Grenada and the Grenadines: Reconstructed Fisheries Catches and Fishing Effort, 1942-2001

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Abstract

An annual time series of catch and effort data are reconstructed for the period from 1942 to 1002 for the fisheries of Grenada and the Grenadines, Eastern Caribbean. Information from historical documents, published and unpublished literature and the Grenada Fisheries Department's Statistical Databases was used. Offshore catches of Grenada increased by a factor of 8.6, from 256 tonnes in 1981 to 2,205 tonnes in 2001. Between 1987 and 2001 inshore catches declined from 1,062 t to 400 t, 62% of the 1987 estimate. Offshore catches in the Grenadines were small (17 t average from 1985 to 2001) compared to inshore catches (2,576 t average between 1985 and 2001). However, inshore catches declined drastically from about 700 t in 1986 to as low as 74 t in 1999, 89% the 1986 estimate. A comparison of reconstructed data with data in the FAO FISHSTAT is made and limitations in reconstructed data discussed. Generally a greater number of species are represented in reconstructed data than corresponding information in FAO FISHSTAT. Fishing effort has increased from 1942 to 1999 in both the offshore and inshore fisheries of Grenada (factors of 411 and 21 respectively) and the Grenadines (factors of three and 10 respectively). The corresponding time series of effort and catch per unit effort are presented and discussed as well.

Introduction

Study Area

Grenada lies on the Grenadines shelf and is the southernmost island of the Lesser Antillean chain (UNEP/IUCN 1988), (Figure 1). Its dependencies include some twenty low-lying islands, including Carriacou and Little Martinique. The associated Exclusive Economic Zone and territorial waters comprise an area of 24,153 km² (Global Maritime Boundaries Database, 2000) with a continental shelf area of 1,595 km² (Mahon, 1993). Total reef cover is estimated at 209 km² [mean of estimates in ReefBase (Oliver and Noordeloos, 2002) and Bacon *et al.* (1984)]. The insular shelf within the 100-fathom line on the west coast is extremely narrow, averaging about 926 m while off the east coast it is broader, ranging from 4,630 m in the southeast to 13,890 m in the northeast (Brown, 1945).

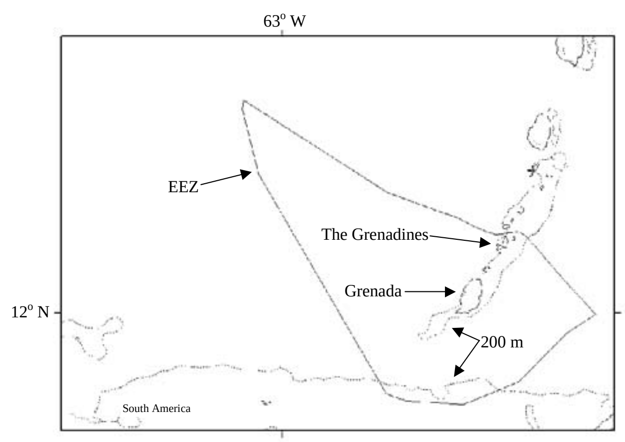


Figure 1: Map of Grenada and the Grenadines, showing the EEZ as well as the 200 depth contour.

Fisheries Development

There is little documentation on the Grenada fisheries prior to the 1980s. Up until 1974, Grenada and the associated Grenadines were British colonies and received assistance from the colonial Development and Welfare Programme. Fisheries development occurred under the administration of the Director of Fishery Investigations in the British West Indies.

Pre 1950s

Prior to the 1950s most of the fishing in Grenada and the Grenadines was of a subsistence nature and targeted mainly the inshore coastal areas (Epple, 1977). Brown (1945) gives a detailed account of fisheries in the Windward and Leeward islands. In Grenada, he noted four major fisheries in the early 1940s: the 'driving' flyingfish and associated large pelagic fishery (caught using the 'ligne dormante' or by trolling); the directed large pelagic fishery; the beach seine fishery for small coastal pelagics, and the hand-line fishery for demersal species. The hand-line fishery operated mainly off the Grenadines. Game fishing was also thought to be quite significant, especially between January and June in the Windward islands (Brown, 1945) because of its association with development of tourism. Already in the early 1940s, Brown (1945) alluded to the depletion of inshore stocks, particularly in the Leeward islands and proposed development of the pelagic offshore and deep water fisheries. All indications are that vessels at the time were all powered either by wind (sail) or oars. However, a significant change occurred after World War II when inexpensive inboard gasoline engines were imported from Europe (Epple, 1977). These were fitted on double-enders or whalers (the design being introduced with the development of whaling in the mid nineteenth century) and pirogue type boats (popular mainly in Trinidad and Grenada). At this time also the government instituted price controls on fish to ensure affordability by all sections of society, even in times of low supply.

1950s to 1980

During the decade from the late 1950s to the early 1960s the government provided loans of up to US$25,000 from the Commonwealth Welfare Program (Vidaeus, 1969) to encourage the mechanization of the fleet. In fact, Grenada was cited as the most advanced in vessel mechanization throughout the Windward islands (Hess, 1961). In 1953, fish-pots were introduced and the Fisheries Department commenced experimentation with outriggers to catch large pelagics by trolling and gillnets to catch flyingfish (Caribbean Commission Secretariat, 1955). Prior to this time, dipnets were used to catch flyingfish for human consumption and as bait for the large pelagic fishery. By the end of the 1950s, gillnets were adopted by the fleet (Hess, 1961). Vidaeus (1969) attests to the consistent popularity of the beachseine, handline and pot fisheries throughout the 1960s. He further noted that the only exports were some 2.7 - 3.6 t of crustaceans (i.e., lobsters) exported annually in the early 1960s. The Grenadines exhibited a greater dependence on demersal fisheries. Beach seining activity was concentrated on the west and north coasts of Grenada and some 15-20 landing areas were being utilized. There appeared to have been a distinct separation in the area of operation of the different fleet types existing at the time. The small row-boats exploited the handline and pot fishery close inshore at depths of 10-15 fathoms. 'Whalers' using handline and pots fished further offshore (10-15 miles) at depths of 30-40 fathoms. They also utilized 'troll' lines when journeying to and from the fishing ground. 'Sloops' utilized both handlines and troll lines. These vessels concentrated more on demersal species and fished further up the Grenadines to St. Vincent. There were also directed lobster and conch fisheries presumably off the south and north coasts of Grenada. By 1969, another government loan scheme was implemented, which provided duty free loans on engines, gear and fishing equipment.

Epple (1977), writing after independence from British rule (1974), gives a detailed account of the impacts of motorization of the fleet, with particular reference to the landing site at Grenville, on the east coast. The most obvious change was the extension of fishing grounds and the increase in fishing time, especially with the reduction in travel time to and from the fishing grounds. Vessels were better equipped to withstand unfavorable sea conditions and this resulted in an increase in the number of possible fishing days. A change in species composition of the catches was also evident, as vessels previously targeting hind, grouper and various reef fish switched, once mechanized, to large pelagics such as blackfin tuna, bonito and billfish (Epple, 1977). Other impacts are related to changes in the marketing system, pattern of vessel ownership, migration of boats, the creation of new economic roles and relationships, the entry of entrepreneurs into the fishery (as boat owners) and a distinct preference for motorized boats by younger fishers while the older ones continued to target inshore demersal and reef resources.

During the 1970s, the industry, however, was still characterized by small artisanal vessels and traditional fishing gear. The marketing structure remained simple, fish being sold at beaches, in the markets or in villages by vendors. Processing was very limited and there was little government support for further development, especially in the area of on-shore cold storage facilities. The 1970s therefore represented a period of stagnation in fisheries development. Retail price control was still in effect and fish catches declined considerably during the late 1970s early 1980s. The fish export policy allowed the granting of export licenses on an *ad-hoc* basis, for species that were abundant and/or unpopular (Peña and Wirth, 1979). Such a situation made it more difficult to acquire a license for dolphinfish, kingfish or tuna than for flyingfish or red hind (Peña and Wirth, 1979). This implies, therefore, that at this time, the landings of large pelagics was still considerably less than demersal/reef species, deep slope and shelf species.

1980s

The period from 1979 to 1984 was marked by tremendous political instability. In 1979, an attempt began to set up a socialist state in Grenada. Four years later, the United States, supported by Jamaica and the Eastern Caribbean States intervened militarily. Finally, in December of 1984, a general election established a new democratic government (Finlay, 1991). Hurricane Allen also struck in 1980 (Finlay, 1991). The extent of hurricane damage on vessels or reef fisheries is uncertain, though considerable impact of an earlier hurricane (Janet, in 1955) on the fleet in Barbados is documented (Barbados Fisheries Department Website, 2000).

Finlay (1990, 1991) also attributed the dramatic decline in landings between 1980 and 1983 to a decline in capitalization in the industry, a lack of government maintenance of on-shore refrigeration holding facilities and the age of the fleet. Another reason for the decline in catches was a reduction in skilled labour associated with the artisanal fleet as a number of the highly skilled fishers opted to work on four semi-industrial vessels donated by Cuba in 1980. These vessels, however, were not equipped for catching a wide range of species, and were fraught with maintenance problems, resulting in substantial reduction in fishing days (Finlay, 1991). The introduction of this fleet however, signaled a new era in the development of fisheries in Grenada: the introduction of longline fishing through he transfer of skill and technology to Grenadian fishers. Initially, however, fishers were very cautious at expanding such a fleet because of the initial high investment costs, the large catches that would be required to ensure profitability, the possible decrease in wholesale fish prices as a result of increased supply, the possible competition with the artisanal fleet and the absence of a proper infrastructure.

From 1982 on, the government invested heavily in the fishing industry through the Artisanal Fisheries Development Project (scheduled to be of 5-6 years duration), a US$ 2.7million project, instituted with financial assistance from the Caribbean Development Bank (Finlay 1990), the International Fund for Agricultural Development (IFAD) as well as technical assistance support from the Venezuelan investment fund (Finlay, 1991). Government's policy focused on increasing fish catches and employment in the industry and reducing fish imports. Among the associated developments were the rehabilitation and expansion of facilities at fishing centers and markets, provision of gear and equipment at duty-free prices and institution of a marketing infrastructure to guarantee the sale of fish (even in times of excessive supply). Price control was, however, still in effect for fish sold on the retail market. Loans were also provided for fleet expansion and development or motorization. The use of outboard engines gained popularity among the artisanal vessels because of the speed this allowed and smaller investment costs compared to inboard engines. Further, by the mid-late 1980s, vessels involved in longlining set to sea with two instead of one outboard engine (Samlalsingh *et al.*, 1995). However, Finlay and Rennie (1989) identified a considerable number of unutilized fishing days despite motorization of the fleet. They attributed this to the high operating costs associated with the outboard engine (used on boats involved in trolling) and indicated the reluctance of fishers to go to sea unless there was a high likelihood that the catches would be high. Nevertheless, fishing with longlines became popular with the artisanal fleet on the west coast.

In 1984, the FAO provided technical assistance to Grenada through its Regional Seas Law Advisory Programme in drafting harmonized Fisheries Laws and regulations tailored to the management needs of the OECS states (Finlay, 1990). Fisheries management in Grenada was thereafter guided by the Grenada Fisheries Act #15 of 1986, and the Grenada Fisheries regulations SRO #9 of 1987.

Apart from the increases in local effort, the Grenada government (unlike that of other

OECS countries) promoted the legalization of foreign fishing and granted licenses to seven US longliners to fish for large pelagics (swordfish, *Xiphias gladius*; yellowfin tuna, *Thunnus albacares*; bigeye tuna, *Thunnus obesus*; and others) within Grenada's EEZ in 1988 and 1989 (Samlalsingh *et al.*, 1995). Also, an unspecified number of locally-based vessels (14-17 m) were licensed to fish for large pelagics; five of these operated out of Grenada (Finlay, 1991). Between 1986 and 1989, a major decrease in landings of large pelagic species was observed (Finlay, 1990). This prompted an investigation of the likely causes under the CARICOM Fisheries Resources Assessment Program. However, the results were inconclusive (Mahon *et al.*, 1990).

By the end of the decade, semi-industrial longliners specifically targeting tuna and swordfish were introduced; there was also a clear preference for inboard diesel engines because of the lower fuel costs compared to outboard engines (Finlay, 1990, 1991). These longliners, capable of ice storage, made fishing trips of several days duration. Very little is documented on fishing in the Grenadines except a decrease in exports to Martinique in late 1980s (Finlay, 1991).

Fisheries development in the 1980s was a result of tremendous government investment and subsidisation of the industry, which contributed to the 'dependency syndrome' of the industry (Finlay, 1990).

1990s

Finlay and Rennie (1998) give a detailed account of fisheries development in the 1990s. The highlight of this period was the tremendous investment in expansion and development of the longline fleet (commencing in the late 1980s) and deregulation of retail fish prices. In 1991 the Japan International Cooperation Agency (JICA) donated eight longliners (10.9 m long and cold storage of 2.4 cubic meters with inboard diesel engine of 70Hp) to the Grenada government. Fishing by seven of these started in 1992 (Samlalsingh *et al.*, 1995). By the mid-1990s, almost the entire west coast pirogue trolling fleet, without any modifications to the vessel design, size (mainly 8 m) or outboard engines, converted to longlining (Samlalsingh *et al.*, 1995). The use of outboard engines, however, continued to result in high operating costs. This prompted the government's formulation of a 'Fishing Vessel Modernization Plan' in 1994, aimed at encouraging fishers to convert from the outboard to more economical inboard engines (Senga, 1995). However, the high initial investment required for inboard engines had been a major deterrent in the conversion of the fleet. With the fleet modernization plan little emphasis was placed on increasing vessel sizes beyond the size of the existing semi-industrial fleet (10-11 m), since this would result in trips longer than the current 3-4 days duration, thereby compromising the quality of the fish brought back for export (Senga, 1995). This has been the reason for the higher prices obtained for tuna caught by the Grenadian fleet compared to the US fleet, which is comprised of larger vessels which stay out at sea for longer time periods. Also, an increase in vessel size will further increase capital and operational costs and would be unattractive to fishers.

Pirogues targeting large pelagics have traditionally restricted fishing activity to the months between November and July (coinciding with the flyingfish fishing season), fishers believing that large pelagics were no longer abundant on the fishing grounds after July. However, the semi-industrial longline fleet fished year-round and demonstrated the occurrence of tuna in what had been called 'off-season' months. The tunas (mainly yellowfin tuna) could be located further offshore (60-80 km) in deeper waters during this period. It should be noted, though, that sea conditions during the hurricane season (July to September) are not conducive to fishing by the smaller (8 m) boats at these distances (Senga, 1995). Fishing trips by the pirogues using longlines now extended to 12 instead of 8 hours and between two and four trips were made per week while the semi-industrial longliners made trips of between 1-4 days duration. Semi-industrial vessels fished in the same areas as pirogues (at least during November to June), and therefore the catches of the two fleets were of similar species composition (yellowfin tuna and Atlantic sailfish, *Istiophorus albicans*). However, less swordfish were caught by the semi-industrial vessels, and less blue marlin, *Makaira nigricans* by the pirogues (Samlalsingh *et al.*, 1995). The year round and increased landings of yellowfin tuna, swordfish and sailfish also prompted increased investment in fish processing and exporting. The latter was also facilitated by improved air transportation to the US, the main export market for yellowfin tuna and swordfish. By 1998, in addition to the ten small processing plants for smaller migratory pelagic species and for lobsters, sea eggs and sea moss, there were four main export packagers for tunas and swordfish. It is not surprising also that given the decline in demersal fisheries in the Grenadines, fishers began switching to longline fishing. This represents an historic move away from the traditional demersal fisheries of these islands.

A less obvious impact of the development of the longline fishery is the change in importance of flyingfish, a traditional food fish, to one of bait in the longline fishery. In fact, the decreased abundance of flyingfish during the months July to September has been known to severely affect longline fishing (Samlalsingh *et al.*, 1995). In an attempt to assist development of the longline fleet, the Japanese provided bait in the form of 700 kg of frozen squid and sea robin to the Government of Grenada, for sale to fishers during the summer months of 1992. There was also a change in fisheries from a subsistence activity to an export oriented one. By the 1990s much of the local consumption consisted of imported processed fish (canned sardines, mackerel, dry/salted cod, smoked herring) which appeared to satisfy the traditional taste and preferences of the Grenada population, while local catches were mainly exported (Finlay and Rennie, 1998).

Fishery developments were matched by significant strides towards fisheries management and compliance with international law. Through the CARICOM Fisheries Resource Assessment and Management Program catch data are submitted to the International Commission for Conservation of Atlantic Tunas (ICCAT) for assessment of billfishes and tuna. The general policy is for expansion of the offshore pelagic fishery, which is perceived as having the greatest potential for expansion in the Caribbean (Mahon, 1990; Chakallal, 1986; Mahon and Singh-Renton, 1992; Finlay, 1991; Finlay and Rennie, 1998).

Fisheries Statistical Data Collection

Grenada was reported to be one of the better equipped countries for fisheries landings data collection in the Caribbean region during the 1960s (Vidaeus, 1969). At the time there were six data collectors who recorded information at five of the six parishes in Grenada: St Georges (fish market), St John (all bays from Halifax to Dothan); St Marks (Victoria fish market and neighboring bays, Duquesne and David Bays); St Patricks (Sauteurs fish market) and St Andrews (Grenville fish market). Landings in the parish of St Davids, and landings of lobsters and turtles were estimated by the Fisheries Officer. The system however, did not incorporate landings in the associated Grenadines, except for that portion landed at the Grenville fish markets. This system of data collection continued into the 1980s.

By 1988 there were improved or new government fish markets at Victoria, Gouyave, St Georges (Melville Street and the Carenage), Grenville and Sauteurs (Finlay *et al.*, 1988). At these sites, the throughput of fish was recorded along with catches for each fishing trip. There existed, however, several sites without markets where data were not collected. These ranged from small landing beaches with only a few boats, through areas where substantial catches of conch and lobster were landed, to points in the Grenadines where substantial amounts of fish were transshipped from fishing boats to trading boats for export to Martinique. Thirteen trading boats operated at the time. The reliability of information obtained from this source was compromised by considerable under-reporting in applications for export permits to avoid high duty fees on landings in Martinique. At this time, the Organization of Eastern Caribbean States hosted a workshop aimed at improving data collection systems in the respective islands (Mahon and Rosenberg, 1988). The plan for Grenada (Finlay *et al.*, 1988) included a total census at major markets, a sampling program for other sites, collection of purchase slips from hotels and restaurants (for lobster, conch and choice fish), review of export licenses, implementation of a logbook system for launches, recreational and charter boats and procedures for estimating foreign catches. Limitations in financial and human resources have, to date, hindered the implementation of this plan.

In the late 1980s, a data collection system was implemented under the Enhanced Research Program for Billfish, initiated under the ICCAT (Andrews, 1990). In addition to data collection at fish landing centers (Gouyave, St John's, Melville Street Market, St George's), the Ministry of Industrial Development and Fisheries was responsible for collecting data from foreign fishing vessels under joint venture arrangements with local investors.

Although there were plans to implement an Observer Program on board these vessels (Andrews, 1990; Samlalsingh *et al.*, 1995), these were not implemented, again due to lack of finances and human resources.

In the early 1990s, under the CARICOM Fisheries Resource Assessment and Management Program, the data collection system was expanded to include landings at Hillsborough in Carriacou, one of the Grenadine islands. More intense efforts were placed on recording catches at the markets. A review of detailed catch statistics provided for 1997 indicate data collection at Grenville market, Melville Street market, Gouyave, Sauteurs, Du Quesne, the artisanal fisheries project, Carriacou and Petit Martinique and eight processors.

It is difficult to pinpoint the gaps in the catch data because of the inconsistency in coverage of the landing sites from year to year. However, it is possible to highlight some of these from discussions with Fisheries Department personnel. Firstly, all fish landed at the markets is recorded. Large pelagics attain the highest prices and are always sold to vendors at markets. After 1995, large pelagics (mainly yellowfin tuna, swordfish and sailfish) have been sold to processing plants and this information is captured in the data collection. By-catch, consisting of billfish, dolphinfish, kingfish and wahoo, are sold to vendors at the markets and these quantities are therefore recorded. Some of the demersal catches are transported to the markets (e.g., Grenville) and are recorded. However a small but unknown proportion is also sold, without records, to the public on the landing beach or to hotels. A major gap exists for landings of the dive fishery which target lobster and conch (mainly the south coast) as these catches are either sold directly to hotels or restaurants, or exported. In these cases data are not recorded though information on the latter may be derived from export statistics. An unknown proportion may also be sold to vendors who may in turn sell at the markets (therefore recorded) or in villages (not recorded). Despite minimum size regulations for the species, there exists a market for undersized lobsters.

Fisheries Policy

A shift in the approach of government to fisheries management was also evident, as Grenada, along with other countries of the Organisation of Eastern Caribbean States, embarked on a program in 1986, with legal assistance from the FAO, to enact a program of harmonized fisheries management legislation. The general fisheries policy focuses on development of the offshore fleet (Finlay and Rennie, 1998).

Objective

The main objective of the present study was to assemble a time series of catch and effort data for Grenada and the Grenadines from 1942 to 2001.

METHODOLOGY

General aspects of the methodology for reconstruction of fisheries catches and fishing effort are discussed in Mohammed (2003).

Fisheries Catches

Catches are reconstructed separately for Grenada and the Grenadine islands north of Grenada for two reasons:
Firstly, the difference in species caught - Traditionally fishers from Grenada target medium sized regional pelagics (small tunas and mackerels) and small coastal pelagics such as scads and jacks, with demersal and reef fisheries being of lesser importance (with the exception of lobster and conch fishing off the south coast). Fishers in the Grenadines have targeted mainly demersal and reef species because of the greater expanse of shallow shelf surrounding these islands. Further, most of the catches do not enter the local market systems but rather are traded with the French Overseas Department of Martinique. This traditional market exerts a tremendous influence on the relative quantities of the various species caught.

Secondly, the quality of the available data – A time series of catch statistics is available from the Fisheries Department since 1978. These statistics are however, confined to Grenada. Up until the mid-1990s, the only available information for the Grenadines was derived from Grenada export and Martinique import statistics. As a result the catch and effort reconstruction is severely limited by unavailability of data for the Grenadines.

Grenada

The essential data sources, for the pre-1980 period, are Brown (1945); Smyth (1957); Vidaeus (1969) and Giudicelli (1978). These data are used as anchor points to define the limits of total annual catches. The Fisheries

Department provided detailed information on annual fish catches by species for the period 1978 to 1999. While this information is collected in sufficient detail to facilitate a more informed estimation of catches by fishery and vessel type, limitations in human resources for data computerization have resulted in the use of data summarized on a weekly basis by market/landing site and species. These data are computerized and annual summaries produced by site and species. Many authors have commented on the limitations of the data collection program which focuses on quantities of fish at the main markets only (Vidaeus, 1969; Chakallal, 1997). Kawaguchi (1985) indicated that apart from the six main markets, where data are collected, there are approximately 25 smaller fish landing areas scattered across Grenada (and 6 across Carriacou), where data are not collected. However, based on observed developments in the fishery, the Fisheries Department has applied adjustment factors to recorded data at markets in Grenville, Melville Street, Gouyave, Victoria, Sauteurs as well as 12 processing/exporting plants (in operation in the 1990s) to estimate total landings. From 1978 to 1998 an adjustment factor of 1.75 was used for all species caught in Grenada. However, from 1998 a smaller adjustment factor (1.4) was utilized for tunas, dolphinfish and billfishes while the 1.75 was applied to records of other species.

Since the Grenada Fisheries Department provided data on combined catches for Grenada and the Grenadines, it was necessary to separate these accordingly. This process was simple since most of the catches reported in the aggregate categories ‘other fish’ or ‘marine fish not elsewhere identified (nei)’, are from the Grenadines. However when these statistics were compared with Martinique import statistics from the Grenadines, there were considerable differences.

Anchor points:
Total catches for the respective years were taken from the following documents: 1942 (Smyth, 1957); 1956 (Salmon, 1958); 1959 to 1968 (Vidaeus, 1969); 1974 to 1975 (Giudicelli, 1978); 1977 (Villegas, 1978); 1978-2001 (unpublished statistics of the Fisheries Department). Estimates provided by the Fisheries Department for 1978 to 2001 included catches in Grenada and exports from the Grenadines to Martinique combined. The difference between total catches and Grenadine exports provided an estimate of catches from Grenada only. Brown (1945) presented a crude estimate of total catches (947 t) for 1942. This figure was much greater that the estimate of 182 t provided by Smyth (1957). Since the latter estimate more closely matched the statistics provided to the FAO it was the preferred anchor point.

First Interpolation: Total catches
Total catches from 1943 to 1955 were estimated by interpolation between the estimates for 1942 and 1956, obtained from the literature. This procedure was also used for estimating total catch for the period 1957 to 1958 and 1969 to 1973 using the anchor points for 1956 (Salmon, 1958) and 1959 (Vidaeus, 1969) and 1968 (Vidaeus, 1969) and 1974 (Giudicelli, 1978) respectively; and for 1976 using the anchor points for 1975 (Giudicelli, 1978) and 1977 (Villegas, 1978).

Some adjustments were made to the anchor points from Giudicelli (1978) since these were quoted as “estimated” figures. This followed, after examination of statistics in Peña and Wirth (1979) who presented both recorded (1,043 t) and raised estimates (3,189 t) for 1978. These statistics were compared to data provided by the Fisheries Department for the same year (1,962 t). The gross discrepancy between the two estimates is attributed to the raising factor used. The Fisheries Department utilizes a raising factor of 1.75. The recorded catch for 1978 according to the Fisheries Department statistics is 1,072 t, quite close to the 1,043 t reported by Peña and Wirth (1979). The raising factor used by these authors (3.0) appears excessive at a time when there is reported to be tremendous lack of investment in fisheries (Finlay, 1991). A review of the literature gives no indication of any factors which would affect the manner in which data were previously collected, and therefore there is no basis for a change in raising factor in computation of total catches. Since the figures presented by Giudicelli (1978) are estimates, it is believed that the same raising factor (3.0) utilized by Peña and Wirth (1979) was used. The data in Giudicelli was therefore adjusted accordingly (applying a raising factor of 1.75 instead), to derive catch estimates of 1,341 t and 1,458 t for 1974 and 1975 respectively.

Second Interpolation: Species Composition
The issue of uncertainty in species identification particularly in earlier years

(Vidaeus, 1969) arises because it is common in data collection either to refer to certain species by local names or to misidentify species (especially the tunas). Vidaeus (1969) listed the following species/groups: jacks, bonito, grouper, ballahoo, cavalli, sprats, albacore, long gar, tuna, flyingfish, herring, red fish, hind shark, shark, dolphin, kingfish, round robin and other fish. The bigeye scad, *Selar crumenophthalmus*, has historically, and continues to be referred to as 'jacks'. Further, since there was a distinct category for sharks, and since there is no known species of shark called 'hind shark' (see www.fishbase.org), it was assumed that 'hind shark' refers to the red hind (*Epinephelus guttatus*, Serranidae). Also, blackfin tuna have historically been mis-identified as albacore, *Thunnus alalunga*, or bonito, *Sarda sarda*, and as such landings of these species were grouped into one category 'blackfin tuna' (*Thunnus atlanticus*). 'Long gar' is the local name for flat needlefish (*Ablennes hians*). For earlier years, the 'herring' category was assumed to represent all other herring species except *Harengula clupeola* and *Opisthonema oglinum*, both of which are reported as separate categories. Both 'red fish' and 'other fish', (Vidaeus, 1969), represent a mixture of perch-like fishes, most often a combination of snapper (Lutjanidae), coney (*Cephalopholis fulva*, Serranidae) and redhind (*Epinephelus guttatus*, Serranidae). For the pre-1978 period, this aggregate category was divided among the three species/groups based on the proportion in the recorded catches of 1978. Hence snapper was comprised of 85% 'redfish' and 37% 'other fish'; redhind was comprised of the category 'hind shark' and 56% 'other fish' and coney was comprised of 15% 'red fish' and 75% 'other fish'. In the post 1978 period the catches of 'marine fish nei' was divided among the three species/groups based on their relative proportions in the recorded catches for the respective years.

Using information on species catches for 1964, 1965 and 1967 (Vidaeus, 1969) and the corresponding annual total catches recorded, an estimate of species composition was derived for each year. In the absence of additional information, the species composition for 1964 was assumed to apply throughout the period 1942 to 1964. For the same reason the species composition of 1967 was assumed to be the same for 1966 and 1968. The species composition between 1968 (Vidaeus, 1969) and 1978 (AFP) was interpolated and used to estimate individual species catches (product of species composition and total catch) using the interpolated estimates of total catch for the respective years.

Adjustment for at-sea processing

Catches of yellowfin tuna, swordfish, sailfish, white marlin and blue marlin from 1992 onwards were adjusted to account for at-sea processing using conversion factors for estimating whole wet weight based on different degrees of processing as indicated in Mohammed (2003) of this report. Yellowfin tuna are gutted at sea and the head, caudal and dorsal fins of sailfish and swordfish are also removed (Samlalsingh *et al.*, 1995). A small proportion of the catch may be attributable to the trolling fleet (and therefore may not be subjected to the strict quality control of longliners supplying foreign markets). As a result the degree of processing may be different for the two fleets. However, since this is a minute quantity of the overall catch (the trolling fleet targeting mainly dolphinfish, mackerels and smaller tunas), it is assumed that all catches of the respective species are attributable to longliners and are processed in the manner described above.

Catches from sport fishing tournaments

Catch data from the annual Spice Island Billfish Tournament (Grenada Fisheries Department, unpublished data) were available for 1992, 1994, 1996 and 1998. Blue marlin, white marlin, sailfish and yellowfin tuna are the main species captured. Estimates for 1993, 1995, 1997 were derived by interpolation between the previous and following years for which data were available.

Estimation of quantities of flyingfish and round robin used as bait

With the development of the longline fleet, commencing in the early 1980s, flyingfish became a popular bait fish for this fishery targeting large pelagics. However, since the flyingfish caught as bait are utilized at sea there are no records of the associated quantities, neither are there records of the quantity of round robin utilized as bait during the flyingfish offseason. Hence a crude estimate is derived for pirogue and semi-industrial longliners as follows:

$$Q = B \times H \times W \times D \qquad \text{...1)}$$

where *Q* is the total weight of flyingfish or round robins utilized as bait each year; *B* is the number of longliners fishing; *H* is the mean number of hooks per vessel; *W* is the mean individual weight of the fish; and *D* is the number of days fishing. The number of longliners (pirogue and semi-industrial) and associated number of fishing days per year are taken from the effort reconstruction component of the present study. Since point estimates for these parameters are available for the years 1982, 1988, 1993, 1995, 1997 and 1999, data for the missing years were estimated by interpolation. No data were available for 2000 and 2001. Hence the same number of boats as that operating in 1999 was assumed for these years. The mean number of hooks is taken from Samlalsingh *et al.* (1995) and the mean individual weight of flyingfish was based on field observations of the author.

The main assumptions in arriving at this estimate are:

1. That mean individual flyingfish weight is 0.15 kg and that each hook is baited with one flyingfish only;
2. That mean individual weight of round robin (utilized as bait from July to October) is the same as for flyingfish;
3. That all hooks are baited once per fishing day regardless of the vessel type;
4. That the number of vessels and fishing days per year are equivalent to that in the effort reconstruction component of this analysis; and
5. That flyingfish is the only species used as bait during the months of November to June. Semi-industrial longliners which fish year round, use other species (e.g., round robin) during the flyingfish 'off-season', July to October, for a total of 30 fishing days.

The quantities of flyingfish utilized as bait is computed separately for pirogues and semi-industrial longliners because of differences in the nature of fishing operations. During the early to mid-1980s, pirogue longliners carried a mainline of 2.5 km and approximately 45 hooks baited with flyingfish (Samlalsingh *et al.*, 1995). Lines were set at depths of 27-54 m and one gear set was made per trip, the vessel staying with the set longline until retrieval. Fishing occurred during the traditional surface pelagic fishing year (November to June) and was constrained by the lack of flyingfish bait from July to October. Modifications by the late 1980s resulted in fishing at greater depth (45-54 m) but the mainline remained at 2.5 km. Hence it is assumed that the same number of hooks (45) is utilized on a trip. Semi-industrial longliners (also referred to as short-stay longliners in Samlalsingh *et al.*, 1995) utilize a hand operated reel for retrieving the line. The mainline is 6 km and the number of hooks about 110-150 (Samlalsingh *et al.*, 1995), the upper limit is used in the analysis. Hooks are set at depths of 45-90 m. Trip length has increased in terms of hours per day for these vessels but this is not reflected in the effort reconstruction. Further, since this fleet targets large pelagics year-round, flyingfish is utilized as bait from November to June while round robins are used from July to October.

Estimation of marine turtle catches

A traditional fishery for turtle exists for local consumption. There was also an export trade in the early 1900s to the value of UK£ 400 per year (Duerden, 1901). Prior to World War II, a trade in live turtles to the United Kingdom existed, and some 180 turtles (each over 82 kg) were shipped annually (Rebel, 1974). A trade with Barbados and Trinidad also existed with some 694 green turtles (*Chelonia mydas*), 279 hawksbill turtles (*Eretmochelys imbricata*) and 2 loggerhead turtles (*Caretta caretta*) being shipped to these two countries in 1948 (Rebel, 1974). Data from Witzell (1984) was used to convert numbers of animals to the equivalent weight as described in Mohammed (this volume). Thus, an estimated 92.9 t was landed in 1948. Rebel (1974) also provides landing estimates of 11.4, 12.5, 13.6 and 32.3 t in 1964, 1965, 1967 and 1969 respectively (the former three estimates were taken from Rebel, 1974 who cited a personal communication from J.L. Dibbs; these also corresponded with data in Vidaeus, 1969). There was however, a discrepancy in the 1969 estimate with Vidaeus (1969) who quoted 13 t. Grenada also exported hawksbill shells, 'bekko', to Japan (Meylan, 1984; Milliken and Tokunaga, 1987). Approximately 499, 132, 59, 9, and 7 kgs of shell were exported in 1973, 1975, 1977, 1980 and 1981 respectively (Milliken and Tokunaga, 1987). Data from Milliken and Tokunaga (1987), Witzell (1984) and the website www.tortoise.org.news/1998s28.html were used to convert hawksbill shell weight to the equivalent animal weight as described in Mohammed (1993). Minimum estimates (since only one species of turtle considered here) of 10.18, 2.69, 7.50, 1.20 and 0.9 t for 1973, 1975, 1977, 1980 and 1981 respectively were derived. The only discrepancy with Fisheries Department data is for 1981 with an estimated 3 t landed, this higher estimate was used in the analysis. Data for missing years were estimated by interpolation. In 1993, an international ban under the Convention for International Trade in Endangered Species (CITES) was imposed on the bekko export trade.

The Grenadines

Anchor points:
Fewer anchor points were derived from the literature for the Grenadines compared to Grenada. These are for 1942 (Brown, 1945), 1980 to 1994 (Chakallal *et al.*, 1997), 1984-2001 (Unpublished fish export statistics for the Grenadines) and 1999-2001 (Fisheries Department unpublished estimates of fish catches).

First interpolation: Total catches
1942: Some adjustment to the estimate provided in Brown (1945) was necessary after the discrepancy with data provided by Smyth (1957) was observed for Grenada. Based on the proportional difference in statistics provided by the two authors for Grenada, the estimate provided by Brown (1945) for the Grenadines was scaled down to 48 t for 1942.

1984 – 1999: There was an overlap in time coverage (1984-1994) of data on Martinique imports from the Grenadines (Chakallal *et al.*, 1997) and Grenadine export data from the Grenada Fisheries Department (unpublished statistics). The data from the two sources were inconsistent. Given a general tendency to underreport, and the need for a precautionary approach, the higher of the two estimates in any given year was used in calculations to arrive at estimated total catch for the Grenadines. In the absence of species composition data, it was assumed that it was from 1985 to 1999 the same as that for Martinique imports from the St Vincent Grenadines (SVG) report (Chakallal *et al.*, 1997, Table 40, p. 55). This was used to disaggregate the Martinique import or Grenadine export statistics into the following broad species categories: reef/demersal fish; large pelagics; seine fish; mixed fish; lobster; conch and other fish. The estimated quantities in the various broad species categories exported to Martinique can also be represented as a proportion of total catches: 85% of the finfish catch; 60% of catches from the dive/shell fishery and 10% of catches from the subsistence fishery (Finlay, 1990). It was assumed that the categories reef/demersal fish, large pelagics, seine fish and mixed fish (from SVG export) combined were analogous to the “finfish” category in Finlay (1990), the lobster and conch categories in the SVG export were assumed analogous to the “dive/shell fishery” (in Finaly, 1990) and the other fish category in the SVG export analogous to the “subsistence” fishery in Finlay (1990). The disaggregated catches from the Grenadine export/Martinique import statistics was raised accordingly to 100% for the respective species groups (in Finlay, 1990) and these were summed across groups each year to provide estimates of total annual catches for the Grenada Grenadines from 1980 to 1999.

Subsequent data provided by the Fisheries Department on estimated catches from 1989 to 1999 were inconsistent with the estimates derived above. Again, the higher of the two estimates was used as representative of total catch.

1943-1979: Annual total catches for the period 1943 to 1979 were estimated by interpolation between the estimate for 1942 (modified after Brown, 1945 and Smyth, 1957) and the estimate for 1980 (derived as described above).

Second interpolation: Species composition
Dis-aggregation of estimated annual total catches involved a two step process. The first involved dis-aggregation of estimated total catches into the broad groupings defined for the Martinique import statistics (Chakallal *et al.*, 1997) from the St Vincent Grenadines (reef/demersal fish; large pelagics; seine fish; mixed fish; lobster; conch and other fish). It was assumed that the relative contribution of each group to the total imports was the same as the relative contribution to estimated total landings each year. The categories which correspond with the fisheries in this study, are the reef/demersal, large pelagic, lobster and conch fisheries. It was assumed that the seine fish category was analogous to the small coastal pelagic fishery (of this study) and that the ‘mixed fish’ and ‘other fish’ could be grouped into a general ‘other fish’ category for this study.

The second step involved further dis-aggregation of the respective fishery catches into the individual species within each fishery. Information on the species composition of the Grenadines fishery was sparse. Details were available for 1999, from the Fisheries Departments first estimation procedure of total landings. From this the species composition was computed separately for each fishery. Using this species composition, the estimated fishery catches were dis-aggregated into the respective species catches. There was some overlap between the reef/demersal fishery and 'other fish' category. It was assumed, based on a list of preferred species for Martinique trading vessels (Chakallal *et al.*, 1997, Table 35 p. 48), that the reef/demersal fishery comprised parrotfish (Scaridae), red hind (*Epinephelus guttatus*, Serranidae), coney (*Cephalopholis fulva*, Serranidae), snappers (Lutjanidae) and groupers (Serranidae) while the 'other fish' category (Finlay, 1990) comprised smaller, lesser important reef species such as grunts (Haemulidae), triggerfish (Balistidae), squirrelfish (Holocentridae), goatfish (Mugilidae), sand tilefish (*Malacanthus plumieri*, Malacanthidae), horse-eye jack (*Caranx latus*, Carangidae) and doctorfish (Acanthuridae). Without a basis for identifying changes in species composition over the period, it was assumed that the composition remained the same for the respective fishery types from 1980 to 1999.

A crude estimate of the relative contribution of each fishery type to total catches was available in Brown (1945). At that time there was no fishery for large pelagics. Catches from beach haul seines were taken to represent the small coastal pelagic fishery and catches from decked sloops, whaleboats and other boats to represent the reef, shelf and slope fishery in the present study. These catches were scaled down according to the procedure described above for the 1942 total catch anchor point. The species composition and individual species catches over the period 1943 to 1979 were estimated by interpolation between the estimated values for 1942 and 1980.

Fishing Effort

The Unit of Fishing Effort

The unit of fishing effort used in the analysis was horsepower-days. The rationale for its selection is discussed in Mohammed (this volume).

Data Sources

Data limitations restricted the estimation of fishing effort to key years for which the required data were available. From these, estimates for missing years were interpolated. Several assumptions had to be made when data was missing, and details are given for the respective years. These assumptions were based on information in the literature and discussions with staff of the Fisheries Department. The key years selected and associated information sources were as follows:

1942: Data were presented by Brown (1945) on the number of boats by design (decked sloop, whaler, sail/row boat), and number of gear units for beach seine and gillnets at landing sites on the leeward (15 sites) and windward (7 sites) coasts as well as for three Grenadine islands (Carriacou, Petit Martinique, Isle Ronde). At the time, all boats except for the decked sloops were un-mechanized. It was assumed that these vessels were fitted with inboard engines of the lowest horsepower (10 Hp) mentioned in the literature for that time. Brown (1945) also gives details from which the number of days fishing could be inferred.

1969: Information on the number of boats by design (sloops, mechanized; whalers, mechanized; whalers, unmechanized; canoes/pirogues, mechanized; canoes/pirogues, unmechanized; transumes; seine boats; balahoo seine boats) for Grenada and the Grenadines were taken from Table 21 in Videaus (1969). Assignment of vessels to fishery types and estimation of likely number of fishing days was derived using information on the description of the fisheries given in Vidaeus (1969). Mechanized vessels at the time carried engines of 5-10 Hp. It was assumed that the smaller canoes carried engines of 5 Hp, while the larger whalers carried engines of 10 Hp.

1982: Information was provided in hard copy by the Fisheries department through their unpublished vessel census of engine type (inboard or outboard), brand and horsepower for each vessel in the fleet. The associated parishes (St Andrews and St David; St Georges; St Johns; St Marys and St Patrick) at which the individual vessels landed, and their catch, was also given. For the Grenadines, information was provided for Carriacou only. As a result the reconstructed fishing effort for the Grenadines is likely an under-estimate. Further, it was possible to ascertain the vessel type based on information about the engine. Hence all sail powered vessels were categorized as sloops, those fitted with outboard engines as pirogues, those with inboard engines of the Seagull brand as dories/open boats and those fitted with inboard diesel and gas engines of the non-Seagull brand as double-enders. Data were computerised and missing values for vessel horsepower were derived by comparison of data for other vessels of similar design and engine type and brand, within the same parish or the entire island. Additional information on the longline fishery (number of pirogues and semi-industrial vessels and associated engine horsepower) was taken from Samlalsingh *et al.* (1995). For other vessels, average engine horsepower was computed directly from census data.

1988: Data on the number of vessels by design (double-ender, launch, pirogue, sloop, whaler) was provided by landing site for Grenada (29 sites) and the Grenadine islands of Carriacou, Petit Martinique and Isla Ronde (total of 10 sites) (Finlay *et al.*, 1988). A qualitative description of the importance of each fishery type to the respective vessel designs was given in Table 1 of the same reference. This was useful in assigning vessels to fishery type, and in estimating the number of fishing days for vessels targeting different fisheries at different times of the year. Information on vessel horsepower was taken from Mahon (1988).

1993: Information was provided on the number of vessels at selected landing sites, the total number of vessels at the respective parishes and the associated engine type (inboard or outboard) by Senga (1993). The associated horsepower for different vessel types was taken from OECS (1995).

1997: Computerized information on a fishery survey conducted in 1997 was available from the Fisheries Department as was the associated report summary (Straker and Jardine, 1998). The details given for each vessel included information on the associated parish, vessel design, engine brand and associated horsepower and number of fishing days per week. The survey targeted all parishes in Grenada (St George, St Patrick, St Andrew and St John, St Mark and St David). However, data for the parishes of St Mark and St David could not be located. The survey also did not cover the Grenadine islands. The mean horsepower was computed directly from census data once the vessels were linked to the respective fisheries.

1999: Computerized information was also provided on vessel characteristics (design/type, length, horsepower, engine type), as well as the associated landing sites and target fishery from the Fisheries Department's 'Trip Interview Program'. The fishery types specified were: coral reef; inshore pelagics; large offshore pelagics; small offshore pelagics; lobster/conch; slope and shelf; spiny lobster. The 'large offshore pelagics' was assumed to be the longline fishery and the 'small offshore pelagics' the trolling fishery. Further, the 'inshore pelagics' was assumed to be the small coastal pelagic fishery usually targeted with beach seines. For the purposes of this analysis, the 'spiny lobster' and 'lobster and conch' fisheries were grouped with the 'coral reef' fishery in the inshore demersal reef category. Missing values on vessel characteristics were estimated by comparing information at same landing site for vessels of a similar type, horsepower, length and fishery type. Mean horsepower was computed directly from information in TIP for each vessel type exploiting the respective fisheries.

Linking fishing effort to fishery type

Specific criteria based on vessel design and length, degree of mechanization and the location of specific fishing areas relative to the respective coasts, landing and mooring sites were identified from a review of the literature to facilitate linking of fishing effort to fishery type. This is described in Mohammed (this volume).

Specifically for the Grenadines, the assumption that from the late 1950s onwards, all unmechanized vessels fished inshore, does not hold since until the mid-late 1990s virtually all vessels, whether or not mechanized, targeted inshore reef, offshore deep slope and shelf and coastal pelagic species (Finlay and Rennie, 1998). Since introduction of longlines in the 1980s, all pirogues and semi-industrial vessels with inboard engines (which are of higher horsepower than outboard engines) were assumed to target large highly migratory pelagics offshore using longlines. Pirogues with outboard engines were assumed to target the regional pelagics (small tunas, mackerels and dolphinfish) with troll lines. Although there are vessels with inboard engines targeting regional pelagics, these are in the minority.

The topography off the respective coasts influences the types of fisheries that can occur. Since the west (leeward) coast of Grenada is characterized by a narrow shelf, deep waters are close to shore. Therefore, large pelagics can be caught without sailing too far offshore. It is therefore assumed that vessels at the parishes of St Georges, St John and St Mark, off this coast, target large pelagics (using troll lines prior to the 1980s and converting to longlines through the mid-1980s into the 1990s). Also, the sandy shore, sheltered bays, calmer seas and fewer reefs make this coast popular for catching small coastal pelagics with beach seines, and so the unmechanized vessels along this coast are assumed to target this resource.

The east (windward) coast is lined by many fringing reefs and the shelf area is wider than that on the west coast. Since the waters off this coast are rougher, it is assumed that all vessels from the parishes of St Patrick, St Andrew and St David targeted mainly demersal reef resources during the pre-mechanization period. Since mechanization there has been an increase in the number of vessels targeting large pelagics using troll gear on the east coast (mainly those from Grenville which is a sheltered bay allowing vessels good landing conditions). The reef resources, however, are still exploited and it is assumed that unmechanized vessels target them year-round while mechanized vessels do so only during the pelagic off-season.

The south coast is characterised by reefs and deep waters close to shore because of the narrow shelf area. Consequently, boats on this coast (St Gerges and St David), are assumed to target both large pelagics and reef demersals. As for the east coast, the main target fishery is determined by the degree of mechanization. Boats at landing sites between Woburn and Calliste also target lobster and conch fisheries.

The north coast of Grenada is characterized by an expansive shelf area. Vessels in the parishes of St Patrick area are assumed to target large pelagics and demersal shelf and slope species, with reef species also taken, if to a lesser extent. As in other areas, it is assumed that unmechanized vessels target inshore resources year-round while mechanized vessels do so during the pelagic off-season.

The expansive shelf area of the north coast is shared with the Grenadines islands of Carriacou, Petite Martinique and Isla Ronde. Traditionally the fisheries targeted by these islands are the reef, deep slope and shelf demersals and, to a lesser extent, the small coastal pelagic fisheries. It is only with the depletion of demersal resources that some of these vessels have started converting to longlining in the 1990s (Finlay and Rennie, 1998). The species targeted in the Grenadines are dictated by the demand of the Martinique market, and to a lesser extent the Guadeloupe market, to which most of the catch is exported.

The assumptions made above are considered to hold throughout the period covered by this study. Detailed notes on assumptions and inferences made are given in Appendix 1.

Assigning fishing days to the respective fleets and fisheries

A review of the literature provided no information from which changes in the annual number of fishing days for the respective fisheries could be quantified, though Epple (1977) noted an increase in number of fishing days as a result of mechanization. The pelagic fishery has traditionally been seasonal, from November to June, and the associated fleet switches to the demersal and reef fisheries during the pelagic –off-season (July to October). The number of fishing days associated with each fishery for this fleet provides a possible way of accounting for the division of annual total effort between the two fisheries.

Large pelagic fishery

Vessels targeting this fishery in the pre-mechanization period were assumed not to fish between November and January due to rough sea conditions. Fishing was assumed to occur 15 days per month from February to June (75 days total per year). Vessels targeting this fishery on the windward coast were also assumed to target inshore demersals from July to October (excluding one month for vehicle maintenance), at an average of 15 days per month (45 days per year). Mechanized vessels were assumed to fish on average 10 days per month between November and January, and on average 20 days per month otherwise (130 days per year). Those on the windward coast are assumed to continue targeting large pelagics from July to October (the hurricane season), on average 15 days per month (excluding one month for vessel maintenance). The total annual number of fishing days is therefore 175. Mechanized vessels on the east coast (pirogues involved in longlining) virtually cease fishing from July to October since the tuna are believed to move further offshore in deeper waters and are inaccessible to this fleet (Finlay and Rennie, 1998). Because of high fuel costs, it is also uneconomical for this fleet to travel to the north and south coasts where demersal and reef resources could be targeted during the pelagic off-season (Finlay, 1991). The estimated number of fishing days for this fleet is thus 130 days per year. Since the semi-industrial longliners on the west coast can track the tunas into deeper waters from July to October they are able to fish year-round (Finlay and Rennie, 1998). It is assumed that fishing occurs on average 20 days per month excluding one month each year for vessel maintenance. The associated total number of fishing days is thus 220. An exception to this occurred in the earlier years (1982-1988), when these vessels targeted reef demersals (Finlay *et al.*, 1988) during the pelagic off-season. It is assumed that, at that time, the large pelagic fishery was ran an average 130 days per year and the demersal and reef fishery 45 days per year (15 days per month from July to October excluding one month for vessel maintenance).

Small coastal pelagic fishery

Unmechanized vessels targeting small pelagics were assumed to fish the same number of days each year throughout the study period. Vessels traditionally target small pelagics using beach seines and other nets year round (Finlay, 1996), but the peak period is from May to October (Brown, 1945). It was assumed that fishing occurred 20 days per month during the peak period and 10 days per month during the non-peak periods, giving a total of 180 fishing days per year. An exception to this occurred in 1997, when the actual number of fishing days was computed at 234 for canoes/transumes from survey data. This was assumed the same for vessels in 1999. This observation is consistent with the expansion of this fishery from subsistence level (provider of bait for the demersal and regional pelagic fishery) to a bait supplier for the offshore fishery for large pelagics.

Demersal reef, shelf and slope fisheries

Unmechanized vessels on the east (windward), south-east (from Calliste to Woburn), south, southwest and north coasts (Victoria and Sauteurs) are assumed to target this fishery year round. On average fishing is assumed to occur 20 days per month from February to October (excluding one month for vessel maintenance) and 10 days per month between November and January. The total number of fishing days is thus 230. Mechanized vessels, which target these resources during the pelagic off-season, are assumed to fish 10 days per month from July to October (excluding one month for vessel maintenance), for a total of 30 days per year.

Annual trends in catch per unit area and catch per unit effort

Using the reconstructed catches for the inshore and offshore fisheries of Grenada and the Grenadines and the estimates of EEZ, reef, slope and shelf areas in Mohammed (2003), a time series of trends in catch per unit area was derived. Catch per unit effort was derived for the Grenada fisheries as the ratio of reconstructed catch and reconstructed effort for the offshore and inshore components. Fishing effort being derived for specific years, missing data were estimated by interpolation between these estimates.

Results

Fisheries catches

The reconstructed catch data for all species combined is presented in Figure 2 for Grenada and the Grenadines. This includes estimated annual catches for the Grenadines derived from Grenadine export and Martinique import statistics (Table 1), catches from billfish fishing tournaments between 1992 and 1998 (Table 2), catches of flyingfish and round robin for use as bait between 1982 and 1998 (Table 3), and catches of turtles between 1942 and 1998 (Figure 3). A comparison of the existing data in the Food and Agriculture Organization FISHSTAT database for Grenada with reconstructed catch data of this study (Figure 2a) indicates major deviations from the mid-1950s to mid 1960s, 1972 to 1977 and 1985 to 2001.

Overall catches increased between 1955 and 1965 from 512 t to 1,444 t, remained stable at between 1,300 t to 1,600 t thereafter until the mid-1970s, early 1980s, when there was a

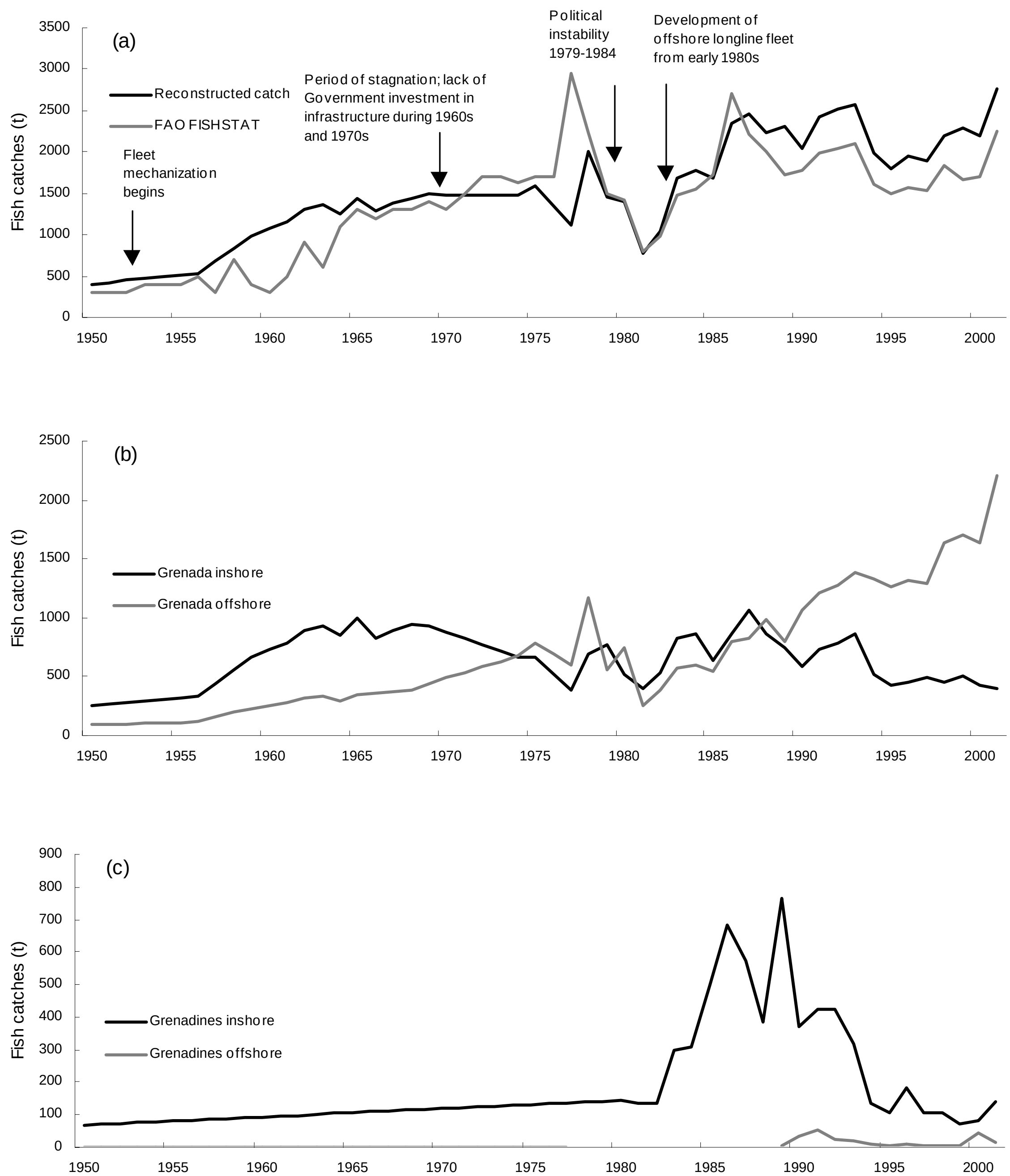


Figure 2. Fisheries catches reconstructed from reported data for (a) Grenada and the Grenadines combined; (b) Grenada; (c) the Grenadines (1950-2001).

Table 1. Estimated annual catches for the Grenadines derived from Grenadine export and Martinique import statistics: 1980 to 1999.

Year	Catch (t)	Year	Catch (t)
1980	144	1990	403
1981	134	1991	479
1982	133	1992	450
1983	297	1993	339
1984	306	1994	141
1985	501	1995	112
1986	688	1996	195
1987	571	1997	113
1988	384	1998	110
1989	768	1999	176

Table 2: Catches (t) landed at annual billfish tournaments in Grenada (1992-1998).

Year	Blue marlin	Sailfish	White marlin	Yellowfin tuna	Total catch (t)
1992	0.05	2.80	0.36	0.00	3.21
1993	0.23	1.84	0.19	0.06	2.31
1994	0.40	0.87	0.02	0.13	1.42
1995	0.23	1.20	0.05	0.06	1.54
1996	0.05	1.53	0.08	0.00	1.66
1997	0.32	1.17	0.05	0.00	1.54
1998	0.59	0.82	0.02	0.00	1.43

Table 3: Estimated quantities of flyingfish and round robin utilized as bait in the longlining fishery. Quantity caught = number of boats x number of fishing days x number of hooks utilized per trip x mean individual weight of fish. Pirogue longliners and semi-industiral longliners use mainlines with 45 and 150 hooks respectively (Samlalsingh *et al.*, 1995). The mean individual weight of flyingfish was estimated at 0.15kg based on field observations. The same mean weight was assumed for flyingfish and round robin. Catches in bold were estimated by interpolation.

Year	Pirogue longliners			Semi-industrial longliners				Total Flyingfish caught as bait (t)
	Number	Fishing days	Flyingfish caught as bait (t)	Number	Fishing days	Flyingfish caught as bait (t)	Round Robin caught as bait (t)[a]	
1982	25	130	21.94	4	130	11.7	-	33.64
1983	-	-	-	-	-	-	-	**58.70**
1984	-	-	-	-	-	-	-	**83.75**
1985	-	-	-	-	-	-	-	**108.81**
1986	-	-	-	-	-	-	-	**133.87**
1987	-	-	-	-	-	-	-	**158.93**
1988	183	130	160.58	8	130	23.4	-	183.98
1989	-	-	-	-	-	-	-	**194.59**
1990	-	-	-	-	-	-	-	**205.20**
1991	-	-	-	-	-	-	-	**215.82**
1992	-	-	-	-	-	-	-	**226.43**
1993	225	130	197.44	11	160	39.6	14.85	237.04
1994	-	-	-	-	-	-	**16.20**	**222.02**
1995	-	-	-	-	-	-	**17.55**	**207.00**
1996	-	-	-	-	-	-	**18.90**	**191.98**
1997	138	132	122.96	15	160	54.00	20.25	176.96
1998	-	-	-	-	-	-	**30.38**	**217.51**
1999	171	130	150.05	30	160	108.00	40.50	258.05

a: It was assumed round robins are targeted 60 fishing days per year.

drastic decline from about 1,900t to 700 t. This was followed by a period of significant increases to about 2,476 t in 1993, until the mid to late 1990s (Figure 2a) when catches declined to 1,469 t in 1997. Thereafter catches continued to increase, reaching to about 2,900 t in 2001. The offshore catch of Grenada increased from 256 t to 2,205 t (a factor of 8.6) between 1981 and 2001 (Figure 2b). Catches in the inshore fishery declined from 1,000 t in the mid to late 1960s (Figure 2b) to about 400 t in 1977, and fluctuated between 381 t and 1,062 t between the late 1970s to 1987. Between 1987 and 2001 inshore catches declined from 1,062 t to 400 t, a decline of 62% of the 1987 estimate. Offshore catches in the Grenadines (Figure 2c) were very small (17 t average between 1985 and 2001) compared to inshore catches (2,576 t average between 1985 and 2001). However, inshore catches declined drastically from about 700 t in 1986 to as low as 74 t in 1999, 89% the 1986 estimate. Subsequently catches have increased to 139 t in 2001.

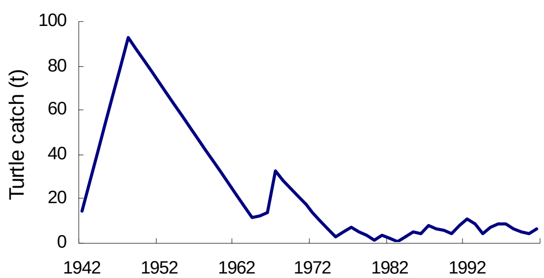


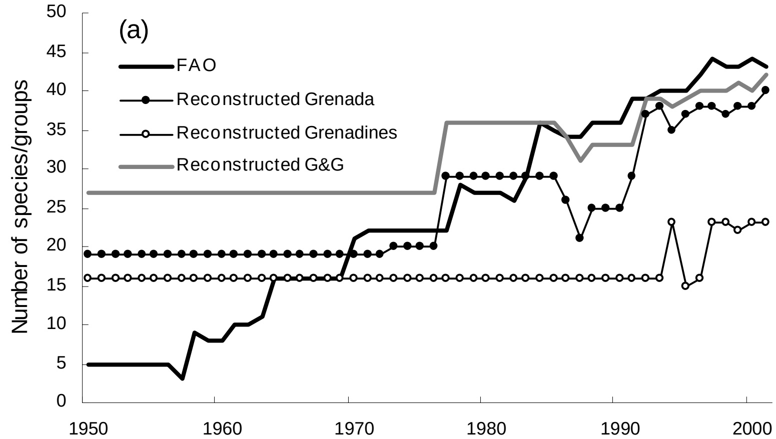
Figure 3. Reconstructed catch of sea turtles (hawksbill: *Eretmochelys imbricata*; green turtle: *Chelonia mydas*) in Grenada (1942-1999).

A comparison of the number of species or species groups and percentage of overall catches attributed to the aggregate category 'marine fish nei' as represented in FISHSTAT and reconstructed statistics of this study are provided in Figure 4. A greater number of species were represented in reconstructed data between 1950 and the mid-1990s (Figure 4a). The number of species or species groups represented in FISHSTAT increased from five (Atlantic moonfish, flyingfishes nei, redhind, scads nei and snappers, jobfishes nei) in 1950 to 43 in 2001. Overall a greater number of species or species groups were represented in Grenada catches (19 to 40 species/groups) compared to catches of the Grenadines (16 to 23 species/groups). In recent years (1994 to 2001) however, the number of species or species groups in FISHSTAT exceeded those in reconstructed data by three species/groups. A comparison of species in the reconstructed data and FAO attributed the differences to a splitting of the 'king mackerel and wahoo' category of this study into the individual species components in FISHSTAT and inclusion of three additional species or species groups: scaled sardines, scads nei, and surgeonfishes. As well, Albacore (*Thunnus alalunga*) and bonito (*Sarda sarda*) are not represented explicitly in reconstructed data, though they are in FISHSTAT. Reconstructed catches were disaggregated among all possible species with no catches attributable to an aggregate category. However, up to 45% of overall catches in the FAO data were attributed to 'marine fish nei' between the early 1960s and 2000 (Figure 4b), with considerable inter-annual variability over the period.

Estimated annual catches for the Grenadines between 1980 and 1999, derived from Grenadine export and Martinique import statistics (Table 1) indicate a considerable increase in catches from just over 100 t in 1982 to a peak of 768 t in 1989. Catches declined thereafter, reaching as low as 110 t in 1998, and increasing to 176 t the following year. Catches from the annual Spice Island Billfish Fishing Tournament (Table 2) were very small, 1.0 – 3.1 t, compared to the commercial fishery. Estimated annual catches of flyingfish utilized as bait (Table 3) have increased from about 50 t in 1982 to over 250 t in 1999. Similarly catches of round robin (Table 3) have increased by a factor of 2.7 between 1993 (14.9 t) and 1999 (40.5 t). Reconstructed catches of turtles (Figure 4) reflect significantly higher catches in earlier years, in particular 1948 and 1967. Catches in recent years have remained below 20 t.

Fishing effort

Fishing effort was calculated using information on the reconstructed number of boats for each fishery type, the associated mean horsepower and number of fishing days each year (raw data can be obtained from the author). Figure 5 indicates the key features in development of fisheries in Grenada and the Grenadines. Generally there has been an increase in fishing effort in both the offshore and inshore fisheries of Grenada (by factors of 411 and 21 respectively) and the Grenadines (factors of three and 10 respectively. In Grenada the number of boats exploiting the offshore fishery has increased linearly while effort has increased exponentially. During the last two decades,



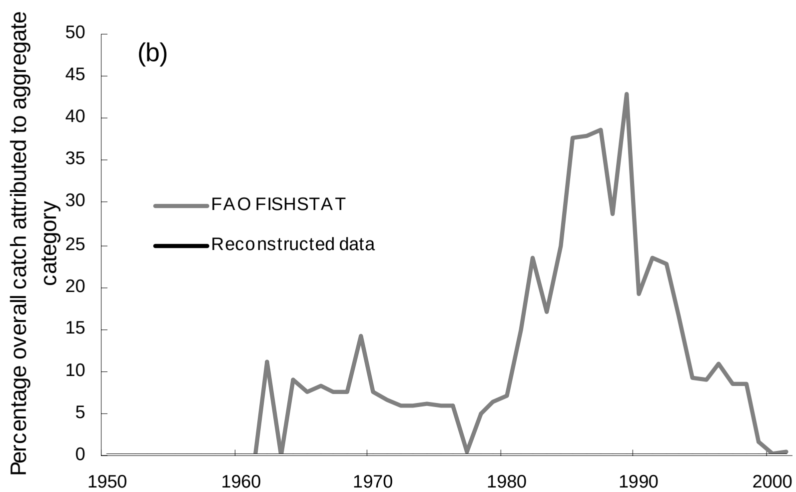


Figure 4. A comparison of reconstructed catch data and statistics in FAO FISHSTAT for Grenada and the Grenadines between 1950 and 2001: (a) number of species/species groups and (b) proportion of overall catch attributed to the aggregate category 'marine fish nei'.

the effort in the offshore fishery of Grenada (Figure 5a) has increased sevenfold from 748 x 10^3 Hp-days in 1982 to 5,273 x 10^3 Hp-days in 1999, while the corresponding numbers of boats (Figure 5a) has increased by a factor of 1.6, from 250 to 390 in the same years. Conversely, between 1982 and 1999, the number of boats targeting the inshore fishery in Grenada (Figure 5b) decreased by a factor of 1.4, from 185 to 136, although overall fishing effort has increased by a factor of 2.5, from 89 x 10^3 Hp-days to 223 x 10^3 Hp-days. In the Grenadines, the number of boats targeting the offshore fishery (Figure 5c) has decreased by a factor of 1.5 between 1982 and 1999, from 80 to 55, while the corresponding effort has increased by a factor of 3.3, from 272 x 10^3 Hp-days to 895 x 10^3 Hp-days. Although the number of boats targeting the Grenadines inshore fishery changed little between 1982 and 1999, the effective effort peaked in 1988 at 691 x 10^3 Hp-days and declined considerably thereafter to 226 x 10^3 Hp-days in 1999.

Annual trends in catch per unit area (CPUA) and catch per unit effort (CPUE)

Overall the annual CPUA was greater, by about one order of magnitude, for the inshore than the offshore fisheries of Grenada and the Grenadines (Figure 6). Generally CPUA in the offshore fishery increased between 1942 and 2000. Between 1981 and 2001 CPUA increased by a factor of nine, from 10.6 x 10^{-3} t·km^{-2} to 93 x 10^{-3} t·km^{-2}. The maximum 93x 10^{-3} t·km^{-2}) in the offshore fishery was observed in 2000.

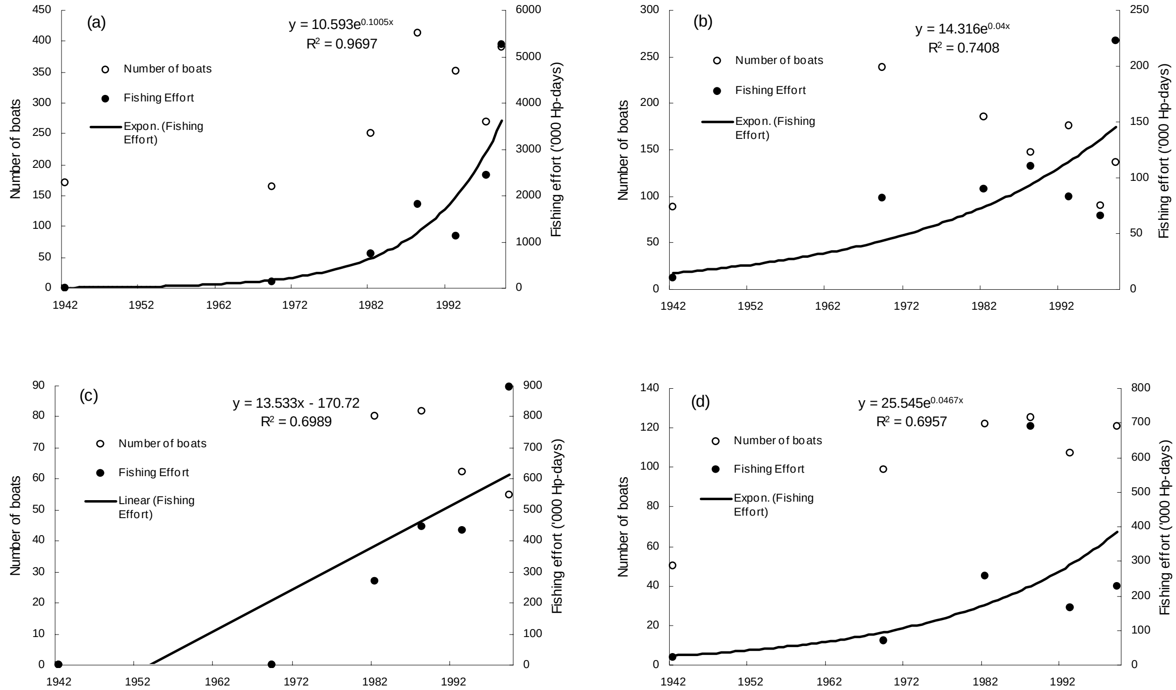


Figure 5. Reconstructed fishing effort for the Grenada (a) offshore and (b) inshore fisheries; the Grenadines (c) offshore and (d) inshore fisheries (1942-1999).

Two peaks in CPUA were observed in the inshore fishery, in 1965 (612 x 10^{-3} t·km^{-2}) and 1987 (905 x 10^{-3} t·km^{-2}). Recently CPUA in the inshore fishery has declined considerably, from 654 x 10^{-3} t·km^{-2} in 1993, to 360 x 10^{-3} t·km^{-2} in 1994 and has remained below 350 x 10^{-3} t·km^{-2} throughout the latter half of the 1990s.

Generally CPUE was greater in the inshore fishery than the offshore fishery of Grenada and the Grenadines (Figure 7). Initial CPUE in 1942 was 5.33 t per thousand Hp-days and 3.69 t per thousand Hp-days in the inshore and offshore fisheries respectively. These declined to 4.37 t per thousand Hp-days and 1.54 t per thousand Hp-days in the respective fisheries by 1957. Although the general pattern in both fisheries was a decline between 1942 and 1999 (92% and 76% in the offshore and inshore fisheries respectively), there was a notable increase in CPUE during the late 1950s, and considerably high CPUEs throughout most of the 1960s. CPUEs in the 1960s ranged between 6.74 and 8.23 t per thousand Hp-days in the inshore fishery and between 2.67 and 3.23 t per thousand Hp-days in the offshore fishery. CPUE in the offshore fishery declined thereafter, reaching a low of 0.269 t per thousand Hp-days in 1981. This increased only slightly to 0.897 t per thousand Hp-days by 1993 and declined again to 0.28 t per thousand Hp-days '000 Hp-days by 1999. CPUE in the inshore fishery also declined rapidly from the highs of the 1960s, ranging between 2.64 t per thousand Hp-days (1982) and 1.56 t per thousand Hp-days (1988) during the 1980s. A peak in CPUE occurred in the mid-1990s ranging between 4.72 t per thousand Hp-days in 1993 and 9.02 t per thousand Hp-days in 1997. However, CPUE declined again towards the end of the decade to only 1.3 t per thousand Hp-days.

Discussion

Fisheries catches

Catches in the Grenada offshore fishery increased by a factor 8.6 between 1981 (256 t) and 2001 (2,205 t), while catches in the inshore fishery declined by 62% between 1987 (1,062 t) and 2001 (400 t). Offshore catches in the Grenadines fishery were insignificant compared to the catches of the traditional inshore fishery. However, inshore catches declined drastically from about 700 t in 1986 to as low as 74 t in 1999, 89% the 1986 estimate. Subsequently catches have increased to 139 t in 2001.

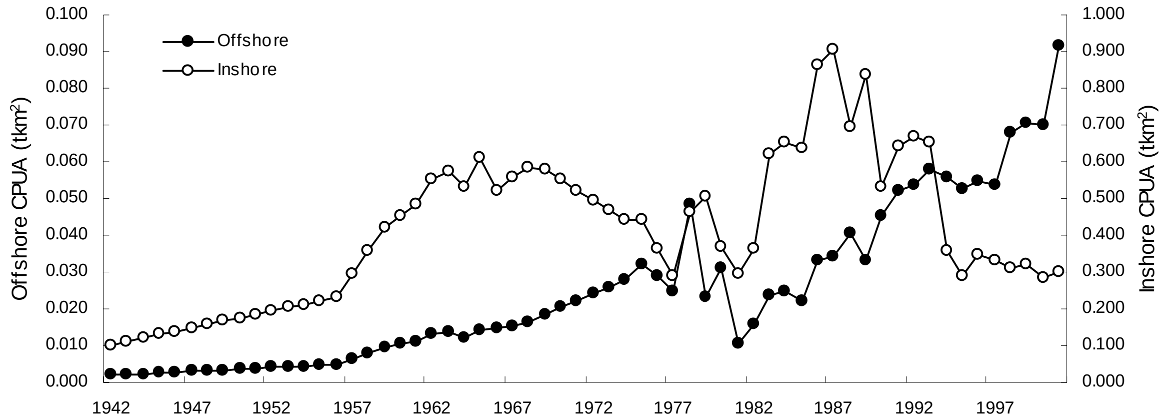


Figure 6. Annual trends in catch per unit area (t·km^{-2}) in the fisheries of Grenada and the Grenadines (1942-2000).

A comparison of annual catches in the Food and Agriculture Organization FISHTAT database and reconstructed catches of this study showed major differences from the mid-1950s to mid-1960s, 1972 to 1977 and 1985 to 1999. Since the information sources used to derive catch estimates submitted to the FAO are not known, it is difficult to comment on the reasons for these differences. A review of the literature however, provided no support for the high catches listed in FISHSTAT for Grenada and the Grenadines during 1977 and 1986. Deviations in the most recent period are attributed mainly to the quantities of flyingfish used as bait in the longline fishery.

Overall catches increased between 1955 and 1965 from 512 t to 1,444 t, remained stable at between 1300 t to 1600 t thereafter until the mid-1970s, early 1980s, when there was a drastic decline from about 1,900 t to 700 t. This was followed by a period of strong increases to about 2,500 t in 1993, until the mid to late 1990s when catches declined to about 1,500 t in 1997. Thereafter catches continued to increase, reaching to about 2,900 t in 2001.

Overall, the increased catches from the mid-late 1950s reflect the initial attempts at fleet mechanization and the associated provision of loans for fisheries development (Vidaeus, 1969). Despite these efforts, however, fisheries stagnated during the mid-1960s to mid-1970s. Several factors may have contributed to this: stricter collateral requirements, resulting in fewer loans being granted by the government; lack of government's support for infra-structural development (including provision of onshore cold storage facilities); a system of retail price control which acted as a disincentive to increase exploitation given the associated increases in fishing (fuel related) costs and the large quantities of imported processed fish. Videaus (1969) estimated that between 1960 and 1968 annual imports represented between 1.64 and 2.76 times domestic landings. This apparent preference for imports, for salted fish in particular, originates from a long tradition of consuming salted cod and smoked herring from northern countries.

The decline in catches between 1979 and 1984 coincides with the political events mentioned above. They impacted negatively on tourism, an industry that accounted for a significant proportion of total fish consumption, and was a major incentive to fishers. The result was a reduction in catches of demersal (including lobster and conch) and large pelagic species which would have otherwise been sold to hotels (Finlay, 1991). This decline was mitigated in 1982 when the government launched the US$2.7 million Artisanal Fisheries Development Project (Finlay, 1990).

A semi-industrial longline fleet was also introduced and the artisanal inshore fleet began conversion to the offshore fishery. Cuba provided technical assistance in the longline fishery and efforts were concentrated in Grenada. Only recently has this extended to the Grenadines. The main species targeted are yellowfin tuna, sailfish and swordfish. Greater efforts were focused on development of the offshore fishery. This accounts for the increased catches from the mid -1980s

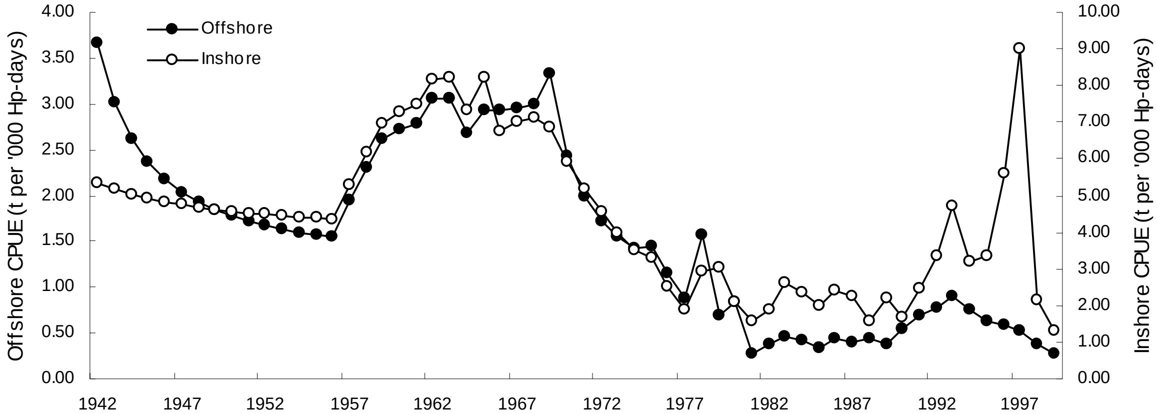


Figure 7. Annual trends in catch per unit of effort (t per '000 Hp-days) in the fisheries of Grenada and the Grenadines (1942-1999).

onwards, which, according to Finlay (1991), was attributed mainly to the artisanal fleet fishing in the Caribbean Zone. Attempts to decrease fishing operation costs through the Fishing Vessel Modernisation Plan (Senga, 1995) in 1994 would also have added to the profitability of the venture. The increased catches are also supported by reports of increased fishing range, and increased duration of the fishing season (from seven to twelve months) of semi-industrial vessels (Samlalsingh *et al.*, 1995).

The 1997 decline in catches (clearly seen in the data for Grenada) results from a regional fish-kill which resulted in closure of fisheries in Grenada and Grenadines. More recent catches show an immediate recovery of the industry.

The reconstructed catches for Grenada reflect a shift in relative importance of the inshore and offshore fisheries. Until 1975 the inshore fishery accounted for a greater proportion of overall catch, but by the mid to late 1980s, the offshore fishery proved to be the greater contributor, and continues to do so at the present time. Catches in the inshore fishery appear relatively stable in recent years. The reasons for this shift in relative importance of the inshore and offshore fisheries are mainly due to the perceived depletion of inshore resources and governments policy to develop the offshore fishery in response to this. The increased jurisdiction provided under the United Nations Convention on the Law of the Sea (1982), and introduction of new longlining technology and more fuel efficient vessels, provided an avenue for geographical expansion of fishing operations targeting high-priced pelagic species to supply the export market. Fishing has therefore changed from a subsistence activity, or for national food production, to one that is export oriented. In the 1990s most of the fresh fish production in was traded overseas (USA, French Martinique, Barbados) and a high proportion of local consumption consisted of imported fish and fish products (Finlay and Rennie, 1998).

There were vast differences in the 1948 and 1967 reconstructed catches of turtles when estimated from information in the literature specific to turtles, compared to estimations using information on species composition and total catch across all fisheries and species, in the general literature. Quite possibly, the estimates of mean weight or weight of shell per turtle used to estimate landed weights from numbers of turtle are incorrect. Further verification of these estimates is required. Also, catches estimated from exported shell weight are minimum estimates since only shell of the hawksbill turtle are exported, while catches of other species (especially the green turtle) are not well recorded.

The reconstructed catches for the Grenadines were incomplete for the pre-1984 period. This is reflected in a sudden increase in catches around the mid-1980s. While the Artisanal Fisheries Project would have promoted an increase in catches it is difficult to establish whether the increase observed is due solely to fisheries development or to improvements in the data collection system, though the latter is more likely. The traditional importance of the inshore fishery is reflected in the broad species composition of the reconstructed catch and the significantly higher overall catch compared to the offshore fishery. Assuming that catches were around 700-900 t in the late 1980s then the drastic decline in catches of the inshore fishery from the early 1990s offers some evidence for overexploitation of these resources. However, successive devaluations in the Venezuelan Bolivar in the late 1980s made the Martinique market more lucrative to Venezuelans and contributed to increased competition for the market (Finlay, 1991) and may also explain the decline. Finlay (1991) reported on the associated decline in exports to Martinique, the traditional market for fisheries in the Grenadines. Further, reconstructed catches using Grenadine export and Martinique import data are quite possibly over-estimates because Finlay (1990) also indicated that 10% of beach seine catches from Grenada are exported to Martinique, though this is not considered in the present analysis.

The reconstructed catches presented in this report are preliminary and should be considered minimum estimates. There are several data limitations. These are associated with the recreational fishery, foreign catches, inadequate data collection on the inshore fishery and associated high level of species aggregation, the increased exploitation of flyingfish as bait to support the longline fishery and the lack of a method for estimating total catches from recorded data in Grenada and the Grenadines.

Catches from the three-day recreational fishing tournament are incomplete, as only the main target species are reported. Other species of lesser importance (small tunas, mackerels and dolphinfish), are also caught, but the data are not recorded. There is also some uncertainty as to whether the data recorded accurately reflects the total catches of target species (C. Isaac, Fisheries Department, pers. comm. 2001). Further, catches of the recreational fishery (excluding fishing tournaments) and the tourist-associated charter boat fisheries are not included. These operate year round and target reef species, and smaller pelagics with regional distributions. A system for collection of these data does not exist and arriving at a crude estimate is difficult, as basic information, e.g., on the number of vessels involved in the fishery, is not available.

Catches of the seven US longliners licensed to fish for large pelagics between 1988 and 1989 in Grenada waters (Samlalsingh *et al.*, 1995) were not recorded and are therefore not included in the analysis. The same is true for the four vessels donated by Cuba to the Grenada government, which targeted large pelagics and sharks in the early 1980s. Further, foreign fishing (legal and illegal) is also almost unavoidable given the proximity of the southeastern Caribbean islands. The associated catches are either not documented or incorporated in the landing statistics of another island. Information concerning the latter is usually not shared among islands.

Catches of the inshore fishery (in particular reef, shelf and slope demersals and lobster and conch resources) are known to be grossly underrepresented in the recorded statistics for Grenada, as important landing sites for these fisheries are not incorporated in the data collection system. As well, lobster and conch are also delivered directly to hotels upon landing, and therefore by-pass the data collection system implemented at the major markets. Also, recorded landings of the inshore fishery are aggregated across several species making it difficult to determine the level of individual species exploitation. This is particularly true for reconstructed catches for the Grenadines.

The flyingfish fishery has also been relegated to a ‘bait fishery’ status, supporting the developing longline fishery. The quantities utilized as bait are not recorded. For other countries of the southeastern Caribbean (Barbados and Tobago), this is a major commercial fishery, with a resource base that is distributed and shared regionally. The associated implication of non-recording of catches is an underestimation of the level of exploitation of the species and the associated ecological impacts since flyingfish is a natural prey of the large pelagic species targeted by the longline fishery.

A method for estimating total catches based on recorded landings and the number of boats operating in the respective fisheries has not yet been developed nationally. Estimates of total catches provided by the Grenada Fisheries Department for the period 1978 to 2001 are derived by applying a fixed raising factor to recorded data, based on general knowledge of the structure of the fisheries and their development. Except for the offshore pelagic fishery, this factor has remained unchanged since 1978. This confounds the interpretation of catch statistics and estimation of depletion of inshore fisheries.

Fishing effort

The increase in fishing effort of the offshore fishery in Grenada is consistent with development of the longline fleet targeting mainly yellowfin tuna, sailfish and swordfish. The exponential increase in effort, as opposed to the linear increase in number of boats, results mainly from the use of engines of higher horsepower since the mid-1980s. This also explains why the overall effort in the offshore fishery in the Grenadines has increased despite a decline in the number of boats involved in the fishery, and highlights the dangers of monitoring solely the number of boats as an indication of fishing effort. Though the increased effort in the Grenadines fishery is consistent with the literature (Finlay and Rennie, 1998), the number of boats is expected to increase given the conversion of the inshore fleet to offshore fishing. Improvements in vessel and fishing technology must also be considered. Increases in fishing effort are matched by an increased geographical range of fishing (Finlay, 1990). Development and expansion of the large pelagic fishery is reflective of the future fisheries policy of Grenada and the Grenadines.

Despite overexploitation and depletion of inshore resources, however, the fishing effort deployed in Grenada has increased. This is due, as in the offshore fishery in the Grenadines, mainly to the use of engines of higher horsepower (the overall number of boats has in fact decreased). Data for the inshore fisheries in the Grenadines are difficult to interpret. They suggest that the inshore fishery has remained purely artisanal, with a low effort. The associated number of boats has increased gradually over the years. However, changes in the number and types of gear deployed are not incorporated in the estimate of effort. These certainly would have contributed to increases in effort and the consequent decline of the resources.

Annual trends in CPUA and CPUE

Overall the annual CPUA was greater, by about one order of magnitude, for the inshore than the offshore fisheries of Grenada and the Grenadines. This is expected since the inshore resources are concentrated over a narrow shelf and the reef areas represent only about 7% of the EEZ. Generally CPUA in the offshore fishery increased between 1942 and 2000. This is consistent with development of this fishery, particularly from the early 1980s onwards, when CPUA increased by a factor of nine. Two peaks in CPUA were observed in the inshore fishery in 1965 and 1987. The associated increases in CPUA leading to these peaks coincide with major developmental periods, firstly the introduction of vessel mechanization in the late 1950s and the Artisanal Fisheries Development Project, which commenced in 1982. Recently CPUA in the inshore fishery has declined considerably, from 654 x 10^{-3} t·km^{-2}in 1993, to 360 x 10^{-3} t·km^{-2} in 1994 (45% the 1993 estimate) and has remained below 350 x 10^{-3} t·km^{-2} throughout the latter half of the 1990s. This is a clear signal of overexploitation.

Catch per unit of effort was greater in the inshore fishery than the offshore fishery of Grenada and the Grenadines. Although the general pattern in both fisheries was one of decline between 1942 and 1999 (92% and 76% in the offshore and inshore fisheries respectively), there was a notable increase in CPUE during the late 1950s, and considerably high CPUE throughout most of the 1960s (ranging between 6.74 and 8.23 t per thousand Hp-days in the inshore fishery and between 2.67 and 3.23 t per thousand Hp-days in the offshore fishery). This coincides with the initial period of vessel mechanization, which promoted considerable increases in catches as vessels could then exploit a greater area and were less affected by adverse weather conditions. CPUE in the offshore fishery declined thereafter, reaching a low of 0.269 t per thousand Hp-days in 1983. This increased only slightly to 0.897 t per thousand Hp-days by 1993, coinciding with development of the longline fishery, but declined again to 0.28 t per thousand Hp-days by 1999.

The CPUE of the offshore fishery has declined between 1993 and 1999. Though catches continue to increase, so too has effort, through the introduction of bigger vessels utilizing more powerful engines, with a higher initial capital investment. Results reflect the general situation across the entire fleet. The economic implications will vary among the individual vessels, depending on the types of engines used, the associated fuel consumption and the catch per trip. This decline in CPUE could be offset financially by increasing prices for the associated species on the foreign market. Management of the large pelagic fisheries is the responsibility of the International Commission for the Conservation of Atlantic Tunas (ICCAT). Hence ICCAT quota regulations, which limit the catches, and the corresponding fleet development (more boats of higher horsepower and increased horsepower of existing boats) may also account for the declining CPUE in this fishery. Normally, under these circumstances, fishing should become unprofitable. However, these vessels have larger inboard diesel engines, with considerably lower fuel costs than outboard gasoline engines, and they supply the more lucrative export markets and local hotels instead of traditional local markets. As a result economic gains (dependent on foreign market prices) would encourage increased investment despite the declining CPUE.

CPUE in the inshore fishery has also declined rapidly from the highs of the 1960s, ranging between 2.64 t per thousand Hp-days (1982) and 1.56 t per thousand Hp-days (1988) during the 1980s. This decline in CPUE of the inshore fishery is consistent with claims of overexploitation and depletion (Mahon, 1990, 1993; Singh-Renton and Mahon, 1996). A peak in CPUE occurred in the mid-1990s ranging between 4.72 t per thousand Hp-days in 1993 and 9.02 t per thousand Hp-days in 1997. However, CPUE declined again towards the end of the decade to only 1.3 t per thousand Hp-days. Further investigation is required to explain the mid-1990s peak.

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APPENDIX 1:

Interpretation of data for fishing effort reconstruction for Grenada and the Grenadines (1942-1999).

Grenada

1942:

It was assumed that sailboats on Leeward coast (114), except those from Sauteurs and Victoria, and sailboats on the windward coast (48) fish for flyingfish and large pelagics (inshore). Whalers at Gouyave (6) and Marigot (3) also targeted large pelagics, the differences being that vessels on the leeward coast cease fishing after June while those on the windward coast (48) target inshore reef demersals from July to October. Beach seines (16) and gillnets (7) targeted small coastal pelagics and an equivalent number of boats is assumed. It is assumed that the vessels from Sauteurs (2 whalers and 4 sailboats) and Victoria (12 sailboats) target inshore reef demersals year round.

1969:

It was assumed that mechanized whalers (95); unmechanized whalers (60), and canoes (9) target large pelagics and flyingfish by trolling. The mechanized whalers however, also target deep water demersals (30-40 fathoms). Coastal pelagics are taken by beach seines (35) and balahoo seines (6) and a similar number of boats was assumed. Inshore reef demersals are assumed to be targeted by unmechanized canoes (30) and transumes (130). The decked sloops (4) and mechanized whalers (95) target deep demersals, however the latter do so during the months of the pelagic 'off-season' while the former do so year-round.

1982:

In the early 1980s there were 25 pirogues using longlines and 4 semi-industrial vessels donated by Cuba also involved in the longline fishery (Samlalsingh *et al.*, 1995). These were assumed to target large pelagics from

November to June and the semi-industrial vessels assumed to catch reef demersals from July to October. It was also assumed that the vessels with outboard engines (121 pirogues and 16 dories) targeted large pelagics by trolling and were involved in fishing for inshore reef demersals during the pelagic off season. The double-enders (83 inboard, mean Hp is 19; 1 outboard, mean Hp is 12) are also assumed to target large pelagics from November to June but do not exploit the reef and demersal fisheries. The number of boats involved in the coastal pelagic (44) fishery were estimated by interpolation between data for 1969 and 1988.

Mean horsepower was computed from the vessel census data. A crude estimate of the range in horsepower during the late 1970s is as follows: whalers were either mechanized by sails or 10-35 Hp engines; canoes and transumes were either mechanized by sails or outboard engines and sloops were either mechanized by 50 to 100 Hp engines (Giudicelli, 1978).

1988:
Based on the qualitative description of the preferred fishery types of the respective vessels a number of assumptions were made: launches (8) were assumed to target large pelagics and flyingfish mainly (November to June) and catch inshore demersals during the large pelagic off season (July to October) and pirogues on the west and east coasts (except those between Woburn and Calliste) assumed to target large pelagics and flyingfish. Further, pirogues on the west coast utilise longlines and those on the east coast utilize troll lines. It is important to separate those utilizing different gear types because of the differences in vessel horsepower. Vessels between Woburn and Calliste (Woburn 17; Lance Aux Epines 3; True Blue 7; Calliste 31) target inshore demersals including lobster and conch (Finlay *et al.*, 1988) as well as seamoss from July to October. The single sloop is assumed to fish for deep water demersals based on the specialization of these vessels in previous years. Further it was assumed that whalers (13) fish for large pelagics (mainly) and inshore reef species with same fishing pattern as launches. There were 45 beach seines targeting the small coastal pelagic fishery; the equivalent number of boats was assumed.

Mean horsepower was taken from Table 1 of Mahon (1988). Estimates for pirogues, launches and sloops were 28, 58 and 101 Hp, respectively. No information on vessel horsepower was provided for whalers. An estimate was derived from interpolation between values for 1982 (vessel census) and 1993 (OECS, 1995). The horsepower of pirogues longlining was taken from Samlalsingh *et al.* (1995).

1993:
It was assumed that vessels with inboard engines target large pelagics with longlines (8 in St Georges and 3 in St Andrews); that all vessels on the west coast (parishes of St Georges – 143; St Johns – 76; and St Marks – 6) carrying outboard engines target large pelagics by longlining; that vessels on the east coast (parishes of St Patrick – 10; Andrews – 75 and St Davids – 31) carrying outboard engines target large plagics with troll lines; other vessels (assumed to be unmechanized) target either the small coastal pelagic fishery (72 on the west coast) or reef demersal (56 on the east coast). Two exceptions to the latter are vessels at Victoria and Sauteurs (48 combined) from where reef demersals are targeted year round by both mechanized and unmechanized vessels.

Mean vessel horsepower was taken from OECS (1995). Estimates for double-enders, pirogues, launches, and sloops were 36, 40, 130 and 120 respectively. The whaler category is not explicitly mentioned in the main data source. However, because of the similar activity with pirogues it is presumed that these two vessel types are combined under the pirogue category and the higher horsepower of the two was used in the analysis.

1997:
Information was extracted from the computerized information of the vessel census by simple querying in Microsoft Access. It was necessary to estimate the number of boats landing at the two parishes (St Mark and St David) for which data were not provided. The assumption was made that the relative number of boats at these two parishes compared to the rest of the island was the same in 1997 as for 1999. Details were available for this year from the Fisheries Department Trip Interview Program. It was estimated that 26 vessels (4 unmechanized, 20 with outboard engines and 2 with inboard engines) landed at these two parishes. It was also necessary to separate the statistics for each parish to account for differences in the

fishing activity on each coast (St Mark is on the north west coast where the typical fishery is for large pelagics (longlining) and St David on the south east where typical fisheries are for large pelagics (trolling) and reef demersals). Based on the relative number of vessels utilizing different engine types at the 2 parishes in 1999, it was estimated that in 1997 there were 9 vessels at St Mark (2 unmechanised; 5 with outboard engines and 2 with inboard engines) and 17 vessels at St David (2 unmechanised and 15 with outboard engines) in 1997. Several assumptions were made in order to assign vessels to fishery types, based on the location of the parishes along the coast. The reconstructed number of vessels is as follows: 'Pirogue (trolling)' comprises 99 pirogues (outboard), 1 double-ender (outboard) and 15 pirogues (outboard) reconstructed for St David. 'Pirogues (longlining)' comprises 10 canoes (outboard), 1 dory (outboard), 1 double-ender (outboard), 112 pirogues (outboard), 8 pirogues (inboard), and 6 vessels (5 outboards and 1 inboard) estimated for St Mark. 'Launches longlining' totals 15. Unmechanized vessels targeting coastal pelagics are listed under 'Canoes, transumes (unmechanized)' and total 31 [canoes (6), dory (2), double-ender (10), pirogue (11) and 2 vessels estimated for St Mark]. Vessels involved in inshore reef fisheries include 19 pirogues (outboard) representing vessels from landing sites between Calliste and Woburn which target these resources during the pelagic off-season and 11 unmechanized vessels (1 dory, 1 double-ender, 7 pirogues) under the heading 'Canoes, transumes (unmechanised)' which target this fishery year round.

Mean horsepower was computed directly from vessel census data for the different vessel types, once the vessels involved in each fishery were identified. The respective fishing days were computed directly from census information.

1999:
The relevant information was extracted by simple querying of the information obtained from the Trip Interview Program in MS Access. The large pelagic fishery was exploited by vessels of several types carrying either inboard or outboard engine. While the type of engine tremendously affects fishing costs, for this analysis, all vessels of a similar type were grouped regardless of engine type (though details by engine type are available in the associated worksheet). The category 'pirogues (longlining)' includes 16 pirogues (inboard), 154 pirogues (outboard) and 1 dory (outboard). The 3 doublenders (inboard) are involved in longlining. Also the category 'semi-industrial longliner/launch' includes 7 launches (inboard); 18 longliners (nf); 3 longliners (nm) and 1 sloop (inboard). The category 'pirogues (trolling)' comprises 1 dory (outboard), 7 pirogues (inboard) and 171 pirogues (outboard). Only 2 launches are involved in trolling (1 inboard and 1 outboard). Data for all unmechanized vessels for a particular fishery type were grouped. Five unmechanized pirogues were listed for the pelagic longline fishery and 5 vessels (1 dory and 4 pirogues) for the pelagic troll fishery. Coastal pelagics are exploited by 17 unmechanized boats (9 are pirogues and 8 are seine boats) as well as 16 pirogues (outboard), 2 dories (outboard) and I unidentified mechanized boat listed under 'beach seine and gillnet'. Inshore demersals are exploited by 8 unmechanized 'sailboats' (2 canoes, 1 dory and 4 pirogues), as well as 47 pirogues (outboard) and 2 dories (outboard). Offshore demersals are exploited by 8 unmechanized boats (1 dory, 6 pirogues and 1 seineboat), 33 pirogues (outboard), 1 dory (outboard) and 1 seineboat (outboard). Mean horsepower was computed directly from information in the Trip Interview Program once the vessels participating in each fishery was identified.

The Grenadines

1942:
Historically, the Grenadines have concentrated fishing on reef and demersal species (Brown, 1945). It is assumed that before the introduction of launches in 1982, all effort was directed at the small coastal pelagic, reef demersal and deep slope and shelf demersals. The beach seines (2) targeted small coastal pelagics and it is assumed that an equivalent number of vessels were involved. Whalers (19) and canoes (23) targeted demersal reef resources and the sloops (6) targeted deep slope and shelf demersal resources. All vessels were unmechanized except the sloops for which it is assumed that they were fitted with inboard engines of 10 Hp.

1969:
No details are given for the small coastal pelagic fishery, i.e., number of seines. It is assumed that the unmechanized vessels target the inshore reef resources. These comprise transumes (50) and whalers (26).

The mechanized sloops (6) and whalers (17) target deep slope and shelf demersals year round. The horsepower of whalers is given as 5-10 Hp, the higher limit is used. It is assumed that sloops carry diesel engines of 10 Hp.

1982:
The number of vessels is the main data source is an underestimate, as Petite Martinique and Isla Rhonde were excluded from the census. Using the 1998 data and assuming that the tow islands contribute the same proportion to the overall total number of boats it was estimated that 113 boats existed in all the Grenadine islands in 1982. Further, assuming the same relative proportion of the different vessel types as in 1988, it was estimated that there were 17 launches, 63 pirogues, 24 sloops and 9 double-enders. In assigning vessels to fishery types, the same pattern as for 1988 was assumed. Mechanized vessels with outboard engines (63 pirogues) targeted large pelagics by trolling and exploited the inshore reef fishery during the pelagic 'off-season' (typically from July to October). The launches were assumed to target the large pelagics from November to June and the deep shelf and slope demersals from July to October. The sloops (24) targeted the offshore shelf and slope demersals year round while the double-enders targeted the small coastal pelagic fishery (seine fishery) mainly but also exploited the reef demersals from July to October.

Mean horsepower was estimated directly from data provided for pirogues. There was no information available for sloops in the census data. Kawaguchi (1985) noted that inboard diesels of about 32 Hp are installed in larger boats or as auxiliary propulsion for larger sailing schooners. This was assumed applicable to the sloops. The horsepower of launches and double-enders was assumed to be the same as for 1988.

1988:
Vessel types were assigned to the corresponding fishery types based on Mahon (1988). It was assumed that the launches (17) and pirogues (65) fished for large pelagics mainly and inshore reef demersals during the pelagic off-season. The double-enders (9) were assumed to fish mainly for coastal pelagics and for reef demersals between July and October. The sloops (25) are assumed to target deep slope and shelf demersals year round as they have traditionally done. Mean horsepower was taken from Table 1, of Mahon (1988).

1993:
It was assumed that the 62 boats (with outboard engines) target the large pelagics from November to June and the inshore reef demersals from July to October. The 42 unmechanized vessels were assumed to target inshore reef demersals year round and the 3 vessels with inboard engines taken to represent the sloops, which traditionally target the offshore demersals. Mean vessel horsepower was taken from OECS (1995). The 62 mechanized vessels were assumed to be pirogues (40 Hp) and the sloops carried engines of 120 Hp.

1999:
Computerized information from the Trip Interview Program was queried in MS Access to extract the relevant information. In the large pelagic fishery vessels were grouped according to whether they were involved in trolling or longlining, rather than engine type. For categories with few vessels, these were often grouped with other categories when the fishing pattern was similar. Vessels targeting large pelagics with troll lines included 3 launches (2 double-enders and 1 launch); 27 pirogues (2 with inboard and 18 with outboard engines and 7 vessels of unknown category) and 1 unmechanized sloop. Vessels utilizing longlines included 8 launches; 12 pirogues (6 with inboard and 6 with outboard engines); 1 unmechanized pirogue and 3 double-enders. The coastal pelagic fishery was targeted by 2 pirogues (one each carrying an inboard and outboard engine). The inshore reef fishery was exploited by 13 mechanized pirogues (outboard engines); 2 unmechanized pirogues and 1 unmechanized sloop. The offshore demersals were targeted by: 2 dories (outboard engines); 3 pirogues (inboard engines); 88 pirogues (outboard engines); 9 unmechanized pirogues and 1 sloop (inboard engine). Mean horsepower was estimated directly from information in the Trip Interview Program for the respective vessel categories.