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# Reef Fish Yield and Reef Condition for San Salvador Island, Luzon, Philippines

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## Abstract

The annual reef fish yield has been estimated for San Salvador Island, Philippines, for 2 consecutive years. From April 1988 to March 1989, reef fish yields were approximately 7.0 t·km<sup>-2</sup>·year<sup>-1</sup>. Reef fish yield increased 100.0% to 14.0 t·km<sup>-2</sup>·year<sup>-1</sup> for the following year, primarily as a result of increased catches of juvenile fusiliers (Caesionidae). Catch per unit effort, however, did not significantly increase over the period of the study and has been estimated at 3.148 kg·work hour<sup>-1</sup> for the 2 years. This information forms a baseline for the future from which to analyze the impact of the establishment of a marine sanctuary and traditional fishing reserve on San Salvador Island. In order to assess the relative condition of San Salvador's fishery, these findings are compared to other coral reefs in the Philippines. San Salvador's reef has a low percent coral cover and low richness and density of fish, possibly as a result of the historic use of destructive fishing methods. However, findings indicate that a community-based resource management plan may have the potential to positively affect the island's fishery.

## Introduction

Estimates of potential total fish harvest from the world's coral reefs amount to 9,000,000 t·year<sup>1</sup>, or approximately 12% of the 1985 total world fish production (Munro and McWilliams 1985; IUCN and UNEP 1988). Yields from coral reefs range widely with estimates as low as 0.7 t·km<sup>-2</sup>·year<sup>-1</sup> for the Kapingamarangi atoll (Stevenson and Marshall 1974) to as high as 31.8 t·km<sup>-2</sup>·year<sup>-1</sup> for Apo Island, Philippines (White and Savina 1987; Alcala 1988). In order to determine the potential yields of coral reefs and the factors affecting these yields, further studies of coral reef yields must consider different levels of fishing pressure, reef type and reef condition.

Murdy and Ferraris (1980) reported that reefs supplied 9.8% in 1976 and 8.4% in 1977 of the total recorded Philippine fisheries production. The impact of sanctuaries on the fringing reefs of a few Philippine islands (e.g., Apo, Pamilacan and Sumilon Islands) have been intensively studied (Russ and Alcala

1989). Depending on the methods employed, estimates of yield vary; Alcala and Luchavez (1981) reported  $16.8 \text{ t}\cdot\text{km}^{-2}\cdot\text{year}^{-1}$  for Apo Island, while White and Savina (1987) estimated yield at  $31.8 \text{ t}\cdot\text{km}^{-2}\cdot\text{year}^{-1}$  for reef fish and invertebrate gleaning. These findings are substantially higher than the  $4\text{--}6 \text{ t}\cdot\text{km}^{-2}\cdot\text{year}^{-1}$  yield suggested by Munro (1984) for a reef under moderately heavy exploitation.

The fringing reef surrounding San Salvador Island, a small island off the west coast of Luzon, Philippines, has been seriously disturbed in the last few decades. Since World War II, blast fishing has been used to capture reef fish for food. Since approximately 1960, sodium cyanide has been used to collect valuable aquarium fish for export. Both of these fishing methods, although not thoroughly studied, are highly destructive for the coral and probably result in reduced fish yields over time.

Considering the difficult socioeconomic conditions in the Philippines and that destructive fishing methods are sometimes condoned by corrupt officials, fishing communities that rely on traditional, nondestructive fishing methods often tolerate the degradation of their fishing grounds by others. Recently, however, community-based resource management plans, implemented with the support of local government officials, have succeeded in reversing the trend of declining fish yields (Russ 1984; White 1988). These programs rely on resource assessment, environmental education and community organization to establish coral reef sanctuaries and traditional fishing reserves that encourage the sustainable harvest of increasing fish stocks.

In July 1989, the community of San Salvador established a 127-ha marine sanctuary off-limits to fishing. The remainder of the island's reef has been designated a traditional fishing reserve that permits only nondestructive fishing methods. The program that established the reserve and sanctuary and the general condition of San Salvador's coral reef has been documented (Christie et al. 1990; Ridao and Cura 1991).

The intent of this study is to report the condition of San Salvador's fishery and reef. The yield from one area of San Salvador's reef over a 2-year period (April 1988–March 1990) is reported. Although this study collected information both before and after the establishment of the sanctuary, it is premature to make conclusions as to the effects of the management plan on fish yields. Fish abundance, diversity and substrate cover are used as measures of reef condition. Findings are related to coral reefs with similar management plans, such as Apo and Pamilacan Island reefs, Philippines (Silliman University 1986; White 1989). Catch per unit effort (CPUE) for San Salvador Island is estimated for the 2 years of the study and is compared to the CPUE of a nearby island's reef. The fish yield baseline data reported here will assist in evaluating the effects of the sanctuary and reserve on San Salvador's fishery in the future.

## **Materials and Methods**

### ***Fish Yields***

Fish yield data was collected by one field worker and a number of community members between April 1988 and March 1990. The data collection sys-

tem was designed to involve the community in the monitoring of the reef's health. Although all four communities of fishers on San Salvador utilize the island's fringing reef, only one community, Libaba, could be regularly monitored for their fishing activities due to personnel shortages. San Salvador residents concentrate their fishing efforts on one area of the reef, a 3.4-km<sup>2</sup> area along the west and north sides of the island bordering either side of the sanctuary, since the remainder of the island's reef has low living coral cover and few fish (Fig. 1). This study's yield figures were calculated from catches in this 3.4-km<sup>2</sup> area. Once a week, the available fishers of Libaba were interviewed as to their previous day's fishing activities in this area. Generally, only 8-10 of the potential 26 Libaba fishers were available for interviews. Since time of day for the surveying varied, the selection of interviewees was random. Information was collected for catch weight, gear, location, time spent for each catch, general species composition, number of fishers involved, expenses and gross profit. Since, in general, at least four types of gear were used in any given month, information about the exploitation of a wide variety of fish types was obtained. San Salvador fishers use a variety of fishing methods on any given day, therefore, fishers were

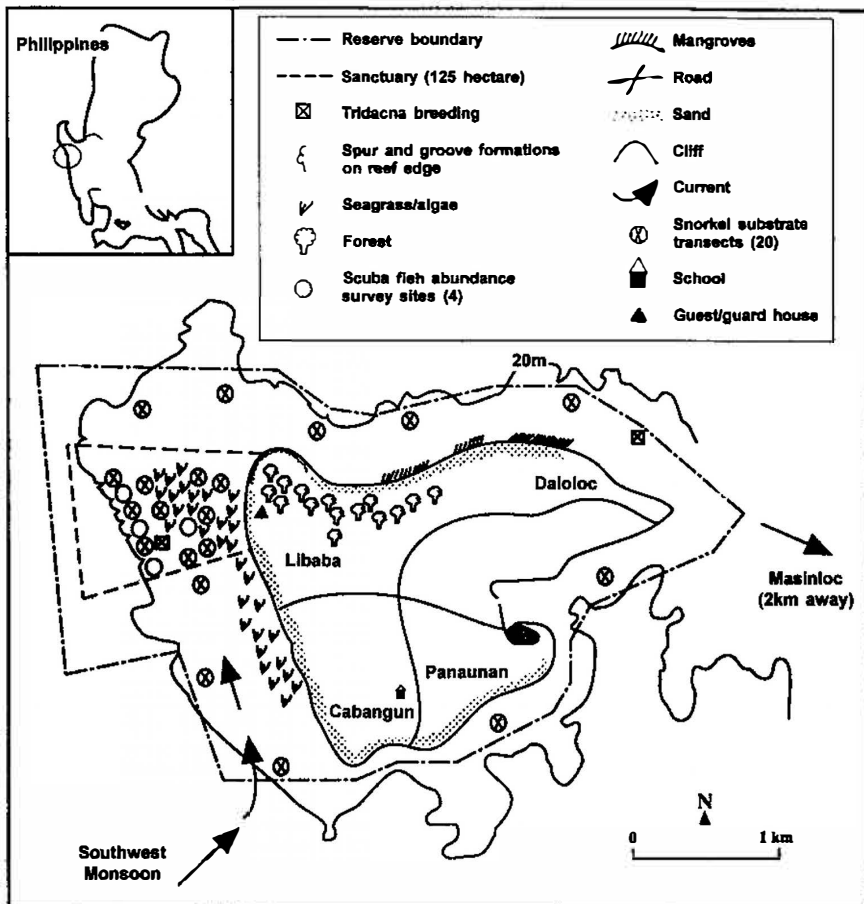


Fig. 1. Map of San Salvador Island.

selected for interviews to represent the relative proportion of gears employed. Seasonal weather conditions and income available to purchase gears affected a fisher's gear selection.

In this study, reef fish were considered any species of marine life commonly caught in waters shallower than 40 m, including Caesionidae (fusiliers) and Siganidae (rabbitfish), octopus and squid, but not mussels, sea urchins, crabs or sea cucumbers. Nonreef species were those commonly caught in waters deeper than 40 m. In the case of San Salvador fishers, Eugraulidae (anchovy) made up the greatest portion of the nonreef class. Anchovy are normally caught in deep waters although they are commonly seen feeding in shallower waters within the reef ecosystem. If possible, catches were weighed directly by the interviewer. Monthly yield (MY) figures were calculated by using the following formula:

$$MY = \frac{[C(\text{kg/fisher}) \times F(\text{fishers/day}) \times FD (\text{day/month})]}{A (\text{km}^2)}$$

where:

MY = monthly yield (kg-month<sup>-1</sup>·km<sup>-2</sup>)

C = catch per fisher

F = average number of fishers per day for a given month on the reef (estimated by random visual surveys of the reef)

FD = number of possible fishing days per month (excluding Sundays and holidays)

A = area of reef fishing grounds for Libaba (3.4 km<sup>2</sup> to 40 m, Fig. 1).

The catches were weighed as a whole without the separation of different species given the high diversity of fish types harvested with any one gear type and the fact that fishers were anxious to sell their catch on the mainland as soon as possible. Monthly yields were summed over 12 months to estimate annual reef fish yields.

In this estimation, the change in fishing effort due to weather conditions (i.e., monsoon season) was reflected by the average number of fishers on the reef per day rather than the number of possible fishing days per month. Due to time constraints, yields from gleaning (collecting by hand at low tide) were not sampled regularly.

### ***Catch Per Unit Effort***

CPUE estimates, measured in kg-work hour<sup>-1</sup>, were based on the same weekly interviews used to calculate yield. For comparative purposes, CPUE was estimated for San Salvador Island fishers when they fished on San Salvador and nearby Magalawa Island reefs.

### ***Fish Population Census***

The method used to census reef fish populations is based on that of Russ (1984). A pre-selected list of 126 species of coral reef fish in 19 families were surveyed within a 500-m<sup>2</sup> area. A total of 18 transects were conducted within the sanctuary. For safety, fish census activities were limited to the calm months between December and May except on one occasion. Transect areas were randomly selected within the sanctuary along the reef crest where the reef steeply sloped from approximately 5 m to greater than 20 m. Surveys were conducted on the reef crest since the greatest diversity of fish is found in this area, and to make the data comparable to other published data sets. Transect areas were demarcated with a 50-m long tape and descended 10 m along the reef slope as measured by a depth gauge. The selection of survey species was based on their level of importance as food fish and indicators of reef health as reported by Russ (1984) and White and Savina (1987). With a tape measure laid closely over the coral substrate, topographic variation on the reef was quantified by measuring the additional surface area per 10 m of horizontal transect line.

Snorkel transects based on Dahl's (1981) methodology were employed to estimate substrate conditions along the island's reef crest. Transects randomly distributed along the reef crest were 60 kick cycles in length. Substrate coverage percentiles were estimated within four sample circles (3-m diameter) evenly spaced along the transects. Substrate types were: sand, rubble (which may increase due to blast fishing), blocks (the solid limestone substrate beneath the coral), dead standing coral (which probably increases due to sodium cyanide and blast fishing), marine plants, live hard coral and live soft coral.

### ***Socioeconomic Survey***

A socioeconomic survey, coordinated with local government agencies, was conducted by a community development worker who did house-to-house interviews of an arbitrarily selected 10% of the population. Information was collected about income level, family size, sources of income and fishing gears owned.

### ***Data Analysis***

Since the primary purpose of this study is to establish a baseline for San Salvador's fishery, much of the data analysis is descriptive. Monthly yields have been calculated to describe the seasonal patterns of the fishery. Annual yields and CPUE have been calculated and compared to other reef fisheries in the Philippines in order to describe the relative condition of the fishery. In order to estimate the initial effect of the management plan, a two-way ANCOVA ( $\alpha=0.05$ ,  $n=309$ ) was used with gear type as a covariant to compare CPUE (kg-work hour<sup>-1</sup>) between the first and second years of the study and between San Salvador and Magalawa Islands. Assumptions of independence of data have been relaxed for this analysis. The assumption of normality of data was met once a log transformation of the data was performed based on values for skewness and kurtosis. Residual plots show acceptable homogeneity of variances.

## Site Description

### Environmental Features

San Salvador Island, with an area of 380 ha, is approximately 2 km west of Masinloc, Zambales, in the South China Sea. Except for the east coast, which is partially denuded mangrove forest, the island's shoreline is white sand beach. The hilly interior is approximately 30% secondary growth forest, 60% ricefields and 10% mango groves (Fig. 1).

Total reef area around San Salvador is 7.5 km<sup>2</sup> to the 40-m isobath. Off the western, northern and southern coast are wide reef flats dominated by seagrass beds (*Thalassia* spp.). The fringing reef shows the effects of a high wave environment with deep spur and groove formations dominated by massive and encrusting coral types. Those areas with more delicate branching corals have been heavily damaged by decades of blast and sodium cyanide fishing. Substrate surveys show 5-50% living coral cover with a mean of 23% for the whole island (Christie et al. 1990). The mean dead standing coral cover is 19%. Table 1 shows the results of substrate surveys in the least damaged area, which was declared a sanctuary, and the surrounding traditional fishing reserve area. This substrate coverage compares with an assessment of Lingayen Gulf reefs 40 km to the north with 37% living coral cover (McManus 1988) and those of Gomez and Yap (1982) where two out of 12 reef sample stations in the province of Zambales were in good condition (50-74.9% living coral cover), three stations were in fair condition (25-49.9%) and seven were in poor condition (0-24.9%).

The reef surrounding San Salvador is affected by a significant difference in weather patterns between the dry, calm season (December-May) and the monsoon, wavy season (June-November). Large waves (3 m) are common along the western reef crest of San Salvador during the monsoon season.

Magalawa Island reef, 2 km south of San Salvador Island, is separated by deep water, thus effectively preventing the movement of mature reef fish between the two islands. Prevailing currents, that may carry fish larvae, are from

Table 1. Coral reef substrate cover and topography, San Salvador Island.

|                     | Sanctuary<br>(n=10) | Traditional fishing<br>reserve<br>(n=10) |
|---------------------|---------------------|------------------------------------------|
| Percent substrate   |                     |                                          |
| Sand                | 8 (±13)             | 13 (±16)                                 |
| Rubble              | 12 (±16)            | 16 (±18)                                 |
| Blocks              | 36 (±23)            | 9 (±14)                                  |
| Dead standing coral | 9 (±14)             | 29 (±22)                                 |
| Marine plants       | 9 (±14)             | 13 (±16)                                 |
| Live hard coral     | 20 (±19)            | 4 (±9)                                   |
| Live soft coral     | 6 (±11)             | 16 (±18)                                 |
| Total coral cover   | 26 (±21)            | 20 (±19)                                 |
| Topography (m)*     | 2.8                 |                                          |

\*Meters of additional surface area per horizontal 10 m  
( )=95% Confidence intervals

Magalawa towards San Salvador Island. Magalawa Island's reef was subjected to destructive fishing methods, such as blast and cyanide fishing, for the last 20-30 years and throughout the course of this study. Based on general snorkel surveys, it has been observed that the structure of Magalawa Island's coral reef, a fringing reef subjected to similar high energy conditions, is essentially the same as San Salvador's reef. Magalawa Island does not have a sanctuary or reserve area.

## Socioeconomic Features

Approximately 1,500 people in 255 families live on San Salvador. The population is dominated by youth with about 52% of the population currently attending school. The birth rate is approximately 3.0%. Most people depend directly on the island's natural resources for their livelihood. About 60% derive their income from fishing, and 36% from farming.

Fishers are categorized into traditional or nontraditional fishing sectors, with the majority considered as traditional. The traditional sector is comprised of manual, small scale operations. The most important traditional fishing methods are *kunay*, baby *basnig*, beach seine, gill net and speargun. *Kunay* is a seine with a scareline of coconut fronds used to herd fish from the reef flat into a fine mesh net (5-cm mesh). Baby *basnig* is a fine meshed lift net (2-cm mesh) used at night with lamps to attract fish, usually anchovies (Eugraulidae), juvenile fusiliers (Caesionidae) or juvenile rabbitfish (Siganidae). Beach seine is a long net (up to 300 m) laid out on the reef flat and hauled in by people on the shore. Spearguns are used to harvest fish from the reef flat and reef crest. Nontraditional fishing operations are blast fishing, spear fishing with air compressors, and aquarium fish collecting. The choice of fishing gear was seasonal given the strong effect of monsoon conditions for a portion of the year. For example, during the dry, calm months, all fishing gears were employed; whereas in the monsoon season, only beach seines and baby *basnig* could be used. Historically, the aquarium fishery has involved the use of sodium cyanide. The majority of fishers using these fishing gears were men, however, women were involved in gleaning, fish processing and fish marketing.

Monthly incomes range from US\$44 to \$66 per household for those involved in traditional fishing. Those involved in aquarium fish gathering have a monthly household income of approximately \$100. Most people live in one of four villages on the island coast depending on occupation, cultural background and family linkages.

## Results

### Fish Yields

#### BASE YIELD FIGURE

Reef yield increased from 7.0 ( $\pm 2.5$ )  $\text{t}\cdot\text{km}^{-2}\cdot\text{year}^{-1}$  the first year to 14.0 ( $\pm 7.8$ )  $\text{t}\cdot\text{km}^{-2}\cdot\text{year}^{-1}$  the second year of the study (Table 2). Nonreef fish catch also increased from the first to the second year by 55%.

Fish caught by outsiders to San Salvador were not formally estimated due to difficulty of sampling their presence or catch. However, random observation showed that an average of two visiting fishers fished daily for 2 hours. Using CPUE estimates for San Salvador, this effort results in a yield of approximately 1.1  $\text{t}\cdot\text{km}^{-2}\cdot\text{year}^{-1}$ .

Table 2. Summary of reef yield and nonreef catch for San Salvador Island, April 1988-March 1990.

|                                                          | April 1988-<br>March 1989 | April 1989-<br>March 1990 |
|----------------------------------------------------------|---------------------------|---------------------------|
| Reef catch (kg)                                          | 23,877 (n=129)            | 47,457 (n=126)            |
| Nonreef catch (kg)                                       | 10,608 (n=60)             | 16,413 (n=44)             |
| Total catch (kg)                                         | 34,485                    | 63,870                    |
| Reef yield<br>(t·km <sup>-2</sup> ·year <sup>-1</sup> )* | 7.0 (±2.5)                | 14.0 (±7.8)               |

\*3.4 km<sup>2</sup> reef area to 40-m isobath

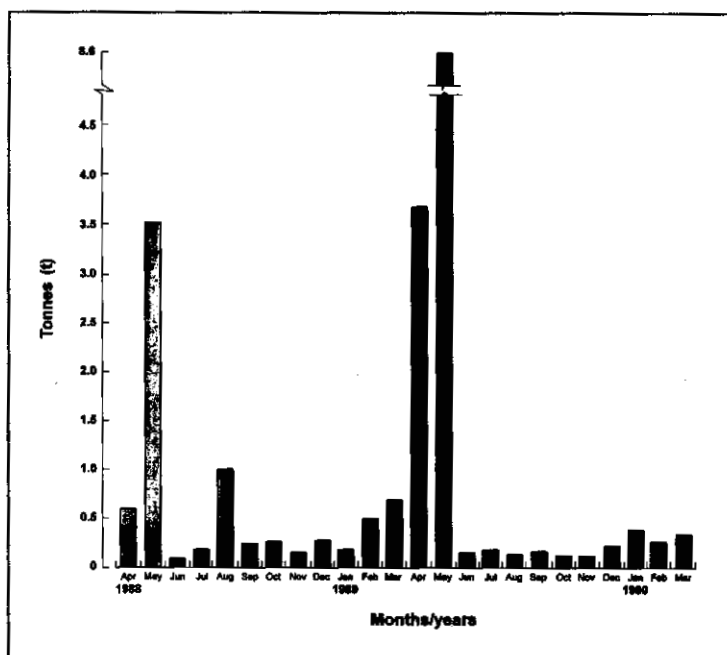


Fig. 2. Monthly reef fish yield, San Salvador Island (t·km<sup>-2</sup>·month<sup>-1</sup>).

#### SEASONAL VARIATION

Fig. 2 shows the wide range of variability in reef yield from month to month. Peak yields are in April and May, which correlates with the calm season in this area and the peak period of recruitment of juvenile *Caesionidae* into the reef area. Although reef yield from the second year of the study is 100% greater than the first year, the increase is a function of the high yield of 2 months, namely April and May 1989. These months' yields of 3.8 and 8.6 t·km<sup>-2</sup>·month<sup>-1</sup>, respectively, are composed mostly of juvenile *Caesionidae* captured with baby basnig. Catches of juvenile *Caesionidae* were commonly over 175 kg per fisher per trip.

### Catch Per Unit Effort

Table 3 displays the CPUE information for the five main gear types during the 2 years of study. Baby basnig shows the greatest CPUE for either year since this is the primary gear which harvests the juvenile *Caesionidae* during April and May. Beach seine and kunay have similar CPUE and essentially exploit the same species of fish, those found on the reef flats. Speargun and gill net, gears which exploit both fish found on the reef flat and among the corals, had the lowest CPUE. On Apo Island, gill net had the highest CPUE of 3.55 kg·hour<sup>-1</sup>, while speargun CPUE of 1.5 kg·hour<sup>-1</sup> was similar to San Salvador (White and Savina 1987).

Table 4 shows the mean CPUE when adjusted for gear type for San Salvador and Magalawa Islands. CPUE was significantly different between San Salvador and Magalawa Islands (ANCOVA,  $p=0.002$ ). However, CPUE for San Salvador did not significantly change between the first and second year of the study due to the great variance in the data (ANCOVA,  $p=0.128$ ).

### Fish Abundance

The results for fish abundance per unit area (density) are shown in Fig. 3. The highest mean abundance for San Salvador was 460 individuals per 500 m<sup>2</sup>. Fish density increased since the earliest measurements taken prior to establish-

Table 3. Catch per unit effort (CPUE) for reef fishing gear used on San Salvador Island.

|             | April 1988-<br>March 1989<br>(n=189) | April 1989-<br>March 1990<br>(n=170) |
|-------------|--------------------------------------|--------------------------------------|
| Gear        |                                      |                                      |
| Kunay       | 1.7 ( $\pm 0.88$ )                   | 2.7 ( $\pm 3.7$ ) *                  |
| Baby basnig | 11.8 ( $\pm 7.90$ )                  | 15.1 ( $\pm 2.5$ )                   |
| Beach seine | 2.3 ( $\pm 1.70$ )                   | 3.0 ( $\pm 2.5$ ) **                 |
| Gill net    | 0.3 ( $\pm 0.05$ )                   | 0.5 ( $\pm 0.2$ )                    |
| Speargun    | 1.2 ( $\pm 0.02$ )                   | 1.0 ( $\pm 0.1$ )                    |

CPUE = kg·work hour<sup>-1</sup>

( ) = 95% Confidence interval

\* Banned halfway through this year

\*\* Fine mesh beach seines banned halfway through this year

Table 4. Mean and adjusted for gear type mean CPUE for San Salvador and Magalawa Islands.

|                                         | San Salvador<br>Island | Magalawa<br>Island |
|-----------------------------------------|------------------------|--------------------|
| Mean CPUE (kg·work hour <sup>-1</sup> ) | 3.148                  | 2.846              |
| Adjusted mean CPUE                      | 1.709*                 | 1.091*             |

\*Adjusted CPUE is significantly different (ANCOVA,  $p=0.002$ )

ing the sanctuary. Fish densities were high during the calm season (December-May) with means of 322 and 431 per 500 m<sup>2</sup> in May 1989 and March 1990, respectively. During the rainy season (June-November), mean fish density was 226 in October 1989. Fish densities were higher again in April 1991 with a mean of 460.

### Income

The mean income per fisher increased 44% between the 2 years (Table 5). This, again, is most likely a result of the large catches of juvenile *Siganidae* and *Caesionidae* in the second year. This increase in per capita income may not be equally distributed throughout the community since not all families can afford to own a baby basnig net, which requires a high initial investment and a motorized boat to operate.

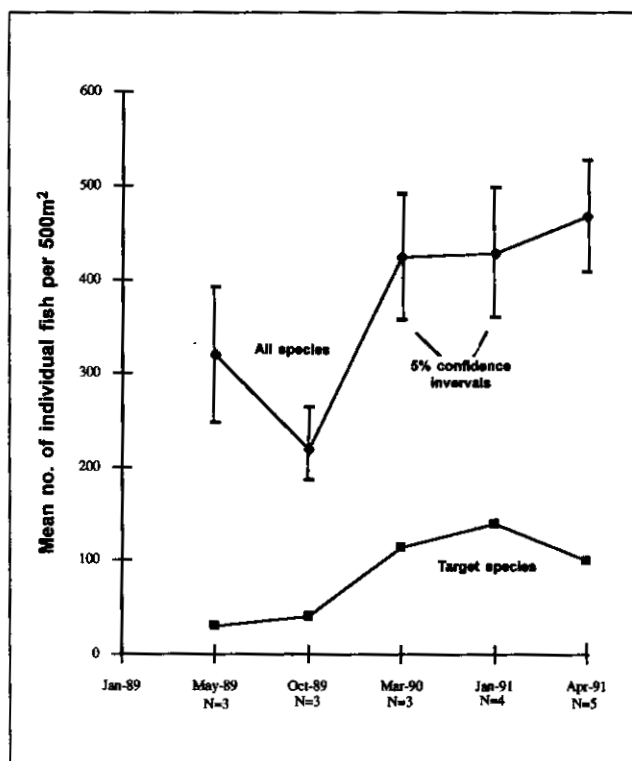


Fig. 3. Temporal changes in fish density in the marine sanctuary of San Salvador Island.

Table 5. Cash income from reef catch, San Salvador Island.\*

|                                 | April 1988-<br>March 1989 | April 1989-<br>March 1990 |
|---------------------------------|---------------------------|---------------------------|
| Annual reef fish catch income   | 250,478                   | 360,176                   |
| Mean reef income for 26 fishers | 9,634                     | 13,852                    |

\*Amounts in Philippine pesos (US\$1=P22 in 1989)

## Discussion

This study has established a baseline for San Salvador's fringing coral reef. The reef yield increased from 7.0 to 14 t·km<sup>-2</sup>·year<sup>-1</sup> during the course of this 2-year study. Large yields in April and May 1989 account for the increase in yield between the 2 years of this study. These estimates are from only the west and north sides of the island and reflect the yields from the most heavily used reef areas. Since fishers are typically suspicious of people asking for information about their catches, data for the first few months of the yield study may be suspect. The yield study, however, was initiated 6 months after a fieldworker was living on the island and had gained the confidence of the local fishers. Since the sanctuary was not established until July 1989 and CPUE did not significantly increase over time, it is not possible to attribute this increase to its establishment. More plausible explanations would be increased fishing effort by San Salvador fishers, a natural cycle in the fish population, or an increase in planktivorous fish species.

The relatively high percentage of planktivores, such as caesionids, in yields from Apo Island's and Sumilon Island's reefs has been noted by Russ (1991). Reported figures for percentage of planktivores in yields are 59-65% for Sumilon Island, and 23-43% for Apo Island. The cessation of blast fishing in the area after January 1989 may have allowed the caesionid population to recover more quickly than other reef species on San Salvador Island. Caesionids are the preferred targets of blast fishing due to their schooling habits. Historically, blast fishing was common around San Salvador, with an average of 3.2 blasts per day along the island's west shore during the calm season. After January 1989, 6 months prior to the establishment of the sanctuary and reserve, the community stopped blast fishing by patrolling. Since these fish are generally found along the reef slope or in deeper water, schools of caesionids may have migrated from nearby reef areas after the cessation of blast fishing. Juvenile caesionids are caught with the use of baby basnig. Whether the large scale harvesting of these fish at a juvenile stage by traditional fishing techniques will ultimately limit the yield from San Salvador requires further investigation.

If yield data from April and May are excluded from the analysis, the total yield from the remaining months actually decreases from 2.9 t·km<sup>-2</sup>·year<sup>-1</sup> the first year, to 1.5 t·km<sup>-2</sup>·year<sup>-1</sup> the second year of the study. This may be explained by the fact that the community banned the use of fine mesh nets (i.e., kunay and beach seines) in the reef area. Fine mesh nets were historically used to capture juvenile siganids and other juvenile reef fish in large quantities in the calm season, and damaged the corals when dragged over the reef. The use of baby basnig, although it also uses a fine mesh net, was allowed by the community in the deep waters of the reserve, since it does not damage the coral.

The overall condition of San Salvador's reef is reflected in its yield which falls in the middle range when compared to healthy reefs such as Apo Island with a yield of approximately 31.8 t·km<sup>-2</sup>·year<sup>-1</sup> (White and Savina 1987) or the degraded reefs of Bolinao in the Lingayen Gulf with a yield of 2.7 t·km<sup>-2</sup>·year<sup>-1</sup> (McManus et al. 1992). According to Russ' (1991) summary of yields from reefs, our findings correlate most closely with those of Pamilacan Island in the south-

ern Philippines with a yield of  $10.7 \text{ t} \cdot \text{km}^{-2} \cdot \text{year}^{-1}$  (Savina and White 1986), or Sumilon Island with a yield of  $14.0 \text{ t} \cdot \text{km}^{-2} \cdot \text{year}^{-1}$  in 1977. Fish yields from Pamilacan have increased subsequent to the establishment of a 14-ha sanctuary and surrounding traditional fishing reserve in 1985 according to fisher reports in 1992. Sumilon Island fish abundances also increased subsequent to the establishment of the island as a sanctuary, but decreased after this management scheme was reversed.

An analysis of CPUE for San Salvador may help assess the condition of this reef in relation to others in the Philippines. Baby basnig has a higher CPUE than any gear reported for Apo Island (White and Savina 1987). Again, this is primarily a result of the large catches in April and May of juvenile siganids and caesionids. Values of CPUE for nets were lower for San Salvador (gill net CPUE =  $0.5 \text{ kg} \cdot \text{work hour}^{-1}$ ) than for Apo Island (gill net CPUE =  $3.55 \text{ kg} \cdot \text{work hour}^{-1}$ ). Speargun CPUE were slightly higher for Apo Island. The higher Apo CPUE values for gears that exploit reef areas is probably a function of the better reef condition of Apo Island.

That mean CPUE, when adjusted for gear type, is higher for San Salvador than Magalawa Island reef, may indicate a higher level of productivity for San Salvador Island. Most of the blast fishers in the area reside on Magalawa Island and continue to use this destructive fishing method today. Fish yield studies should be continued for these two islands to determine if the establishment of the sanctuary and reserve on San Salvador will continue to raise San Salvador's CPUE in comparison to Magalawa Island.

The generally poor quality of San Salvador's reef is reflected in the low abundance of fish in the sanctuary. In the sanctuary of Apo Island, 1,427 fish were counted per  $500 \text{ m}^2$  in 1985, and 3,899 fish were counted in 1986 representing a 173% increase. San Salvador had only 322 per  $500 \text{ m}^2$  as the mean count in May 1989 followed by 431 in March 1990 and 460 in April 1991. These results represent a 33% increase between May 1989 and March 1990, and a 7% increase between March 1990 and April 1991.

Based on daily observations of the reef, certain untested hypotheses may be forwarded to explain the slow recuperation of the reef fishery of San Salvador. Slow recovery may be attributed to the heavy damage incurred in the past and the high wave energy on the reef for part of the year. Given the destructive fishing methods used on Magalawa Island, the low recruitment of new species and fish may also be partially due to the distance of the sanctuary from a source of fish larvae and currents that do not favor the transport of larvae to this area. Also, informed surveys seem to support the idea that the most productive part of the San Salvador sanctuary may be the seagrass beds rather than coral areas (Miclat, pers. comm.). No fish abundance surveys were made in the seagrass beds.

Although absolute numbers are low, fishers have noted the increase of fish in the area. This is directly correlated to the increased income of fishers in Libaba. Ultimately, this trend will probably determine the future of the sanctuary and reserve on San Salvador Island.

In conclusion, the annual yield for San Salvador Island's coral reef has been calculated. From April 1988 to March 1989 reef fish yields were approxi-

mately  $7.0 \text{ t}\cdot\text{km}^{-2}\cdot\text{year}^{-1}$ , increasing to approximately  $14.0 \text{ t}\cdot\text{km}^{-2}\cdot\text{year}^{-1}$  from April 1989 to March 1990. In agreement with yield studies of other Philippine reefs, planktivores such as caesionids compose a significant portion of the yield from San Salvador. CPUE was approximately  $3.148 \text{ kg}\cdot\text{work hour}^{-1}$  during the course of this study and did not change significantly between years. This information, along with results from substrate and fish abundance surveys, forms a baseline for San Salvador. The condition of San Salvador's reef reflected in fish yield is comparable to that of Pamilacan Island, where fish yields have increased subsequent to the establishment of a sanctuary and traditional fishing reserve. Future studies, after the reef has had sufficient time to recover from destructive fishing methods, may be able to determine the effect of the traditional fishing reserve and sanctuary.

This study has shown that the establishment of a resource management plan has not adversely affected the fishery on San Salvador and, possibly, will lead to increased yields and incomes in the long term for the community. Considering the poor condition of coral on San Salvador's reef, it may take years before the effects of improved management will be significant.

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