A Successful Small-Scale Longline Fishery in Grenada

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ABSTRACT

A small-scale longline fishery began in Grenada in the early 1980's with assistance from Cuba. It has now become the main fishery on the west coast of the island involving approximately 320 fishermen who operate from about 110 pirogue longliners (6.0 to 8.8 m long) and from seven short-stay longliners (10.9 m long). In 1991/92, the fishery accounted for about 466 mt (28%) of the island's total annual fish catch, and was valued at around US$ 1 million wholesale. The average catch per pirogue longline trip was 141 kg with a wholesale value of about US$ 304. The longline fleet operates from the west (leeward) side of the island up to a distance of 40 km from shore, fishing on a daily basis, leaving the shore around 8.30 am and returning between 8.00 pm and midnight. The fishery is presently constrained during the summer months (July to September) by the lack of fresh flyingfish bait.

The main species taken by the longline gear are yellowfin tuna (*Thunnus albacares*), Atlantic sailfish (*Istiophorus albicans*) and blue marlin (*Makaira nigricans*) which account for 63%, 23% and 5% respectively of the catch taken on a pirogue longline fishing trip. The species composition of the catch has changed over the fishing years 1983/84 to 1992/93, with development of the fishery and small changes in the fishing gear and fishing techniques. Yellowfin tuna shows bimodal seasonality in abundance with a major peak from March to May and a minor peak in October, while Atlantic sailfish and blue marlin appear to have unimodal seasonality with peak abundance from December to June and from November to June respectively.

Recent developments in this fishery have been the addition of eight Government-owned longliners to the fleet and an increase in fish exports. In 1992, 98 mt of yellowfin tuna were exported at a value of US$ 467,350. Future plans for this fishery focus on establishing a fish processing plant with assistance from Japan.

KEY WORDS: Atlantic sailfish, blue marlin, Grenada, longline, yellowfin tuna

INTRODUCTION

There are a number of important fishery resources in the Caribbean. These include demersal shelf species (*e.g.* conch, lobster, reef fish and shrimp), inshore pelagic species (*e.g.* shark, bonito, barracuda and blackfin tuna) and offshore pelagic species (*e.g.* dolphinfish, wahoo, large tunas and billfish) (Chakalall,

1984; Wolf and Rathjen, 1984; Marcille and Caddy, 1985; Mahon and Hunte, 1987; Oxenford, 1991; Mahon, 1993). However, many of these stocks are now over-exploited or heavily exploited owing to the demands of increasing local and tourist populations on these resources (Chakalall, 1984; Oxenford, 1991). This has drawn attention to the need for development and management of sustainable fisheries in the region (Mahon and Hunte, 1987; Mahon, 1992). One of the ways in which this can be achieved is by diverting fishing effort from presently over-exploited fisheries to those which still have potential for expansion, and by implementing management strategies in the early stages of development.

The offshore pelagic fishery for large migratory oceanic species is perceived as having the greatest potential for expansion in the Caribbean (Stevenson, 1981; Chakalall, 1984; FAO, 1989; Mahon and Singh-Renton,1992). In the eastern Caribbean these species have traditionally been taken mainly by small-scale local fleets using surface- trolling handlines, primarily for dolphinfish (*Coryphaena hippurus*) and wahoo (*Acanthocybium solandri*) and by large-scale foreign fleets using subsurface longlines (primarily for tuna, billfish and, more recently, for swordfish). Successful large-scale longlining has been practised in the Caribbean region by Japanese, American, Taiwanese, Venezuelan and Korean fleets since the 1950's (Chakalall, 1984; Oxenford, 1991). The longlining technology has not spread to local fleets largely due to the high costs of a typical foreign longline vessel and gear.

However, since the 1982 United Nations Convention on Law of the Sea (UNCLOS) which created the potential for claiming Exclusive Economic Zones of 200 nm, there has been increasing interest in the eastern Caribbean in developing local longlining capability to exploit the subsurface pelagic species (Mahon, 1990; McIntosh, 1993). This interest has been put into action on the island of Grenada where an adaptation of the longlining technology suitable to local financial and human resources has been successfully implemented. A small-scale longline fishery was first established in Grenada in the early 1980's and has developed rapidly over the last ten years to become the primary method of harvesting large migratory oceanic pelagic species for the island.

The main objectives of this study are to document the development of the small-scale longline fishery of Grenada, to describe the current small-scale longline fishing technique used by this fishery, and to determine the present value of the fishery as well as the typical catch rates, species composition and seasonal variation in availability of the target species. It is hoped that by documenting this fishery for the first time, useful information will be provided for the development of other local longline fleets in the region.

METHODS

Data Collection

Data on the present technique employed by the longline fishery and on its development were gathered by observation at the fish landing sites and markets of the longline fishery (Careenage, Melville St. and Gouyave; Fig. 1) and by holding informal interviews with fishermen, vendors, fisheries data collectors, exporters, representatives of fishing cooperatives and staff of the Fisheries Division and Coastal Fisheries Project (CFP, a joint venture between the Grenada Government and the National Fisheries Association which comprises six private-sector fishing cooperatives).

Data on past and present catch rates and species composition of catches of the pirogue longline fleet were obtained from Government fish landing records at the two main landing sites of the pirogue longline fleet (Gouyave and Melville St.) covering the period December 1983 to April 1993 and for those pirogue longliners landing catches at the CFP in the Careenage from April 1992 to April 1993. Accurate interpretation of these records entailed working with the staff of the Fisheries Division, to ensure that catches were always attributed to the correct boat. This was necessary since landings from a given boat on any given day were recorded variously under the name of the boat captain, crew member or owner. Landings were recorded by weight separately for each species and in many cases separately by individual fish. A representative subsample of 21 pirogue longliners which were active for at least several years between December 1983 and April 1993 was chosen for examination of their catch records.

Data on present catch rates and species composition of catches taken by the seven new Government-owned, short-stay longliners operating as commercial vessels were obtained from Government landings recorded by the CFP from April 1992 to March 1993.

Data on the present wholesale value of the catch by species were obtained from the Fisheries Division price records, and data on the total annual catches of all species for the entire island were obtained from summarised landings records kept by the Fisheries Division.

Data Analyses

The present total annual longline catch was determined for the calendar year 1992, using the average catch per trip of the sample of 21 pirogue longliners multiplied by the total number of trips made by all pirogues, and the total catch of all seven short-stay longliners over the year. The wholesale value of the total pirogue longline catch was estimated using Government data on the wholesale value of each species, the average species composition of longline catches and the total annual catch. The wholesale value of the total short-stay longline catch was obtained directly from the CFP records.

Mean monthly and mean annual catch per unit effort (as weight of fish per trip and as weight of fish per 100 hooks) were calculated for each fishing year (September-August) from 1983/84 to 1992/93. Catch per trip data were used to examine changes in the efficiency of fishing trips with development of new gear and techniques. Catch per 100 hooks data were used to examine trends in species abundance. Hooks were preferred over trips as the standard unit of fishing effort since the number of hooks used on a trip have varied over the years. Furthermore, hooks have always been set at a constant distance (54.5 m) apart (Mr. A. Searles, longline fisherman, Melville St., pers. comm.).

Mean species composition of pirogue longline catch was quantitatively compared among three distinct development phases (1983/84-1985/86, 1986/87-1987/86 and 1988/89-1992/93 fishing years) of the fishery. Mean species composition of the short-stay longline catches taken in the period April 1992 to March 1993 was quantitatively compared with mean species composition of pirogue longline catches for the same period.

Government catch per trip data for pirogue longliners were missing for three or four months of the 1983/84, 1987/88 and 1992/93 fishing years. These were filled in based on the seasonality of mean catch per trip over the 10-year period (1983/84-1992/93).

RESULTS

Development of the Small-Scale Longline Fishery

The Grenada longline fishery started in the early 1980's as a Government initiative with assistance from Cuba who donated four ferrocement fully equipped longlining boats and provided training for local fishermen. The local longline fishery subsequently developed in three distinct stages as described below.

1983/84-1985/86: The simple Cuban longline gear and fishing method was quickly adopted by 25 of Grenada's 400 surface-trolling pirogues (6.0 to 7.5 m long) in the local pelagic fleet. This Cuban longline gear comprised a simple plywood box in which the mainline and droplines were stored, with the hooks attached to the sides of the box (Fig. 2). The early pirogue longliners operated from two main landing sites on the west coast of Grenada (Gouyave and Melville St.; Fig. 1) fishing to a distance of 5.5 km from shore. The new technology was not adopted by any east (windward) coast boats, where sea conditions were considered too rough for safe handling of the gear and large-sized fish.

The pirogue longliners fished on a daily basis leaving the shore at 6.00 am and returning between 6.00 and 7.00 pm. The mainline was 2.5 km long and carried approximately 45 hooks baited with flyingfish and set at a depth of 27 to 54 m (Table 1). They made one gear set per trip and stayed with the longline until retrieval. They fished only during the traditional surface pelagic fishing

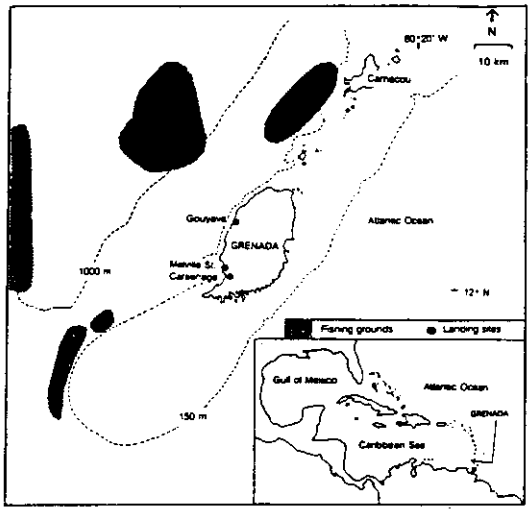

Figure 1. Main fishing areas and landing sites of the longline fishery of Grenada.

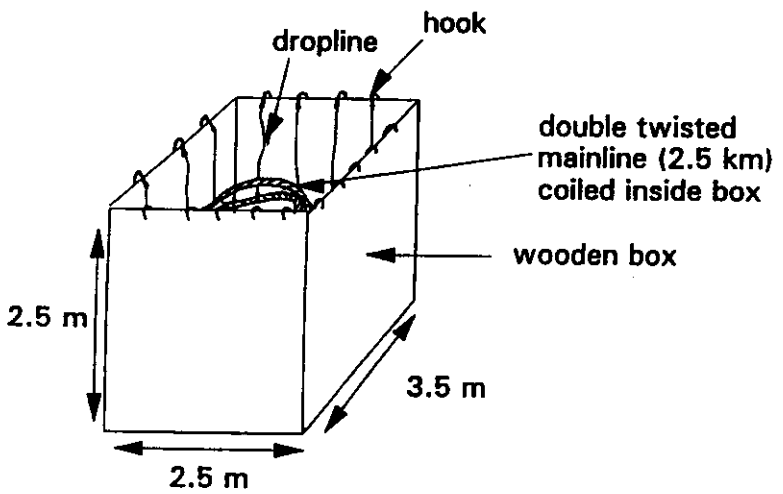

Figure 2. Longline "box" gear used by the early longliners (1980-1988) in Grenada.

year (October to June), being constrained by the lack of flyingfish bait from July to September. The total cost of these early longline pirogues including an outboard engine of 25 to 30 hp and the longline gear was approximately US$ 4,500. This early pirogue longliner was popular for about three years during which time the longlining fleet size gradually increased. The main target species of the longline gear were yellowfin tuna (*Thunnus albacares*), Atlantic sailfish (*Istiophorus albicans*) and blue marlin (*Makaira nigricans*). Flyingfish, dolphinfish and shark were also caught on the same fishing trips using alternative gear.

1986/87-1987/88: In early 1986 a local boat building company bought a hull mould of the Trinidadian offshore pirogue, designed a small cabin top and began building fiberglass longliners which were 8.8 m long, carried three fishermen and were operated with two outboard engines. They began marketing these fiberglass pirogue longliners before the start of the 1986/87 fishing season, fully equipped with two 40-60 hp outboard engines, box-type longline gear and safety equipment (radio, flares, lifejacket, compass etc.) for around US$ 18,000. Builders of wooden boats quickly copied this new design and the new wooden pirogues fully equipped with the same gear as the fiberglass model came on the market for around US$ 8,000-10,000. Speed had become important with the increasing size of the longlining fleet since there was often a glut of longline species on the market by late evening and fishermen competed with one another to reach the shore first and sell their catch.

As well as a change in pirogue design, there were also changes to the early fishing gear which were adopted by the entire longlining fleet. Although the box was still used for storing the longline gear, the 2.5 km mainline now comprised a double line twisted together for easier handling since the gear was set and retrieved by hand, and the length of the floatline was increased to 18 m and the droplines ranged from 27 to 36 m such that the hooks were set at a depth of 45-54 m (Table 1).

1988/89-1992/93: In early 1988 a Grenada/USA joint venture was undertaken and seven US longline boats were allowed to fish in Grenadian waters for one and a half years with one Grenadian fisherman onboard acting as observer. The catch was landed in Grenada and air-freighted back to the US mainland for marketing. These boats stored their mainlines and droplines on hydraulically operated reels, had 20-32 km of mainline and used about 355 hooks baited with squid and lightsticks. They fished at night, set their gear around 6.00 to 7.00 pm and retrieved it early the next morning. They were not restricted by seasonal availability of bait and consequently fished year-round. A modification of the US gear was quickly adopted by the local longline fleet and is still in use today.

The box is no longer used to store the mainline but has now been replaced by two or three hand operated reels onto which the mainline, droplines and floatlines are coiled (Fig. 3). The mainline is now single again and untwisted

since it is no longer pulled in and coiled by hand, but retrieved using the hand operated reel. The mainline has also been increased from an average of 2.5 to 6 km in length with approximately 110 hooks set per trip (Table 1). The length of the floatline now ranges from 9 to 18 m and the dropline from 36-72 m such that the hooks are now set to a depth of 45-90 m. The length of the fishing trip also increased, now lasting from about 8.30 am to between 8.00 pm and midnight of the same day. The longliners typically make one to two trips per week but may make up to four trips per week during periods of peak catch rates.

Recent Initiatives: A recent development in the longline fishery is a Government initiative to export swordfish and yellowfin tuna to the USA. However, fish for export must be Grade A quality which has required a change in traditional fish handling techniques. The tuna and swordfish must be bled and gutted at sea immediately after capture; must be stuffed with frozen "gel packs" and must be handled with extreme care to prevent bruising. The present pirogue design has very limited deck space which is not really adequate for the careful handling of Grade A fish for export, and is too small for the installation of an icehold for cold storage of gutted fish at sea. Furthermore, there is a lack of shore-based ice making and fish storage facilities at landing sites to handle and transport Grade A fish. This situation has so far constrained further development of a large-scale export trade. However, in 1991 the Japan International Consultants Agency (JICA) came to the assistance of the Grenadian fishery with a gift of eight short-stay longliners jointly designed by the Grenadians and Japanese to suit the local sea conditions and fishing technology whilst at the same time allowing for easier handling and temporary storage of Grade A fish at sea.

The short-stay longliners are 10.9 m long and have greater deckspace with a cold storage capacity of 2.4 m3 for holding fish and ice at sea. They are constructed of fibreglass, have an inboard diesel engine of 70 hp and have an endurance of 370 km at a full and maximum speed of 16.5 km/hr. They are equipped with a small sleeping cabin and beds for three crew, a depth sounder, wireless telephone, longline winch, hydraulically operated mainline reel with droplines and floatlines, buoys, 140 litres of potable canned water and cooking apparatus. In the first year, seven of these Government-owned, short-stay longliners were operated as commercial vessels from April 1992 to March 1993 by the CFP. The eighth vessel was designated as a Government fisheries research and training vessel whilst the other seven vessels have recently been sold to private owners who were able to meet criteria including longlining experience and management skills.

In 1992, in an attempt to further develop the longline fishery, year-round fishing by the local longline fleet was encouraged by the Government with assistance from the Japanese who supplied about 700 kg of frozen squid and sea robin (*Decapterus punctatus*) bait to the Government of Grenada for sale to

Table 1. Main changes which occurred during development of the longline fishery.

CHARACTERISTIC	FISHING YEARS			
	PIROGUE LONGLINERS			SHORT-STAY LONGLINERS
	1983/84-	1986/87-	1988/89-	1992/93
Main gear type	box & line	box & line	line & reels	line & reels
Main pirogue type	wooden	fiberglass	fiberglass	fiberglass
Mean boat length (m)	6.0-7.5+	8.8	8.8	10.9
Mean engine Hp	29	40-60+	66	70
No. of crew	1-2	3	3	3
Mean length of longline (km)	2.5	2.5	6	8
Mean no. of hooks	45	45	110	150
Depth of fishing (m)	27-55	45-54	45-90	45-90
Distance from shore (km)	5.5	?	35-40	35-40
Mean catch* per trip (kgs)	43	63	120	166

* – Target longline species only yellowfin tuna, Atlantic sailfish and blue marlin
+ – Represents range of engine sizes in use

local fishermen at a reasonable price during the summer months when flyingfish bait were not available. Future development plans for the longline fishery include plans by the CFP to establish a fish processing plant with assistance from Japan (McIntosh, 1993).

Description of the Present Longline Fishing Techniques

There are now approximately 320 fishermen who operate from 110 pirogue longliners (Fig. 3) and seven short-stay longliners (Fig. 4) in the Grenada fleet. This represents a conversion of almost the entire west coast surface-trolling pirogue fleet to pirogue longliners and an addition of purpose-built pirogue and short-stay longliners. These two boat types employ slightly different fishing techniques as described below.

Pirogue longliners: The pirogue fishermen operate on a daily basis leaving shore around 8.30 am and travelling for about one and a half hours to the fishing area located 24 to 40 km from shore (Fig. 1). On reaching the fishing area the engines are stopped and the longline gear is set from the hand-operated reels whilst the boat is drifting. Simultaneously a surface gillnet is set to catch fresh flyingfish bait which is said by fishermen to be much more effective than iced or frozen bait. The mainline measuring an average 6 km in length is made of monofilament nylon with a 180 kg breaking strain. Braided nylon loops 1.5 cm thick are inserted every 54 m along the mainline, onto which the floatline and/or droplines (stored on separate reels) are clipped during the gear set. Buoyed floatlines (9 m in length) are attached every fourth loop (162 m apart) and one dropline (36-72 m in length) baited with iced or fresh flyingfish is attached to every loop (Fig. 5)

The mainline is paid out until all the hooks are baited or (as is often the case during the periods of low flyingfish availability) until all the bait has been used. The end of the set longline is then left attached to the drifting pirogue for the duration of the "soak" time (8-10 hours). While the longline is "soaking" single hook handlines are often set to catch large surface pelagic species such as dolphinfish and shark.

The longline gear is retrieved sometime between 6 and 8 pm in the same order as it was set (*i.e.* the pirogue detaches itself from the end of the mainline and travels back to the beginning of the mainline to the first set dropline). From here the pirogue then travels parallel to the mainline observing the buoys in the order that they were set. A buoy standing on end is an indication that a fish is hooked on a dropline below. On observation of such a buoy the engine is cut and the fish and the extent of mainline that was previously set and has no target fish are retrieved. All three crew are required for catch and gear retrieval. One retrieves the mainline and unsnaps the floatlines and droplines, another coils the mainline and droplines on the respective reels and the third coils the floatlines and stacks the buoys to ensure that the deck is left clear for handling the catch. On reaching a dropline with a hooked fish, the dropline is unsnapped from the

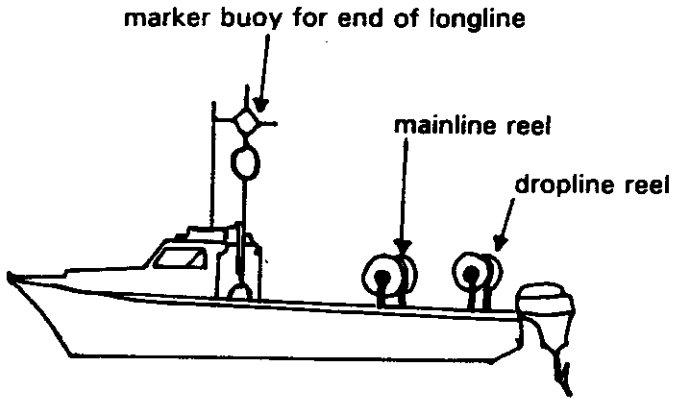

Figure 3. A typical Grenadian built pirogue longliner (8.5 m) showing the small cabin and position of the reels used for setting and retrieving the longline gear.

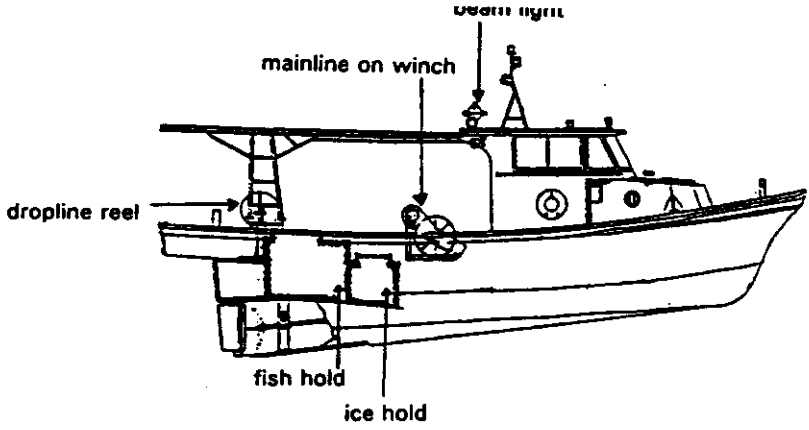

Figure 4. Japanese donated short-stay longliner (10.9 m) from the Grenadian longline fleet showing enlarged deckspace, gear reels, ice and fish holds.

mainline and reattached to a separate heavy braided nylon line (200 m long) attached to the deck. This is to ensure that the power and weight of the fish does not damage the mainline during retrieval. The fish is then pulled to the boat by hand, "gaffed" in the head so that it is stunned and pulled over the side of the deck by two crew members. Once on the deck the fish is killed by hitting on the head with a wooden club. Yellowfin tuna for export are then bled by cutting slashes on both sides of the finlets and under the pectoral fins and the fish is gutted through the operculum, so as to leave the fish whole. The gutted cavity of the fish is packed with frozen "gel packs" which are held in place by a sponge inserted under the operculum. Gear and catch retrieval can take from four to six hours after which the deck is washed and the boat returns to shore.

Short-stay longliners: During the 1992/93 fishing year these vessels fished for periods of one to four days within the same fishing areas as the pirogue longline fleet (Fig. 1). The longline gear is set in the same manner as from the pirogues except that the vessel motors at about 5.5 km/hr during gear deployment and as much as 8.5 km of mainline (150 hooks) are set at one time. The length of time gear is set to catch fish ("soaktime") is approximately 14 hours (either overnight from 4 pm to 6 pm, or during daytime from 4 am to 6 pm). The target fish are "dressed" onboard by cutting off the head and caudal fin (for Atlantic sailfish the dorsal fin is also cut off) and then stored on ice in the cold storage facility on deck (Fig. 4). Back on shore the fish are carried up the beach with meat hooks to the market facility and laid on sponge mattresses to prevent bruising. A long, narrow corer is inserted in the fish's flesh and the colour of the core of flesh is noted for Grade A export quality. Once the fish is passed for export it is then stored in cold storage facilities at the landing sites.

Present Size of the Longline Catch

The mean catch per trip by the pirogue longliners in 1991/92 was 141 kg and the number of pirogue longline trips was estimated at 3,303. Therefore the estimated total catch of all species taken by the pirogue longliners in 1991/92 was 466 mt.

Present Value of the Longline Fish Catch

The mean wholesale value of a pirogue longline catch per trip in 1991/92 was US$ 304, and the total annual revenue generated by the pirogue longline fleet was estimated at US$ 1,004,112.

Changes in Catch Rates

The annual mean catch per trip of the target longline species (yellowfin tuna, Atlantic sailfish, blue marlin) has changed with development of the pirogue longline fleet, increasing almost three-fold from 57 kg in 1983/84 to 167 kg in 1992/93 (Fig. 6). This is mainly due to an increase in catch per trip of yellowfin tuna (Fig. 6). Mean catch per trip for the three development phases of the fishery were 43 kg for the early period (1983/84-1984/85), 63 kg for the period 1985/86-1986/87 and 120 kg for the period 1987/88-1992/93 (Table 1).

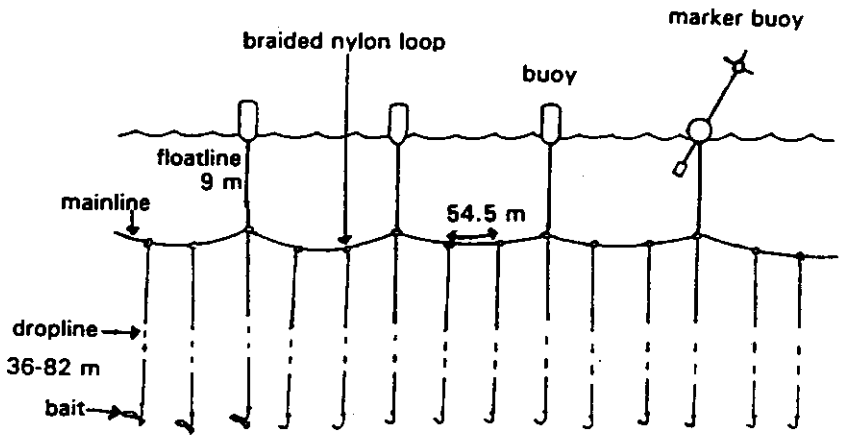

Figure 5. Diagram to illustrate a longline set typical of that used by the present longline fishery of Grenada.

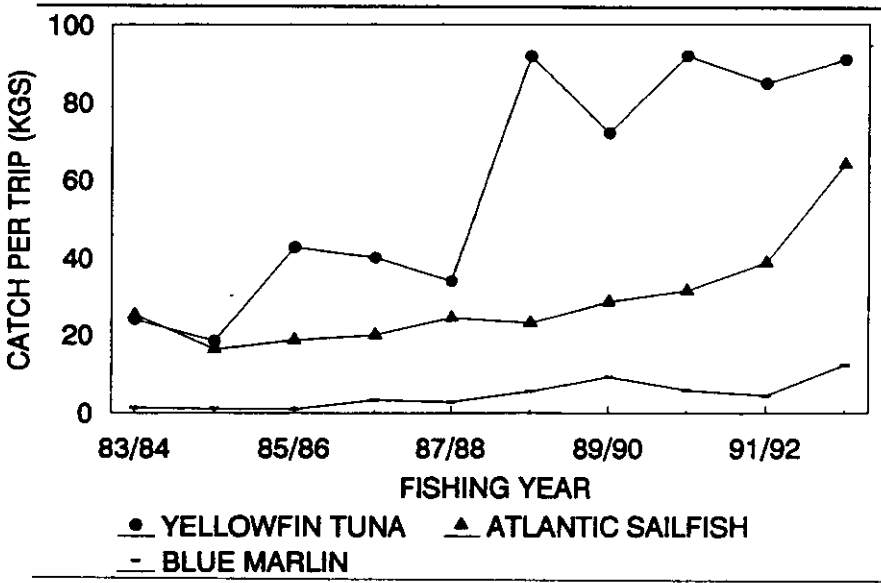

Figure 6. Annual mean catch per trip (kg) for pirogue longliners from 1983/84 to 1992/93 showing catch rate of target species (yellowfin tuna, Atlantic sailfish and blue marlin) separately.

Linear regression analysis revealed an average increase in catch of target longline species per trip of 13.5 kg per year ($r = 0.933$, $p < 0.001$; catch per trip (kg) = 19 + 13.5 years). The annual mean catch per 100 hooks of the target species taken by the pirogue longliners has not increased, but appears to fluctuate around a mean of 125 kg (Fig. 7). This trend is similar for each species, although high and low abundance years were not generally the same across all species except for 1984/85 in which both yellowfin tuna and Atlantic sailfish catch per 100 hooks were low (Fig. 7). Mean catch per 100 hooks fluctuated from 96 kg in the early years of fleet development (1983/84-1984/85), to 140 kg in the period 1985/86-1986/87, to 109 kg in the period 1987/88-1992/93 (Table 1).

The present (April 1992-March 1993) annual mean catch per day trip of target species (yellowfin tuna, Atlantic sailfish, blue marlin and swordfish) for the short-stay longliners is 166 kg. This is significantly less than the annual mean catch per trip (201 kg) for the target species taken by the pirogue longliners during the same period (Student's t-test: $t = 2.39$, $p = 0.009$, $n = 614$).

Changes in Species Composition of Catches

The mean species composition (by weight) of the pirogue longline catches does not appear to have changed much with the development of the pirogue longline fleet. The proportion of target species (yellowfin tuna, Atlantic sailfish, blue marlin) comprised 83 % of the catch in the early stages of development (1983/84-1985/86), 89 % for the period 1986/87-1987/88 and 91 % for the period 1988/89-1992/93 (Fig. 8). The proportion of yellowfin tuna, Atlantic sailfish and all other species combined has not changed significantly over the 10 year period (Comparing more than two proportions (Zar 1984): For yellowfin tuna, $X2 = 1.8$, $P > 0.05$; for Atlantic sailfish, $X2 = 0.446$, $P > 0.1$; for all other species pooled, $X2 = 1.99$, $P > 0.5$). However, the proportion of flyingfish taken has fallen sharply from 5% of the catch in the early years (1983/84-1984/85) to 1% in the latter years (1987/88-1992/93) (Fig. 8).

The species composition of the short-stay longliner catch and the pirogue longliner catch for the period April 1992 to March 1993 is shown in Fig. 9. The proportion of yellowfin tuna and Atlantic sailfish in the catch taken by the two vessel types did not differ significantly (Comparing two proportions (Zar 1984): For yellowfin tuna, $Z = 0.85$, $P > 0.1$; for Atlantic sailfish, $Z = 1.42$, $P > 0.05$). However, pirogue longliners caught no swordfish and only 2% of the catch comprised blue marlin, while swordfish comprised as much as 6% and blue marlin 9% of the catch taken by the short-stay longliners.

Seasonality of Target Species

Seasonal abundance patterns (determined by monthly mean catch per 100 hooks) for each target species (yellowfin tuna, Atlantic sailfish, blue marlin) were consistent over the 10-year period (1983/84-1992/93). The seasonality of each species was therefore determined using 10-year monthly mean catch per

100 hooks (Fig. 10.). Marked seasonality in availability to the longline gear is apparent for all three species. Yellowfin tuna shows bimodal seasonality with a major peak in abundance (112-145 kg/100 hooks) occurring from March to May and a minor peak in abundance (69 kg/100 hooks) in October (Fig. 10a). Atlantic sailfish appears to have unimodal seasonality with a major peak in abundance (29-58 kg per 100 hooks) from October to June (Fig. 10b). Blue marlin appears to have unimodal seasonality with peak abundance (5-9 kg per 100 hooks) from November to June (Fig. 10c). All target species show low abundance in August and September.

DISCUSSION

A small-scale longline fishery has developed quite rapidly since the early 1980's in Grenada with the conversion of most of the surface-trolling pirogues operating on the west coast to pirogue longliners and the subsequent addition of purpose-built pirogues and short-stay longliners to the fleet. The number of pirogue longliners has grown from zero to approximately 110 from 1980 to 1993, and of short-stay longliners from zero to seven over the last two years.

The longline fishing technology has developed from an amalgamation of Cuban and American technologies. Changes made during the development of the pirogue longline fleet included an increase in boat speed resulting from a change from one to two outboard engines, and an increase in gear storage facilities from the box to large reels. These changes allowed longliners greater fishing time and enabled them to handle a much longer mainline. As a result the length of the longline increased from 2.5 km (45 hooks) to 6 km (110 hooks). Recent further development has resulted in a change in vessel design. These new short-stay longliners have an extended deck and gear storage space and a capability to stay at sea for several days. This should increase the economic efficiency of longline fishing trips, since boats can now increase the gear soaktime, decrease travelling costs and handle Grade A fish. An increase in catch per trip compared with pirogue longliners was not evident in this study using 1992/93 data since these short-stay longliners were operating mainly on a daily basis during this period, their first year of commercial operation.

Mean catch per trip of target species for pirogue longliners has shown a marked increase over the period of fleet development from around 57 kg to 167 kg. This could reflect a real change in the abundance of longline species around Grenada, or a change in the efficiency of the trip. Since there was no net increase in the mean catch per 100 hooks over this period, the former would seem unlikely. The increase in catch per trip presumably reflects an increasing efficiency of the longline trip as the length of the mainline, number of hooks set and soaktime of the gear have all increased. This is particularly evident in the marked increase in catch per trip which occurred after 1987/88 when mainline length increased from 2.5 to 6 km (Fig. 6).

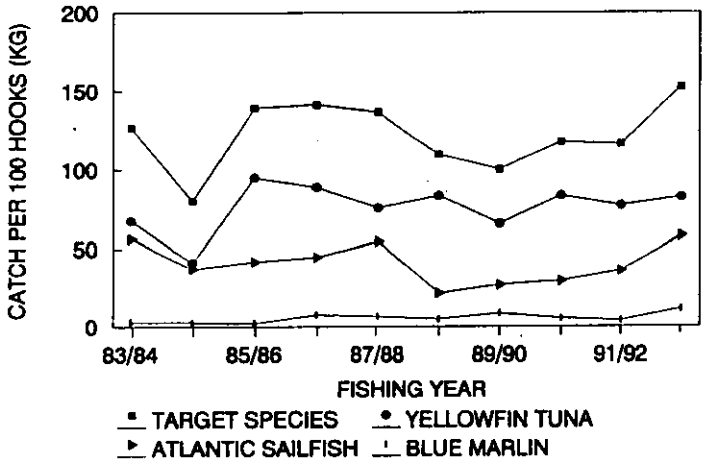

Figure 7. Annual mean catch per 100 hooks (kg) for the pirogue longliners from 1983/84 to 1992/93 showing catch rate of target species (yellowfin tuna, Atlantic sailfish and blue marlin) separately.

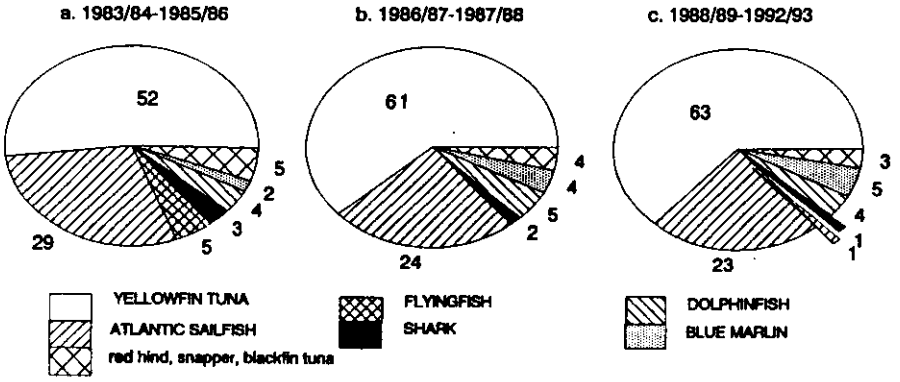

Figure 8. Mean species composition (percentage by weight) of the pirogue longline catch during the different stages of development of the longline fishery of Grenada from 1983/84 to 1992/93. (a) 1983/84 to 1995/86 when pirogues were using a mean of 45 hooks and fishing at depths of 27-54 m; (b) 1986/87-1987/88 when pirogues were using a mean of 45 hooks and fishing at depths of 45-54 m; (c) 1988/89-1992/93 when pirogues were using a mean of 110 hooks and fishing at depths of 45-90 m.

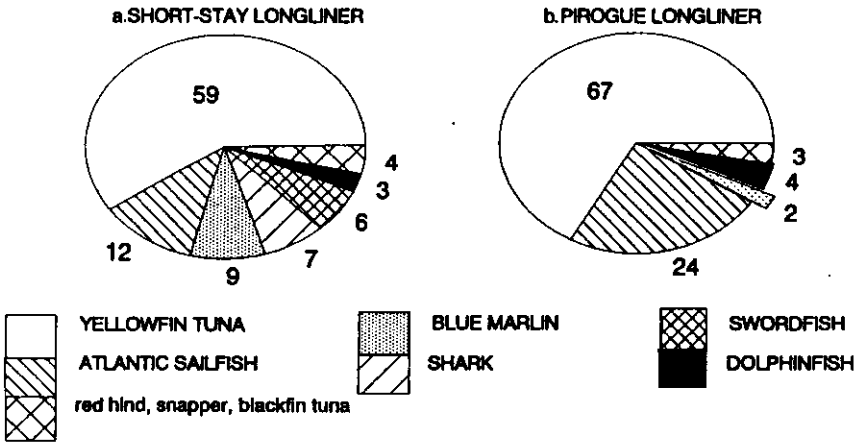

Figure 9. Mean species composition (percentage by weight) for the period April 1992 to March 1993 for (a) the short-stay longliner catch when using a mean of 150 hooks and fishing at depths of 45-90 m, and (b) the pirogue longliner catch when using a mean of 110 hooks and fishing at depths of 45-90 m.

Annual fluctuations in catch per 100 hooks presumably reflect changes in abundance of the target species or in their availability to the gear. 1984/85 was a poor year for both yellowfin tuna and Atlantic sailfish, 1988/89 was particularly poor for Atlantic sailfish and 1989/90 was poor for yellowfin tuna and Atlantic sailfish (Fig. 7). A drop in catch rates of other pelagic fisheries in the eastern Caribbean was experienced in 1988/89 (Mahon *et al.*, 1990). This decline could not be attributed to any climatological or overfishing impacts and was thus considered to be an inherent variability in the abundance of local pelagic fish stocks (Mahon *et al.*, 1990). Yellowfin tuna have shown similar sharp declines in catch rate in other commercial fisheries which have been attributed to a deepening of the thermocline and thus a decrease in the availability of yellowfin tuna to the gear (ICCAT, 1991). This may explain the variability seen in this fishery, but we have no data on thermocline depth changes.

Species composition of catches for pirogue longliners has not changed over the period of fleet development. This implies that the vulnerability of yellowfin tuna and Atlantic sailfish to the longline gear is the same throughout the area fished during development of the fishery (*i.e.* 5.5 to 45 km from shore and for depths of 27 to 90 m) during the development of the fishery. Species composition of catches for pirogue longliners differed little from that of the

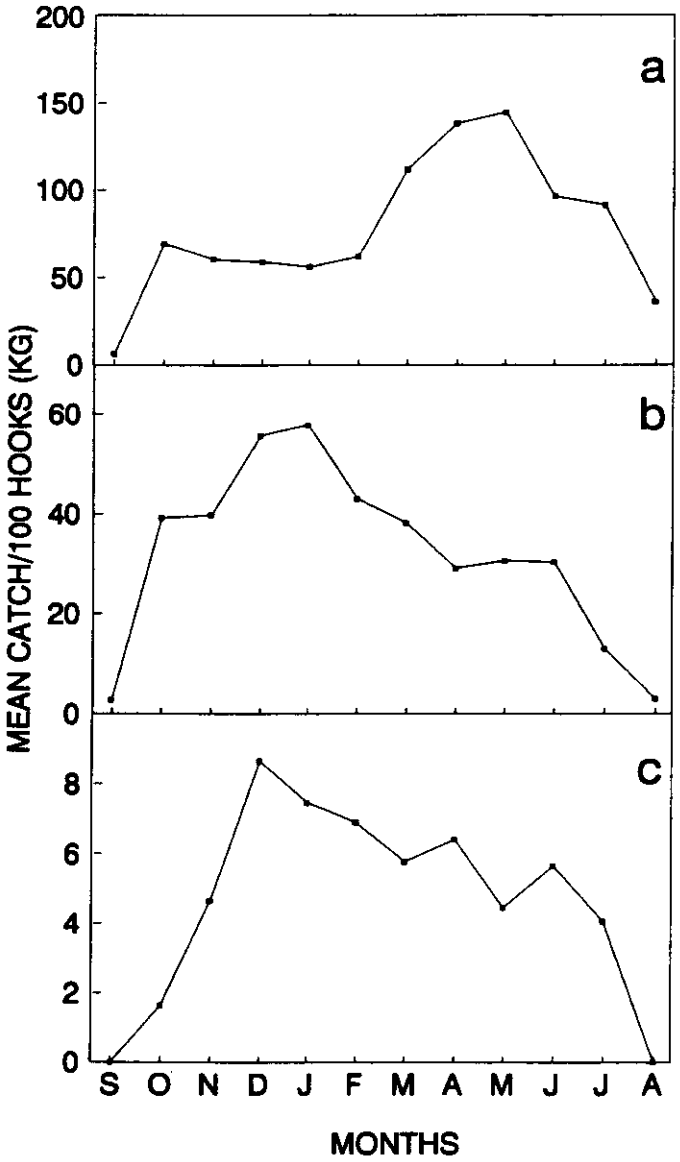

Figure 10. Seasonal variation in mean catch per 100 hooks (kg) for target species: a) yellowfin tuna, b) Atlantic sailfish, c) blue marlin taken by the pirogue longliners. Data represent 10-year (1983/84 to 1992/93) monthly means.

short-stay longliners during the period April 1992 to March 1993. This is presumably because the short-stay longliners were fishing in the same area and at the same depths as the pirogue longliners during this period. The presence of swordfish in the short-stay longliner catch is most likely a result of some gear sets occurring overnight when swordfish appear most vulnerable to capture (Hunte *et al.*, 1994). The marked decline in flyingfish landings is probably due to a combination of less fishing time for alternative gear and an increase in the number of longline hooks requiring flyingfish bait and therefore leaving less flyingfish for the landed catch.

Seasonal variation in catch rates for the target longline species compares well with inferences made by Mahon (1993) on seasonality of the same species in the Lesser Antilles. All target species showed low abundance in August and September. However, this is the period when flyingfish are unavailable for use as bait and alternative bait such as small jacks may be used. This could affect the efficiency of the gear at attracting the target species and may therefore have artificially depressed their abundance. When frozen squid and sea robin were used in August and September of 1992, catch rates were slightly higher, indicating a better potential for year round fishing by the longline fishery.

In summary, the development of a small-scale longline fishery in Grenada appears to have been highly successful. The fishing technique and gear technology developed here for exploiting large, highly priced, oceanic pelagic species has been made accessible to the local Grenadian fishermen, and the mean revenue per trip is highly attractive. Furthermore, there has been a consistent increase in the efficiency of a longline trip throughout the development of the fishery, resulting in a higher catch per trip. Participation in the longline fishery by Grenadian fishermen had not been possible previously, due to the high cost of a typical foreign longliner and gear.

REFERENCES

Chakalall, B. 1984. Perspectives and Alternatives for Fisheries Development in the Lesser Antilles. *Proc. Gulf Carib. Fish. Inst.*, **37**: 154-168.

FAO. 1989. Review of the State of World Fishery Resources. *FAO Fisheries Circular* **710** (6): 55 pp.

Hunte, W., H. A. Oxenford, P. McConney and G. Dharmaratne. 1994. The Feasibility of Developing Longline Fisheries in Barbados. Barbados Development Bank Technical Report. 146 pp.

ICCAT 1991. Report of the Yellowfin Year Program. *Collect. Vol. Sci. Pap.* **36**: 586 pp.

Mahon, R. 1990. Fishery Management Options for Lesser Antilles Countries. FAO Fish. Tech. Pap. No. 313. 126 pp.

Mahon, R. 1992. The CARICOM Fisheries Resource Assessment and Management Programme (CFRAMP). An Overview. Prepared for the FAO Subregional Meeting on Fishery Exploitation within EEZs of English Speaking Caribbean Countries (St. Georges, Grenada). 4 pp.

Mahon R. 1993. Lesser Antilles. Pages 5-98 in FAO, Marine Fishery Resources of the Antilles: Lesser Antilles, Puerto Rico and Hispaniola, Jamaica, Cuba. FAO Fish. Tech. Pap. No. 326.

Mahon, R. and W. Hunte. 1987. Management Options for a Diverse Resource Base. CARICOM Technical Seminar on Fisheries, Kingston, St. Vincent. 13 pp.

Mahon, R. and S. Mahon. 1987. Seasonality and Migration of Pelagic Fishes in the Eastern Caribbean. Pages 192-278 in R. Mahon, ed. Report and Proceedings of the Expert Consultation on Shared Fishery Resources of the Lesser Antilles Region. FAO Fish. Rep. No. 383.

Mahon, R. and S. Singh-Renton. 1992. Report of the CARICOM Fisheries Resource Assessment and Management Program (CFRAMP). SCRS/92/154. 7 pp.

Mahon, R., F. Murphy, P. Murray, J. Rennie and S. Willoughby. 1990. Temporal Variability of Catch and Effort in Pelagic Fisheries in Barbados, Grenada, St. Lucia and St. Vincent. FAO FI:TCP/RLA/8963 Field Doc. 2. 74 pp.

Marcille, J. M. and J. Caddy. 1985. Tuna Resources of the Lesser Antilles: Present State of Fishing and Prospects for Development. *Proc. Gulf Carib. Fish. Inst.*, **38**: 620-654.

Mc. Intosh, R. 1993. Fishing is a Business. *The Barnacle*. **3**(6): 1.

Oxenford, H. A. 1991. Management of Marine Resources for Sustainable Development in the Caribbean. Pages 120-126 in Moore, E. A. and J. Rudder, eds. *Sustainable Development for the Caribbean.* CERMES, Univ. West Indies.

Stevenson, D. K. 1981. A Review of the Marine Resources of the Western Central Atlantic Fisheries Commission Region. FAO Tech. Pap. 211: 132 pp.

Wolf, R. S. and W. F. Rathjen. 1984. Exploratory Fishing Activities of the UNDP: FAO Caribbean Fishery Development Project, 1965-1971: A Summary. *Mar. Fish. Rev.* **36**(9): 87 pp.

Zar, J. H. 1984. *Biostatistical analysis.* Prentice-Hall Inc., Englewood Cliffs, USA. 718 pp.