An Assessment of the Belize Coral Reef Fishery

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ABSTRACT

This investigation was done to assess the state of the Belize coral reef finfish fishery. Catch and effort data were taken from seven sites ranging in levels of exploitation from lightly to heavily exploited during a period of one year. A surplus production model was then fitted to the catch and effort data. The resulting plot showed no decrease in catch per unit of effort (CPUE) with increase in effort. This may be due to 1) violations of some of the assumptions of the model, or 2) effort levels in Belize which are as yet not large enough to affect the resulting CPUE.

The annual yield per area estimated for the reef finfish fishery was 0.338mt/km^2. This is less than the yields of 0.45-4.53 mt/km^2 which have been estimated for the Caribbean.

The catch comprised primarily the valuable snappers and groupers. Although the catch composition and yield per area suggest that the Belize coral reef finfish fishery as a whole may be lightly to moderately exploited presently, catches of a single species, the commercially valuable Nassau grouper, have been declining.

It is suggested that it is possible for a surplus production model to be fitted to a time series of catch and effort data for a single species.

INTRODUCTION

The Belize commercial fishery is a well established one; in 1990, it was the country's fifth largest foreign exchange earner. The lobster *(Panulirus argus)* and queen conch (*Strombus gigas*) made up 73% of the total value of the fishery exports for 1990. Coral reef finfish composed approximately 5% of the total value of fishery exports in the same year. The fishermen primarily target lobster or conch and secondarily finfish.

The mode of transport used is either a motor powered skiffs or sloop equipped with engine and sails. The predominant gear for the demersal fishery is the handline followed by the sling, weir, and trap. Nets (*i.e.*, gill nets and seines) are not used for the demersal fishery.

Fish traps used in Belize are rectangular pimento-framed boxes (dimensions 101.6 cm x 76.2 cm x 63.5 cm) with galvanized wire covering of different mesh sizes (2.54 – 3.81 cm) and a single entrance (Figure 1).

Weirs are used exclusively in the northern fishing grounds. A typical weir extends approximately 36 to 46 meters from the shoreline. It has a heart-shaped trap with two entrances (Figure 2). It is made of galvanized wire with a mesh size of 3.28 cm. The wire is supported with mangrove sticks.

The maximum number of fishermen involved in the fishery is 3500. Records for the period 1985 to 1990 show an almost doubling in exports of finfish from 101,618 kg to 200,093 kg. Similarly, licensed fishermen for that time period also doubled from 1714 (Glaholt, 1986) to 3500.

This increase in fish production and number of fishermen prompted the Belize Fisheries Department to initiate a study aimed at assessing the status of the coral reef finfish fishery in Belize.

The study used to assess the fishery.

METHODOLOGY

The study comprised a two part survey which began in January 1990 and continued until July 1991. Part one consisted of a baseline survey aimed at determining landing sites, fishing grounds, and the number of fishermen per area. Information was also obtained on vessel and gear types, fishing seasons and the fishermen's opinion on the levels of exploitation occurring in Belize.

Part two of the survey involved the collection of catch and effort data which were fitted to an adaption to the Munro and Thompson (1983) version of the Fox Surplus Production Model. The study followed Munro and Thompson method of using catch and effort data from a single point in time over a range of sampling sites. This model was thought to be appropriate for Belize as its data requirements are relatively simple and the results may provide fishery managers with an idea of maximum sustainable yield (MSY). However, some alterations were made to the Munro and Thompson model. Fishing grounds were quantified based on actual areas fished and not on total offshore shelf area and effort was calculated based on gear instead of number of boats in each district.

Catch and effort data were collected by fortnightly sampling at four landing sites. This was done for a period of one year for three of the four landing sites; the fourth site, Placencia, was visited in the last six months of the survey. Based on the baseline survey, it was determined that the fishermen who deliver to these four sites fish the major fishing grounds in Belize. Information on fishing effort and catch was obtained and recorded from all fishing captains who delivered to the landing site on a sampling day. The objective of this paper is to present the results of the second part of this study.

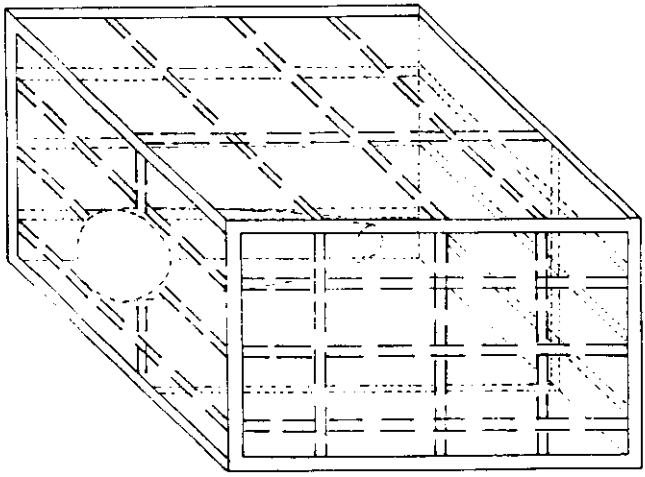


Figure 1. Rectangular fish traps used in Belize.

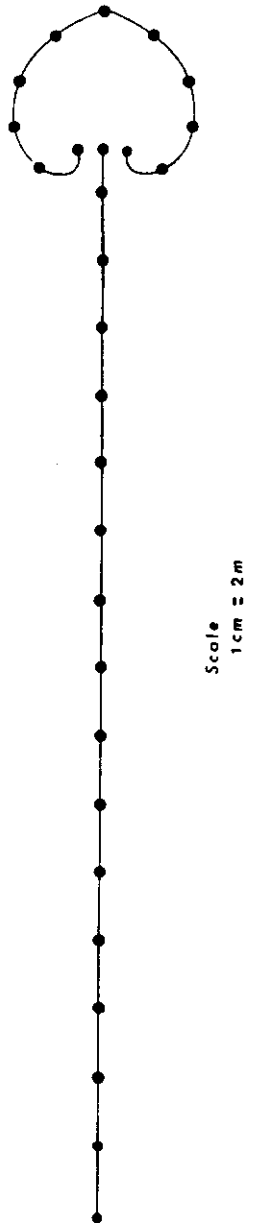
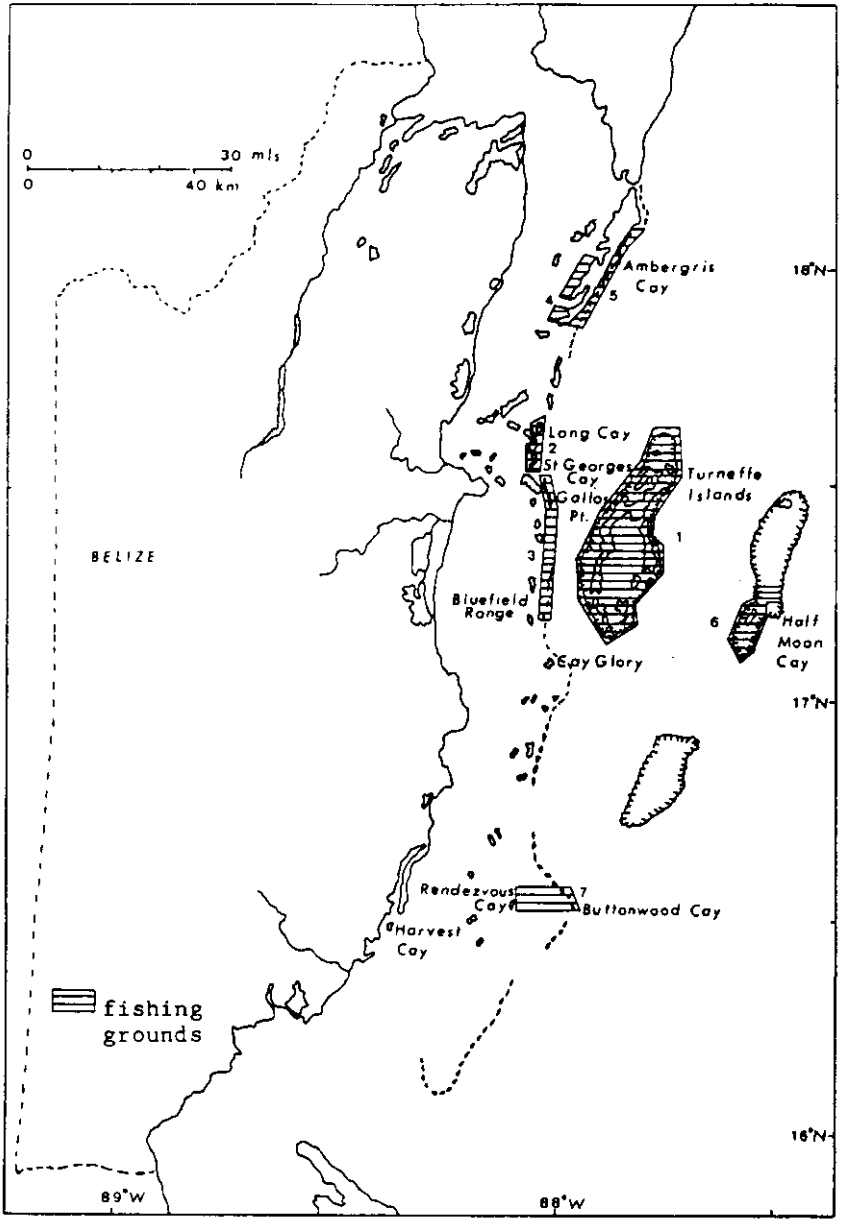


Figure 2. Weir used in Belize.



Fishing 3. Map showing fishing grounds used in the surplus production mode.

Catch and effort data were collected from seven fishing grounds, which been determined, *a priori*, to represent varying levels of fishing effort. The grounds were: 1) The Turneffe Islands, 2) Long Cay to St. George's Cay, 3) Gallows Pt. to Bluefield Range, 4) West Ambergris Cay, 5) East Ambergris Cay, 6) Half Moon Cay, and 7) the Buttonwood Cay/Gladden Cay/Rendezvous Cay area (Figure 3). The fisheries of West Ambergris Cay consisted of fish resident on coral reefs and in lagoons. In this case, only catch and effort data from coral reef fishes were used in the study.

Catch from spawning aggregations was recorded from six of the seven fishing grounds. Since one does not know where the aggregating species come from, the seven fishing grounds had to be redistributed in larger groups when determining CPUE. Carter (pers. comm.) studied the spawning aggregation of the Nassau grouper, *Epinephelus striatus*, in Belize and observed a spawning site on each atoll. On the main barrier reef, he observed a spawning site near Ambergris Cay in the north, one near Cay Glory in the central region, and one near Gladden Cay in the south (Figure 3). The regrouping was done in accordance with these observations. The regrouping was carried out by lumping sites two (St. George's and Long Cay) and three (Gallows Pt.-Bluefield Range). Sites four (W. Ambergris Cay) and five (E. Ambergris Cay) were also lumped, and the remaining sites – Turneffe Islands, Half Moon Cay, and the Buttonwood to Gladden Cay area) – were left as they were.

Catch was recorded in pounds (lbs) and later converted to kilogrammes (kg). Yield was determined by calculating catch per sampling day and then expanding these sampling figures over a year to get annual yield per unit of area for each site. An area of fishing ground was delineated on maps by the fishermen, and the actual area of each site was then determined using a planimeter. The outer barrier reef was used to demarcate the outer limit of each fishing ground.

Effort was calculated for the four types of gear used in the fishery, and is expressed as annual effort per square kilometre. In order to obtain total effort, the different gear types had to be standardized. As the handline is the most widely used gear in Belize, fishing effort was standardized to the handline. This was done by estimting the catch rates of finfish by different gear types and comparing these to handline catches. These estimates were then used to calculate ratios of effectiveness compared to handlines. This analysis was done separately for each area, allowing the summation of catch from each gear type within an area.

Catch composition was recorded and tabulated for each fishing ground. Catches were recorded in family. As the fishing industry is export based, the value of fish in Belize is dependent both on size and type of fish. Grade A fish are generally the mackerels (Scombridae) and the larger (>227 g, whole weight) snappers (Lutjanidae) and groupers (Serranidae). The snappers and groupers

may be marketed either gutted or filleted. The grade B fish include the barracudas (Sphyraenidae) and the smaller snappers and groupers (141 – 227g). Grade C fish include the grunts (Haemulidae) and porgies (Sparidae). However, as the study examined demersal fish stocks, pelagics were not considered in the survey. In addition, as it was not possible to measure all snappers and groupers, grade A and B fish were therefore combined in this study. Filleted fish were also encountered in the study. Converting it to gutted fish (assuming 1/3 of the fish is utilized as the fillet), it is sold for approximately 17% more than a grade A fish.

RESULTS

Landings from all fishing grounds totalled 240 metric tonnes of fish taken from approximately 709 km^2 of fishing area, giving a total yield per area of 0.338mt/km^2.

The yields from the regrouped fishing grounds ranged from 0.08mt/km^2 to 2.92 mt/km^2 (Table 1). The plot of the relationship between CPUE (kg/hook-hr) relative to fishing intensity (hook-hr/km^2) produced a positive slope and MSY based on the regression could not be determined (Figure 4).

Table 1. Yields obtained from fishing grounds during the course of this study.

Fishing Ground	Yield (mt/km^2)
Half Moon Cay	0.08
Turneffe Island Atoll	0.10
St. George–Bluefield Range	0.47
Ambergris Cay	0.58
Gladden Cay Area	2.92

The relationship of CPUE to fishing effort was also plotted using data from the seven fishing grounds, excluding the data from spawning aggregations. The plot produced a slope and the intercept of -0.00007 and 1.43 respectively (Figure 5). Yet, no significant relationship between CPUE and the fishing effort was found (correlation coefficient =-0.028; r^2 =0.0009) and no MSY could be calculated.

The economically important snappers, groupers and barracudas were recorded in all fishing grounds. They made up more than 85% of the total catch. Catches of the lesser valued grunts and porgies comprised less than 3% by weight of the total catch and in some areas were not fished (Table 3). Catches of parrotfish (Scaridae) and wrasses (Labridae) were also recorded. Fish from these two families are filleted. The parrotfish and hogfish comprised approximately 10% of the total catch (Table 3). The hogfish (*Lachnolaimus maximus*), was the only species of wrasse that is commercially fished. .

Table 2. Calculation of CPUE using catch and effort data. Sites are: 1 = Turneffe, 2 = St. Georges & Long Cay, 3 = Gallows Pt.-Bluefield Range, 4 = West Ambergris Cay, 5 = East Ambergris Cay, 6 = Half Moon Cay, 7 = Buttonwood Cay /Rendezvous Cay/Gladden Cay.

SITES	YIELD (Y) (kg/km^2)	EFFORT (f) (hook-hr/km^2)	CPUE (Y/f)
SPAWNING DATA INCLUDED			
6	79.3	27.1	2.9
1	97.1	51.1	1.9
2 & 3	473.1	275.7	1.7
4 & 5	580.1	557.0	1.0
7	2929.0	971.3	3.0
Correlation Coefficient =0.29		slope =0.0006	
r^2 = 0.084		intercept =1.99	
SPAWNING DATA EXCLUDED			
6	37.9	38.4	1.0
2	109.6	46.7	2.4
1	97.1	59.4	1.6
5	170.5	166.5	1.0
7	201.9	202.2	1.0
3	496.3	510.2	1.0
4	1189.2	616.8	1.9
Correlation Coefficient =0.03		slope =0.00007	
r^2 =0.08%		intercept =1.43	

DISCUSSION

The survey produced a yield of 0.338 mt/km^2 for the fishery. Munro (1983) estimated potential yields for demersal reef fishes in the Caribbean to be 1.19 – 1.49 mt/km^2 and Mahon (1990) gave estimates of yields of demersal fish which varied from 0.45-4.53 mt/km^2. The overall yield per unit area obtained in the present study was below the range of yields suggested for the Caribbean. However, looking at the fishing grounds separately, Ambergris Cay and the St. Georges to Bluefield Range area were found to be within the suggested yield range and the Buttonwood Cay area had a yield of 2.92 mt/km^2 which is within the upper range of yields suggested in the literature for the Caribbean region.

An attempt was made to apply the catch and effort data to a surplus production model, however, the CPUE did not increase with increases in effort and MSY could not be determined.

There are a number of reasons why the Belize coral reef fishery could not be fitted to a surplus production model. The effort exerted may not be great

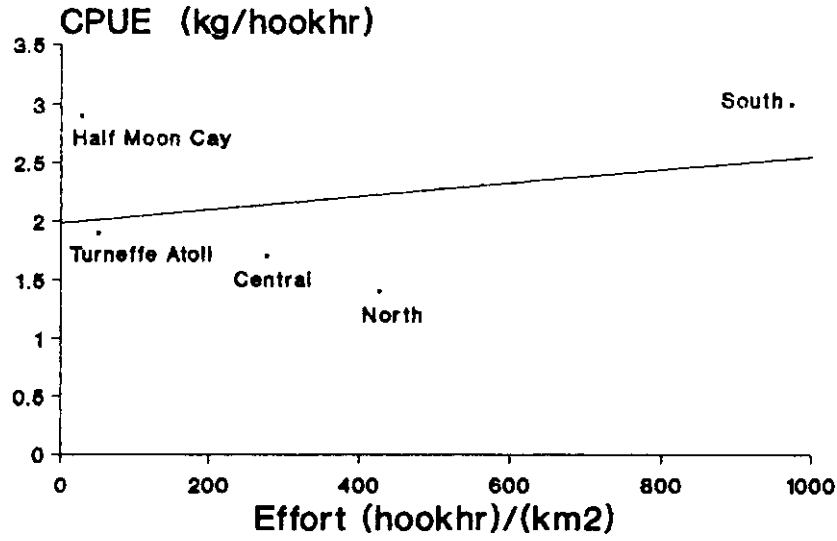


Figure 4. Plot of the relationship between catch per unit effort relative to fishing effort.

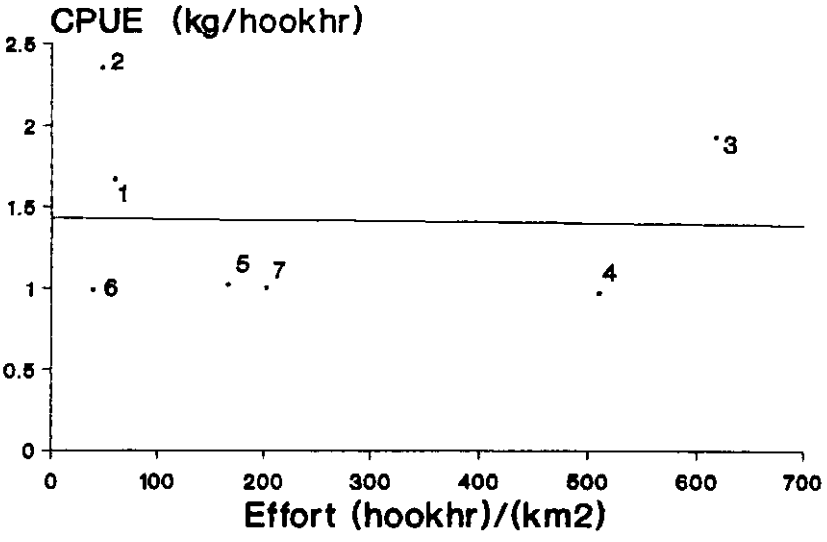


Figure 5. Plot of the relationship between catch per unit effort relative to fishing intensity, spawning data excluded.

Table 3. Catch composition and frequencies obtained from the fishing grounds for the period August, 1990 to July, 1991. Catch is recorded in gutted weight (kg). S/per = snapper, g/per = grouper, b/cuda = barracuda, p/fish = parrotfish, h/fish = hogfish.

	Family (% of total catch)						
Sites	**S/per**	**g/per**	**grunt**	**porgy**	**b/cuda**	**p/fish**	**h/fish**
1	77.00	8.00	0.75	1.00	1.00	—	12.00
2	50.40	48.00	0.40	0.6	—	—	0.60
3	36.00	39.00	4.00	2.00	2.00	2.00	15.00
4	51.70	10.00	0.30	—	22.00	6.00	10.00
5	31.00	2.50	29.00	0.10	14.5	17.00	5.90
6	59.00	15.00	—	—	16.00	—	10.00
7	91.00	3.00	0.40	0.16	2.00	—	3.00
Total	67.80	13.80	2.00	0.70	5.70	2.00	8.00

enough to affect catch . Alternatively, as the lobster and conch fisheries are the most valuable fisheries in Belize, fishermen may have given information on effort that may have included effort used when catching lobster or conch. Also, the fishing practices employed in the Belize coral reef finfish fishery may not show a decline in catch with increasing effort. For example fishermen in a particular fishing ground may exploit one area and when that area shows a decline in catch the fishermen may then move to another area within the fishing ground. Finally, one or more of the assumptions of the model may have been violated. Munro and Thompson (1983) makes the assumption that each area under investigation has a separate stock of fish. However, the aggregations noted during the period of the study brings this assumption into question. Although the grounds were regrouped to account for this, no study has been done to confirm where the fish originate from and one can only speculate about their distribution pattern.

The catch and effort data failed to define a level of MSY; however, one can use the catch composition as an indication of fishing levels. Lorance (1989) used a description of catches on the bank of Saint Martin and Saint Barthelemy as a qualitative index of exploitation. As the snappers and groupers accounted for more than 50% of the total catch, he estimated the banks to be moderately exploited. Haughton (1988) reported in 1981 catches of common and low-valued fish such as Scaridae and Acanthuridae to account for more than 65% of the total catch in Jamaica. He concluded that fishing intensity was high in the north coast and reported a decline in catch per unit of effort.

The low levels of catch per unit of area determined from the study theoretically suggest either over- or underexploitation of the fishery. As catch

was comprised primarily of the more valuable snappers and groupers, however, the assumption that the fishery as a whole is lightly to moderately exploited is a more reasonable one. Although the study suggested that the fishery as a whole may be slightly to moderately exploited, annual catches of a single species fishery, the Nassau grouper, have been decreasing (Carter *et al.*, 1994). It is therefore recommended that further use of the surplus production model be done using a time series of catch and effort data obtained from a single species fishery. This may fulfill the assumptions of the surplus production model and will allow levels of exploitation and maximum sustainable yields to be determined for individual species.

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