Marine fisheries of Jamaica: total reconstructed catch 1950-2010[1]

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Abstract

Jamaica, a single island country in the eastern Caribbean, has a long history of human settlement and overfishing. The country is considered one of the most overfished in the Caribbean region. Despite fish featuring heavily in the cuisine and culture of the island, non-commercial (subsistence and recreational sectors) catches have not previously been estimated comprehensively. These non-commercial catches, as well as discards, are missing from the data presented by the FAO on behalf of Jamaica. This study estimates total catches for all marine fisheries sectors for 1950-2010, including non-commercial catches and discards. Our total reconstructed catch equated to almost 3 million tonnes during the 1950-2010 time period. Our estimate is 4.3 times the data reported by the FAO on behalf of Jamaica. The discrepancy between our estimate and the reported data is attributable to large unmonitored non-commercial catches. Improved monitoring and public outreach to subsistence and recreational fishers is imperative if recent management initiatives to create marine protected areas are to succeed.

Introduction

Jamaica, a lush tropical island country in the Caribbean Sea, lies at 18° 15' N and 77° 30' W (Figure 1). The island has a land area of 10,991 km² and an exclusive economic zone (EEZ) of 263,283 km² (www.seaaroundus.org; accessed: August 16, 2012; Figure 1). Jamaica's southern continental shelf extends 25 km from shore, while the northern coast has only a narrow shelf of 1.6 km before dropping to a depth of more than 300 m (Munro 1983). Seven off-shore banks (Pedro, Walton, Morant, Albatros, Henry Holmes, Grappler, and Formigas) are separated from the coastal shelf by deep oceanic waters (Figure 1). Coastal marine areas are characterised by sand or limestone bedrock overlaid with seagrass beds and coral reefs. Large rivers, which flow into the ocean in both the north and south, have for the past few decades brought increasing sediment and nutrients to the coastal environment. These additional inputs are having a negative impact on the health of Jamaica's coral reefs (Goreau and Thacker 1994).

Jamaica has endured a long history of political and social hardship including two colonisations (Spain [1517-1655] and the United Kingdom [1656-1960]), and played a major role in the slave trade (Beckwith 1929). The now-independent country continues to face immense economic challenges that hinder development; presently it is rated as the world's fourth most severely indebted country (Hurley *et al.* 2010). In 2009/2010, more than half of the annual budget was committed to debt servicing (Planning Institute of Jamaica 2009). The economy of this small island is heavily reliant on bauxite, tourism and remittances which contribute over 85% of foreign exchange (Planning Institute of Jamaica 2009). The slow-growing economy of the country was negatively affected by the recent global recession (Planning Institute of Jamaica 2009). Additionally, Jamaica is annually threatened by hurricanes, as the country lies in the hurricane belt of the central Atlantic. Despite these hardships, Jamaica has made positive achievements towards the United Nations Millennium Development Goals with significant reductions in poverty, malnutrition, and hunger, as well as increased enrolment in primary education

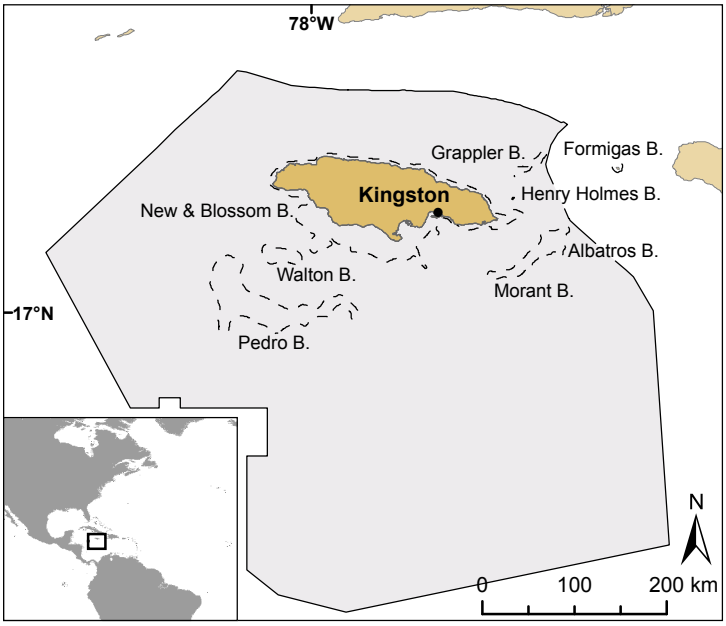

Figure 1. Map of Jamaica and its exclusive economic zone. Outer fishing banks are shown with dashed lines.

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(Planning Institute of Jamaica 2009). Tourism remains an important industry with 2.9 million visitors attracted to the stunning and culturally unique island in 2009 alone (Planning Institute of Jamaica 2009).

Jamaica has a vibrant culture, which includes a spicy and flavourful cuisine. Local produce, fish, chicken, goat, and pork feature heavily in the island's gastronomy. In addition to imported salt fish, a long time dietary staple in Caribbean nations dating back to the slave trade (Kurlansky 1997), local fresh fish is integral to the Jamaican diet and culture. Reef fish also feature in social gatherings, and holiday meals. Despite the importance of fish in the nation's culture, and the popularity of beaches for recreation and social gatherings, Jamaicans are typically not seafaring people and marine environments beyond the high-water line receive little attention (S. Lingard, pers. obs.).

This contrasts with Pacific island countries, such as Palau, which have traditionally focused heavily on managing the sea and its associated resources, which are integral to the local way of life and sense of self identity (Ota 2006). In Jamaica, marine resources have been undervalued by both the government and the public, leading to the marginalization of Jamaica's small-scale fishers. For example, the joint Ministry of Agriculture and Fisheries received 0.9% of the annual budget in 2008/2009 (Hurley *et al.* 2010). Marginalization of small-scale fisheries by governments, which contributes to the degradation of fisheries resources, is common in developing countries (Pauly 1997). In addition to marginalization of the fisheries sector, Jamaica has degraded the habitats necessary for the maintenance of fisheries resources on a large scale. Beginning in the 1960s, the majority of mangrove and wetland habitats were altered for construction of large resorts (Bacon 1987). Information available at the time suggested wetlands were important to fisheries, serving as nurseries to many species of Caribbean reef fish (Austin 1971). Despite a history of marginalization of fisheries and marine resources in Jamaica, recent attempts have been made to alter this misconception by highlighting the value of marine resources to tourism, and the total value of the artisanal fishery (Gustavson 2002; Sary *et al.* 2003; Kushner *et al.* 2011; Waite *et al.* 2011).

In the past, Jamaica's marine resources were overfished by indigenous Arawak communities (Hardt 2009). Recovery from early exploitation was possible due to reduced fishing pressure during colonization events (Hardt 2009). Prior to independence in 1960, the main activities fuelling Jamaica's economy were agricultural exports of produce, such as banana and sugar cane (Dunn 1972). As a result of the restrictive nature of plantation life, which did not allow residents to capture fish, colonization activities reduced fishing pressure. Therefore, fisheries are thought to have been minor prior to emancipation in 1832 (Hardt 2009). In the post-emancipation period, there was rapid development of open-access, multi-gear fisheries in near-shore areas (Thompson 1945; Munro and Thompson 1973; Hardt 2009). By 1945, Jamaica's near-shore areas had already been declared overfished (Thompson 1945). However, it was not until 1950 that a management body, the Fisheries Division, was established (Oswald 1963).

Fishing activities have remained small in scale, even in recent times. The majority of fishing activities are multi-species and multi-gear, but the fisheries for Caribbean spiny lobster (*Panulirus argus*) and queen conch (*Strombus gigas*) are monitored separately (Munro and Thompson 1973; Aiken 1985a, 1998; Aiken *et al.* 1999; Aiken and Kong 2000; Aiken *et al.* 2002; Aiken *et al.* 2006; Murray and Aiken 2006). The conch fishery operates solely on Pedro Bank with mother ships (typically 24 m in length) collecting the catch taken by divers (Aiken *et al.* 1999). Lobster is caught both by industrial[2] fishers on Pedro Bank (there is a limit of 12 industrial licences per annum; Kong 2003), and by small-scale trap fishers on both Pedro Bank and in near-shore waters. Lobsters are often caught as valuable by-catch (i.e., catch of non-target species) in the Antillean Z trap (the most common gear type used in the Jamaican artisanal fishery; Aiken 1982). Industrial lobster fishers, which operate on Pedro Bank, use steel hull vessels 25-30 m in length (Kong 2003). The majority of conch and lobster captured by fishers with designated licences are destined for export (Aiken and Kong 2000).

Jamaican fishing canoes range from a minimum of 4 m to more than 18 m in length (Aiken and Kong 2000). The larger canoes are used by fishers traveling to Pedro and other outer banks. While some smaller canoes are still wooden dugouts, the majority of fishing vessels are constructed of fibreglass (S. Lingard, pers. obs.). Prior to 1960, the majority of fishing canoes were powered by oar or sail (Oswald 1963). In 1956, however, government subsidies were offered to aid fishers in the mechanization of their vessels (Oswald 1963). During this period a marginal increase in production was seen as fishers were capable of exploiting new offshore banks; however, offshore resources were quickly exhausted (Koslow *et al.* 1988). The subsequent increase in landings in the early 1990s was due to the establishment of the Pedro Bank queen conch fishery (Aiken *et al.* 1999).

While the Fisheries Division has traditionally been the sole governing body responsible for the management of Jamaica's marine fisheries, several NGOs have been awarded funding to manage the newly designated fish sanctuaries.[3] The most recently enacted legislation regarding fisheries management is the Fisheries Industry Act of 1976,[4] with a new draft policy having been in the final stages of arbitration for almost 10 years. Enforcement of existing regulations has been insufficient due to limited financial and human resources within the department. In addition to overfishing, several environmental factors have combined to amplify degradation of fisheries resources, such as hurricanes, herbivore population crashes, marine pollution, coral diseases and bleaching events (Woodley *et al.* 1981; Liddell and Ohlhorst 1986; Hughes 1994; Lapointe 1997). There has been little development of the pelagic fishery due to the absence of a market for large fish (Aiken 1985b; Harvey *et al.* 1989; Aiken and Kong 2000).

[2] Industrial is used here as it is by defined by Kong (2003). However, we consider industrial lobster fishing activities in Jamaica to be small-scale commercial (artisanal) due to the use of traditional gear.

[3] Caribbean Coastal Area Management Foundation, Blue Fields Bay Fishermen's Friendly Society, St Mary Fishermen's Cooperative, Oracabessa Foundation, Negril Coral Reef Preservation Society, Montego Bay Marine Park Trust, Fisheries Division, Alloa Fisherman's Group and Business Community

[4] http://www.moa.gov.jm/fisheries.php; accessed June 13, 2011

To date, Jamaica's official record-keeping has made no attempt to account for recreational catches, subsistence catches, or discarded by-catch. In other countries, these sectors have been shown to contribute significantly to the total catch (Zeller *et al.* 2006; Wieglus *et al.* 2010). Previous attempts to account for missing data include an assessment of the economic contribution of Jamaica's artisanal fisheries (Gustavson 2002; Sary *et al.* 2003; Waite *et al.* 2011); however, these studies do not attempt to estimate all sectors. This report seeks to establish a comprehensive time series of Jamaican fisheries catches (1950-2010) including all fisheries catch components.

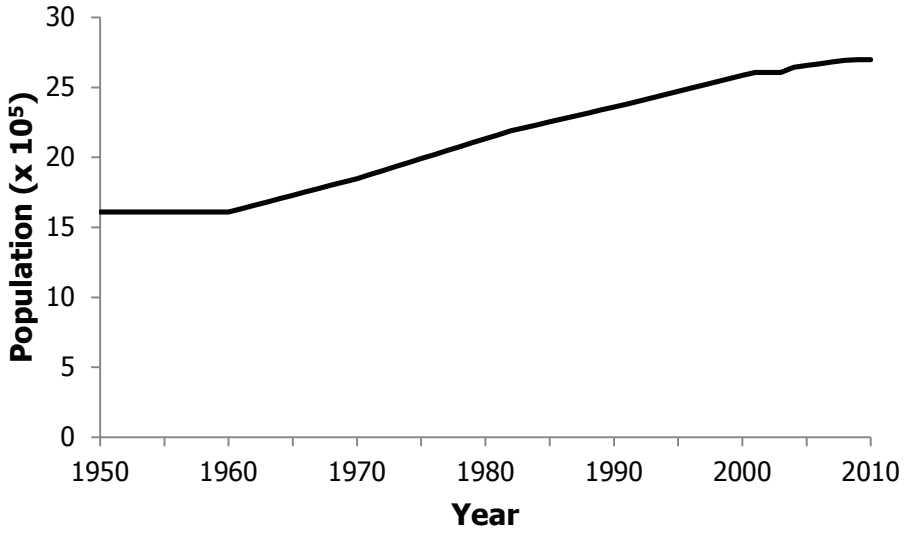

Figure 2. Population of Jamaica, 1950-2010.

Methods

Population

Population data were obtained in order to calculate subsistence catch rates for the 1950-2010 time period. Census data were only available for the years 1960, 1970, 1982, 1991, and 2001.[5] We carried the 1960 estimate back to 1950 and the 2001 estimate forward to 2010. Linear interpolations were done between estimates to create a complete time series of population data (Figure 2).

Artisanal

Landings presented by the FAO on behalf of Jamaica were found to be similar to those reported by the Fisheries Division, and were therefore assumed to be representative of the artisanal catches for the time period considered. Admittedly, there are problems with accurately estimating catches in many Caribbean artisanal fisheries due to highly dispersed landing sites, the large range of species caught, multiple gear types, and irregular fishing patterns as a result of socio-economic conditions within fishing communities (Munro 1980). Therefore a portion of the below described subsistence catch may be considered unreported artisanal catch, but was here referred to as subsistence catch as we were unable to further disaggregate the data.

Total demand

To estimate subsistence catch, total seafood demand was calculated using population data combined with estimates of *per capita* fish consumption. Few sources of *per capita* fish consumption estimated independently of fisheries landings were available for the Caribbean region. Cole (1976 in Olsen *et al.* 1984) estimated a *per capita* consumption rate of 30 kg·person^{-1}·year^{-1}. We assumed this estimate referred to only fresh fish. Although other seafood products are consumed in Jamaica, we focused here on fresh fish consumption as it comprises the majority of the Jamaican seafood diet. We carried this estimate of 30 kg·person^{-1}·year^{-1} back unaltered to 1950 and forward to 1980. Adams (1992) estimated that consumption of fresh fish averaged 1.7 times per week, or 20 kg·person^{-1}·year^{-1}, for the Caribbean region. We applied Adams (1992) estimate from 1990-2008. Between 1980 and 1990 linear interpolation was used to derive a complete time series of *per capita* fish consumption. We then combined the consumption estimates with population data to estimate total demand for fresh fish.

To estimate imports of fresh fish, we used import data from Thompson (1945) to calculate the proportion of total imports that fresh fish products represented during the 1940s. From Thompson (1945) we calculated that 0.07% of fisheries imports were fresh fish. We applied this 0.07% figure to Thorne's (1965) fisheries import figures for 1950-1959 to estimate imports of fresh fish. From the amount of fresh fish imported we also calculated *per capita* fresh fish import rates. Using FAO reported imports of fresh fish (1976-2010) and population data, we calculated *per capita* imports of fresh fish for 1976. Linear interpolation of *per capita* fresh fish imports was done for 1960-1975 using the calculated *per capita* import rates from Thorne (1965) for 1959 and the FAO for 1976. We combined these estimates of *per capita* imports with population estimates to calculate total imports of fresh fish. For the period of 1976-2008 we used the summed FAO fresh fish imports. We then multiplied our population by the *per capita* import rates to deduce total fresh fish imports. By combining demand for fresh fish with total fish imports, we were able to calculate total demand for fishery products from 1950-2010.

[5] http://statinja.gov.jm/Popcensus.aspx; accessed: August, 2011

Subsistence catch

To convert our estimated total demand for fresh fish to an estimate of subsistence production we subtracted FAO reported aquaculture production, reconstructed estimates of fresh fish imports, and FAO reported landings (adjusted for fresh fish exports) from the total demand for fresh fish.

Discards

Several fishing techniques employed in Jamaica are non-selective and therefore likely to incur by-catch and result in discards. For example, trap and net fishing gears, which utilize fine mesh and wire, can cause substantial catch of non-target species. There is also an unmonitored bait fishery for penaeid shrimp (S. Lingard. pers. obs.), which are caught in fine nets that result in the capture of juvenile reef fish. Thus far, no attempts have been made to estimate bait shrimp and reef fish by-catch in Jamaica. To account for these missing catch components, we needed to disaggregate the FAO reported landings by gear type using the available literature. For the period 1950-1981, we applied Sahney's (1983) breakdown of catch by gear type: 53% trap, 23% net, 17% line, and 7% other gears. For the period from 2000 to 2008 we applied estimates of catch by gear type from Sary *et al.* (2003): 49% trap, 10% line, 3% net, and 38% spear. For the period 1982-1999, we interpolated linearly between the two sets of percentages of catch by gear type. To calculate discards in the trap fishery, we applied the discard rate of 29% from Nicholson and Hartsuijker (1982) for the 1950-1981 period. For this early time period, when larger, more valuable species were more abundant, we assumed that the market was more selective and that a discard rate of 29% would be a conservative estimate. However, catches of large, valuable species such as large jacks, groupers, and snappers declined from 1950 to 1982 (Aiken and Haughton 1987). Therefore, these species have disappeared from catches during the recent time period (Murray and Aiken 2006), and species that were previously considered trash species and discarded, have become targeted catch (Aiken and Haughton 1987). Due to this shift in target catch, discard rates from 1990 to 2010 were much lower (estimated to be 2-5%; K. Aiken, University of the West Indies, pers. obs.). Thus, for the time period 1990-2010 we applied a conservative discard rate estimate of 2% for trap gears. Although a higher discard rate of 18% was reported for the Morant Cays trap fishery in 1996 (Pears and Sary 1996), this estimate was only for a single bank. We considered the estimated discard rate of 2% to be more representative of all trap fisheries for the recent time period, given the overfished state of the southern shelf and the increasing retention of non-targeted catch. For the years from 1981-1989, a complete time series of fisheries discards for trap catches was created using linear interpolation between 29% and 2%.

Table 1. Species composition (% of catch) of sport fishery catches, 2002-2010.

Taxon name	Common name	Catch (%)
Makaira nigricans	Blue marlin	48.0
Acanthocybium solandri	Wahoo	23.0
Coryphaenidae	Dolphin fish	14.0
Scombridae	Tunas and mackerels	7.6
Others	All other species	7.6

Adapted from Quinn (2005).

To estimate discards from net gears, we applied the 4.4% discard rate estimated by Kelleher (2005) to the landings from nets over the entire time period. Discard rates were only applied to the artisanal catches from nets and traps as they are non-selective. Whereas discard rates were not applied to artisanal catches from hook-and-line, and spear gear types, due to their more selective nature. We also did not apply discard rates to subsistence catches due to the types of gears used in this sector. The gear most commonly used by non-commercial fishers (i.e., subsistence and recreational) in Jamaica is line and spear,[6] which we assumed to have negligible discards.

Shrimp

The FAO presents landings for penaeid shrimps, but only for some years. To obtain a complete time series estimate of shrimp catches, we combined information available from FAO with national data presented in Waite *et al.* (2011). Shrimp catches were set at zero for 1950 as no shrimp fishery is discussed in the early literature (Thompson 1945) and shrimp does not seem to feature heavily in the Jamaican diet (S. Lingard, pers. obs.). We then interpolated linearly between the 1950 anchor point and the first year of shrimp landings presented by the FAO (277 t in 1994). For the period 1994-2003, we used the FAO shrimp landings, and from 2004-2008, we used national data presented by Waite *et al.* (2011). Discard rates were not applied to catches for this fishery due to the small-scale, low-impact hand nets used by these fishers (Galbraith and Ehrhardt 2000).

Table 2. Anchor points (% of catch) used in the taxonomic breakdown of Jamaica's south coast artisanal fisheries catches. Linear interpolations were used between data points to establish a complete time series, 1950-2010.

Family	1950-1971	1980	2001-2010
Acanthuridae	6	7	6
Balistidae	3	1	1
Carangidae	9	5	1
Clupeidae	15	16	13
Coryphaenidae	0	0	0
Haemulidae	8	8	5
Holocentridae	1	3	6
Lutjanidae	7	15	3
Mugilidae	1	1	1
Mullidae	1	4	12
Palinuridae	6	4	0
Scaridae	9	12	28
Scombridae	0	3	2
Serranidae	9	1	6
Sparidae	0	1	1
Sphyraenidae	1	1	1
Others	23	17	13

Sources: Munro (1974a, 1974b), Sahney (1983), Murray and Aiken (2006).

[6] S. Lingard, 2011 unpublished data submitted in report to Fisheries Division

Sport fishery (recreational)

A sport tournament fishery has been in operation in Jamaica since 1959 (Harvey *et al.* 1989). In its early years, the fishery targeted blue marlin (*Makaira nigricans*; Harvey *et al.* 1989). However, in recent years the catch has included a diversity of scombrids and other oceanic pelagic species (Quinn 2005). Tournament catches for the period of 1976-1986 were calculated using the number of fish caught and average weights taken from Ortiz and Farber (2001). Average weight per fish was calculated for the Ortiz and Farber (2001) length data using the FishBase Life History Tool (www.fishbase.org). The average weights were then multiplied by the total number of *M. nigricans* landed in each year of the tournament fishery as quoted by Harvey *et al.* (1989). This resulted in estimated landings (in tonnes) for the sport fishery from 1976-1986. We carried the 1976 estimate back unaltered to 1959 as a small tournament fishery has been in operation since this date (Harvey *et al.* 1989). Quinn (2005) estimated sport fishery landings from tournament records in 2002. Utilizing the taxonomic information from Quinn (2005), we have assigned catches from this sector to four taxa (*M. nigricans, Acanthocybium solandri, Coryphaena* spp., and Scombridae) plus an "Others" category of 7.6% (Table 1). We interpolated from a catch composed of 100% *M. nigricans* in 1986 (Harvey *et al.* 1989) to the taxonomic composition of tournament catches in Quinn (2005) in order to create a complete time series of tournament catches.

Table 3. Anchor points used (% of catch) in the taxonomic breakdown of Jamaica's north coast artisanal fisheries catches. Linear interpolations were used between data points to establish a complete time series, 1950-2010.

Family	1950-1968	1980	2001-2010
Balistidae	1.4	1.5	1.4
Carangidae	16.8	17.9	8.5
Clupeidae	0.1	1.1	1.1
Coryphaenidae	1.4	1.4	1.4
Haemulidae	2.4	2.5	2.4
Lutjanidae	12.4	19.6	10.9
Mullidae	5.0	3.5	3.0
Mugilidae	4.1	1.9	0.0
Palinuridae	1.3	1.4	0.0
Scaridae	18.9	11.1	17.0
Serranidae	11.4	1.1	4.4
Scombridae	1.9	9.4	1.0
Others	23.1	27.5	49.0

Sources: Sahney (1983) and Sary (2003).

Taxonomic breakdown

Three geographically distinct areas are fished in Jamaica: the north coast (narrow shelf), south coast (wide shelf), and outer banks. The majority of the banks have been exposed to significant fishing pressure since the mechanization of boats began in 1956 (Koslow *et al.* 1988). Due to the different gear types, shelf widths, and historical fishing pressure in each area, we separated artisanal catches by area and applied separate taxonomic breakdowns. The only comprehensive species-level breakdowns available for trap and line fisheries were from Munro (1974a, 1974b). We weighted these two gear types according to estimates of catch by gear type in Sahney (1983) and created a single catch composition. Catch composition for other gear types were unavailable, except for Sahney (1981); therefore we recalibrated the estimated catch by gear type in Sahney (1983) to include only trap and line. Munro's (1974a, 1974b) estimates of the taxonomic composition of catches were presented as the contribution to total catch. To make the breakdown applicable to all sources, we grouped the species by family. We combined the aggregated species data from Munro (1974a, 1974b) with the family composition data from the studies outlined below for each of the three fishing grounds. Although family composition varies by fishing ground, we assumed the species composition within families to be similar across fishing grounds.

South coast

For catches from the south coast, we compared several sources of taxonomic information for different years: 1971 (1974a, 1974b), 1980 (Sahney 1983), and 2001 (Murray and Aiken 2006; Table 2). Using Sahney's (1983) breakdown of south coast landings by gear type (66.6% trap and 33.4% line), we weighted the trap and line landings from Munro (1974a, 1974b) to create a comprehensive estimate of south coast catches by taxa. Munro (1974a, 1974b) assigned catches by species; therefore, we aggregated species into families to allow comparison with the other two sources. Families present in Munro (1974a, 1974b) but not present in other sources were grouped into an "Others" category. The combined estimate from Munro (1974a, 1974b) was carried back unaltered to 1950. Sahney's (1983) catch composition was used as a mid-point between Munro (1974a, 1974b) and Murray and Aiken (2006). Several families were not estimated in Murray and Aiken (2006) and in Sahney (1983), but are known to be caught regularly. These families include Balistidae, Clupeidae, Coryphaenidae, Mugilidae, Scombridae and Sphyraenidae. To accommodate these additional taxa, catch compositions for Murray and Aiken (2006) and Sahney (1981) were adjusted by carrying forward estimates of these missing taxa. Also Murray and Aiken (2006) had no "Others" category in their estimates, so the "Others" estimate from Munro (1974a, 1974b) was also carried forward. Linear interpolation between estimates was then used to complete the times series. Murray and Aiken's (2006) estimate, adjusted for missing taxa, was carried forward to 2010.

Table 4. Anchor points (% of catch) used in the taxonomic breakdown of Jamaica's outer banks artisanal fisheries catches. Linear interpolations were used between data points to establish a complete time series, 1950-2010.

Family	1956-1980	2001-2010
Acanthuridae	0	6
Balistidae	7	0
Carangidae	10	1
Clupeidae	1	0
Coryphaenidae	4	3
Haemulidae	9	5
Holocentridae	0	7
Lutjanidae	6	4
Mugilidae	0	0
Mullidae	4	13
Palinuridae	3	0
Scaridae	10	30
Scombridae	4	3
Serranidae	14	6
Sparidae	0	1
Others	28	20

Sources: Sahney (1983), Murray and Aiken (2006).

North coast

For the north coast, taxonomic information was available for 1968 (Sary *et al.* 2003), 1980 (Sahney 1983), and 2001 (Sary *et al.* 2003; Table 3). We applied linear interpolation between estimates for these three years. Picou-Gill *et al.* (1996) also provided disaggregated Discovery Bay catches for 1990-1991 to the family level; however, as these estimates concerned a single bay, we consider them to be unrepresentative of the entire north coast area and chose not to incorporate them. Several important taxa (families Balistidae, Clupeidae, Coryphaenidae, and Haemulidae) were absent from the estimates put forth by Sary *et al.* (2003). To avoid recording the catch of these important taxa as zero, we have carried Sahney's (1983) estimates for these taxa back to 1950 and forward to 2010. The taxonomic compositions for 1968 and 2001 in Sary *et al.* (2003) were then recalibrated to accommodate these additional taxa. The recalibrated estimate for 1968 was carried back to 1950, and the recalibrated estimate for 2001 carried forward to 2010. Linear interpolation of percentage breakdowns between years of known data was done to establish a complete time series of catch composition from 1950-2010.

Table 5. Anchor points (%) used in the taxonomic breakdown of Jamaica's subsistence fisheries catches. Linear interpolations were used between data points to establish a complete time series, 1950-2010.

Family	1950-1968	2001-2010
Carangidae	0.28	0.06
Carcharhinidae	0.08	0.05
Haemulidae	0.11	0.03
Holocentridae	0.01	0.03
Lutjanidae	0.20	0.05
Muraenidae	0.00	0.01
Scaridae	0.17	0.25
Scombridae	0.00	0.01
Serranidae	0.17	0.09
Sphyraenidae	0.04	0.27
Others	0.10	0.20

Source: Sary (2003).

Outer banks

The only comprehensive study detailing taxonomic composition for Pedro Banks and the other outer banks was for 1980 (Sahney 1983). However, Murray and Aiken (2006) completed an extensive study in 2001-2002 of Whitehouse – one of the largest fishing villages on Jamaica's south coast. A large portion of the fishers on the south coast target the outer banks (Pears and Sary 1996; Grant 1999; Murray and Aiken 2006). The absence of large predatory species is reported on the outer banks as well as the southern shelf (Koslow *et al.* 1988; Pears and Sary 1996; Murray and Aiken 2006). In light of these observations, we assumed landings from south coast fishing beaches were representative of those on the outer banks for the recent time period. We applied the breakdown from Sahney (1983) for the years 1956-1980, and interpolated linearly to the 2001 estimate from Murray and Aiken (2006; Table 4). We recalibrated Murray and Aiken's (2006) estimate for 2001 to accommodate the addition of targeted taxa that were not included, but we know to contribute to catches (Coryphaenidae, Scombridae, and "Others;" described previously).

Subsistence

Subsistence catches were assigned taxonomically to the family level. Recent data suggest the majority of subsistence fishers use lines and spears as their primary gear types.[7] We have applied the taxonomic compositions for 1968 and 2001 from Sary (2003), with linear interpolation between intervening years, to subsistence catches, as they were most representative of observed catches by subsistence fishers in Jamaica (S. Lingard, pers. obs.; Table 5).

Results

Reported landings

Landings reported by the FAO on behalf of Jamaica for the period 1950-2010 amounted to just over 683,000 t (Figure 3a). Reported landings were presented for six taxonomic categories: miscellaneous marine fishes (505,527 t), spiny lobster (7,689 t), stromboid conch (168,916 t), penaeus shrimps (889 t), marine crabs (106 t), and tuna-like fishes (726 t). All reported landings are from the artisanal sector.

South coast

Total estimated catches on the south coast amounted to approximately 284,000 t over the 1950-2010 time period. Reef fish catches totalled 283,100 t, and reported penaeus shrimp catches totalled 889 t. The most abundant families caught on the south coast were Clupeidae, Scaridae, Lutjanidae, and Haemulidae with total catches of approximately 44,700 t, 43,000, 21,500 t and 20,800 t respectively.

North coast

Total catches from the north coast between 1950 and 2010 were approximately 93,200 t. The most abundant families were Scaridae (14,700 t), Carangidae (13,100 t), Lutjanidae (12,400 t), and Serranidae (6,000 t).

[7] S. Lingard, 2011 unpublished data submitted in report to the Fisheries Division

Outer banks

Catches from the outer banks totalled 304,900 t from 1950-2010. The most abundant catches on the outer banks were for the taxa *Lobatus gigas* (168,900 t), Scaridae (31,700 t), Serranidae (15,400 t), and Mullidae (13,700 t).

Reconstructed catch

Subsistence

Total subsistence catches over the 1950-2010 time period were estimated to be 2,186,633 t (Figure 3a). The most important families in the subsistence sector were Carangidae (380,700 t), Sphyraenidae (296,300 t), Scaridae (296,300 t) and Serranidae (279,000 t). In 1950, catches consisted mainly of Carangidae (11,700 t·year^{-1}), Lutjanidae (8,300 t·year^{-1}), and Serranidae (7,000 t·year^{-1}). In 2010, catches were dominated by Sphyraenidae (6,100 t·year^{-1}), Scaridae (5,700 t·year^{-1}), and Serranidae (2,000 t·year^{-1}).

Discards

Discarded catches, which include shrimp caught as bait, and discarded fish from trap and net fisheries, were estimated to be 81,425 t from 1950-2010 (Figure 3a). Discards in 1950 amounted to 1,160 t·year^{-1} and declined to 400 t·year^{-1} in 2010. Peak discards occurred in 1962 with 2,800 t of discarded fish.

Shrimp

The total reconstructed catch for penaeid shrimp was 8,725 t from 1950-2010, which included 889 t of reported landings. Shrimp landings started in 1951 and grew from 6 t·year^{-1} to 277 t·year^{-1} in 1994. Catches then proceeded to follow an oscillating trend of decrease followed by increase followed by decrease with a peak in 2005 of 875 t.

Sport fishery

Tournament landings were estimated to be 470 t over the 1950-2010 period. Total catches of *M. nigricans* and *A. solandri* (wahoo) were estimated to be 379 t and 40 t respectively over the entire time period (Figure 4).

Total reconstructed catch

Total reconstructed catches of Jamaica for the 1950-2010 time period were estimated to be 2,960,000 t (Figure 3a). The total catches were 4.3 times larger than the FAO reported landings, which were considered to represent only artisanal landings.

Catches of Carangidae, the most important taxon caught throughout the study period, decreased by 86% from 12,200 t·year^{-1} in 1950 to 1,700 t·year^{-1} in 2010 (Figure 3b, Table 6). Similar trends were visible in Serranidae, Lutjanidae, and Haemulidae (Figure 3b, Table 6). Total catches of Carcharhinidae (requiem sharks) were 139,400 t over the 1950-2010 time period. The most abundant species of finfish in the artisanal sector

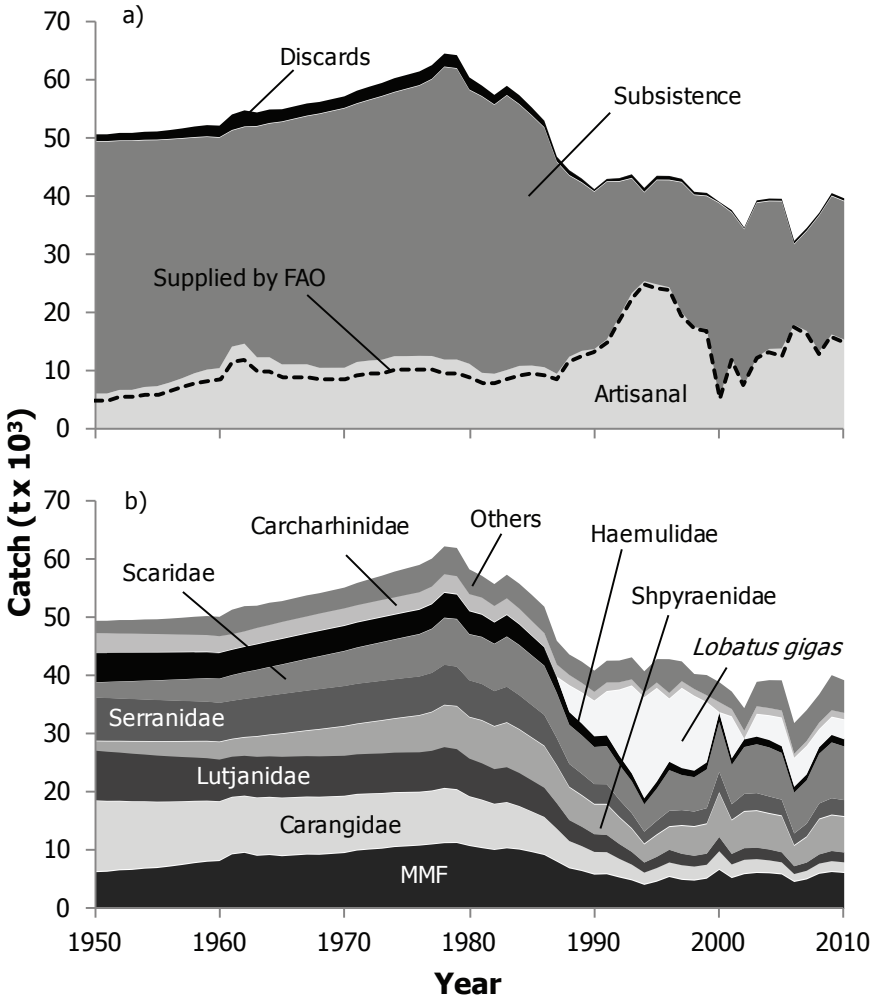

Figure 3. Total reconstructed catch of Jamaica, 1950-2010, a) by sector (recreational fishery not visible), with comparison to the FAO reported landings, and b) by major taxa. "MMF" equals miscellaneous marine fishes and the "others" category includes 29 additional taxonomic groups.

were *Opisthonema oglinum*, *Sparisoma viride*, *Ocyurus chrysurus* (yellowtail snapper), and *Epinephelus guttatus* (red hind) totalling 43,400 t, 27,700 t, 15,100t, and 13,200 t respectively. Catches from the targeted Caribbean spiny lobster (*P. argus*) and queen conch (*L. gigas*) fisheries equated to 19,500 t and 168,900 t, respectively. Significant is the shift over time from top predators (Serranidae, Carangidae, and Lutjanidae) to taxa lower in the food chain (e.g. Scaridae; Figure 3b).

Appendix tables (A1 and A2) present total reconstructed catches by year, sector and taxa.

Table 6. Change in catch of Jamaica's most valuable fish taxa between 1950 and 2010.

Taxon	Catch (t)		Decrease (%)
	1950	2010	
Carangidae	12,180	1,703	86
Lutjanidae	8,688	1,713	80
Serranidae	7,470	2,749	63
Haemulidae	5,093	1,337	74

Discussion

The total reconstructed catch for Jamaica was estimated to be approximately 3 million tonnes over the 1950-2010 time period. This is 4.3 times the landings reported by the FAO on behalf of Jamaica (683,855 t). This considerable difference between the total reconstructed catch and landings presented by the FAO is attributable to the absence of subsistence catches, discards, and tournament landings from officially reported data. Detailed studies exist for various aspects of Jamaica's fisheries for the period 1945-2010 (Thompson 1945; Oswald 1963; Munro and Thompson 1973; Munro 1983; Aiken 1985a, 1985b; Aiken and Haughton 1987; Koslow *et al.* 1988; Pears and Sary 1996; Picou-Gill *et al.* 1996; Aiken *et al.* 1999; Grant 1999; Aiken and Kong 2000; Aiken *et al.* 2002; Sary *et al.* 2003; Quinn 2005; Aiken *et al.* 2006; Murray and Aiken 2006; Passley *et al.* 2009); however, this is the first study to estimate all fisheries catch components as a complete time series from 1950 to present. Total catch, as estimated using the reconstruction approach (Zeller *et al.*, 2007), increased from 49,400 t in 1950 to a peak of 62,300 t in 1978 where catches then declined and have only recently appeared to start to level out. In contrast, data reported to the FAO suggest that catches have been relatively stable over the entire time period considered (excluding the marked increase during the 1990s as a result of the Pedro Bank conch fishery).

This study highlights the importance of fresh fish in the Jamaican diet. A substantial portion of this fresh fish demand is met through subsistence fisheries, a sector that has been largely ignored in the collection of Jamaican fisheries data. Similar contributions by the non-commercial sector have been seen in other regions of the world, such as Pacific island nations (Zeller *et al.* 2006; Zeller *et al.* 2007; Lingard *et al.* 2011), where the importance of this sector to the economy has also gone unrecognized.

Catches from the growing spear fishing sector make up a considerable portion of the reconstructed subsistence catch. Trap, net and line fishing have traditionally been the most common gear types used in Jamaica (Munro and Thompson 1973; Sahney 1983), but the use of spears is increasing (Sary *et al.* 2003; Passley *et al.* 2009). Catch from spear fishers in 2009 was estimated to be 3,000 t per year (Passley *et al.* 2009). The landing sites used by these fishers are often outside the normally surveyed locations (N. Hado, pers. obs., Food for the Poor). Thus it is likely that a large portion of catches by this sector are not reported as they are consumed directly by fishers (i.e., for subsistence purposes).

The use of non-selective gear types, such as traps and nets (e.g., seine nets, sprat nets, trawl nets, shove/push nets, trammel nets, lobster traps, china traps), can result in high levels of by-catch. In many cases this by-catch is discarded. To reduce by-catch, attempts have been made to encourage the use of larger mesh in traps (Sary *et al.* 1996). Additionally, a recent initiative has involved retraining fishers to use more selective fishing techniques, such as deep-water hand lining, instead of traps and nets (S. Lingard, pers. obs.).

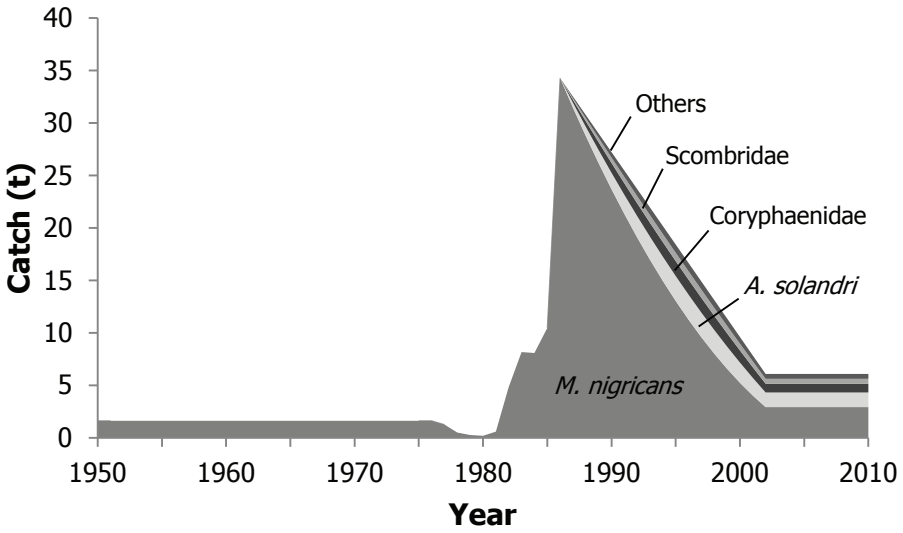

Figure 4. Catch composition of Jamaican tournament sport fishery catches, 1950-2010.

Fisheries in Jamaica provide a substantial source of employment. An estimated 20,000 licensed fishers are presently operating in Jamaica (CFRAMP 2000) out of an employable population of 1,255,000.[8] Women are heavily employed in Jamaican fisheries, typically as vendors, although some women also go to sea as fishers (Gustavson 2002). The ratio of vendors to fishers in Jamaica is estimated at 3:1 (Gustavson 2002). Women control the income of fishers through the sale of fish and

[8] http://statinja.gov.jm/labourforceAgeGroup.aspx; accessed October, 2011

therefore also indirectly control fishing activities, as well as cooperation with management plans and government officials (Grant 2004).

Potential profits for fishers in Jamaica are limited by a lack of adequate processing and marketing facilities (Bélisle 1984a). The majority of fisheries products, with the exception of those from the conch and lobster industries (the majority of products go to export markets; Aiken *et al.* 1999; Aiken and Kong 2000), are sold domestically, beach-side, and unprocessed (Bélisle 1984a; Grant 1998; Aiken *et al.* 1999; Waite *et al.* 2011). Improved distribution and marketing of fresh fish to hotels would be beneficial in reducing waste and improving revenues from dwindling fish resources (Bélisle 1984b), but must also be properly accounted for in official statistics.

Fisheries development projects and government subsidies have traditionally focused on capacity-enhancing subsidies, which increase fishing effort (Sumaila *et al.* 2010). These include building rural market facilities, mechanization of boats, fuel, and gear exchange. In Jamaica, infrastructure such as gear sheds (built by international donors) sit empty and unused, due to lack of local management capabilities, while fishers continue to suffer great economic hardships (S. Lingard, pers. obs.). International donors and local government should instead focus on beneficial subsidies (enforcement of marine protected areas and alternate livelihood development), which work to increase natural capital and decrease fishing effort (Sumaila *et al.* 2010). Joint efforts by The Nature Conservancy, local NGOs and the Fisheries Division are currently under way to establish and enforce fish sanctuaries (i.e., no-take areas).

Despite management efforts, Jamaica has long been considered overfished (Thompson 1945; Aiken and Haughton 1987; Haughton 1988; Koslow *et al.* 1989), and at present, Jamaica's marine resources, appear to be in a state of Malthusian overfishing (Pauly *et al.* 1989). Few alternatives exist for employment, and fishers rarely make enough to recover operational costs, including subsidized fuel (Aiken and Haughton 1991; S. Lingard, pers. obs.). Schemes that aim to reduce fishing pressure, but provide no alternative employment, would further contribute to economic hardships for fishers and their families in the short term. These socio-economic challenges, as well as distrust of the government by members of fishing communities (Grant 2004), make management decisions difficult in Jamaica. Co-management was suggested in the 1980s as a possible solution to these management challenges (Aiken and Haughton 1987). Recently, the Improving Jamaica's Agricultural Productivity Project has been launched to develop co-management within six south coast fishing villages (S. Lingard, pers. obs.).

The magnitude of unreported catches estimated here suggests that improvements to Jamaica's fisheries data collection system are urgently needed. More importantly, this study suggests that many people in Jamaica, previously overlooked in fisheries management and policy, are reliant on marine resources. From a policy perspective, in a country that has long been reliant on seafood, the destruction of natural marine capital (i.e., fish resources) has serious implications for national food security and livelihoods.

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Appendix Table A1. Total reconstructed catch (by sector) vs. FAO reported landings (in tonnes) for Jamaica, 1950-2010.

Year	FAO landings	Total reconstructed catch	Artisanal	Subsistence	Discards	Recreational
1950	5,000	49,400	6,160	43,300	1,160	1.62
1951	5,000	49,500	6,170	43,300	1,160	1.62
1952	5,500	49,600	6,790	42,800	1,276	1.62
1953	5,500	49,600	6,800	42,800	1,276	1.62
1954	5,900	49,700	7,290	42,400	1,369	1.62
1955	6,000	49,700	7,420	42,300	1,392	1.62
1956	6,500	49,800	8,050	41,800	1,508	1.62
1957	7,100	50,000	8,790	41,200	1,648	1.62
1958	7,800	50,100	9,660	40,500	1,810	1.62
1959	8,300	50,300	10,280	40,000	1,926	1.62
1960	8,500	50,100	10,540	39,600	1,973	1.62
1961	11,500	51,400	14,240	37,100	2,669	1.62
1962	11,900	52,000	14,740	37,200	2,762	1.62
1963	10,000	52,100	12,400	39,600	2,321	1.62
1964	10,000	52,600	12,410	40,200	2,321	1.62
1965	9,000	52,800	11,180	41,700	2,089	1.62
1966	9,000	53,300	11,190	42,200	2,089	1.62
1967	9,000	53,800	11,200	42,600	2,089	1.62
1968	8,500	54,200	10,590	43,600	1,973	1.62
1969	8,500	54,700	10,590	44,100	1,973	1.62
1970	8,500	55,200	10,600	44,600	1,973	1.62
1971	9,300	56,000	11,590	44,400	2,158	1.62
1972	9,500	56,600	11,840	44,800	2,205	1.62
1973	9,600	57,200	11,970	45,300	2,228	1.62
1974	10,100	57,900	12,600	45,300	2,344	1.62
1975	10,100	58,500	12,600	45,900	2,344	1.62
1976	10,130	59,100	12,640	46,400	2,351	1.62
1977	10,110	60,200	12,620	47,600	2,346	1.27
1978	9,600	62,300	12,010	50,300	2,228	0.50
1979	9,600	62,000	12,010	50,000	2,228	0.27
1980	9,000	58,300	11,280	47,000	2,089	0.20
1981	7,740	57,200	9,730	47,500	1,796	0.59
1982	7,750	55,800	9,570	46,200	1,621	4.84
1983	8,440	57,400	10,220	47,200	1,573	8.17
1984	9,200	55,800	10,920	44,900	1,505	8.09
1985	9,430	53,900	10,970	42,900	1,327	10.46
1986	9,360	51,900	10,690	41,200	1,105	34.28
1987	8,520	46,000	9,560	36,400	811	32.51
1988	11,430	43,600	12,500	31,100	827	30.75
1989	12,640	42,400	13,510	28,900	626	28.99
1990	13,200	40,900	13,800	27,000	353	27.23
1991	14,800	42,600	15,450	27,100	395	25.47
1992	18,650	42,600	19,410	23,200	498	23.71
1993	22,550	43,100	23,420	19,700	602	21.94
1994	24,830	40,700	25,490	15,200	663	20.18
1995	24,300	42,800	24,950	17,900	649	18.42
1996	23,810	42,800	24,440	18,400	636	16.66
1997	19,590	42,400	20,110	22,300	523	14.90
1998	17,100	40,300	17,550	22,700	457	13.14
1999	16,860	40,100	17,310	22,800	451	11.37
2000	5,140	38,900	5,280	33,600	137	9.61
2001	11,890	37,300	12,210	25,000	318	7.85
2002	7,400	34,400	7,590	26,800	198	6.09
2003	12,080	38,900	12,400	26,500	323	6.09
2004	13,070	39,200	13,840	25,400	349	6.09
2005	12,700	39,200	13,910	25,300	339	6.09
2006	17,510	31,800	17,970	13,800	468	6.09
2007	16,150	34,100	16,930	17,100	431	6.09
2008	12,780	36,800	13,350	23,400	341	6.09
2009	15,890	40,100	16,320	23,800	337	6.09
2010	15,040	39,200	15,440	23,800	5,326	6.09

Appendix Table A2. Total reconstructed catch (in tonnes) for Jamaica by major taxa, 1950-2010.

Year	Miscellaneous marine fish	Carangidae	Lutjanidae	Sphyraenidae	Serranidae	Scaridae	Haemulidae	*Lobatus gigas*	Carcharhinidae	Others[1]
1950	6,350	12,180	8,690	1,600	7,470	2,620	5,090	0	3,336	2,120
1951	6,420	12,020	8,580	1,760	7,410	2,770	5,040	0	3,314	2,140
1952	6,670	11,780	8,420	1,910	7,320	2,940	4,960	0	3,254	2,320
1953	6,740	11,630	8,320	2,070	7,270	3,080	4,900	0	3,233	2,340
1954	6,950	11,410	8,170	2,220	7,180	3,250	4,830	0	3,181	2,490
1955	7,060	11,240	8,050	2,370	7,120	3,390	4,770	0	3,152	2,540
1956	7,310	11,020	7,900	2,510	7,040	3,560	4,700	0	3,093	2,710
1957	7,590	10,780	7,740	2,630	6,950	3,720	4,630	0	3,028	2,900
1958	7,900	10,540	7,580	2,750	6,860	3,890	4,560	0	2,956	3,120
1959	8,150	10,320	7,430	2,870	6,790	4,040	4,490	0	2,899	3,270
1960	8,270	10,110	7,280	3,000	6,700	4,170	4,410	0	2,851	3,340
1961	9,420	9,710	7,030	2,980	6,580	4,430	4,350	0	2,654	4,220
1962	9,690	9,640	6,980	3,130	6,590	4,610	4,340	0	2,643	4,350
1963	9,170	9,850	7,120	3,460	6,720	4,740	4,370	0	2,794	3,830
1964	9,310	9,820	7,100	3,650	6,750	4,920	4,360	0	2,810	3,850
1965	9,110	9,890	7,140	3,940	6,820	5,090	4,370	0	2,893	3,590
1966	9,240	9,850	7,110	4,140	6,840	5,280	4,360	0	2,906	3,610
1967	9,380	9,800	7,080	4,350	6,860	5,480	4,340	0	2,918	3,630
1968	9,350	9,790	7,080	4,610	6,900	5,670	4,330	0	2,964	3,510
1969	9,500	9,730	7,040	4,830	6,900	5,860	4,320	0	2,974	3,540
1970	9,650	9,660	7,010	5,050	6,900	6,050	4,300	0	2,983	3,580
1971	10,080	9,550	6,940	5,200	6,890	6,250	4,280	0	2,947	3,830
1972	10,260	9,460	6,940	5,410	6,850	6,460	4,260	0	2,950	4,020
1973	10,410	9,370	6,950	5,640	6,810	6,680	4,240	0	2,959	4,180
1974	10,680	9,250	6,930	5,820	6,750	6,890	4,220	0	2,941	4,450
1975	10,810	9,160	6,930	6,070	6,720	7,110	4,190	0	2,955	4,570
1976	10,930	9,070	6,910	6,310	6,680	7,330	4,170	0	2,966	4,710
1977	11,140	9,070	6,970	6,640	6,720	7,630	4,180	0	3,013	4,810
1978	11,360	9,300	7,150	7,210	6,930	8,120	4,270	0	3,160	4,790
1979	11,380	9,050	7,020	7,350	6,800	8,240	4,180	0	3,117	4,870
1980	10,870	8,370	6,600	7,100	6,310	7,980	3,920	0	2,909	4,270
1981	10,500	8,150	6,370	7,340	6,250	8,130	3,800	0	2,912	3,750
1982	10,180	7,750	6,080	7,320	6,040	8,180	3,640	0	2,811	3,780
1983	10,470	7,760	6,110	7,660	6,140	8,670	3,680	0	2,845	4,060
1984	10,250	7,290	5,800	7,470	5,860	8,670	3,520	0	2,686	4,300
1985	9,810	6,820	5,450	7,300	5,580	8,600	3,320	0	2,546	4,500
1986	9,310	6,370	5,110	7,160	5,310	8,520	3,130	0	2,419	4,550
1987	8,170	5,500	4,430	6,470	4,670	7,810	2,740	0	2,122	4,090
1988	7,010	4,540	3,650	5,650	3,930	6,780	2,260	4,500	1,798	3,530
1989	6,540	4,140	3,370	5,350	3,670	6,650	2,120	5,250	1,653	3,660
1990	5,920	3,770	3,080	5,110	3,410	6,420	1,950	6,000	1,534	3,660
1991	5,990	3,660	3,000	5,230	3,390	6,610	1,910	7,500	1,524	3,750
1992	5,420	3,090	2,580	4,570	2,940	6,060	1,660	11,250	1,291	3,740
1993	4,930	2,590	2,210	3,960	2,550	5,570	1,450	15,000	1,088	3,800
1994	4,150	1,990	1,750	3,130	2,030	4,760	1,180	17,250	834	3,670
1995	4,710	2,230	1,940	3,740	2,330	5,580	1,320	16,000	970	4,040
1996	5,510	2,370	2,210	3,930	2,640	7,060	1,560	10,740	987	5,820
1997	5,020	2,390	1,990	4,820	2,570	6,080	1,320	13,660	1,188	3,410
1998	4,890	2,290	1,880	4,980	2,510	5,950	1,240	12,750	1,197	2,590
1999	5,230	2,270	1,930	5,090	2,620	6,720	1,320	10,250	1,188	3,490
2000	6,740	3,060	2,480	7,610	3,520	8,630	1,650	0	1,736	3,450
2001	5,320	2,220	1,840	5,770	2,650	6,810	1,240	7,100	1,281	3,020
2002	6,000	2,340	2,020	6,290	2,940	8,110	1,420	0	1,357	3,910
2003	6,210	2,250	1,990	6,330	2,950	8,450	1,420	3,780	1,330	4,210
2004	6,150	2,090	1,900	6,160	2,850	8,490	1,380	4,130	1,260	4,810
2005	5,960	1,950	1,750	6,220	2,710	8,090	1,260	4,800	1,242	5,190
2006	4,650	1,250	1,370	3,500	1,990	7,090	1,110	4,880	673	5,310
2007	5,100	1,370	1,430	4,370	2,180	7,520	1,130	4,800	824	5,330
2008	6,060	1,630	1,600	6,050	2,600	8,610	1,230	3,000	1,115	4,880
2009	6,370	1,730	1,770	6,150	2,820	9,650	1,400	3,000	1,131	6,050
2010	6,210	1,700	1,710	6,140	2,750	9,290	1,340	3,300	1,131	5,630

[1] Others category represents 29 additional taxonomic groups.