*Asian Fisheries Science* 4(1991):295-306.
Asian Fisheries Society, Manila, Philippines

# Coral Reef Fisheries at Cape Bolinao, Philippines: Species Composition, Abundance and Diversity

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## Abstract

The abundance, diversity and species composition of a multispecies reef fishery of Cape Bolinao, Philippines, were studied using catches by trap, spear and hook-and-line fishers from June to December 1986. A total of 144 species were caught by these gears during the study. Of these species, 127 were caught by trap, 40 by spear and 15 by hook-and-line fishers. Traps fished 101 species, dominated by siganids (42%) from the backreef area and 90 species, dominated by labrids (26%) from the reef flat. Spear fishers collected many *Siganus fuscescens* contributing 84% of the total catch of the fishery. The family Lethrinidae dominated the catch (70%) of hook-and-line fishers.

The Shannon-Weaver diversity index (H') and species evenness (J) were calculated for the trap fishery. Mean diversity index was higher in the reef flat (2.60) than in the backreef (2.04). This was mainly due to the differences between these two sites in terms of intraspecific distribution as exemplified by the higher J of 0.78 in the reef flat than in the backreef (J=0.62).

## Introduction

Traps, hook-and-line and spear are some of the most popular methods used by coastal fishers to harvest coral reef fishes. These methods are highly selective in terms of size and species composition and usually suitable only for certain reef types or topographies (Gomez et al. 1981; Sale 1982). These traditional fishing methods have been successfully used in the study of reef-fish ecology, despite the sampling biases inherent in them. The studies conducted by Munro et al. (1973), Munro (1976) and Thompson and Munro (1983) using fish traps as sampling gears provide highly creditable examples of estimating catch

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composition and fish yields using traditional approaches (see Sale 1982). A habitat approach, giving emphasis on species composition (including a classification of fish communities), differences of fish communities in different habitats, and how community structure responds to human activities (such as fishing) has been recommended by some reef fish ecologists (Smith and Taylor 1973; Marten and Polovina 1982). A study of this kind, in which the origin of the catch and its species composition can be determined, is needed in order to compare fish yields among different communities.

The coral reefs adjacent to Santiago Island, Bolinao, Philippines, have recently been the subject of an intensive ecological survey by the Marine Science Institute of the University of the Philippines and the University of Rhode Island (USA). As a component of this survey, our study looked at species composition, catch abundance by weight and number of individuals of the three major fishing gears used in the study area. Species diversity (H') (Shannon and Weaver 1963) and species evenness (J) (Pielou 1966) were also estimated for the trap fishery.

## Materials and Methods

The study area was a fringing reef system in Santiago Island, Cape Bolinao, on the western side of Lingayen Gulf, Pangasinan, Philippines (Fig. 1). The reef flat varies in depth from approximately 1 to 5 m.

The forereef is dominated by *Millepora* and *Porites* species (MSI 1986). Seagrass beds of varying densities occur on the reef flat; dense stands occur over approximately 50% of the study area (Fortes 1984). In addition, the reef flat includes open areas covered with coral fragments, stands of *Sargassum* and isolated patches of living corals.

Data used in this study were collected from the catches of commercial trap, hook-and-line and spear fishers from Cape Bolinao during June-December 1986 (Acosta 1987; Acosta and Recksieck 1989).

There are two fishing grounds for the trap fishery: a) in the southwest part of the study area, west of Silaqui Island, which is referred to as reef flat in this study and, b) along the forereef slope and crest and into the backreef zone; this area is collectively called backreef here since the majority of trap fishing is inside the crest. Most fishing is done from bamboo rafts, each carrying 15-40 traps (average of 20) for an overnight soak. Small bamboo strip traps, 51 x 45 x 13 cm, with a mesh size of 2.5 cm and fitted with horseneck funnels, are fished unbaited and covered with coral rubble fragments.

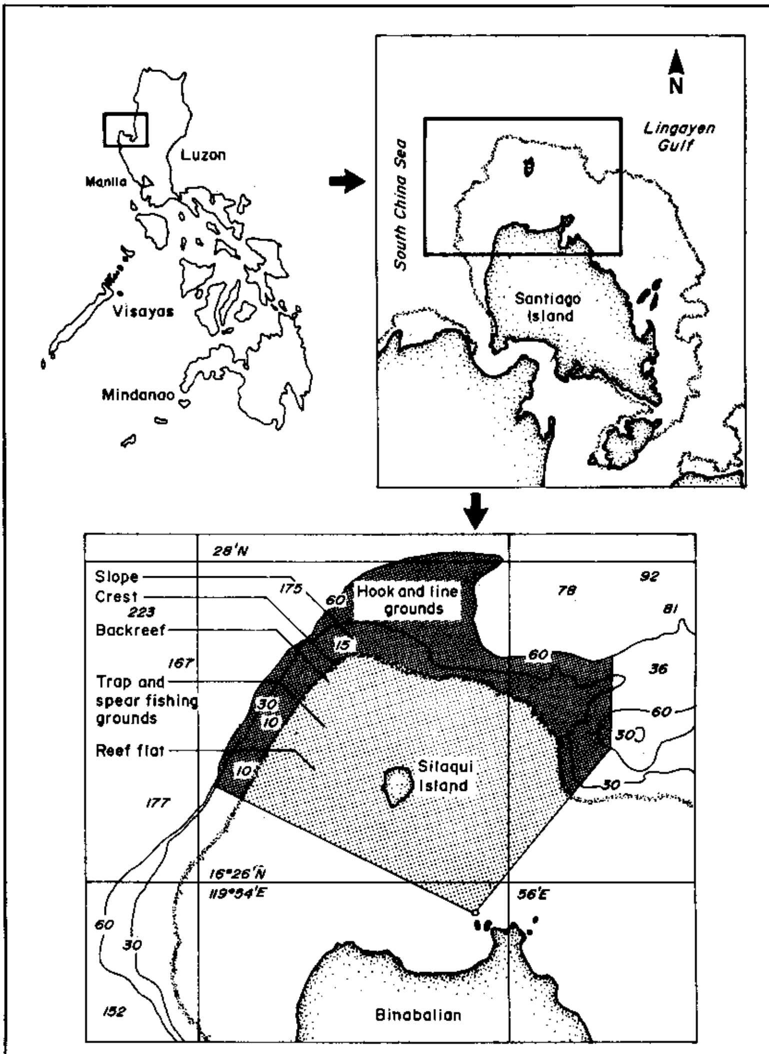


Fig. 1. Sampling area for three coral reef fisheries, Cape Bolinao, Philippines.

Hook-and-line fishing is generally carried out at night from one-person outrigger canoes propelled by paddles and sails. Fishing grounds are seaward of the reef crest to around the 18 m isobath.

The spear fishery is directed primarily at *Siganus fuscescens* and other members of the family Siganidae within the reef flat. Note that *S. fuscescens* was misidentified as *S. canaliculatus* in previous fish studies from the Bolinao area (Del Norte and Pauly 1990). Principal fishing grounds are southeast and northeast of Silaqui Island and north-northeast of Binabalian (Fig. 1). Fishing is done at night under artificial light. The spear fishers equipped with sling spear and goggles, hunt in seagrass beds for fish illuminated by the light.

The number of individuals for each species was enumerated by gear type.

The species diversity index (H') for the trap fishery was estimated by computing the Shannon and Weaver (1963) diversity index: $H' = -\sum [Ni/N \ln(Ni/N)]$, where N is the total number of individuals for all the species, Ni is the number of individuals for the ith species (i=1 to S, S = total number of species) and ln is natural logarithm. The distribution of individual fishes among species was further analyzed by determining the index of species evenness (J) (Pielou 1966): $J = H'/\ln S$.

## Results

A total of 127 species belonging to 23 familes were caught by trap fishers during the study. Families comprising more than 1% of the total weight and number of species caught are listed in Table 1. Ten families comprised 97% of the fish sampled, with the family Siganidae accounting for 36% of the catch. Wrasses (Labridae) were the most speciose group, with 21 species observed. Damselfishes (Pomacentridae) were second. Ninety species representing 18 families were collected from the backreef area. Siganids were the most abundant fish group comprising 42% of the total catch by weight. One hundred-one species representing 23 families were collected on the reef flat. Labrids were most abundant, accounting for 26% of the total catch by weight, followed by siganids with 17% (Table 1).

Data from the trap fishery were used to characterize the community structure of the reef fishes. Mean diversity index (H') for the reef flat was estimated at 2.60, while the value for the backreef was 2.04. The evenness component of diversity (J) was calculated at 0.78 and 0.62 for these zones, respectively. Monthly variations in number of species and of the diversity and evenness indexes are summarized in Fig. 2.

There seemed to be no significant monthly variation in species diversity for the entire study site (One-way ANOVA, $F_{1,12}$ $P>0.05$). However, average monthly diversity was higher on the reef flat than in the backreef (Paired t-test, $P<0.05$). This significant difference in species diversity between the two reef sites cannot be explained by the

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

| Family | | Trap | | | Spear | | | Hook-and-line | | |
|---|---|---|---|---|---|---|---|---|---|---|
| R=Reef flat<br>B=Backreef<br>T=Total | | Number of species | Weight (%) | Number (%) | Number of species | Weight (%) | Number (%) | Number of species | Weight (%) | Number (%) |
| Labridae | R | | 26.5 | 21.5 | | | | | | |
| | B | | 20.1 | 17.5 | | | | | | |
| | T | 21 | 23.0 | 19.5 | 6 | 2.8 | 1.0 | | | |
| Pomacentridae | R | | 9.5 | 11.0 | | | | | | |
| | B | | 6.9 | 8.2 | | | | | | |
| | T | 15 | 8.2 | 9.6 | | | | | | |
| Scaridae | R | | 13.0 | 9.4 | | | | | | |
| | B | | 14.3 | 11.2 | | | | | | |
| | T | 13 | 13.8 | 10.4 | 3 | 2.6 | 1.5 | | | |
| Balistidae | R | | 3.4 | 4.7 | | | | | | |
| | B | | 1.1 | 1.8 | | | | | | |
| | T | 10 | 2.1 | 3.2 | | | | | | |

Continued

Table 1. (continued)

| Family<br>R=Reef flat<br>B=Backreef<br>T=Total | | Trap | | | Spear | | | Hook-and-line | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Number of species | Weight (%) | Number (%) | Number of species | Weight (%) | Number (%) | Number of species | Weight (%) | Number (%) |
| Lethrinidae | R | | 5.2 | 6.4 | | | | | | |
| | B | | 1.4 | 2.3 | | | | | | |
| | T | 8 | 3.0 | 4.2 | 5 | 1.8 | 1.6 | 5 | 65.8 | 69.1 |
| Serranidae | R | | 14.6 | 10.4 | | | | | | |
| | B | | 6.6 | 4.4 | | | | | | |
| | T | 8 | 10.0 | 7.2 | 5 | 2.0 | 1.1 | | | |
| Siganidae | R | | 16.8 | 24.5 | | | | | | |
| | B | | 42.2 | 46.5 | | | | | | |
| | T | 7 | 31.5 | 36.1 | 3 | 83.7 | 88.7 | | | |
| Mullidae | R | | 2.2 | 2.6 | | | | | | |
| | B | | 1.7 | 1.7 | | | | | | |
| | T | 6 | 2.1 | 1.9 | 5 | 2.9 | 2.1 | | | |
| Apogonidae | R | | 3.6 | 4.8 | | | | | | |
| | B | | 1.7 | 1.7 | | | | | | |
| | T | 4 | 2.1 | 3.3 | | | | | | |

Continued

Table 1. (continued).

| Family<br>R=Reef flat<br>B=Backreef<br>T=Total | | Trap | | | Spear | | | Hook-and-line | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Number of species | Weight (%) | Number (%) | Number of species | Weight (%) | Number (%) | Number of species | Weight (%) | Number (%) |
| Scorpaenidae | R | | | | | | | | | |
| | B | | | | | | | | | |
| | T | 2 | 1.4 | 1.2 | | | | | | |
| Lutjanidae | | | | | | | | 5 | 23.2 | 24.3 |
| Priacantidae | | | | | | | | 1 | 1.7 | 0.5 |
| Gobiidae | | | | | 3 | 1.2 | 2.0 | | | |
| Others | R | | 5.1 | 4.8 | | | | | | |
| | B | | 2.1 | 2.2 | | | | | | |
| | T | 33 | 2.8 | 3.4 | 10 | 3.0 | 2.0 | 4 | 3.3 | 6.1 |
| Total | | 127 | 100 | 100 | 40 | 100 | 100 | 15 | 100 | 100 |

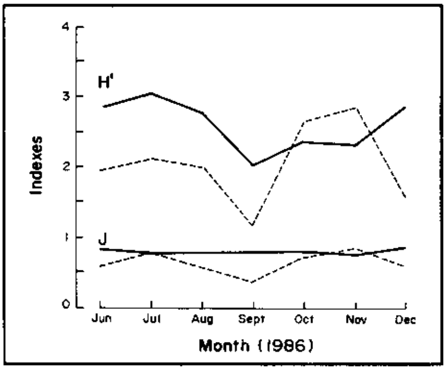


Fig. 2. Monthly diversity (H') and evenness (J) for the reef flat (—) and backreef (- - - - -) coral reef sections of Silaqui Island.

species component of diversity. The monthly average number of species was not significantly different between the two reef sections (Paired t-test, NS). It is the intraspecific distribution of individuals that apparently accounts for the difference in species diversity between the reef flat and the backreef. Average monthly species evenness is greater in the former than in the latter (Paired t-test, $P<0.05$).

The length-frequency distributions for the eight dominant species from the trap fishery are presented in Fig. 3. The Kolmogorov-Smirnov test indicated significant differences in length-frequency distributions between the reef flat and backreef for *S. fuscescens, S. spinus, E. merra,* Labrid A and *Stegastes* sp. The length-frequency distributions for the other species showed no significant differences between these two reef sections.

Sixteen species representing six families were caught by the hook-and-line fishery. The family Lethrinidae was most abundant, comprising 69% of the total catch in terms of numerical abundance and 66% by weight. Family Lutjanidae was second with 24 and 23% by abundance and weight, respectively.

Spear fishing in Cape Bolinao was primarily for siganids, which accounted for 84% of the catch by weight and 89% by numerical abundance (Table 1).

## Discussion

Out of the 127 species recorded for the trap fishery, 101 species (79%) were collected from the reef flat and 90 species (70%) from the backreef. Forty-one species (32%) were observed only on the reef flat. More or less distinct species assemblages were associated with each habitat type, although sixty (47%) of the fish species occurred in both habitats and can be considered "reef cosmopolitan." This is in contrast to Goldman and Talbot (1976), who reported only a few species overlapping (7%, 26 species) among different habitats in One Tree Island reef system, Australia.

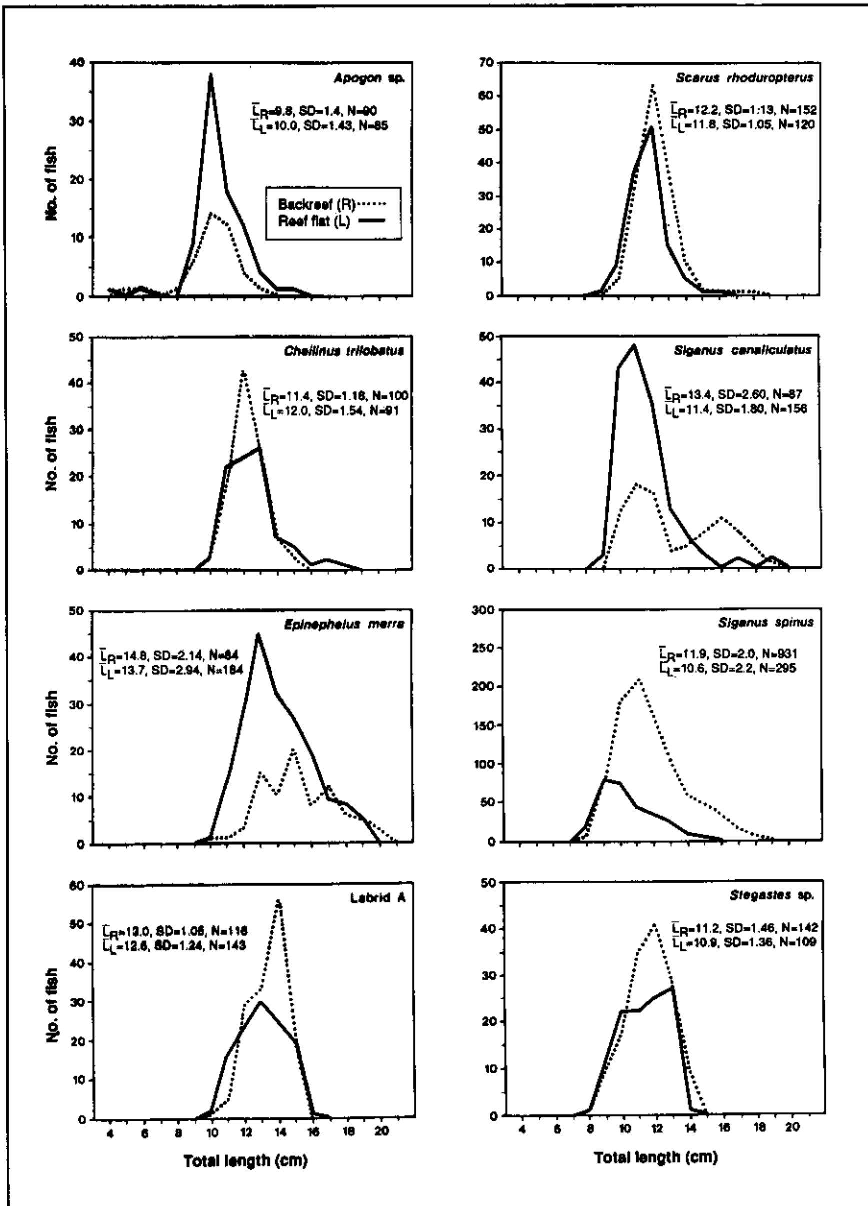


Fig. 3. Length-frequency distributions of the eight most abundant species caught by traps in the study area. $\overline{L}_R$ = mean length of fish caught from the backreef and $\overline{L}_L$ = mean length of fish caught from the reef flat.

Murdy (1979) reported 48 species representing 24 families on an artificial reef in the lagoon at Cape Bolinao. Thirteen of the 24 families reported in his study were represented in trap catches on the reef flat.

Caution must be taken in interpreting these data because of a number of potential sampling biases, one of which is the selective nature of fishing gears. Differences in species composition among gear types (including visual survey) are influenced by the behavior of coral reef fishes. For example, most coral reef fishes exhibit a diel activity pattern. Harmelin-Vivien (1989) reported that diurnally active species predominate. They make up about two-thirds of the reef fish community at Tulear (Madagascar) and Moorea (French Polynesia).

The inclusion of both diurnally and nocturnally active fish in the trap catches brings about the relatively high diversity observed at Bolinao. There seems to be a similar trend in the monthly diversity indexes for both reef sections, although the monthly variations can be attributed to different aspects of the fish communities in each section. Species evenness for the reef flat was constant through all the sampling period. The only factor that apparently affected the monthly fluctuations in diversity for this site is the number of species per sampling period. Monthly diversity (H') for the backreef varied due to changes in both the number of species collected and the distribution of individual fishes within each species.

Demersal reef-associated species were the dominant component of the hook-and-line catch. Five species each of the family Lethrinidae and Lutjanidae were collected, but the lethrinids dominated the catch by number and weight. The species composition of the hook-and-line fishery is similar to that recorded in Papua New Guinea by Wright and Richards (1985).

Calvelo and Ginon (1974) found that *Siganus* sp. accounted for 20-50% of the catch in fish corrals at Cape Bolinao. The species composition of the spear fishery there differed greatly from those recorded by Wass (1982) in American Samoa and by Wright and Richards (1985) in Papua New Guinea. These researchers reported a wide variety of species taken by gear, mainly reef-associated and pelagic forms such as groupers, snappers, jacks and mackerels. The difference may be explained by the presence of extensive seagrass beds and tidal flats in the Cape Bolinao area where schools of *Siganus fuscescens* tend to concentrate, as well as the degree of overfishing (Del Norte et al. 1989).

Direct observations and interviews with the fishers and traders in the landing places allowed us to assume that little variability occurs in the catch composition of these gears in Cape Bolinao throughout the year. Bellwood (1988) observed little variability in the species composition of fishes caught by fishers from the central Philippines. He also observed that only a few families (10) accounted for 93% of the catch, a condition similar to Cape Bolinao where 10 families accounted for 97% of the trap fishery, 7 families accounted for 97% of the spear catches and 3 families accounted for 91% of the hook-and-line catches. Although Bellwood did not break down the catch composition by fishing gear type, the similarity of the results of his study and ours shows what seems to be a common pattern of smallscale coral reef fisheries.

## Acknowledgements

We thank the personnel of the Marine Science Institute of the University of the Philippines for their help and support. We are indebted particularly to Conrad Recksieck, Saul Saila and John McManus. We thank Richard Appeldoorn, George Dennis III and Daniel Pauly for their comments on the drafts. Our most sincere thanks go to the people of Bolinao, and to the fishers of Silaqui and Binabalian in Santiago Island for their friendship and trust.

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 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).

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*Manuscript received 15 March 1990; revised ms received 3 December 1990; accepted 20 May 1991.*