The Depth Distribution of Exploited Reef Fish Populations off the South and West Coasts of Barbados

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ABSTRACT

Exploratory surveys using Antillean fish traps set at various depths off the south and west coasts of Barbados were conducted between September and December, 1989. A total of 88 sets were completed and 681 fish caught, representing 51 taxa. The five most common taxa included in the catches were, in descending order, silk snapper (*Lutjanus vivanus*, 23%), squirrelfish (Holocentridae, 9%), blackfin snapper (*L. buccanella*, 9%), striped grunt (*Haemulon striatum*, 7%), and French grunt (*H. flavolineatum*, 7%). A negative relationship between increasing depth fished and number of species caught was found. The average size of blackfin snapper increased with depth fished, but such a relationship was not present for other species in general. The greatest catch biomass per trap was noted in sets made at intermediate depths of 60 to 120 m. In many cases, congeners had distinctly different depth distributions. For example, silk snapper were usually found in deeper water than blackfin snapper. The information on depth distributions presented here represent some of the first such data for many reef-dwelling species in the Eastern Caribbean.

KEYWORDS: depth, distribution, snappers, reef fish.

INTRODUCTION

Artisanal demersal fishing is pursued mainly along the relatively calm south and west coasts of Barbados (latitude 13° N and longitude 59° W). The most actively growing coral reefs on the island occur in that region. The fishery exploiting reef fish accounts for about 8% of total annual landings of 2500-3000 metric tonnes per year, in an industry typically dominated by landings of pelagic species. Traditionally, demersal fish landings peak from July to October when pelagic species are scarce. During that period, demersal landings may account for more than 50% of total landings in Barbados (Willoughby, 1989).

The demersal fishery can be divided into an inshore and offshore component. The inshore fishery targets a variety of reef fish and uses Antillean fish traps. The catch consists mainly of hinds (Serranidae), surgeonfish (Acanthuridae), grunts (Haemulidae), parrotfish (Scaridae), and squirrelfish (Holocentridae). The offshore fishery takes snappers (Lutjanidae) and groupers

(Serranidae). The gear employed offshore is typically handlines, but also includes Antillean fish traps. Those fishermen employing the latter gear type have increased their efficiency recently by using pot-haulers to retrieve their traps. This mechanisation has enabled fishermen to venture into deeper waters.

Little information exists, however, on either the nature of the fisheries resources or their depth distributions in deeper water. Consequently, the Fisheries Division of Barbados mounted a survey to determine the availability and distribution of fish resources that could be exploited using traps set in relatively deep water. It was anticipated that the data collected would be of value to fishermen and fisheries managers alike since they would reveal the availability and location of exploitable stocks. The possibility that exploitable deep water resources exist might also result in the transfer of present fishing effort from the apparently over-exploited inshore fishery (Wilson, 1983).

Our paper reports the findings of the survey. In particular, the size and species-related aspects of the depth preferences of demersal fish off the south and west coasts of Barbados are described, as is the overall relationship of biomass versus depth.

METHODS

Antillean fish traps were set on reefs, at depths ranging from 6 to 198 m, along the south and west coasts of Barbados during the period September to December 1989 (Figure 1). The location of fishing activity was in Paynes Bay and Carlisle Bay, and off Batt's Rock and Brighton. The traps were made from 3.8 cm hexagonal mesh chicken coop wire, reinforced with wild tamarind sticks. The traps used were "Z"-type (2.7 x 1.8 x 0.9 m), arrowhead (2.4 x 1.8 x 0.9 m), and rectangular (2.1 x 1.0 x 0.9 m). The volumes of these traps were 4.4, 3.9, and 3.4 m^3, respectively. The trap most frequently employed was the Z-type, with the other two used occasionally, irrespective of depth. The traps were baited with either fish or squid.

An echo sounder was used to position traps on relatively flat rocky areas on the reef. The location of the traps was recorded and marked with buoys. Unfavourable sea conditions and occasional mechanical difficulty resulted in variable soak time which was often considerably longer than intended. The mean was 149 hours, with a standard deviation of 44 hours. At sea, the catch of each trap was placed in separate containers. On return to the laboratory, the fish were identified and measured (fork length). The total catch weight was also noted.

Due to the relatively small distances separating the four trapping sites, the similar depth ranges fished at each site, and the short study duration likely resulting in an absence of seasonal effects, we elected to combine data from the four sites. To better describe the results of the study, we defined three depth intervals as follows: shallow (<60 m), intermediate (60-120 m), and deep

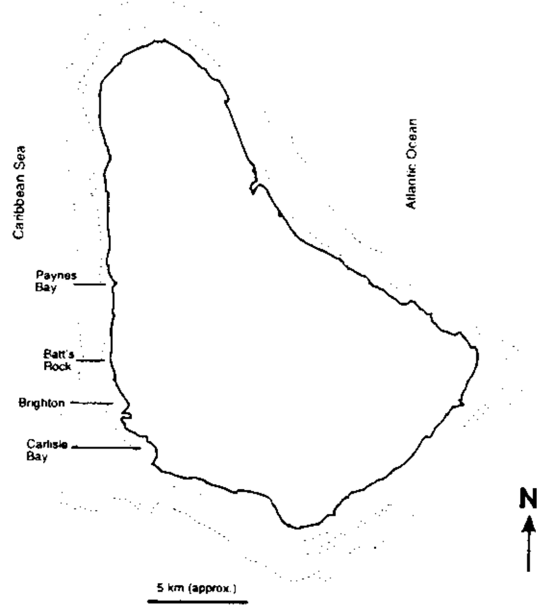

Figure 1. Location of sites off the west coast of Barbados fished during a survey of reef fish resources conducted between September and December, 1989. Isobaths shown are at 18 m (10 fathoms) and 183 m (100 fathoms).

(>120 m). Most commercial trap fishing activity occurs within the first interval, at depths less than 20 m (Wilson, 1983). The statistical analyses were completed using SPSS-PC (Norusis, 1990) or standard spreadsheet software.

RESULTS

As noted earlier, soak time varied considerably. Catch biomass appeared only weakly correlated with soak time (Figure 2). Since each depth interval fished was associated with a similar range of soak times, we made no attempt to standardize for varying soak time.

We completed 88 sets and captured 681 fish, representing 51 taxa. The five most common species included in the catches were, in descending order, silk snapper, squirrelfish, blackfin snapper, striped grunt, and French grunt (Table 1). The range of depths fished is shown on Figure 3, with the mean depth being 102 m.

We noted a negative relationship between increasing depth fished and number of taxa caught, as indicated below:

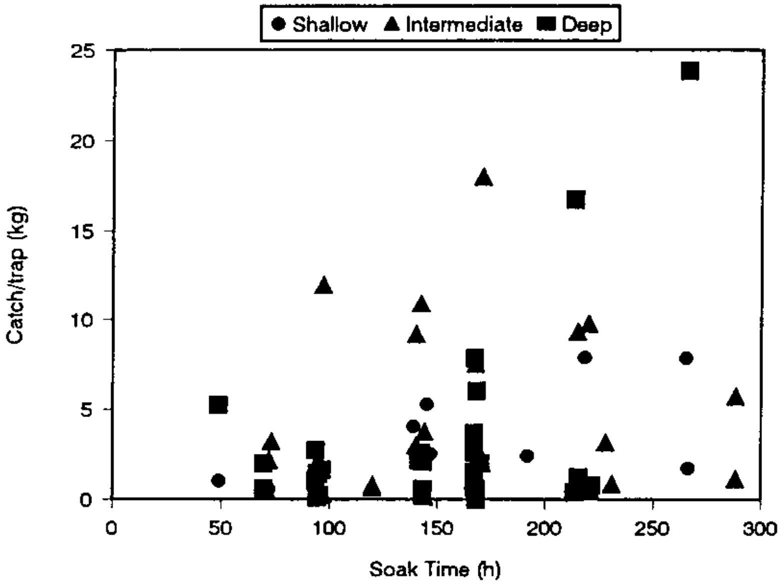

Figure 2. Relationship between catch/trap (biomass) and soak time (h) observed during a survey of reef fish resources, Barbados, September and December, 1989. Shallow sets were those < 60 m, intermediate sets were 60-120 m, and deep sets were > 120 m.

Depth Interval (m)	Number of Taxa Caught	+One Standard Error
< 60	4.07	0.48
60-120	2.49	0.19
>120	1.84	0.17

One-way analysis of variance indicated that the differences among depth intervals were significant ($F = 15.64$, $P<0.0001$). There also appeared to be a tendency for the largest catch weight to be taken in intermediate depths:

Depth Interval (m)	Average Catch Weight (kg)	+One Standard Error
< 60	3.23	0.64
60-120	4.74	0.86
>120	3.03	0.88

However, the differences in catch weight among depth intervals were not significant (one-way analysis of variance, $F=1.22$, $P=0.3002$).

Table 1. Fish species caught during a trap survey off the south-west coast of Barbados, 1989.

Common Name	Scientific Name	Total # Caught
silk snapper	*Lutjanus vivanus*	159
squirrelfish	Holocentridae (unidentified)	61
blackfin snapper	*L. buccanella*	63
striped grunt	*Haemulon striatum*	49
French grunt	*H. flavolineatum*	48
blackbar soldierfish	*Myripristis jacobus*	38
yellow goatfish	*Mulloidichthys martinicus*	31
blue tang	*Acanthurus coeruleus*	27
queen triggerfish	*Balistes vetula*	21
amberjack	*Seriola dumerili*	21
vermilion snapper	*Rhomboplites aurorubens*	12
spotted moray	*Gymnothorax moringa*	11
ocean surgeonfish	*Acanthurus bahianus*	11
horse-eye jack	*Caranx latus*	8
mahogany snapper	*L. mahogoni*	7
red hind	*Epinephelus guttatus*	7
scrawled filefish	*Alutera scripta*	9
moray eel	Muraenidae (unidentified)	6
Sargassum triggerfish	*Xanthichthys ringens*	6
yellowtail snapper	*Ocyurus chrysurus*	6
rock hind	*Epinephelus adscensionis*	5
cavally	*Scomberomorus cavalla*	5
brotulus	Brotulinae (unidentified)	5
bigeyes	Priacanthidae (unidentified)	5
black margate	*Anisotremus surinamensis*	5
honeycomb cowfish	*Acanthostracion polygonius*	5
cowfish	Acanthostracion (unidentified)	5
French angelfish	*Pomacanthus paru*	4
yellowfin grouper	*Mycteroperca venenosa*	4
coney	*Cephalopholis fulva*	4
graysby	*Epinephelus cruentatum*	3
sand tilefish	*Malacanthus plumieri*	3
yellowmouth grouper	*Mycteroperca interstitialis*	3
boxfish	Lactophrys (unidentified)	3
unidentified parrotfish	Scaridae (unidentified)	2
Caribbean red snapper	*Lutjanus purpureus*	2
whitespotted filefish	*Cantherhines macrocerus*	2
black snapper	*Apsilus dentatus*	2
longfin damselfish	Pomacentridae (unidentified)	1
conger eel	*Conger triporiceps*	1
cottonwick grunt	*Haemulon melanurum*	1
trumpetfish	*Aulostomus maculatus*	1

Table 1. Continued.

Common Name	Scientific Name	Total # Caught
soapfish	*Rypticus saponaceus*	1
gray angelfish	*Pomacanthus arcuatus*	1
rock beauty	*Holacanthus tricolor*	1
banded butterflyfish	*Chaetodon striatus*	1
viper moray	*Enchelycore nigricans*	1
bar jack	*Caranx ruber*	1
queen snapper	*Etelis oculatus*	1
barracuda	Sphyraenidae (unidentified)	1
snowy grouper	*Epinephelus niveatus*	1
TOTAL		681

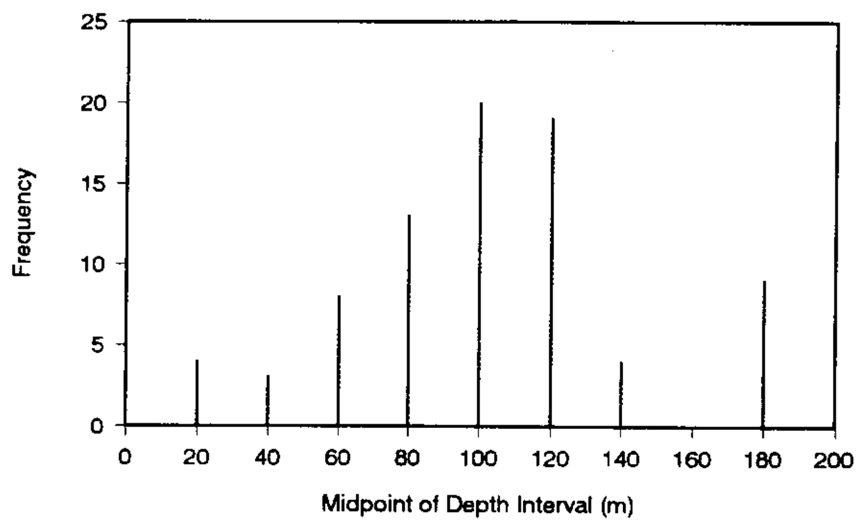

Figure 3. Frequency distribution of depth classes fished during a during a survey of reef fish resources, Barbados, September and December, 1989.

We examined relationships between depth of set and the size of fish caught. A positive relationship existed for blackfin snapper (F test for significance of the slope of the regression = 18.561, $P < 0.0001$, $r^2 = 0.260$, Figure 4), but no such relationship was found for silk snapper ($F = 0.862$, $P = 0.355$). Among other species caught, we had sufficient data to examine the relationship for French grunt only. In that instance, the relationship was also not significant ($F = 3.377$, $P = 0.075$).

In certain cases, confamilials or congeners had distinctly different depth distributions (Figure 5). There were sufficient fish of certain species caught to complete a statistical comparison of their depth distributions. For silk and blackfin snappers, both the mean depths differed (Mann-Whitney $U = 1487.5$, $P<0.0001$), as did the distributions of depths over which the fish were found (Kolmogorov-Smirnov 2-sample test $Z = 4.122$, $P<0.0001$). Two sets in deeper water caught vermilion snappers, at depths of 183 m (10 fish) and 198 m (two fish). A second example of marked differences in the depth of occurrence of congeners was found in the Haemulidae. In that case, the mean depth in which French grunt were found was significantly shallower than striped grunt (Mann-Whitney $U = -8.990$, $P<0.0001$), as was the distribution of depths over which the fish were found (Kolmogorov- Smirnov 2-sample test $Z = 4.899$, $P<0.0001$).

The percentage composition (by number) of the catch by family is shown in Figure 6. As can be seen, the Haemulidae and Acanthuridae dominated the catch in shallow waters. The Lutjanidae, however, became dominant in catches made in deeper water.

DISCUSSION

Although our sample size was small, we did not, however, observe the asymptotic relationship between soak time and catch predicted by the model of Munro (1974). It may be that fish densities off Barbados were insufficient to achieve a trap saturation effect. It has also been noted that species composition changes with soak time (Munro, 1974; Stevenson and Stuart-Sharkey, 1980; and Hartsuijker and Nicholson, 1981). As indicated earlier, soak time was not correlated with depth fished in our survey, so relationships between species composition and soak time are not of concern for the inferences presented here.

We found a significant negative relationship between depth fished and number of taxa caught. This is consistent with an earlier report by Wolf and Chislett (1974), who conducted extensive trap fishing surveys throughout the Caribbean region. Wolf and Chislett also noted an increased proportion of snappers with depth, consistent with our observations summarized in Figure 6.

The positive correlation between depth fished and average size of blackfin snapper (Figure 4) is consistent with previous observations of the Serranidae and Lutjanidae (Appeldoorn *et al.*, 1986). The absence of such a relationship for

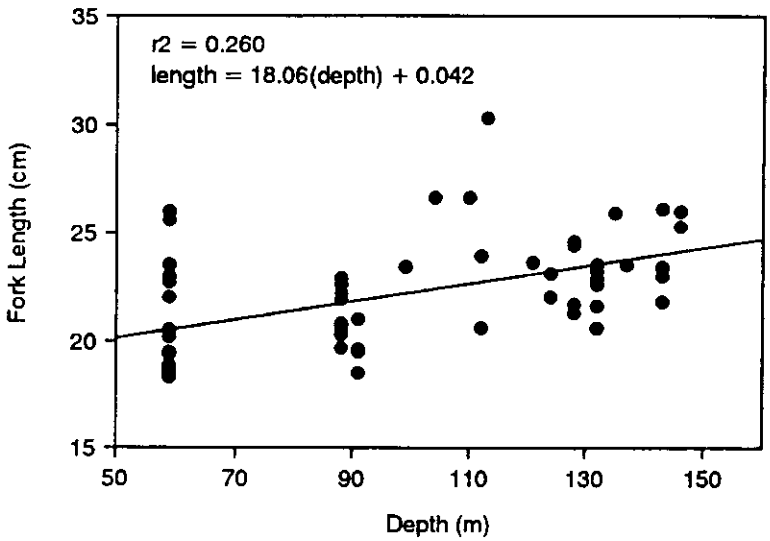

Figure 4. Relationship between the length of blackfin snapper (*Lutjanus buccanella*) and depth of capture during a survey of reef fish resources, Barbados, September and December, 1989.

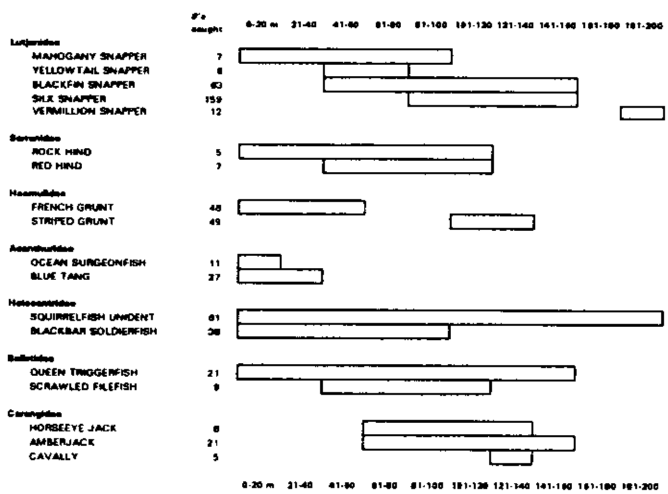

Figure 5. The ranges of depth over which reef fish were captured during a survey of reef fish resources, Barbados, September and December, 1989. Only those taxa which had at least 5 representatives in the catch are shown.

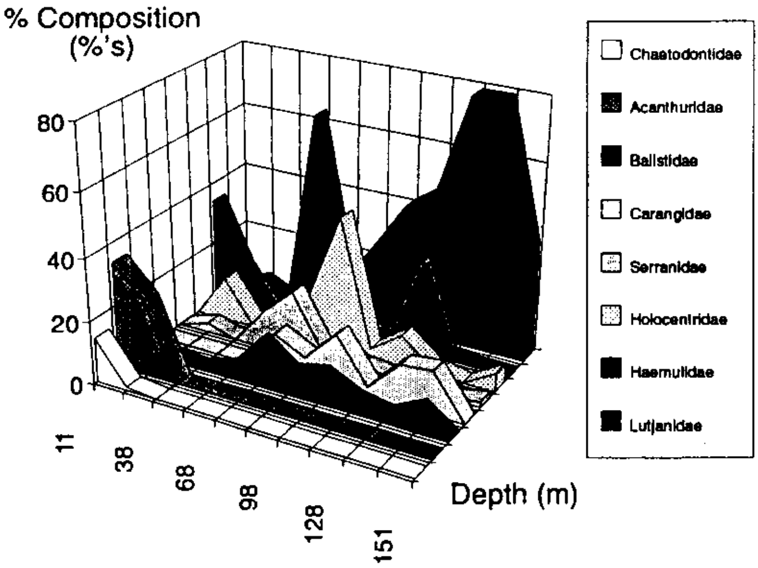

Figure 6. The percent composition by family with depth of trap catches observed during a survey of reef fish resources, Barbados, September and December, 1989.

other snappers and groupers caught in our survey may be due to the small sample size and the depth range of the survey area. For example, for many species, it appears that juveniles are found in water as shallow as 5 m (Appeldoorn *et al.*, 1986). The shallowest set completed during our survey was 6 m.

In a review of the distribution of snappers obtained from research vessel surveys operating in the Caribbean Sea from 1950-1975, Roe (1976) concluded that blackfin snapper occurred in depths from 8 - 197 m. Silk snapper occurred somewhat deeper, with mean depths ranging from 55 - 225 m, although no data were presented for the Lesser Antilles. The deeper distribution of silk snapper is consistent with our data (Figure 5), although we found somewhat more truncated depth distributions, probably reflecting the narrower geographic scope of our survey compared with those summarized by Roe (1976).

One of the objectives of the survey was to determine the extent of resources in deeper water. To place our results in perspective, we present some values for catch weight per trap from other studies in the Caribbean in Table 2. This is a relatively crude comparison, as there is no attempt to standardise for other factors which might influence trap catch rates, such as season (Munro, 1983), time of day, or trap size (Wolf and Chislett, 1974). However, it is clear that

Table 2. Comparison of catch rates obtained in this survey with others completed in the Caribbean region.

Source	Location	Depth	Catch/trap	Comments
This study	Barbados	6 - 198 m	3.90 kg	
Wilson (1983)	Barbados	< 20	1.95	Oistins & Pile Bay data only
Stevenson (1978)	Puerto Rico	10 - 60 m	5.0	
Olsen (1984)	St. Kitts/Nevis	not specified	2.6 (St. Kitts), 3.7 (Nevis)	Calculated on assumed number of sets per day
Munro (1983)	Jamaica	variable	0.60-4.52	Catch rate was location dependent
Gobert (1991)	Martinique	not specified	0.83-1.65-0.71	Highest catch rates at intermediate depths

catch rates in the Barbados commercial fishery (Wilson, 1983) are not as high as some other locations in the Caribbean, and fishermen could improve catch rates by moving into deeper water. In our survey, we also noted an increase in highly-valued species such as the Serranidae and Lutjanidae (Figure 6), indicating that not only would biomass increase as fishermen exploited deeper waters, but the average value of the landings would also increase. Gobert (1991) has also noted higher catch rates of Serranidae with increasing depth off Martinique.

The increased cost of vessels and gear limit fishermen from operating in deeper waters. Wilson (1983) also notes that fishermen may be reluctant to set their traps in depths where they are unable to visually locate them, because buoys would be required to mark their locations. In the fishermen's view, the likelihood of trap stealing then increases, and also trap loss due to inadvertent parting of the buoy lines by passing vessels.

In summary, we have established some relationships between depth and organization of a coral reef fish community off Barbados. Such information should be of use as recent reviews such as Williams (1991) concluded that few data are available to compare the distribution of families within reefs.

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