WORKING PAPER SERIES

FISHERIES STOCK ASSESSMENT

TITLE XII
Collaborative Research Support Program

Fisheries Stock Assessment CRSP Management Office
International Programs, College of Agriculture
The University of Maryland, College Park, Maryland 20742

In cooperation with the United States Agency for International Development (Grant No. DAN-4146-G-SS-5071-00) the Fisheries Stock Assessment CRSP involves the following participating institutions:

The University of Maryland—Center for Environmental and Estuarine Studies
The University of Rhode Island—International Center for Marine Resource Development
The University of Washington—Center for Quantitative Sciences
The University of Costa Rica—Centro de Investigación en Ciencias del Mar y Limnología
The University of the Philippines—Marine Science Institute (Diliman)—College of Fisheries (Visayas)

In collaboration with The University of Delaware; The University of Maryland—College of Business and Management; The University of Miami; and The International Center for Living Aquatic Resources Management (ICLARM).

WORKING PAPER SERIES

Working Paper No. 41

"CORAL REEF FISHERIES AT CAPE BOLINAO, PHILLIPPINES: AN ASSESSMENT OF CATCH, EFFORT, AND YIELD

by
Alejandro R. Acosta and
Conrad W. Recksiek
University of Rhode Island

April, 1988

Fisheries Stock Assessment
Title XII
Collaborative Research Support Program

The Fisheries Stock Assessment CRSP (sponsored in part by USAID Grant No. DAN-4146-G-SS-5071-00) is intended to support collaborative research between the U.S. and developing countries' universities and research institutions on fisheries stock assessment and management strategies.

This Working Paper was produced by the University of Rhode Island research component in collaboration with the University of the Philippines and in association with the International Center for Living Aquatic Resources Managment. Additional copies are available from the CRSP Management Office and from:

International Center for Marine Resource Development
The University of Rhode Island
126 Woodward Hall
Kingston, Rhode Island 02881

ABSTRACT

Monthly catch per unit effort, total effort, and total catch were estimated in an 11 km intensively fished corraline shelf area near Cape Bolinao, Pangassinan, Philippines, June through October 1986, for three principal artisinal fisheries: fish trap, spear, and hook-and-line. Catch per unit effor estimates and annual catch per fishing ground estimates were, respectively: trap, 129 g/haul, 2.28 mton/km^2 year; spear, 1.33 kg/man hr, 4.13 mton/km^2 yr; hook-and-line, 590 gm/line hr, 1.15 mton/ km^2 yr. The estimated annual yield for the entire study area was 4.39 mton/km^2 yr. This figure was found comparable to other, similar exploited Indo-Pacific systems. It is probably conservative because other fishing methods were employed in the area, principally, gleaning and fish blasting. The latter is probably significant but it was proved impossible to estimate. A matrix presentation of catch per unit of effort and catch per defined area is proposed and discussed.

INTRODUCTION

Coastal coral reefs in the Philippine archipelago contribute significantly to fisheries production. From total Philippine capture fishery landings of 1.65 million mton/yr, (FAO, 1981) about 60% is derived from coastal waters (Gomez et al., 1981). At least 10 to 15% of the total is from coral reef areas (Carpenter, 1977).

Various workers have provided estimates of fisheries production from coral reefs. However, there is as yet no universally accepted system for classifying or cataloging reef ecosystems or their fisheries with respect to production.

Conflicting opinions have emerged concerning the productive potential of coral reef fisheries, mostly as a result of different perceptions of what constitutes a coral reef fishing ground and what species are to be included in the definition of exploited coral reef fishes and invertebrates. Stevenson and Marshall (1974) attempted a generalization of the fisheries potential of coral reefs and adjacent shallows, and suggested that "coralline shelves" with good cover of actively growing coral reef, seagrass beds, and algae usually produced around 4 to 5 $mton/km^2$ yr.

More recently, Alcala (1981), Alcala and Luchaves (1981), Marriot (1984), and Wass (1982) reported various estimates up to 36.9 $mton/km^2$ yr. Conflicting reports on yield from coral reefs have in part resulted from comparison of areas with greatly different mean depths and physiographic features (Alcala and Gomez, 1985; Munro and Williams, 1985). A habitat approach emphasizing species composition (or fish community structure) in different habitats has been taken by Smith and Tyler 1973; Marten, 1981; Marten and Polovina, 1982; Jones and Chase, 1975.

Reliable estimates of fishing effort are important in calculating yields since the latter are generally obtained by multiplying catch per unit effort (from sampling data) by the total effort in the fishery (Gulland, 1979; Marten and Polovina, 1982). Determining fishing effort in coral reef fisheries can be extremely difficult because of the large number of fishermen involved, the diversity of gear types, and the lack of centralized landing points.

Marshall (1980) suggested that in order to improve fish yield estimates, better and additional catch observations plus more experimental fishing, such as carried out by Koslow et al. (1986) in Jamaica, would be very useful. Various workers have perceived a need to clarify the gathering and reporting of catch data with respect to species composition, fishing effort, gear type and source times and habitats (Williams, 1977; Marshall, 1980; Miller, 1986).

A wide variety of fishing methods is employed to harvest coral reef areas. Perhaps most important worldwide are hook-and-line, fish traps (pots), and gillnets (Munro and Williams, 1985). Other methods in the Philippines include gleaning, spearing, seining, fish corrals (weirs), set gillnets and 'drive in' gillnets, explosives and poisons (both illegal), and pushnets (personal observation; see von Brandt, 1984 for survey of gear and methods). These methods among others, in the Philippines are used to harvest a variety of fishes and invertebrates for subsistence and the market. The harvest, in addition to human food products, includes ornamental fishes, materials for shellcrafts, bait and juvenile animals for aquaculture.

In this study we estimated annual catch, effort and yield from three coral reef fisheries, characterized by trap, spear, and hook-and-line fishing gears, from a 11 km^2 coral reef area at Cape Bolinao, Pangasinan, Philippines. We provide comparisons with other Indo-Pacific exploited reef systems.

MATERIALS AND METHODS

Description of study area

The study area was a barrier reef system in the vicinity of Cape Bolinao, Pangasinan, Philippines. Our sampling area proper was delimited by imaginary lines bearing west-northwest and northeast from the village of Binabalian, Santiago Island, to the approximate 60 ft (18 m) isobath (Figure 1). The lagoon varies in depth from approximately 3 to 15 ft (1 to 5 m).

The fore reef is dominated by *Millepora* and *Porites* species; *Acropora* and *Montipora* species are predominant along the reef crest toward the rear zone (MSI, 1986). Seagrass beds occur on the lagoon floor; dense stands occur over a major fraction of the study area (on the order of 50%). The seagrasses at Bolinao have been described by Fortes (1984); dominant genera are *Enhalus*, *Thalassia*, and *Cymodocea*.

In addition to seagrass beds of varying densities, the lagoon floor in the study area includes open areas covered with variously sized coral rubble fragments, stands of *Sargassum*, and isolated patches of living coral.

Description of the fisheries sampled in the study area

There are two fishing grounds for the trap fishery: a) in the southwest part of the study area, west of Silaki Island and, b) along the reef crest and into the rear zone (Figure 1). The bulk of fishing is done from bamboo rafts (balsas), each carrying 20 to 40 traps for an overnight soak. Small bamboo strip traps (nasas or bubos), fitted with 'horse neck' funnels, are fished unbaited and unbuoyed after being weighted to the bottom with coral rubble fragments (Figure 2). Traps are not placed where seagrasses are particularly dense or in areas where living corals are predominant. Trap fishermen fishing the study area live in Silaki Island and the village of Binabalian.

Hook-and-line fishing is carried out at night from single man, unmotorized outrigger canoes (bancas) propelled by paddles. Fishing grounds are seaward of the reef crest to around the 60 ft (18 m) isobath; the grounds are within a nautical mile of the reef crest (Figure 1). Most hook-and-line fisning takes place due north of Silaki Island. Hook-and-line fishermen live in Binabalian (Figure 1).

The spear fishery in the study area is directed primarily at Siganids within the lagoon proper. Principal fishing grounds are southeast and northeast of Silaki Island and north-northeast of Binabalian (Figure 1). Fishing is carried out at night under artificial light. Each spear fisherman, equipped with a sling spear and goggles, hunts the seagrass beds for fish illuminated by the light. The fisherman tows a small raft equipped with a catch basket and pressurized gasoline mantle lantern with reflector. All fishermen in the study area appeared to use the same kind of gear. Fishermen reach the fishing grounds via a motorized outrigger canoe (banca). Each vessel usually carries five fishermen (the owner of the banca fishes a light-raft as well). Most spear fishermen fishing the study area live in Binabalian.

Sampling Procedures

Catches in the trap, hook-and-line, and spear fisheries were periodically sampled through outright purchase of an entire day's catch. This transaction took place either on the fishing grounds or nearby while fishermen were returning home, i.e., before any sales or catch sorting took place.

We took numerous trips to the trap fishing grounds and spear fishing grounds to become acquainted with the fisheries and to be reasonably certain that the obtained catches were representative samples of production for particular units of fishing effort. Although we did not accompany hook-and-line fishermen to their grounds beyond the reef crest, we frequently intercepted them on their return from open water. Units of effort in this study for the trap, hook-and-line, and spear fisheries were, respectively, trap haul (overnight soak), line hour (spent fishing, i.e., effective fishing time), and man hour (hours each man spent in the water).

We repeated the catch purchases and effort recordings as many times as possible for the three fisheries. We varied the individuals interviewed as much as possible. During the course of a month, in the trap fishery we would buy from one to as many as ten different individuals; in the hook-and-line fishery from one to as many as four different individuals; in the spear fishery from one to as many as five individuals. In the spear fishery, we usually interviewed and purchased fish from one fisherman in a banca's crew.

Estimates of the total fishing effort in the study area over time were obtained through a combination of relying on log book records, conducting interviews in the field, and frequent on-site verification visits to the grounds.

A trusted individual fisherman in each of the three fisheries maintained log books for us wherein they recorded, on a daily basis, 1) the times they fished and 2) the times and numbers of other fishing units sharing the grounds. We used the records of total units fishing in these log books as our estimates of monthly total effort.

In the trap, hook-and-line, and spear fisheries, respectively, the fisherman's report of fishing units included: total balsas fishing each day and total traps per balsa; number of fishermen on the grounds each day; number of bancas operating each day (banca crews were known to us -- usually four or five men). In addition, supplementary catch information was provided to us in the log books. The fishermen maintaining logs recorded total catch through informally questioning each fisherman some time after returning from the grounds. These catch figures were based upon each fisherman's report of his landings and were used by us only to validate our own estimates based upon catch purchases.

Monthly estimates of catch per unit of effort (CPUE) were derived from our purchase and subsequent debriefing of individual fishermen. Monthly estimates of total catch in the study area were obtained by multiplying total effort by our monthly estimates of catch per unit of effort.

Mean and variance for monthly catch in the study area were computed for seven months. Total catch for the area was extrapolated to a year's period by multiplying mean monthly catch by twelve. Annual yield per unit area for each fishery was obtained by dividing the estimate of yearly catch in each fishery by the surface area of the fishing ground.

Surface areas for the fishing grounds were taken from Philippine Coast and Geodetic Survey chart 4238 (Bolinao Harbor, 1:20,000). Areas were determined by counting 0.1 in squares in a rectangular coordinate paper overlay. The total study area for the three fisheries is 10.96 km^2. The total fishing ground area of the trap fishery was delimited by the arbitrary study area borders (Figure 1) and the reef crest: 6.75 km^2. The spear fishery area is coincident with this. The hook-and-line fishing area was delimited by the arbitrary study area borders, the reef crest, and the 60 ft (18 m) isobath: 4.21 km^2 (Figure 1).

Before initiating the formal data gathering phase of this study, we noted that trap fishermen fished either on or near the reef crest or well within the lagoon proper. We differentiated between catch samples taken in each of these but we did not attempt to delimit areas (See RESULTS section).

Catch samples were transported ashore and enumerated fresh in the laboratory; collections were chilled with ice until ready to process. Each fish was weighed to the nearest gram and measured for total length to the nearest millimeter. Identifications were to species if possible based primarily upon Masuda et al. (1975), Schroeder (1980), and Rau and Rau (1980).

Four labrid species are not identified conclusively as of this writing, but we report here only numbers of presumed species within each family (as in Table 1).

RESULTS

From the trap, spear, and hook-and-line fisheries in the 10.96 km² study area, 152 fish species of 30 families were encountered in 80 catch samples June-December 1986. Families representing in excess of 1% by weight in each fishery are presented in Table 1. Trap catches were dominated by Siganids and Labrids, the spear fishing catch by Siganids, the hook-and-line catch by Lethrinids (Table 1).

From the trap fishery, 37 samples, representing 1,002 trap hauls, were enumerated (Table 2). From these hauls, 4,274 fish of 127 species (Table 1) weighing 127.8 kg were taken. The estimated mean catch per unit of effort (CPUE) averaged over 7 months was 129.4 (110.7 to 148.2; 95% CI) g/trap haul. Trap fishing was conducted either on the reef crest or behind it in the lagoon proper. We classified sample catches accordingly as 'reef crest' (19 samples) or 'lagoon' (18 samples). These yielded, respectively, 2,228 fish of 90 species weighing 73.9 kg, and, 2,046 fish of 101 species weighing 53.9 kg (Table 3). The estimated mean monthly trap catch in the 6.75 km² study area (Figure 1) was 1,285 (1004 to 1567; 95% CI) kg (Table 2). The yield estimate for the trap fishery in the 6.75 km² area extrapolated to an entire year is 2.28 (1.78 to 2.79; 95% CI); mton/km² yr; for the entire 10.96 km² area, 1.41 (1.10 to 1.72; 95% CI) mton/km² yr.

From the spear fishery 23 samples representing 70 man hr were enumerated (Table 4). From these collections, 2,135 fish of 40 species (Table 1) weighing 94.2 kg were taken. The estimated mean CPUE averaged over 7 months was 1.33 (0.98 to 1.68; 95% CI) kg/man hr. The estimated mean monthly spear fishing catch in the 6.75 km^2 study area (Figure 1) was 2,322 (1,325 to 3,319; 95% CI) kg (Table 4). The yield estimated for the spear fishery in the 6.75 km^2 area extrapolated to an entire year is 4.13 (2.44 to 5.82; 95% CI) mton/km^2 yr; for the entire 10.96 km^2 area, 2.54 (1.50 to 3.58; 95% (CI) mton/km^2 yr.

From the hock-and-line fishery 20 samples representing 80.5 line hr were enumerated (Table 5). From these collections, 176 fish of 15 species weighing 49.2 kg were noted. The estimated mean CPUE averaged over 7 months was 590 (392 to 788; 95% CI) gm/line hr. The estimated mean monthly hook-and-line catch in the 4.21 km^2 study area (Figure 1) was 402 (215 to 590; 95% CI) kg (Table 5). The yield estimate for the hook-and-line fishery in the 4.21 km^2 area extrapolated to an entire year is 1.15 (0.61 to 1.86; 95% CI) mton/km^2 yr; for the entire 10.96 km^2 area, 0.44 (0.24 to 0.65; 95% CI) mton/km^2 yr.

When mean monthly catch of all three fisheries is added together extrapolated to a full year (x 12 mo) over the 10.96 km^2 study area, the total yield estimate is 4.39 (3.10 to 5.68; 95% CI) mton/km^2 yr.

DISCUSSION

We have compared our estimate of annual yield for our entire 11 km^2 study area, 4.39 mton/km^2 yr with estimates from other investigations of coralline area production in the Indo-Pacific. These are summarized in Table 6. Our estimate is not substantively different from those for other intensively fished systems such as the Selinog Island reef, with 5.9 mton/km^2 yr, and the Hulao-hulao reef, with 5.0 mton/km^2 yr (Alcala and Luchaves, 1981; Alcala and Gomez, 1985).

Our estimate is also in the neighborhood of that suggested by Stevenson and Marshall (1974), 5 mton/km^2 yr, but it is well below estimates from intensively fished reefs at American Samoa, with 26.6 mton/km^2 yr (Wass, 1982), or Sumilon Island, with over 14 mton/km^2 yr (Alcala, 1981; Alcala and Gomez, 1985; Table 6).

The accuracy of our yield estimate is probably biased most by inaccuracies in estimating effort in the study area and by not having sampled throughout an entire year. We believe that our estimates of CPUE are relatively accurate since we were certain of the origin of all the sampled catches and since we could easily assess effort that the fisherman must have expended to get it. Because we were so often on the fishing grounds, we are confident that our log-book based estimates are reasonable. Since inclement weather was a powerful deterent to fishing and since we were prevented from venturing onto the lagoon during such conditions, estimates of total fishing days each month are probably fairly accurate. As to our seven-month study being representative of an entire year, we base this upon extensive conversations with certain fishermen. Since we operated through the southwest monsoon and two typhoon 'near misses,' our implied estimates of total, and therefor total yield, are probably conservative.

Although we concentrated upon the three fishing practices that appeared to account for most of the finfish production in the 11 km^2 study area, other methods were used. There were several fish corrals (weirs) in the study area; they did not appear to be producing much and were in apparent poor repair. Gillnetters and seine fishermen were seen ocassionally but did not appear successful or productive; drive-in gillnetters were active on the lagoon but outside the study area proper. The most productive 'other' methods appeared to be gleaning and fish blasting. We observed gleaners at work most prominantly during low spring tides. Sea urchin tests littered the beach at Silaki Island (Figure 1). It is likely that the gleaned catch is significant. Wass (1982) estimated a 25% contribution to the total yield at American Samoa. We did not attempt to assess gleaned catch. We made several attempts to estimate catches from fish blasting through intermediaries but we were completely unsuccessful. Blast fishing is outlawed but it was widely practiced throughout the lagoon during the time we operated. Fish blasters usually worked from motorized bancas. In our sojourns to the lagoon, we would often hear or see explosions, sometimes as many as 10 per hour in the study area. Therefore, our yield estimate, 4.39 mton/km^2 yr, is probably conservative.

We measured CPUE in the trap fishery as weight per haul. Other studies have used weight per time. In order to facilitate comparisons with the literature, we propose a conversion factor: if one assumes that eight hours are expended on the water by a fisherman hauling and setting his pots each day and that 27 pots are deployed from the typical balsa (1002 trap hauls/37 samples; Table 2), we have 27/8 haul/man hr. For our average CPUE estimate, 0.13 kg/haul (Table 2, column 7), we have, 0.13 kg/haul x 27/8 haul/man hr = 0.44 kg/man hr.

This figure is slightly above upper values for reefs as Apo Island (Alcala and Luchavez, 1981) and Hulao-hulao (Luchavez et al., 1984) and near half that for the Sumilon Island reef (Alcala and Gomez, 1985; Table 6).

Our spear fishing CPUE estimates are within estimates from other studies, particularly those of Wass (1982) for American Samoa (Table 6). Night spear fishing CPUE in the 'lightly fished' Tigak Islands (Wright and Richards, 1985) is almost double our maximum.

The hook-and-line CPUE estimate at a mean of 0.59 kg/line hr is generally lower than those reported from other studies, with the exception of Alcala and Luchavez's (1981) figures below 0.2 kg/man hr from Apo Island (Table 6). Since the catches we recorded were comprised mostly of Lethrinids and Lutjanids (Table 1), the CPUE may probably be accorded to 'local' reef dwellers, as opposed to, for instance, Scombrids. Other studies are not clear on whether or not the time component is 'effective fishing time' or 'total fishing time.' We believe that catch per line hour is a reasonable unit of CPUE in this fishery since it facilitates comparison of areas. In our study area, it was a long paddle to the fishing grounds so this unit seemed appropriate.

The major contributor to yield was the spear fishery, where the catch was dominated by herbivorous siganids (Table 1). This fishery is conducted in the extensive sea grass bed areas. The fact that much of the shallow lagoon floor in the study area is dominated by these plants leads one to assume that herbivore production must be intense. (Unfortunately, we do not have quantitative data on distribution and density of aquatic plants in the study area, so our inferences remain necessarily speculative.)

One problem in comparing our results with those of other studies (as in Table 6) is the lack of a standard set of criteria. We propose using a matrix that summarizes mean (or median) CPUE, annual yields over fishing grounds, and annual yields over entire reef study areas. CPUE could be expressed as weight per effective fishing time (time spent fishing). This would, for example, overcome some difficulties due to differently sized traps and due to different transit times to the grounds. Annual yield of the fishing ground would depend on the latter's known size. In our case this yield estimate is very conservative because we were unable to map the grounds, i.e., our fishery areas are too large but we are certain that they contain the actual fishing grounds. An example from the results of this study follows:

TRAP	SPEAR	HOOK/LINE	TOTAL	UNITS
0.44	1.33	0.5	-	Mean CPUE kg/man hr
6.75	6.75	4.21	10.96	Area grounds km^2
2.29	4.13	1.15	-	Yield grounds mton/km^2 yr
1.41	2.54	0.44	4.39	Yield study area mton/km^2 yr

Using the elements of this matrix, mean CPUE values in the trap and hook-and-line fisheries are together most reminiscent of the Apo Island reef (Table 6). Mean CPUE in the spear fishery for high priced Siganids is, by contrast, comparable to that from other areas (Table 6). Yield comparisons are tenuous but the fishing ground based estimates of the spear fishery is indicative of substantial production. Had we the resources to map in detail the seagrass beds and the spear fishing grounds (which nearly coincide), the figure probably would have been considerably higher.

ACKNOWLEDGMENTS

Many individuals contributed to the successful conduct of this study. We thank Dr. Edgargo Gomez for making laboratory facilities available at the University of the Philippines' Marine Science Center laboratory at Bolinao. This work could not have been carried out without the sponsorship and support of Drs. Liana McManus-Talaue, John McManus, and Saul Saila. We thank Drs. Richard Appeldoorn and Saul Saila for their comments on the draft. Elizabeth Watkins prepared the illustrations; Margaret Mann typed the manuscript. We are indebted to Mr. Ralph Turingan who assisted us with the field work, translated for us, and helped with the fish identifications.

This project was partially supported by the University of Rhode Island's Graduate School of Oceanography, The Department of Fisheries, Animal and Veterinary Science, and the International Center for Marine Resource Development. The United States Agency for International Development funded this work under Grant No. DAN-4146-G-SS-5071-00, the Fisheries Stock Assessment Collaborative Research Support Program (CRSP). This article is a CRSP Working Paper and is contribution ____ of the Rhode Island Experiment Station.

Portions of the work described here contributed to fulfilling partial requirements for the degree of Master of Science in Fisheries and Aquaculture, Department of Fisheries, Animal and Veterinary Sciences, University of Rhode Island for the senior author.

REFERENCES

Alcala, A. C. 1981. Fish yield of coral reefs of Sumilon Island, Central Philippines. Nat Res. Counc. Philipp. Res. Bull. 36: 1-7.

Alcala, A. C. and E. D. Gomez. 1985. Fish yields of coral reefs in Central Philippines. Proc. Fifth Int. Congress. 5: 521-524.

Alcala, A. C. and T. Luchavez. 1981. Fish yield of the coral reef surrounding Apo Island, Negros Occidental Central Visayas, Philippines. Proc. Fourth Int. Coral Reef Symp. 1: 69-73.

Carpenter, K. E. 1977. Philippine coral reef fisheries resources. Philipp. J. Fish. 17: 95-125.

Dalzell, P. and A. Wright. 1986. An assessment of the exploitation of coral reef fishery resources in Papua New Guinea. in: Maclean, J. L., L. B. Dizon, and L. V. Hosillos (eds.) First Asian Fish. Forum (Proc.). Asian Fish. Soc., Manila. pp. 477-482.

FAO 1981. Yearbook of fishery statistics. Food and Agriculture Organization of the United Nations. Vol 52. 357 pp.

Fortes, M. D. 1984. Ecological assessment and cultivation of seagrasses at Bolinao Bay for biomass production. NRCP Research Bull., Vol. 39, #1.

Gomez, E. D., A. C. Alcala, and A. C. San Diego. 1981. Status of Philippine coral reefs. Proc. Fourth Int. Coral Reef Symp. 1: 275-282.

Gulland, J. A. 1979. Report of the FAO/IOP workshop on the fishery resources of the western Indian Ocean south of the Equator. Maje, Seychelles, October-November 1978. DFDEV70/45.

Jones, R. S. and J. A. Chase. 1975. Community structure and distribution of fishes in an enclosed High Island lagoon in Guam. Micronesia 11(1): 127-148.

Koslow, J. A., F. Hanley, and R. Wicklund. 1986. The impact of fishing on the reef fish of Pedro Bank and Port Royal, Jamaica: a comparison of trap surveys, 1969-73 and 1986. In press: Proc. Gulf Caribb. Fish. Inst. 38 (1986).

Luchavez, T., J. Luchavez, and A. C. Alcala. 1984. Fish and invertebrate yields of the coral reefs of Selinog Island in the Mindanao Sea and Hulao-hulao in Panay Gulf, Philippines. Siliman Journal, Contrib. Mar. Laboratory, Siliman Univ. 31(1): 53-71.

Marriot, S. P. 1984. A summary report on the South Tarawa artisanal fishery. Mimeo Rept.; Fisheries Division; Kiribati: 1-21.

Marshall, N. 1980. Fisheries yields of coral reefs and adjacent shallow water environments. in Saila, S. B. and P. M. Roedel (eds.) Stock assessment for tropical small-scale fisheries. Proc. Int. Workshop, International Center for Marine Resource Development, Univ. of Rhode Island, September 1979: pp 103-109.

Marten, G. G. 1981. Ecological data requirements for managing Hawaii's coastal zone fishery. Coastal Zone Fishery Management Program, Division of Fish and Game, Honolulu, Hawaii.

Marten, G. G. and J. J. Polovina. 1982. A comparative study of fish yields from various tropical ecosystems. in: D. Pauly and G. Murphy (eds.). Theory and management of tropical fisheries. ICLARM Conference Proc. 9, pp 255-289.

Masuda, H., C. Araga, and T. Yoshimo. 1975. Coastal fishes of southern Japan. Tokyo; Tokai University Press. 379 pp.

Miller, R. J. 1986. Traps as a survey tool for animal density. In press: Proc. Gulf Caribb. Fish Inst. 38 (1986).

MSI. 1986. Trophic dynamics and fisheries yields in a coral reef. Coral Reef Research Team, Marine Science Institute, Univ. Philippines, Annual Report.

Munro, J. L. and D. McB. Williams. 1985. Assessment and management of coral reef fisheries: biological, environmental and socio-economic aspects. Proc. Fifth Int. Coral Reef Congress 5.

Rau, N. and A. Rau. 1980. Commercial fishes of the Philippines. German Agency for Technical Cooperation (GTZ), Escherborn, Germany, 623 pp.

Smith, C. L. and J. C. Tyler. 1973. Direct observations of resource sharing in coral reef fish. Helgolander Wiss. Meeresunters. 24: 264-275.

Stevenson, D. K. and N. Marshall. 1974. Generalization on the fisheries potential of coral reef and adjacent shallow water environments. Proc. Second Inter. Coral

Reef Symp. 1: 147-156.

von Brandt, A. 1984. Fish catching methods of the world. Fishing News Books Ltd. 418 pp.

Wass, R. C. 1982. The shoreline fishery of American Samao - past and present. in: Munro, J. L. (ed.) Ecological aspects of coastal zone management. Proc. Seminar on Marine and Coastal Processes in the Pacific. Motupore Island Res. Centre, July 1980. UNESCO-ROSTSEA; Jakarta; 51-83.

Williams, T. 1977. The raw material of population dynamics in: Fish population dynamics. Gulland, J. A. (ed.) John Wiley & Sons, Ltd.

Wright, A. and A. H. Richards. 1985. A multispecies fishery associated with coral reefs in Tigak Islands Papua New Guinea. Asian Marine Biology. 2 pp. 69-84.

Table 1. Disposition of fish catch by family (>1% by weight) in trap, spear, and hook-and-line barrier reef fisheries, June through December 1986, Cape Bolinao, Pangasinan, Philippines.

Family	Trap			Spear			Hook-and-line		
	Number of species	Percent weight	Percent number	Number of species	Percent weight	Percent number	Number of species	Percent weight	Percent number
Scorpaenidae	2	1.4	1.2						
Serranidae	8	10.0	7.2	5	2.0	1.1			
Priacanthidae							1	1.7	0.5
Apogonidae	5	2.1	3.3						
Lutjanidae							5	23.2	24.3
Lethrinidae	8	3.0	4.2	5	1.8	1.6	5	65.8	69.1
Mullidae	6	2.1	1.9	5	2.9	2.1			
Balistidae	10	2.1	3.2						
Pomacentridae	15	8.2	9.6						
Labridae	19	23.0	19.5	6	2.8	1.0			
Scaridae	13	13.8	10.4	3	2.6	1.5			
Gobiidae				3	1.2	2.0			
Sigañidae	7	31.5	36.1	3	83.7	88.7			
Others	34	2.8	3.4	10	3.0	2.0	3	9.3	6.1
Total	127	100	100	40	100	100	15	100	100

Table 2. Summary of monthly trap fishing catch and effort sampling and total monthly catch from a 6.75 km area of barrier reef lagoon, Cape Bolinao, Pangasinan, Philippines, June through December 1986.

Month	Number of samples[1]	Number of trap hauls	Number of species	Number of fish	Number of fish/haul	Weight fish (kg)	Weight fish/haul (gm) CPUE	Estimated total fishing days	Estimated total trap hauls E[2]	Estimated total catch (kg) C[3]
June	6	136	59	542	4.0	19.8	145	30	12,000	1,740
July	7	188	69	985	5.2	24.6	130	26	10,400	1,352
August	10	274	69	1320	4.8	37.9	138	22	8,800	1,214
September	3	64	36	226	3.5	7.7	120	25	10,000	1,200
October	5	200	55	546	2.7	17.7	88	23	9,200	810
November	3	83	48	365	4.3	12.0	144	26	10,400	1,498
December	3	57	41	290	5.0	8.1	141	21	8,400	1,184
Totals	37	1002	127*	4274		127.8		173	69,200	8,998

Mean monthly catch 1,285 kg [95% CI: 1017 kg, 1554 kg]
Annual yield of fishing ground [4]: 2,285 kg/km² yr [95% CI: 1,808 kg/km² yr, 2,762 kg/km² yr]
Annual yield of study area [5]: 1,407 kg/km² yr [95% CI: 1,114 kg/km² yr, 1,701 kg/km² yr]

* Total species in 37 samples.
[1] Outright purchase from one fisherman for one day's fishing from several traps soaked.
[2] [Total fishing days] x [traps per balsa (20)] x [Balsas operating (20)]
[3] CPUE x E
[4] [Mean monthly catch (kg)] [12 mo/yr] [1/6.75 km²]
[5] [Mean monthly catch (kg)] [12 mo/yr] [1/10.96 km²]

Table 3. Disposition of trap catch samples according to fishing grounds, 1) on or adjacent to the barrier reef crest and 2) away from the reef crest in the lagoon proper, June through December 1986, Cape Bolinao, Pangasinan, Philippines

Area	Number of samples	Number of species	Number of fish	Percent total number	Weight fish (kg)	Percent weight fish
Reef crest	19	90	2228	52.1	73.9	57.8
Lagoon	18	101	2046	47.8	53.9	42.1
Total	37	127 *	4274	99.9	127.8	99.9

*Total species in 37 samples.

Table 4. Summary of monthly spear fishing catch and effort sampling and total monthly catch from a 7.02 km^2 areas of barrier reef lagoon, Cape Bolinao, Pangasinan, Philippines, June through December 1986.

Month	Number of samples[1]	Man hours[2]	Number of species	Number of fish	Number of fish/man hr	Weight of fish (kg)	Weight of fish/man hour (kg) CPUE	Estimated total fishing days	Estimated total man hours E[3]	Estimated total catch (kg) C[4]
June	3	9.5	12	373	39.2	19.0	2.00	30	2,276	4,552
July	5	16	5	320	20.0	16.7	1.04	23	1,745	1,815
August	4	9	5	152	16.8	8.0	0.90	22	1,669	1,502
September	2	5	5	144	28.8	6.8	1.35	23	1,745	2,355
October	3	9	16	412	45.7	15.0	1.66	17	1,290	2,141
November	3	12	9	390	32.5	14.6	1.23	23	1,745	2,146
December	3	12	18	344	28.6	13.9	1.15	20	1,517	1,744
Total	23	70	40*	2,135		94.2		158		16,255

* Total species in 23 samples.
Mean monthly catch: 2,322 kg [95% CI: 1,374 kg, 3,271 kg]
Annual yield fishing ground [5]: 4,129 kg/km^2yr [95% CI: 2,442 kg/km^2 yr, 5,816 kg/km^2 yr]
Annual yield of study area [6]: 2,543 kg/km^2 yr [95% CI: 1,504 kg/km^2 yr, 3,582 kg/km^2 yr]

[1] Outright purchase from one fisherman for one day's fishing.
[2] Effective fishing time.
[3] [Total fishing days] x [Men per banca (5.02)] x [Bancas operating (5.14)] x [Average effective fishing time (2.94 hr)
[4] CPUE x E
[5] Mean monthly catch (kg)] [12 mo/yr] [1/6.75 km^2]
[6] Mean monthly catch (kg)] [12 mo/yr] [1/10.96 km^2]

Table 5. Summary of monthly hook-and-line fishing catch and effort sampling and total monthly catch from a 4.21 km² area adjacent to a barrier reef lagoon, Cape Bolinao, Pangasinan, Philippines, June through December 1986.

Month	Number of samples[1]	Line hours[2]	Mean fishing time; line hours[2] per man	Number of species	Number of fish	Number of fish per line hour	Weight of fish (kg)	Weight fish per line hour (gm) CPUE	Fishermen operating each month	Estimated total fishing days	Estimated total line hours E[3]	Estimated total catch (kg) C
June	4	20.5	5.1	7	46	2.2	12.0	585	9	16	734	430
July	2	10	5	6	29	2.9	6.82	682	11	15	825	563
August	1	5	5	6	11	2.2	2.34	468	8	14	560	262
September	3	13	4.3	8	28	2.1	8.97	690	12	18	929	6[illegible]
October	3	12	4	6	35	2.9	11.22	935	8	19	608	568
November	3	12	4	3	16	1.3	5.26	438	10	14	560	245
December	4	8	2	4	11	1.3	2.59	324	10	16	320	104
Total	20	80.5		15*	176		49.2			112		2813

*Total species 20 samples.
Mean monthly catch 402 kg [95% CI: 215 kg, 590 kg]
Annual yield of fishing ground [4]: 1,147 kg/km² yr [95% CI: 613 kg/km² yr, 1,861 kg/km² yr]
Annual yield of study area [5]: 441 kg/km² yr [95% CI: 235 kg/km² yr, 646 kg/km² yr]

[1] Outright purchase from one fisherman for one day's fishing.
[2] Effective fishing time.
[3] [Mean fishing time (line hr)] [Total fishing days] [Fishermen operating]
[4] [Mean monthly catch (kg)] [12 mo/yr] [1/4.21 km²]
[5] [Mean monthly catch (kg)] [12 mo/yr] [1/10.96 km²]

Table 6. Selected estimates of yield and effort for various Indo-Pacific coralline shelf are[illegible] M, mean; R, range; CI, 95% confidence interval; FRF, fringing reef; BRF, barrier reef; INTSF "intensively" fished; MDF, "moderately" fished; LTLF, "lightly" fished; HL, hook-and-line; GN, gillnet; T, trap; SN, seine netting; SP, spear; MO, muro-ami; GL, gleaning

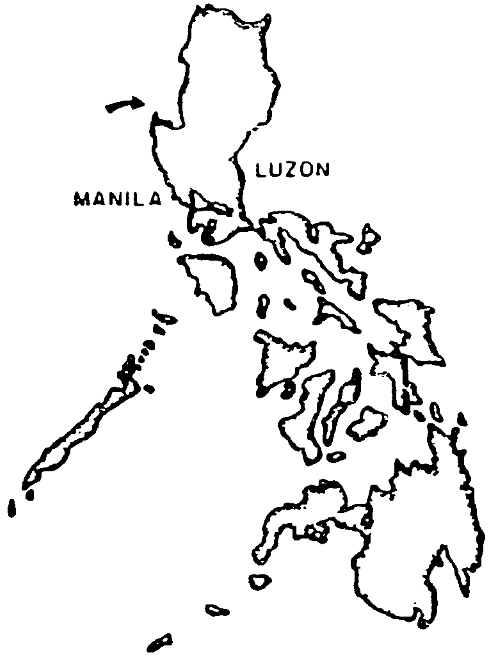
Location	Annual yield mton/km² yr		Fishing gear	Catch per unit of effort (CPUE)	Sources	Notes
Apo Island Mindanao Sea	11.4(M)	8-14(R)	HL GN, T	0.13-0.17 kg/man hr 0.03-0.13 kg/man hr	1,2	156 ha FRF; MDF; 1980, 1981 data; GN and T CPUE lowest during NE monsoon
Selinog Island Mindanao Sea	5.9		T GN HL SP MO	0.11-0.23 kg/man hr 4.77-8.70 kg/man hr 1.18-2.91 kg/man hr 1.16-2.55 kg/man hr 151 kg/man hr	2,3	126 ha FRF; ITNSF; 1982-1983, 1984 data; CPUE data from 1982; non-reef species included
Hulao-hulao Panuy Gulf	5.0		GN MO HL SP	2.81 kg/man hr 1.42 kg/man hr 1.25 kg/man hr 0.39 kg/man hr	2,3	50 ha BRF (area); ITNSF; 1982-1983 data; no fishing during NE monsoon; non-reef species included
Sumilon Island Bohol Strait	36.9		GN,T HL	0.7 kg/man hr 0.6 kg/man hr	2A	50 ha FRF; INTSF; 1983-1984 data
Sumilon Island Bohol Strait		14-23.7(R)	-	-	2,4	50 ha FRF; INTSF; 1977-1980 data
Papua New Guinea coralline areas'	0.23				5	4x10 ha 'coralline areas'; LTLF; 1984 data
Tigak Islands Bismark Archipelago	0.42		HL SP(day) SP(night) SN	1.2 kg/line hr 1.2 kg/man hr 3.6 kg/man hr 3.9 kg/man hr	6	2x10 ha 'coralline areas'; LTLF; 1980-1981 data
Tutuila Island American Samoa	26.6		HL SP(day) SP(night) SN GL	0.54-0.87 kg/man hr 1.30 kg/man hr 1.49 kg/man hr 2.14 kg/man hr 1.05 kg/man hr	7	356 ha 'local reefs' to 8 m isobath; INTSF; 1977-1980 data
Cape Bolinao, Philippines	4.39	3.10-5.68 (CI)	HL T SP(night)	0.32-0.94 kg/line hr (R) 0.59 kg/line hr (M) 0.09-0.15 kg/haul (R) 0.44 kg/man hr (M)* 0.13 kg/haul (M) 0.90-2.00 kg/man hr (R) 1.33 kg/man hr (M)	8	1090 ha BRF to 18 m isobath 1986 data

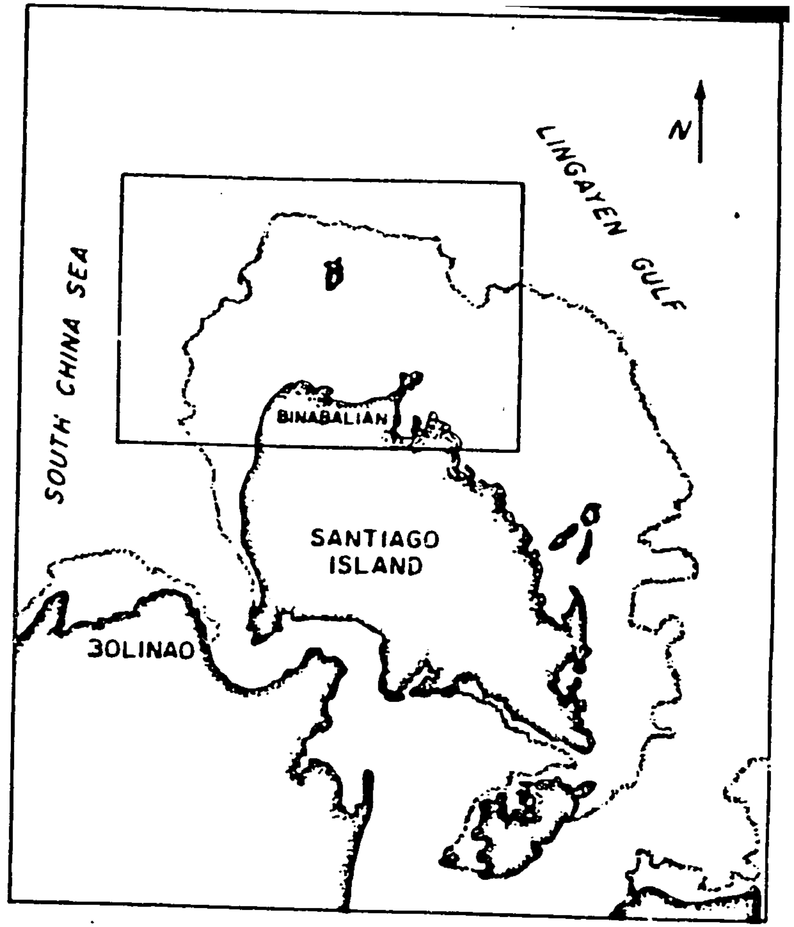
1. Alcala and Luchavez (1981)
2. Alcala and Gomez (1985)
2A. Alcala and Gomez (1985) citing Alcala, unpublished manuscript.
3. Luchavez et al. (1984)
4. Alcala (1981)
5. Dalzel and Wright (1986)
6. Wright and Richards (1985)
7. Wass (1982)
8. This study
* Converted from kg/haul; see text.

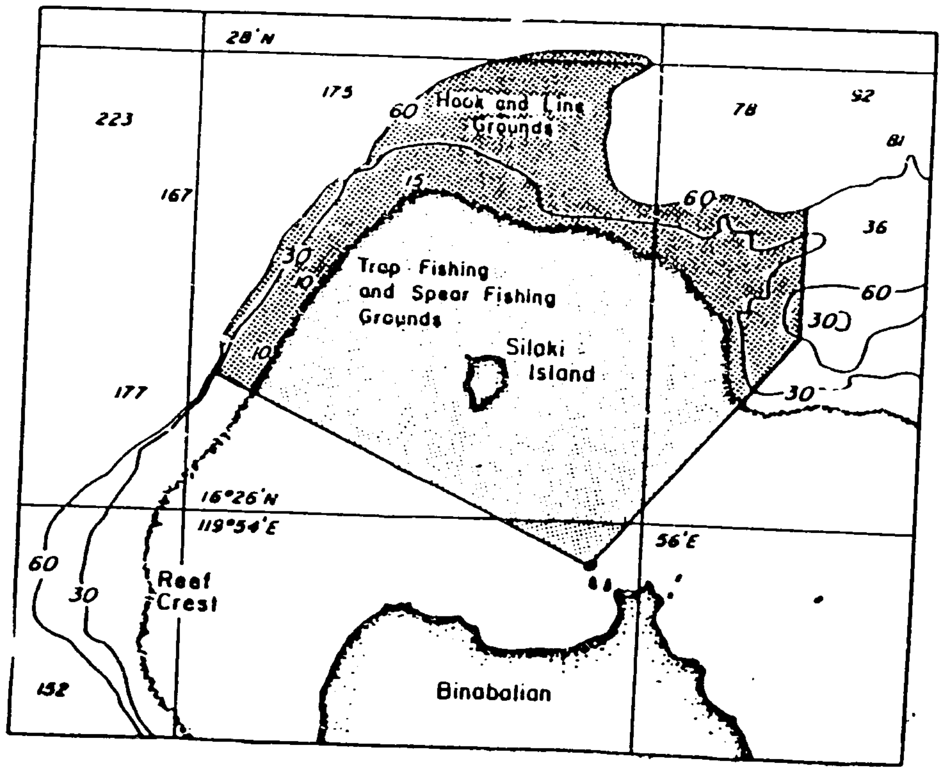
FIGURE CAPTIONS

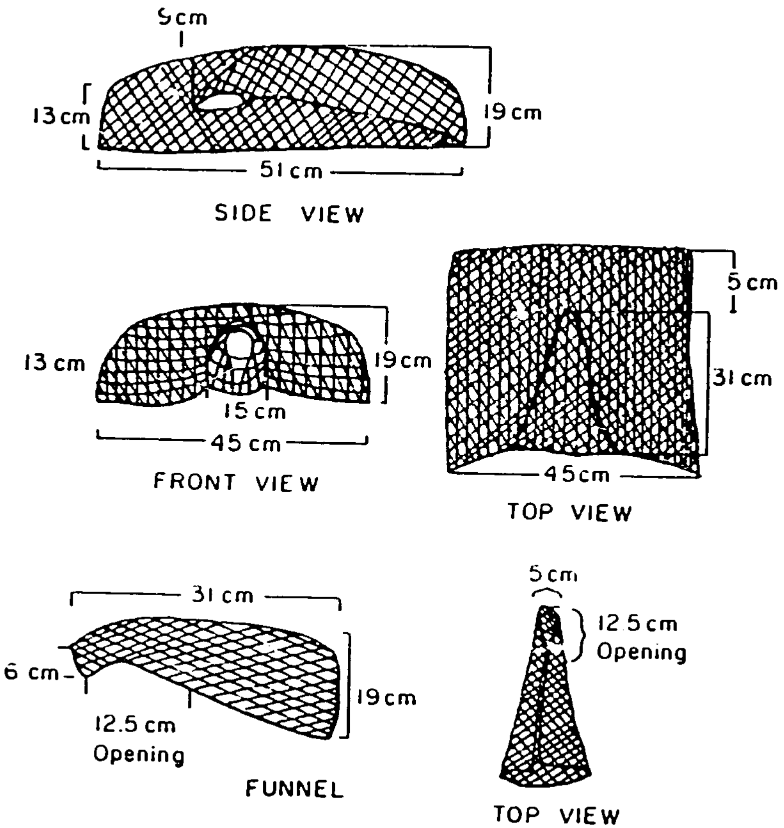
Figure 1. Sampling area for three coral reef fisheries, Cape Bolinao, Pangasinan, Philippines. Map based upon Philippine Coast and Geoditic Survey Chart 4238 (Bolinao Harbor, 1:20,000); soundings in feet. Trap and spear fishing grounds shown as stippled area; hook-and-line fishing ground shown as heavier stipple.

Figure 2. Bamboo strip fish trap used in the Santiago Island Lagoon, Cape Bolinao, Pangasinan, Philippines.


MANILA
LUZON


N
LINGAYEN GULF
SOUTH CHINA SEA
BINABALIAN
SANTIAGO ISLAND
BOLINAO


28'N
223
175
78
92
81
167
177
152
36
Hook and Line Grounds
Trap Fishing and Spear Fishing Grounds
Siloki Island
16°26'N
119°54'E
56'E
Reef Crest
Binabalian


9 cm
13 cm
19 cm
51 cm
SIDE VIEW
13 cm
19 cm
15 cm
45 cm
FRONT VIEW
5 cm
31 cm
45 cm
TOP VIEW
31 cm
6 cm
12.5 cm
Opening
19 cm
FUNNEL
5 cm
12.5 cm
Opening
TOP VIEW