PHILIPPINE CORAL REEF FISHERIES RESOURCES

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INTRODUCTION

Coral reefs are highly productive complex communities thriving in warm, well-lighted, marine environments. Their gross annual primary productivity is roughly 20 times greater than the open ocean, 10 times greater than coastal waters, and over three times greater than upwelling zones (Odum, 1971).

The immense concentration of life on coral reefs is sustained primarily by a coral-algal symbiosis and the coral's ability to efficiently hoard and recycle nutrients received from flowing water.

The coral-algal colony contribute to the primary productivity and structural complexity of the reef community. The coral algae's primary productivity is transferred to higher trophic levels through direct release of algal photosynthetic products, and predation upon the coral and its by-products by other organisms. The various coral forms provide an elaborate shelter creating new niches and enlarging niche size. The diversity and number of reef niches determine the density of fish and invertebrate populations.

Reef organisms are best adapted to low stress environments. Consequently, most reef species are particularly vulnerable to changes in temperature, salinity, siltation, as well as pollution and other forms of human interference. Once the integrity of the reef has been disturbed, its recovery may take decades (Maragos *et. al.*, 1973, Pearson 1974, Johannes 1976).

Despite the susceptibility of coral reefs to disturbance, they represent a wealth of renewable natural resources which could be exploited continually under proper management without degradation. Coral reefs in the Philippines are currently being exploited through commercial, municipal and sustenance fisheries. Reefs also contribute substantially to the economy through local sale and export of reef-related products (e.g. ornamental corals, coral jewelry, shells, shell-craft, aquarium fish, etc.). Due to improper management, bureaucratic oversight, destructive methods of exploitation, and inadequate law enforcement, the future of this valuable resource is uncertain.

The purpose of this paper is to consolidate existing information on coral reefs as a fisheries resource, (including fish production and reef-related products), and outline a realistic approach for their management in the Philippines.

CORAL REEFS OF THE PHILIPPINES

Coral reefs of the Philippines are primarily of the fringing type with atolls, barrier reef and shoal reefs (as defined by Faustino 1931) occurring to a lesser extent. Fringing reefs border much of the Philippines' 18,417 km coastline. Most Philippine atolls are found in the Sulu Archipelago and Sulu Sea, with one notable atoll, Apo Reef, located west of Mindoro. Sizeable barrier reefs occur on the northwest of Bohol and off Tawi-Tawi. Shoal reefs are scattered around the Philippine Archipelago occurring mostly in major shelf areas.

Major concentrations of coral reefs occur in five principal shelf areas: Polillo Shelf, east of Quezon Province; the Visayan Shelf, between Northern Panay, Northern Negros, Northern Cebu and Masbate, the Palawan Shelf, surrounding Palawan; the Leyte-Samar Shelf south of Samar; and the Sulu shelf surrounding the Sulu Archipelago. The highest concentration of reefs, by area, occurs in the Palawan group (37.86% of the total Philippine coral reefs), the Sulu Archipelago (27.81%), the Visayan group (21.7%) and the Turtle Islands (1.74%); while they are less extensive around Northern Luzon (7.63%) and Central and Southern Mindanao (3.21%) (Gomez 1977).

A reliable assessment of the extent of Philippine coral reefs is still lacking. A University of the Philippines' Marine Science Center team, using maps and charts, estimated that Philippine coral reefs cover a total area of 44,096.54 km^2 (Gomez, 1977). Their first approximation suffers from two faulty assumptions that:

1. the reef area extends from the surface to a depth of 40 fathoms.

2. the maps and charts are correct.

A better approximation of total actual coral reef area can be obtained by correcting the assumed depth of reef extent.

The lower limit adopted by Gomez for reef extent (40 fathoms) is excessive in terms of significant coral diversity and fisheries resource assessment. Due to light attenuation, the number of coral species decreases sharply at about the 10-fathom contour (in Stoddart, 1969). Therefore in terms of coral diversity, the 10-fathom contour is a better limit of significant coral reef extent.

To approximate the total fisheries resources of reefs, the assumed depth limit of the reef should be deeper than that used for approximating the significant number and occurrence of coral species. Many fish and other mobile reef inhabitants migrate back and forth from deeper to shallower portions of the reef according to diurnal and nocturnal feeding behavior. Migrations away from the reef are well known in many nocturnal predators schooling on or near reefs during inactive periods.

Migration is also typical of nocturnal plankton feeders who travel just beyond the outer edge of the reef, which is known to be exceptionally rich in plankton (Hobson, 1972). Large predators often travel at night from deeper, daytime haunts to shallower portions of the reef or to shallower, proximate feeding grounds such as grass flats or mangrove swamps (Hobson 1972, 1973, 1974).

Energy overflow from the reef community appears to be the dominant influence in determining the ichthyofaunal identity of adjacent, hard substrate, and deeper water. The only exceptions are the pelagic species which often utilize reef productivity during migrations or as part of their home range. Reef-related fishes are often caught in depths of about 20 fathoms. This is also the depth at which most hermatypic coral growth ceases (Yonge, 1969), and most reef-related species are no longer conspicuous.

In terms of fisheries resource assessment, the 20-fathom depth contour is a more justifiable approximation for reef extent. However, when using maps and charts without sufficient bottom type information, the use of this depth contour to determine reef area suffers from irregularities in bottom characteristics. For sharply sloping reefs, the reef community usually extends to approximately the 20-fathom depth contour. But in areas where the slope is gradual, the reef is often bordered by sand or mud flats at depths much shallower than the 20-fathoms. In this case, some reef ichthyofauna still range over the adjacent flats (Parish *et al.* 1977, Hobson 1972). However, where the slope is gradual these flats can extend great distances before reaching a depth of 20 fathoms and it is doubtful if reef productivity is significant in these extensive flats. Due to these inconsistencies it is better to discuss reef extent in terms of 10 to 20 fathoms range.

The coastal contour may, at first glance, seem to be an overestimation of the upper limit of coral reef extent since shallower habitats adjacent to coral reefs are often grass flats or mangrove swamps. In terms of fisheries resource, these adjacent communities should be considered as one complex ecological unit. The importance of these continguous feeding grounds to schooling reef predators is well known (Randall 1963; Hobson 1968, Parish, *et al.* 1977). Mobile organisms in the adjacent communities often utilizes the diversified feeding and productive features of the reef-grass flat complex. The reef-grass flat-mangrove complex may also provide the necessary habitat requirements to fulfill certain life history requirements (Stevens and Marshall, 1974).

The reefs, grass flats, and mangroves generate approximately the same high gross productivity in comparison to one another. Coral reef tracts and high algae-covered reefs have a gross productivity of 40-10 gmC/M^2/day. The gross productivity of turtle grass beds is 12 gmC/M^2/day, and mangroves' gross productivity is 8 gmC/m^2/day (in Stevenson and Marshall, 1974). When using available maps and charts to approximate reef extent, the coastal contour becomes acceptable in terms of total gross productivity when comparing total marine productivity and coral reef areas.

The inaccuracy of existing maps and charts must also be considered if they are to be used in resource assessment. Existing maps are often old and lacking information on bottom characteristics. Field surveys sometimes reveal uncharted coral reefs and, sand or mud bottom where coral reefs are recorded as bottom type.

Satellite multi-spectral remote sensing may be useful in assessing total reef extent, if the optical properties of sea water under dif-

ferent conditions and depths do not prove to be an obstacle in delineating bottom types. A systematic sampling of chartered reefs and chartered shallow, non-reef areas should be undertaken to provide a statistical basis for over-all map correction.

Despite the inconsistencies encountered in using maps and charts to assess the area of coral reefs, it is still useful to obtain a second estimate using Gomez's (1977) figures. This can be done by making simple interpolations using slopes obtained from known total area of Philippine waters within the 7, 24.6 and 100 fathom depth contours; and assuming that the average slopes between the seven-fathom and 24.6-fathom contours and the 24.6 fathom and 100 fathom contours are approximately even, and that the majority of significant coral reef extent occurs within the 20 fathom depth contour.

Using the calculated total area of Philippine waters under 40 fathoms and the coral area of reef extent under 40 fathoms obtained from charts and maps, coral reefs occupy approximately 30% of Philippine shallow marine areas. From this, we can estimate that the total coral reef area within the 10 fathom contour is approximately 12,171 km^2, and within the 20-fathom contour is approximately 33,088 km^2. Despite the rough calculations, the range 12,171 km^2 — 33,088 km^2 of total Philippine coral reef area can serve as a useful second approximation in fisheries resource assessment.

Much of Philippine coral reefs are in progressive stages of degeneration (Gomez 1977, author's observation 1975-1977). Causes of destruction are numerous, some of which are natural calamities, increased siltation from poor land use, dynamite fishing, collection of corals for ornamental, handicrafts and construction purposes, use of of cyanide and other poisons in collecting aquarium and food fishes, industrial and agricultural coastal pollution, and destructive fishing techniques.

Areas along coastlines like in Bataan where forests have been denuded and where slash and burn agriculture is prominent, extensive reef stretches are silted over. Most reefs throughout the Philippines have pock-marked areas of physically disrupted corals where dynamite has been used for catching reef fishes. Entire coral reefs have been removed for use in constructing foundations, roads, and fishpond dikes in the Hundred Islands and Bolinao, Pangasinan, as well as in other areas. Where corals are extensively collected for ornamental purposes such as the reefs near Cebu City and Zamboanga City, many proximate reefs are stripped. Use of poisons in areas of intense aquarium fish collection has killed many reef organisms. Where industrial, agricultural or human wastes empty into reef-fringed coastal areas, the reef community is generally degraded. This is particularly evident near sugar centrals. The muro-ami and kayakas fishing methods which operate over coral reefs use scare-line techniques which are destructive to corals. Both of these methods could easily be modified to be less destructive while retaining effectiveness.

III. CORAL REEFS AS A FISHERIES RESOURCES

Coral reefs are valuable fish producing communities which have been generally neglected in fisheries management throughout most of the Indo-Pacific region. Much of fisheries development in tropical countries has been guided by various foreign aid agencies coming from temperate countries. Since foreign aid experts from these countries are reared on traditional temperate approaches to fisheries assessment, their tendency is to apply their efforts to the marine ecosystem with which they are most familiar, i.e., pelagic and soft sediment demersal resources

Thus habitats such as coral reefs which are endemic to tropical areas tend to be overlooked. The difficulty of fishing in the irregular substrate of reefs, limits most fishing efforts to small-scale fisheries which are also basically neglected by foreign aid fisheries development programs because they tend to think in terms of large-scale commercial operations. In addition, a large percent of fish on coral reefs are small and less attractive as food according to certain cultural tastes. There is also a notion that since the high productivity of reefs is partly due to tight nutrient recycling, reefs cannot sustain considerable harvest pressure.

The inability to recognize reefs as a significant fisheries resource has, perhaps indirectly, been the major contributing factor to the deteriorating condition of reefs today. Lack of emphasis on the resource management of small-scale reef fisheries has allowed destructive fishing methods to run rampant on many reefs.

The view that reefs cannot sustain considerable harvest pressure stems from examples of large valuable fish being rapidly fished out

from coral reefs. This is probably not due to the close cycling nature of coral reefs. Closed cycling on reefs is actually an applicable description only of the coral themselves, since it is well known that organisms attached or associated with hard substrate in flowing water gain energy subsidy benefits from nutrients coming from other systems.

Overfishing on reefs is more likely due to the inability to manage them properly. Intense localized fishing of large territorial reef predators with comparatively long life spans will obviously and substantially deplete the abundance. These fish types should be fished more wisely and exploitation of lower trophic level should be intensified to sustain continual significant harvests.

Size distribution of fishes is often an indication of harvest pressures, but in the case of many tropical marine environments, mature small fish are often present in higher relative abundance. Although many fish on reefs are relatively small at maturity, they should not be ignored as a fisheries resource. In many countries small fish are eaten as readily as large ones. Harvesting, handling and processing of small fish may deter large commercial operations, but artisan and sustenance fisheries can thrive due to consumer demand. The harvesting of small fish along with the large could also serve as a better balance to intercommunity pressures caused by fisheries mortality, as all trophic levels would be affected. This could allow easier population recoveries and insure continual profitable harvesting.

As a fisheries resource, coral reefs have a distinct advantage over most other marine ecosystems in that their exceptionally high primary productivity results in a comparatively high secondary productivity. A comparison of Tables I and III show that the average standing crop of fish of those reefs sampled is 30-40 times higher than representative Southeast Asian marine environments, and 20-2,000 times higher than representative temperate demersal stocks.

Methods of fish productivity data collection on reefs and other representative areas are not standardized and in many cases, inadequate in sampling specific fish populations. Also, in many cases, local fishing pressures in the sample areas are not known. However, sufficient data are presented in Table I to illustrate the exceptional fish productivity of reef areas.

In comparing temperate and tropical fisheries, coral reef fisheries with recorded catch statistics produce more than substantial harvests. From Tables III and IV we see that harvest data from high effort fisheries over coral reefs compare favorably with harvest data of demersal stocks from important fisheries areas such as the North Sea and Western Greenland. Average yield of high effort reef fisheries probably lies between 2.0 and 5.0 metric ton/km² (Stevenson and Marshall 1974). Many other important fisheries area harvests, combining both demersal and pelagic harvests, lie substantially below this average.

IV. REEF FISHERIES OF THE PHILIPPINES

Although resource assessment and management of reef fisheries in the Philippines has been given little attention, reefs contribute notable quantities of fish in commercial, municipal (artisan) and sustenance fishereies. Rich harvest are extracted from reefs by such fishing methods as hook and line, diver set long lines, gill nets, spear fishing, fish traps, drag seines, drive-in-nets (i.e., Muro-ami and kayakas) and unfortunately, explosives and poisons. Over 20 families of fish are harvested from Philippine coral reefs.

Employing existing data on area size of reefs, the potential fisheries resources of Philippine reefs can be roughly determined. Given the estimated area of reefs as between 12,000 and 33,000 km² (see Section II) and the maximum probable sustainable harvest derived from reef fisheries as 5.0 wt/km² (Stevenson and Marshall 1974), Philippine reefs could yieled 60,000 to 176,000 mt/yr. In a country whose total production for 1975 was 1,336,803 metric tons, (Fisheries Statistics of the Philippines) this could represent 4.5 to 13.2 percent of the total Philippine fisheries production. Admittedly, these are rough calculations but they may be of use in resource assessment and are supported by other data on reef fisheries available from commercial and regional fisheries statistics. These will be discussed later.

A closer look at commercial and municipal fisheries will emphasize the importance of reef fisheries in the Philippines and the need for increased attention and management.

Commercial Reef Fisheries

Reef fisheries are exploited commercially by the Muro-ami (Japanese drive-in-net) and hook-and-line.

The Muro-ami operates almost exclusively over coral reefs, and the hook-and-line primarily over coral areas. Table V shows that these fisheries have contributed substantially to the total catch since 1960. In terms of total fisheries production, fishing gear have produced between 5.1 to 7.2% of the commercial production, and 1.9 to 2.7% of the total Philippine fisheries production during the years 1970 to 1975. These figures can be put in a different perspective regarding total reef fisheries production when we consider that proportionally, much more effort over reefs is applied by municipal and sustenance fisheries production, we would expect them to contribute a higher percentage of production in reef fishing than commercial fisheries. Thus, the estimate calculated from the size of Philippine reefs that 4.5 to 13.2% of total fisheries production is taken over coral reefs is further supported.

From 1965 to 1975, in all except three years, the muro-ami has been the highest in average annual production per unit vessel (Table V). This high production seems to be due to the inherent high productivity of reefs and not due to the efficiency of the gear (Carpenter and Alcala, in preparation). A study of muro-ami statistics and methods of operation revealed a need to manage these fisheries closely (Carpenter and Alcala in preparation). The relation between production and number of vessels suggests that the regulations of fishing grounds and fishing effort could increase the efficiency of the fishery. A modification of the scare-line is also necessary to decrease its habitat debilitation.

Close examination of hook-and-line and muro-ami statistics reveals that many pelagic species are included in the catch (Fisheries Statistics of the Philippines). As was mentioned earlier, pelagic species often benefit from reef productivity either during migrations or as part of their normal life range. In terms of total energy budget of the reef (and therefore gross reef productivity), it is difficult to separate these reef visitors. They obviously benefit from reef productivity by feeding over reefs, and often in fulfilment of an obligate portion of their life cycle. It is impossible at this time to proportionalize the amount of pelagic species taken over reefs as belonging to either reef or open sea productivity. Since an unknown amount of pelagic species benefit from reef productivity which are not caught over reefs, it is fair to include those caught over reefs as an integral part of reef fisheries productivity.

Municipal and Sustenance Reef Fisheries

Municipal and sustenance fisheries contribute more than half of the total fisheries harvest in the Philippines (Fisheries Statistics of the Philippines). Due to limitations in the monitoring of these fisheries, statistics are often inadequate and therefore, that portion of municipal and sustenance fisheries which operate over coral reefs cannot be directly determined. It can, however, be ascertained that a substantial portion of the municipal and sustenance fisheries production comes from reef fisheries. This is directly supported from statistics of areas having hard-substrate fisheries landings recorded and indirectly supported from the basic assumption that a much greater proportion of reef fisheries production comes from municipal and sustenance effort than from commercial fisheries.

In a fisheries assessment workshop (South China Sea Development Programme, 1977), hard-substrate (reef) demersal fish catch statistics have been separated from demersal soft-substrate and pelagic catches from the Sulu Sea, Bohol Sea and Moro Gulf areas. The hard substrate fisheries of this area contributes 30% of the total catch of the area (Table VII). Of the total reef catch in this area 37% was from commercial fisheries or, 11.0% of the total catch in the area comes from commercial reef fisheries (Table VIII). Municipal and sustenance reef fisheries contributed 19% of the total fisheries production (Table IX). This supports the assumption that proportionally, more fishing effort over reefs comes from municipal and sustenance fisheries than commercial fisheries. This is emphasized when we consider that 87% of Philippine commercial reef fisheries comes from the Sulu Sea, Bohol Sea, and Moro Gulf areas although this area accounts for only 65.7% of the total Philippine reefs.

If we consider the reef area proportional to reef fisheries production, from the data on the Sulu Sea, Bohol Sea and Moro Gulf areas; and data on relative reef distribution, we would expect 12.5% of the 1975 total Philippine fisheries production to have come from municipal and sustenance effort over reef areas (Table IX). This

represents about 23% of the total 1975 municipal and sustenance production.

If we use the same type of extrapolation for commercial fisheries, we would expect the 1975 commercial reef fisheries production to have contributed 7.2% of the total fisheries production. This is far above the actual calculated commercial reef fisheries production of around 2% of the total production (Table V). This discrepancy is understandable when we note that over 86% of commercial reef fisheries in the Sulu Sea, Bohol Sea, and Moro Gulf areas comes from the Northern Sulu Sea alone (Table VIII). The choice of fishing grounds for commercial reef fisheries is understandably a function of proximity to a large market e.g. City of Metro Manila) as well as reef area distribution. The proportional effort of municipal and sustenance reef fisheries would however, be more a function of reef area distribution. Small-scale reef fisheries would only need the rural population in proximity to reefs as consumers for their catch. Therefore, the estimate derived from the information on the Sulu Sea, Bohol Sea and Moro Gulf that municipal and sustenance fisheries contribute about 12.5% of the total fisheries productivity can be considered reliable. In relation to total potential production, it should be considerd as a conservative estimate because the information available from the Sulu Sea, Bohol Sea, and Moro Gulf areas indicate that the reef fisheries there have not yet been fully developed.

If we consider that municipal and sustenance reef fisheries in 1975 contributed 12.5% of the total fisheries production (Table IX) and commercial reef fisheries in 1975 contributed 1.9% of the total fisheries production (Table V); then total reef fisheries contributed 14.4% of the 1975 fisheries production. This is close to the upper limit of the range 4.5 to 13.2% of total production contributed by reef fisheries estimated from Philippine reef area size and maximum expected sustainable yields. This second estimate tends to support the upper limit of the expected reef fisheries production. The higher estimate is more acceptable when we consider the difference in Philippine reef fisheries as opposed to those reef fisheries in which the maximum sustainable yield was estimated to be 5.0 mt/km^2/year (Stevenson and Marshall, 1974). These reef fisheries rely heavily on large fishes, primarily predators, for the bulk of their production. Philippine reef fisheries utilizes almost all fish sizes and all trophic levels of reef fish assemblages. The use of fish traps, drive-in-nets, and gill nets on reefs is common in the Philippines, and they are less selective than bottom hook-and-line fisheries. Large fish and fish as small as 10 grams are caught and sold as food fish in the Philippines. It is not unreasonable to assume that the average sustainable yields of Philippine reef fisheries is as high as or higher than the maximum sustainable yields of the high intensity more selective reef fisheries (Table III.) Therefore, it is believed that the portion of total Philippine fisheries production which is contributed by reef fisheries is likely to be at least 15%, and probably higher.

A municipal reef fishery which exemplifies the high productivity of reefs is the "kayakas" or Bohol drive-in-net (Carpenter and Alcala, in preparation). This gear harvests an average of 1.8 mt/day (Deanon and Carpenter, 1977, unpublished data). As is the case with muro-ami fisheries, the kayakas fisheries is in need of management and gear modification to increase its efficiency and decrease its habitat destructiveness.

V. OTHER CORAL REEF RESOURCES

Besides food fish, coral reefs yield an abundance of valuable marine products. Corals, aquarium fish, shells, sponges, seaweeds, reptile skins, abalone, sea urchins, and sea cucumbers are gathered from Philippine coral reefs. These products, which are exploited and consumed locally, bring substantial revenue and play an important role in the lives of many coastal people.

Exports of coral reefs products contribute a substantial portion of total fisheries exports yearly (Table X). In addition to those already exported, there still lies a wealth of potentially exportable coral reef resources. An example of this is the sea urchin roe, for which a large market exists in Japan. The future of such export enterprises will rely on the ability of coastal people to cooperate and conserve while exploiting.

Export sales of aquarium fish have increased astoundingly in the past few years (Table XI). From 1975 to 1976 alone, exports have nearly quadrupled. Since there are virtually no controls on this booming industry, the question arises as to what effect it is having on the environment and the fish populations. Removal of certain species such as cleaner organism is known to be harmful to the reef ichthyofauna (Johannes 1975) yet there are no controls on their capture or export. Many of the aquarium fish are caught by environmentally disturbing poisons such as cyanides. The future of this industry is unpredictable due to the lack of environmental effects data and proper resource management controls.

Indeed, almost all export products derived from coral reefs could be considered endangered due to reef destruction, and lack of control in the gathering and export of these products. Severe depletion of certain shells is well known in areas of unchecked gathering (e.g., the Cebu City proximate reefs). The gathering of abalone has resulted in extreme habitat disturbances in some areas (e.g., Guiuan, Samar). The gathering of corals for ornamental purposes has resulted in entire reefs being stripped of corals (e.g., in the Cebu and Zamboanga areas).

Another coral reef "product" is tourism. Coral reefs and diving are the Philippines' most potentially valuable aquatic sport attraction (Carpenter *et al.,* 1977). Obviously, the future of this major foreign currency attraction relies on the ability of the Philippines to conserve the beauty of her reefs while developing the diving industry. The establishment of well-managed marine parks and marine reserves will also play an important role in this aspect of coral reef resource management.

VI. DISCUSSION AND CONCLUSIONS:

The most important concept in coral reef resource management is that each component of the reef ecosystem must be considered before any portion can be exploited. The narrow-niche and tight nutrients recycling nature of the coral reef community demands careful resource management. Any significant change or reapportionment of the trophic structure could affect populations adversely. This is particularly important in the case of fish and coral populations. Talbot (1965) found a clear relationship between quantity of fish and percentage of coral cover. Thus the issue of managing corals as a primary part of an important marine ecosystem is important to proper fisheries management. This relationship requires a coordinated management of both corals and coral reef fisheries as living renewable resources.

Reef fisheries are a substantial fish-producing industry, and fulfillment of protein needs is a major concern of the country. Gathering and marketing of all other products from coral reefs should only be allowed if their exploitation is not deleterious to reef fish populations. This is particularly important in case of corals because their disruption affects fish populations. All other reef products should be managed with protection of the habitat as the primary concern.

Coral reefs are long overdue for proper recognition as an important, fish-producing resource. The emphasis placed on development of aquaculture and commercial fisheries by foreign aid programs has influenced Philippine resource management to ignore reef fisheries. Emphasis on commercial fisheries development instead of development of municipal and sustenance fisheries could be a major error in attempting to enhance expanded fish production and conservation programs. More than half of the total Philippine fisheries production comes from municipal and sustenance fisheries, while management of this sector is proportionally inadequate. These management oversights stem from attempts to manage tropical fisheries according to techniques used by successful temperate fisheries.

While approaching development from a large, commercial viewpoint, there is a tendency to overlook the advantages of municipal and sustenance fisheries in a tropical ecosystem (ecosystem here also includes human populations). It should not be overlooked that multiple small-scale ports can effectively provide jobs and a protein source of a large portion of the population. Currently, commercial fisheries cannot be more efficient at supporting the majority of the population than municipal and sustenance fisheries. In cases where commercial fisheries are competing with municipal and sustenance fisheries, it is more likely that commercial fisheries will be a hindrance to overall development.

Fish processing in the tropics is more amenable to municipal and sustenance fisheries. Due to multiple-species catches and the case at which small fish can be marketed, the handling and processing of tropical catches is difficult at the large scale necessary for commercial fisheries.

More emphasis should be placed on development and protection of municipal and sustenance fisheries. They will remain a major fish-producing sector and therefore, rightfully deserve additional efforts toward resource management. Commercial operations should be encouraged in areas where their exploitation would be more efficient

than those of municipal and sustenance fisheries. However this encouragement should not direct the development effort away from municipal and sustenance fisheries.

The majority of Philippine reef fisheries belong to municipal and sustenance fisheries rather than commercial fisheries. This is a result of fish size distribution, diverse catches, and the inherent difficulties in gear operation over irregular-bottomed substrate. Because of these limitations, reef fisheries will probably remain chiefly the territory of small-scale operators. The contribution of reef fisheries to the total fisheries production should not be underestimated. The productive future of this valuable resource can only be sustained through efforts at management of the small scale fisheries and teaching coastal people the concepts necessary to make them realize the importance of conserving this resource.

Reef fisheries contribute 15% of the total Philippine fisheries production and therefore, should receive proportional attention in resource management. Attention is badly needed for these reef fisheries as they are endangered due to abuse and neglect. Their deterioration will hamper expanded fish production and conservation programs. It is certain that if coral reefs are destroyed, then the Philippines will loose a valuable marine resource.

The distribution of Philippine coral reefs show where the management of reef fisheries should be undertaken. Permanent fisheries stations devoted to reef studies, and monitoring of reef fisheries should be constructed in areas of extensive reefs. These areas include the Palawan Shelf, the Sulu Archipelago, the Cebu-Bohol area, the Cebu-Masbate Shelf, and the Southern Samar Shelf.

More research is needed to adequately assess and manage reef fisheries. Baseline studies are needed in reef fish productivity and community analysis. The ecological characteristics of corals and their relationship to fish productivity and diversity needs to be studied. Coral reef distribution and quality assessment should be continued using satellite remote-sensing techniques. Methods need to be developed for adequate collection of statistics on reef fisheries. More information is needed on the important reef gears such as *muro-ami* and *kayakas*. Investigations are needed for the other reef-derived products, particularly the aquarium fish trade. Most important is that all these reef research activities be closely coordinated to effectively meet the needs of this endangered valuable resource.

The future of Philippine coral reefs will rely heavily on the ability of coastal people to conserve this valuable resource. Without the proper guidance through resource management agencies, many of these people will continue using methods which are harmful to the habitat and their livelihood. This situation is due primarily to economic hardships and their ignorance of basic ecological concepts. To alleviate the problems of destructive methods of coral reefs exploitation, a massive extension campaign should be launched. This campaign should be aimed at teaching coastal people basic ecological concepts so they understand the need for coral reef conservation. In conjunction with the conservation aspects, they should also be taught proper exploitation techniques so they may continually profit from coral reef resources.

RECOMMENDATIONS

As it has been shown that coral reefs contribute 15% or more of the total fisheries production and a substantial portion of fisheries export products, proportional attention should be given to coral reefs in resource management.

Any activity which decreases the quality and quantity of corals on reefs should be prohibited to preserve the fish-producing integrity of reefs.

Research activities concerning secondary productivity, community analysis, related products, resource management, and fishing gear, for coral reefs should be increased.

An extension program, aimed at teaching the basic ecological concepts necessary to understand the need to conserve and wisely exploit coral reefs, should be launched. This extension effort should be directed toward people living near coral reefs areas, to law enforcement agencies, and to resource management agencies.

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4. Barrier reef, Great Barrier Reef, Australia (Talbot and Goldman, 1972)	209	43-390	Explosives and poison	Data from outer reef slopes and lagoon back reef. Poisons (rotenone) used to standardize explosives stations.
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6. Fringing reefs, Virgin Islands (Randall, 1963)	160	-	Poison	Rotenone used as poison.

TABLE II

Estimated fish standing crop from representative fishing grounds

	STANDING CROP (metric tons/km^2) Mean	Range	METHODS	REMARKS
I. South China Sea fishing grounds (Ayoma, 1973)				
- South China Sea Basin	1.25	-	Trawling	Maximum estimated standing crop
- Palawan and Luzon			"	" " " "
a. Within 50 meter depth contour	3	-	"	" " " "
b. Within 500 meter depth contour	2	-	"	" " " "
- Philippines and Sulu Sea (excluding Palawan and Luzon)	4	-	"	" " " "
a. Within 50 meter depth contour	2	-	"	" " " "
b. Within 500 meter depth contour			"	" " " "
- Gulf of Tonkin			"	" " " "
a. Within 50 meter depth contour	5	-	"	" " " "
b. Within 500 meter depth contour	2	-	"	" " " "
- Gulf of Thailand			"	" " " "
a. Within 50 meter depth contour	5	-	"	" " " "
b. Within 500 meter depth contour	2	-	"	" " " "
II. Temperate and Mediterranean fishing grounds				
- North Sea (in Moiseev, 1969)	3.0	-	Fish hauls	Demersal fish only
- Barents Sea (in Moiseev, 1969)	0.45	-	" "	" " "
- White Sea (in Moiseev, 1969)	0.12	-	" "	" " "
- Baltic Sea (in Moiseev, 1969)	0.6	-	" "	" " "
- Mediterranean Sea (in Moiseev, 1969)	0.15	-	" "	" " "
- Azov Sea (in Moiseev, 1969)	0.8	-	" "	" " "
- Japan Sea (in Moiseev, 1969	2.9	-	" "	" " "
- English Channel (in Stevens and Marshall, 1974)	5.6	-	Trawling	" " "
- Block Island Sound, U.S.A. (in Stevens and Marshall, 1974)	9.2	2-20	Trawling	" " "

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Harvest data from some bottom reef fisheries (after Stevenson and Marshall, 1974)

LOCATION	YEAR	HARVEST metric tons/km^2	REMARKS
Jamaica	1945	2.0	High Effort Fishery
Jamaica	1962	4.0	" " "
Jamaica	1971	2.2	" " "
Mauritius	1945	4.7	" " "
Bermuda	1956	0.4	Low Effort Fisheries
Cuba	1962	0.5	" " "
Lamotrek Atoll	1964	0.4	" " "

TABLE IV

Harvest data of demersal and pelagic fish of representative fishing regions, assumed to be high effort, (after Moiseev, 1969)

LOCATION	YEAR	HARVEST metric tons/ km^2	REMARKS
North Sea	1965	2.75	Demersal fish only
North Sea	1965	2.55	Pelagic fish only
Barents Sea	1965	0.47	Demersal and pelagic fish
South West Africa	1965	3.970	Demersal and pelagic fish
Atlantic epipelagic	1965	0.013	No demersal fisheries; pelagic only
Sea of Japan	1965	1.39	Demersal and pelagic fish
E. Coast Japan	1965	2.57	Demersal and pelagic fish
Philippines	1965	1.21	Demersal and pelagic fish
Pacific epipelagic	1965	0.01	No demersal fisheries; pelagic only
Western Greenland	1965	5.35	Demersal fish only

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Productivity of two Philippine commercial fisheries working primarily over coral reefs 1960-1975
(Fisheries Statistics of the Philippines)

YEAR	HOOK AND LINE (metric tons)	MURO-AMI (metric tons)	Total Commercial Reef Fisheries (metric tons)	Percent of total commercial productivity	Percent of total Philippine Fisheries Productivity
1960	2752	9573	12325	10.3	2.8
1961	3338	9362	12900	10.3	2.8
1962	5252	10878	16130	10.8	3.3
1963	5217	11622	16839	8.1	3.1
1964	4909	18321	23230	9.0	3.8
1965	7565	14160	21725	7.2	3.3
1966	11512	11722	23234	7.4	3.3
1967	8915	10246	19161	5.8	2.6
1968	9959	16642	26601	6.5	2.8
1969	9311	19307	26618	7.8	3.0
1970	8282	16823	25105	6.6	2.5
1971	7638	17894	25442	6.7	2.5
1972	5273	16827	22100	5.2	1.9
1973	6521	26475	32996	7.1	2.7
1974	9795	24033	33828	7.2	2.2
1975	6252	18992	25244	5.1	1.9

TABLE VI

Average annual production in metric tons of commercial fishing vessels per unit vessel, by gear used, 1960-1975
(Fisheries Statistics of the Philippines)

GEAR / Year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Bagnet	84	76	78	99	122	118	112	111	171	145	146	116	160	51	67	64
Beach Seine	6	10	24	43	56	22	28	87	53	122	94	109	54	40	26	15
Gill net	3	14	9	23	100	5	1	14	32	16	25	25	47	35	55	20
Hook and line	61	60	76	76	70	79	85	80	113	96	94	92	56	81	128	99
Long line	-	-	-	-	-	-	-	165	136	127	68	40	37	-	-	73
Muro-ami	*204	*195	*236	*242	*436	*179	*249	*277	366	*804	*647	*484	431	*716	650	*542
Purse seine	7	12	11	34	57	171	114	230	*362	316	354	444	*465	495	*732	537
Push net	-	-	-	-	-	-	-	-	-	-	-	-	-	179	4	2
Otter trawl	103	108	132	162	211	208	223	243	237	201	208	224	209	192	244	314
Round haul seine	44	66	73	94	97	63	83	99	219	62	44	40	57	73	69	54
Ring net	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	276

* Highest average annual production per unit vessel.

TABLE VII

1975 Demersal and pelagic fisheries production of the Sulu Sea, Bohol Sea and Moro Gulf areas
(South China Sea Development Programme, 1977)

Fishery	Production (metric tons)	Percent of Total Production in Area
Demersal		
Hard substrate(reef)	55,092	30
Soft substrate	17,414	10
Pelagic	1,805	1
Otoshi-ami	2,668	1
Yellowfin tuna		
Skipjack	16,854	9
Roundscad	42,684	23
Big-eyed scad	11,771	6
Chub mackerel	13,908	8
Anchovies	21,580	12
Total	183,776	100

TABLE VIII

Production of commercial reef fisheries in Sulu Sea, Bohol Sea and Moro Gulf areas, 1975
(Fisheries Statistics of the Philippines)

Fishing Ground	Muro-ami	Hook and line	Total
Bacuit Bay	-	127	127
Moro Gulf	20	5	25
Sulu Sea (south)	2,362	264	2,626
Sulu Sea (north)	13,624	3,866	17,490
TOTAL			20,268

TABLE IX

Comparison of total Philippine fisheries with reef fisheries from Sulu Sea, Bohol Sea and Moro Gulf areas, 1975

	PRODUCTION (metric tons)	Percent of Total Fisheries Productivity	Percent of Total Fisheries Productivity in Sulu Sea, Bohol Sea and Moro Gulf areas
Total Philippine fisheries productivity*	1,336,803	100	-
Total Philippine commercial fisheries productivity*	498,617	37.3	-
Total Philippine municipal and sustenance fisheries productivity*	731,725	54.7	-
Total Philippine reef fisheries****	192,500	14.4	-
Total Philippine commercial reef fisheries*	25,244	1.9	-
Total Philippine municipal and sustenance reef fisheries***	167,100	12.5	-
Total reef fisheries of Sulu Sea, Bohol Sea, and Moro Gulf areas (65.67% of total Philippine reef area)**	55,092	-	30
Commercial reef fisheries of Sulu Sea, Bohol Sea and Moro Guld areas*	20,268	-	11.0
Municipal and sustenance reef fisheries of Sulu Sea, Bohol Sea and Moro Gulf Area**	34,824	-	19.0

*From: Fisheries Statistics of the Philippines, 1975
**From: South China Sea, 1977
***Calculated from municipal and sustenance reef fisheries productivity from Sulu Sea, Bohol Sea and Moro Gulf areas assuming these types of fisheries are proportional to reef area distribution.
****Addition of Philippine commercial reef fisheries obtained directly from Fisheries Statistics of the Philippines and the calculated total Philippine municipal and sustenance reef fisheries.

TABLE X

Exports of Philippine fishery products related to coral reefs cleared by the Bureau of Fisheries, by Kind, Quantity and Value, 1971-1975
(Fisheries Statistics of the Philippines)

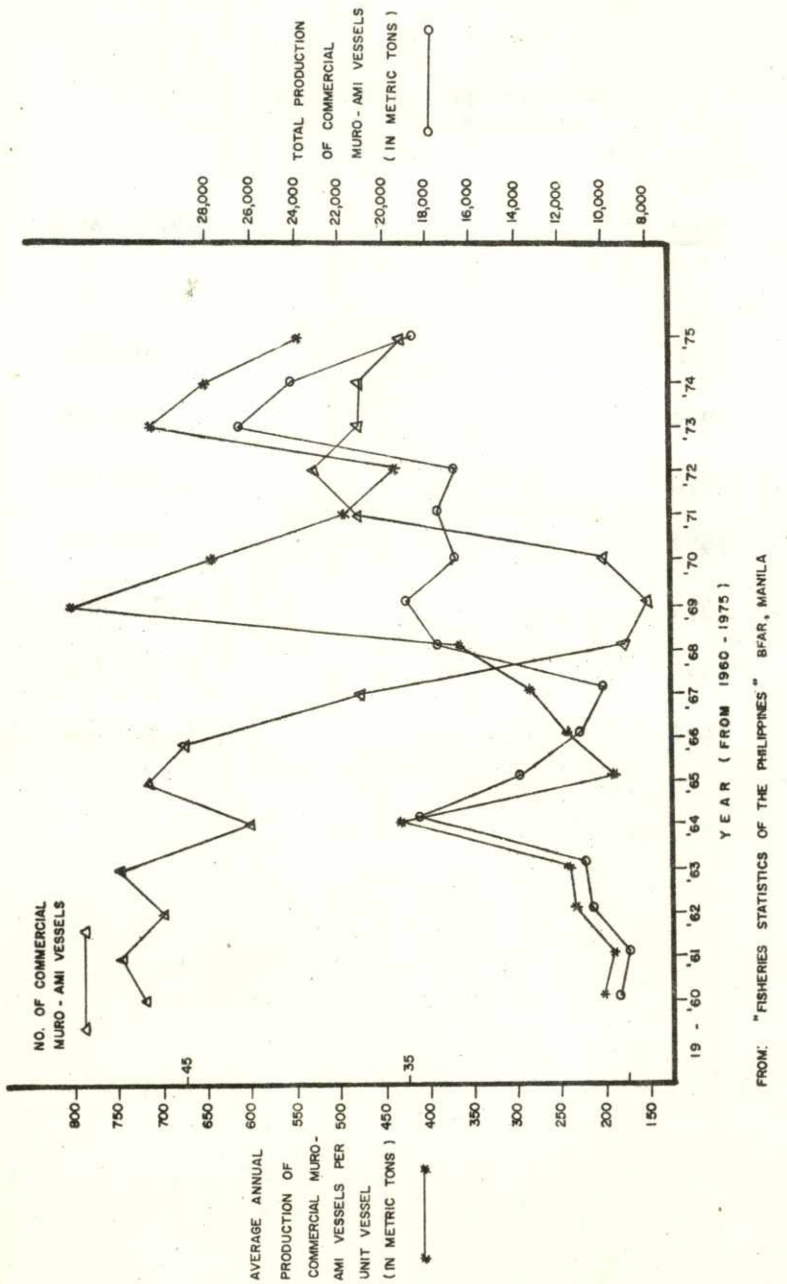
ITEMS	1971		1972		1973		1974		1975	
	Quantity (kg.)	Value (₱)	Quantity (kg.)	Value (₱)	Quantity (kg.)	Value (₱)	Quantity (kg.)	Value (₱)	Quantity (kg.)	Value (₱)
Corals	54,375	55,320	88,079	83,322	152,479	169,695	492	1,032	30,274	667,342
Ornamental Shells	1,188,166	1,801,661	642,903	1,560,311	1,167,196	2,379,209	1,847,075	3,315,902	3,042,495	15,704,310
Shellcraft	210,400	1,038,006	145,815	1,372,014	207,214	1,235,813	293,855	2,122,210	3,455,185	158,637,200
Dried Sponges	4,361	168,971	5,238	166,007	7,254	276,266	1,530	196,918	6,075	352,854
Seaweeds	339,820	675,504	483,999	1,414,051	1,432,775	1,897,159	5,039,636	14,973,151	4,514,845	13,292,226
Reptile Skin	5,199	381,150	96,873	606,654	10,234	1,897,159	8,521	1,224,277	11,525	1,588,745
Processed Abalone	-	-	10,217	72,093	49,110	1,002,828	10,918	320,952	16,234	160,057
Aquarium fish	-	1,000,263	-	3,289,262	-	5,738,062		6,304,677	-	10,504,620
TOTAL		5,120,875		8,563,714		14,596,191		28,459,119		200,907,355

TABLE XI

Philippine aquarium fish exports, 1970-1976
(Fisheries Statistics of the Philippines)

YEAR	PESO VALUE
1970	1,000,263
1971	1,693,366
1972	3,289,262
1973	5,738,062
1974	6,304,677
1975	10,504,620
1976	36,256,826

Figure I. Muro-Ami Statistics (1960-1975)



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	Quantity (kg.)	Value (P)	Quantity (kg.)	Value (P)	Quantity (kg.)	Value (P)	Quantity (kg.)	Value (P)	Quantity (kg.)	Value (P)
Corals	54,375	55,320	88,079	83,322	152,479	169,695	492	1,032	30,274	667,342
Ornamental Shells	1,188,166	1,801,661	642,903	1,560,311	1,167,196	2,379,209	1,847,075	3,315,902	3,042,495	15,704,310
Shellcraft	210,400	1,038,006	145,815	1,372,014	207,214	1,235,813	293,855	2,122,210	3,455,185	158,637,200
Dried Sponges	4,361	168,971	5,238	166,007	7,254	276,266	1,530	196,918	6,075	352,854
Seaweeds	339,820	675,504	483,999	1,414,051	1,432,775	1,897,159	5,039,636	14,973,151	4,514,845	13,292,226
Reptile Skin	5,199	381,150	96,873	606,654	10,234	1,897,159	8,521	1,224,277	11,525	1,588,745
Processed Abalone	-	-	10,217	72,093	49,110	1,002,828	10,918	320,952	16,234	160,057
Aquarium fish	-	1,000,263	-	3,289,262	-	5,738,062		6,304,677	-	10,504,620
TOTAL		5,120,875		8,563,714		14,596,191		28,459,119		200,907,355

TABLE XI

Philippine aquarium fish export's, 1970-1976
(Fisheries Statistics of the Philippines)

YEAR	PESO VALUE
1970	1,000,263
1971	1,693,366
1972	3,289,262
1973	5,738,062
1974	6,304,677
1975	10,504,620
1976	36,256,826

Figure I. Muro-Ami Statistics (1960-1975)