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ABSTRACT

Total marine fisheries catches were estimated for Guyana from 1950-2010. Our reconstruction of marine fisheries catches included estimates of all domestic fisheries catches. These included the small-scale fisheries for subsistence, the local commercial artisanal sector, the seabob and finfish fishery, the red snapper fishery, the penaeid shrimp fishery, and discarded bycatch from the shrimp, seabob and finfish trawlers. Foreign fisheries catches in Guyana's waters that target shrimp were estimated but were not included in the final reconstruction. Total catches by domestic fisheries in Guyana were estimated to be approximately 2.7 million t over the period 1950-2010, which were 1.59 times the landings presented by the FAO on behalf of Guyana. This difference was mainly due to a lack of reporting of subsistence fisheries. This study emphasized the need for improved accounting of fisheries catches in Guyana, in order to effectively manage its fisheries and preserve the resource that provides food security, employment and economic benefit to the country.

INTRODUCTION

Guyana, formerly known as British Guiana, is located on the northeast coast of South America, between Venezuela and Suriname (Figure 1). The country was formerly a British colony, until gaining independence in 1966. Guyana has a land area of about 215,000 km^2, and 48,000 km^2 of continental shelf (www.seaaroundus.org). With an Exclusive Economic Zone (EEZ) of approximately 136,000 km^2, Guyana has a very productive fisheries sector.

Figure 1. Map of Guyana.

Guyana has three distinct marine fisheries sectors: the subsistence sector, the artisanal sector (small-scale commercial) and the industrial (large-scale commercial) sector. Guyana also has an inland fishery, but this report focuses only on marine fisheries.

The two small-scale sectors (subsistence and artisanal) operate nearshore, and are exclusively dominated by the Guyanese population. The development of small-scale fisheries in Guyana was accelerated in 1971 when the Government banned the importation of fish and fish products, thereby increasing the need for locally-supplied seafood to meet demand (Dragovich and Villegas 1982). It is thought that there are approximately 4,500 local artisanal fishers, of which only 1,000 are boat owners (Anon. 2000). The remaining 3,500 fishers use traditional methods for subsistence catch (Anon. 2000).

The artisanal sector (small-scale, commercial) not only supplies the local market, but has also more recently dominated the export market for finfish due to the increased value of finfish and the decrease in prawn landings (Anon. 2000). Until the 1980s, the entire artisanal catch of finfish and shrimp was absorbed into the fresh fish market and consumed domestically. However, since then, artisanal fishers have exported certain valuable fish such as grey snapper (*Cynoscion acoupa*) and shark (Dragovich and Villegas 1982).

There is also an artisanal fleet for red snapper (*Lutjanus campechanus)*, which began in the 1970s and is dominated by the local fishers, but includes the use by locals of Venezuelan-owned vessels. However, the red snapper fishery declined by 1995 due to inefficient technology (Anon. 2006).

The large-scale commercial seabob fishery began in the early 1980s and utilizes bottom trawls to target mainly seabob (*Xiphopenaeus kroyeri*) and various finfish species, including bangamary (*Macrodon ancylodon),* croaker (*Micropogonias furnieri*), butterfish (*Nebris microps*), catfish (*Arius* spp.), and weakfish (*Cynoscion* spp.) (Goodbody 1984; Shepherd *et al.* 1997; Froese and Pauly 2010). Bycatch from this fishery includes penaeid shrimp and juvenile finfish (Anon. 2006). Whitebelly shrimp (*Nematopalaemon schmitti*) are also caught seasonally, at much smaller catch rates, and are incidental catch in the seabob fishery, since these vessels operate much closer to shore than industrial trawl vessels (Shepherd *et al.* 1997; Anon. 2000). Trawlers configured to catch seabob target finfish when seabob is not in abundance (Anon. 2000). These locally-owned vessels will also shift their operations to penaeid species when resources are scarce, since the same gear can be used in the penaeid shrimp fishery (Shepherd *et al.* 1997).

The large-scale offshore fishery, which began in 1959, targets mainly shrimp, including brown shrimp (*Penaeus subtilis*), pink-spotted shrimp (*Penaeus brasiliensis*), pink shrimp (*Penaeus notalis*) and the most economically valuable species, whitebelly shrimp (*Nematopalaemon schmitti*) (Jones and Dragovich 1977). Bycatch and discards associated with the commercial shrimp fishery include juvenile finfish, croakers and snappers, as well as small amounts of squid (*Loligo pealeii*, *Loligo plei*) and lobster *(Panulirus argus, Panulirus guttatus, Panulirus laevicauda*).
Exploratory surveys for shrimp in the Guianas-Brazil region began in the late 1940s, which identified large aggregations of penaeid shrimp (Dragovich 1981). British vessels exploited this resource until Guyana gained independence in 1966.

In 1955, a company from the United States conducted a survey in order to determine the trawling potential off the coast of Guyana (Anon. 1946). Positive survey results prompted commercial shrimp trawl operations by U.S. vessels to begin in 1959 (Jones and Dragovich 1977). From the data available, it is evident that these operations by U.S. vessels continued until 1977. However, no records exist of U.S. vessels fishing in Guyanese waters for the recent period.

Japan began commercial shrimp fishing in waters off the Guyana coast in the 1960s (Dragovich 1981). By the end of the 1960s, Japan had approximately 70 vessels along the Brazil-Guianas shelf. The Japanese effort continued to increase until a peak in the early to mid-1970s with 128 vessels and a reported catch of 3,400 t (Kawahara 1982). The oil crisis at the end of 1973 resulted in the mooring and sale of much of the Japanese fleet (Kawahara 1982). Catch rates off the coast of Guyana gradually increased after 1977 due to the enforcement of the 200-mile EEZ (Kawahara 1982). However, as of November 1996, the Japanese fleet, which fished further offshore than other fleets and targeted mainly *P. brasiliensis*, ceased operations off the coast of Guyana (Shepherd and Ehrhardt 1989).

Marine fisheries landings data are available from FAO's FishStat database from 1950-2010 (www.fao.org/fishery/statistics/en). FAO data are based on national fisheries statistics supplied by its member countries. Therefore, the quality and accuracy of the data depend on the statistical collection within each member country, and the proper transfer of these data to FAO. Data as represented by FAO on behalf of various countries have been the foundation of many global fisheries studies (Pauly *et al.* 1998), however they are often incomplete (Zeller *et al.* 2006; Zeller *et al.* 2007). Data supplied to FAO often include only

commercial landings and rarely account for other fisheries catch components such as subsistence catches, Illegal, Unreported and Unregulated (IUU) catches, and discarded bycatch.

The objective of this study is to estimate Guyana's total marine fisheries catches from 1950-2010, including catches taken by commercial and non-commercial components of Guyana's domestic fisheries, as well as discards. The purpose of these estimates is to provide a more comprehensive estimate of total marine fisheries extractions from Guyanese waters, in order to serve as a scientific baseline in the face of continued fisheries exploitation and climate change.

METHODS

Total marine fisheries catches for Guyana were estimated from 1950-2010 by estimating catches from the large-scale commercial, artisanal (small-scale commercial) and subsistence (non-commercial) sectors. Specifically, estimates were made for catches in Guyanese EEZ waters that were considered part of the domestic fisheries. These include the domestic catches that were destined for the local market, and those caught for subsistence. The estimate also includes catches by the Guyanese component of the trawl fishery for seabob, finfish and shrimp, and associated discarded bycatch. We compared the total of all domestic fisheries components from 1950-2010 to total landings as supplied to FAO for this same period.

Population

Human population data were obtained from national censuses presented by the Guyana Bureau of Statistics for the years 1960, 1970, 1980, 1991 and 2002, and presented in British Annual Colonial Reports (Anon. 1946, 1947, 1948, 1949, 1950, 1951, 1952, 1953, 1954, 1955, 1956, 1957, 1958, 1959, 1960, 1961; Beaie 2007) in order to calculate *per capita* consumption and subsistence catch rates. Since census data were only available for some years, linear interpolations were done between years of reported data to estimate a complete time series of population data (Figure 2). We assumed that the entire population consumed marine fish, as the majority of the population lives along the coast.

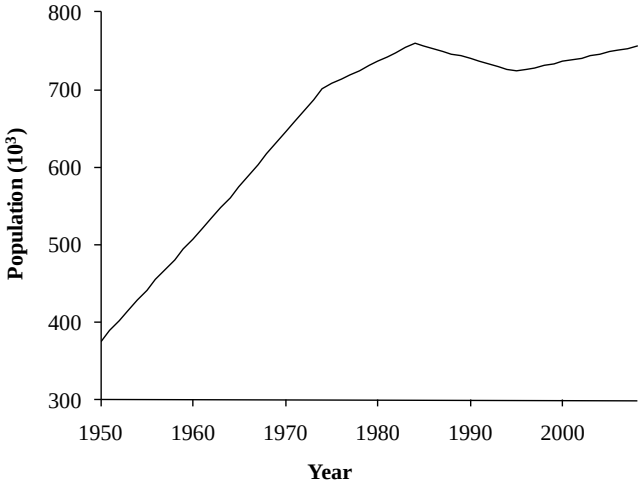

Figure 2. Human population of Guyana for the period 1950-2008.

Domestic fisheries

Subsistence fishery:

To derive estimates of subsistence catches, we used a supply-demand approach. This approach assumed that the supply of fish and fish products, including domestic production, adjusted for imports and excluding exports, was the amount available to the local population for consumption. We calculated the artisanal supply destined for local consumption in 1978 as this was a year with no reported imports, and we assumed that the artisanal catch (small-scale commercial) was consumed locally, whereas the large-scale commercial catch (mainly shrimp) was exported (Chackalall and Dragovich 1982; Anon. 2000). Further, we assumed that the consumption rate in 1950 was the same as in 1978. Using domestic production in 1950 as presented in the British Annual Colonial Report, we estimated the amount of additional production needed to meet the consumption demand. We took this amount as that supplied by the subsistence sector to meet the country's seafood consumption demands.

More specifically, we used the following equation:

$$\textit{per capita artisanal supply} = \frac{\textit{(national production + imports – exports)}}{\textit{population}}$$

As previously mentioned, in 1972 the Government of Guyana instituted a ban on the importation of fish and fish products. Since near-zero imports were reported for 1972 until 1993, we assumed that this ban remained in place for many years, and that the importation of fish and fish products began again in 1993. Therefore, between 1972 and 1993, we assumed that the large-scale commercial production was exported and therefore artisanal production represented the supply of seafood available for consumption. The *per capita* artisanal supply for 1978 was calculated to be 24.5 kg·person^{-1}·year^{-1} (Table 1).

In 1950, we assumed a consumption rate similar to that in 1978. We also assumed that in 1950 the local demand for seafood was met, in part, through artisanal catch with the remaining amount being supplied by the subsistence (non-commercial) sector. Using the estimated supply of seafood in 1950 and our assumption-based estimate of overall consumption, we calculated the subsistence catch rate for 1950, as per the following equation:

per capita subsistence catch= (1978 per capita consumption) – (1950 per capita artisanal supply)

In order to determine *per capita* consumption for 1978, we used the following equation:

$$\textit{per capita consumption} = \frac{\textit{[national production + imports (if applicable)]} – \textit{exports (if applicable)}}{\textit{population}}$$

Over time, subsistence catches likely decreased due to the re-introduction of fish imports as well as improved access to local markets, increasing reliance on a cash-economy and better processing and storage facilities (which would allow for the growth of both small- and large-scale commercial fisheries). Therefore, we assumed that the *per capita* subsistence catch rate in 2000 was 10% that of the 1950 *per capita* subsistence catch rate, which was 22.5 kg·person^{-1}·year^{-1} (Table 1). The 2000 per *capita* rate was carried forward to 2010 unaltered.

We calculated the *per capita* consumption rate for years that exports, imports and national production data were available. Using our consumption estimate, we then calculated subsistence as per the above calculation. To derive *per capita* subsistence catch rate for years with missing data, we interpolated linearly between years of known data.

Table 1. Breakdown of *per capita* consumption rates used in estimating the catch by the subsistence fishery. Catch rates were interpolated for intermediate years.

Year	Consumption rate (kg·person^{-1}·year^{-1})	Source(s)	Subsistence catch rate (kg·person^{-1}·year^{-1})	Source(s)
1950	24.5	(Chackalall and Dragovich 1982; Anon. 2000)	22.5	Assumption
1978	24.5	(Chackalall and Dragovich 1982; Anon. 2000)	8.8	Interpolated
2000	-	-	2.5	Assumption

Artisanal fishery:

FAO data were compared to national data and were found to be equivalent. The penaeid shrimp, and the seabob and finfish fishery were considered large-scale fisheries, while the remaining catch represented by the FAO data was considered to be small-scale commercial (artisanal).

We assumed that boat owners who are members of fishers' cooperatives are registered, and that their catches are reported. However, only 60-70% of Guyanese boat owners are members of fishers cooperatives; therefore, we estimated that 30% of boat owners (and therefore 30% of the total catch by the artisanal fishery) were unaccounted for in the reported data (Shepherd *et al.* 1997; Anon. 2000). We therefore added 30% to the artisanal catch across the entire time period.

Red snapper fishery

The red snapper fishery of Guyana has operated as a fleet of 7-11 vessels since the 1970s. Initially using handlines, there was a decline in the fishery between 1970 and 1995 when operators began using drift seines and saw a decrease in their efficiency (Anon. 2006). As of 2006, the red snapper fishery of Guyana consisted of 45 vessels. Over the years, Guyana leased vessels from Venezuela to use in the red snapper fishery.

The catches by the artisanal red snapper fishery are reported to FAO as a separate category starting in 2000. Prior to this improved reporting, we assumed that red snapper was included in the miscellaneous marine fishes category. We assumed that the taxonomic breakdown associated with the artisanal fishery included a reasonable estimate for the domestic artisanal catch of red snapper, which allowed us to conservatively estimate red snapper catches for periods prior to better reporting that began in 2000.

Industrial fishery

Seabob and finfish fishery

The seabob and finfish fishery operates as part of the local industrial fishery. This fishery is limited to local ownership (Chakalall *et al.* 1989). Vessels will shift their operations to finfish or penaeid species, when seabob resources are scarce, since the same gear can be used in the penaeid shrimp fishery (Shepherd *et al.* 1997). Seabob and finfish are also exploited by the inshore artisanal fishery, but are considered here to be large-scale (Shepherd *et al.* 1997; Anon. 2000). These trawlers operate 15-30 km from the Guyanese shoreline (Shepherd *et al.* 1997).

Discarded bycatch

Trawler fleets that fish from Venezuela to northern Brazil targeting seabob (*Xiphopenaeus kroyeri)* have an average discard rate in excess of 70% (Kelleher 2005). Therefore, in order to estimate discards as a result of the seabob and finfish fishery, we applied a 70% discard rate to the total catch of seabob for the period 1981-2010. There was no seabob fishery prior to 1981.

Shrimp fishery

Data obtained from British Colonial Reports, as well as national data from the Guyanese Department of Fisheries were comparable with the data reported by the FAO under the category 'Penaeus shrimp nei', and therefore FAO data were assumed to be a good representation of industrial shrimp catches for the period of 1950-2010.

Discarded and landed bycatch

Discarded bycatch for the period 1950-1980 for the shrimp trawl fishery were calculated using a discard rate of 52.7% given by Kelleher (2005) for Guyana's shrimp trawl fisheries. In the 1970s, Guyana set a regulation that required all shrimping vessels to land 15 t of bycatch annually (Greenidge 1983; Anon. 2000). In order to remain conservative, we assumed that this regulation was effective, and therefore, there were no discards from this fishery from 1980-2010. Using the number of Guyanese-owned trawlers estimated by Greenidge (1983), we were able to estimate the amount of landed bycatch for this period by multiplying 15 t by the number of Guyanese-owned trawlers. However, depending on gear types, seasonal variation and the number of trips, it is possible that some boats caught less than 15 t of bycatch. Instead of quantifying landed bycatch based on the number of boats, we instead used the discard rate provided in Kelleher (2005) as a landed bycatch rate, as it was more conservative.

Foreign Fisheries

Shrimp fishery

Although catches by foreign fleets were not included in our total reconstruction of Guyanese fisheries catches, catches by U.S. vessels were estimated for the period 1957-1977, as well as Japanese vessels for the period 1969-1977.

In order to estimate catches and discards by U.S. vessels for the period 1972-1977, effort and catch per unit effort data were used (Jones and Dragovich 1977; Dragovich 1981; Dragovich and Coleman 1983). Since the U.S. did not begin trawling operations off the Guyana coast until 1957, we set the catch for 1956 as zero tonnes and interpolated between 1957 and 1972 for the years of missing data. After determining the catch for this time period, we applied the associated discards using the discard rate of 52.7% as per Kelleher (2005).

To estimate catches and discards by Japanese vessels, effort and catch per unit effort data were estimated from a report by Kawahara (1982). After determining the catch for this time period, we applied the associated discards using the discard rate of 52.7% as per Kelleher (2005).

Since Guyana declared its EEZ in 1977, and no access agreements could be found between Guyana and the U.S. or Guyana and Japan, we assumed that these foreign vessels were no longer fishing in Guyanese waters after 1977.

Taxonomic Breakdown

The species composition for artisanal catches was derived using information in Chackalall and Dragovich (1982) and a report by the Guyanese Department of Fisheries (Anon. 2006) (Table 2). Chackalall and Dragovich (1982) provide an estimate of the annual catch by gear-type used in the artisanal fleet. We then calculated the proportion of the catch taken by each gear-type, and used the report by the Guyanese Department of Fisheries (Anon. 2006) to determine the main species that are caught by each gear-type (Table 2). We assigned 60% of the derived artisanal catch to the species breakdown by gear type, and the remaining 40% to be represented as 'miscellaneous marine fishes' (MMF).

The species composition for subsistence catches in Guyana was assumed to be similar to that for artisanal catches. However, the artisanal fishery did not catch seabob and whitebelly shrimp, which are caught closer to shore. In order to remove these species from the breakdown, we redistributed the proportion of catch of those two species to the remaining species caught by the Chinese seine gear type. Therefore, for the artisanal breakdown of catch by Chinese seine, 60% of catch was bangamary (*Macrodon ancylodon*) and butterfish (*Nebris microps*) with the remaining 40% of the catch as 'Miscellaneous Marine Fishes'.

Table 2. Taxonomic composition for the Guyanese artisanal and subsistence fisheries derived from reports by Chackalall and Dragovich (1982) and (Anon. 2006).

Taxon name (% of catch by gear type)	Family	Common name	% of catch
Gill net (45%)			
Arius grandicassis	Ariidae	Gillbacker catfish	3.38
Carcharhinus spp.	Carcharhinidae	Sharks	3.38
Cynoscion acoupa	Sciaenidae	Grey snapper	3.38
Cynoscion jamaicensis	Sciaenidae	Bashaw	3.38
Cynoscion virescens	Sciaenidae	Sea trout	3.38
Lobotes surinamensis	Lobotidae	Pargee	3.38
Scomberomorus maculatus	Scombridae	Spanish mackerel	3.38
Megalops atlanticus	Megalopidae	Tarpon	3.38
Miscellaneous Marine Fishes			18.03
Handlines (29.5%)			
Lutjanus campechanus	Lutjanidae	Red snapper	5.92
Lutjanus synagris	Lutjanidae	Lane snapper	5.92
Rhomboplites aurorubens	Lutjanidae	Vermillion snapper	5.92
Miscellaneous Marine Fishes			11.83
Chinese Seine (8.5%)			
Macrodon ancylodon	Sciaenidae	Bangamary	1.27
Nebris microps	Sciaenidae	Butterfish	1.27
Nematopalaemon schmitti	Palaemonidae	Whitebelly shrimp	1.27
Xiphopenaeus kroyeri	Penaeidae	Atlantic seabob	1.27
Miscellaneous Marine Fishes			3.38
Cadell Line (8.5%)			
Arius parkieri	Ariidae	Gillbacker catfish	1.27
Arius phrygiatus	Ariidae	Kwakwari	1.27
Bagre bagre	Ariidae	Sea catfish	1.27
Carcharhinus spp.	Carcharhinidae	Sharks	1.27
Miscellaneous Marine Fishes			3.38
Pin Seine (8.5%)			
Ariidae	Ariidae	Catfish	0.85
Centropomus spp.	Centropomidae	Snook	0.85
Macrodon ancylodon	Sciaenidae	Bangamary	0.85
Micropogonias furnieri	Sciaenidae	Golden croaker	0.85
Mugil spp.	Mugilidae	Mullet	0.85
Mugilidae	Mugilidae	Mullet	0.85
Miscellaneous Marine Fishes			3.38

The main species harvested by the commercial shrimp fishery are brown shrimp (*Penaeus subtilis)*, pink-spotted shrimp (*P. brasiliensis)*, pink shrimp (*P. notialis)*, and whitebelly shrimp (*P. schmitti)*, with finfish and small amounts of squid (*Loligo pealeii*, *Loligo plei*) and lobster *(Panulirus argus, Panulirus guttatus, Panulirus laevicauda*) as bycatch (Dragovich 1981; Anon. 2006). Data regarding the species composition of catches of the Guyana coast were used in order to determine the proportion of the species caught by trawlers. Pink shrimp are found in small numbers off the coast of Guyana, and whitebelly shrimp are caught in even smaller quantities. Neither species is thought to constitute more than 5% of the total catch, therefore we assumed that each of these species represented 5% of the total catch (Furnell 1982; Dragovich and Coleman 1983). We estimated, based on species composition studies, that brown shrimp represent 41.15% of the total catch, pink-spotted shrimp represent 19.15%, with the remaining 29.7% classified as 'penaeid nei' (Jones and Dragovich 1977; Dragovich and Coleman 1983).

The species composition for the landed and discarded bycatch by the shrimp fisheries (local and foreign) and the seabob and finfish fishery were taken from Furnell (1982) (Table 3). Landed bycatch were assumed to be the 'marketable species', which Furnell (1982) describes as being valued in the bycatch, present in sufficient abundance and size. Discarded bycatch were assumed to be what Furnell (1982) describes as the 'less-marketable' and 'unmarketable species'. Less-marketable species are those that are less abundant, have poor storage qualities, are small, or have only limited use in other areas, whereas the unmarketable species are poisonous fish or those suspected of being poisonous. All species listed were cross-referenced in FishBase (Froese and Pauly 2010) to verify common names, species names, families and distributions.

Table 3. Taxonomic composition of landed bycatch and discarded bycatch by the national and foreign penaeid fisheries, as well as the seabob and finfish fishery derived from Furnell (1982).

Taxon name	Family	Common name	% of catch
Landed			
Bothids	Bothidae	Flounder	46.53
Conodon nobilis	Haemulidae	Barred grunt	0.67
Dactyloptena volitans	Dactylopteridae	Flying gurnard	36.56
Eucinostomus argenteus	Gerreidae	Silver mojarra	3.15
Haemulon aurolineatum	Haemulidae	Tomtate grunt	0.84
Haemulon steindachneri	Haemulidae	Chere-chere grunt	1.51
Harengula jaguana	Clupeidae	Scaled herring	0.07
Menticirrhus americanus	Sciaenidae	Southern kingcroaker	1.51
Otholithes ruber	Sciaenidae	Tigertooth croaker	3.25
Pomadasys carvinaeformis	Haemulidae	Roughneck grunt	1.27
Priacanthus arenatus	Priacanthidae	Atlantic bigeye	0.97
Pristipomoides macropthalamus	Haemulidae	Dara	0.50
Rhomboplites aurorubens	Lutjanidae	Vermillion snapper	2.48
Selene setapinis	Carangidae	Atlantic moonfish	0.67
Discarded			
Bairdiella ronchus	Sciaenidae	Ground croaker	1.66
Bellator militaris	Triglidae	Horned searobin	7.43
Chaetodipterus faber	Ephippidae	Atlantic spadefish	1.49
Chilomycterus spp.	Diodontidae	Burrfish, Spiny Boxfish	0.38
Chloroscombrus chrysurus	Carangidae	Atlantic bumper	5.26
Ctenosciaena gracilicirrhus	Sciaenidae	Barbel drum	2.86
Cynoscion arenarius	Sciaenidae	Sand weakfish	2.80
Diapterus rhombeus	Gerreidae	Caitipa mojarra	0.29
Mullids	Mullidae	Goatfish	8.06
Polydactylus octonemus	Polynemidae	Atlantic threadfin	0.11
Porichthys porosissimus	Batrachoididae	Toadfish	29.26
Prionotus rubio	Triglidae	Blackwing searobin	36.98
Sphoeroides spp.	Tetraodontidae	Pufferfish	2.92
Sphyraena guachancho	Sphyraenidae	Guachanche Barracuda	0.17
Trichiurus lepturus	Trichiuridae	Largehead hairtail	0.34

RESULTS

Reconstructed total catch

The reconstructed total domestic catch for Guyana, excluding U.S. and Japanese catches, was estimated to be approximately 2.7 million t for the period 1950-2010 (Figure 3a). This total is 1.59 times the officially reported catch of 1.5 million t as presented in the FAO landings statistics on behalf of Guyana (Figure 3a). The largest components of the reconstructed total catch were the unreported subsistence and the underreported artisanal catches, which were estimated to be approximately 750,000 t and represented 25% of the total catch

(Figure 3a). Of note is the increasing concentration of industrial catches to total catches starting in the early 1990s, while the artisanal sector experience a proportional decline. This is a result of the artisanal catches being an artifact of removing industrial catches from total catches. Improvements could be made in future studies to calculate artisanal catches independently, instead of as a by-product of excluding industrial catches. Miscellaneous marine fishes constituted the majority of the catch (25%), followed by seabobs (*Xiphopenaeus kroyeri*; 11%) and flounders (Bothidae; 4%). Snappers also represented a substantial portion of reconstructed total catches (12%), with each of the following snapper taxon composing 4% each of total catches; Vermillion snapper (*Rhomboplites aurorubens*; 4%), southern red snapper (*Lutjanus purpureus*; 4%) and lane snapper (*Lutjanus synagris*; 4%). The other 47% of reconstructed total catches are represented by species from 55 other taxonomic categories (Figure 3b).

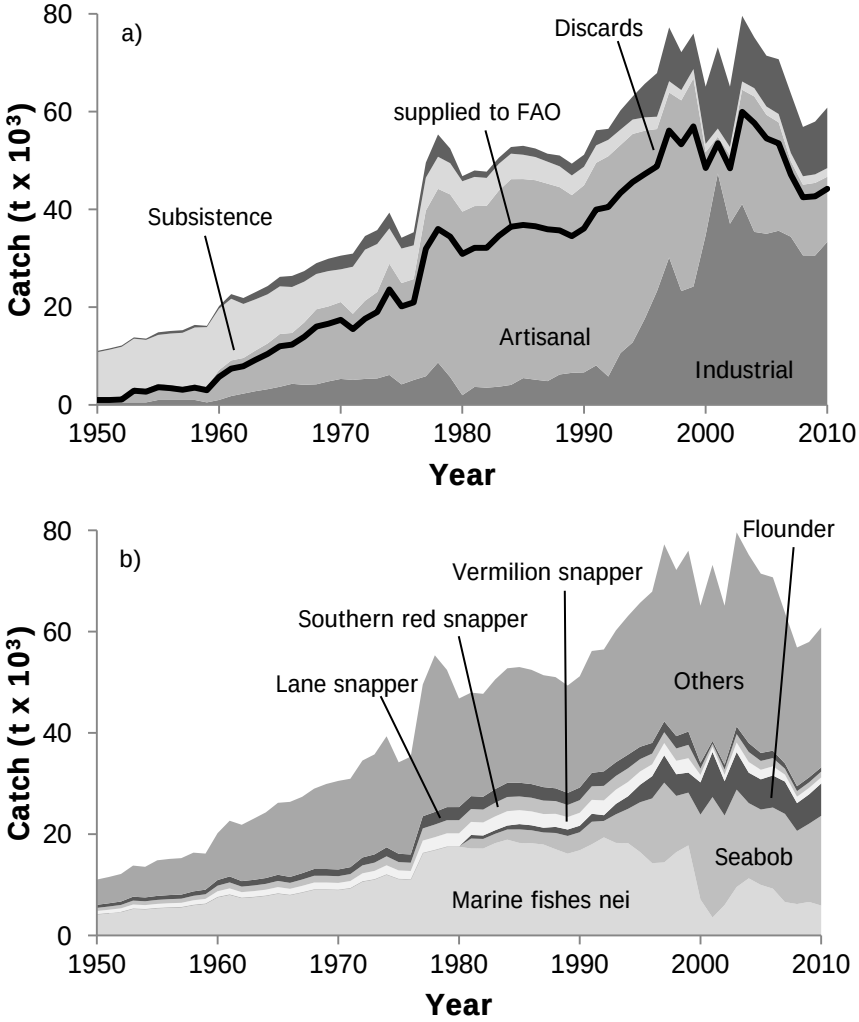

Figure 2: Reconstructed total catch of Guyana by a) sector with discards shown separately. Solid line represent FAO landings, and b) by taxonomic composition with "others" consisting of 23 taxonomic categories.

Subsistence fishery

Subsistence catches were estimated to be 9,600 t in 1950, increasing to a peak of 12,600 t in 1961 and then decreasing to 1,760 t in 2010 (Figure 4). Reconstructed total catches by the subsistence sector over the period 1950-2010 were estimated to be 6,230 t·year^{-1}, which represents an addition of 14% to reported landings. Landings of red snapper by the subsistence fishery were estimated to be 368 t·year^{-1} for 1950-2010 (Figure 5).

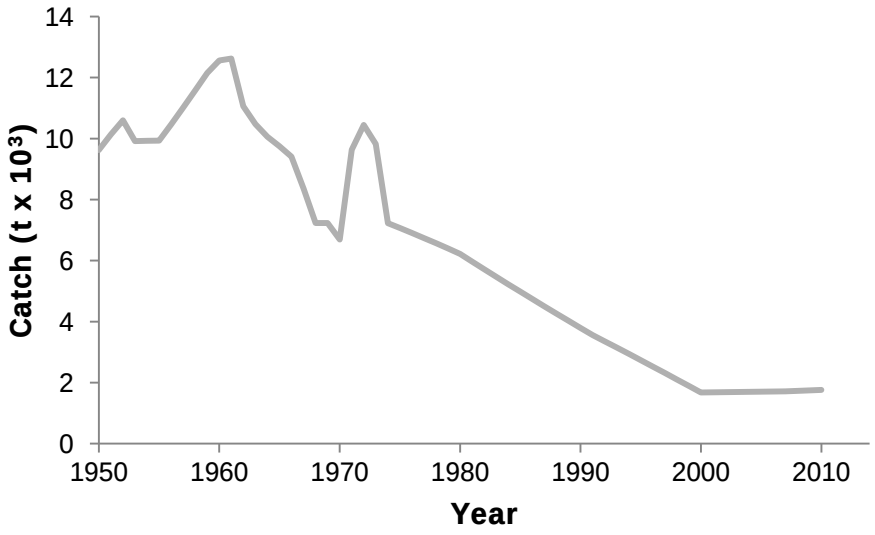

Figure 4: Estimated catches by the Guyanese subsistence fishery

Artisanal fisheries

The total landings of red snapper by the artisanal red snapper fishery for the period 1950-2010 were estimated to be approximately 1,300 t·year^{-1} (Figure 5). This estimation included the data supplied to FAO for the period 2000-2010.

The total landings reported by the FAO for the period 1950-2010, excluding shrimp, seabob and finfish landings, were greater than 1 million t (Figure 6). As we determined that 22.5% of catches were not reported, the total artisanal fisheries sector is represented by 1.3 million t. Reconstructed total artisanal catches were estimated to be 650 t in 1950, increasing to a peak of 45,100 t in 1992 before decreasing to 13,000 t in 2010.

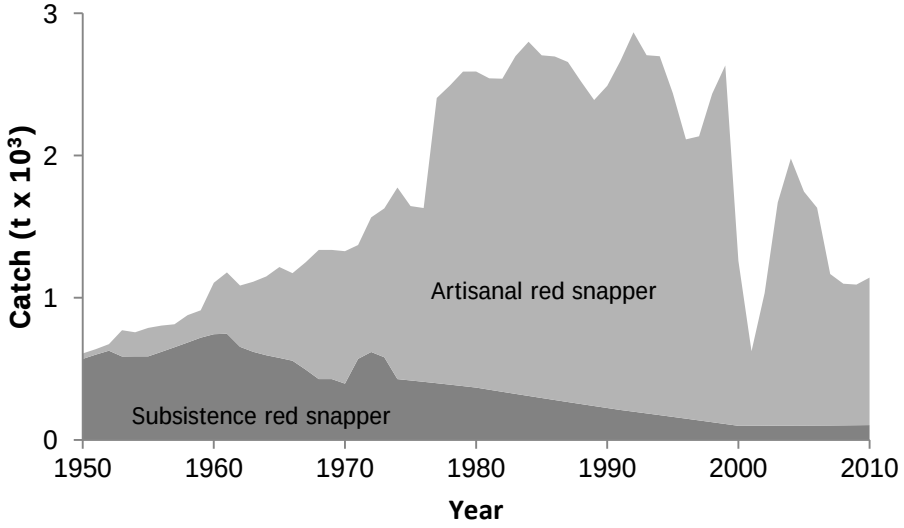

Figure 5: Subsistence and artisanal red snapper fisheries

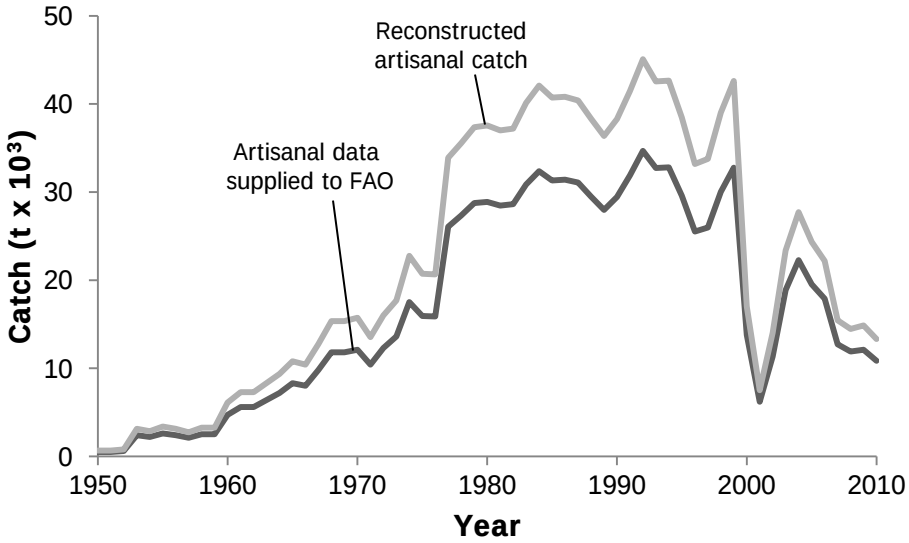

Figure 6: Reconstructed artisanal catch compared to FAO artisanal landings for Guyana, 1950-2010.

Industrial fisheries

The large-scale commercial fishery for seabob and finfish began in the early 1980s. From 1981-2010, Guyanese vessels participating in the seabob and finfish fishery were estimated to catch approximately 509,000 t (293,000 t of seabob and 216,000 t of finfish). Discards by the seabob and finfish fishery were estimated to be 205,000 t for the period 1981-2010 (Figure 7). Catches and discards by the seabob and finfish fishery were estimated to be 4,600 t in 1980, increasing to a peak of 58,000 t in 2001 and then decreasing to 43,000 t in 2010.

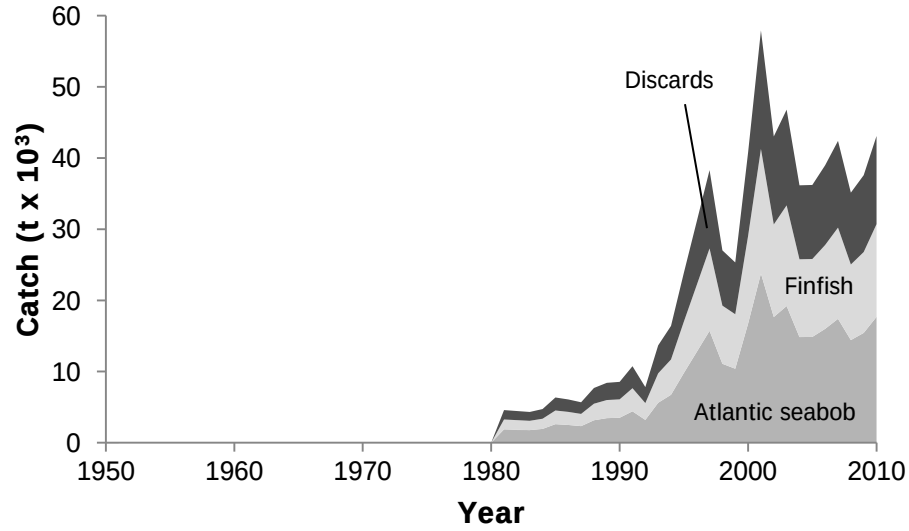

Figure 7: Estimated catches and discards by the Guyanese seabob and finfish fishery.

The Guyanese shrimp fisheries were estimated to catch approximately 138,000 t between 1950-2010 (Figure 8). Estimated discards for the 1950-1980 period from the shrimp trawl fishery were substantial, with Guyanese vessels discarding 51,600 t of bycatch. Landed bycatch amounted to 21,000 t for the period of 1981-2008 once compulsory bycatch landing rules came into effect (Figure 8). Catches and discards by the shrimp fishery were estimated to be 760 t in 1950, increasing to a peak of 13,000 t in 1978 and then decreasing to 2,100 t in 2010.

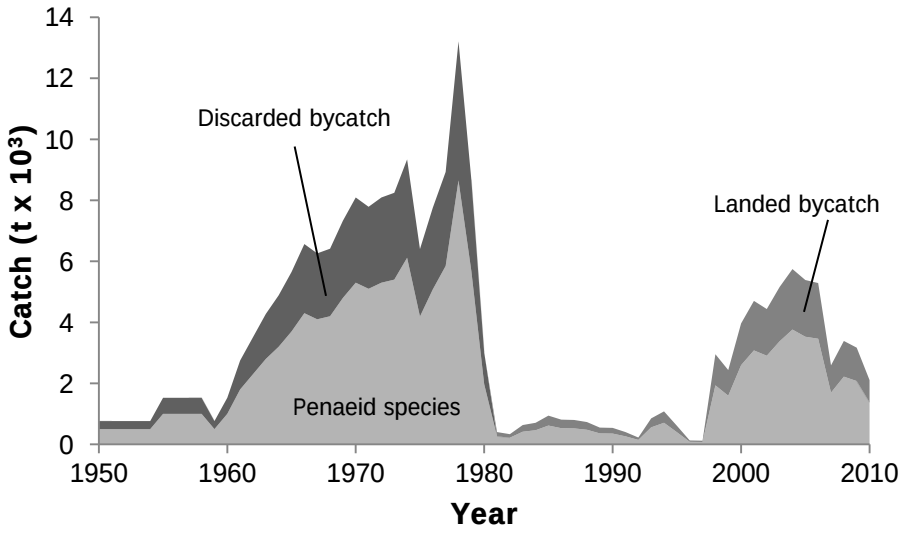

Figure 8: Estimated catches including landed and discarded bycatch by the Guyanese shrimp fishery.

Foreign fisheries:

Our total reconstruction estimates of Guyanese fisheries catches did not include foreign fisheries. However, catches by U.S. vessels were estimated for the period 1957-1977, and Japanese vessels for the period 1969-1977, and are reported here (Figure 9). We estimated the total catch for the period 1957-1977 by U.S. trawlers in Guyanese waters to equal 14,000 t. We also estimated the associated discards to be 5,000 t. We estimated catches by Japanese vessels in Guyanese waters for the period 1969-1977 to be approximately 7,400 t, and discards to be 3,900 t.

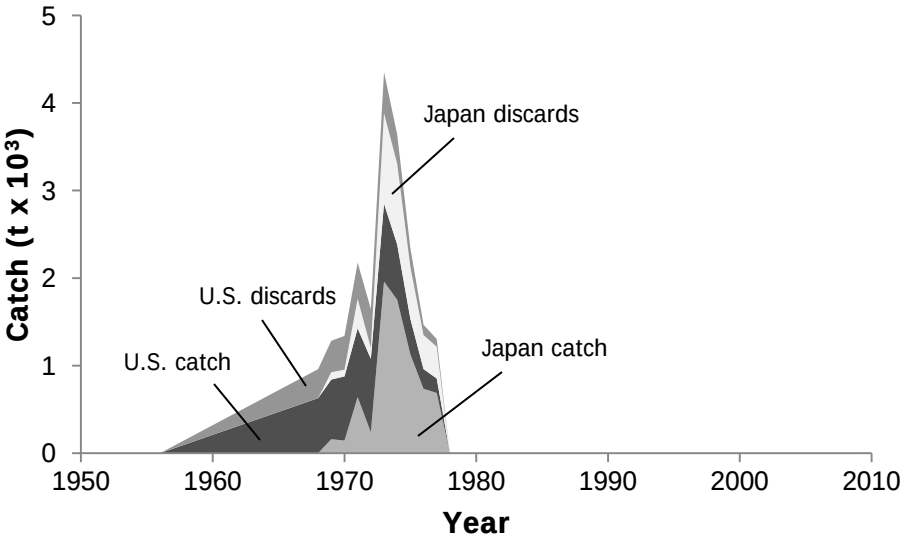

Figure 9: Estimated catches and discards by the United States vessels in Guyanese waters for the period 1957-1977, and for Japanese vessels for the period 1969-1977.

DISCUSSION

Total marine fisheries catches by Guyana from 1950-2010 were estimated to be approximately 2.7 million t. This reconstructed catch is 1.54 times the amount reported by the FAO on behalf of Guyana. This discrepancy is due mainly to underreported artisanal catches, unreported subsistence catches and industrial fisheries discards in Guyanese waters that were included in our reconstruction, but that are currently not accounted for in the data provided to the FAO. Our reconstruction incorporated all domestic fisheries which included subsistence fisheries catches, artisanal commercial catches for the local market, subsistence fisheries catches, the industrial shrimp fishery, the industrial seabob and finfish fishery and discarded bycatch from the seabob and shrimp fisheries.

FAO data for Guyana present landings for the artisanal sector, shrimp fishery and seabob and finfish fisheries. Landings by the shrimp and seabob fisheries, as presented by FAO, were similar to those obtained from independent and national reports. The drastic decrease in penaeid catches coincides with the introduction of new regulations, as well as an increase in catches by the seabob fishery. This expansion may have been due to fewer regulations and the accessibility of this fishery. Artisanal catches were underestimated by 23%, while subsistence catches were completely unaccounted for. The largest added components of our reconstruction were subsistence catches and the unreported catches by the artisanal fishery, which were estimated to be approximately 302,000 t and 380,000 t, respectively.

Reported landings for Guyana's marine fisheries underestimate the amount of fish actually being caught. Due to resource limitations, the Guyanese Department of Fisheries struggles to monitor and manage the various fisheries of Guyana efficiently (National Development Strategy, 1996; National Development Strategy, 2006). The total marine fisheries catch estimates shown in this report account for subsistence catches, unlicensed artisanal catches and discarded bycatch. The reconstruction of the Guyanese fisheries catches establishes the inconsistencies between the officially reported fisheries landings and the estimated total catch. In order to effectively manage its fisheries and preserve the resource that provides food, employment and economic benefit to the entire country, Guyana needs to better account for all catches from its waters. Factors that commonly contribute to the limited capabilities for management of a fishery include: a limited amount of

trained personnel, lack of financial support for gathering information independently of landings, and a lack of well-defined programs to evaluate resources on a permanent basis (Salas *et al.* 2007). One option is to develop a survey approach to estimate total resource extractions every 2-5 years (depending on funding) complemented with interpolations between survey years, thereby providing a better account of the status of the fishery (Zeller *et al.* 2007).

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Appendix Table A1: FAO landings vs. reconstructed total catch (in tonnes), and catch by sector with discards shown separately, for Guyana, 1950-2010.

Year	FAO landings	Reconstructed total catch	Industrial	Artisanal	Subsistence	Discard
1950	1,000	11,000	500	650	9,620	264
1951	1,000	11,500	500	650	10,140	264
1952	1,100	12,100	500	780	10,600	264
1953	2,900	13,800	500	3,120	9,910	264
1954	2,700	13,600	500	2,860	9,930	264
1955	3,600	14,800	1,000	3,380	9,930	527
1956	3,400	15,100	1,000	3,120	10,460	527
1957	3,100	15,300	1,000	2,730	11,010	527
1958	3,500	16,400	1,000	3,250	11,570	527
1959	3,000	16,200	500	3,250	12,150	264
1960	5,700	20,200	1,000	6,110	12,560	527
1961	7,400	22,600	1,800	7,280	12,620	949
1962	7,900	21,900	2,300	7,280	11,060	1,212
1963	9,200	23,100	2,800	8,320	10,470	1,476
1964	10,400	24,300	3,200	9,360	10,060	1,686
1965	12,000	26,200	3,700	10,790	9,750	1,950
1966	12,300	26,400	4,300	10,400	9,410	2,266
1967	13,900	27,400	4,100	12,740	8,360	2,161
1968	16,000	29,000	4,200	15,340	7,230	2,213
1969	16,600	29,900	4,800	15,340	7,230	2,530
1970	17,400	30,500	5,300	15,730	6,690	2,793
1971	15,500	30,900	5,100	13,520	9,630	2,688
1972	17,600	34,500	5,300	15,990	10,450	2,793
1973	19,000	35,700	5,400	17,680	9,820	2,846
1974	23,617	39,300	6,117	22,750	7,230	3,224
1975	20,123	34,200	4,192	20,710	7,070	2,209
1976	20,956	35,300	5,080	20,639	6,900	2,677
1977	31,907	49,500	5,848	33,877	6,740	3,082
1978	35,978	55,300	8,652	35,524	6,570	4,560
1979	34,413	52,400	5,682	37,350	6,390	2,994
1980	30,849	46,800	1,974	37,538	6,220	1,040
1981	32,117	48,300	2,306	38,754	5,970	1,317
1982	32,113	48,100	2,180	38,913	5,720	1,280
1983	34,566	50,900	2,439	41,765	5,470	1,242
1984	36,439	53,100	2,685	43,881	5,220	1,359
1985	36,779	53,500	3,605	43,127	4,980	1,826
1986	36,530	53,000	3,352	43,131	4,740	1,747
1987	35,915	51,900	3,177	42,560	4,500	1,633
1988	35,680	51,700	3,935	41,269	4,260	2,210
1989	34,504	50,100	4,041	39,602	4,030	2,418
1990	36,072	51,900	4,087	41,581	3,790	2,457
1991	39,941	57,100	4,844	45,626	3,560	3,088
1992	40,452	57,200	3,446	48,108	3,360	2,246
1993	43,323	61,400	6,535	47,824	3,150	3,930
1994	45,567	64,500	7,916	48,947	2,940	4,716
1995	47,200	67,800	10,488	47,726	2,740	6,860
1996	47,783	69,400	13,879	44,075	2,530	8,926
1997	53,373	77,100	18,601	45,204	2,320	11,004
1998	52,215	73,100	15,512	47,713	2,100	7,764
1999	53,241	73,300	16,864	47,290	1,890	7,277
2000	48,087	69,200	22,227	33,618	1,680	11,713
2001	52,605	77,200	31,856	26,974	1,680	16,640
2002	47,217	68,100	24,373	29,697	1,690	12,361
2003	58,895	83,800	26,344	42,316	1,690	13,444
2004	55,919	77,700	23,593	42,024	1,700	10,389
2005	52,570	73,500	23,128	38,275	1,700	10,404
2006	52,963	74,900	22,866	39,126	1,710	11,200
2007	46,648	68,000	21,639	32,512	1,710	12,183
2008	41,368	59,600	19,927	27,874	1,730	10,094
2009	42,805	62,400	19,361	30,478	1,750	10,799
2010	44,386	65,500	21,043	30,346	1,760	12,380

Appendix Table A2: Reconstructed total catch (in tonnes) by major family for Guyana, 1950-2010. "Others" contain 23 additional taxonomic categories.

Year	Sciaenidae	Lutjanidae	Seabob	Ariidae	Penaeidae	Triglidae	Others
1950	1,510	1,820	122	825	475	117	6,160
1951	1,590	1,910	129	867	475	117	6,460
1952	1,670	2,020	135	914	475	117	6,810
1953	1,970	2,310	126	1,047	475	117	7,750
1954	1,930	2,270	126	1,028	475	117	7,600
1955	2,040	2,360	126	1,069	950	234	8,060
1956	2,070	2,410	133	1,092	950	234	8,220
1957	2,080	2,440	140	1,104	950	234	8,320
1958	2,250	2,630	147	1,191	950	234	8,950
1959	2,310	2,730	154	1,237	475	117	9,140
1960	2,880	3,310	159	1,500	950	234	11,160
1961	3,110	3,530	160	1,599	1,710	421	12,120
1962	2,910	3,260	140	1,474	2,185	538	11,350
1963	3,020	3,340	133	1,510	2,660	655	11,750
1964	3,150	3,450	128	1,560	3,040	749	12,230
1965	3,370	3,650	124	1,650	3,515	866	13,020
1966	3,280	3,520	119	1,592	4,085	1,006	12,780
1967	3,510	3,740	106	1,695	3,895	959	13,440
1968	3,790	4,010	92	1,813	3,990	983	14,300
1969	3,820	4,010	92	1,813	4,560	1,123	14,480
1970	3,830	3,980	85	1,801	5,035	1,240	14,540
1971	3,870	4,110	122	1,860	4,845	1,193	14,950
1972	4,410	4,690	133	2,124	5,035	1,240	16,900
1973	4,610	4,880	125	2,210	5,130	1,264	17,520
1974	5,120	5,320	92	2,409	5,811	1,431	19,130
1975	4,680	4,930	90	2,232	3,982	981	17,280
1976	4,680	4,890	88	2,213	4,826	1,189	17,420
1977	6,920	7,210	86	3,263	5,556	1,369	25,140
1978	7,280	7,470	83	3,382	8,219	2,025	26,840
1979	7,450	7,760	81	3,515	5,398	1,330	26,880
1980	7,320	7,770	79	3,516	1,875	462	25,750
1981	7,510	7,940	1,958	3,593	251	585	26,500
1982	7,500	7,930	1,901	3,586	208	568	26,400
1983	7,950	8,390	1,843	3,795	394	551	27,990
1984	8,280	8,720	2,008	3,946	440	604	29,140
1985	8,160	8,550	2,672	3,866	586	811	28,890
1986	8,120	8,510	2,556	3,846	504	776	28,670
1987	7,980	8,360	2,390	3,781	498	725	28,130
1988	7,770	8,090	3,211	3,658	455	981	27,510
1989	7,460	7,750	3,505	3,506	342	1,074	26,450
1990	7,770	8,060	3,558	3,646	336	1,091	27,460
1991	8,460	8,740	4,457	3,952	251	1,371	29,890
1992	8,790	9,140	3,251	4,135	140	997	30,710
1993	8,840	9,060	5,654	4,096	530	1,745	31,510
1994	9,070	9,220	6,774	4,170	673	2,094	32,520
1995	8,980	8,970	9,835	4,055	380	3,046	32,550
1996	15,560	13,170	12,784	7,677	80	3,964	16,170
1997	16,050	13,460	15,749	7,852	75	4,886	19,050
1998	16,680	14,190	11,118	8,260	1,838	3,448	17,570
1999	16,460	14,020	10,420	8,171	1,515	3,231	19,500
2000	6,950	6,140	16,754	3,112	1,132	5,201	29,940
2001	6,270	5,140	23,792	2,516	1,698	7,389	30,350
2002	6,370	5,400	17,680	2,775	1,505	5,489	28,900
2003	8,600	7,530	19,226	3,896	1,161	5,970	37,420
2004	8,340	7,400	14,864	3,879	1,293	4,613	37,310
2005	7,700	6,670	14,885	3,556	1,021	4,620	35,060
2006	7,850	7,070	16,022	3,604	1,663	4,973	33,710
2007	6,690	6,420	17,426	2,967	657	5,410	28,480
2008	5,750	5,620	14,442	2,558	931	4,482	25,840
2009	6,290	5,910	15,449	2,808	747	4,795	26,380
2010	6,330	6,170	17,708	2,768	854	5,497	26,210