a moderately productive coral reef area under relatively undisturbed conditions (Figure 2.2). After partial destruction, coral reefs do not quickly return to a high level of productivity. It may take up to 50 years for a dynamited reef to regain 50% of its original healthy state and to be productive again[4]. Let us now look at the various reef uses and their values.

Figure 2.2. Fish yield decline and loss on a destroyed and recovering coral reef over 10 years.



*Assumes a good quality coral reef with a yield of 20 $t/km^2/year$ and use of non-destructive fishing methods

One way to analyze the loss from reef destruction is to compare the net benefits to individuals involved in destructive activities as compared to the net losses to society from the decreased production of the coral reef ecosystem. This type of analysis is summarized in Table 2.4 and shows the losses to fisheries, coastal protection and tourism[25]. For example, the total net present value of quantifiable loss from overfishing 1 km^2 of coral reef over a 25-year period and discounted at 10% is US$108,900. Although overfishing does not destroy a coral reef, it lowers its natural productivity and the potential of the reef to attract tourists who want to see a diversity of large fish. On average, coral reef fisheries could produce an additional US$70,000 in net present value per km^2 of reef if effective management was introduced[25]. In Bolinao, Philippines, an extensive research effort determined that fishing effort must be reduced by 60% to avoid overfishing and achieve optimal sustainable yields[72].

The losses to society from blast fishing, known to shatter the physical structure of the coral reef, are shown in Figure 2.3. Here, the net benefits from blast fishing in the form of fish harvested are only about US$15,000 (net present value over 25 years for 1 km^2 of reef). In contrast, the net present value of losses to society in terms of foregone coastal protection (US$193,000), earnings from sustainable fisheries (US$86,300) and tourism (US$482,000) is many times higher than the gain to the blast fisher(s).

Table 2.4. Total net benefits and losses due to threats of coral reefs[25].
(present value; 10% discount rate; 25 years; in thousand US$; per km^2)

Function / Threat	Net benefits to individuals	Net losses to society					
		Fishery	Coastal protection	Tourism	Food security	Bio-diversity	Total net losses (quantifiable)
Poison fishery	33.3	40.2	0.0	2.6-435.6	n.q.	n.q.	42.8-475.6
Blast fishing	14.6	86.3	8.9-193.0	2.9-481.9	n.q.	n.q.	98.1-761.2
Coral mining	121	93.6	12-260.0	2.9-481.9	n.q.	n.q.	175.5-902.5
Sediment-logging	98	81	-	192.0	n.q.	n.q.	273.0
Overfishing	38.5	108.9	-	n.q.	n.q.	n.q.	108.9

n.q. - not quantifiable

Another powerful example shows the impact of pollution from the large city of Jakarta on the average depth of coral reefs in Jakarta Bay (Figure 2.4). Because of increasingly turbid water and the presence of various pollutants the average depth of corals has decreased from about 10 m in 1931 to a present average depth of less than 1 m[108]. In many areas, the reefs are dead so that all economic and ecological benefits have been eliminated. This scenario, although not well-documented, appears to be occurring near the cities of Cebu, Manila and others and will have a similar impact on Philippine reefs if unchecked.

In addition to reef growth, reef fisheries lose much of their productivity in areas where siltation is prevalent. The coral reef fishery of the Lingayen Gulf was analyzed for losses from siltation where damages are computed as the difference between potential

Figure 2.3. Net present value of blast fishing to individuals and associated losses to society per km² of reef from destruction to tourism, physical coastal protection and foregone sustainable fishery income (in thousand US$; over 25 years; 10% discount rate)[25].

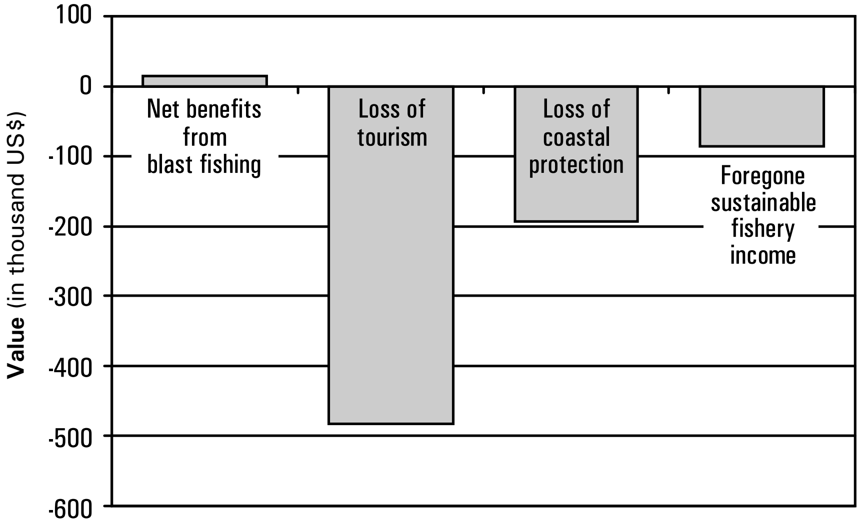
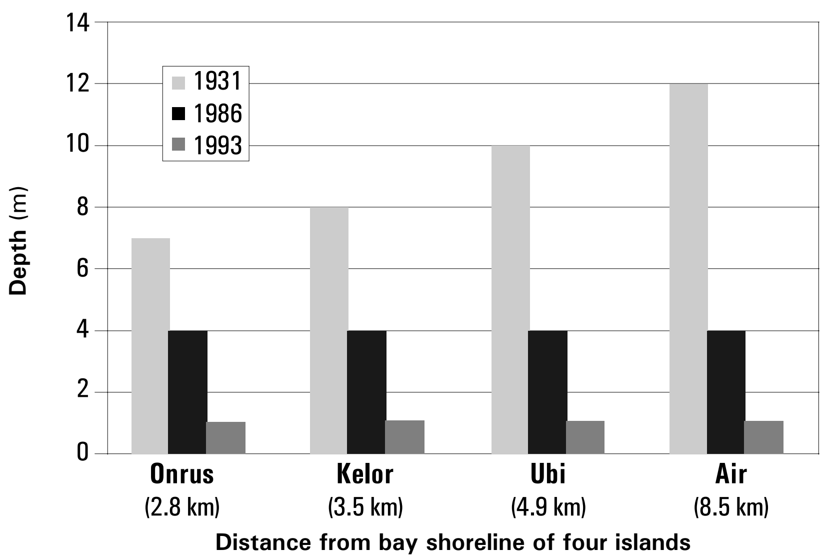


Figure 2.4. Changes in average depth of coral growth caused by increasing water pollution in relation to distance from shore and time in Jakarta Bay[108].



yields of good and degraded coral reefs. Using the stated difference in productivity of a good and degraded reef, Padilla et al.[83] estimated damage to municipal fisheries of the area amounted to P6.17 million (US$250,000) in 1995.

The economic value of shoreline protection from the presence of coral reefs has been estimated for different situations around the world. In Sri Lanka, the commonly quoted cost to illustrate the economic value of beach and shore protection from wave action and currents due to the presence of coral reefs is the cost of building shoreline revetments and structures to prevent erosion. The one-time cost of building such structures not including maintenance is about US$1,000/m of shoreline or about US$1 million/km[80]. And to make matters worse, these structures are not permanent and require expensive maintenance[32].

Another estimate uses the value of coastal roads and other structures along the shoreline in rural Indonesia which are physically protected by the presence of a reef. The cost per km of roads ranges from US$5,000 to 50,000 depending on quality and terrain. With this information, US$25,000/km has been used to estimate the value of shoreline protection provided by the existence of coral reefs in Indonesia[25]. This value is used in this book unless coastal circumstances dictate otherwise.

ECONOMIC GAINS FROM CORAL REEF PROTECTION

The returns from coral reef protection and management are really just the other side of the destruction and loss equation. First, it is useful to summarize the productive fishery aspects of reefs and the potential gains from well-managed tourism. All the potential benefits from 1 km^2 of good quality and healthy coral reef are shown in Table 2.5. These values assume a typical coral reef in the Philippines with no overfishing or destruction and some moderate level of tourism potential.

The sustainable fisheries (local consumption) potential for our example coral reef in Table 2.5 is based on known fish yields

Table 2.5. Sustainable annual coral reef economic benefits (direct and indirect) per 1 km² of typical healthy coral reef in the Philippines with tourism potential.

Resource use	**Production range**	**Potential annual revenue** (US$)(range)
Sustainable fisheries[a] (local consumption)	10 to 30 t	15,000-45,000
Sustainable fisheries[b] (live fish export)	0.5 to 1 t	5,000-10,000
Tourism[c] (on-site residence)	100 to 1,000 persons	2,000-20,000
Tourism[d] (off-site residence)	500 to 1,000 persons	2,500-5,000
Coastal protection[e] (prevention of erosion)		5,000-25,000
Aesthetic/Biodiversity value[f] (willingness-to-pay)	600 to 2,000 persons	2,400-8,000
Total		**31,900-113,000**

Assumptions:
[a]Average market price of US$1.5/kg of reef fish[20, 127].
[b]Average market price to fishers of US$10/kg of live reef fish[13].
[c]Average expenditure of US$20/day/tourist staying at the site[113].
[d]Average expenditure of US$5/day/tourist for purchases at the site[113] (A. White, pers. obs).
[e]Physical protection value of US$5,000-25,000/km/year of reef front beach[25].
[f]Average expenditure of US$4/day for entrance to marine sanctuary or for a donation to the maintenance of the area or anchor buoys[11].

from coral reefs noted above (Table 2.1). Sustainable fisheries (live fish export) is based on the presumption that a small portion of all reef fish capture could be harvested for live fish export which brings a higher value than local consumption of dead fish. This conservative estimate is used to illustrate the higher return from fish export and the potential value added for a small portion of reef fish yield.

Tourism (on-site residence) is based on documentation of tourism at Apo Island, Negros Oriental, where up to 1,000 tourists come annually to the island as residents for at least one night. A conservative estimate of their expenditure (US$20/person/night) represents direct revenue to island residents as a result of the presence of their coral reef. Tourism (off-site residence) represents the visitors who come to Apo Island for day visits and spend a small amount on the island for food or souvenirs (US$5/person/day). These same tourists also contribute a much larger sum to economies outside of the island but cannot be directly attributed to the presence of the coral reef of the island visited.

Finally, the aesthetic and biodiversity value of the reef is based on a contingent valuation survey for Philippine reefs in the tourism areas of Mabini, Batangas; Mactan Island, Cebu; and Panglao Island, Bohol[11]. The willingness-to-pay of visitors for entrance to marine reserves and sanctuaries and for the placement of anchor buoys is summarized in Table 2.6. This substantial amount of revenue is being foregone for the management and conservation of coral reefs which could be collected from some visitors if they knew that the fees collected were for specific uses. Based on the average number of visitors, the gross annual revenue from entrance fees and donations to anchor buoys being foregone from Mabini, Batangas, alone is estimated at more than US$300,000 (Table 2.7). This small sample survey is only indicative for the Mabini area and may not be representative for other parts of the country.

If we carry the analysis one large step further using conservative estimates of annual revenues from 1 km^2 of coral reef in the Philippines, we realize that the reefs in the country contribute an enormous amount to the economy of local communities and the nation. With 27,000 km^2 of coral reef, if 50% of this is in a condition which will support the estimated revenues of Table 2.5 at an average level, coral reefs contribute almost US$1 billion annually to the Philippine economy. In this light, the habitat losses from destructive fishing are huge and not justified[69, 70].

Several well-documented coral reef areas in the country will help to illustrate the sizable benefits derived from coral reef management. One example, Tubbataha Reef National Marine Park and World Heritage Site, is a large coral reef atoll in the middle of the Sulu Sea. This reef contains one of the most diverse and potentially productive coral reefs in the country and in Southeast Asia[12]. Although the cost of management and protection has not been estimated, the potential annual economic benefits from the

Table 2.6. Willingness-to-pay (WTP) to enter a marine sanctuary and to maintain anchor buoys in three popular scuba diving areas, Philippines[11].

	Mabini, Batangas	**Mactan Island, Cebu**	**Panglao, Bohol**
Entrance to marine sanctuary	n = 37	n = 39	n = 44
Average WTP	P92	P139	P85
(daily/person)	$3.54	$5.34	$3.27
Donation to anchor	n = 37	n = 36	n = 46
buoy maintenance	P235*	P138**	P78**
Average WTP	$9.04	$5.31	$3.00

*Annual donation per person.
**Daily donation per person.
US$1 = 26 pesos in mid-1997

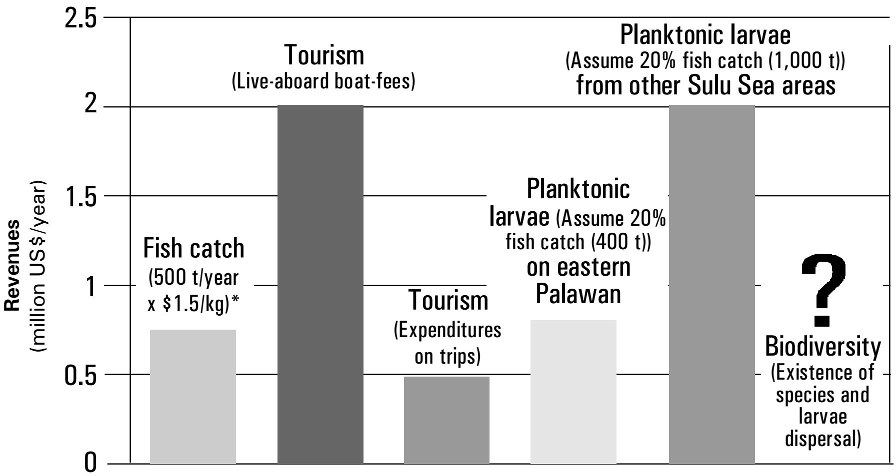
Table 2.7. Total potential annual revenues from entrance fees to marine sanctuaries and donations for anchor buoy maintenance in two popular scuba diving areas, Philippines[11].

	Mabini, Batangas[a] (n = 37)	**Panglao, Bohol**[b] (n = 44)
Entrance fees	P5,936,740 - P7,272,966 ($228,336-$279,729)	P460,080 - P690,120 ($17,695 - $26,543)
Donation for buoys	P504,957 - P618,611 ($19,421-23,792)	P419,580 - P629,370 ($17,695 - $24,205)

[a]Study estimated a minimum of 64,600 and a maximum of 79,140 visitor days per year.
[b]Study estimated a minimum of 5,400 and a maximum of 8,100 person diving days.
US$1 = 26 pesos in mid-1997

continued healthy existence of the reef area are substantial (Figure 2.5). With benefits totaling more than several US$million/year, it is easy to justify the cost of management, which is much less as shown for Apo Island below.

Figure 2.5. Annual direct and potential indirect economic revenues derived from Tubbataha Reefs (conservative estimates)[12, 123].



*This estimate is based on potential fish yield if fishing were allowed in the park. It is noted that the direct fish catch is valued much lower than other economic revenues from the park.

Now, if we look at the cost of management of 1 km^2 of coral reef, we can decide if the investment is justified based on the known benefits. First, if left alone without any disturbance except non-destructive and managed fishing and tourism practices, a coral reef will do very well and produce the revenues indicated above. But assuming we need to control damage and bring back the natural status quo, we have to support management programs. Apo Island provides an example to compare the costs of management with the revenues gained over the last 15 years.

Conservatively, Apo Island coral reef covering slightly more than 1 km^2 to the 60-m isobath, can support an annual revenue from sustainable fishing and tourism of about US$50,000/year[113, 127]

Figure 2.6. Annual gross revenues derived from the existence of one small marine sanctuary on Apo Island, Negros which was established in 1985 and receiving between 500 and 1,000 tourists annually[113, 127].

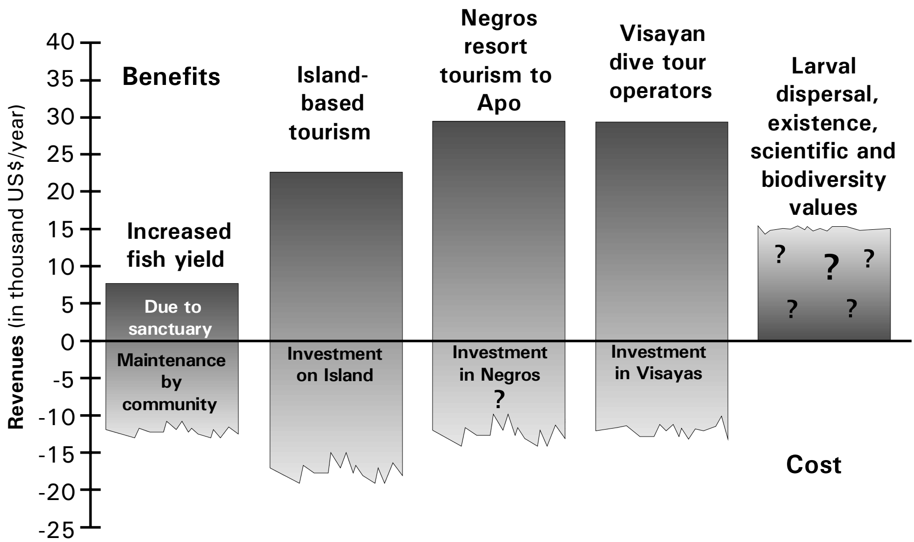
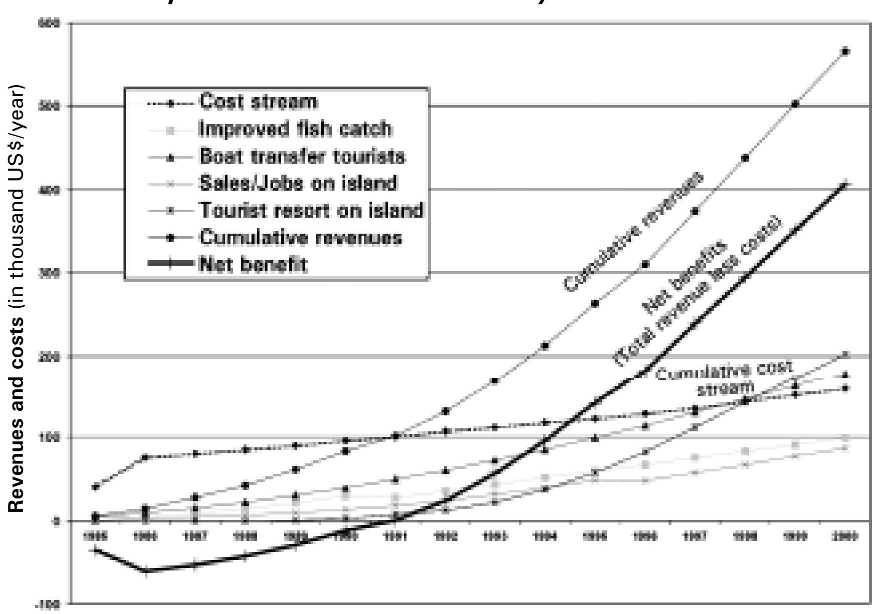


Figure 2.7. Accrued revenues and costs from the sustainable use of Apo Island coral reef and fishery resources[113, 122, 127].



(Figure 2.6). What is the cost of management to guarantee this annual revenue? In 1985 and 1986, a conservation project for Apo Island helped establish the current regime of a marine reserve and sanctuary managed by the island community. The project for Apo Island cost about US$75,000. The annual maintenance cost since then has been about US$5,000 to a variety of interested parties such as volunteers of the barangay and municipal government, Silliman University, the Department of Environment and Natural Resources and contributions from visitors to the island. Based on this, it appears that the cost of management is easily justified given the annual revenues now accruing to the island residents and tourism operators (Figure 2.7). It should also be noted that the cost of management is generally not borne by the persons who gain most from the reef-generated revenues! In this case, the costs were initially borne by Silliman University, a foreign donor and outside volunteers.