Fisheries Centre

The University of British Columbia

Working Paper Series

Working Paper #2015 - 40

Grenada: Reconstructed Fisheries Catches, 1950-2010

Elizabeth Mohammed and Alasdair Lindop

Year: 2015

Email: eliza_moham@yahoo.com

GRENADA: RECONSTRUCTED FISHERIES CATCHES, 1950-2010

Elizabeth Mohammed[a] and Alasdair Lindop[b]

[a] Research and Resource Assessment, Caribbean Regional Fisheries Mechanism Secretariat, Eastern Caribbean Office, St Vincent and the Grenadines.
[b] *Sea Around Us*, Fisheries Centre, University of British Columbia, 2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada

eliza_moham@yahoo.com; alindop@gmail.com

ABSTRACT

Grenada is a small country in the south eastern Caribbean Sea consisting of the primary island of Grenada and several islands at the southern end of the Grenadine chain. Fisheries are largely artisanal and for many years utilized traditional techniques. An industrial fishery began in the early 1990s when eight longliners with cold storage entered the fishery. This report reconstructed fisheries for Grenada for 1950-2010 and found that the reconstructed catches were 1.5 times the data reported to the FAO for the same time period. Fish caught from Grenada made up 89% of the catch. Artisanal fisheries contributed 71% of the total catch, with subsistence and industrial sectors contributing 20.5% and 8.4%, respectively, whilst the recreational fishery made up less than 0.1%. Yellowfin tuna (*Thunnus albacares*) was the primary taxon in the catch, mostly caught by the industrial fishery in the later part of the time period, and contributing 12.3% to the overall removals. Bigeye scad (*Selar crumenophthalmus*; 11.4%), red hind (*Epinephelus guttatus*; 10.6%) and flying fish (Exocoetidae; 8.9%) were also important.

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 several low-lying islands, including Carriacou and Little Martinique. The associated Exclusive Economic Zone and territorial waters comprise an area of 26,000 km^2 (www.seaaroundus.org) with a continental shelf area of 1,600 km^2 (Mahon 1993).

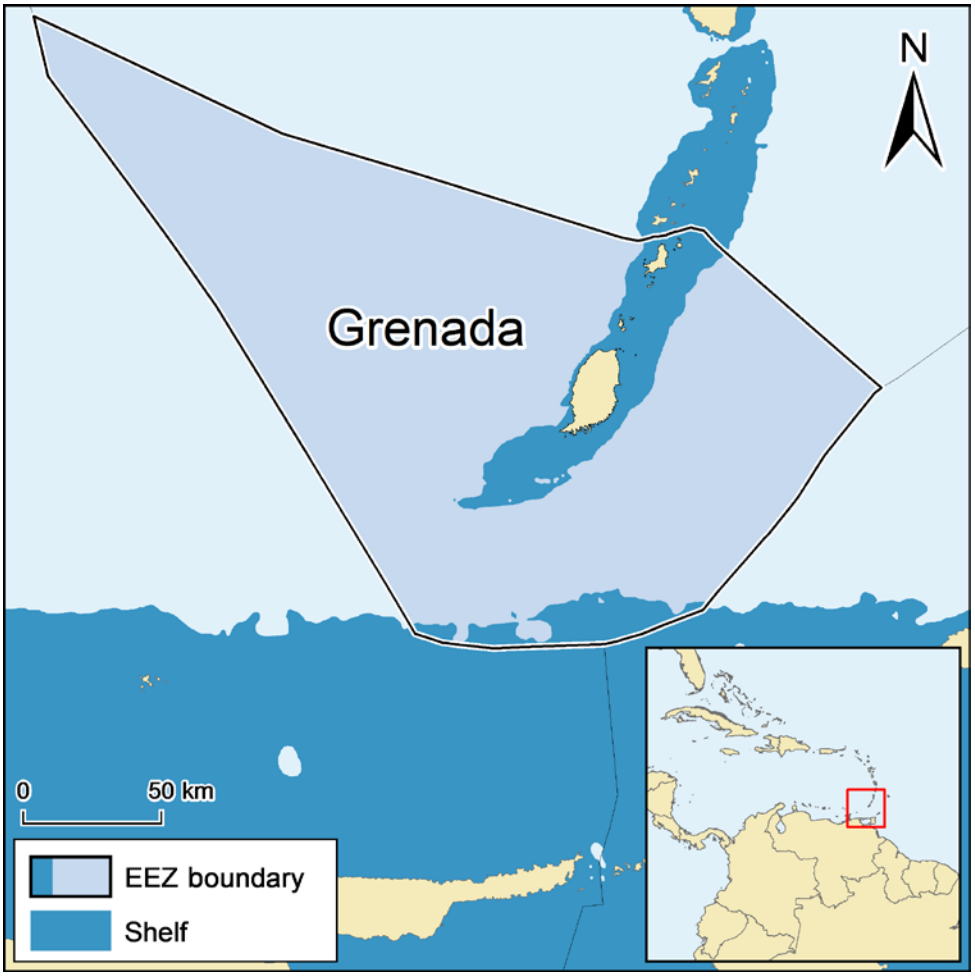

Figure 1. The Exclusive Economic Zone (EEZ) and shelf area (to 200 m depth) of Grenada.

Fisheries Development

There is little documentation on the Grenada fisheries prior to the 1980s. Up until 1974, Grenada and the associated smaller islands 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 was of a subsistence nature and targeted mainly the inshore coastal areas (Epple 1977). Brown (1945) gave 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 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 boats, at the time, were either wind (sail) or manual (oar) powered. However, a significant change occurred after World War II. 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 considered the most advanced throughout the Windward Islands at the time in terms of boat mechanization (Hess 1961). In 1953, fish-pots were introduced and the Fisheries Department commenced experimentation with outriggers to catch large pelagics by trolling, and flyingfish by gillnets. 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 beach seine, 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 18 to 27 m. 'Whalers', using handline and pots, fished further offshore (18-28 km) at depths of 55 to 73 m. They also utilized 'troll' lines when journeying to and from the fishing ground. 'Sloops' utilized both handlines and troll lines. These boats concentrated more on demersal species and fished further up the Grenadines island chain 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 in 1974, gave a detailed account of the impacts of motorization of the fleet, with particular reference to the landing site at Grenville, on the east coast of Grenada. 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. Boats 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 boats previously targeting hind (*Epinephelus guttatus*), grouper (Serranidae) and various other reef fishes switched, once mechanized, to large pelagics such as blackfin tuna (*Thunnus atlanticus*), bonito (*Sarda sarda*) and billfish (Istiophoridae and Xiphiidae; Epple 1977). Other impacts are related to changes in the marketing system, the pattern of boat ownership, migration of boats, creation of new economic roles and relationships and the entry of entrepreneurs into the fishery (as boat owners). As well, younger fishers tended to prefer

motorized boats and hence were involved in the pelagic fishery, while the older fishers continued to target inshore demersal and reef resources with less-mechanized boats.

However, throughout the 1970s, the industry was still characterized by small artisanal boats 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 (*Coryphaena hippurus*), kingfish (*Scomberomorus cavalla* and *Acanthocybium solandri*) or tuna (Scombridae) than for flyingfish (Exocoetidae, mainly *Hirundichthys affinis*) 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 establish 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 boats or reef fisheries is uncertain, though possibly considerable.

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 aging 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 boats donated by Cuba in 1980. These boats, however, were not equipped for catching a wide range of species, and were fraught with maintenance problems, resulting in a 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 the transfer of skill and technology to Grenadian fishers. Initially, however, fishers were very cautious at expanding such a fleet. Their apprehension was due mainly to the initial high investment costs, the large catches that were required to ensure profitability, possible decreases in wholesale fish prices as a result of increased supply, possible competition with the artisanal fleet and the absence of proper infrastructure.

From 1982, the government invested heavily in the fishing industry through the Artisanal Fisheries Development Project (scheduled to be of 5-6 years duration). This was a US$ 2.7 million project, instituted with financial assistance from the Caribbean Development Bank (Finlay 1990), the

International Fund for Agricultural Development (IFAD) and the Venezuelan investment fund (Finlay 1991). The Government's policy focused on increasing fish catches and employment in the industry as well as 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 when landings may be otherwise disposed of). Retail price control was, however, still in effect. Loans were also provided for fleet expansion and development or motorization. The use of outboard engines gained popularity among the artisanal boats because of the speed this allowed and smaller investment costs compared to inboard engines. Further, by the mid-late 1980s, boats involved in longlining set to sea with two instead of one outboard engine (Samlalsingh *et al.* 1995). However, (Finlay *et al.* 1988) 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 noted the reluctance of fishers to go to sea unless there was a high likelihood of substantial catches. Nevertheless, fishing with longlines became popular with the artisanal fleet, particularly 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 boats (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, results of the investigation were inconclusive (Mahon 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 gasoline-powered outboard engines (Finlay 1990, 1991). These longliners, capable of ice storage, made fishing trips of several days duration. Except for a decrease in exports to Martinique in the late 1980s (Finlay 1991), very little is documented on fishing in the Grenadines at this time.

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) provide 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 70 hp) to the Grenada government. Seven of these boats started fishing in 1992 (Samlalsingh *et al.* 1995). By the mid-1990s, almost the entire west coast pirogue trolling fleet, without any modifications to the boat design, size (mainly 8 m) or outboard engines, had 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 Boat 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 boat sizes beyond the size of the existing semi-industrial fleet (10-11 m). It was felt that increasing boat sizes would have increased the length of fishing trips beyond the existing 3-4 days duration and therefore compromised the quality of 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 boats which stay out at sea for longer time periods. Increased capital and operational costs associated with increasing boat sizes would have also deterred fishers.

Pirogues targeting large pelagics have traditionally restricted fishing activity to the months between November and July (coinciding with the flyingfish fishing season), since fishers believed 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, *Thunnus albacares*) could be located further offshore (60-80 km) in deeper waters during this period. However, 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 boats fished in the same areas as pirogues (at least during November to June), and therefore the catches of the two fleets comprised similar species (yellowfin tuna and Atlantic sailfish, *Istiophorus albicans*). However, fewer swordfish were caught by the semi-industrial boats, and fewer 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 (Palinuridae), sea eggs (Echinoidea) and seaweeds (*Gracilaria* spp.), 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 a bait fish 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. Fishing changed from a subsistence to an export-oriented activity. 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 (Chakalall 1986; Mahon 1990; Finlay 1991; Mahon and Singh-Renton 1992; Finlay and Rennie 1998).

Fisheries statistical data collection

Grenada was considered 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 market. 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. 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 boats under joint venture arrangements with local investors. Although there were plans to implement an Observer Program on board these boats (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, Duquesne, the artisanal fisheries project, Carriacou and Petit Martinique as well as eight processing plants.

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 provided to local 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 also captured in the data collection system. 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 also recorded. However, an unknown proportion is also sold, without records, to the public on the landing beach or directly to hotels. A major data gap exists for the dive fishery that targets lobster and conch (mainly on 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

Table 1. Management policy, objectives and regulations of the Grenada and the Grenadines fisheries. (Source: FAO[1])

Fishery	Target Species & Gear	Stock status	Management policy and objectives[1]	Regulations
Oceanic pelagic fishery	Species: Yellowfin tuna, marlins, sailfishes, dolphinfish, wahoo, small tunas Gear: longlines and trolling	Status of small tunas, dolphinfish and mackerels is unknown. ICCAT assessments indicate that large tunas and billfishes are either fully exploited or over exploited.	To cooperate with members of ICCAT, particularly Caribbean states, to assess, protect and conserve large pelagics and to promote development of the large scale offshore fishery.	Licensing of boats to facilitate management
Demersal fishery	Species: Snappers, groupers and other coral reef fish, lobsters, turtles and conch Gear:	Fishing area to the north of Grenada exploited beyond maximum sustainable yield	To promote stock recovery of the inshore fishery and to maximize catches of deep slope fisheries within the limits of potential yield.	Four-month closed season for all shellfish annually, mesh size restrictions for active (e.g., gillnets) and passive gear (e.g., fish pots)
Beach seine inshore pelagic fishery	Species: Scads (*Decapterus* spp., *Selar crumenopthalmus*), rainbow runner, other carangids and small tunas Gear: Beach seine	Production has been reliable and robust over the years	To encourage co-management and maintain the artisanal nature of the fishery.	Licensing system for nets and restrictions on mesh sizes. A traditional user right system exists.

1. No information currently available, assumed the same as for St Vincent and the Grenadines.

A shift in the approach of government to fisheries management was also evident, as Grenada, along with other countries of the Organization 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). Details of the current fisheries management policy, objectives and regulations are provided in Table (1).

Objective

This report is an update and extension of a previous study that assembled a time series of catch and effort data for Grenada and the Grenadines from 1942 to 2001 to enable assessment of the ecosystem impacts of fishing (Mohammed and Rennie 2003). The present extension covers the time period 1950-2010 and provides a fishing sector analysis as well as comparing the reconstructed catches with the data officially reported to the FAO. Small updates were made to the Mohammed and Rennie (2003) data to match *Sea Around Us* database standards.

[1] Information on fisheries management in Grenada, Jan. 2000: http://www.fao.org/fi/oldsite/FCP/en/GRD/body.htm

METHODS

General aspects of the methodology for reconstruction of fisheries catches and fishing effort are presented 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 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 since 1978 was available from the Fisheries Department. However, these statistics were 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 was severely limited by unavailability of data for the Grenadines.

Grenada

The essential data sources, for the pre-1980 period, were Brown (1945); Smyth (1957); Vidaeus (1969) and Giudicelli (1978). These data were 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 was collected in sufficient detail to facilitate a more informed estimation of catches by fishery and boat 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 landed at the main markets only (Vidaeus 1969; Chakalall 1997). Kawaguchi and Cortez (1985) noted that apart from the six main markets, where data were collected, there were approximately 25 smaller fish landing areas scattered across Grenada (and 6 across Carriacou), where data were 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 original 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)', were 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 (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 for Grenada only. Brown (1945) presented a crude estimate of total catches (947 t) for 1942. This figure was much greater than 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 1950 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 (3,189 t) estimates 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 were 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, ballyhoo, 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 misidentified 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 were 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 percent 'redfish' and 37 percent 'other fish'; redhind was comprised of the category 'hind shark' and 56 percent 'other fish' and coney was comprised of 15 percent 'red fish' and 75 percent '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 for 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). 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 overall 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 was 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 and 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 was derived for pirogue and semi-industrial longliners as follows:

$$Q = B \times H \times W \times D$$

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 boat; 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 that operated 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.

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 boat type;
4. That the number of boats 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 (130 fishing days). Semi-industrial longliners, which fish throughout the year, use other species (e.g., round robin) during the flyingfish 'off-season', July to October, for a total of 60 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 boat

staying with the set longline until retrieval. Fishing occurred during the traditional 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 was assumed that the same number of hooks (45) was 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 was 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 boats but this is not reflected in the effort reconstruction.

The Grenadines

Anchor points

Fewer anchor points were derived from the literature for the Grenadines compared to Grenada. These were for 1942 (Brown 1945), 1980 to 1994 (Chakalall 1997), 1984 to 2001 (Unpublished fish export statistics for the Grenadines) and 1999 to 2001 (Fisheries Department).

First interpolation: Total catches

1950-1979: Some adjustment to the estimate provided in Brown (1945) was necessary after the discrepancy with data provided by (Smyth 1957) for Grenada was observed. 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 from 252 t to 48 t for 1942. Annual total catches for the period 1950 to 1979 were estimated by interpolation between the modified estimate for 1942 and the estimate for 1980 (derived as described below).

1984 – 1999: There was an overlap in time coverage (1984-1994) of data on Martinique imports from the Grenadines (Chakalall 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 to management, 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 this was, from 1985 to 1999, the same as that for Martinique imports from the St Vincent Grenadines (SVG) report (Chakalall 1997). 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 also represented a proportion of total catches for the Grenadines: 85 percent of the finfish catch; 60 percent of catches from the dive/shell fishery and 10 percent 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 the 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” 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 percent 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, on estimated catches from 1989 to 1999, provided by the Fisheries Department were inconsistent with the estimates derived above. Again, the higher of the two estimates was used as representative of total catch for the reason given previously.

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 (reef/demersal fish; large pelagics; seine fish; mixed fish; lobster; conch and other fish) defined in the Martinique statistics on imports from the St Vincent Grenadines (Chakalall 1997). 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 that 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. Total landings by species were available for 1999 from the Fisheries Department. The landings were estimated using the 1.75 raising factor described previously. From these data 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 boats (Chakalall 1997), 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, less 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 surgeonfish (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 between 1980 and 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.

Update 2002-2010

Calculating totals

2002-2010:

For the update, catches were extrapolated forward to 2010. This was achieved by first calculating the ratio of overall reconstructed catches to the FAO total for each year and taking an average of the ratios 1997-2001. The average ratio was applied to the FAO total annually for 2002-2010 to estimate an overall catch for the islands in each year. This estimation was split by the average percentage contribution of the Grenadines and of Grenada to the total reconstructed catch for 1995-2000 to give an estimated catch total for each of the areas in 2002-2010.

Species breakdown

Grenada

2002-2010

A taxonomic breakdown was estimated by applying the average catch contribution of each species in 1999-2001 to the total catches in each year 2002-2010.

The Grenadines:

2000-2010

The same breakdown methods as for Grenada were applied.

Marine mammals and turtles

Earlier work by Mohammed and Rennie (2003) contained reconstructions of catches of marine mammals and turtles. However, the *Sea Around Us* does not include marine mammals or reptiles in its database, thus, for the present consideration, marine mammals and turtles were removed from the database and final reconstruction totals.

Sector breakdowns

Industrial

Catch data for Grenada and the Grenadines did not contain information on contributions to specific sectors, so an industrial component had to be estimated. Industrial catches were assumed to begin with the introduction of the (semi-industrial) longlining boats capable of cold storage in 1991 and restricted to the offshore element of the catch. Therefore, the total offshore catches were split by percentage from 0% industrial catch in 1990, and conservatively assuming 50% of offshore catches were industrial by 2010.

Industrial contribution to the offshore catch was interpolated for each year 1990-2010 and applied to the annual offshore catch total.

Artisanal

It was assumed that all inshore catches and the proportion of offshore catches that were not classified as industrial were from the artisanal sector, which side fined as small-scale and commercial in nature.

Subsistence

The reconstruction may already address part of the subsistence contribution for the islands, in terms of parts of the reported catch that was landed through reporting stations but taken home, but it is likely that fishing purely for subsistence bypassed the reporting process. Using case studies from Martinique, Dominica, Guadeloupe, Montserrat, and St Kitts and Nevis (Frotté *et al.* 2009a, 2009b; Ramdeen *et al.* 2012; Ramdeen *et al.* 2014a; Ramdeen *et al.* 2014c), an approximate average *per capita* subsistence rate of 0.013 $t \cdot person^{-1} \cdot year^{-1}$ in 1950 and 0.006 $t \cdot person^{-1} \cdot year^{-1}$ in 2010 was calculated and an interpolation applied for the intervening years. We conservatively applied 50% of this to the population for Grenada and the Grenadines for the 1950-2010 time period to estimate a first-order subsistence catch. This is a highly simplified approach and it is likely that subsistence catches are underestimated.

Taxonomic breakdown

A taxonomic disaggregation was achieved by assuming that the subsistence catch composition was proportionally similar to the inshore catch and applying the same percentage breakdown for each year to the estimated subsistence annual totals.

Recreational

Recreational participation in fishing in Antigua and Barbuda was found to be 0.23% of the population (Cisneros-Montemayor 2010; Cisneros-Montemayor and Sumaila 2010) and the same rate was assumed to be true of Grenada and Grenadines. It was assumed that the vast majority of recreational fishers were tourists, so the participation rate was applied to the tourist population only. Tourist arrivals data were only available from 1995[2], so estimated tourist numbers for 1950-1994 were calculated by interpolating from 60,000 tourists in 1995 to an assumed 0 tourists in 1945. Recreational participation was then calculated by applying the 0.23% participation rate to the tourist numbers. Ramdeen *et al.* (2014b) estimated a catch rate of 0.001 $t \cdot tourist^{-1} \cdot year^{-1}$ for the British Virgin Islands, which we assumed to be representative also for Grenada and applied it to the estimated participation total for each year 1950-2010 to obtain a recreational catch.

Taxonomic breakdown

Mike and Cowx (1996) reported on the domestic recreational fishery in Trinidad and Tobago and estimated the percentage of each fish taxon sold. This was used as a proxy for the composition of recreational catches in Grenada. The proportion of each taxon sold was estimated from Mike and Cowx

[2] http://data.worldbank.org/indicator/ST.INT.ARVL?page=3

(1996) and then all percentages were normalised to give a species breakdown for the recreational sector, which was applied to the estimated total for each year.

Discards

No discards were calculated for this study.

RESULTS

The total reconstructed catch for 1950-2010 was 1.5 times the data reported for the same period. Artisanal fisheries were the most important sector, contributing 71% of fish removals, with the subsistence sector adding a further 20.5%. The industrial sector made up 8.4% (active only since the 1990s), with recreational catches less than 0.1%.

Catches grew throughout the time period, increasing from 900 t in 1950 to nearly 3,500 t by 2010 (Figure 2a). Yellowfin tuna (*Thunnus albacares)* were the most important component of the overall catch, despite only appearing significantly in the second half of the time period, with 12.3% of the total overall reconstructed catch. Bigeye scad (*Selar crumenophthalmus*; 11.4%), red hind (*Epinephelus guttatus*; 10.6%) and flying fish (Exocoetidae; 8.9%) were other major contributors to the total catch. (Figure 2b)

Industrial sector

The reconstructed industrial sector appeared in the 1990s and rose steadily, increasing from 32 t in 1990 to 1230 t in 2010. Like the overall catch, yellowfin tuna (34.4%) were the most important taxa caught, with flying fish (14.7%), dolphinfish (*Coryphaena hippurus;* 10.1%) and blackfin tuna (*Thunnus atlanticus*; 10%) also significant taxa.

Artisanal sector

Artisanal catches grew overall throughout the time period, increasing from 400 t in 1950 to 1,950 t in 2010. The highest catches were through the 1986-1993 period, averaging 2,300 t·year^{-1}, following a small crash to 780 t in 1981. By 1995, the catch had dropped by 34% to 1,630 t, thereafter catches started increasing again, with another peak in 2003. The primary taxa were almost the same as for the industrial sector, although yellowfin tuna were less dominant. Yellowfin tuna contributed 13.2% of the overall artisanal catch, with flying fish (10.8%), bigeye scad (10%) and red hind (9.8%) all making up a similar amount.

Subsistence sector

The subsistence sector decreased over the time period, dropping from 500 t in 1950 to 300 t in 2010. Initially, the sector maintained steady catches of 520 t·year^{-1}until the mid-1970s, before beginning a steady decline. Bigeye scad (21%) made up most of the catch followed by redhind (17.9%), round scad (*Decapterus punctatus*; 13.4%) and snappers (Lutjanidae; 11.2%).

Recreational sector

Reconstructed recreational catches were very small, and contributed less than 0.1% to the total catch. Overall, they gradually rose through the time period, increasing from 0.25 t in 1950 to 2.5 t in 2010.

Grenada

Catches in Grenada made up 89.2% of the total catches and therefore followed a very similar trend as the overall reconstruction, increasing over the time period and growing from 745 t in 1950 to 3,320 t in 2010, with a peak of 3,530 t in 2009. Artisanal catches contributed 70.4%, subsistence 20.3% and industrial 9.3%.

Like the overall reconstruction, yellowfin tuna (*T. albacores*) was again the most dominant taxa, making up 13.8%. It was closely followed by bigeye scad (*S. crumenophthalmus*; 12.8%), flying fish (Exocoetidae; 10%) and red hind (*E. guttatus*; 9.8%).

The Grenadines

The Grenadines contributed only 10.8% of the total catch and had a very different trend to the overall reconstruction. Catches remained low and stable throughout the first 30 years, averaging 162 t·year^{-1}from 1950-1982, before a rapid rise to peaks of 817 t and 904 t in 1986 and 1989, respectively. Catches dropped to their original levels by 1995 and maintained an average of 156 t·year^{-1}until the end of the time period.

With 77% of the total catch, artisanal fisheries made up a bigger percentage than in Grenada, with industrial fisheries only contributing 0.8%. Subsistence fishing made up 22%. The species composition was also markedly different, with two species, redband parrotfish (*Sparisoma aurofrenatum*; 30.1%) and red hind (17.3%) making up almost 50% of the catch. Snappers (9.4%) and grunts (9.3%) were also important.

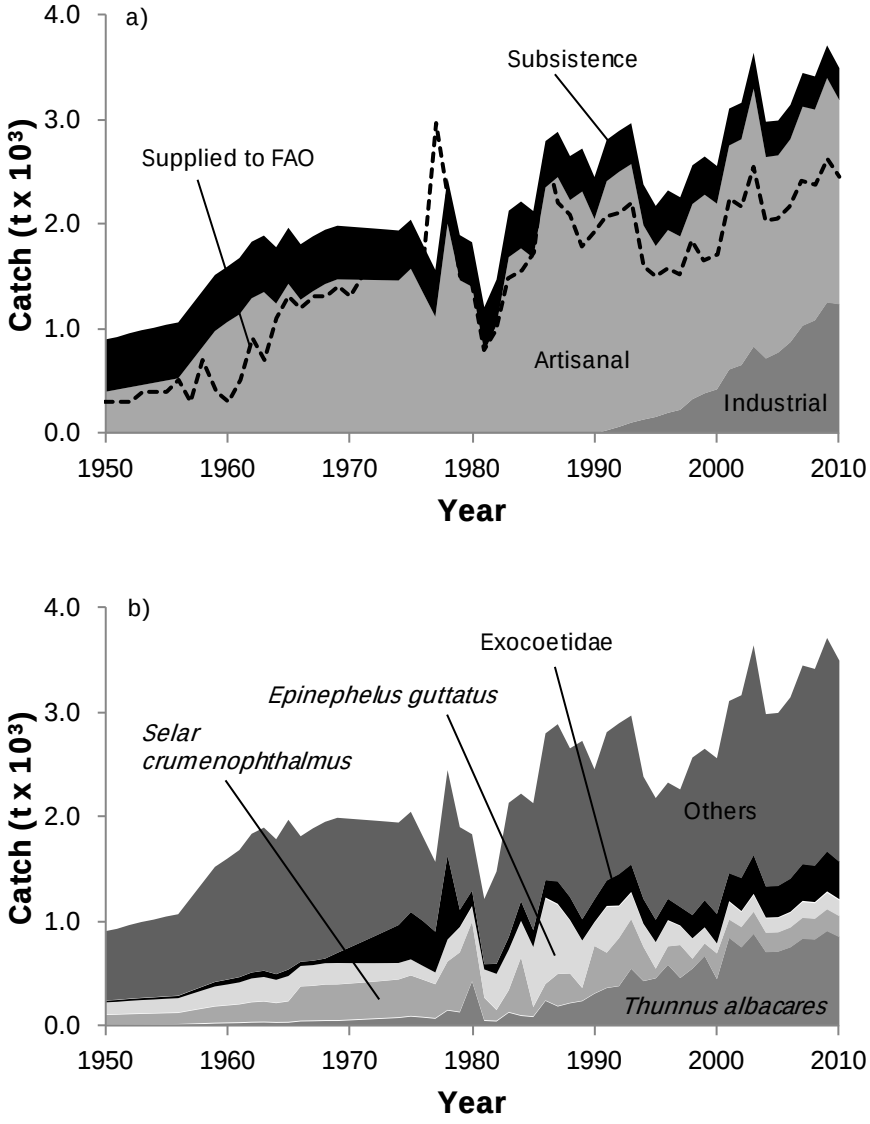

Figure 2. Reconstructed catches for Grenada from 1950-2010 by a) fishing sector, with data officially reported to FAO overlaid as line graph; and b) major taxa, with 'others' accounting for an additional 55 taxa.

DISCUSSION

Fisheries catches

Catches in the Grenada offshore fishery increased by a factor 9.5 between the most recent low in 1981 and 2010, from 256 t to 2,437 t. In contrast, catches in the inshore fishery declined by 62 percent between the peak in 1987 (1,062 t) and 2001 (598 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 percent the 1986 estimate. Subsequently catches have increased to 130 t in 2010.

A comparison of annual catches in the FAO FISHSTAT database and reconstructed catches of this study showed major differences from the mid-1950s to mid-1960s. 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.

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. (Vidaeus 1969) estimated that between 1960 and 1968 annual imports represented between 1.64 and 2.76 times domestic landings. The apparent preference for imported, salted fish in particular, originates from a long tradition of consumption of salted cod and smoked herring from northern countries (Kurlansky 1998).

The decline in catches between 1979 and 1984 coincides with the political events mentioned previously. These events 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 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 Boat 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) for semi-industrial boats (Samlalsingh *et al.* 1995).

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 government's policy to develop the offshore fishery as a result. 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 boats, 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 predominantly subsistence-based or national food production activity to one based on increasing foreign exchange (export oriented). In the 1990s most of the fresh fish production 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).

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 Development 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 percent of beach seine catches from Grenada are exported to Martinique, though this is not considered in the present analysis.

The trend towards development of the offshore fishery targeting large, highly migratory pelagics, is evident from the change in species composition from greater quantities of small tunas throughout the 1960s to mid-1970s to a domination of the catch by large tunas since the 1980s. In the inshore fishery small coastal pelagics continued to dominate the catch in the last decade. Snappers and groupers followed and invertebrates continued to contribute very little to overall catch.

The reconstructed catches presented here are preliminary and should be considered minimum estimates. There are several data limitations. These limitations 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, estimations of the rest of the domestic recreational fishery are not included and the tourist-associated charter boat fisheries reconstruction relies on crude assumptions. 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 accurate estimates is difficult, as basic information, e.g., on the number of boats 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. This is also the case with the four boats 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 are 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 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, especially since flyingfish is a natural prey of the large pelagic species targeted by the longline fishery of many islands in the region.

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 were 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.

ACKNOWLEDGEMENTS

This is a contribution of the *Sea Around Us*, a collaboration between the University of British Columbia and The Pew Charitable Trusts. We thank Justin Rennie and A. Maharaj for considerable assistance with sourcing catch data, as well as the Paul G. Allen Family Foundation for supporting the *Sea Around Us*.

Andrews JK (1990) Analysis of billfish fisheries in Grenada. ICCAT SCRS Collective Volume of Scientific Papers 32(2): 407-409.

Brown HH (1945) The fisheries of the Windward and Leeward Islands. Development and Welfare Bulletin 20: 1-91.

Chakalall B (1986) Perspectives and alternatives for fisheries development in the Lesser Antilles. *In* Proceedings of the Gulf and Caribbean Fisheries Institute 37. 154-168 p.

Chakalall B (1997) The status of marine fishery resources and fisheries management in the Lesser Antilles. The Food and Agriculture Organization of the United Nations, Rome (Italy). 93 p.

Cisneros-Montemayor A (2010) The economic benefits of ecosystem-based marine recreation: implications for management and policy. MSc thesis, University of British Columbia, Vancouver. 105 p.

Cisneros-Montemayor A and Sumaila UR (2010) A global estimate of benefits from ecosystem-based marine recreation: Potential impacts and implications for management. Journal of Bioeconomics 12(245-268).

Epple GM (1977) Technological change in a Grenada W.I. fishery, 1950 - 1970. pp. 173-193. *In* Smith ME (ed.), Those who live from the sea. West Publishing Company Inc., San Francisco (USA).

Finlay J (1990) Socio-economic situation of small-scale fisheries in Grenada. The Fourth Session of the Western Atlantic Fishery Commission: Committee for the Development and Management of Fisheries in the Lesser Antilles, The Western Central Atlantic Fishery Commission, Kingstown (St. Vincent and the Grenadines).

Finlay J (1991) Preliminary study on the economic and social situation of small scale fisheries in the Caribbean English speaking countries: The Grenada situation. 125.

Finlay J and Rennie J (1998) OECS regional fisheries management/development workshop: Grenada profile. Organisation of Eastern Caribbean States, Fishery Unit, Cane Garden (St. Vincent and the Grenadines).

Finlay J, Rennie J, Mahon R and Rosenberg AA (1988) A fishery data collection system for Grenada. *In* Fishery data collection systems for eastern Caribbean islands: Proceedings of an OECS/ICOD Workshop, Cane Garden (St. Vincent and the Grenadines).

Frotté L, Harper S, Veitch L, Booth S and Zeller D (2009a) Reconstruction of marine fisheries catches for Guadeloupe from 1950-2007. pp. 13-20 *In* Zeller D and Harper S (eds.), Fisheries catch reconstructions: Islands, part I. Fisheries Centre Research Report 17 (5). University of British Columbia, Vancouver.

Frotté L, Harper S, Veitch L, Booth S and Zeller D (2009b) Reconstruction of marine fisheries catches for Martinique, 1950-2007. pp. 21-26 *In* Zeller D and Harper S (eds.), Fisheries catch reconstructions: Islands, part I. Fisheries catch reconstructions: Islands, part I 17 (5). University of British Columbia, Vancouver.

Giudicelli M (1978) Grenadian fisheries development mission findings and recommendations. Western Central Atlantic Fishery Commission, Panama. 35 p.

Hess E (1961) Fisheries Development in the West Indies: 1960 - 1961. *In* Part of a statement submitted to the Meeting of Caribbean Fisheries Officers, Hato Rey (Puerto Rico).

Kawaguchi K and Cortez J (1985) FAO fisheries policy, planning and programming mission to Grenada: Reports prepared for the Government of Grenada. Food and Agriculture Organization of the United Nations, Rome (Italy).

Kurlansky M (1998) Cod: A biography of the fish that changed the world. Penguin, USA.

Mahon R (1990) Fishery management options for Lesser Antilles countries. FAO Fisheries Technical Paper 313: 126.

Mahon R (1993) Marine fishery resources of the Lesser Antilles, Puerto Rico and Hispaniola, Jamaica, Cuba. FAO Fisheries Technical Paper No. 326.

Mahon R and Singh-Renton S (1992) Report of the CARICOM Fisheries Resource Assessment and Management Program (CFRAMP). International Commission for the Conservation of Atlantic Tunas. 4 p.

Mike A and Cowx IG (1996) A preliminary appraisal of the contribution of recreational fishing to the fisheries sector in north-west Trinidad. Fisheries Management and Ecology 3: 219-228.

Mohammed E (2003) Reconstructing fisheries catches and fishing effort in the southeastern Caribbean (1940-2001): General methodology. pp. 11-20 *In* Zeller D, Booth S, Mohammed E and Pauly D

(eds.), From Mexico to Brazil: Central Atlantic fisheries catch trends and ecosystem models. Fisheries Centre Research Reports 11 (6). University of British Columbia, Vancouver, (Canada).
Mohammed E and Rennie J (2003) Grenada and the Grenadines: Reconstructed fisheries catches and fishing effort, 1942 - 2001. pp. 67-94 *In* Zeller D, Booth S, Mohammed E and Pauly D (eds.), From Mexico to Brazil: Central Atlantic fisheries catch trends and ecosystem models. Fisheries Centre Research Reports 11 (6). University of British Columbia, Vancouver (Canada).
Peña MS and Wirth AJ (1979) Inter-regional project for the development of fisheries in the Western Central Atlantic: Report on the mission to Grenada. Western Central Atlantic Fishery Commission. 48 p.
Ramdeen R, Harper S and Zeller D (2014a) Reconstruction of total marine fisheries catches for Dominica (1950-2010). pp. 33-42 *In* Zylich K, Zeller D, Ang M and Pauly D (eds.), Fisheries catch reconstructions: Islands, part IV. Fisheries Centre Research Reports 22 (2). University of British Columbia, Vancouver.
Ramdeen R, Harper S, Zylich K and Zeller D (2014b) Reconstruction of total marine fisheries catches for the British Virgin Islands (1950-2010). pp. 9-16 *In* Zylich K, Zeller D, Ang M and Pauly D (eds.), Fisheries catch reconstructions: Islands, part IV. Fisheries Centre Research Report 22 (2). University of British Columbia, Vancouver.
Ramdeen R, Ponteen A, Harper S and Zeller D (2012) Reconstruction of total marine fisheries catches for Montserrat (1950-2010). pp. 69-76 *In* Harper S, Zylich K, Boonzaier L, Le Manach F, Pauly D and Zeller D (eds.), Fisheries catch reconstructions: Islands, part III. Fisheries Centre Research Reports 20 (5). University of British Columbia, Vancouver.
Ramdeen R, Zylich K and Zeller D (2014c) Reconstruction of total marine fisheries catches for St. Kitts and Nevis (1950-2010). pp. 129-136 *In* Zylich K, Zeller D, Ang M and Pauly D (eds.), Fisheries catch reconstructions: Islands, part IV. Fisheries Centre Research Report 22 (2). University of British Columbia, Vancouver.
Salmon GC (1958) Report on the fisheries industry in the countries served by the Caribbean Commission. Food and Agriculture Organization, Rome (Italy). 86 p.
Samlalsingh S, Oxenford H and Rennie J (1995) A successful small-scale longline fishery in Grenada. Unpublished document. 12 p.
Senga K (1995) Outline for requesting a grant of additional fishing vessels for Grenada. Japan International Cooperation Agency. 22 p.
Smyth JA (1957) The fisheries and fisheries resources of the Caribbean area. Report of the United States Department of the Interior, Bureau of Commercial Fisheries. Fishery Leaflet 259. Updated from an earlier mission by R.H Fiedler.
UNEP/IUCN (1988) Coral reefs of the world: Atlantic and Eastern Pacific. International Union for the Conservation of Nature (IUCN), Gland (Switzerland).
Vidaeus L (1969) An inventory of the Grenada fishing industry. Report of the UNDP/FAO Caribbean Fishery Development Project, SF/CAR/REG/16 M6. 34 p.
Villegas L (1978) Review of the status of fishery statistics and fishery research capabilities in the WECAF Project Area. UNDP/FAO. 27 p.

Appendix Table A1. Reconstructed fish catches of Grenada by sector, 1950-2010. Including data reported to FAO

Year	FAO landings	Reconstructed total catch	Industrial	Artisanal	Subsistence	Recreational
1950	301	900	0	400	499	0
1951	301	923	0	421	501	0
1952	301	959	0	443	516	0
1953	400	989	0	464	524	0
1954	400	1,012	0	486	525	0
1955	400	1,041	0	507	533	0
1956	500	1,063	0	529	534	1
1957	300	1,214	0	679	534	1
1958	701	1,365	0	830	535	1
1959	401	1,517	0	980	536	1
1960	301	1,595	0	1,066	528	1
1961	501	1,678	0	1,139	538	1
1962	901	1,833	0	1,293	539	1
1963	701	1,893	0	1,353	539	1
1964	1,102	1,781	0	1,243	538	1
1965	1,301	1,967	0	1,431	535	1
1966	1,201	1,810	0	1,279	529	1
1967	1,301	1,885	0	1,360	524	1
1968	1,301	1,948	0	1,429	518	1
1969	1,401	1,986	0	1,473	512	1
1970	1,302	1,978	0	1,471	505	1
1971	1,503	1,969	0	1,469	498	1
1972	1,702	1,960	0	1,467	492	1
1973	1,702	1,951	0	1,465	485	1
1974	1,636	1,941	0	1,462	477	1
1975	1,702	2,044	0	1,574	468	1
1976	1,702	1,803	0	1,344	458	2
1977	2,959	1,565	0	1,116	447	2
1978	2,235	2,443	0	2,005	437	2
1979	1,492	1,897	0	1,465	431	2
1980	1,415	1,829	0	1,402	425	2
1981	785	1,209	0	781	426	2
1982	980	1,472	0	1,036	434	2
1983	1,478	2,130	0	1,685	443	2
1984	1,554	2,218	0	1,768	447	2
1985	1,724	2,126	0	1,678	447	2
1986	2,697	2,795	0	2,350	443	2
1987	2,207	2,883	0	2,448	432	2
1988	2,086	2,652	0	2,229	420	2
1989	1,778	2,723	0	2,311	410	2
1990	1,908	2,451	0	2,048	401	2
1991	2,065	2,806	32	2,378	395	2
1992	2,106	2,891	65	2,433	391	2
1993	2,207	2,965	105	2,468	390	2
1994	1,598	2,380	134	1,855	389	2
1995	1,495	2,175	159	1,631	383	2
1996	1,572	2,324	198	1,744	378	2
1997	1,527	2,258	227	1,655	374	3
1998	1,834	2,564	328	1,863	370	3
1999	1,656	2,647	384	1,896	365	3
2000	1,699	2,557	421	1,773	360	3
2001	2,246	3,105	610	2,140	352	3
2002	2,165	3,160	652	2,157	348	3
2003	2,538	3,638	828	2,464	343	3
2004	2,034	2,979	715	1,924	337	3
2005	2,048	2,991	771	1,885	332	2
2006	2,166	3,140	870	1,940	327	3
2007	2,405	3,445	1,026	2,094	322	3
2008	2,384	3,412	1,077	2,016	316	3
2009	2,617	3,708	1,248	2,147	311	3
2010	2,453	3,491	1,232	1,951	306	3

Appendix Table A2. Reconstructed catch in Grenada by major taxa, 1950-2010. "Others" includes 55 taxa.

Year	*Thunnus albacares*	*Selar crumenophthalmus*	*Epinephelus guttatus*	Exocoetidae	Others
1950	9	89	124	15	662
1951	10	91	127	16	679
1952	10	95	132	17	705
1953	11	98	136	18	726
1954	12	100	139	19	743
1955	12	103	143	20	764
1956	13	105	145	21	780
1957	17	122	162	28	886
1958	21	138	179	34	994
1959	25	154	195	41	1,101
1960	27	161	204	45	1,157
1961	29	170	214	49	1,217
1962	34	186	231	56	1,328
1963	35	191	238	58	1,370
1964	32	179	226	53	1,291
1965	33	195	245	61	1,433
1966	45	326	198	40	1,201
1967	47	330	200	41	1,267
1968	50	340	205	44	1,309
1969	50	341	206	96	1,293
1970	55	344	197	149	1,233
1971	61	347	188	202	1,172
1972	66	351	178	255	1,110
1973	72	355	169	308	1,047
1974	78	361	159	361	983
1975	91	386	154	450	962
1976	81	354	133	428	807
1977	70	322	114	388	670
1978	148	463	209	801	822
1979	130	569	240	164	794
1980	423	571	145	148	542
1981	50	213	273	49	623
1982	45	100	349	94	884
1983	128	208	388	119	1,287
1984	97	553	347	189	1,032
1985	86	87	576	161	1,217
1986	239	157	824	168	1,408
1987	186	305	669	215	1,508
1988	216	280	511	219	1,426
1989	236	121	454	203	1,709
1990	306	455	224	217	1,249
1991	360	337	443	244	1,423
1992	377	460	307	301	1,447
1993	542	478	253	264	1,429
1994	425	327	217	237	1,173
1995	451	91	253	213	1,167
1996	579	178	247	204	1,115
1997	454	316	184	177	1,127
1998	543	95	194	222	1,510
1999	663	122	151	259	1,452
2000	444	246	93	282	1,493
2001	835	182	168	268	1,652
2002	745	199	147	317	1,752
2003	873	219	162	372	2,012
2004	700	189	140	298	1,653
2005	704	189	139	300	1,658
2006	745	194	144	317	1,739
2007	827	207	153	352	1,905
2008	820	204	152	349	1,887
2009	900	216	161	383	2,048
2010	844	206	153	359	1,929