St. Lucia, Eastern Caribbean: Reconstructed Fisheries Catches and Fishing Effort, 1942-2001

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Abstract

Time series of catch and effort data were reconstructed for the fisheries of St. Lucia in the eastern Caribbean, for the period from 1942 to 2001. Information from historical documents, published and unpublished literature and the St. Lucia Fisheries Department's Statistical databases were used. General trends indicated increasing catches since the 1960s and an exponential increase in fishing effort since 1942. A comparison of reconstructed data with statistics reported in the FAO FISHSTAT database was made and limitations in reconstructed data discussed. Generally, the offshore fishery contributed the greater proportion of the catch, averaging 72% between 1990 and 2001. Between 1989 and 2001 catches increased by 381% and 291% in the offshore and inshore fisheries, respectively. Between 1942 and 2000 fishing effort increased by factors of 257 and 27 in the offshore and inshore fisheries, respectively, and by factors of 4.71 and 1.73 between 1988 and 1999. Catch per unit area has increased by over 300% in both fisheries during the 1990s. Between 1942 and 1999 the catch per unit effort has strongly declined. Throughout most of the 1990s the catch per unit effort of the inshore fishery has exceeded that of the developing offshore fishery.

Introduction

Study Area

Saint Lucia, situated between 30º and 40ºN and 61º and 62ºW (Figure 1) is one of the northern Windward Islands. The island is separated from Martinique in the north and St. Vincent in the south by channels about 30 km wide. The submerged insular shelf is very narrow along the western coast (about 0.1 km) and wider (5 km) to the east, north and south (UNEP/IUCN, 1988). The associated Exclusive Economic Zone covers an area of 18,002 km^2 as estimated from data in the Global Maritime Boundaries Database (Veridian MRJ Technology, 2002), while the coastal shelf covers an area of 522 km^2 (Mahon, 1993). Reefs are found on all coasts, but are generally small and most numerous around the east and south coasts, especially around Laborie Bay, Anse Galette and between Savannes Bay and Maria Islands (Villegas, 1979). Those on the windward coast (east) are mainly small patch reefs or broken fringing reef systems and those on the mid-leeward coast (west) are diverse, coral-dominated communities forming an almost solid fringing reef along the narrow slope (Villegas, 1979). The total reef area is 160 km^2 (Oliver and Noordeloos, 2002).The volcanic nature of the island has resulted in reef restriction to the narrow, steeply sloping shelf area. The degree of exposure to the rough Atlantic waters and coastal extent of the shelf determine the physical structure and community composition of the reefs (St. Lucia Fisheries Department, 1995). Those on

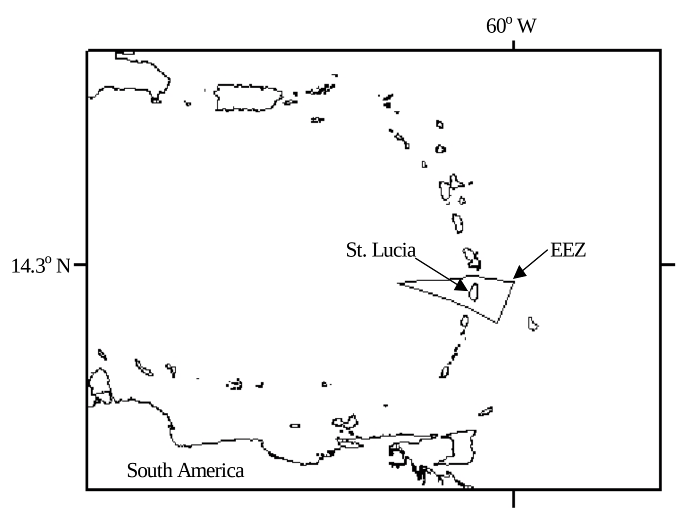


Figure 1. Map of St. Lucia, part of the Lesser Antilles island chain in the south-eastern Caribbean. Shown also is the island's EEZ.

the windward coast are mostly small patch reefs or broken fringing reef systems while those along the mid-leeward coasts are diverse, coral-dominated communities providing an almost solid fringe long the extremely narrow slope (St. Lucia Fisheries Department, 1995). Until 1995, no serious attempts at accurately determining the extent of the reef habitat had been made (St. Lucia Fisheries Department, 1995).

Fishery Development

The fisheries of St. Lucia comprise several components. These include the offshore pelagic fishery targeting flyingfish and large migratory pelagics with gillnets, handlines, troll lines and longlines; the small coastal pelagic fishery targeting mainly small jacks (Carangidae) with beach seines and gillnets; the shallow and deep demersal fishery targeting mainly snappers (Lutjanidae) and groupers (Serranidae) with fish pots and handlines, and the lobster and conch dive fishery. Turtles are caught incidentally in nets, and cetaceans are targeted with harpoons, while seaweeds and sea urchins are harvested by hand.

Pre 1950s

Very little is documented on fisheries prior to the 1950s. Fishing was mainly for subsistence and all boats were unmechanized. There are however, unpublished reports of export trade in hawksbill turtle shells, lobster and whale oil from as early as 1928, 1937 and 1918, respectively.

1950s to 1970s

In the early 1950s, a turtle export trade was established with the United Kingdom (Anon., 1955). The lobster trade was revived, following transportation problems in the 1940s, as Trinidad increased its lobster imports from St. Lucia (Anon., 1955). Reports of the capability to supply the total demand for lobster in Trinidad attests to the possible high catches at the time. The first attempt at boat mechanization, through the introduction of outboard engines, occurred at the ends of the 1950s (Scholz, 1980). The fleet consisted mainly of canoes but the few existing whaleboats were considered more advanced (Smyth, 1957).

Development of the offshore pelagic fishery was promoted to satisfy the local demand for fish, though it was felt that the existing fleet was not operating at its full potential. The government's policy focused on development of all sectors of the fishing industry through the provision of credit for improvement of fishing crafts and gear, granting of duty free concessions on engines and specific fishing gears and improvement of marketing facilities (Vidaeus, 1969). The Fisheries Department, comprising just two staff members, also facilitated the granting of loans to fishers through the Agricultural Development Bank (Vidaeus, 1969).

St. Lucia also allowed the offloading of catches from foreign boats duty-free (Vidaeus, 1969). As a result boats from Venezuela, Martinique and even the US landed their catch in St. Lucia. By the late 1960s crustaceans were exported to Puerto Rico, Barbados and the USA, and frozen snapper to Puerto Rico. It is presumed that this trade is linked to activities of foreign boats. The local retail trade in fresh fish, as well as wholesale and retail trade for frozen and processed fish was regulated by maximum prices enforced by the Government (Vidaeus, 1969). The Caribbean Training and Development Project implemented by the United Nations Food and Agriculture Organization (FAO) between 1965 and 1971 provided technical training in all aspects of industrial fishing and highlighted the possibility of increased catches from the Guyana banks.

In 1967 surface gillnets were introduced to the flyingfish fishery. Previously, dipnets and handlines were utilized (Brown, 1945; Murray and Jennings-Clarke, 1993). About 50% of existing boats were already mechanized, using mainly outboard engines (15-18 Hp). However, rising fuel prices in the late 1960s and early 1970s, affecting about 70% of the fleet (Walters, 1981), along with the fixed fish prices introduced by the government, were limiting factors to fisheries development. It became necessary to introduce more fuel-efficient boats. Assistance was obtained from FAO to train fishers at Vieux Fort to use inboard powered boats and to construct and operate improved fishing gear (Scholz, 1980; Walters, 1983). The associated project also conducted exploratory multi-gear fishing and introduced three boats designed specifically for this purpose. However, despite this support, fishers were reluctant to adopt the new inboard-powered boats because they were slower than those powered by outboard engines and also required a higher initial capital outlay. Further, the lack of market facilities was a discouragement to fisheries development and traditional ties to the canoe were strong (Scholz, 1980). Fishers resorted to using outboard engines of higher horsepower, but rising fuel prices, high maintenance costs and low lifespan of these engines continued to inhibit development.

During the early 1970s the government requested assistance from the Canadian International Development Agency (CIDA) to review the fishing industry and make recommendations for development. The latter included the establishment of cold storage facilities and establishment of a Fisheries Management Unit with responsibility for development of the fisheries sector and the conduct of stock assessment and management research (Walters, 1984). The Unit was established in 1976. Organization of fishers into co-operatives was encouraged to assist with marketing of catches, supply subsidized fuel and duty-free acquisition of fishing materials. Nine such co-operatives were set up in the 1970s (Walters, 1981).

1980s and 1990s

The early 1980s was marked by considerable destruction of fishing boats, engines, and equipment due to hurricane Allen (Fisheries Management Unit, 1981). At the time the fishery was still in the early development phase, mainly artisanal and inshore, utilizing hook and line, beach seines and pots (Matthews, 1983). Though a dramatic change in the industry was not envisaged or advised, efforts focused on careful planning, identifying, and addressing major constraints to development (Matthews, 1983). Existing constraints included the low potential of fishers to adopt new technology, inadequate onshore infrastructure (landing, cold storage, processing), lack of a marketing structure, lack of effective organization among fishers, inefficient boats and fishing techniques and government's price control on fresh fish (Matthews, 1983).

Although the canoe was still the main boat type used, a more efficient boat to target the offshore pelagic fishery was required. Fiberglass pirogues were imported from Trinidad and St. Vincent (Walters, 1981) and the Windward Island Fishing Boat Construction Project, funded by the Caribbean Food Corporation, constructed fiberglass pirogues for sale to St. Lucia, Dominica, St. Vincent and Grenada (Matthews, 1983). Through this project 100 fiberglass pirogues, fitted with either outboard or inboard engines were introduced to the St. Lucia fleet. The marketing system was improved and with assistance from CIDA a fisheries complex, complete with cold storage facilities, was constructed.

The protection of reef and coastal resources has been a major concern. Extensive coral reef management has been undertaken through the co-operative efforts of the Eastern Caribbean Natural Area Management Program (ECNAMP), the St. Lucia Fisheries Department and local groups (UNEP/IUCN, 1988). A 1981 project sought to find solutions to conflicts among various users and to the stresses on critical resources while promoting healthy and sustainable development through a multi-disciplinary approach in the southeastern region (UNEP/IUCN, 1988). This has been used as a case study in integrated coastal zone management.

Through collaboration with other members from the Organization of Eastern Caribbean States (OECS) a Harmonized Fisheries Bill (Walters, 1984) was prepared. This outlined co-operation in fisheries surveillance and enforcement of regulations in the region and mandated that Governments develop and manage fisheries in harmony with the fishing communities. At this time also St. Lucia embarked on a project of diversification of its fishing industry. Through assistance from CIDA, aquaculture projects using tilapia (*Oreochromis mossambicus* and *O. niloticus*), prawns (*Macrobrachium rosenbergi*) and seamoss (*Gracilaria* spp.) were introduced (Walters, 1981). Conservation oriented measures to sustain inshore resources were also introduced. These included a system of marine reserves and fishing priority areas, set up in 1986, and implementation of co-management schemes for the sea urchin (*Tripneustes ventricosus*) fishery (George and Joseph, 1994).

In 1986 a number of coastal marine reserves and fishing priority areas were established. However, prohibition of traditional fishing while allowing Scuba diving resulted in tremendous resource user conflicts. In addition, the level of protection to reef resources was affected by a lack of proper demarcation of fishing priority areas and enforcement (St. Lucia Department of Fisheries, 1995). In 1992 a coordinated approach between the Department of Fisheries and the Soufrière Foundation, with technical assistance from the Caribbean Natural Resources Institute (CANARI) resulted in the formation of the Soufrière Marine Management Area (SMMA) (St. Lucia Department of Fisheries, 1995). This involved zonation of the area according to use and appropriate management with the involvement of user groups. A similar exercise was to be conducted at the Anse la Raye/Canaries coastal areas with support under a USAID/ENCORE project. By the early 1990s there were 20 marine reserves comprising turtle nesting beaches, coral reef areas and mangrove habitats with the use of resources being strictly controlled (St. Lucia Fisheries Department, 1992). The SMMA is a well-documented success story on the usefulness of marine reserves (Hatcher *et al*., 1995; Roberts *et al*., 1996; Goodridge *et al*., 1997). Scuba diving was permitted in these areas, but fishing was prohibited. A joint project with France aimed at conservation and sustainable use of the marine resources within the SMMA was also launched. The project assisted in the construction of a jetty and the introduction of fish attraction devices off the west coast to promote aggregation of offshore pelagic species for the fishery (Pierre, 1999).

By the late 1980s, development of the offshore fishery was evident. Between 1989 and 1992 five 15 m longliners were introduced and an additional 20 boats of 9 m length began exploiting the pelagic fishery (Mahon and Singh-Renton, 1993). Japan assisted with the introduction of fiberglass boats equipped with longlines. Some fishers were trained in the construction and operation of sub-surface tuna longlines, bottom horizontal and vertical longlines with assistance from the Governments of Japan and the France (George, 1999). This has resulted in increased interest in the adaptation and use of these gears from fiberglass pirogues (George, 1999). The fishery is considered as being in a transitional stage, with the capacity and efficiency expected to increase with adoption of improved boats and gear technology (George, 1999). Considerable government subsidies are still provided and a fisheries complex was constructed with financial assistance from Japan. However, fishers are still limited by their ability to self-finance larger boats with advanced gear.

In the 1990s a limited entry system in the conch fishery was implemented through a licensing system, trammel nets were banned for the capture of lobsters, a buy-back scheme for bottom gillnets was implemented and small meshed pots were replaced with large mesh (George, 1999). The sea urchin fishery is also controlled by a licensing system and a co-management system set up for this fishery (Smith and Walters, 1991). Further details on management efforts are available in George (1999) and the Fisheries Department website at www.slumaffe.org.

Fisheries statistical data collection

The first data collection system, set up in the 1960s, sought to resolve disputes between fishers and vendors over selling commission at the main market in Castries rather than management of the resources (Brown, 1945). Data were aggregated across all species so it was not possible to examine species specific changes in the catch. Fish sold at market was supplied mainly from landing sites predominantly out of town. Only about 25% of fish caught off Castries was actually sold at the market. This system of data collection remained unchanged until the late 1970s (Villegas, 1979).

Between the late 1970s and mid-1980s the data collection system was expanded to include landings at nine of the 13 major landing sites (Goodwin *et al*., 1985; Walters and Oxenford, 1986; Murray *et al*., 1988). A correction procedure, accounting for non-recorded sites and days in the estimation of total catches from recorded data, was also instituted (Murray *et al*., 1988) together with a boat registration system (Fisheries Management Unit, 1981). During the late 1980s the OECS instituted a data computerization system to member countries for entry of fisheries catches, fishing effort and other management related data. Currently, information for the 1980s is available only from the Annual Agricultural Reports, based on data submitted by the Fisheries Department. Two relocations of the Fisheries Department and a major fire have contributed to the loss of data collected prior to the 1990s. At an OECS hosted workshop (Mahon and Rosenberg, 1988) plans for upgrading the data collection system were presented (Murray *et al*., 1988). However, these were not implemented due to financial and human resource constraints.

By the mid-1990s a revised data collection system was implemented (Joseph, 1996) under the CARICOM Fisheries Assessment and Management Program (CFRAMP).

CFRAMP introduced two new databases for computerization of catch and effort data: the Trip Interview Program (TIP) and the Licensing and Registration System (LRS), respectively. Selected landing sites (primary and secondary) were the target of data collection and a system for raising the recorded catch to account for non-enumerated fishing days (at recorded sites) and non-enumerated boats (at non-recorded sites) was derived (Joseph, 1999). Estimates of total catches from 1995 onwards are available from this system. Though reporting is still confined to estimated total catches of the major categories listed previously, with the inclusion of an additional group for snappers, dis-aggregation into the respective species groups is now possible.

Fisheries Policy

In the 1980s the government embarked on a program of increased development of the industry. The overall policy was to increase local production through improved gear and boat technology (Walters, 1981) and to diversify the industry by introducing aquaculture production (Walters, 1984). It was the intention to reduce the quantities of fish imported. There were also improvements in infra-structural facilities, cold storage, marketing and distribution of fish. The fisheries policy since the 1990s is to "promote self-sufficiency through increased production of marine and aquaculture products, and to develop the fishing industry and implement measures to ensure its sustainability" (St. Lucia Fisheries Division Website: www.slumaffe.org; accessed August 12, 1999). Since the inshore resources are found to be depleted, the offshore large pelagic fishery is seen as the avenue for future development (George, 1999). A conservative approach to development also includes the establishment of marine reserves and fishing priority areas and a co-management approach to assessment and management of the sea urchin (*Tripneustes ventricosus*) resources.

The two main bodies of legislation are the Fisheries Act of St. Lucia (Statutory Instrument No. 10 of 1984) and the Fisheries Regulations of St. Lucia (Statutory Instrument No. 9 of 1994) (St. Lucia Fisheries Department, 1999). The latter represents a comprehensive package of revised legislation which was put into effect in 1994. This is discussed in detail in the St. Lucia Fisheries Department publication of 1999 and the associated website: www.slumaffe.org. The Fisheries Act provides for the formation of Local Fishery Management Areas to facilitate more effective management of shelf resources.

METHODOLOGY

Catches

The major sources of information were published and unpublished documents, including reports of the St. Lucia Agricultural Department, the St. Lucia Game Fishing Association, the National Archives, and the St. Lucia Fisheries Department Statistical Database. Where estimates from different sources differed, those derived from the most recent methodology to estimate total landings by accounting for unrecorded landing sites and fishing days (e.g., Joseph, 1999) were used.

Anchor points:

1942: Smyth (1957) provided an estimate of total catch (341 t) for 1942, but gave no details on the methodology for arriving at this figure. This estimate however does not agree with the 1,555 t total catch in Brown (1945). Brown computed a gross estimate of total catch for each boat/fishery type using the associated number of boats, the associated weekly catch rate and number of weeks fishing per year. It is unlikely however, that the estimated catches for the 1940s, derived from an artisanal, unmechanized fleet, would be similar to catches in the 1990s from a still largely artisanal but fully mechanized fleet. This would be the case if Brown's estimate was considered. Thus, the estimate of Smyth (1957) was used in the analysis. However, if over-fishing has occurred (due to industrialization and increased effort), it is possible that declines in catch per unit effort may result in estimates of recent catches that are comparable in magnitude to catches from the early pre-industrialized period.

1956: A total catch of 500 t for 1956 (Salmon, 1958) was used as an anchor point for the respective year.

1960–1968: Catches delivered to the fish market at Castries are available for 1960 to 1968 and range from 80-177 t (Vidaeus, 1969). Cecil (1966) also provided annual recorded landings at Castries for 1961 to 1964 and this was thought to represent one third of total landings. Using this raising factor and data in Vidaeus (1969) and Cecil (1966), total catches were estimated for 1960 to 1968 as

531, 432, 504, 525, 471, 240, 255, 267 and 483 t, respectively.

1981–1994: Estimated total catches by five major species categories: tuna (Scombridae); dolphinfish (*Coryphaena hippurus*); shark (Carcharhinidae); kingfish (*Acanthocybium solandr*i and *Scomberomorus cavalla*); flyingfish (mainly *Hirundichthys affinis*) and snapper (Lutjanidae), and one aggregate category (‘other fish’) were provided by the St. Lucia Fisheries Department. These were derived by adjusting recorded data to account for non-recorded fishing days and landing sites, using the methodology in Joseph (1999).

1995–2001: The St. Lucia Fisheries Department provided detailed estimates of annual catch for 1995 to 2001, following the methodology of Joseph (1999). Catches were disaggregated into 153 to 171 species or groups in each respective year

First interpolation: Total catches
Annual catches for 1943 to 1955 were estimated by interpolation between estimates for 1942 (Smyth, 1957) and 1956 (Salmon, 1958). Similarly, annual total catches for 1957 to 1959 were estimated by interpolating between estimates for 1956 and 1960 (Vidaeus, 1969). Annual catches for 1969 to 1980 were estimated by interpolation between 1968 (Vidaeus, 1969) and 1981 (Fisheries Department unpublished statistics). The relative contribution of the offshore and inshore fisheries to overall catches was estimated for 1942, 1960 to 1969 and 1981 to 2001 from actual catch estimates as described above. Similar estimates were derived for missing years by interpolation. Along with the overall reconstructed catches for 1943 to 1959 and 1970 to 1979 (estimated by interpolation) the corresponding offshore and inshore components were estimated as the product of the respective proportional contribution to overall catches and reconstructed total annual catch.

Species Composition
The species composition of catches in St. Lucia has not been documented in the past (Vidaeus, 1969). As a result this is either inferred from descriptions of the fishery (Brown, 1945) or assumed to be the same as for neighboring islands, e.g., St. Vincent (Cecil, 1972).

1942: Brown (1945) estimated catches by fleet type, from which the percentage contribution of each fishery type to total catch was computed. Canoes target flyingfish; whaleboats target large pelagics; haul seines and gillnets target coastal pelagics, and troll and pot canoes target both the reef and large pelagic fisheries. It was assumed that 75% of the catch of the troll and pot canoes was attributable to the pelagic fishery since this is the main fishery over 7-8 months of the year, with the other 25% being assigned to the pot fishery. The percentage contribution of the flyingfish, large pelagic, small coastal pelagic (beach seine and gillnet) and reef fisheries were 44%, 16%, 35% and 4.8% respectively. Using the species listed for the large pelagic and small coastal pelagic fishery in Brown (1945), and the list of common and local names in the same document, the species composition of the catches of the respective fisheries was inferred. It was assumed that species caught in each fishery were listed in decreasing order of importance, with the first accounting for 50% of the catch of the fishery. The major species in the small coastal pelagic fishery and corresponding proportional contribution to the total catch are: *Selar crumenophthalmus* (50%); halfbeaks (20%); *Euthynnus alletteratus* (15%); *Thunnus atlanticus* (10%); Cavalli (5%; comprising of equal portions of *Caranx ruber*, *C. latus* and *C. crysos*). The major species in the large pelagic fishery and corresponding contribution to the total catch are: *Coryphaena hippurus* (50%); *Scomberomorus cavalla* (15%); *Acanthocybium solandri* (10%); *Thunnus albacares* (10%); *Thunnus atlanticus* (5%); *Katsuwonus pelamis* (5%); *Makaira nigricans* (2.5%) and *Istiophorus albicans* (2.5%). No information on the species composition of the reef fishery was available. However, consistent with the observation that the species taken in the early stages of fisheries are usually those of higher trophic levels (Pauly *et al*., 1998) it was assumed that catches comprised 50% each of the major snapper and grouper groups.

1960-1969: Cecil (1972) provided a crude estimate of species composition based on personal communication with the Fisheries Officer at the time. Tuna (Scombridae), bonito (*Sarda sarda*) and dolphinfish (*Coryphaena hippurus*) accounted for 40% of the catch; flyingfish (*Hirundichthys affinis*) accounted for 30%; jackfish (*Selar crumenopthalmus*) accounted for 20% and the remaining 10% comprised all other species (mainly reef species). A more detailed species composition was provided for landings in 1966 at the Kingstown market in St. Vincent (Cecil, 1972). At the time the markets at Castries and Kingstown were the only markets existing in the respective neighboring islands. To further disaggregate catches of the broad species groups above, the same species composition at the Kingstown market was assumed. Species were identified by local names. Based on Brown (1945) the associated scientific classification was identified as follows (the name of the species or group used is given in brackets): jackfish – *Trachurops crumenophthalma* (*Selar crumenopthalmus*); gar – *Tylosurus* spp. (Needlefishes- Belonidae); hind – *Petrometropon cruentatus* (*Epinephelus cruentatus*); ocean gar – sailfish, *Istiophorus americanus* (*Istiophorus albicans*); robin (*Decapterus punctatus*); yellowtail – yellowtail snapper (*Ocyurus chrysurus*). Based on the author's general knowledge of local names, dodgers were identified as bigeye scad, *Selar crumenopthalmus* (data combined with jackfish), and red fish assumed to be the queen snapper *Etelis oculatus*. Similarly, amber cavalli was assumed to be the greater amberjack (*Seriola dumerili*) and cavalli was assumed to be the crevalle jack, *Caranx hippos*. Catches of anchovy (Engraulidae) and sprats (Clupeidae) were included under 'herrings and sardines'. This process resulted in disaggregation of tuna catches into yellowfin tuna (*Thunnus albacares*), referred to as 'albacore' and skipjack (*Katsuwonus pelamis*) and the 'other species' category into 21 groups.

1981-1994: The 'other fish' category from 1981 to 1990 was disaggregated into its species components assuming the same species composition of this category for 1990. It was assumed that this species composition remained unchanged over the period.

1990-1994: Recorded data for 1990, 1992 and 1993 were extracted from a discontinued database system introduced under an OECS data management project. The 'other fish' category comprised between 39 (1990) and 81 (1992) species groups in this database. It was used to disaggregate the estimated total catch of the corresponding category into the species components for the respective years. The major assumption is that the species composition of the recorded catches is reflective of the true species composition of catches in the fishery as depicted by the estimated figures obtained from the St. Lucia Fisheries Department. Similarly catches of the aggregate tuna, shark and snapper categories were disaggregated into the respective species based on the species composition of these groups from recorded data for the respective years. Data for 1991 and 1994 were available in the aggregated form mentioned previously. The respective 'other' categories were disaggregated by species using the mean species composition of the same category for 1993 and 1995 as representative of 1994; and for 1990 and 1992 as representative of 1991. Since sharks were not recorded as a separate category in 1991, it was assumed that the species composition of 1990 and 1991 was the same as for 1992. Further, the total shark catches for 1991 was estimated by interpolation between the 1990 and 1992 estimates available from the Fisheries Department.

1995-2001: Data provided by the St. Lucia Fisheries Department was disaggregated into 235 possible species or species groups.

It was difficult to compare reconstructed catches given the vast differences in the species groups represented for the different time periods. Hence, species were aggregated into 61 broad groups across the 1942 to 2001 period. A list of species (local and scientific names) and the associated broad species grouping can be obtained form the senior author. Lobsters and sea turtles were included but cetacean catches are represented separately.

Second Interpolation: Species Composition

Using the aggregated catches represented by 61 species groups, catches of the following species, from 1943 to 1959, were estimated by interpolation between estimates for 1942 and 1960: groupers; halfbeaks; reef jacks; jacks (small coastal pelagics); snappers; billfishes; dolphinfish; flyingfish; pelagic jacks; mackerels; pelgics sharks and tunas. Similarly, catches for the following species between 1970 and 1979 were estimated by interpolation between estimates for 1969 and 1980: barracudas; groupers; reef jacks; jacks (small coastal pelagics); snappers; billfishes; dolphinfish; flyingfish; pelagic jacks; mackerels and tunas. Estimates of marine turtle and lobster catches for missing years were derived as described below. Since it was not possible to estimate catches for all species by interpolation, the difference between the sum of interpolated catches and estimated total catches across all species was attributed to the aggregate category 'miscellaneous marine fish' in the respective years.

Species catch adjustments

Catches of billfishes, tunas, kingfish/wahoo and dolphinfish from 1991 to 2001 were adjusted to incorporate landings from the annual main fishing tournament in St. Lucia. Mahon *et al.* (1994a, 1994b) conducted a detailed analysis of the pelagic fishery, and estimated annual catches of yellowfin tuna for 1980 to 1990. These estimates were used instead of those derived from methods outlined previously. Queen conch (*Strombus gigas*) catch in 1990 was based on Mulliken (1996). The 1993 catch estimate was based on data in George (1997) which incorporated sales at local markets, purchases at the fish market complex (7.54 t) and authorized exports to Martinique (1.95 t). Queen conch catches from 1994 to 1997 were taken from George (1999). A comparison of estimated catches based on George (1997; 1999) and those estimated from the St. Lucia Fisheries Department statistical database is given in Table 1.

Table 1. Estimated catch of Queen conch (*Strombus gigas*) in St. Lucia, 1993-1997, compared between sources.

Year	Catch (t)	
1993	15.91[a]	9.76[c]
1994	19.75[b]	9.95[c]
1995	31.92[b]	8.28[c]
1996	26.80[b]	19.79[c]
1997	24.53[b]	11.09[c]

a: George (1997); b: George (1999); c: St. Lucia Fisheries Department Statistical Database

Catches from sport fishing tournaments

The annual number of fish landed, and associated species composition for 1991 to 1994 (De Beauville-Scott, 1994), and the weight of individual fish species landed for 1996, 1998 to 2000 were available from the unpublished records of the St. Lucia Game Fish Association. The mean individual weight of the landed species was estimated from data for the latter period and used to convert numbers of fish to the corresponding weight for the earlier period, assuming no change in the sizes of fish landed during the 1990s. Species catches for 1995 and 1997 were estimated by interpolation using the catch of the previous and following years.

Estimation of turtle catches

The weight of hawksbill shell exported during 1928 to 1929, 1931 to 1933 and 1935 to 1940 were available from reports of the St. Lucia Agricultural Department (1929, 1930, 1933, 1934, 1938) and Caribbean Commission Central Secretariat (1948). Rebel (1974) gave estimates of green turtle (17.05 t) and hawksbill turtle (10.91 t) obtained from personal communication with C. Matthews. The weight of hawksbill shell exported between 1970 and 1986 were provided in Milliken and Tokunaga (1987) and estimates of turtle catches from 1993 to 1999 were available from the St. Lucia Fisheries Department. Shell weights were converted to the equivalent animal numbers using the conversion factors in Milliken and Tokunaga (1987) and the website www.tortoise.org.news/1998s28.html. The number of animals was converted to the equivalent weight using the mean animal weight in Witzell (1994). Catches for missing years were estimated by interpolation.

Estimation of Marine Mammal Catches

Historically, cetacean catches were not incorporated in the data collection system. Data are available on the quantity (gallons) of blackfish (pilot whale) oil exported from St. Lucia in 1918 (Agricultural Department of St. Lucia, 1918, 1919, 1920), 1920 (Rambally, 2000a), 1924 (Agricultural Department of St. Lucia, 1924), 1926 (Rambally, 2000a), 1928 (Agricultural Department of St. Lucia, 1939), 1931 (Anon., 1932) and 1935 (Rambally, 2000a). The quantities of oil were converted to the equivalent number of animals using the conversion factor in Brown (1945). Estimates of porpoise (mainly *Tursiops truncatus*) catches between 1960 and 1969 were derived using data on species composition in Cecil (1972) and estimates of total marine catches derived from data in Vidaeus (1969). It was assumed that there were no catches of porpoises in 1918 and catches between 1918 and 1960 were estimated by interpolation. Estimates of cetacean catch numbers for 1995 to 1999 were available from the St. Lucia Fisheries Department's unpublished records and Rambally (2000b). The associated species were: bottlenose dolphin (*Tursiops truncatus*), Atlantic spotted dolphin (*Stenella frontalis*), Fraser's dolphin (*Lagenodelphis hosei*), common dolphin (*Delphinus delphis*), spinner dolphin (*Delphinus delphis*), Dall's porpoise (*Phocoenoides dalli*), false killer whale (*Pseudorca crassidens*); short-finned pilot whale (*Globicephala macrorhynchus*), pygmy killer whale (*Feresa attenuata*) and humpback whale (*Megaptera novaeangliae*). Data for 1994 were not disaggregated by species so the same species composition, specific to the respective landings site in 1995 was assumed. Catch numbers were converted to the equivalent weight using the mean individual weight for the respective species in Trites and Pauly (1998). Catches for missing years were estimated by interpolation.

Estimation of lobster catches

The quantity of live lobster exported in 1937 and 1938 was obtained from the 1938 report of the Agricultural Department of St. Lucia. The associated value of the export trade was also provided for 1936 to 1938. Assuming the same average price per unit weight for 1937 and 1938 the weight of live lobster exported in 1936 was estimated. Exports for 1935 to 1941 (Caribbean Commission Central Secretariat, 1948), estimated catch for 1965 to 1967 (Idyll, 1971) and exports in 1968 (Vidaeus, 1969) were also available. Estimated lobster catches between 1981 and 1991 were obtained from the St. Lucia Fisheries Department statistical database. Joseph (2000) gave data on the annual purchases of lobsters at the St. Lucia Fish Marketing Cooperative between 1992 and 1999. A crude estimate of total catch for 1997 was given in George (1999). The ratio of this estimate and the purchase of the Cooperative for the same year was assumed to be the same for each year from 1992 to 1999. Therefore, using data from Joseph (2000) and George (1999), estimates of annual catch of the species for the 1992-1999 period were derived.

Fishing Effort

Data Sources

The unit of fishing effort used in analyses is horsepower-days. Data limitations restricted the estimation of fishing effort to key years for which the required data were available. From these, estimates for missing years were interpolated. Several assumptions were also made based on information in the literature and discussions with staff of the Fisheries Department when there was missing data and the details are given for the respective years. The key years selected and associated information sources were:

1942: Details on the number of boats by landing or mooring site were available from Brown (1945). All boats were unmechanized. A horsepower of one was assumed for all unmechanized boats.

1969: Details on the number of boats by fishery type were available from Vidaeus (1969). Approximately 50% of the boats were mechanized with engines of 15-18 Hp (Vidaeus, 1971).

1972: Data on the number of whalers involved in the fishery for cetaceans was available from Gaskin and Smith (1977). Boat horsepower was taken from Vidaeus (1971), who gave a range of 6 to 33 Hp. The higher estimate was used to provide an estimate of the fleet potential.

1988: The number of boats by type/design were provided in OECS (1989). Boat horsepower were taken from OECS (1993). Canoes, transoms (dories) and whalers carried engines of 36 Hp, 23 Hp and 30 Hp, respectively. It was assumed that pirogues carried engines of 48 Hp, similar to St. Vincent in OECS (1993) and that the single launch carried an engine of 48 Hp as indicated in OECS (1995) for St. Lucia.

1993: Data on the overall number of fishing boats and the percentage composition by type/design was provided in OECS (1993). Associated engine horsepower was available in OECS (1995). Canoes, pirogues, transoms, whalers and launches carried engines of 81 Hp, 67 Hp, 16 Hp, 30 Hp and 48 Hp, respectively.

1994–2000: Data are provided on the number of boats registering each year by their respective landing sites, including the associated boat category (canoe, shaloop, pirogue, longliner, launch etc), boat length and horsepower form the St. Lucia Fisheries Department Licensing and Registration System (unpublished statistics). Since boats do not re-register each year, it was necessary to include the boats for all previous years (from 1993) in the analyses for the post 1993 period in order to give an accurate depiction of fishing effort. The most recent data (1994-2000) facilitates detailed examination of changes in fishing effort. Missing data, e.g., boat length and/or horsepower were estimated as the average of similar boat type and length/Hp operating at the same site, or the average of similar boat types and length/Hp throughout the island.

Linking fishing effort to fishery type

1942: Except for those boats involved in the beach seine, jack seine and other net fisheries, all boats on the leeward coast fished for flyingfish and large pelagics from November to June (Brown, 1945). These boats also targeted inshore demersals using fishpots during the flyingfish off-season. At Castries, six whalers were involved in fishing for large pelagics (trolling) year round. Except for those boats involved in the beach seine, jack seine and other net fisheries, all boats on the windward coast were assumed to fish for inshore demersals year round. In the beach seine, jack seine and other net fisheries it was assumed that twice the number of boats as nets were involved in the fisheries. Usually a large boat (6.67-9.09 m) and a small boat (< 5.67 m) were associated with one net.

1969: There were about 435 boats involved in the handline and pot fishery. Of these, 350 were canoes and assumed to target the large pelagics from November to June and the pot fishery during the pelagic off-season. The remaining 85 were smaller transoms which were assumed to target the pot fishery year-round. About 110 boats were involved in the beach seine fishery and 16 boats (12 at Castries and four at Vieux Fort) involved in whaling. It was assumed that mechanized boats targeted the offshore pelagic fishery. These were estimated at 323 canoes, the remaining 27 canoes and other boats were unmechanized.

1988; 1993; 1994-2000: Based on Murray *et al*. (1988) and personal communication with Fisheries Field Extension Officers, the following inferences were made in assigning boats to fishery type: All transoms and shaloops target the inshore reef resources year-round. However, these boats also fish for coastal pelagic with beach seines. The relative time spent on each fishery is not known. Canoes, pirogues, whalers and launches target the offshore pelagic and flyingfish fisheries from November to June, and the reef, deep slope and bank resources (depending on the landing sites) from July to October.

Longliners target large pelagics year–round. All whalers in 1988 targeted pilot whales only.

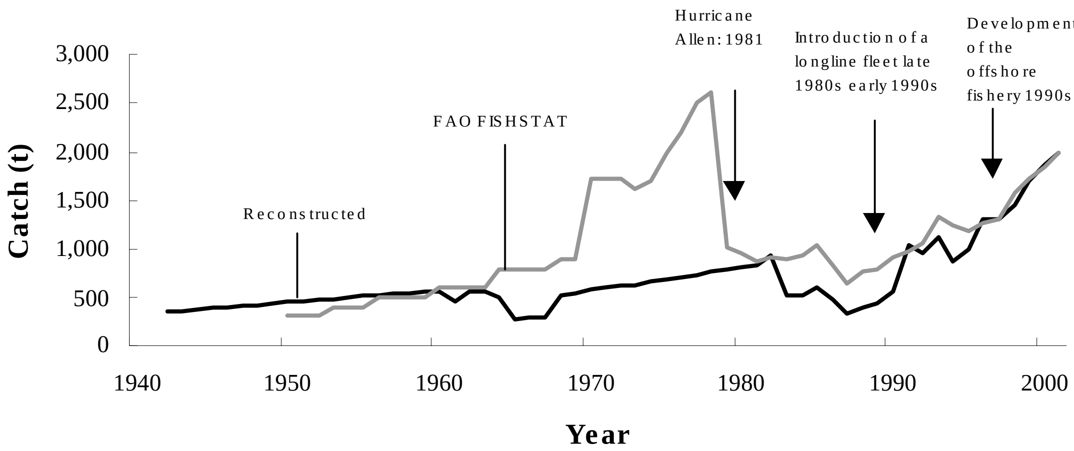
Assigning fishing days to the respective fleets and fisheries

The fishing days associated with each fleet type was dependent on the resources targeted and whether or not the fleet was mechanized. Details are provided in the 'General Methods' chapter by Mohammed (this volume). The only exception pertains to whalers operating in the early 1940s. Brown (1945) reported that these fished for large pelagics year round. They were also not mechanized. It was assumed that they fished the same number of days overall each year (120) as boats targeting large pelagics from November to June (75 days) and demersals during the pelagic off-season (45 days). Transoms targeted both the inshore coastal pelagics and reef fishery (Murray *et al*., 1988). Without a basis for apportioning annual effort into the respective components, it was assumed that these boats targeted the inshore fishery generally, for about 230 days per year. Based on George (1999) and communication with staff of the Fisheries Department (H. Walters, pers. comm.) fishing effort and the number of fishing days in the pelagic fishery had increased in the offshore fishery and decreased in the inshore fishery by the end of the 1990s. To reflect this, pirogues were assumed to fish for large pelagics (offshore fishery) 220 days per year from 1998, and to desist from fishing inshore demersals.

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 EEZ (18,002 km^2, Veridian MRJ Technology, 2003), reef (160 km^2, Oliver and Noordeloos, 2002), slope and shelf (522 km^2, Mahon, 1993) areas, a time series of trends in catch per unit area was derived. Catch per unit effort was estimated as the ratio of reconstructed catch (excluding marine mammals) and reconstructed effort for the respective fisheries.

(a)



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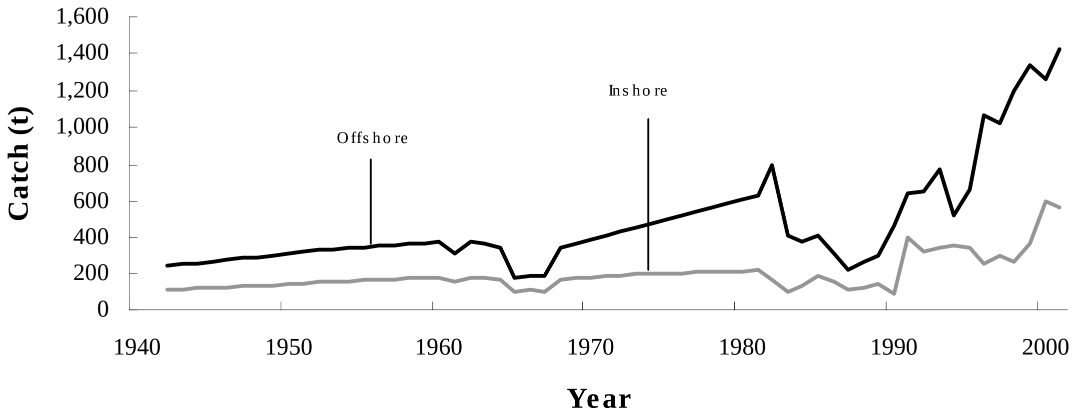


Figure 2: Fisheries catches (t) in St. Lucia. (a) Reconstructed catches (1942–2001) and catches in FAO FISHSTAT (1950–2001), (b) Reconstructed catches dis-aggregated for offshore and inshore fisheries (1942–2001).

RESULTS

Catches

Reconstructed catches, excluding catches of cetaceans, and corresponding statistics in the FAO FISHSTAT database are presented in Figure 2a. The major difference in catches from the two sources occurred between 1964 and 1980, with data in FISHSTAT exceeding reconstructed statistics by between 145 t in 1980 and 1,700 t in 1977. Differences in estimated catch from the two sources ranged between 323 t and 452 t between 1983 and 1989. The associated fish categories attributed to the higher catches in FISHSTAT are 'miscellaneous marine fish' and 'miscellaneous marine crustaceans'. Reconstructed catches (Figure 2a) indicate a gradual increase between 1942 and 1982 from 349 t to 949 t (172%). This was followed by a sharp decline (54%) to 440 t by 1989. Thereafter, catches increased dramatically from 550 t in 1990 to 1998 t in 2001 (an increase of over 260%).

The offshore fishery contributes a greater proportion to overall catch (Figure 2b), averaging 72% between 1990 and 2001. Catches in the offshore fishery increased by 381%, from 295 t to 1,420 t between 1989 and 2001. Similarly, over the same period catches in the inshore fishery increased by 291%, from 145 t to 567 t.

Overall, a greater number of species are represented in the reconstructed data compared to FAO FISHSTAT, and a higher level of species dis-aggregation was achieved

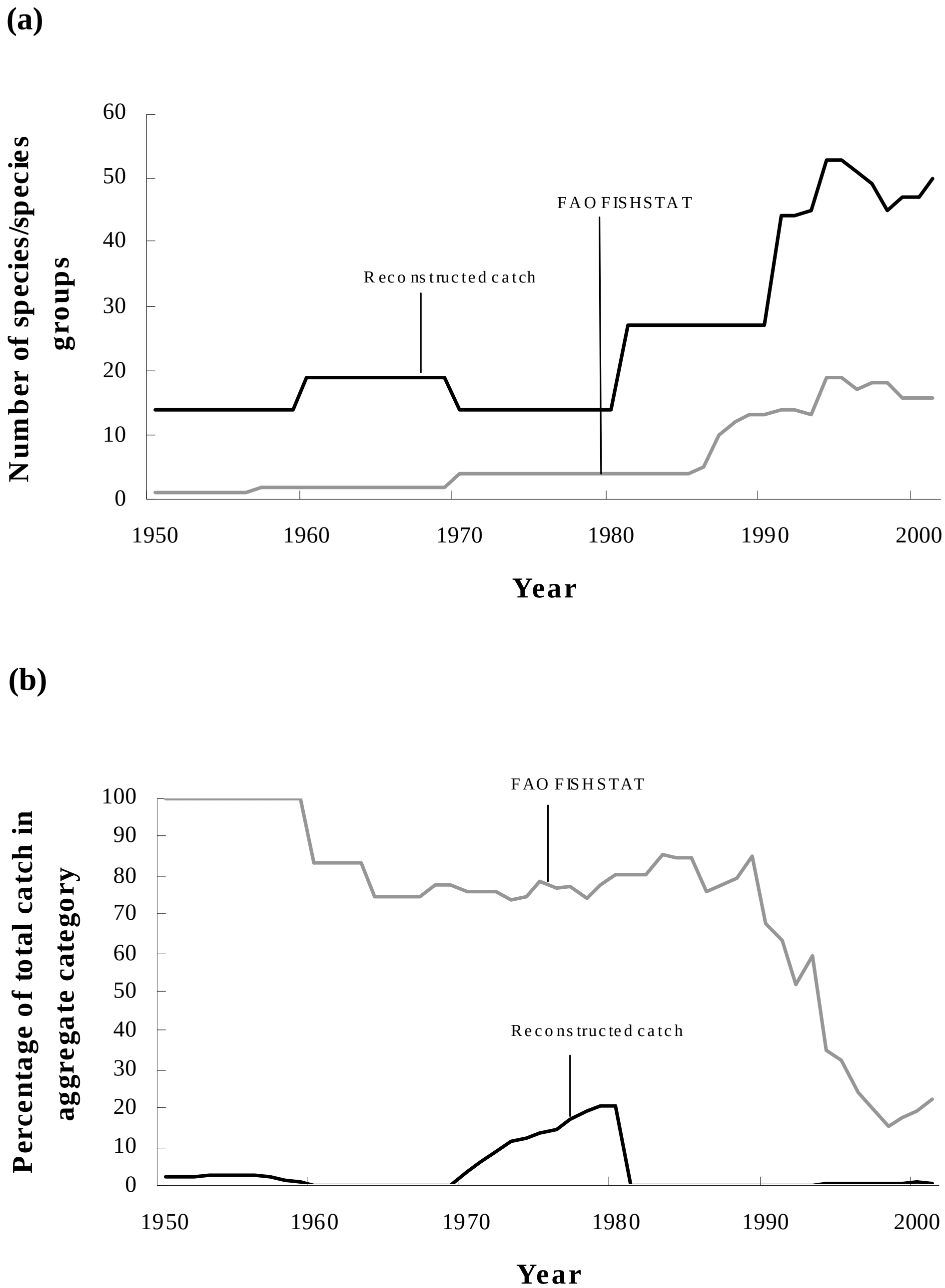


Figure 3: A comparison of reconstructed catch data and statistics in FAO FISHSTAT for St. Lucia between 1950 and 2001: (a) number of species/species groups and (b) percentage of total catch in aggregate category.

in the last decade for both sources (Figure 3a). For most of the time series, a smaller percentage of overall catch was attributed to the aggregate category 'miscellaneous marine fish' in the reconstructed data than that in FAO FISHSTAT (Figure 3b). From 1950 to 1959, all catches in FISHSTAT were recorded as 'miscellaneous marine fish' or 'miscellaneous marine crustaceans'. The percentage of overall catch attributed to this aggregate category declined drastically only during the 1990s, ending at 22% in 2001. The highest proportion of the catch (21%) attributed to the aggregate 'miscellaneous marine fish' category in reconstructed catches occurred in 1980.

Reconstructed catches from the major annual sport fishing tournament in St. Lucia (Table 2) were minimal (less than 3 t) compared to overall landings of the respective species.

Table 2: Reconstructed catches (t) from sport fishing tournaments in St. Lucia (1991-2000).

Species	1991	1992	1993	1994	1995*	1996	1997*	1998	1999	2000
Blue marlin	1.06	0.48	0.48	1.17	1.66	2.16	1.44	0.72	0.80	0.54
Sailfish	0.07	0.03	0.03	0.08	0.07	0.06	0.06	0.07	0.05	0.05
Wahoo	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.06	0.06	0.03
Dolphinfish	0.05	0.02	0.02	0.05	0.03	0.01	0.01	0.01	0.03	0.01
Spearfish	-	-	-	-	-	-	-	0.02	-	-
Tunas	0.06	0.03	0.03	0.06	0.06	0.05	0.05	0.04	-	-
Barracuda	0.16	0.07	0.07	0.18	-	-	-	-	-	-
Mackerel	0.01	0.01	0.01	0.01	-	-	-	-	-	-
TOTAL	**1.43**	**0.64**	**0.64**	**1.57**	**1.84**	**2.25**	**1.60**	**0.92**	**0.94**	**0.63**

* Estimated by interpolation

Table 3: Summary of number of annual of boats and mean engine horsepower between 1994 and 2000. (Data Source: St. Lucia Fisheries Department Licensing and Registration System).

Boat Type	Details	1994	1995	1996	1997	1998	1999	2000
Canoe	No. of boats	196	252	291	302	309	318	337
	Mean Hp	41.01	40.60	40.86	41.38	41.32	41.65	41.37
Pirogue	No. of boats	140	212	242	270	312	363	421
	Mean Hp	69.19	68.21	67.67	67.93	68.94	70.14	71.20
Transom	No. of boats	56	79	85	87	87	92	95
	Mean Hp	20.33	18.97	19.42	20.01	20.01	20.64	20.65
Whaler	No. of boats	3	6	8	8	9	9	12
	Mean Hp	37.00	40.83	38.50	38.50	35.78	35.78	52.25
Shaloop	No. of boats	3	14	25	31	34	36	43
	Mean Hp	24	17.01	13.08	13.89	13.93	14.46	16.52
Launch	No. of boats	2	2	2	2	2	2	2
	Mean Hp	48	48	48	48	48	48	48
Longliner	No. of boats	-	-	2	2	5	7	7
	Mean Hp	-	-	315	315	301	353.71	353.71
Aluminum	No. of boats	1	2	3	3	3	3	3
	Mean Hp	6.50	103.25	135.50	135.50	135.50	135.50	135.50
Yacht	No. of boats	1	1	1	1	1	1	1
	Mean Hp	500	500	500	500	500	500	500
Yaule	No. of boats	-	-	-	3	3	4	4
	Mean Hp	-	-	-	23.63	23.63	21.48	21.48
Total Number of Boats		**402**	**568**	**659**	**709**	**765**	**835**	**925**
Mean Hp		**48.88**	**48.37**	**48.84**	**49.39**	**51.49**	**53.91**	**54.96**

Reconstructed turtle catches reached nearly 25 t in the late 1970s (Figure 4). Between 1928 and 1938 catches were less than 18 t year^{-1} and in the most recent years catches are insignificant. Lobster catches appeared low (less than 10 t) prior to the 1980s, but increased dramatically to 26 t by 2000 (Figure 4). Catches of porpoises were low compared to pilot whales (Figure 5). Porpoise catches were less than two tons throughout most of the 20th century, but increased to almost 9 t by the end of the 1990s. Reconstructed catches of pilot whales (Figure 5) show a peak of almost 45 t in the mid 1920s and have declined to less than 10 t by the late 1990s.

Fishing effort

Considerable increases in the number of canoes and pirogues, and to a lesser extent shaloops and transoms were characteristic of the 1994 to 2000 period as illustrated by data obtained from the St. Lucia Fisheries Department Licensing and Registration system (Table 3). Only whalers and longliners demonstrated any appreciable increases in horsepower.

The annual trend in the number of boats and fishing effort in the offshore and inshore fisheries of St. Lucia between 1942 and 2000 is provided in Figure 6. Generally the number of boats declined between 1942 and the late 1980s but there were substantial increases in the 1990s (Table 3). Potential fishing effort increased exponentially over the period examined. Overall the number of boats in the offshore fishery increased from 411 to 780 between 1942 and 2000 and the corresponding effort increased by a factor of 257 (Figure 6a). Conversely, the number of boats in the inshore fishery decreased from 568 to 493 between 1942 and 2000, while effort increased by a factor of 27 (Figure 6b). Initially fishing effort was greater in the inshore fishery (51 x 10^3 Hp-days compared to 31.1 x 10^3 Hp-days in the offshore fishery), however, the situation was entirely reversed by 2000. In the most recent year fishing effort in the offshore fishery was 9,111 x 10^3 Hp-days compared to 1,390 x 10^3 Hp-days in the inshore fishery. Between 1988 and 1999 the effort in the offshore and inshore fisheries has increased by factors of 4.71 and 1.73 respectively.

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

Catch per unit area was greater, by one order of magnitude, in the inshore fishery compared to the offshore fishery (Figure 7). The general trend was a gradual increase in CPUA from 0.013 $t{\cdot}km^{-2}$ in 1942 to 0.044 $t{\cdot}km^{-2}$ in 1982 in the offshore fishery (Figure 7). The inshore fishery also experienced an increase in CPUA from 0.157 $t{\cdot}km^{-2}$ in 1942 to 0.313 $t{\cdot}km^{-2}$ in 1981 (Figure 7). Thereafter, a decline in CPUA was experienced throughout the 1980s in both fisheries. Throughout the 1990s, CPUA increased distinctly, culminating in 2001 estimates of 0.079 $t{\cdot}km^{-2}$ (394% increase) and 0.832 $t{\cdot}km^{-2}$ (530% increase) for the inshore and offshore fishery, respectively.

Generally, catch per unit effort declined exponentially in both the offshore and inshore fisheries between 1942 and 1999 (Figure 8a). Initial CPUE in 1942 was 6.616 t per '000 Hp-days and 2.109 t per '000 Hp-days in the offshore and inshore fisheries, respectively (Figure 8a). By 1999 CPUE had declined to 0.167 t per '000 Hp-days and 0.291 t per '000 Hp-days in the respective fisheries, representing a 97.5% and 86.2% decline over the 1942 to 1999 period. The decline in CPUE in the last two decades shows generally higher CPUE in the inshore fishery in the early and late 1990s compared to the offshore fishery (Figure 8b).

DISCUSSION

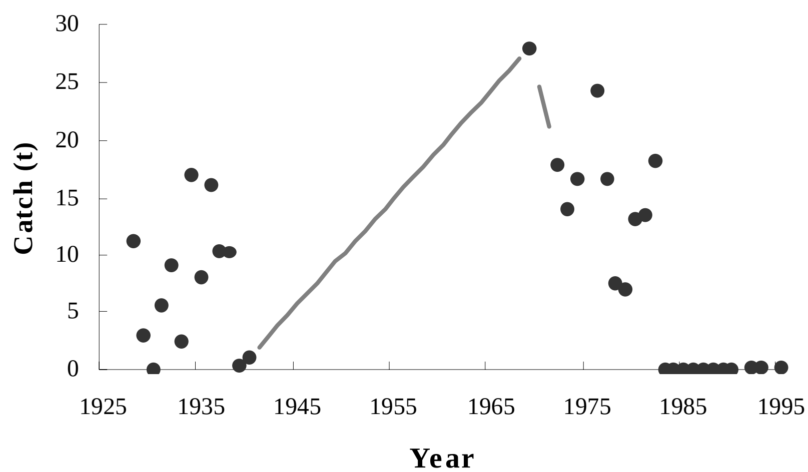
Catches

Reconstructed fisheries catches for St. Lucia indicated a 172% increase between 1942 - 1982, a 54% decline between 1982 and 1989, and a 260% increase between 1990 and 2001. The offshore fishery has been the greater contributor to overall catches, averaging 72% between 1990 and 2001. Between 1989 and 2001 catches increased by 381% and 291% in the offshore and inshore fisheries, respectively. Increased catches in the offshore fishery are consistent with the development of this fishery, particularly during the 1990s.

The decreased catches during 1965 to 1967 coincide with protest actions by fishers against vendors who offered exceedingly low payments to fishers compared to the prices at which they sold the catch (Vidaeus, 1969).

The difference between reconstructed catches and statistics in FAO FISHSTAT between 1964 and 1980 is most likely due to landings in St. Lucia of catches by foreign boats. The local fishery was not capable of catching such vast quantities of fish, e.g., 2600 t in 1978. Such catches are comparable to those of the present day fleet utilizing engines of higher horsepower and more technically advanced gear. Many have reported on the stagnation of the industry during the 1970s as a result of increasing cost of production associated with rising fuel prices (Walters, 1981), and a lack of cold storage, marketing and distribution facilities (Fisheries Management Unit, 1981). Individuals were reluctant to enter the industry since the price control system, which resulted in reduction of prices to 25% of the allowed maximum when landings were excessive, acted as disincentives to development of the industry (Walters, 1983). Vidaeus (1969) noted the lack of change in number of boats and their distribution around the island since the previous 25 years. At the time however, there were no restrictions, e.g., customs duty, on landings of non-locally registered boats. This was an unusual arrangement in the region. As a result, boats from Venezuela, Martinique and

(a)



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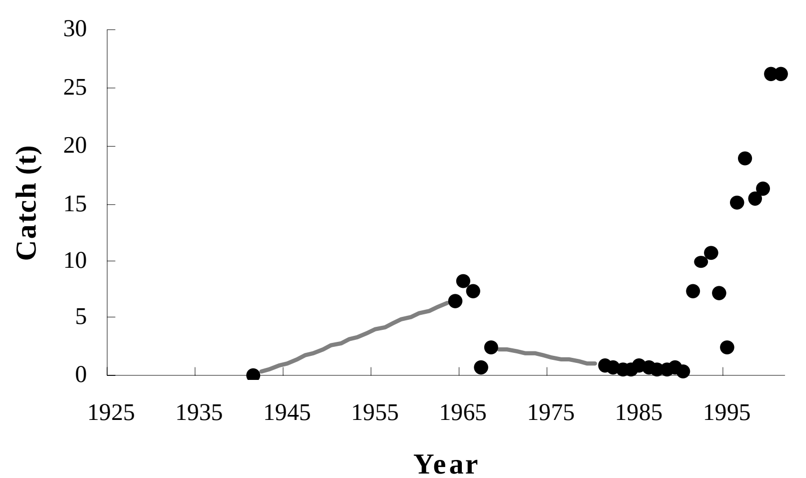
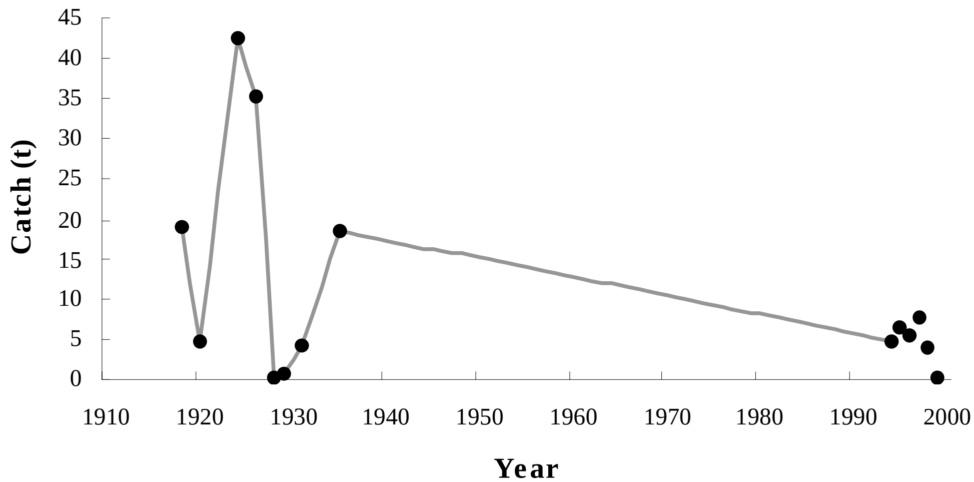


Figure 4: Reconstructed catch (t) of (a) hawksbill turtle (*Eretmochelys imbricata*) from 1928 to 1995 and (b) lobster (*Panulirus* sp.) from 1936 to 2001 in St. Lucia. Solid circles represent reconstructed data and solid lines joining circles are interpolated values.

freezer boats from the United States landed fish in St. Lucia (Vidaeus, 1969). During the late 1960s there was also an agreement between the St. Lucia Marketing Board and a St. Lucian firm allowing for the sale of fish caught by trawlers off the Guyana's via a Guyanese firm. These were usually croaker (*Micropogon furnieri*), whiting (*Malacanthus plumieri*), moonshine (*Selene vomer)* and sea trout (*Cynoscion* spp.).

The differences between reconstructed data and corresponding data in FISHSTAT between 1983 and 1989 are less easily explained. Personal communication with officials of the St. Lucia Fisheries Department yielded no explanation. The methodology accounting for unrecorded fishing days and landing sites (Joseph, 1999) has been applied to recorded data from 1980 onwards, thereby increasing the credibility of the estimates. Other sources of information for this period are based on assumptions regarding the proportion of overall catch recorded at Castries (Walters, 1981, 1983, 1984; Matthews, 1983; Murray, 1984; Goodwin *et al.*, 1985), and were therefore not used in the catch reconstruction. The decline in landings however, especially in the late 1980s, is supported by the literature (Mahon, 1990).

(a)



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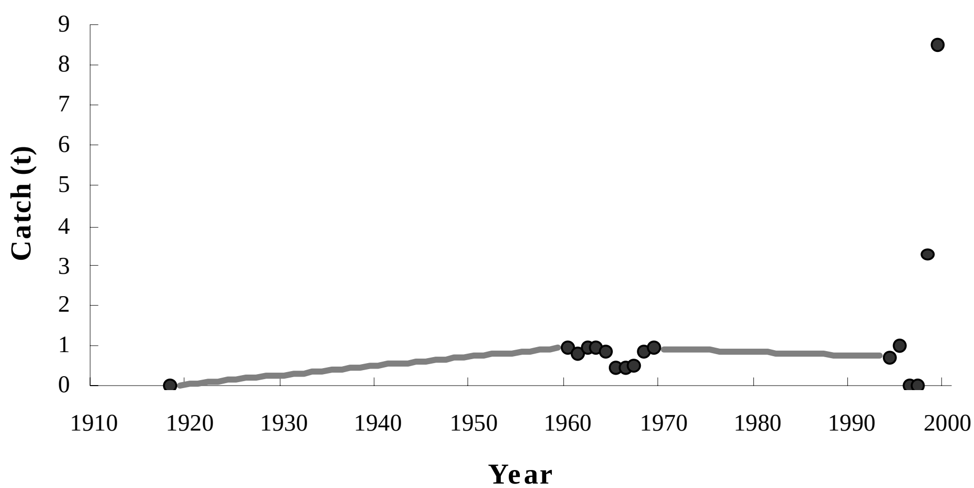
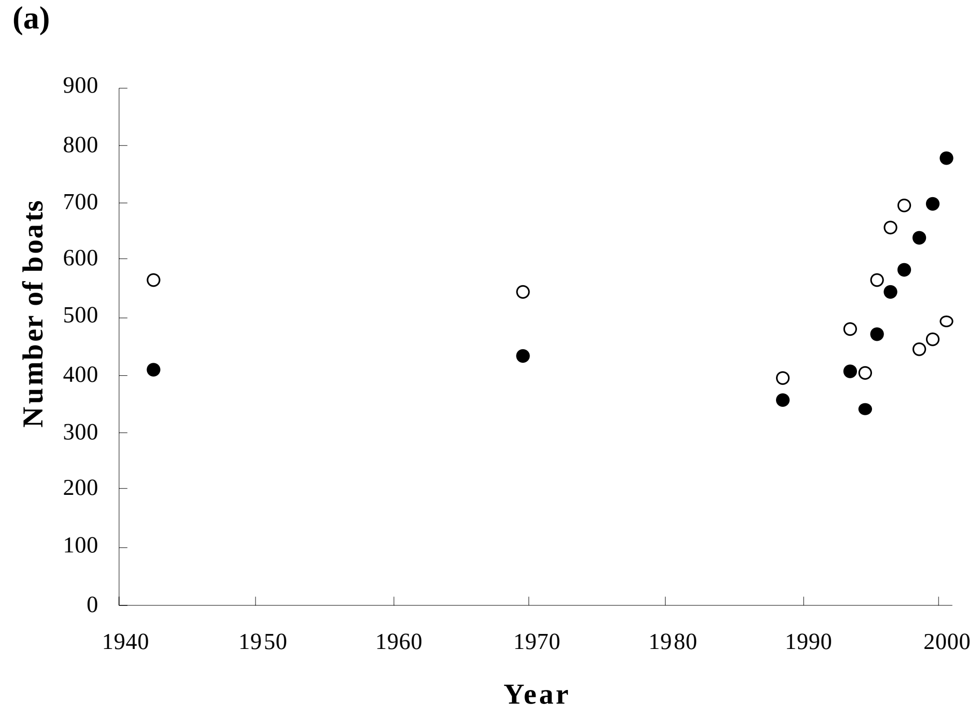


Figure 5: Reconstructed catch (t) of (a) the pilot whale (*Globicephala macrorhynchus*) and (b) porpoises (mainly *Tursiops truncatus*) in St. Lucia (1918-1999). Solid circles represent reconstructed data and solid lines joining circles are interpolated values.



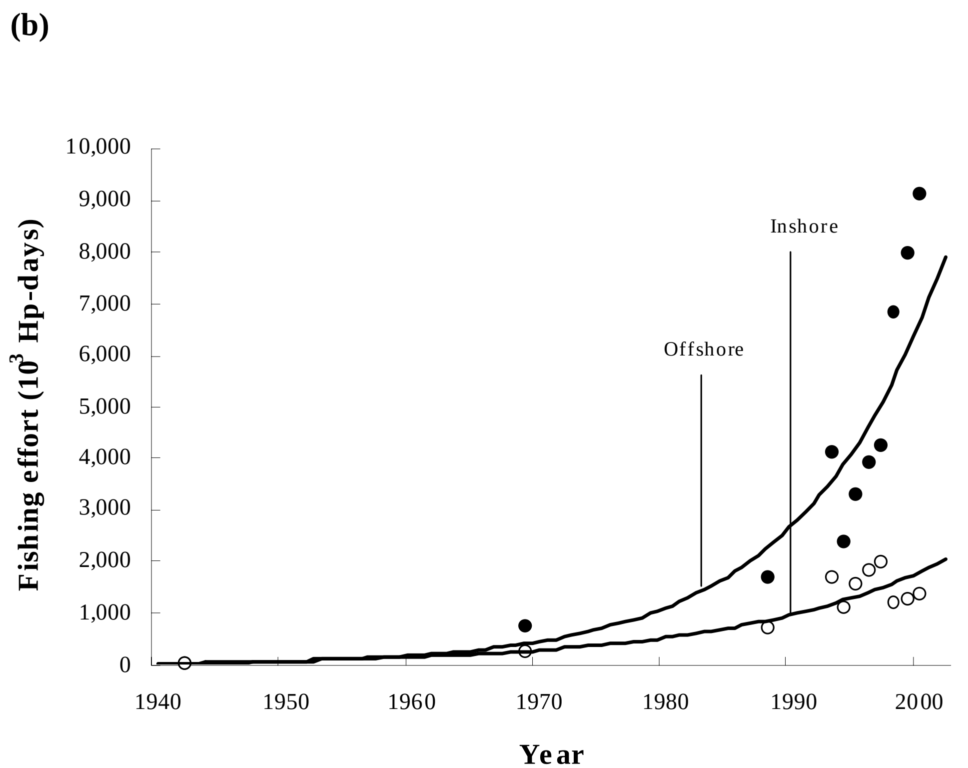


Figure 6: Reconstructed (a) number of boats and (b) fishing effort (10^3 Hp-days) for St. Lucia (1942 – 2000). Solid circles represent the offshore fishery and open circles represent the inshore fishery.

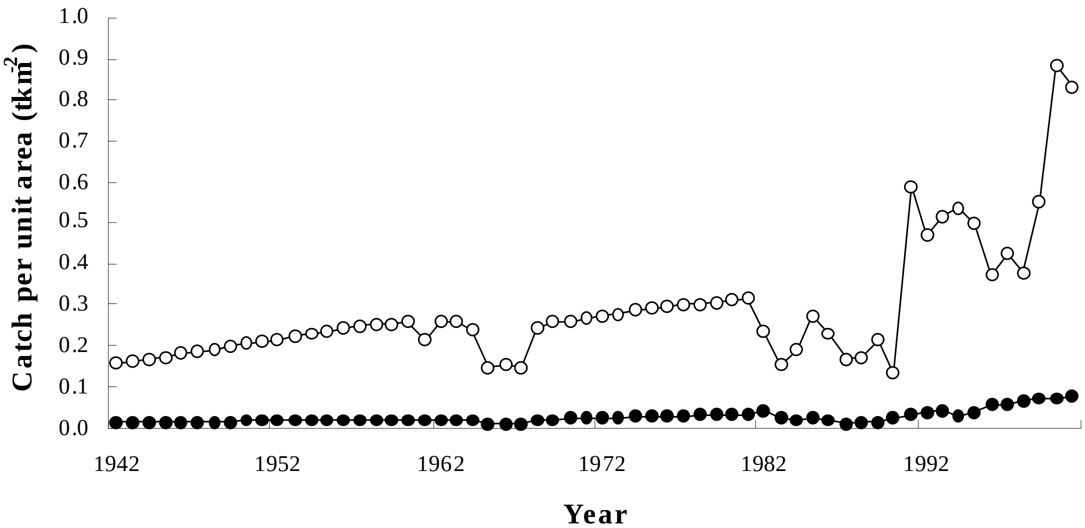


Figure 7: Annual trends in catch per unit area (t km^{-2}) in the fisheries of St. Lucia (1942-2001). Solid circles represent the offshore fishery and open circles represent the inshore fishery.

Similar declines in landings were observed in other islands of the eastern Caribbean, prompting an FAO study to investigate the reasons for such low catches, particularly in the 1987/88 season. Results however, were inconclusive.

The reconstructed data were disaggregated into a greater number of species or species groups than corresponding data in FISHSTAT. There was also a considerably lower proportion of overall catch attributed to the aggregate category of 'miscellaneous marine fish' in reconstructed data. Observations from 1990 onwards are, however, more reliable as these are based on reconstruction from actual data compared to previous years where assumptions of constant species compositions, similarities in species composition with landings in St. Vincent and estimation of annual catches by interpolation were employed. The estimates of annual catches disaggregated into 44 to 53 species or species groups between 1990 and 2001 is a significant improvement on estimates in FISHSTAT, which are disaggregated into some 19 species groups. In addition, reconstructed data for 1995 to 2001 can be further disaggregated into some 235 species or species groups.

The present reconstructed catches represent preliminary estimates. Several limitations to are apparent. These relate to incomplete records of catches in the recreational fishery, lack of data on catches by foreign fleets and the quantities of bait fish utilized locally, incomplete records of species catches in the inshore reef, slope and shelf fishery and the offshore flyingfish fishery and uncertainties in species identification of the catch.

Recreational fishing began in the 1950s (DeBeauville-Scott, 1994). An associated club was formed in 1972 and formally registered as the St. Lucia Game Fishing Association in 1984. The Association organizes informal fishing tournaments on national holidays and a major tournament in October of each year. In 1991 the major tournament was upgraded to an international billfish tournament. Informal tournaments target dolphinfish, tuna, kingfish, wahoo, barracuda and small sharks (H. Otway, pers. comm.). The formal tournament targets larger pelagics such as blue marlin (*Makaira nigricans*), sailfish (*Istiophorus albicans*), white marlin (*Tetrapturus albidus*), swordfish (*Xiphias gladius*) and longbill spearfish (*Tetrapturus pfleugeri*). Catches at informal tournaments are not recorded, while only catches of important species (large tunas and billfishes) are recorded at the major tournament. These were found to be insignificant in this analysis.

Also, catches of small pelagics, e.g., kingfish (*Scomberomorus cavalla*), wahoo (*Acanthocybium solandri*) dolphinfish (*Coryphaena hippurus*), barracuda (*Sphyraena* spp.) and small tunas (Scombridae) taken by tourists are not recorded.

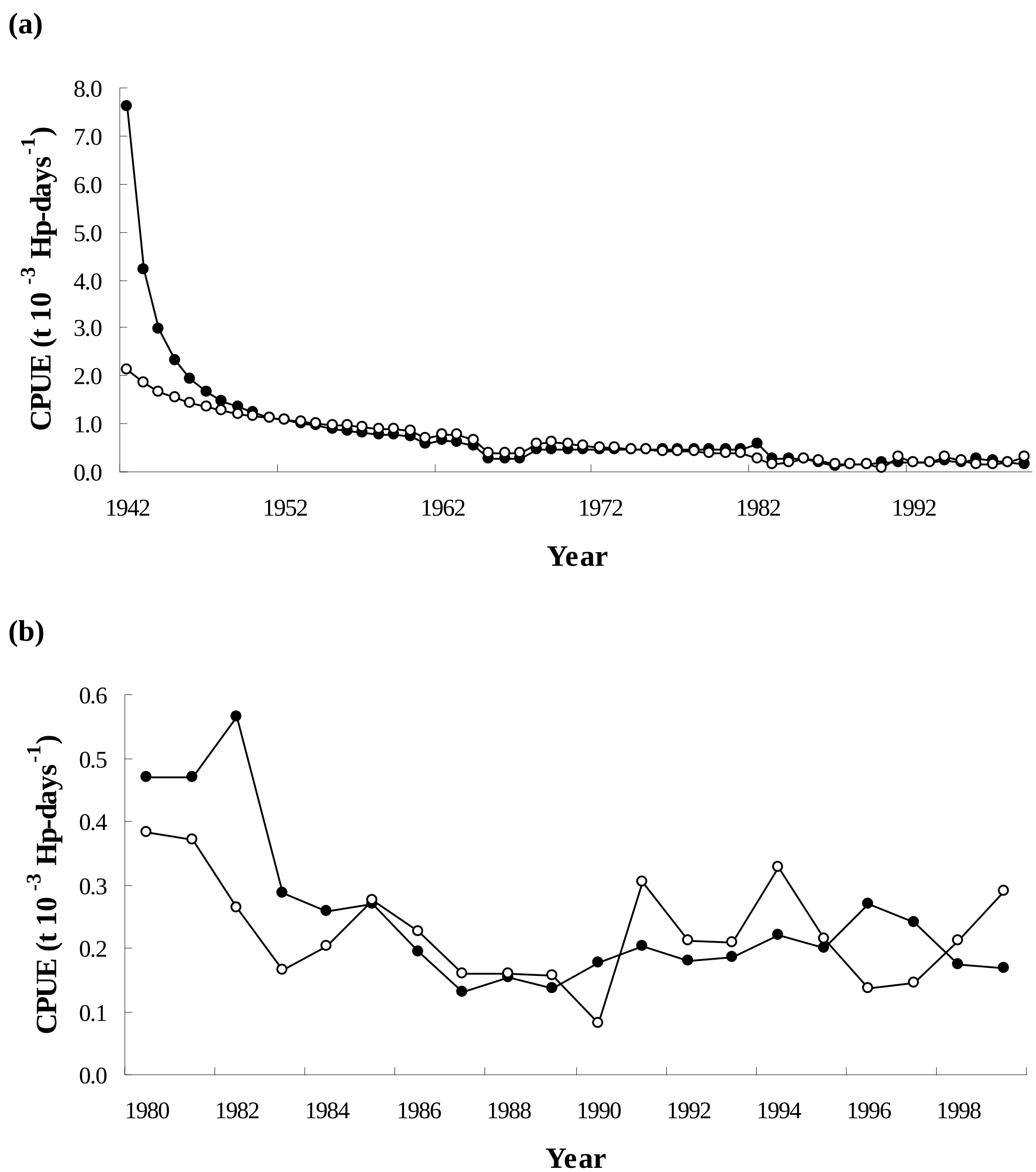


Figure 8: Annual trends in catch per unit effort (t 10^{-3} Hp-days) in the fisheries of St. Lucia (a) 1942 to 1999 and (b) 1980 to 1999. Solid circles represent the offshore fishery and open circles represent the inshore fishery.

In the late 1980s, 12 private charter and sport fishing boats were in operation, the present number is not known. Persons also fish with handlines from shore. The associated catches are not recorded.

Catches of foreign fleets are not available. Vidaeus (1969) alluded to monthly consignments of about 9 t from the Guyanese firm in the 1960s but gave no estimates of landings by fleets from Venezuela, Martinique and the United States. While catches of these fleets are possibly taken outside of St. Lucia's EEZ, fishers from Martinique fish for demersal species in St. Lucia waters and those from Barbados target flyingfish and large pealgics, and US longliners target swordfish in the EEZ of St. Lucia (Murray *et al*., 1988).

The quantities of bait utilized in pot, handline and longline fisheries are not recorded. Popular bait-fish in St. Lucia include anchovy (Engraulidae), pilchards *(Harengula* spp.), sardines (*Sardinella* spp.) silversides (Atherinidae) and thread herring (*Opisthonema oglinum*) (Mahon, 1993). It is unknown whether flyingfish are used as longline bait as is the case in Grenada.

The inshore fishery is not well represented in the data collection system since landing activities are spread across several sites (George, 1999). Important landing sites for lobster and conch are not incorporated in the system (George, 1999). Catches of lobster and conch are either sold to local markets, to hotels or supermarkets directly or exported (either legally or illegally) to Martinique. Only catches sold to markets and exported legally are recorded (Nichols and Jennings-Clark, 1994). Until 1993 it was illegal to export lobster and conch to Martinique (George, 1997). However, up to 5 t were exported illegally in the late 1980s (George, 1997). Currently exports are permitted and are carefully monitored according to regulations of the Convention for International Trade in Endangered Species. Reconstructed landings of lobsters indicate considerable increases in catch throughout the 1990s, starting from almost zero at the end of the 1980s to 26 t in 2001. Important landing sites for reef fish are also not sampled (George, 1999), resulting in underestimation of total catches. Three important landing sites for flyingfish are not incorporated in the data collection system (Murray and Jennings-Clarke, 1993), with similar consequences for estimated total catch as for reef fish.

Information on species composition of the catch was not available prior to 1980. Vidaeus (1969) reported the lack of associated data in the 1960s. Data from 1980 to 1989 were available for only five or six major species groups with all other fish aggregated into one category. There were also uncertainties in species identification arising from differences in vernacular names used by fishers and data collectors (Murray, 1986), and the high diversity of species landed in the demersal fisheries (Gobert, 1995). This renders it almost impossible for data collectors to record reliably the catch composition of most fishing trips at the species level (Gobert, 1995). There are also differences in local names of pelagic species e.g, the blackfin tuna (*Thunnus atlanticus*) is referred to as 'bonito', a common name elsewhere used for *Sarda sarda*; wahoo (*Acanthocybium solandri*) is referred to as 'kingfish', a name normally used for the king mackerel, *Scomberomorus cavalla*. Further, the flyingfish *Cypselurus cyanopterus* is referred to as 'denn' and *Parexocoetus brachypterus* as 'tee-wai' (Murray and Jennings-Clarke, 1993). Rambally (2000b) noted problems with species identification in the cetacean fishery. The Pygmy killer whale is referred to as 'sperm' and the sperm whale as 'sea guap' (Rambally, 2000b). Often, recorded catches of all small cetaceans are grouped and classified as 'blackfish'. This makes examination of species differences or relative contributions to overall catch difficult. Nevertheless, it is evident from the results that the fishery targeting pilot whales has declined considerably. This has been matched by an increased fishery for porpoises, resulting in an almost ten fold increase in catches in recent years compared to the 1960s.

Assignment of some species to the respective fisheries was difficult. This is because juveniles of pelagic species are also captured in the inshore net fisheries. The relative quantities harvested in the offshore and inshore fisheries are not known. As a result, all catches of large pelagic species were attributed to the offshore fishery.

Fishing effort

Reconstructed fishing effort increased exponentially between 1942 and 2000. Overall the number of boats in the offshore fishery increased from 411 to 780 between 1942 and 2000, and the corresponding effort increased by a factor of 257. Conversely, the number of boats in the inshore fishery decreased from 568 to 493 between 1942 and 2000, while effort increased by a factor of 27. Initially, fishing effort was greater in the inshore fishery compared to the offshore fishery, however, the situation was reversed by 2000. Considerable increases in effort in the offshore fishery were observed in the 1990s. This was attributed mainly to increases in the number of boats, since only whalers and longliners demonstrated any appreciable increases in horsepower. The changes in fishing effort reflect what has been documented about general developments in the fishing industry (George, 1999).

There were several constraints in the estimation procedure. Murray *et al.* (1988) noted that all boats were involved in all fisheries. The assignment of fishing boats to the respective fisheries was based on the main fishing method employed, except for boats targeting the inshore reef, slope and shelf fisheries during the pelagic off-season. Uncertainties in the linkages between boats and fishery type, and changes in the number of fishing days between 1942 and 1999 impacted effort estimates.

Apart from Vidaeus (1971), who described fishing effort at Vieux Fort, the number of fishing days is not mentioned elsewhere in the literature. Vidaeus (1971) also noted that activity at Vieux Fort could not be assumed as representative of other sites on the island. While the estimation of the annual number of fishing days can be guided by management regulations such as closed fishing seasons, the lack of surveillance and enforcement results in contravention of these regulations e.g., illegal harvesting of sea urchins (Smith and Berkes, 1991). Hence the number of fishing days so derived would be an under-estimate of the true figure and unsuitable for estimating fishing effort. Further, fishing effort is reconstructed for all components of the inshore fishery collectively. To account for the increased effort directed at the offshore fishery by the pirogue fleet in the late 1990s, the number of fishing days was increased and these boats were assumed to desist from exploiting the inshore fishery, traditionally exploited during the pelagic off-season.

The unit of fishing effort does not allow for investigating changes in gear efficiency as a component of effort. Adaptation of trolling and longline gear for increased catchability, e.g., increasing the number of hooks and number of branch lines for manually operated gear (vertical and horizontal longlines) or the use of mechanized gear in larger boats (George, 1999) is not incorporated in the unit of effort. The same applies to the use of Scuba for capture of lobster and conch in deeper water. Fishing effort of foreign fleets, e.g., boats from Barbados, Martinique or the United States is not incorporated in this analysis.

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

The higher magnitude of CPUA in the inshore fishery is expected, given that inshore resources are concentrated within a narrow shelf area, representing approximately 3% of the entire EEZ. CPUA has increased throughout the 1990s by 394% and 350% in the offshore and inshore fisheries, respectively. The increase for the offshore pelagic fishery is consistent with the targeted development of that fishery, instituted to preserve the remaining inshore resources. The overall fishing effort directed at these resources has declined in recent years, although the long-term trend demonstrates an exponential increase between 1942 and 1999. This decline in effort along with the system of marine reserves implemented from the late 1980s may have contributed to increases in biomass which are reflected in the associated catches of the remaining boats in the fishery. It is interesting to note that the incentive system in St. Lucia, and to a certain extent management regulations (the use of trammel nets has been banned), discourages development of the inshore fleet targeting reef and other demersals.

Generally, catch per unit effort declined exponentially in both the offshore and inshore fisheries between 1942 and 1999. The decline in CPUE in the last two decades showed generally higher CPUE in the inshore fishery in the early and late 1990s compared to the offshore fishery. This is despite measures taken to develop the offshore fishery. The changes in effort account for these differences. Between 1988 and 1999 the effort in the offshore fishery has increased by a factor of 4.71 compared to 1.73 for the inshore fishery. The considerable increase in overall effort, mainly due to increasing number of boats, increases the competition for fish within the EEZ, manifested in declining CPUE. The decline in CPUE of the inshore fishery is less marked because the situation is quite the opposite to that in the offshore fishery, i.e., fewer boats are now exploiting this fishery.

ACKNOWLEDGEMENTS:

The authors thank staff of the St. Lucia Fisheries Division and the St. Lucia Game Fishing Association for data, and A. Maharaj, Fisheries Documentalist at the Trinidad Fisheries Division for provision documents from the Fisheries Management Information System. Assistance of staff at the St. Lucia National Archives in providing historical documents is also acknowledged. The first author 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 on and review of a draft version of this report.

REFERENCES

Anon. 1932. Quantities of whale oil exported from St. Lucia in 1931. Journal of the Imperial College of Tropical Agriculture, 1 p.

Anon. 1955. Report of the Second Caribbean Fisheries Seminar. Kent House, Port of Spain, Trinidad, 12 pp.

Agricultural Department of St. Lucia 1918. Annual report of the Agricultural Department.

Agricultural Department of St. Lucia 1919. Annual report of the Agricultural Department.

Agricultural Department of St. Lucia 1920. Annual report of the Agricultural Department.

Agricultural Department of St. Lucia 1924. Annual report of the Agricultural Department.

Agricultural Department of St. Lucia 1929. Annual report of the Agricultural Department.

Agricultural Department of St. Lucia 1930. Annual report of the Agricultural Department.

Agricultural Department of St. Lucia 1933. Annual report of the Agricultural Department.

Agricultural Department of St. Lucia 1934. Annual report of the Agricultural Department.

Agricultural Department of St. Lucia 1938. Annual report of the Agricultural Department.

Agricultural Department of St. Lucia 1939. Annual report of the Agricultural Department.

Brown, H.H. 1945. The fisheries of the Windward and Leeward Islands. Development and Welfare Bulletin 20, 91 pp.

Caribbean Commission Central Secretariat 1948. The Fish Trade of the Caribbean. External Trade Bulletin No. 3, 261 pp.

Cecil, R.G. 1966. A comparative study of the fisheries of Martinique and St. Lucia. Department of Geography, McGill University, Montreal, 177 pp.

Cecil, R.G. 1972. Geographical characteristics of fisheries in selected southeastern Caribbean islands. PhD Thesis, McGill University, Montreal, 394 pp.

DeBeauville-Scott, S. 1994. An overview of recreational fishing in St. Lucia, West Indies. Proceedings of the Gulf and Caribbean Fisheries Institute 43: 21.

Fisheries Management Unit 1981. Programme of Work 1981-1982: Towards Increasing Fish Production. Fisheries Management Unit, Ministry of Agriculture, Lands, Fisheries and Co-operatives, Castries, St. Lucia, 19 pp.

Gaskin, D.E. and Smith, G.J.D. 1977. The small whale fishery of St. Lucia, West Indies. Paper L. 15, 493 pp.

George, S. and Joseph, W. 1994. A new participatory approach towards sea urchin management in Saint Lucia, West Indies. Proceedings of the Gulf and Caribbean Fisheries Institute 43: 2-15.

George, S. 1997. Conch and lobster fisheries of Saint Lucia, pp.64-65. *In*: Lobster and Conch Sub-Project Specification and Training Workshop Proceedings, Lobster and Conch Resource Assessment Unit, Belize, CARICOM Fishery Research Document No. 19.

George, S. 1999. Fisheries sector review for Saint Lucia. Department of Fisheries, Ministry of Agriculture, Fisheries and Environment, Castries, Saint Lucia, 42 pp.

Gobert, B. 1995. Statistical analysis of the fisheries of St. Lucia (West Indies): 1990-1993, ORSTOM, 64 pp.

Goodridge, R., Oxenford, H.A., Hatcher, B. and Narcisse, F. 1997. Changes in the shallow reef fishery associated with implementation of a system of fishing priority and marine reserve areas in Soufrière, St. Lucia. Proceedings of the Gulf and Caribbean Fisheries Institute 49: 316-340.

Goodwin, M., Orbach, M., Sandifer, P. and Towle, E. 1985. Fishery sector assessment for the eastern Caribbean: Antigua/Barbuda, Dominica, Grenada, Montserrat, St. Christopher/Nevis, St. Lucia, St. Vincent and the Grenadines. The United States Agency for International Development, Regional Development Office/Caribbean, 149 pp.

Hatcher, B.G., Corless, M., Goodridge, R. and Scott, S. 1995. Testing mechanisms by which marine protected areas export fish to adjacent habitats: The Soufrière Experiment in Reef Fisheries Sustainability (SERFS). Proceedings of the Gulf and Fisheries Caribbean Institute 48: 15.

Idyll, C.P. 1971. Spiny lobster fishery of the Caribbean. The University of Miami, Rosenstiel School of Marine and Atmospheric Sciences, Miami, pp. 134-138.

Joseph, W. 1996. Small coastal pelagics and flyingfish fisheries of Saint Lucia. CARICOM Fisheries Resource Assessment and Management Program (CFRAMP): Small Coastal Pelagics and Flyingfish Sub-project Specification Workshop, Grenada. SCPFF Assessment SSW/WP/11, 7 pp.

Joseph, W.B. 1999. Procedure for analyzing annual fish landings for Saint Lucia. Fisheries Department, Ministry of Agriculture, Fisheries and Environment, Castries, Saint Lucia, 11 pp.

Joseph, W.B. 2000. Assessment of the status of the Caribbean spiny lobster (*Panulirus argus*, Latreille 1804) fishery in St. Lucia and proposals for sustainable management. MSc Thesis, University of Hull, United Kingdom, 122 pp.

Mahon, R. 1990. Trends in pelagic fishing effort in the eastern Caribbean: with reference to possible effects on island fisheries. FAO Field Document 1 (FI/TCP/RLA/8963), 13 pp.

Mahon, R. 1993. Marine Fishery Resources of the Lesser Antilles. Marine fishery resources of the Antilles: Lesser Antilles, Puerto Rico and Hispaniola, Jamaica, Cuba. FAO Fisheries Technical Paper No. 326, 98 pp.

Mahon, R. and Rosenberg, A.A. 1988. Fishery data collection system for the eastern Caribbean islands. The

Fishery Unit, Organization of eastern Caribbean States, Cane Garden, St. Vincent and the Grenadines. OECS Fishery Report No. 2, 185 pp.

Mahon, R. and Singh-Renton, S. 1993. Report of the CARICOM Fishery Resource Assessment and Management Program (CFRAMP). ICCAT Collective Volume of Scientific Papers 40(2): 418-420.

Mahon, R., Rennie, J., Ryan, R. and Singh-Renton, S. 1994a. Billfish catch and effort data from Barbados, Grenada, St. Lucia and St. Vincent and the Grenadines. ICCAT Collective volume of Scientific Papers, 42: 431-441.

Mahon, R., Singh-Renton, S., Jennings-Clarke, S., Rennie, J., Ryan, R. and Willoughby, S. 1994b. Yellowfin tuna catch and effort data from Barbados, Grenada, St. Lucia and St. Vincent and the Grenadines. ICCAT Collective Volume of Scientific Papers 42: 199-203.

Matthews, C. 1983. National report on fisheries for St. Lucia. FAO Fisheries Report 278(Supp.), pp. 45-48.

Milliken, T. and Tokunaga, H. 1987. The Japanese Sea Turtle Trade: 1970-1986. Traffic (Japan) and Center for Environmental Education.

Mulliken, T.A. 1996. Status of the queen conch fishery in the Caribbean. TRAFFIC Bulletin 16(1): 17-28.

Murray, P.A. 1984. The fisheries of St. Lucia: A status report. Proceedings of the Gulf and Caribbean Fisheries Institute 36: 24-26.

Murray, P.A. 1986. National report - St. Lucia. Fourth Session of the WECAFC Working Party on Fishery Statistics, Port of Spain, Trinidad and Tobago.

Murray, P.A. and Jennings-Clarke. S. 1993. The flyingfish fishery of St. Lucia, p. 160. *In*: H.A. Oxenford, R. Mahon and W. Hunte (eds.) The Eastern Caribbean Flyingfish Project, OECS Fishery Report No. 9, 171 pp.

Murray, P.A., Charles, J. and Mahon, R. 1988. A fishery data collection system for St. Lucia, pp.140-149. *In*: R. Mahon and A.A. Rosenberg (eds.) Fishery data collection systems for eastern Caribbean islands. OECS Fishery Report No. 2, 185 pp.

Nichols, K. and Jennings-Clarke, S. 1994. An overview of the conch industry in St. Lucia, West Indies, pp. 25-28. *In*: R.A. Appeldoorn and Q. Rodriguez (eds.) Queen Conch Biology, Fisheries and Mariculture. Fundacion Cientifica Los Roques, Caracas.

OECS Natural Resource Management Unit 1989. OECS Fisheries Statistical Review: 1979-1988. Organization of Eastern Caribbean States, Cane Garden, St. Vincent, 116 pp.

OECS Natural Resource Management Unit 1993. Fisheries Statistical Digest. Organization of Eastern Caribbean States Cane Garden, St. Vincent.

OECS Natural Resource Management Unit 1995. Fisheries Statistical Digest. Organization of Eastern Caribbean States, Cane Garden, St. Vincent, 129 pp.

Oliver, J. and Noordeloos, M. (Editors) 2002. ReefBase: A Global Information System on Coral Reefs. World Wide Web electronic publication. www.reefbase.org.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R. and Torres, F. Jr. 1998. Fishing down marine food webs. Science 279: 860-863.

Pierre, D.D. 1999. Adjusting to a new way of life - Marine Management Areas and Fishers. Department of Fisheries, Ministry of Agriculture, Forestry, Fisheries and the Environment, Castries, St. Lucia, 8 pp.

Rambally, J. 2000a. Whaling in St. Lucia, a dying tradition? Department of Fisheries, Ministry of Agriculture, Forestry and Fisheries, Castries, St. Lucia, 6 pp.

Rambally, J. 2000b. St. Lucia: progress report on cetacean research, January 1999 to May 2000, with statistical data for the calendar year 1999. Department of Fisheries, Ministry of Agriculture, Forestry and Fisheries, Castries, St. Lucia, 4 pp.

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.

Roberts, C.M., Nowlis, J.S. and Hawkins, J.P. 1996. Status of reef fish and coral communities of St. Lucia: 1994-1995. University of the Virgin Islands, St. Thomas, 98 pp.

Salmon, G.C. 1958. Report on the fisheries industry in the countries served by the Caribbean Commission. Food and Agriculture Organization, Rome, 86 pp.

Scholz, R. 1980. Investigations into the optimization of the St. Lucian fishing canoes. (unpublished MS) 8 pp.

Smith, A.H. and Berkes, F. 1991. Solutions to the “tragedy of the commons” sea-urchin management in St. Lucia, West Indies. Environmental Conservation 18(2): 131-136.

Smith, A.H. and Walters, R. 1991. Co-management of the white sea urchin resource in St. Lucia. Paper presented at the IDRC Workshop on Common Property Resources. International Development Research Centre, Winnipeg, 12 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.

St. Lucia Fisheries Department 1992. National policy issues to enhance the EEZ contribution to national development in Saint Lucia, pp. 111-115. *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, 160 pp.

St. Lucia Fisheries Department 1995. The status of coral reefs and reef management in Saint Lucia. Unpublished document, 7 pp.

St. Lucia Fisheries Department 1999. Website of the Ministry of Agriculture, Forestry, Fisheries and the Environment, Saint Lucia: Fisheries Section. www.slumaffe.org.

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. Available on CD-ROM.

Vidaeus, L. 1969. An inventory of the St. Lucia fishing industry. Report of the UNDP/FAO Caribbean Fishery Development Project, SF/CAR/REG/16 M4, 31 pp.

Vidaeus, L. 1971. Report on four landing surveys at Vieux Fort, St. Lucia: 1969-1971. Report of the UNDP/FAO Caribbean Fishery Development Project, SF/CAR/REG/189 M22, 21 pp.

Villegas, L. 1979. Review of the status of fishery statistics and fishery research capabilities in the WECAF Project Area. WECAF Reports No. 2, 26 pp.

Walters, H. and Oxenford, H.A. 1986. The flyingfish fisheries of St. Lucia, pp. 19-22. *In*: R. Mahon, H. Oxenford and W. Hunte (eds.) Development strategies for flyingfish fisheries of the eastern Caribbean: Proceedings of an IDRC-Sponsored Workshop at the University of the West Indies, Barbados. Marine Fisheries Institute, Bedford Institute of Oceanography, Nova Scotia, Canada and Bellairs Research Institute of McGill University, St. James,148 pp.

Walters, H.D. 1981. Fisheries Development in St. Lucia. Proceedings of the Gulf and Caribbean Fisheries Institute 34: 38-42.

Walters, H.D. 1983. The fisheries of St. Lucia: a status report, (unpublished MS) 4 pp.

Walters, H.D. 1984. Fisheries development in St. Lucia and the Lesser Antilles. The Courier 85 (May-June, 1984): 94-95.

Witzell, W.N. 1994. The origin, evolution and demise of the US sea turtle fisheries. Marine Fisheries Review 56: 8-23.