

## St. Vincent and the Grenadines: Reconstructed Fisheries Catches and Fishing Effort, 1942-2001

Elizabeth Mohammed<sup>1</sup>, Leslie E.  
Straker<sup>2</sup> and Cheryl Jardine<sup>2</sup>

<sup>1</sup>Trinidad Fisheries Division  
Ministry of Agriculture, Land and Marine  
Resources  
St. Clair Circle, Port of Spain  
Trinidad, West Indies  
Email: e.mohammed@tstt.net.tt

<sup>2</sup>St. Vincent Fisheries Division  
Ministry of Agriculture, Lands and Fisheries  
Bay Street, Kingstown.  
St. Vincent and the Grenadines  
Email: fishdiv@caribsurf.com

### ABSTRACT

Time series of catch and effort data were reconstructed for the fisheries of St. Vincent and the Grenadines for the time period 1942 to 1999. Information was obtained from the St. Vincent Fisheries Department's Statistical databases, from historical documents, and from published and unpublished literature. General trends indicated increasing catches since the 1960s and an exponential increase in fishing effort since 1942. A comparison of reconstructed data with reported statistics incorporated in the FAO FISHSTAT database was made, and limitations in reconstructed data are discussed. Generally, catch per unit area (CPUA) for both offshore and inshore fisheries increased over the 58-year period, but considerable inter-annual variability was observed for 1977 onwards. Catch per unit of effort (CPUE) declined exponentially between 1942 and 1999 in the St. Vincent offshore and in the Grenadines inshore fisheries. Compared to other fisheries, CPUE has been consistently higher in the St. Vincent inshore fishery, which operates during the pelagic off-season. Although a decline in catch per unit effort was experienced from the mid 1970s to late 1980s, this has increased again in the 1990s, though at levels substantially below the pre-1975 period.

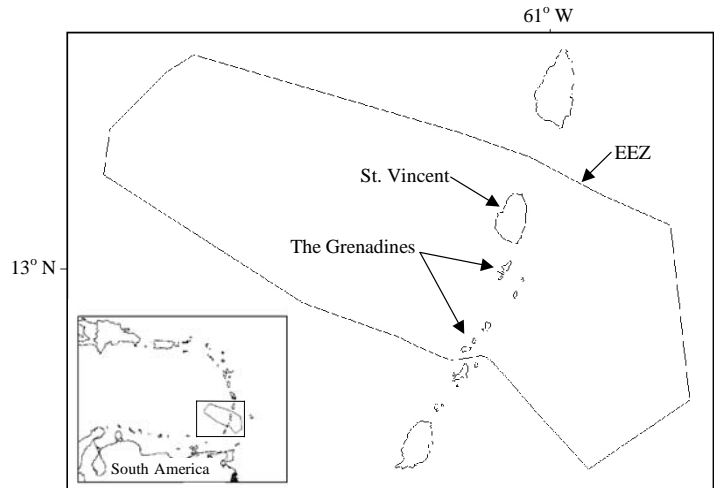
### INTRODUCTION

#### Study area

St. Vincent is the youngest of the major volcanic islands in the Windward group of the Lesser Antilles (Figure 1). It lies between Grenada and St. Lucia, due west of Barbados (UNEP/IUCN, 1988). Dependencies of St. Vincent include some 28 rocky islands extending south and including Bequia, Mystique, Canouan, Union and Little Vincent. The Exclusive Economic Zone of St. Vincent and the associated Grenadines occupies an area of 27,069 km<sup>2</sup> (Veridian MRJ Technology, 2000). Total reef habitat is estimated at 140 km<sup>2</sup> (Oliver and Noordeloos, 2002) and slope and shelf area at 1,800 km<sup>2</sup> (Mahon, 1993).

#### Fishery development

Fisheries in St. Vincent and the Grenadines are multi-gear and multi-species. Detailed descriptions are provided in Brown (1945), Vidæus (1969), Chakallal (1982), Matthes



**Figure 1:** Map of St Vincent and the Grenadines in the Lesser Antilles of the southeastern Caribbean. Indicated also is the EEZ.

(1984) and Morris (1991, 1992, 1993, 1995). The reef, slope and shelf fisheries are targeted by handlines, bottom-set longlines, fish pots, spear guns and trammel nets. These capture species such as snappers (Lutjanidae), groupers (Serranidae), parrotfish (Scaridae), squirrelfish (Holocentridae), grunts (Haemulidae), surgeonfishes (Acanthuridae) and triggerfish (Balistidae). The small coastal pelagic fishery utilizes beach seines and cast nets, and captures species such as jacks (Carangidae), herrings (Clupeidae), silversides (Atherinidae), anchovies (Engraulidae), balahoo (*Hemiramphus* spp.)

and robins (*Decapterus* spp.). Large pelagics like tunas (Scombridae), billfishes (Istiophoridae), dolphinfish (*Coryphaena hippurus*), wahoo (*Acanthocybium solandri*), sharks (Carcharhinidae) and swordfish (*Xiphius gladius*) are caught by troll and surface longlines. Non-fish species such as lobster (*Panulirus argus*), conch (*Strombus gigas*) and sea urchins (*Tripneustes ventricosus*) are taken by divers. A small traditional whaling industry utilizing gun harpoons is also operating out of Barrouallie and Bequia (Grenadines), targeting mainly short-finned pilot whales (*Globiocephala macrorhynchus*) and humpback whales (*Megaptera novaeangliae*), respectively (Brown, 1945; Rack, 1952; Vidaeus, 1969; Adams, 1971, 1973; Caldwell and Caldwell, 1971, 1975).

There is a clear distinction between the various fisheries of importance to St. Vincent and the Grenadines. The dominant fisheries in St. Vincent are the trolling and longline fisheries targeting large pelagics, the beach seine fishery targeting small coastal pelagics and the taking of humpback whales, which are landed at Barrouallie (Chakalall, 1982). Handlining for snappers and groupers, the lobster and conch fisheries and whaling for short-finned pilot whales, which are landed in Bequia, are more popular in the Grenadines (Chakallal, 1982).

### **Pre 1950s**

Little is documented on fisheries in St. Vincent and the Grenadines prior to the 1950s. Whaling was the first important fishing industry, which was established by Americans in the early 1860s (Adams, 1971), and by 1875 a local whaling station was established in Bequia, one of the Grenadine islands. Although the industry declined in the 1920s, it contributed substantially to the knowledge and technology of boat building and sailing, later required for exploiting fin fish (Adams, 1971). Commercial exploitation of fish and shellfish was insignificant until the 1940s, mainly because of a small and unreliable markets for fish. The main source of protein was derived from cheap, salted cod from Newfoundland (Kurlansky, 1997). The small demand for fish in Bequia resulted in little momentum to develop the fishing industry (Adams, 1980). Canouan exported small quantities of processed fish to Kingstown, but transport difficulties associated with the distance between the islands limited trade. Fishing was mainly at

the subsistence level in Union Island, although there was some export of turtle shell to Trinidad and processed fish to Grenville (Adams, 1980).

In 1940 the government enacted a price control on fish (Adams, 1985), whereby wholesale and retail prices were set according to a grading system for landed fish. The measure was implemented to ensure the affordability of fish to low income people. However, it was thought to encourage a black market in the selling and buying of fish and to act as a hindrance to the development of the industry (Adams, 1985).

Fishing activity declined considerably during World War II as fishers sought alternative employment on military bases. At the end of the war, there was a mass entry to the fishing industry (Adams, 1980), the only readily available employment. Under the jurisdiction of the Agriculture Department, a 'fisheries administration' was created in 1946 with the hiring of one person. This situation prevailed until 1982, when the Fisheries Division was created. Tremendous dissatisfaction with marketing conditions at the main market in Kingstown resulted in the sale of catches, particularly by fishers from the Grenadine island of Canouan, to Grenada. The higher prices and fewer restrictions in Grenada were added incentives to this activity (Agricultural Department, unpublished report, 1949). At the time retailing activities by fishers were prohibited in St. Vincent and the Grenadines, a regulation that was later rescinded. The price control on fish was lifted in 1946.

By the end of the 1940s, Canouan emerged as an important island for salting of fish catches (Agricultural Department, 1949), mainly demersal species caught with bank lines and fish pots. Several reports of fish trading between the Grenadines islands and Martinique indicate this activity as commencing in the late 1940s (Adams, 1971) or early 1950s (Agriculture Department, unpublished report, 1951). Lobster, conch, turtles and demersal fish were sold to boats from Martinique.

In early 1946, an assistance scheme for the development of the shark industry in Barrouallie was implemented, but this was short lived (3 months) due to lack of technical supervision. By the end of the 1940s, there were also demonstrations on the use of trammel nets and construction of the first

purse seine net (Agricultural Department, unpublished report, 1948). Though trammel nets later became very important in the Grenadines demersal fishery, purse seines are limited to beach seining (Chakallal, 1982).

### **1950s to 1980**

#### *Grenadines*

Little is documented on fisheries during the 1950s. However, the trade between the Grenadines and Martinique acted as an incentive to increased fishing. Between 1955 and 1958 nearly 227 t of fish was exported to Martinique (Adams, 1980). Conch fishing became an important activity on Union Island (Grenadines), stimulated by the strong demand in Grenada and Trinidad, growing unemployment and the observed high abundance in nearby waters (Adams, 1970). Throughout most of the 1950s and 1960s conch caught at Union Island was sold to Grenada (Adams, 1980) and Trinidad (Adams, 1970). During the 1960s this fishery was the most important economic activity on Union Island (Mahon, 1987), although, by the early 1970s virtually all conch was sold to Martinique (Adams, 1980). The resource was rare in the northern Grenadines (Bequia and Mystique) and by 1966 the resource was already showing signs of depletion in established fishing areas due to overfishing (Adams, 1970).

Fishing in the 1960s was still mainly a subsistence activity with most fishers operating on a part-time basis (Vidaeus, 1969). Activities at Canouan received government support through the introduction of a cold storage facility and construction of a loading jetty in Canouan in 1960 (Agricultural Department, 1961). Iced and salted fish were purchased from the island and sold in the main market at Kingstown in St. Vincent and in Grenada. An auxiliary sloop was introduced in 1962 to transport ice to Canouan and purchase iced fish from the island. The sloop also transported fish to neighbouring islands of St. Lucia and Dominica (Lewis, 1964). By 1964 however, fishers had reverted to drying and salting fish for sale in St. Vincent or Grenada. Bequia had emerged as an important trading island for lobster and demersal fish and two trading schooners from Martinique were sent to the Grenadines each month for this purpose (Lewis, 1964).

The government's policy of increased fish production was manifested in its

participation in a joint program sponsored by the United Nations Development Program (UNDP) and the Food and Agriculture Organization (FAO). The Caribbean Fishery Development Project supported market development and the training of fishers (Vidaeus, 1969). Financial assistance was provided through a loan scheme initially implemented by the Agricultural Department in the early 1960s which was taken over by the St. Vincent Agricultural and Co-operative Bank in 1969. This offered duty-free privileges for the purchase of engines, timber (for boat construction) and gear. However, there were problems with the efficient implementation of the scheme (Vidaeus, 1969). In 1963, a four-fold increase in the catches of blackfish (short-finned pilot whale) over the previous year was attained through the introduction of mounted harpoon guns (Lewis, 1964).

A fisheries development program was instituted in association with the Ministry of Overseas Development in the United Kingdom beginning in the early 1960s, which included infrastructure development in Canouan and cold storage and ice facilities at Kingstown. The government also granted licenses to companies in the French Antilles facilitating the purchase of fish from the Grenadines at guaranteed prices. This arrangement did not last very long, however, and was eventually abandoned. In addition to Martinique, fish from the Grenadines (Canouan and Bequia) were sold to Guadeloupe (Vidaeus, 1969).

#### *St. Vincent*

Most fishing off St. Vincent was conducted off the west and south coasts at which there were ten 'fishing centers'. Facilities at the 'fishing centers' included, at most, a shed used as the fish market and running water. No fuel facilities were available. Fishing on the windward (east) coast was insignificant and there were no fishing centers. Three of the fish markets (Chateau Belair, Layou and Calliaqua) were the property of the Town Board, while the main market in Kingstown was administered by the St. Vincent Marketing Board. The price control implemented in 1940 was discontinued (Vidaeus, 1969). However, a new fish marketing scheme was implemented in the Kingstown market in 1969: the market had the sole buying authority and guaranteed a fixed price to fishers, based on a new pricing structure. The intention was to relieve the

fishers of dependency on 'middle-men' and thereby promote increased fishing and a better supply of fish to the public.

In the early 1970s, only 6.13% and 14.8% of the fleets in St. Vincent and the Grenadines, respectively, were motorized (Cecil, 1972). Although it is reported that engines were being used 15-18 years previously, the bulk of the engines were acquired starting in the early 1960s.

The blackfish (pilot whale) industry also started to decline in the 1970s (Adams, 1973). This was attributed to reduced interest by potential fishers, increased evasion of whales from the motorized boats (sound), world inflation and associated high fuel and equipment costs, and the 1972 US Marine Mammal Protection Act which prohibited the export of high priced melon oil to the US. By the mid-1970s depletion of lobsters and turtles was apparent (Agricultural Department, 1975) and the extension of closed seasons for these resources were being considered.

In the 1970s, the government sought to decrease the substantial imports of processed fish by increasing local fish catches. In addition to increasing the number and technical capability of staff, improved methods of fish harvesting, greater monitoring of duty-free importation and other incentives such as fuel subsidies, establishment of fishing co-operatives and revitalization of the blackfish (pilot whale) industry were also to be introduced. International assistance was sought to address inadequate cold storage and processing capabilities (Agricultural Department, 1975). Efforts to set up fishing co-operatives continued throughout the late 1970s (Agricultural Department, 1979). The smuggling of lobsters, fish and conch from the Grenadines by boats from Martinique was a major on-going problem, especially since the activity was supported by local fishers who obtained high prices for their catch (Agricultural Department, 1979).

### **1980s**

In August 1980 Hurricane Allen caused fleet and gear damage of about US\$ 26,000. Altogether 31 boats were affected and beach seines and fish pots were destroyed (Agricultural Department, 1980). At this time fishers were also complaining about the sharp increases in fuel prices and the lack of a

proportional increase in fish prices (Agricultural Department, 1980). This resulted in a decline in fishing activity. Exports from the Grenadines were particularly affected as only 2 boats operated in 1980. Apart from high fuel costs, the high costs of engines and scarcity of spare parts were also contributing factors for the substantial decline in fishing activity. At this time, several resources were already showing signs of over-exploitation (Matthes, 1984). Conch catches were limited with exports going primarily to Martinique (Mahon, 1987). The use of Scuba gear and faster boats utilized in the fishery suggested that greater effort was required to extract the catch from depleted populations (Chakallal, 1982). Smaller sizes of lobsters in the catch and unavailability in shallow waters suggested a similar fate of this resource. Fishers responded by fishing in deeper waters. The whaling industry was also in decline.

The general consensus was that demersal resources, excluding lobster and conch, could withstand an increase in artisanal fishing effort (either by increasing the number of boats or the efficiency of existing methods). However, industrialization of the fleet was not recommended until the status of the resource was determined. The pelagic fishery was thought able to accommodate an increase in fishing effort, though under controlled conditions to avoid population declines in transboundary stocks. Unlike neighboring islands, the flying fish fishery was not important in St. Vincent and the Grenadines. This fishery was seen as another avenue for development (Chakallal, 1982).

Attempts to set up fishing co-operatives mostly failed, with only those under the guidance/control of the fisheries administration being successful. A loan scheme was still in effect, and engines and gear were provided free of duty. However, facilities at the major fish market in Kingstown were in disrepair and there was no organized marketing scheme. Wholesale and retail prices were still under government control (Morris, 1984). Fishing activity was still largely for subsistence as most fishers operated part-time, and had alternative sources of employment (Matthes, 1984).

Japanese assistance commenced in 1987 and was aimed at development of offshore fisheries, domestic distribution, export systems, and training of fishers (St. Vincent

Fisheries Department, 1999). These came to fruition in the 1990s.

### **1990s**

A joint project funded by the government of St. Vincent and the Grenadines and the Canadian International Development Agency was implemented in the early 1990s (St. Vincent Fisheries Department, 1999). The project aimed to support and enhance the St. Vincent and the Grenadines fisheries institutional capacity, community self-help activities and organizations, and to allow sustainable growth of the industry.

Significant development was also achieved through a Japanese Grant Aid Program. This included the upgrade of facilities at the main market at Kingstown (Morris, 1992) and construction of fisheries centers at Union Island, Canouan, Bequia and Calliaqua (St. Vincent Fisheries Department, 1999). In 1991 five new 12.5 m multi-gear vessels equipped with longline and trolling gear were acquired from Japan (Mahon and Singh-Renton, 1992). This marked the establishment of a tuna longline fleet resulting in escalation of the importance of large pelagic resources such as tuna, billfish and shark in the 1990s (Morris, 1992, 1995). Research and management support to assess the status of pilot whales and the bottlenose dolphin were also sought from the Japanese Grant Aid Program. Another program in collaboration with St. Lucia and Grenada aimed at assessing the status of the warsaw grouper (*Epinephelus nigritus*).

Fisheries were still predominantly small-scale and artisanal (Morris, 1995) with most vessels being open and powered by outboard engines. However, by the end of the 1990s considerable infrastructure development had occurred in the Grenadines (Paget Farm, Britannia Bay, Mystique, Friendship, Clifton) and Calliaqua in St. Vincent (Straker *et al.*, 2001). Similar facilities were planned for Barrouallie and Chateaubelair. The improvement and establishment of facilities and the increased harvesting of off-shore fisheries are indicative of the future developments in the fisheries sector.

### **Fisheries statistical data collection**

Prior to 1992 data collection was confined to landings at the major market at Kingstown and exports from the Grenadines to Martinique. The Barrouallie Fisherman's Co-operative Society had historically recorded

captures of whales and porpoises (Adams, 1973). In the 1960s fish landings at the market represented 60% of total landings throughout St. Vincent and the Grenadines (Vidaeus, 1969). In 1988 plans were formulated under the Organization of Eastern Caribbean States (OECS) for a revised data collection system (Morris *et al.*, 1988). This revised data collection system was implemented in 1992 under the CARICOM Fisheries Resource Assessment and Management Program (CFRAMP) and is still in effect. A system of random stratified cluster sampling was implemented at seven zones, with catch and effort data recorded at representative sites within each zone. Landing sites are categorized into primary, secondary and tertiary sites based on the number of fishing boats landing regularly at the site, the amount of fish landed and the level of infra-structure development (Straker *et al.*, 2001). At Kingstown and Barrouallie there are two primary sites, 14 secondary sites and 20 tertiary sites. Data are also collected from trading vessels operating in the Grenadine/Martinique fish trade. Total landings are estimated by applying a raising factor to account for days when data are not recorded. A licensing and registration program is in effect and an inventory of distant water fishing vessels registered with St. Vincent and the Grenadines is maintained. The Trip Interview Program (TIP), a data management program introduced under the CFRAMP, is presently being used for data entry, management and analysis.

### **Fisheries policy**

The fishery policy in the 1980s focused on the provision of jobs in the industry by upgrading the performance of existing fishermen and improving services and facilities (Andersen *et al.*, 1983). St. Vincent, being a member of the Organization of Eastern Caribbean States (OECS), has also enacted the harmonized fisheries legislation. Presently the three pieces of legislation governing fisheries management include: the Maritime Areas Act No. 15/1983 declaring an Exclusive Economic Zone; the Fisheries Act No. 8/1986 for the promotion and management of fisheries and related matters and the Fisheries Regulations for regulation of foreign fishing licenses, fish processing establishment licenses, fishery conservation measures, fish aggregation devices and fisheries research. The aim of policy in the 1990s was to promote sustainable utilization of all fishery resources within the EEZ (Morris, 1992). Policy

promoted the gradual development and expansion of a national offshore fleet, while ensuring the legal framework existed to protect the smaller artisanal boats that traditionally targeted the same species.

### **Objectives**

The main objective of the present study was to assemble a time series of catch and effort data for St. Vincent and the Grenadines.

## **METHODOLOGY**

### **Catches**

Most available data were from recorded landings at the fish market in Kingstown. Fish from throughout St. Vincent (but mainly the leeward coast) and the Grenadines were transported to this market. Information in Brown (1945) and Vidaeus (1969) was used to disaggregate recorded catches into the respective components for St. Vincent and the Grenadines. Landings attributed to St. Vincent accounted for 50% in the early 1940s to 60% from the late 1950s to late 1960s (Vidaeus, 1969). It was assumed that minimal landings from the Grenadines were transported to St. Vincent after the late 1960s as the fish trade with Martinique was well established after this point (Chakallal *et al.*, 1997). Landings at the Kingstown market were reported to represent 50% of the overall landings in St. Vincent during the early 1940s to mid-1960s; 60% from the mid to late 1960s and declined steadily from 45% in the late 1960s to 29% in 1995.

### **St. Vincent**

#### *Anchor Points*

1942: Smyth (1957) provided total annual catch estimates of 181 t Brown (1945) derived a crude annual estimate of 1,684 t (67% attributable to St. Vincent with the remaining 33% to the Grenadines).

1948-1949: Recorded landings at the Kingstown Fish Market were available in the reports of the Agricultural Department. Data were adjusted accordingly to represent total catches in St. Vincent only, assuming that the recorded data represented 50% of total landings in St. Vincent. The report of 1949 also provided data for landings at Layou and Calliaqua which were estimated to represent 3.4% and 6.4% of the total, respectively.

1958-1968: Recorded landings at the Kingstown market were available in Vidaeus (1969). Data for 1959 to 1964 matched those

in the Colonial Report (Part I) of 1964/65 (Anon., 1965). Data for 1962 to 1964 matched those in the Fisheries Report of Lewis (1964). Recorded data in the Colonial Report exceeded that from other sources for 1965. This higher estimate was used in calculations. It was assumed that 60% of recorded landings were from catches by the St. Vincent fleet and that recorded catches represented 60% of the overall total for the island.

1975-1981: Chakallal (1982) provided data on fish landings at the Kingstown Fish market. He assumed this represented 45% of the total fish catch in St. Vincent, which was used in estimation of the associated annual total catch. The St. Vincent Fisheries Department's Statistical Database also provided data on landings at the Kingstown Fish Market from 1979 to 1981. However, these estimates were lower than those stated in Chakallal (1982), and were also lower than estimates from the Agricultural Department for 1979 and 1980. The higher estimates were used in subsequent analyses.

1982-1999: Data were obtained from the St. Vincent Fisheries Department's Statistical Database. Prior to 1993, data consisted solely of landings at the Kingstown Fish Market and exports, mainly from the Grenadines Islands. Beginning in 1993, data sources consisted of 1) a total census of landings at the Kingstown Fish Market; 2) data from 36 additional landings sites obtained from a random stratified cluster sampling system; and 3) fish exports. It was assumed that landings at the Kingstown Fish Market accounted for 45% of total landings in St. Vincent prior to 1985. Since data on landings at the Kingstown market were not available for 1993 and 1994, the estimated total landings for 1995 (which utilized data for both the Kingstown market and other landing sites) was used to estimate the relative contribution of catches from the Kingstown Fish Market (46.6%) to the overall total. The relative contribution of landings at the Kingstown Fish Market to overall total landings in St. Vincent between 1986 and 1994 was estimated by interpolation between the 1985 and 1995 values. This was used to derive estimates of total annual catch for 1985 to 1992 from recorded data at the market.

#### *First Interpolation: Total catches*

Total catches from 1943 to 1947 were estimated by interpolation from estimates for 1942 (Smyth, 1957) and 1948 (Agricultural Department, 1948). The same procedure was

used to estimate the total catch for the periods 1950 to 1957 and 1969 to 1974.

*Second Interpolation: Species Composition*

There was no documentation on species composition prior to 1967. Brown (1945) derived a crude estimate of total catch by fleet. Although the estimate was not used in the actual catch reconstruction because of uncertainties associated with the magnitude of total catch and respective fleet catches, it was used to apportion the 1942 catch into the respective offshore and inshore components. It was assumed that catches from part-time fishing comprised solely of inshore species, harvested during the pelagic off-season. Vidaeus (1969) provided information on the species composition of landings/catches at the Kingstown Fish Market in 1967 and 1968. This comprised of 12 species: robin (*Decapterus macarellus*), jacks (*Selar crumenophthalmus*), skipjack tuna (*Katsuwonus pelamis*), redfish (Serranidae and Lutjanidae), hind (*Epinephelus guttatus*), dolphin (*Coryphaena hippurus*), spratt (*Harengula pensacolae*), ballahoo (*Hemiramphus balao*), dodger (*Decapterus punctatus*), bonito (*Thunnus atlanticus*) and barracuda (Sphyraenidae). All other species were grouped in an aggregate category accounting for 6-14% of the total. The species composition between 1969 and 1978 was estimated by interpolation of estimates for 1968 (Vidaeus, 1969) and 1979 (based on the Fisheries Department's Statistical Database on recorded catches at the Kingstown Fish Market). The proportion of total catch attributed to the offshore and inshore fisheries between 1943 (Brown, 1945) and 1966 was interpolated, using data from Brown (1945) for 1942 and Vidaeus (1969) for 1967. The corresponding estimates of offshore and inshore catch were calculated as the product of the respective annual proportion of total catch and the total catch estimated previously. Between 1979 and 1992 the species composition from recorded data at the Kingstown Fish Market was assumed representative of total catches. In all instances, the actual species weights were estimated using the associated species composition and total catch estimated. Annual estimated total landings by species were available for 1993 to 1999 from the St. Vincent Fisheries Department.

*Estimation of marine mammal catches*

Barrouallie is the main site from which marine mammals are targeted in St. Vincent.

Catches include mainly blackfish and porpoises. Comprehensive descriptions of the fishery are provided in Brown (1945), Rack (1952), Vidaeus (1969), Adams (1971, 1973), and Caldwell and Caldwell (1971, 1975).

**Pilot Whales:** The number taken was estimated based on 'fish oil' exports (assuming the oil was derived only from pilot whales) or from landings at Barrouaille. In 1944 about 596 gallons of blackfish oil were shipped to Trinidad, Barbados and Grenada (Brown, 1945). Using the mean quantity of oil produced per whale (14 gallons; after Brown 1945), a minimum of 43 animals were estimated to be taken. This was converted to the equivalent weight using the mean individual weight of 0.64 tonnes for short-finned pilot whales (Trites and Pauly, 1998). The annual report of the Agricultural Department (1946) indicated 1,627 gallons of fish oil was exported in 1946. Similar reports for 1948 and 1949 indicated 135 and 272 pilot whales caught in the respective years. Approximately 937 and 293 gallons of oil were exported to Trinidad in 1960 and 1961, respectively (Agricultural Department, 1960, 1961). Using the conversion after Brown (1945) and Trites and Pauly (1998) the equivalent weight was estimated. Caldwell and Caldwell (1975) provided estimates of annual numbers of blackfish landed at Barrouallie from 1962 to 1974. Except for 1964 and 1965 these estimates exceeded the annual numbers for 1962 to 1968 in Vidaeus (1969), and for 1962 to 1964 in Lewis (1964). Chakallal (1982) gave an estimate of 125 animals. The higher estimates were used. The annual reports of the Agricultural Department for 1979 and 1980 indicated 25 and 23 blackfish landed in the respective years. Records of the St. Vincent Fisheries Department indicated the quantity of blackfish oil exported from 1986 to 1999. Using the conversion factor after Lewis (1964), the corresponding number of whales was estimated and converted to the equivalent weight using the mean weight from Trites and Pauly (1998).

**Sperm Whales:** The 1949 annual report of the Agricultural Department provided an estimate of the number of sperm whales caught in the respective year while Vidaeus (1969) gave estimates for 1962 to 1968. Corresponding weights were estimated using a mean individual weight of 18.5 tonnes (Trites and Pauly, 1998). Lewis (1964) also provided estimates of sperm whale catches

from 1962 to 1964, although only the estimate for 1963 was used as this was greater than that provided in the Agricultural report. Caldwell and Caldwell (1975) provided estimates of landings at Barrouaille between 1967 and 1974. Estimates for 1967 and 1968 were, however, lower than those provided by Vidaeus (1969). Consequently, the higher estimates were used.

**Other Whales:** Caldwell and Caldwell (1975) provide estimates of killer whales (*Orcinus orca*) and false killer whales (*Pseudorca crassidens*) landed at Barrouaille between 1967 and 1974. Landings of porpoises at the Kingstown market between 1972 and 1974 are also provided. This comprised several species but the spinner dolphin (*Stenella longirostris*) accounted for a large portion of the catch. The reports of the Agricultural Department for 1979 and 1980 provided estimates of 18 and 15 dolphins landed in the respective years. The weight of porpoise caught between 1979 and 1999 were available from the St. Vincent Fisheries Department's statistical database.

#### *Estimation of marine turtle catches*

Four species of turtles are present: the green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*) and loggerhead turtle (*Caretta caretta*) (Matthes, 1984). Only the green and hawksbill are regularly fished, either by net or harpoon. The quantity of turtles exported between 1935 and 1946 was taken from the Caribbean Commission Central Secretariat (1948). The fishery is based mainly on green and hawksbill turtles with approximately 65 to 70% of the total catch coming from Bequia (Rebel, 1974). There is no market data available for the green turtle so it was assumed that all exports were hawksbill turtles with a mean weight of 51 kg (Witzell, 1994). Exports of hawksbill shell ('bekko') from 1974 to 1986 were taken from Milliken and Tokunaga (1987). Assuming 1.15 kg of shell per individual (Ogren, 1989) the corresponding numbers of turtles was estimated. For the periods 1987 to 1989 and 1992 to 1999, data were from the Fisheries Department's statistical database and pertain mainly to the export of turtle meat. No conversion factor is available to translate this into total weight of turtles caught.

### **The Grenadines**

#### *Anchor Points*

1942: Smyth (1957) provided an annual estimate of 205 t for the Grenadines.

1949: Assuming the same relative contributions of St. Vincent as in 1942, and using the 1949 estimate of total catch for St. Vincent (Agricultural Department, 1949), an estimate of 265 t was derived for the Grenadines.

1958-1968: Vidaeus (1969) provided data on recorded landings at the Kingstown Fish Market, 40% of which was assumed to be landed by boats from the Grenadines. Based on a crude estimate of total annual landings of the respective fleets using assumed catch rates for the respective islands (Vidaeus, 1969), St. Vincent and the Grenadines accounted for 55% and 45% of the total landings, respectively. Total annual landings in the Grenadines were estimated using the relative percentage contributions and estimates of total landings derived for St. Vincent. It was assumed that Grenadine landings at the Kingstown market were also accounted for using this method. Recorded landings at the Kingstown market accounted for 35-49% of total annual catches in the Grenadines using this method.

1975-1980: Chakallal (1982) gave exports of fish from the Grenadines derived from statistics of the Fisheries Division, Ministry of Agriculture, Trade and Tourism. Specific limitations of the data include the disregard of fish consumed locally, the non-inclusion of unofficial exports and the inaccuracy of weights which are usually estimated by eye rather than measured directly. Export data for 1979 was taken from the Annual report of the Agricultural Department for the respective year (120 t) as this slightly exceeded the estimate for the corresponding year in Chakallal (1982). Export data for this period represent minimum estimates as these include exports from Union Island but exclude exports from Bequia and Canouan. Fish exports represented about 60% of total catch (Matthes, 1984), hence recorded exports were adjusted accordingly to represent total catch. Based on raised estimates for 1993 (provided by the St. Vincent Fisheries Department), Union Island accounted for 38.54% of total catches from the Grenadines. Export data were adjusted accordingly to account for landings at Bequia



and Canouan in total catch estimates for 1979 and 1980.

1981-1994: Data were available from two main sources. Firstly, the Statistics Bureau of Martinique Customs summarized in Chakallal *et al.* (1997) gave estimates of fish imports from St. Vincent and the Grenadines from 1981 to 1993. Secondly, records of the St. Vincent Fisheries Department statistical database provided data on fish exports from 1984 to 1994. Based on Matthes (1984) and Morris *et al.* (1988), fish exports were assumed to account for 60% of total landings of seine and demersal fish caught in the Grenadines. Exports from St. Vincent were assumed negligible. Annual catch was estimated by adjusting export data accordingly. Except for 1989 and 1993, data from Chakallal *et al.* (1997) exceeded corresponding estimates in the Fisheries Department Statistical Database. In all instances the higher estimates were used, consistent with a precautionary approach to assessment.

1995-1999: Estimates of total catch were provided by the St. Vincent Fisheries Department for 1995 to 1999. These estimates were derived from recorded data for 15 sites in the Grenadines (Admiralty Bay; Friendship Bay; Lapompe Bay; Lower Bay; Paget Farm; Shipping Bay; Trading Vessels; Ashton; Canouan; Clifton; Palm Island; Petit Martinique; Petit St. Vincent; Saline Bay and Union Island). Recorded data were adjusted to account for non-enumerated days.

#### *First Interpolation: Total Catches*

Annual total catches for 1943 to 1948 were estimated by interpolation between the 1942 estimate (Smyth, 1957) and the 1949 estimate (Agricultural Report, 1949). Similarly, estimates were derived for 1950 to 1957 and 1969 to 1974 using the anchor points described previously.

#### *Second Interpolation: Species Composition*

Pre 1984: No data are available upon which the species composition of the catch could be estimated.

1984-1991: Export data were disaggregated for specific groups only. These included lobster, conch, whelk (*Cittarium pica*), turtle and tri-tri (*Sicydium plumieri*), while all other fishes were aggregated into one category. No data were available from which the aggregate fish category could be

disaggregated into its species components. Based on Chakallal *et al.* (1997) the species preferred by trading vessels from Martinique are snapper, redhind, grouper, butterfly/coney (*Cephalopholis fula*), caca belly/parrotfish (*Sparisoma aurofrenatum*), mackerel, cavalli (*Caranx* spp.), jacks and robins.

1993-1999: Export data are disaggregated into the respective species groups. There is however, a high level of aggregation in 1993. Exports of large pelagics, including yellowfin tuna (*Thunnus albacares*), swordfish and bigeye tuna (*Thunnus obsesus*) were assumed to have originated from St. Vincent (Morris, 1995).

#### *Estimation of marine mammal catches*

Humpback whales (*Megaptera novaeangliae*) are caught off Bequia in the Grenadines. The annual number of whales caught from 1898 to 1938, and 1950 to 1984 were taken from Price (1985) and were based on the amount of oil produced. The 1979 estimate concurs with that provided by the report of the Agricultural Department for the respective year. Weights were estimated using a mean individual weight of 30.408 tonnes (Trites and Pauly, 1998). Brown (1945) indicated that no whales were caught between 1940 and 1944, while three were killed in 1945. The 1982 annual Agricultural report indicated two whales were harpooned in that year.

#### **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 a general methodology report by Mohammed (this volume).

##### ***Data Sources***

There were several sources of information, however, only those which enabled separation of effort for St. Vincent from the Grenadines were used.

1942: Estimates of the number of boats by size as well as the number of gear units (beach seines, jack seines and gillnets) used at several landing sites along the windward (seven sites) and leeward coasts (21 sites) of St. Vincent, and seven sites in the Grenadines was provided in Brown (1945). The number of whale boats at Barrouaille and Bequia was also given.

1949: The 1949 annual Agricultural report gave data on the total number of boats in St. Vincent as well as Bequia, Canouan, Mayreau and Union Island. The associated number of whale boats, beach seines and fishermen was also provided.

1959: Adams (1971) estimated six whaleboats at Bequia, targeting humpback whales.

1968: Data were extracted from Vidauis (1969) from a description of the respective fisheries and gave the number of boats involved in the handline and pot fishery in St. Vincent and the Grenadines (Bequia, Canouan, Mayreau, Union Island, Mystique). The relative quantity of mechanized and unmechanized boats was also provided and the number of beach seines given.

1971: Adams (1971) estimated nine whaleboats at Barrouallie, targeting pilot whales and porpoises.

1981: Chakallal (1982) provided data from an artisanal fishery survey in St. Vincent and the Grenadines. Specifics on the number of vessels by size and design (fiberglass pirogue, planked or dug-out canoe), the number of mechanized boats and the corresponding number of fishers for 18 landing sites in St. Vincent, and the Grenadine islands of Bequia, Canouan, Mayreau and Union Island. The number of flyingfish nets, beach seines, ballyhoo nets, trammel nets, cast nets and turtle nets was also provided. Based on Matthes (1984) mechanized vessels carried outboard engine of 25-40 Hp average, while Morris (1984) gave a range of 25-55 Hp. An estimate of 40 Hp was used. Matthes (1984) indicated inboard engines of 40-70 Hp average. An estimate of 70 Hp was used.

1999: Data were available from the Fisheries Department's Licensing and Registration System. Details on vessel type, engine type, engine horsepower and port of operation were used. Missing data on vessel type and engine horsepower were estimated by comparing information on vessel length at similar sites and for similar fishery types. Mean horsepower was estimated directly for specific vessel types in St. Vincent and the Grenadines. In St. Vincent the mean horsepower of pirogues (commercial), pirogues (sport), canoes, bow and stern vessels, and semi-industrial longliners was 65, 438, 45, 51 and 241, respectively. The same mean horsepower of canoes and bow

and stern vessels was estimated for the Grenadines. However, the mean horsepower of commercial pirogues (n = 59), sport pirogues (n = 500), semi-industrial longliners (n = 172) was different. Sloops and mechanized double-enders in the Grenadines carried engines of 50 and 32 Hp, respectively.

### ***Linking fishing effort to fishery type***

1942: Based on a description of the respective fisheries in Brown (1945) the St. Vincent fleet consisted of 285 boats. Eighty-four boats and 42 beach seines operated year round in the small coastal pelagic fishery (Brown, 1945) on the leeward coast of St. Vincent. These were divided equally among large and small boats. It was assumed that all other boats targeted flyingfish and large pelagics from February to May, and demersal resources during the pelagic off-season. These comprised 81 small boats and 120 large boats. The two whaleboats in St. Vincent (Barraouallie) targeted the pilot whale and porpoises. All boats were unmechanized.

In the Grenadines there were 127 boats. The large pelagic fishery was unimportant. Based on the number of beach seines, 11 small boats and 11 large boats targeted the coastal pelagic fishery, year round. The remaining boats (42 small boats and 63 large boats) exploited the demersal fishery year round. The four whaleboats in Bequia (Grenadines island) targeted humpback whales (Brown, 1945). All boats were unmechanized.

1949: There were 180 boats in St. Vincent and 124 in the Grenadines all of which were unmechanized. In St. Vincent 32 boats targeted the small coastal pelagic fishery (based on the number of beach seines). It was assumed that the remaining boats (148) targeted large pelagics from December to June and demersal resources during the pelagic off-season. In the Grenadines, 24 boats targeted the small coastal pelagic fishery and the remaining boats (100) targeted the demersal resources.

1969: There were 30 beach seines in St. Vincent. The associated number of boats was 60, all unmechanized. Of the 275 boats involved in the handline/pot fishery (large pelagics and demersals), 35 were mechanized and 240 unmechanized. It was assumed that these fished with the same pattern as in previous years (i.e., targeting demersal resources during the pelagic off-season).

In the Grenadines there were 20 beach seines and 40 associated boats. There were 227 boats involved in the handline and pot fishery, 52 of these were mechanized and 175 unmechanized. It was assumed that all vessels targeted demersals (on reef, shelf and deep slope) year round. There were 12 boats involved in whaling. Four of these were based in Barrouallie (involved in whaling for pilot whale) and carried inboard motors. It was assumed that the remaining eight boats operated out of Bequia and targeted humpback whales. No information was available on the horsepower of mechanized vessels. An estimate of 25 Hp was assumed.

1981: In St. Vincent a total of 508 boats existed. Of these, 179 were over six meters and the remainder (329) were smaller. The large boats comprised 38 fiberglass boats, 107 planked boats and 34 canoes. The smaller boats comprised four fiberglass pirogues and 325 planked boats. Of the total number of vessels only six were powered by inboard engines and 121 powered by outboard engines. There were also two flyingfish nets, 64 beach seines, 19 ballyhoo nets, 13 trammel nets, 25 cast nets and four turtle nets. Based on the number of beach seines it was assumed that 64 of the 107 large planked boats and 64 of the 325 small planked boats were involved in this fishery. All vessels were unmechanized. It was also assumed that other nets were utilized occasionally by the same boats utilizing beach seines. All other boats were assumed to target mainly pelagic species during the associated season and demersals during the pelagic off-season. Of the large planked boats not involved in the beach seine fishery (43), six were assumed to carry inboard engines and the remaining 37 outboard engines. The fiberglass boats (large and small), canoes and 15 of the small planked boats were assumed to carry outboard engines, while the remaining 246 small boats were assumed to be unmechanized.

In the Grenadines a total of 305 boats were recorded, 95 of which were planked and over six meters and the remaining 210 were smaller. There were 126 mechanized boats, seven of them carrying inboard engines, and the remainder carrying outboards. There were 27 beach seines, 66 trammel nets, 175 cast nets and 61 turtle nets combined in the respective Grenadine islands. It was assumed that 27 of the large planked vessels and 27 of the small planked ones were involved in

beach seining year round. These were all unmechanized and assumed to utilize the other net types as well. The remaining boats (68 large planked and 183 small planked) targeted the demersal fishery (125 were unmechanized, 119 carried outboard engines and seven carried inboard engines). It was assumed that seven of the large planked boats carried inboard engines and the remaining 61 carried outboards, while 58 of the small planked vessel carried outboard engines and the remaining small vessels (125) were unmechanized. There were also five whalers at Barrouallie targeting pilot whales and two at Bequia, targeting humpback whales. It was assumed that all beach seine boats were unmechanized.

1999: Vessels were assigned to fishery type based on data in Morris *et al.* (1988) assuming the same conditions as the late 1980s. In St. Vincent double-enders utilize beach seines only, while pirogues utilize mainly troll gear to capture large pelagics and target demersals during the pelagic 'off-season'. The bow and stern vessels and canoes target the same resources as pirogues. Launches or semi-industrial vessels target large pelagics year-round utilizing both troll and longline gear. In the Grenadines, double-enders target mainly demersals (shallow and deep water) using traps and handlines. These vessels also utilize beach seines. Since they troll and fish for conch only occasionally, the associated effort was considered negligible and therefore not incorporated. Pirogues are not linked to a specific fishery, but it is assumed that these use troll gear for large pelagics mainly, and fish for demersals during the pelagic 'off-season'. Sloops fish for demersals and bow and stern vessels target mainly lobster, conch and utilize beach seines. Whalers target mainly humpback whales. In 1999 only one semi-industrial launch operated from the Grenadines. It was assumed that these targeted offshore pelagic fishery. Also, there were five pirogues involved in the recreational fishery in St. Vincent and one in the Grenadines. These were assumed to target pelagics as well.

#### ***Assigning fishing days to the respective fleets and fisheries***

Recreational pirogues were assumed to fish from January to July, on weekends only. The total number of fishing days was 56. Double-enders, and bow and stern vessels in the Grenadines were assumed to fish year round, on average 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 using this method was calculated to be 230. The 230 fishing days were divided equally between the small coastal pelagic and the demersal reef and slope fishery components of the inshore fishery. The same was assumed for 1988. Semi-industrial vessels were all assumed to be involved in longline fishing for large offshore pelagics year round and that fishing occurred on average 20 days per month excluding one month each year for vessel maintenance, leading to a total of 220 fishing days. Unpowered double-enders, bow and stern vessels, dories and pirogues were assumed to target the beach seines fishery for small coastal pelagics in St. Vincent, year round.

Humpback whales are targeted by fishers from Bequia, from January to May, but mainly around March and April. It was assumed that whaling occurred 12 days per month in March and April and 6 days in other months leading to a total of 42 fishing days. Pilot whales are hunted by fishers from Barrouallie between May and September. It was assumed that fishing occurred 12 days per month, giving a total of 60 days.

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

Using reconstructed catches for the inshore and offshore fisheries and the estimates of the EEZ, reef, slope and shelf areas in the methodology report by Mohammed (this volume), a time series of trends in catch per unit area was derived. Catch per unit effort was estimated as the ratio of reconstructed catch and reconstructed effort for the respective fisheries. Data for missing years were estimated by interpolation between point estimates for years based on the literature.

### **RESULTS**

#### **Fisheries catches**

Estimated total catches for St. Vincent and the Grenadines are presented in Figure 2. Since St. Vincent operates an open register for foreign vessels, catches are reported for several regions, including the north Atlantic and Pacific regions. Only catches in the western central Atlantic region are presented here, since these reflect catches of the local St.

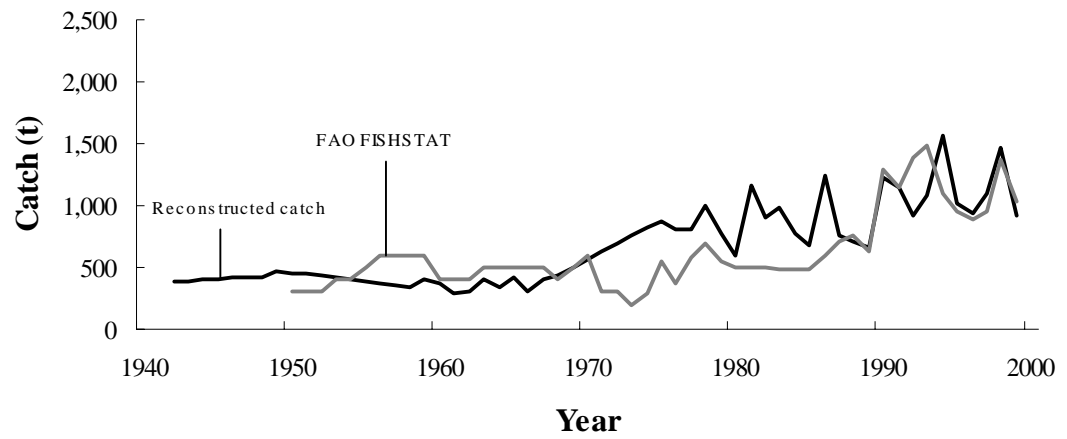
Vincent and the Grenadines fleet. Reported catches in FAO FISHSTAT exceeded reconstructed catches between 1954 to 1971 by four to 262 t. Reconstructed catches between 1971 and 1987 were consistently higher than data for corresponding years in FISHSTAT, but exceeded reconstructed catches in the early 1990s and late 1990s. Generally, reconstructed catches from the late 1980s mirrored reported catches in FISHSTAT.

Overall, reconstructed catches increased by over 194% between 1962 and 1999. Reconstructed catches remained generally low (below 500 t) and constant between 1942 and 1969 (Figure 2a), but increased between 1969 and 1975 from 496 t to 878 t. Considerable variability was observed thereafter, with reconstructed catches ranging between 602 t in 1980 and 1,605 t in 1994. Catches in the St. Vincent inshore fishery far exceeded those from the offshore fishery from the late 1960s, throughout the 1970s and in the most recent years (Figure 2b). Catches in the inshore fishery have ranged between 400 t and 800 t between 1995 and 1999. The majority of the catch in the Grenadines was from the inshore fishery (Figure 2c). The general trend is a decline from the early 1950s to late 1970s, followed by a considerable and sudden increase in the early 1980s. Catches declined thereafter, from about 811 t in 1981 to 88 t in 1997.

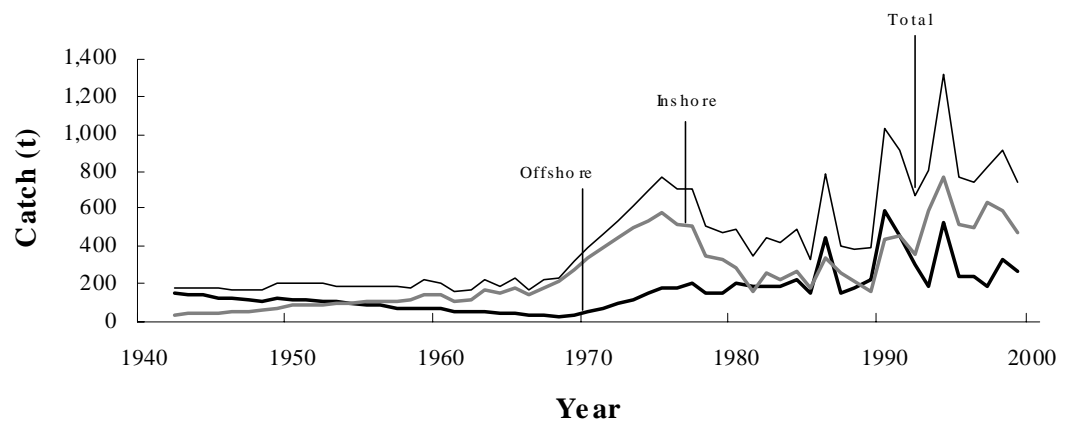
Excluding marine mammals and turtles, reconstructed catches are reported for up to 91 species/groups. Several of these groups, however, remain very broad, e.g., 'snappers' or 'groupers'. Catches for St Vincent were disaggregated from the late 1960s, beginning with 11 groups and increasing to 70 species/groups by 1994 (Figure 3a). Fewer species/groups were represented for the Grenadines, beginning with 5 groups in 1986 and increasing to 25 groups by 1998 (Figure 3a). Reported catches in FAO FISHSTAT was disaggregated into considerably fewer categories, beginning with four groups in 1988 and increasing to a maximum of 13 groups in any one year (Figure 3a). The proportion of the catch reported in aggregate category declined from the early 1980s (Figure 3) from about 69% to less than one percent in 1999.

Reconstructed catches of marine mammals (Figure 4) indicate considerable historical catches of humpback whales (over 1,550 t in

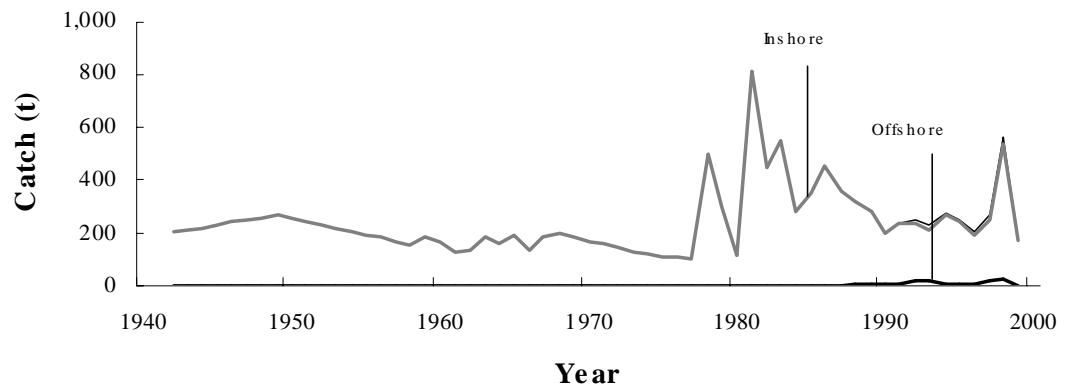
(a)



(b)

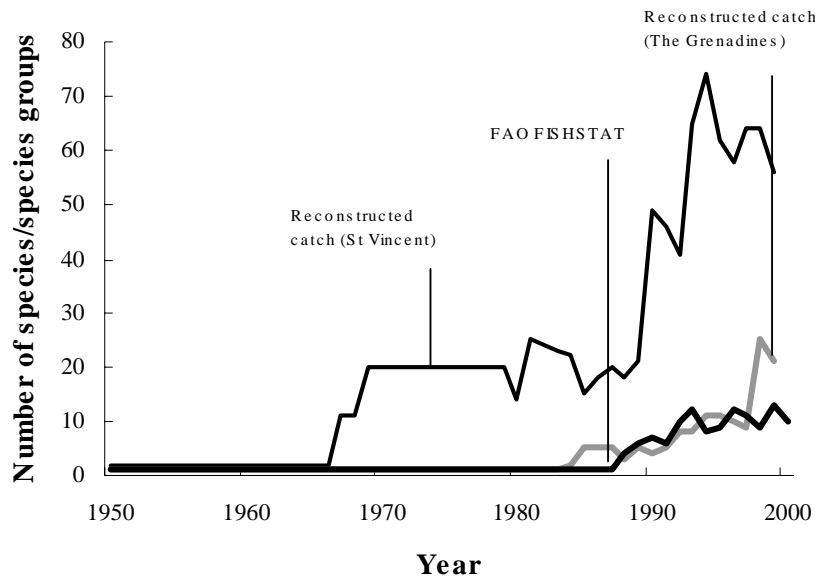


(c)

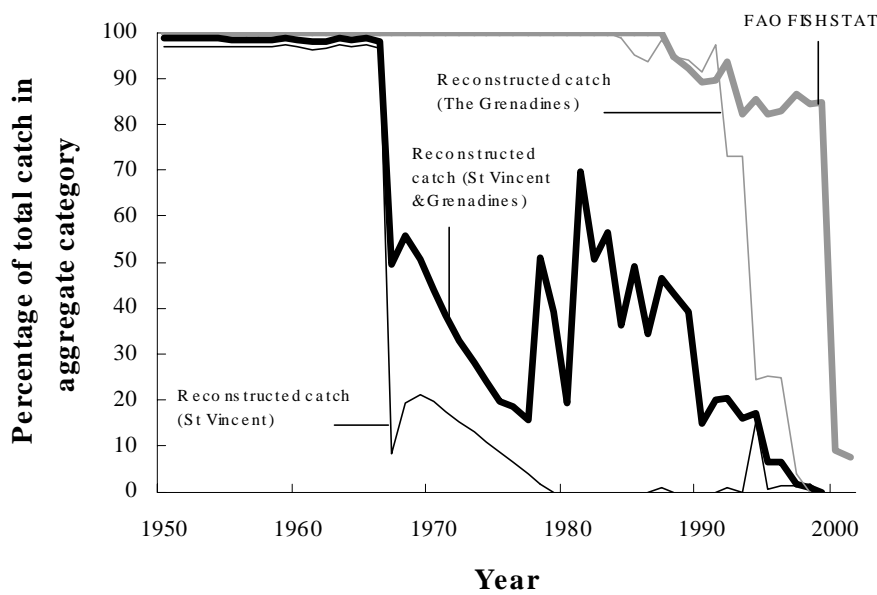


**Figure 2:** Catches (t) in St Vincent and the Grenadines (a) Reconstructed catches (1942–1999) and catches in FAO FISHSTAT (1950–1999), (b) Reconstructed offshore and inshore catches in St Vincent (1942–1999) and (c) Reconstructed offshore and inshore catches in the Grenadines (1942–1999).

(a)



(b)

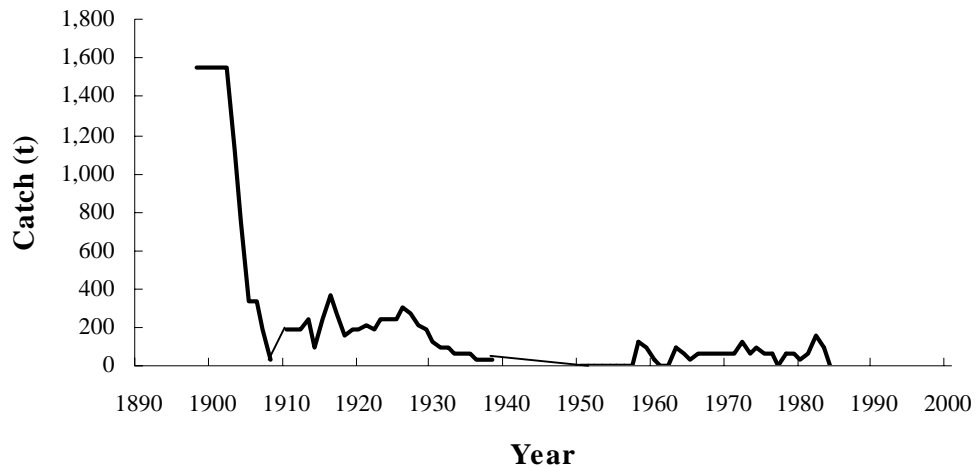


**Figure 3:** A comparison of reconstructed catch data and statistics in FAO FISHSTAT for St Vincent and the Grenadines between 1950 and 1999: (a) number of species/species groups and (b) percentage of total catch in aggregate category.

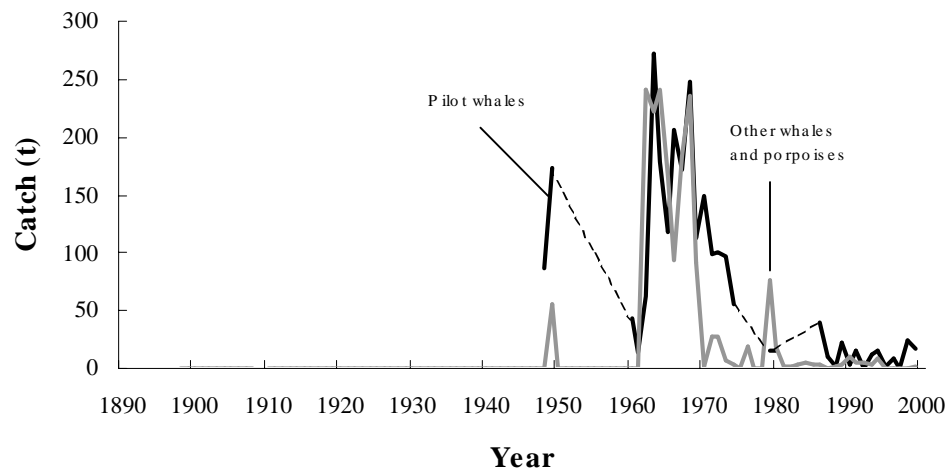
1898). This declined in the early 1900s where catches remained below 365 t and declined from about 300 t in the late 1920s to only 30 t by the late 1930s. Thereafter, catches fluctuated between zero and about 152 t until 1984. No catches have been reported since then. Catches of pilot and other whales and porpoises were reconstructed for a shorter time period (late 1940s to 1999). High catches, in excess of 100 t were experienced for both pilot whales and other whales and

porpoises during the late 1950s to late 1960s, but this has declined over the years to less than 25 t in the last decade for both categories. Reconstructed catches of marine turtles (Figure 5) indicate considerable inter-annual variability. Between 1935 and 1945 catches varied between 0.4 t and 20 t. In the later period (1975 to the present) annual catches remained below 12 t and in some years, no catches were reported.

(a)



(b)



**Figure 4:** Reconstructed catches (t) of (a) humpback whales and (b) other whales and porpoises in St Vincent and the Grenadines (1898-1999). Dashed lines represent interpolated values.

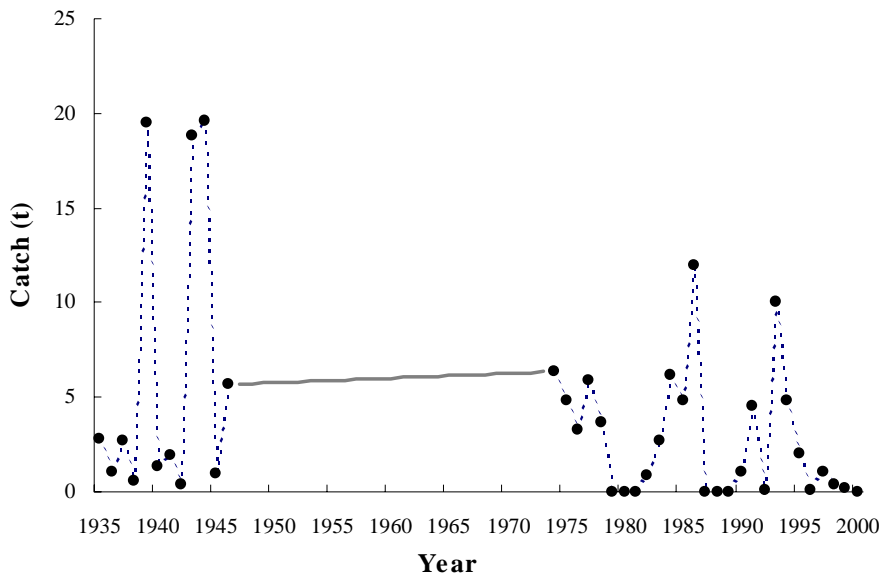
### Fishing Effort

Reconstructed fishing effort is represented in Figure 6. Effort in the St. Vincent offshore fishery was comparable in magnitude to effort in the Grenadines inshore fishery. Effort increased by a factor of 115 in the St. Vincent offshore fishery, and by a factor of nearly 19 in the St. Vincent inshore fishery between 1942 and 1999. In the Grenadines offshore fishery effort increased by a factor of 11 between 1981 and 1999 and by a factor of 35 in the inshore fishery, between 1942 and 1999. The increase in effort was more pronounced in recent years. Fishing effort is observed to increase by a factor of 2.35 from 739,000 Hp-days to 1,736,000 Hp-days in the St. Vincent offshore fishery between 1981 and 1999 (Figure 6c). Similarly, effort in the inshore fishery increased by a factor of 1.68, from 283,000 Hp-days to 476,000 Hp-days

over the same period (Figure 6c). The corresponding number of boats decreased from 380 to 174 and from 508 to 286 in the offshore and inshore fisheries, respectively. The offshore fishery in the Grenadines remained unexploited until the mid-1980s and effort has not increased throughout the 1990s (11,000 Hp-days, Figure 6c). In the inshore fishery, effort has decreased from 1,246,000 to 1,024,000 Hp-days between 1981 and 1999 (Figure 6c). The number of boats has decreased from 305 to 191 over the same period. Between 1981 and 1999 effort directed at the humpback whale off Bequia has decreased from 760 to 380 Hp-days (Figure 6c), while effort in the Barrouallie fishery for pilot whales and porpoises has remained relatively constant at between 720 and 1,200 Hp-days.

**Trends in catch per unit area (CPUA) and catch per unit effort (CPUE)**

Annual trends in CPUA and CPUE are shown in Figures 7 and 8, respectively. Generally, CPUA was higher in the inshore than offshore fishery. There was a gradual decline between the early 1940s to early 1960s (Figure 7) from 0.0054 t·km<sup>-2</sup> to as low as 0.0007 t·km<sup>-2</sup> in the offshore fishery. Catch per unit area remained relatively stable in the inshore fishery during this time, ranging between 0.123 t·km<sup>-2</sup> and 0.192 t·km<sup>-2</sup>. Throughout the 1960s and 1970s the CPUA increased considerably from 0.143 t·km<sup>-2</sup> in 1966 to 0.340 t·km<sup>-2</sup> in 1975 in the inshore fishery, and from 0.0007 t·km<sup>-2</sup> to 0.007 t·km<sup>-2</sup> in the offshore fishery. Although there is a general increase in CPUA in both fisheries, considerable inter-annual variability is observed from 1977 onwards. Catch per unit area in the most recent five years ranged from 0.0195 t·km<sup>-2</sup> to 0.007 t·km<sup>-2</sup> in the offshore fishery and 0.780 t·km<sup>-2</sup> to 0.371 t·km<sup>-2</sup> in the inshore fishery.



**Figure 5:** Reconstructed catch (t) of marine turtles in St Vincent and the Grenadines (1935-2000). Solid circles represent reconstructed data and solid lines joining the circles are interpolated values.

A pattern of exponential decline in CPUE was observed for all fisheries examined (Figure 8). Except for the St. Vincent offshore fishery, CPUE was found to increase between 1942 and 1949. Catch per unit effort in 1949 was greatest in the St. Vincent offshore fishery (11 t per thousand Hp-days) compared to the St. Vincent inshore (6.13 t per thousand Hp-days) and Grenadine inshore (9.70 t per thousand Hp-days) fisheries. The decline in

CPUE is more pronounced in the Grenada offshore and Grenadines inshore fisheries, compared to the St. Vincent inshore fishery. The most recent (1999) estimates of CPUE are 0.15 t, 1.0 t and 0.31 t per thousand Hp-days for St. Vincent offshore and inshore, and the Grenadines inshore, respectively.

**DISCUSSION**

**Fisheries catches**

Reconstructed catches indicate a general increase from the mid-1960s onwards, with an increase of over 190% between 1962 and 1999. This increase was attributed mainly to increased landings in the St. Vincent inshore fishery. Vessel mechanization began in the late 1950s (Cecil, 1972), and throughout the 1960s there were financial incentive programs to encourage fishery development. Reconstructed data for the late 1950s and throughout the 1960s was lower than data in FISHSTAT for corresponding years. This may be due to underestimation in this study, but is

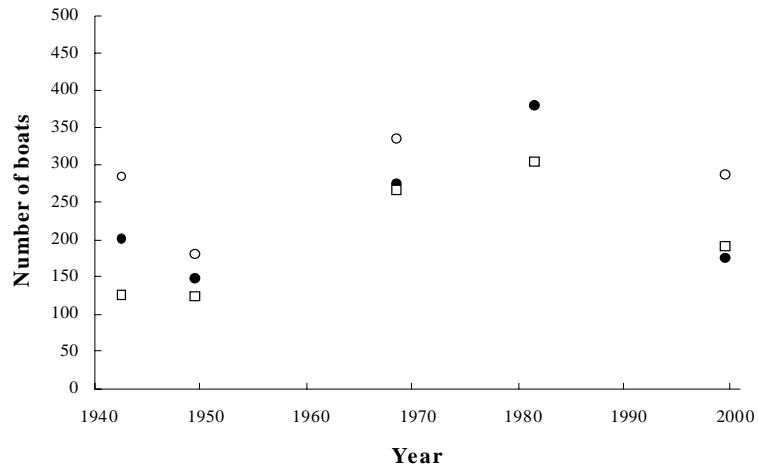
more likely due to the inclusion of catches by foreign fleets in data submitted to the FAO. Vidaeus (1969) reported on activities of foreign vessels during this time, however, there is no documentation on the magnitude of the catches or the associated fishing areas. Despite tremendous inter-annual variability, increasing catches throughout the 1980s reflect the government's efforts to increase local fish catches and employment in the fishing industry (Chakallal, 1982).

The higher catches reported to the FAO in the late 1990s, compared to reconstructed data can only be accounted for by inclusion of catches of foreign vessels registered in St. Vincent and fishing in the western central Atlantic. St. Vincent has an open vessel registry, with vessels fishing in the Pacific, and North and South Atlantic.

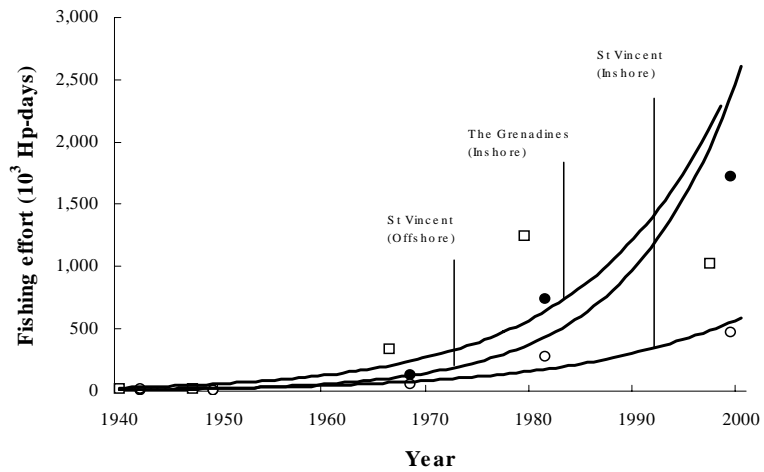
Declining catches in the 1990s concur with studies by Straker (2001). He indicated that the institutional and technical development



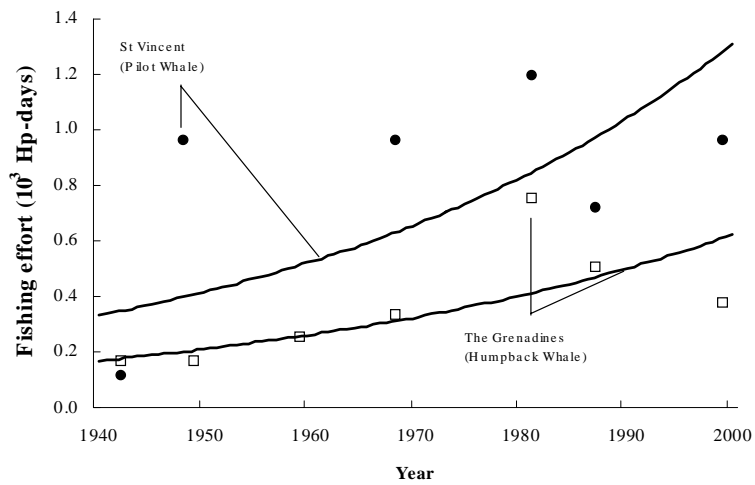
(a)



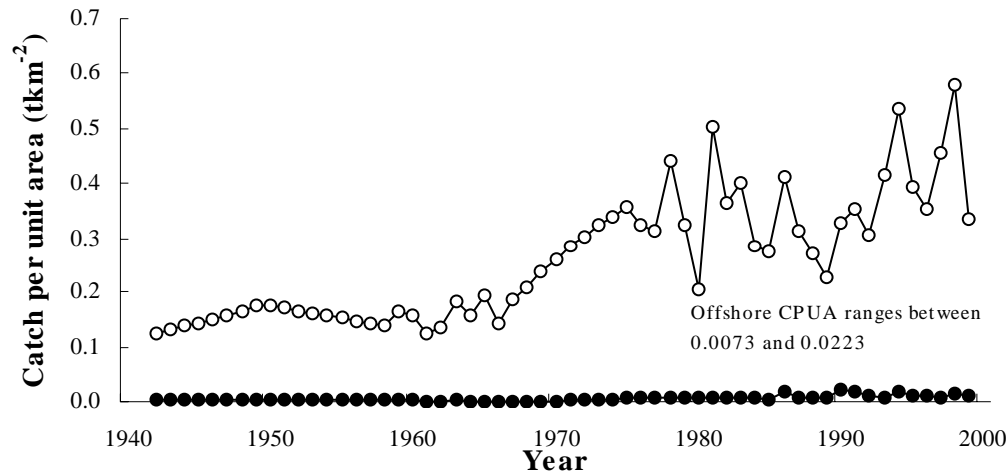
(b)



(c)



**Figure 6:** Reconstructed (a) number of boats, (b) fishing effort ( $10^3$  Hp-days) in the fisheries of St Vincent and the Grenadines and (c) fishing effort ( $10^3$  Hp-days) directed at marine mammals (1942–1999). Except for (c) solid and open circles represent the offshore and inshore fisheries of St Vincent respectively and solid and open squares represent the offshore and inshore fisheries of the Grenadines respectively. In (c) solid circles represent effort in the St Vincent pilot whale ‘fishery’ and open squares represent the Grenadines humpback whale ‘fishery’



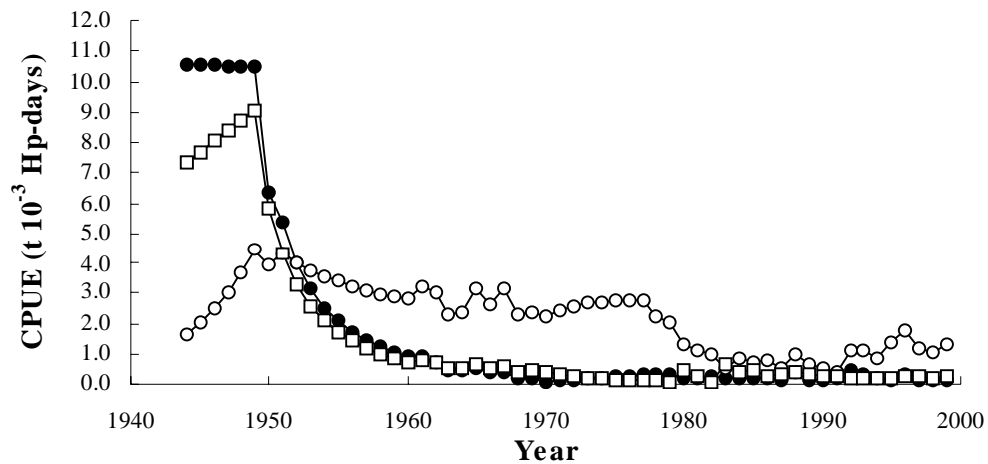
**Figure 7:** Annual trends in catch per unit area (tkm<sup>-2</sup>) in the fisheries of St Vincent and the Grenadines (1942-1999). Solid circles represent the offshore fishery and open circles represent the inshore fishery.

along with improved infrastructure, distribution and marketing of fish in the early 1990s promoted additional entry to the fishing industry. This was manifested as an increase in effort and associated increase in catch. By the late 1990s, however, catches began to decline. The refinement in the data collection program and procedures for estimating total catch since the early 1990s may also account for the observed pattern. However, it seems that other factors may have contributed to the decline as the local industry was unable to meet the increasing demand, resulting in increased fish imports throughout the period (Straker, 2001). The decline in catches in the 1990s was offset by increasing fish prices to the extent that the value of landings had actually increased throughout the 1990s (Straker, 2001).

Despite reports of the greater importance of the offshore fishery to St. Vincent (Brown, 1945; Vidaeus, 1969; Chakallal, 1982; Morris, 1984) results suggest that the inshore fishery is the greater contributor to overall catches, especially throughout the late 1960s and 1970s as well as in the late 1990s. The inshore fishery comprises both the small coastal pelagic fishery and the demersal, reef, slope and shelf fishery. Traditionally the small coastal pelagic fishery has contributed significantly to catches landed at the main market in Kingstown (Vidaeus, 1969) and still do (Straker, 2001). Catches in the offshore fishery have increased since the early 1970s but given recent developments in the 1990s (introduction of semi-industrial longliners) catches have not reflected this. Reconstructed

catches for the Grenadines indicate considerable decline from 1982 onwards.

A longer time series of reconstructed catch data, disaggregated by the respective species components, is available compared to current data for St Vincent and the Grenadines in the FAO FISHSTAT. From the late 1960s reconstructed catch data were disaggregated into the respective species components while all reported data between 1950 and the late 1980s incorporated in FAO FISHSTAT were assigned to a single aggregate, unidentified category. Reconstructed catch data are also disaggregated into a greater number of species groups (up to 91 for St Vincent and the Grenadines combined) compared to reported data in FAO FISHSTAT for St Vincent and the Grenadines (a maximum of 13 species/species groups represented in any given year). A smaller percentage of annual total catch is attributed to the aggregate, unidentified category in reconstructed data compared to current catch statistics in FAO FISHSTAT. This level of dis-aggregation is attributed mainly to the fisheries of St Vincent, since the species composition of catches from the Grenadines, prior to the early 1980s, have not been quantified in the literature examined. Nevertheless, reconstructed data in general, represent a considerable improvement in terms of the number of species groups reported and breakdown of the aggregate, unidentified fish category, compared to current data in FAO FISHSTAT for St Vincent and the Grenadines.



**Figure 8:** Annual trends in catch per unit effort ( $t \cdot 10^{-3}$  Hp-days) in the fisheries of St Vincent and the Grenadines (1942-1999). Solid and open circles represent the offshore and inshore fisheries of St Vincent respectively and open squares represent the inshore fishery of the Grenadines.

Reconstructed catches of marine mammals show considerable decline in catches of pilot whales from the late 1960s onwards. Catches of humpback whales have been declining since the early 1900s with estimates of about 400 t, to less than 100 t in recent years. Morris (1984) confirmed the decline in the fishery for humpback whales since effort had not increased between 1974 and 1984 and there was no indication of future increases in effort. He stated further that overseas markets for oil had declined drastically due to pressure from both conservation groups as well as the signatories of Convention on International Trade in Endangered Species (CITES). Hence, the pilot whale fishery is on the decline with no indication that the whaling industry would ever attract more than the four boats presently involved. Reconstructed catches of marine turtles showed inter-annual variability in catches, which ranged between zero and 13 t between 1975 and 1999.

Our reconstructed catches represent preliminary estimates at this time, as several limitations in the data exist. These relate to recreational fishing, discarding, quantities caught as bait, landings of fish caught in St. Vincent and the Grenadines at other islands, foreign fishing and under-estimation of catches in components of the inshore fishery.

In the 1980s, at least 8,000 tourists visited St. Vincent and the Grenadines each year (Matthes, 1984). A considerable portion was involved in unlicensed sport fishing with fishing rods, spears and nets (Matthes, 1984). Some tourists fished commercially and sold the catch to local and foreign hotels. These

catches, however, are not documented. Unlike other Caribbean islands, there were no charter boat operations in St. Vincent or the Grenadines in the 1990s (Morris, 1991), although there were several private sport fishing boats.

Several species of fish are discarded at sea (Adams, 1985), either because of size or preference for other species. Based on the types of species discarded, it appears that this practice is common in all fisheries. The trammel net fishery which targets snapper, grouper, cavalli, shark, barracuda and turtle off the Grenadines is regarded as unsustainable (Chakallal, 1982). Since these nets capture everything in their path and are lifted every 12 hours, those fish caught early are unfit for export. This accounts for about 50% of the catch, of which one-fifth is unfit for human consumption and discarded, while the rest is sold locally or processed by salting and drying (Chakallal, 1982). There are no records of the quantities of fish discarded. In the Grenadines, preference for specific species by Martinique traders may result in up to 40% of the landings remaining unsold, and much may be dumped because of lack of suitable transport to St. Vincent (Andersen *et al.*, 1983). Historically, only export data have been recorded and therefore the quantities dumped are not incorporated in the data.

Bait is utilized in the longline, pot and handline fisheries. Usually dwarf herring (*Jenkinsia* spp.), pilchards (*Harengula* spp.), round scad (*Decapterus* spp.), sardines (*Sardinella* spp.), silversides (Atherinidae) and thread herring (*Opisthonema oglinum*) are used as bait in St. Vincent and the

Grenadines (Mahon, 1993). Although catch rates from directed exploratory fishing in the 1970s are available (Wagner, 1974) these do not give an indication of the associated quantities utilized as bait.

Apart from catches of finfish, lobster, conch and whelks caught in the Grenadines and traded illegally with Martinique, catches are also sold in St. Lucia, while catches from Bequia are also taken to Kingstown market in St. Vincent, and a portion of catches from vessels operating off the north leeward and northeast coasts (Fancy, Owia, Sandy Bay) of St. Vincent are sold in St. Lucia (Matthes, 1984). Records of these catches, if they do exist, are incorporated in the landing statistics of the island to which the catch was sold. Ryan (1999) indicated trading of beach seine catches in St. Vincent with vessels of Martinique, Dominica and St. Lucia and trading of catches in the Grenadines with vessels from Martinique and seine boats or charter boats from Grenada or Carriacou. These data are not recorded in landings data.

Catches of foreign fleets fishing in the waters of St. Vincent and the Grenadines either do not exist or are incorporated in the landing statistics of the country to which the fleets belong. In the 1960s vessels from Martinique fished off the Grenadines and supplied entrepreneurs from Martinique (Chakallal *et al.*, 1997). The activity was illegal and there are no accompanying records. Such activity is also known off Grenada and Carriacou (Peña and Wirth, 1979). Fishers from Martinique also fish for large pelagics (especially tunas) in the EEZ of St. Vincent and the Grenadines (Andersen *et al.*, 1983), as do distant water longliners, including US swordfish boats as well as Venezuelan pole and line boats, and purse seiners (Morris, 1991). Large, deep-water snappers (*Etelis oculatus*) occurring on the slopes at 80-180 m were fished occasionally by boats from Barbados (Morris, 1991). In the Grenadines, fishers from Grenada have traditionally fished for demersal finfish, lobster and conch in the waters of St. Vincent and the Grenadines and until the early 1990s continued to do so (Morris, 1991). Boats from Barbados and St. Lucia also target flyingfish and large pelagics within the EEZ of St. Vincent and the Grenadines. There is also evidence of St. Vincent fishers catching pilot whales in the territorial waters of St. Lucia (Cecil, 1972). If landed in St. Vincent then these are incorporated in the landings data for St.

Vincent and represent an over-estimate of harvests from waters of St. Vincent and the Grenadines.

Catches in the inshore fishery, specifically the demersal component as well as lobster, conch and turtles are under-estimated. Data were particularly lacking for the Grenadines where, until the mid-1990s, data were available only on fish exports to Martinique. The quantity of catches consumed locally was not recorded. The species composition of the catch was not known, though it was possible to separate exports of finfish from shellfish. Export weights were estimated by eye. Exports of processed fish were not adjusted to whole weight since the associated species was not known. Also, conch exports refer to meat only, i.e., were not corrected to represent whole weight. There are also reports of ongoing illegal trading with Martinique confirming that export data are minimum estimates at best. This made analyses on the Grenadines fishery impossible. Catches of turtles are under-estimated, representing shell exports of one species only (hawksbill) in most instances. Further, the quantity of marine turtles caught on land when they come ashore to lay eggs, is not recorded.

### **Fishing effort**

Reconstructed fishing effort increased exponentially for all fisheries. Effort increased by a factor of 114 in the St. Vincent offshore fishery, and by a factor of 18.6 in the St. Vincent inshore fishery between 1942 and 1999. In the Grenadines offshore fishery effort increased by a factor of 11 between 1981 and 1999 and in by a factor of 35.42 in the inshore fishery, between 1942 and 1999. The increase in effort is attributed to increases in the horsepower of engines rather than number of boats. In fact in all fisheries the number of boats was found to decline in all fisheries between 1981 and 1999.

Changes in effort due to the introduction of the gun harpoon in the whaling fishery during the 1940s, use of Scuba gear in the demersal lobster and conch fisheries in the 1980s and possibly increased numbers of fish pots or handlines used are not incorporated in the unit of effort. Such detail however, is not available (Straker, 2001). Andersen *et al.* (1983) noted that engines were used as auxiliary power, suggesting that they were not utilized on all fishing trips. As such the reconstructed effort more accurately represents potential effort rather than actual

effort. Prior to 1999 all reports indicated that vessels involved in the beach seine fishery (inshore) were unmechanized. However transoms (flat bottom boats), which carry outboard engines of 14-115 Hp, were responsible for the high mobility of beach seine units around the islands and for towing other fishing boats associated with the seine unit from one fishing area to another, and to transport the catch to the market. A seine unit was reported to comprise a seine net, a flat transom boat or pirogue and two double-enders. Mechanized boats were not considered in the effort of the beach seine component of the inshore fishery.

The assumption of constant fishing days was used purely to represent the division of effort by boats targeting both the offshore and inshore fisheries each year. However, the introduction of mechanization, government financial incentives and infrastructure development over the period examined would have contributed to changes in the number of fishing days. In the Grenadines, adverse weather conditions, strong tides and the absence of trading vessels all affect the number of fishing days in the Grenadine Islands (Chakallal *et al.*, 1997). Assumptions regarding effort directed at whales do not consider the time spent on the 'look-out' for whales. Adams (1980), commenting on the handline fishery in the Grenadines, indicated that the decision on whether or not a fishing trip is feasible is dependent on a number of highly variable physical and cultural factors; namely weather conditions, current and tide, immediate financial needs of the fisher, access to fish markets and the demand and price for the associated species.

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

Generally, CPUA has increased, reflecting responses to fisheries development, over the period examined. Further investigation is required to explain the inter-annual variability from the mid-1970s to late 1990s. The CPUA in the inshore fishery was higher by one order of magnitude than that in the offshore fishery. This higher inshore CPUA is expected given the concentration of the associated resources over a narrow shelf area. CPUE has declined exponentially in all fisheries since 1952. Higher CPUE in the St. Vincent inshore fishery is influenced by the high catches of small coastal pelagics and associated low effort, since all vessels were assumed unmechanized. The development of

the longline fishery, which utilizes coastal pelagic species as bait, may account for the higher CPUEs in the inshore fishery during the late 1990s.

#### **ACKNOWLEDGEMENTS**

The authors would like to thank the staff of the St Vincent Fisheries Division for the provision of fisheries data. Gratitude is also extended to A. Maharaj, Fisheries Documentalist at the Trinidad Fisheries Division for provision documents from the Fisheries Management Information System. The St Vincent Agricultural Department and St Vincent National Archives are also acknowledged for access to their respective Documentation Centers. The first author also acknowledges financial support from the CARICOM Fisheries Resource Assessment and Management Program, the Government of Trinidad and Tobago and the *Sea Around Us* Project at the UBC Fisheries Centre. The authors would also like to thank D. Pauly and D. Zeller of the UBC Fisheries Centre for their comments and reviews of the report.

#### **REFERENCES**

- Adams, J.E. 1970. Conch fishing industry of Union Island, Grenadines, West Indies. *Tropical Science* 12(4): 279-288.
- Adams, J.E. 1971. Historical geography of whaling in Bequia Island, West Indies. *Caribbean Studies* 11(3): 55-74.
- Adams, J.E. 1973. Shore whaling in St Vincent, West Indies. *Caribbean Quarterly* 19: 42-50.
- Adams, J.E. 1980. Seafaring Grenadines: an historical geography of traditional fisheries in the Caribbean. University of Minnesota, Duluth.
- Adams, J.E. 1985. The fisheries and fish markets of St. Vincent Island, eastern Caribbean. *Singapore Journal of Tropical Geography* 6(1): 1-12.
- Agricultural Department 1946. Annual report on the Agricultural Department: 1946. Fisheries Section.
- Agricultural Department 1948. Annual report on the Agricultural Department: 1948. Fisheries Section.
- Agricultural Department 1949. Annual report on the Agricultural Department: 1949. Fisheries Section.
- Agricultural Department 1951. Annual report on the Agricultural Department: 1951. Fisheries Section.
- Agricultural Department 1960. Annual report on the Agricultural Department: 1960. Fisheries Section.
- Agricultural Department 1961. Annual report on the Agricultural Department: 1961. Fisheries Section.
- Agricultural Department 1975. Annual report on the Agricultural Department: 1975. Fisheries Section.
- Agricultural Department 1979. Annual report on the Agricultural Department: 1979. Fisheries Section.
- Agricultural Department 1980. Annual report on the Agricultural Department: 1980. Fisheries Section.
- Andersen, A., Ruppin, A. and Gummy, A. 1983. Outline of the structure of the fishing industry. Report of the EEZ Policy and Planning Mission to St Vincent: FAO EEZ

- Policy Program. FAO. Rome, Food and Agriculture Organization of the United Nations, FAO/NORWAY Cooperative Program. FI:GCP/INT/398 (NOR): 1-3.
- Anon. 1965. Colonial Report: 1964/65. Part I: A Review of the Years 1964-1965, pp. 13-14.
- Brown, H.H. 1945. The fisheries of the Windward and Leeward Islands. Development and Welfare Bulletin 20, 91 pp.
- Caldwell, D.K. and Caldwell, M.C. 1971. Porpoise fisheries in the southern Caribbean: Present utilizations and future potentials. Proceedings of the Gulf and Caribbean Fisheries Institute 23: 195-206.
- Caldwell, D.K. and Caldwell, M.C. 1975. Dolphin and small whale fisheries of the Caribbean and West Indies: occurrence, history and catch statistics with special reference to the Lesser Antillean island of St Vincent. Journal of the Fisheries Research Board of Canada 32: 1105-1110.
- Caribbean Commission Central Secretariat 1948. The Fish Trade of the Caribbean. External Trade Bulletin No. 3, 261 pp.
- Cecil, R.G. 1972. Geographical characteristics of fisheries in selected southeastern Caribbean islands. PhD Thesis, Mc Gill University, Montreal, 394 pp.
- Chakalall, B. 1982. The fishing industry of St Vincent and the Grenadines. The Inter-American Institute for Co-operation in Agriculture, 47 pp.
- Chakalall, Y.S., Mahon, R., Oxenford, H. and Ryan, R. 1997. Fish exporting in the Grenadine Islands: Activities of Trading Vessels and Supplying Fishers. CARICOM Fishery Research Document No. 17, 84 pp.
- Kurlansky, M. 1997. Cod: A biography of the fish that changed the world. Knopf, Toronto, 294 pp.
- Lewis, A.V. 1964. Fisheries Report for the period 1962-1964. Annual report on the Agricultural Department 1962-1964, 65 pp.
- Mahon, R. 1987. Report and proceedings of the expert consultation on shared fishery resources of the Lesser Antilles. FAO Fisheries Report 383, 278 pp.
- Mahon, R. 1993. Lesser Antilles: Marine fishery resources, pp. 1-98. *In*: Marine Fishery Resources of the Antilles: 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 Programme (CFRAMP), 4 pp.
- Matthes, H. 1984. Saint Vincent and the Grenadines: formulation of a fisheries development program. FAO Field Document 1 (FI: TCP/STV/2201) (MF), 190 pp.
- Milliken, T. and Tokunaga, H. 1987. The Japanese Sea Turtle Trade: 1970-1986. Traffic (Japan) and Center for Environmental Education.
- Morris, K. 1984. Artisanal fisheries in St Vincent and the Grenadines. Proceedings of the Gulf and Caribbean Fisheries Institute 36: 15-20.
- Morris, K. 1991. Fisheries Country Profile: 1984-1990. Ministry of Agriculture and Labour, Fisheries Division, Kingstown, St Vincent, 36 pp.
- Morris, K. 1992. National policy issues to enhance the EEZ contribution to National Development in St Vincent and the Grenadines, pp. 116-117. *In*: B. Chakalall (ed.) Report and proceedings of the meeting on fisheries exploitation within the Exclusive Economic Zones of English-speaking Caribbean countries. FAO Fisheries Report No. 483.
- Morris, K. 1993. The flyingfish fishery of St Vincent and the Grenadines, p. 160. *In*: H.A. Oxenford, R. Mahon and W. Hunte (eds.) The Eastern Caribbean Flyingfish Project. OECS Fishery Report No. 9.
- Morris, K. 1995. Exploitation of large pelagics in St Vincent and the Grenadines. Ministry of Agriculture and Labour, Fisheries Division, Kingstown, St Vincent, 39 pp.
- Morris, K., Cruikshank, J. and Mahon, R. 1988. A fishery data collection system for St Vincent and the Grenadines, pp. 150-163. *In*: R. Mahon and A.A. Rosenberg (eds.) Fishery data collection systems for eastern Caribbean islands. OECS Fishery Report No. 2
- Oliver, J. and Noordeloos, M. (Editors) 2002. ReefBase: A Global Information System on Coral Reefs. [www.reefbase.org](http://www.reefbase.org).
- Ogren, L., Berry, F., Bjorndal, K., Kumpf, H., Mast, R., Medina, G., Reichart, H., and Witham, R. (Editors) 1989. Proceedings of the Second Western Atlantic Turtle Symposium. National Oceanic and Atmospheric Administration Technical Memorandum, 401 pp.
- Peña, M.S. and Wirth, A.J. 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 pp.
- Price, S. 1985. Whaling in the Caribbean: Historical perspective and update. Report of the International Whaling Commission 35: 413-420.
- Rack, R.S. 1952. Black-fish hunting off St Vincent. Caribbean Commission Central Secretariat, Port of Spain, Trinidad, pp. 80-83.
- Rebel, T.P. 1974. Sea turtles and the turtle industry of the West Indies, Florida and the Gulf of Mexico. University of Miami Press, Coral Gables, 250 pp.
- Ryan, R.J. 1999. The beach seine fishery of St Vincent and the Grenadines: Fishing practices, socio-economic importance and biological characteristics. MSc thesis, University of the West Indies, Cave Hill, 135 pp.
- Smyth, J.A. 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.
- Straker, L.E. 2001. The assessment of the reef fishery of St Vincent and the Grenadines, using red hind (*Epinephelus guttatus* L.) and coney (*Cephalopholis fulva* L.) as indicator species. MSc thesis. University of Hull, Hull, 102 pp.
- St Vincent Fisheries Department 1999. Website of the St Vincent Fisheries Department, accessible at: [www.vincy.com/fisheries](http://www.vincy.com/fisheries).
- Trites, A.W. and Pauly, D. 1998. Estimating mean body masses of marine mammals from maximum body lengths. Canadian Journal of Zoology 76: 886-896.
- UNEP/IUCN 1988. Coral Reefs of the World: Atlantic and Eastern Pacific. International Union for the Conservation of Nature (IUCN), Gland.
- Veridian MRJ Technology 2002. Global Maritime Boundaries Database.
- Vidaeus, L. 1969. An inventory of the St Vincent fishing industry. Report of the UNDP/FAO Caribbean Fishery Development Project, SF/CAR/REG/16 M5, 35 pp.
- Wagner, D.P. 1974. Results of live bait and pole and line fishing explorations for pelagic fishes in the Caribbean. Marine Fisheries Reviews 36(9): 35-43.
- Witzell, W.N. 1994. The origin, evolution and demise of the US sea turtle fisheries. Marine Fisheries Review 56(4): 8-23.