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# Over-looked and under-reported: A catch reconstruction of marine fisheries in the Canary Islands, Spain, 1950 – 2010

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## Abstract

Total marine fisheries catches within the Exclusive Economic Zone (EEZ) of the Canary Islands, Spain, were reconstructed to include catches of the various small-scale artisanal fleets and their discards, as well as subsistence, recreational, and other unreported catch. Total reconstructed catch was estimated at 38,600 t in 1950, increasing to 81,200 t in 1985, declining to approximately 43,700 t·year$^{-1}$ in the early-2000s and finally spiking to about 65,300 t·year$^{-1}$ by the late-2000s. These catches coincide with a severe depletion of fish stocks, especially those of bentho-demersal species, due in part to fishing overcapacity in the artisanal sector, despite attempts to limit effort by the government. Only starting in 2006 were catches reported in national statistics and from 2006 to 2010 reconstructed catch was seven times the reported catch. Nearly 70% of this catch was from the recreational fishing sector, due in part to technological advancements and increased investments in the construction and improvement of secondary ports.

## Introduction

The Canary Islands are an archipelago composed of seven main islands located approximately 100 km from the northwest coast of Africa (Figure 1). Due to their political designation as an autonomous community of Spain, they are the southern-most point of the European Union (EU) and thus are in a geographically unique position as a navigation base between Europe, Africa, and the Americas. Another distinguishing trait of the archipelago is its role as a barrier to the Canary Current and the northern trade winds that generate the upwelling system of the Northwest African coast, one of the richest regions worldwide in fishery production (Barton *et al.* 1998; Pelegrí *et al.* 2005; Aristegui *et al.* 2006). In contrast to the neighboring African coast, the productivity of waters within the Exclusive Economic Zone (EEZ) of the Canary Islands are low (Bas *et al.* 1995), compounded by the narrow insular shelf which limits demersal life. While the abundance is low, the species represented are extremely diverse, with approximately 200 species targeted in small-scale fishing operations alone (Pascual 2004; Santamaría *et al.* 2013).

Industrial fishing operations (i.e., large-scale) generally take place outside the EEZ of the Canary Islands, where the fishing grounds are considerably more productive, e.g., sardine and cephalopod fishing off Western Sahara. These catches are nonetheless landed in the large port of Las Palmas for transport to Europe and are generally reported by the Fishery Committee for the Eastern Central Atlantic (CECAF). Unfortunately, the archipelago has also been a well-known center of illegal fishing activities, where half of all the EU vessels operating under flags of convenience reside (Pramod *et al.* 2006). The port of Las Palmas in the Canary Islands is a major entry point to the EU market for illegal products, including illegally caught fish products (Pramod *et al.* 2006). A series of catch reconstructions has already been performed to estimate the true withdrawals from the West African waters (e.g., Belhabib *et al.* 2012; Belhabib *et al.* 2014) including those by industrial fleets based in the Canary Islands. Thus, industrial operations are not the focus of the present paper; rather, we aim to reconstruct catch for various small-scale fishing sectors, i.e. artisanal (along with bait and discards), subsistence, and recreational catch that occurred within the EEZ of the Canaries from 1950 to 2010.

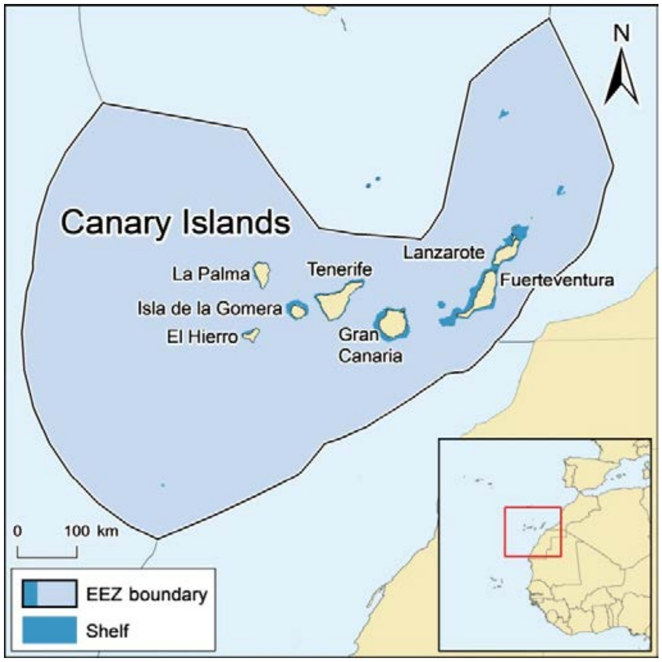


**Figure 1**. The Exclusive Economic Zone (EEZ) and shelf waters (to 200 m depth) of the Canary Islands.

Since most attention for this fishery has traditionally been placed on the industrial operations, these small-scale sectors have been over-looked, and hence catch from these fisheries has been severely under-reported. A system of regular reporting by the Canarian government was only established in 2006, and we assumed that these catches were reported by Spain to the FAO. Nevertheless, this cannot be verified because Spanish catches in the Central East Atlantic are consolidated with no distinction as to the waters from where catch was taken. Additionally, while catch of tuna and tuna-like species has been assembled by the Spanish Oceanography Institute (IEO) since 1970 and reported to ICCAT, these catches were not reported to the FAO, a point which will be further delved into in the section on methodology. To this end, we consider the small-scale fisheries of the Canary Islands to be data-poor fisheries and in the following section we briefly introduce their history.

**Small-scale fisheries of the Canary Islands**

For most of the history of the islands, their relatively rich soils supported agriculture, the mainstay of the economy. Fishing was only carried out seasonally to supplement agriculture due to the low abundance of fish, low level of market exchange, and the difficulty of fishing in winter months due to strong northwest winds (Pascual 2004). Hence, fishing activities were of little significance until the 1900s when an increase in population and urbanization brought a new demand for fish for both the poor, who ate low-priced and salted fish, and for the rich, who ate higher valued white fish and crustaceans (Pascual 2004). During this time, fishing villages were established in the *calmas* or 'calms' of the islands, the southern regions of the islands which are sheltered from the strong northern trade winds by mountainous land masses and were otherwise relatively uninhabited (Pascual 2004). This was ideal for fishers who were able to fish tuna species during summer months and other bentho-demersal species during other seasons.

According to García-Cabrera (1970), tuna species were caught since the 1500s as a result of the unique location of the Canary Islands, which are located in the tuna migratory pathway. The most common tuna species are both the temperate—albacore (*Thunnus alalunga*) and Atlantic bluefin (*Thunnus thynnus*)—and the tropical tuna—bigeye

(*Thunnus obesus*)*,* skipjack (*Katsuwonus pelamis*) and yellowfin (*Thunnus albacares*). These highly migratory fish reach the islands from several areas of the Atlantic at different times of the year and are one of the main fishery resources of the Canary Islands (Delgado de Molina *et al.* 2014). In the 1830s, there are reports of local salted tuna on several islands, and in the 1920s numerous tuna canning factories sprung up among the islands (Pascual 2004). The fishing fleet targeting tuna species is highly diverse in size and equipment, with LOA between 3 and 35 meters and GRT between 1 and more than 200. The artisanal tuna fleet generally uses pole and line gear along with live bait of small pelagic species in order to lure tunas (Gillett 2012).

While some fishers exclusively target tunas, the vast majority only target tunas in the summer months when the abundance of tunas near the islands is high and the abundance of other species is relatively low. This fleet of fishers targets over 200 bentho-demersal and small pelagic species using on average 30 different gears (Santamaría *et al.* 2013). Although the fleet is heterogeneous, the types of boats can generally be grouped into three types of vessels: (i) undecked, multi-gear vessels measuring 5-8 m in length and motorized; (ii) polyvalent boats of 7-14 m long targeting both demersal and pelagic species around various islands of the archipelago; and (iii) traíñas, i.e., purse seiners, which are 10-16 m long and only fish small pelagic fishes with surrounding nets (Santamaría *et al.* 2013). Besides the introduction of the motor in the 1950s and 1960s, the small-scale fishing fleet operating in the Canary Islands has not suffered significant structural changes. In 2013, approximately 800 artisanal boats were, on average, 37 years old, 8.3 m in length (6.3 GRT), and equipped with 36.6 hp engines (MAAyMA 2013). Most of them target bentho-demersal species over nearly the entire year using mainly fish traps, and to a lesser extent gillnets and handlines (Rico *et al.* 2001). The artisanal fleet employed 1,457 men in 2012, a number which has declined significantly over time. Generally, small boats are manned by two fishers and larger ones by three to four fishers. Fishing is carried out at depths ranging between 18 m to over 300 m. Most ports are small, with only a few artisanal units carrying out extractive activities, frequently changing gears, and selling products through informal markets. For a long time, men and women from fishing villages sold fish directly to nearby cities, but this form of selling fish was abandoned towards the late 1980s due to changes in the law of fish commerce. Ultimately, co-operatives (cofradías), middlemen, and restaurants became involved with selling catch (Pascual 2004).

As fisheries greatly expanded in the 1950s and 1960s, due to changes in consumer habits and new demand from tourist and public service sectors, fishing stocks of the littoral zone have had significant pressure placed on them. In recent times, the abundance of these fishery resource has severely diminished due to the precarious ecosystem that is vulnerable to overfishing, especially of the highly prized demersal fishes that are extensively fished on the narrow shelf (Pascual 2004). This has been compounded by the human modification of the shoreline and pollution from the construction of 'sun and beach' resorts built in the 1960s and 1970s. Most of these resorts were also built in the *calmas*, which originally "encouraged the settlement of fishing companies, but later attracted the tourist industry" with factors such as the warm weather and large areas of available land (Pascual 2004). Littoral fishing communities suffered the most from the effects of the tourist expansion, e.g., displacement of fishing families from shore, construction of tourism infrastructure, impossibility of using traditional beaches to land catch, and destruction of fishing grounds due to building of tourist resorts (Pascual 2004). The resulting displacement of traditional fishing communities, the pollution of surrounding ecosystem during construction, and declining fish production were all reasons for the decline of the artisanal fishery. Many fishers shifted to new jobs in the construction industry or touristic sectors to support themselves and their families. Since the 1970s, tourism has been the "motor of the economy" (Pascual 2004).

Simultaneous with the expansion of tourism, regulations were put in place by the MAGP (EU Multiannual Guidance Programs) to limit the growth of artisanal fishing effort. While originally boats were inherited within fishing families, these guidelines required professional fishers to enter their boats into the fishing list register, which ultimately created a 'paper market' and made it difficult for young people wishing to continue their family career (Pascual 2004). MAGP also limits investment in larger and more efficient boats (Pascual 2004), while simultaneously the recreational fishing fleet has greatly expanded and put "unprecedented pressure" on coastal and marine resources (Pascual-Fernandez and De la Cruz Modino 2011), where catch is estimated to be high and difficult to monitor (Santamaría *et al.* 2013).

Ultimately, the small-scale fisheries of the Canary Islands share many characteristics and problems of other European, especially Mediterranean artisanal fisheries (Guyader *et al.* 2013; Maynou *et al.* 2013). These fisheries are operated by a heterogeneous fleet composed of small boats, small crews, and varying gears that change their target species throughout the year. This sector also has low extraction rates and low total capital investments, and it lacks comprehensive data on catch and fishing effort (Bas *et al.* 1995; Hernández-García *et al.* 1998). Moreover, this fleet competes for the same resources with a substantial number of recreational boats (MAPyA 2006). Hence, assessing the current level of exploitation using traditional methods of fish population dynamics has not been possible (Csirke 1989; Lleonart 1994; Sparre and Venema 1998). Hopefully, the present reconstruction will shed more light on total catch removals from the waters around the Canary Islands, and hence assist fishers and policy makers in understanding the current state of their fishery.

## Methods

### Reported data

The Food and Agriculture Organization of the United Nations (FAO) maintains a publicly accessible database of reported landings by country, species, Major Fishing Area (MFA), and year for the period from 1950 to 2010 (www.fao.org/fishery/statistics/en). The Fishery Committee for the Eastern Central Atlantic (CECAF) is the Regional Fishery Body of the FAO responsible for the fisheries of the Eastern Central Atlantic. This region also corresponds to FAO Major Fishing Area 34, which includes the Exclusive Economic Zones (EEZ) of 20 independent West African countries, three groups of Islands (Madeira, the Canaries, and Cape Verde), along with the waters of the high seas (Everett 1976). Since FAO data are reported by Major Fishing Area, this leaves uncertainty for the present reconstruction as to where catches were taken in over 14 million $km^2$ of surface fishing area of MFA 34 (Garibaldi and Limongelli 2003) and in whose EEZ. This is compounded by the fact that Spain, whose industrial fleet is based in the Canary Islands, fishes predominantly in West African waters. Thus, there is no way of accurately knowing what catches, if any, were reported by Spain on behalf of those incurred within the waters of the Canary Islands. Hence, we looked to regional data to understand which catches were reported and hence included in the FAO catches.

A system of regular fishing data collection in the Canary Islands began in 2006, yet only starting in 2008 did the monitoring of landings improve with First Sale Spot System (Popescu and Ortega Gras 2013; Santamaría *et al.* 2013). We assumed that these catches were reported to Spanish authorities, who then in turn reported these catches to the FAO.

Additionally, catch data for tuna and tuna-like species were collected separately by the Spanish Oceanography Institute (IEO) since 1970 and reported to the International Commission for the Conservation of Atlantic Tunas (ICCAT). Several fleets target tuna in the waters of the Canary Islands. We distinguish between artisanal and industrial tuna fishing, where the artisanal fleet is defined as bait boats between 1 – 200 GRT, as opposed to, for example, the tropical tuna purse seine fleet which is industrial. The present analysis of tuna catch only considered the artisanal fleet, as opposed to the industrial fleet which is more likely to fish outside the EEZ of the Canary

Islands. Furthermore, industrial tuna catches are reconstructed separately by the *Sea Around Us* on a global basis (Le Manach *et al.* in press). The artisanal fleet is also represented in ICCAT data from 1962 – 1969, and while it is possible that these data were also supplied by the IEO, this was not confirmed.

Whether data on tuna catches were reported to the FAO, and hence can be considered in the baseline of reported catch for the present paper, is a different matter. From a data query on FAO's online database (FishStat) with specific parameters (i.e., the Eastern Central Atlantic region, Spain as the fishing entity, and the ISSCAAP species group of tunas, bonitos, and billfish) it was clear that catches in their entirety were not reported to FAO even though they were reported to ICCAT. Specifically, starting in 1965 to the present time period, ICCAT catches of the artisanal baitboat fishery were on average 12 times higher than FAO tuna catches for both industrial and artisanal catch, ranging from twice as high to 38 times as high depending on the year. Another important distinction is that FAO catches include industrial catches and thus it is more likely that industrial catches of tuna were reported to the FAO than the artisanal catch of the bait boats, as has been the case for other species.

Therefore, our 'baseline' of reported catch only includes catch reported by the Canarian Government starting in 2006, and the purpose of the present paper is to reconstruct catches for the artisanal fleet from 1950 – 2010 where data gaps remain, as well as sectors not covered in official catch data such as subsistence catch, recreational catch, bait catch, and discards.

**Artisanal fisheries**

Since official, reported data on catches were not available prior to 2006 (except for tuna), we used a comprehensive compilation of fisheries-relevant data compiled by the senior author (Appendix 1). These data were composed of historic and current information available in the grey literature (García-Cabrera 1970; Hernández-García *et al.* 1998; Melnychuk *et al.* 2001; González 2008; among others) as well as data obtained directly from fisher associations. Key data relevant for the reconstruction of artisanal catches include: (i) number of artisanal fishers, (ii) number of artisanal boats, (iii) catch data, and (iv) CPUE data points for the trap fishery targeting bentho-demersal species.

(i) Number of artisanal boats

As outlined before, the commercial fisheries of the Canary Islands are composed of small-scale fisheries which fish within the EEZ of the Canaries, as well as industrial fishing activities operating mostly in the fishing grounds of Northwest Africa, e.g., West Sahara bank, hence making it difficult to identify what part of the whole fleet, i.e., number of boats, Gross Registered Tonnage (GRT), and horsepower (hp), was dedicated to the artisanal fishery in each period.

Nonetheless, grey literature has provided some data on the artisanal fleet. The number of artisanal boats for all islands was available for the years 1987 and 2005 – 2010. Prior to this, data were only available for La Palma, Gomera, and Lanzarote in 1968; Gran Canaria, Fuerteventura, and Tenerife in 1969; Fuerteventura and Gomera in 1982; and La Palma, Tenerife, and El Hierro in 1983. Existing data gaps were resolved by interpolating catch for the missing years. This resulted in 1,390 artisanal boats in 1968, increasing to 1,709 boats in 1983. The island of El Hierro only had data for 1983 at 50 boats, which we extended back to 1968. According to the number of artisanal boats seen on beaches in old photos (from 1950 to 1968), it appears that the number of boats was similar during this time period, so we extended the data point of 1,390 boats in 1968 back to 1950 (Figure 2).

In addition to estimating the number of all artisanal boats, we separated out artisanal bait boats targeting tunas. From 1980 to 2010, data on the number of artisanal tuna boats were available (Delgado de Molina *et al.* 2012), and for 1950 to 1979 we assumed that the number of bait boats followed the same trend as total artisanal boats (Figure 2). We believe this estimate for the early period is appropriate because of the existence of tuna canneries since the 1920s and 1930s, indicating that a substantial and consistent tuna catch must have been available since then to operate. The number of bait boats was divided by boats with GRT greater than 50 and boats less than 50. This distinction was vital for some assumptions, notably, that medium/large boats (GRT > 50) normally fish further from the islands (but can also fish between islands) and hence focus primarily on tuna all year-round. In contrast, small boats with GRT< 50 are dedicated to fish tuna near the shore or close to the island during the summer season (usually with installed tanks for bait) and during other seasons fish various bentho-demersal species.

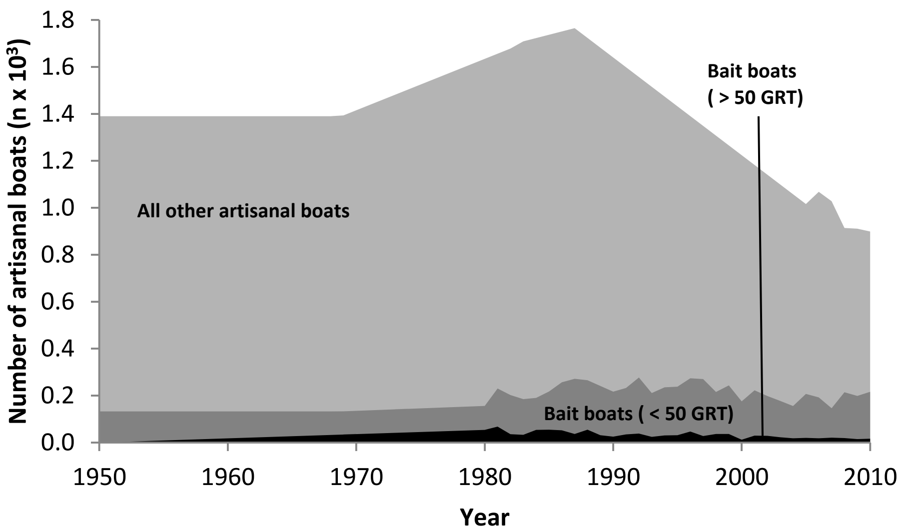


**Figure 2**. Number of artisanal boats in the Canary Islands, 1950 – 2010.

(ii) Number of artisanal fishers

Data on the number of artisanal fishers in the Canary Islands were available by island for the years 1969, 1987, 1995, 1997 – 2002, 2005, 2008, and 2012. In 1950, the crew required to operate the same number of boats was 60% higher than in 1970, as motors had not yet been introduced and most of the boats at this time were row-boats. With the introduction of the engine, among other technological improvements, the crew necessary for fishing operations gradually declined. We interpolated data between years with missing data.

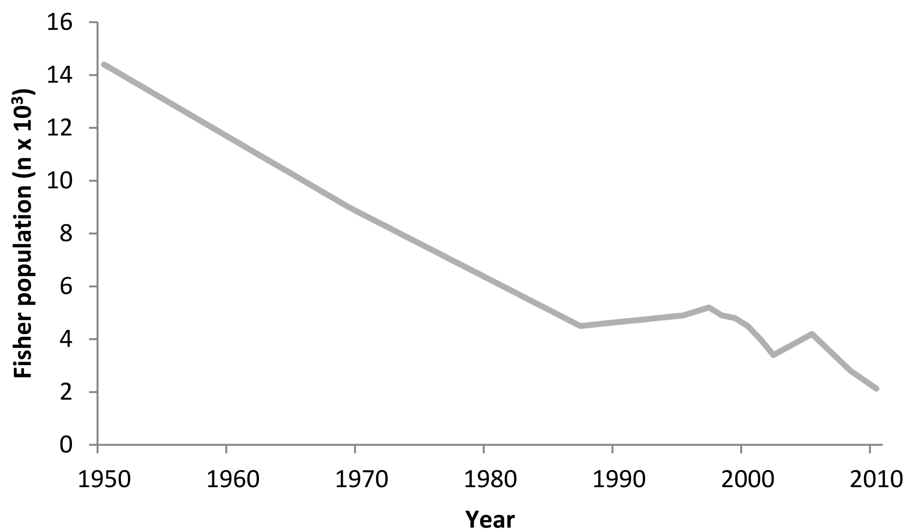


**Figure 3**. Number of artisanal fishers in the Canary Islands, 1950 – 2010.

The total amount of fishers has declined over time (Figure 3), as has its relative representation in the resident population of the Canary Islands, from 1.74% of the resident population being fishers in 1950 to 0.10% by 2010.

(iii) Fisheries catch

Artisanal catch data were available for several key anchor points, starting with 1968 where data were available by island with varying levels of detail on the taxonomic composition of the catch (García-Cabrera 1970) as can be seen in Table 1.

**Table 1**. Artisanal catch in 1968 in the Canary Islands (García-Cabrera 1970).

| Island | Total artisanal catch (t) | Bentho-demersal fishes | Pelagic fishes | Non-specified catch |
|---|---|---|---|---|
| La Palma | 600 | | | 600 |
| El Hierro | 100 | 100 | | |
| Gomera | 11,000 | 1,100 | 9,900 | |
| Tenerife | 11,200 | 1,200 | 10,000 | |
| Gran Canaria | 6,000 | | | 6,000 |
| Fuerteventura | 250 | | | 250 |
| Lanzarote | 698 | 698 | | |
| **Total** | **29,848** | **3,098** | **19,900** | **6,850** |

Cumulatively, there were 3,098 t of bentho-demersal species, 19,900 t of pelagic species, and 6,850 t of species where the taxonomic breakdown was unclear. Due to the 6,850 t of non-specified catch, bentho-demersal catch in 1968 was between a minimum of 3,098 t up to a maximum of 9,948 t. Equivalently, pelagic catch in 1968 could range from 19,900 t to 26,750 t.

Subsequent data sources after 1968 were only for select islands and only for catch of bentho-demersal species. These data were available for the years 1980, 1981, and 1982 from a compilation of various sources (Table 2; Barrera-Luján *et al.* 1983a; Santos-Guerra *et al.* 1983; Gafo-Fernández *et al.* 1984a, 1984b). In particular, catch data for the islands of Gomera and Tenerife were presented by Gafo-Fernández *et al.* (1984a, 1984b) for the years 1980 and 1981 and by Santos-Guerra *et al.* (1983) for 1982. Fuerteventura catch estimates for 1982 are from Barrera-Luján *et al.* (1983a).

As can be seen in Table 2, a min and max catch of bentho-pelagic species were presented for 1968, e.g. between 3,098 t to 9,948 t. Furthermore, we compared the average increase in bentho-demersal catch for select islands. In order to extend estimates of bentho-demersal catch to all islands, we applied the average increase from 1968 to the min and max catch of 1968.

**Table 2**. Data on bentho-demersal catches for select islands (1980-1982), based on several sources (Barrera-Luján *et al.* 1983a; Santos-Guerra *et al.* 1983; Gafo-Fernández *et al.* 1984a, 1984b).

| Year | Fuerteventura | Gomera | Tenerife | Average increase from 1968 (%) | Total estimated catch (t)* | |
|---|---|---|---|---|---|---|
| | | | | | *Min* | *Max* |
| 1968 | 0 - 250 | 1,100 | 1,200 | | 3,098 | 9,948 |
| 1980 | | 842 | 10,696 | 502% | 15,541 | 49,904 |
| 1981 | | 342 | 8,163 | 370% | 11,456 | 36,786 |
| 1982 | 1,378 | 789 | 7,622 | 419% | 12,995 | 41,729 |

** Rate of increase extrapolated to all islands*

According to a partial survey during eight months of 1982 (Barrera-Luján *et al.* 1983b; Delgado de Molina *et al.* 1983; La-Roche Brier *et al.* 1983) the catch of bentho-demersal species (including cephalopods, sharks and rays, and crustaceans) was only 893 t compared to the minimum estimate of 12,995 t of catch. Even if we scale this to include the entire year, resulting in 1,340 t of catch, this amount is still over seven times lower than the catch for only three of the seven islands (Fuerteventura, Gomera, Tenerife). Thus, we excluded this anchor point; however, we did utilize this information for other components of the present catch reconstruction.

Data for recent years were available from 1999 – 2004 (Canarian Government 2006). We depicted these data next to the reported data (Popescu and Ortega Gras 2013) from 2006 – 2010 (Table 3).

**Table 3.** Unreported catches (t) from 1999 – 2004 (Canarian Government 2006) alongside reported catch for 2006 – 2010 (Popescu and Ortega Gras 2013); including all species.

| | | | | | | | Reported data | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species group** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2006** | **2007** | **2008** | **2009** | **2010** |
| Bentho-demersal | 2,166 | 1,243 | 1,372 | 1,263 | 1,166 | 1,028 | 355 | 543 | 953 | 1,052 | 621 |
| Pelagic | 6,454 | 8,821 | 7,660 | 4,769 | 7,117 | 9,152 | 6,734 | 4,138 | 7,642 | 6,544 | 6,268 |
| MMF* | | | | | | | 621 | 922 | 1,440 | 1,657 | 1,453 |
| **TOTAL** | **8,620** | **10,064** | **9,032** | **6,032** | **8,283** | **10,180** | **7,710** | **5,603** | **10,035** | **9,253** | **8,342** |

** MMF = Miscellaneous Marine Fishes*

(iv) Catch Per Unit Effort (CPUE) of bentho-demersal species

The fishing data available before 2006 were obtained from data recorded by two fishers of Gran Canaria (from 1971 to 2009) and La Palma (from 1975 to 2012), and commercial fish transactions between all the small-scale fleet of Mogán and a wholesale fishmonger (from 1989 onward). We also reviewed documents and grey literature, from which it was possible to obtain survey-based information regarding the description of the fleet and gears used in different parts of the Archipelago (Barrera-Luján *et al.* 1982; Barrera-Luján *et al.* 1983a; Barrera-Luján *et al.* 1983b; Delgado de Molina *et al.* 1983; La-Roche Brier *et al.* 1983; Pérez-Artiles *et al.* 1987; Caldentey-Morales *et al.* 1988; González *et al.* 1988; González *et al.* 1991; García-Santamaría *et al.* 2001; among others), as well as data on the trends in the abundance of fishing resources from changes in the CPUE.

Since about 30 different gears exist, to create a time series of CPUE which would be ideal for comparison, we chose to model the development of the trap gear, as traps are used extensively all the year, around all islands (except in El Hierro and Fuerteventura after 2000, when its use was forbidden in this last island). The use of other gears (i.e. longline and gillnets) is only permitted during certain periods of years and in specific areas of the islands. Therefore, trap CPUE is a more homogenous index of changes in fish abundance.

From fishing research surveys (García-Cabrera 1970; Barrera-Luján *et al.* 1982; Barrera-Luján *et al.* 1983b; Pérez-Artiles *et al.* 1987; Caldentey-Morales *et al.* 1988; and senior authors unpublished data), the CPUE for fish traps targeting bentho-demersal species can be grouped into four well-defined periods: (i) a period of high abundance in the 1950s and early 1960s, (ii) a period of relatively lower CPUE in the late 1960s, as indicated by García-Cabrera (1970), who pointed out that fishing grounds shallower than 100 m depth were already overfished, (iii) a period of intermediate-low abundance during the 1980s, and (iv) a period of low abundance between the end of the 1990s to the present day. Such data enabled us to partially rebuild the temporal changes in CPUE over the time period from 1950 to 2010 (Figure 4). Prior to 1969, we assumed that CPUE increased at half the rate after the late 1970s. Throughout these sixty years in the trap fishery, we observed a progressive decrease in CPUE values by 93.3%.

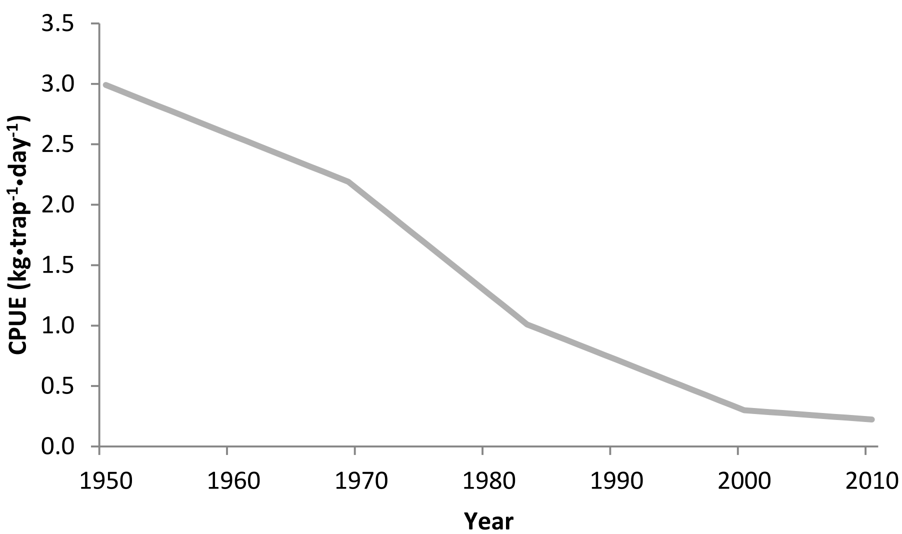


**Figure 4**. Catch Per Unit Effort (CPUE) in kg·trap$^{-1}$·day$^{-1}$ of the bentho-demersal artisanal trap fishery in the Canary Islands, 1950–2010.

**Estimation of artisanal catch**

Using the previously mentioned data, we estimated catch based on their broad taxonomic classifications, i.e., bentho-demersal species, tuna and tuna-like species, and other pelagic species.

**Bentho-demersal species**

Of the 30 different gears used to target bentho-demersal species, the most common gear utilized is the pot, or trap gear, which is used by 94% of the vessels (Popescu and Ortega Gras 2013) and corresponds to nearly 50% of the catch of bentho-demersal species. As described previously, we derived the evolution of CPUE data on the trap gear, which provides the most homogenous index of catch over time. There are insufficient data on the other gears to estimate catch, hence we first reconstructed catch for the trap gear and then scaled it for other catch. We also compared our final estimate to the anchor points cited for bentho-demersal species.

Therefore, we utilized the data on the number of boats (Figure 2) and the CPUE of the trap fishery (Figure 4) in Gran Canaria to build a temporal representation of catch. We assumed that the CPUE of Gran Canaria was representative of all seven islands and that the average number of fishing days per boat was 250 days in a year, which is conservative given the year-round nature of fishing operations (Melnychuk *et al.* 2001).

As seen in Figure 2, we made a distinction between boats that fish all species and bait boats that primarily target tuna species. Furthermore, only bait boats with GRT > 50 target exclusively tuna and hence were excluded from any calculations on the catch of bentho-demersal species. Bait boats with GRT smaller than 50 GRT primarily fish tuna during summer months yet still maintain their traps deployed at sea, hoisting them less frequently than other times. For example, during the autumn-spring season the traps are hoisted every 5-7 days, while during the summer months they are hoisted every 10-14 days. The vast majority of boats, however, fish bentho-demersal species year-round, especially in numerous small ports like the port of Castillo del Romeral in the southeast of Gran Canaria. For these non-bait boats, we assumed that they hoist their traps 250 days in the year. For bait boats with GRT less than 50 we assumed they hoist traps about 94 days in the year. This corresponded to assuming that in summer they hoisted them every 10 days, and in spring autumn every 5 days. We used the lower bound of how often they hoisted traps to account for the fact that hoisting the traps less often would likely also result in a slightly higher CPUE.

Also, effort was adjusted to reflect the number of traps set per day and other factors that influenced effort. While the yield of fish traps on the island of Gran Canaria CPUE declined nearly 54% between 1969 and 1983, this decrease coincided with an increase in the fishing capacity (potential to catch) of the fleet. In 1969, almost none of the small-scale vessels had power-assisted fishing gear (many of them were rowboats), whereas in the early 1980s, over 60% of the fleet was equipped with onboard engines and hydraulic fishing winches for hoisting traps. During this period, the fishing capacity of a boat was multiplied by almost 10, and fishers went from handling half a dozen fish traps per day per boat (3 sets of 2 traps each and in a depths shallower than 50 m) to approximately 30-60 in the same time interval, and at much greater depths (deeper than 200 m). The onboard engines added a greater displacement capacity, increasing the size of the accessible fishing grounds and reducing the duration of fishing operations. Between 1981 and 1983, this mentioned increase in fishing capacity was associated with an important increase in catches, particularly in the leeward zones of the biggest islands. Given this information, we adjusted the effort to represent the number of traps set per day by boat, assuming that from 1950 until 1969, fishers set six traps per day, interpolated to 45 traps in 1983, after which this value remained constant.

Finally, we multiplied each fleet sector (regular artisanal boats or smaller bait boats) by the number of traps set per day, CPUE, and the number of days fished. This resulted in an estimate of total trap catch, as was seen in Figure 5. Then we extended this estimate of trap catch of bentho-demersal species to catch from all gears based on survey data from 1982 whereby trap catch accounted for 47.7% of total catch. The 1982 survey made along the archipelago was done separately for the eastern islands, i.e., Lanzarote, Fuerteventura, and Gran Canaria (Barrera-Luján *et al.* 1983b) and the western islands, i.e., Tenerife, Gomera, Hierro, and La Palma (La-Roche Brier *et al.* 1983). While La-Roche Brier *et al.* (1983) stated that trap catch represents 17% of the catch of bentho-demersal species, we do not believe this is representative of the entire fishery and furthermore this assumption would result in catches as high as 100,000 $t{\cdot}year^{-1}$ of bentho-demersal species from 1982 – 1985, which is not realistic given the western islands are less productive in bentho-demersal species than the eastern ones because they have very narrow and abrupt insular shelves. Indeed, installing traps in the western island is more difficult due to these great depths and marine currents, which produce a high trap loss (more than 10% per fishing journey when fishing in waters deeper than 200 m). In contrast to the western islands, the trap fishery of the eastern islands has been more developed due to relatively larger insular shelves, especially in the east, south and west sides of these islands. In particular, Gran Canaria is the most productive island for bento-demersal catch. Hence, data for the western islands where trap catch was only 17% of total catch were not utilized due to the above mentioned factors, as well as the fact that such as estimate would grossly overestimate bentho-demersal catch. Rather, we used data from the eastern islands where trap catch accounted for 47.7% of all catch.

We assumed that the trend line was representative until the early 1990s, as we do not have substantial data points for the later time period on the number of traps set per day, and it is possible this trend changed by the 2000s. Hence, we interpolated our estimates in the 1990s to 2008, which is considered to be more reliable than the reported catch of 2006 and 2007 (Popescu and Ortega Gras 2013; Santamaría *et al.* 2013). Thereafter, the estimated catch of bentho-demersal species by the artisanal fleet was equivalent to reported catch for 2009 and 2010.

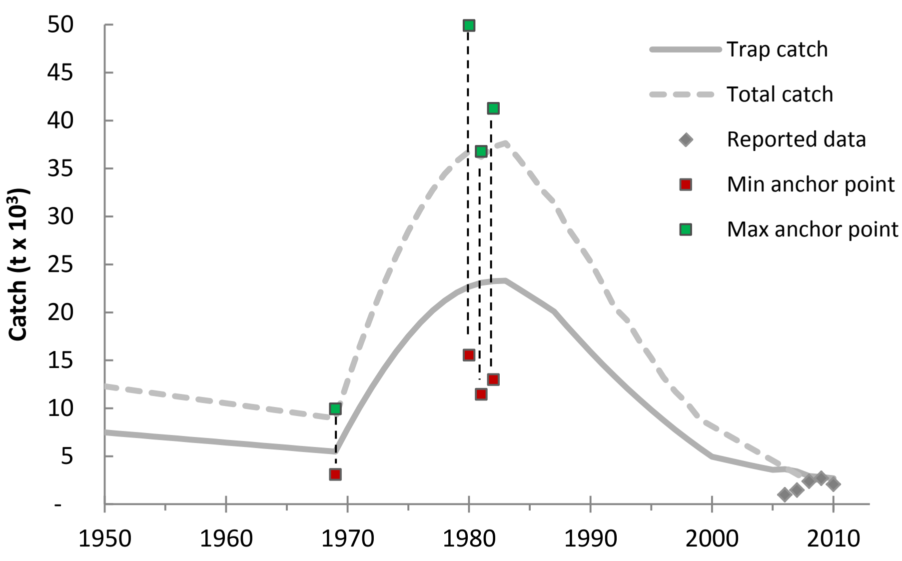


**Figure 5**. Estimated catch of bentho-demersal species form the trap fishery plotted against various anchor points, 1950 – 2010.

After scaling, this resulted in the total catch represented in Figure 5, results which were plotted against the anchor points of catch (Figure 5). Our estimate fell within the minimum and maximum range of anchor points for 1968 and 1980 - 1982. In 1968, our estimate suggests that 88% of the catch that was not taxonomically classified as either bentho-demersal or pelagic was in fact bentho-demersal catch. We classified this catch as such, which left the remaining 12% of catch to be classified as catch of various pelagic species.

**Pelagic species**

Anchor points for pelagic species were available for 1968, 1982, and from 2000 – 2010. Given that we assumed that 12% of taxonomically unclassified catch in 1968 was of pelagic species, total pelagic catch in 1968 was approximately 25,100 t. Data specifically for tuna and tuna-like species were available from 1962 – 2010.

<u>Tuna and tuna-like species</u>

Data on tuna catch were collected by the Spanish Oceanography Institute (IEO) and reported to ICCAT between 1970 and 2010, which we believe is an accurate representation of true catch (Figure 6). Prior to this, data on tuna catches were not reported, yet given the longstanding history of tuna fishing and indications from other sources such as (García-Cabrera 1970), it can be concluded that a substantial tuna fishery existed. Therefore, we reconstructed catch for years 1950 – 1969 using a mixture of various sources.

Catches reported by ICCAT for the bait boat tuna fishery from 1962 – 1969 were quite low, and since data by García-Cabrera (1970) indicate catches in 1968 at least three times as high (and at most nine times as high), we believe they are underestimated significantly. Additionally while there was an upward trend in catches from 98 t in 1962 to 3,298 t in 1969, we did not believe this trend was representative, as this simply represented an increase in reporting capacity rather than any significant changes in the tuna fishery. Nonetheless, we utilized the ICCAT data to generally understand the relative change of catch from year to year while using the magnitude suggested by the 1968 data point as well as IEO data from the early 1970s.

Regarding the data for 1968 (Table 1), it appears this was a year of especially high tuna catches, i.e. in the island of Gomera alone, most of the 11,000 tons of catch was tuna, we assumed 90% resulting in 9,900 t. In Tenerife, 10,000 t of catch were reported to have been large pelagic fish and medium-size pelagic fish. Without a clear indication we simplistically assumed 50% was large pelagic species (tunas) and the rest were other pelagic species. Catch from La Palma, Gran Canaria, and Lanzarote totalled 6,850 t with no indication into what species were caught. While most of this was assumed to have been bentho-demersal species, the remaining 822 t of catch were pelagic species and we again assumed a 50% split between tuna-like species and other pelagic species. This resulted in an estimate of 15,311 t of catch of tunas in 1968.

For all years prior to 1968 we assumed that catch was approximately the same as the average catch of from 1968 and 1970 – 1972, as effort in terms of the number of boats was constant for this time period (Figure 2). Hence, from 1950 – 1961, which are years when no data exist from any source on tuna catches, we assumed catches averaged the catch of 1968, 1970, 1971, and 1972. Starting in 1961 when there are data on catch at 98 t, increasing to 491 t in 1963 and declining to 144 t in 1964, we utilized a similar pattern but maintained the average previously described for this time period. Finally, we maintained catch at the average used for the years 1950 – 1961 also for the period from 1965 – 1967. For the year 1969 an average was taken between the 1968 and 1970 data.

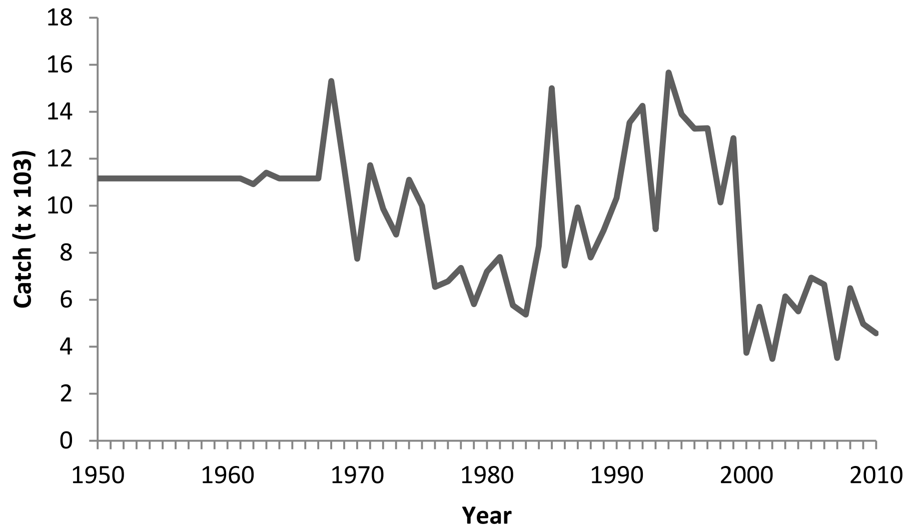


**Figure 6**. Tuna catch by the artisanal bait boat fleet in the Canary Islands, 1950 – 2010.

<u>Bait for pelagic catch</u>

Pole and line fishing such as that of the Canary Islands requires a substantial amount of bait to lure tuna and tuna-like species. According to various sources, it appears that the most common species used for bait are the Atlantic chub mackerel (*Scomber colias*), followed by the European pilchard (*Sardina pilchardus*). The former was originally cited as chub mackerel (*Scomber japonicus*) yet this designation was incorrect (see section of species distribution for pelagic species other than tunas). Other common species used as bait were bogue (*Boops boops*), longspine spinefish (*Macroramphosus scolopax*), European anchovy (*Engraulis encrasicolus*), sand smelt (*Atherina presbyter*), jack and horse mackerels (*Trachurus* spp.), and sardinellas (*Sardinella* spp). Finally, some species of squids are used in areas like La Graciosa. See Table 4 for a complete list of species common for use as bait in the tuna bait boat fishery.

Logbook data from the IEO suggest that a medium-large sized bait boat uses about 2,300 to 2,500 kg of live bait per month, or on average 28.8 t of live bait per year. Since bait boats range from 1 GRT to 200 GRT, we assumed that medium-large bait boats were boats greater than 50 GRT and that small baitboats were those less than 50 GRT. Furthermore, we made the conservative assumption that bait boats smaller than 50 GRT used half the amount of bait as medium-large boats, averaging 14.4 t of bait annually.

We applied these rates to the number of boats previously described in the section on the number of artisanal boats (Figure 2).

**Table 4**. Species commonly caught as bait by the artisanal baitboat fleet targeting tunas and tuna-like species within Canary Islands water, 1950 – 2010.

| Scientific Name | Common Name | Contribution to total bait catch (%) |
|---|---|---|
| *Scomber colias* | Atlantic chub mackerel | 50 |
| *Sardina pilchardus* | European pilchard | 25 |
| *Boops boops* | Bogue | 4 |
| *Macroramphosus scolopax* | Longspine snipefish | 4 |
| *Engraulis encrasicolus* | European anchovy | 4 |
| *Atherina presbyter* | Sand smelt | 4 |
| *Trachurus* spp. | Jack and horse mackerels | 4 |
| *Sardinella* spp. | Sardinellas | 4 |
| Teuthida | Squids | 1 |

Pelagic species, excluding tunas

Anchor points of catch of pelagic species were available for the years 1968, 1982, and from 2000 – 2010. We excluded using the anchor point for 1982, which reported that 4,644.6 t of pelagic species (less tuna) were caught in 8 months. While this was considered a minimum, we treated this estimate with skepticism due to the severe underestimation on bentho-demersal species catch by this survey in comparison with other data. Likewise, we excluded the data from 1999 – 2004 (Canarian Government 2006) which also included captures in the African fishing grounds, hence making the data not appropriate to estimate catch from within the waters of the Canary Islands. Thus, we interpolated the catch between the 1968 anchor point of 5,411 t (the remaining portion of pelagic catch) and the 2008 anchor point of 1,222 t, thereafter following the trend of official reported data (Figure 7).

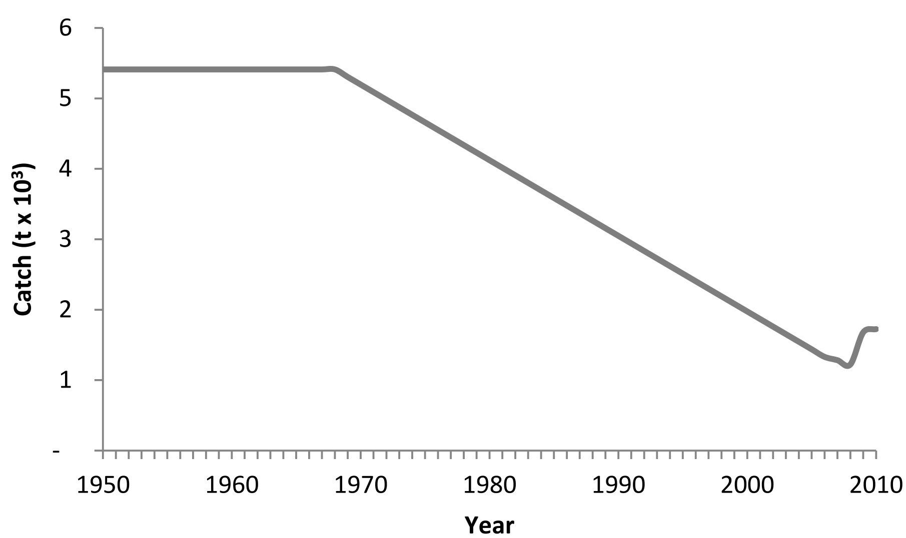


**Figure 7**. Pelagic catch (except tuna and tuna-like species) of the artisanal fleet in the Canary Islands, 1950 – 2010.

**Species breakdown**

For tuna, the species composition for the years 1950 – 1969 was the average of the species composition of reported data from 1970 – 1972. For all other species, both pelagic and bentho-demersal, we used the resulting species distribution of the eight-month survey in 1982 (Barrera-Luján *et al.* 1983b; Delgado de Molina *et al.* 1983), the reported data for 2006 – 2010, as well as expert assessment to develop a representative species distribution for the entire time period.

Our starting place for the time period from 1950 to 1982 was the species distribution suggested in the 1982 survey. For the time period from 2006 to 2010 we used the average species composition of the reported data. In between the two representative time periods, we interpolated the relative taxonomic composition.

Some adjustments were made using expert assessment in order to have a more appropriate species composition for all unreported catches. First, the reported data indicate catches of the mackerels (*Scomber* spp.) and chub mackerel (*Scomber japonicus*), but we re-identified both as Atlantic chub mackerel (*Scomber colias*), as this is the only mackerel species in the Canary Islands. Chub mackerel has been the common misidentification of Atlantic chub mackerel for many years until molecular studies by Collette (2001) indicated that Atlantic chub mackerel was common to the Atlantic (including the Mediterranean and Black sea) and chub mackerel in the Pacific and Indian Oceans. We thus changed any catch of the mackerel species or chub mackerel to Atlantic chub mackerel for both reported and unreported catch. A complete list of pelagic species and their relative contribution to catch is seen in Table 5.

**Table 5.** Species composition of pelagic catch (other than tunas) in the Canary Islands, 1950 – 2010.

| **Common name** | **Taxon name** | **Species composition (%)** | |
|---|---|---|---|
| | | *1950 - 1982* | *2006 - 2010** |
| Atlantic chub mackerel | *Scomber colias* | 73.9 | 44.8 |
| European pilchard | *Sardina pilchardus* | 9.6 | 16.3 |
| Round sardinella | *Sardinella aurita* | 6.3 | 10.7 |
| Madeiran sardinella | *Sardinella maderensis* | 5.0 | 8.5 |
| Blue jack mackerel | *Trachurus picturatus* | 3.9 | 10.6 |
| Greater amberjack | *Seriola dumerili* | 0.5 | 1.3 |
| White trevally | *Pseudocaranx dentex* | 0.4 | 1.1 |
| Atlantic horse mackerel | *Trachurus trachurus* | 0.3 | 0.7 |
| European anchovy | *Engraulis encrasicolus* | 0.0 | 3.2 |
| Yellowmouth barracuda | *Sphyraena viridensis* | 0.0 | 2.6 |

**Average species composition of the 2006 – 2010 reported data*

For bentho-demersal species, we assumed that the species of Benguela hake (*Merluccius polli*) in the reported data was actually European hake (*Merluccius merluccius*) which is far more common in Canarian waters. We also assumed that catches in 1982 within the Congridae family were European conger (*Conger conger*), which is the only species in this taxonomic classification caught commercially in the Canary Islands. Finally, the 1982 data show some quantities of the damselfishes (Pomacentridae) family caught, but historically this catch is discarded. Thus we incorporated this taxon in discards but removed it from commercial species landed catch. Table 6 depicts the species composition of landed catch of bentho-demersal species.

**Table 6.** Species composition of bentho-demersal catch in the Canary Islands, 1950 - 2010.

| Common name | Taxon name | Species composition (%) | |
|---|---|---|---|
| | | ***1950 - 1982*** | ***2006 - 2010**** |
| Parrotfish | *Sparisoma cretense* | 22.4 | 21.2 |
| Black seabream | *Spondyliosoma cantharus* | 10.6 | 13.7 |
| Red porgy | *Pagrus pagrus* | 10.5 | 13.5 |
| Pink dentex | *Dentex gibbosus* | 8.3 | 10.7 |
| Serranidae | Serranidae | 7.8 | 0.0 |
| Salema | *Sarpa salpa* | 7.7 | 9.9 |
| Cephalopods | Cephalopoda | 6.3 | 0.0 |
| Muraenidae | Muraenidae | 4.5 | 0.0 |
| Marine fishes | Marine fishes not identified | 4.4 | 0.0 |
| Common pandora | *Pagellus erythrinus* | 2.8 | 3.6 |
| Surmullet | *Mullus surmuletus* | 2.6 | 1.4 |
| Canary dentex | *Dentex canariensis* | 2.3 | 3.0 |
| Gempylidae | Gempylidae | 2.1 | 0.0 |
| Moroccan white seabream | *Diplodus sargus cadenati* | 2.3 | 2.9 |
| Sharks and rays | Elasmobranchii | 1.5 | 0.0 |
| Scorpaenidae | Scorpaenidae | 1.3 | 0.0 |
| Crustaceans | Crustacea | 1.3 | 0.0 |
| European conger | *Conger conger* | 1.2 | 0.0 |
| Rubberlip grunt | *Plectorhinchus mediterraneus* | 0.0 | 9.6 |
| Splendid alfonsino | *Beryx splendens* | 0.0 | 6.6 |
| European hake | *Merluccius merluccius* | 0.0 | 2.1 |
| Common octopus | *Octopus vulgaris* | 0.0 | 1.8 |

**Average species composition of the 2006 – 2010 reported data*

**Unregulated catch**

As the number of artisanal boats began to decline, due in part to the regulations of MAGP, this gave way to a rise in unregulated fishing activities by those who were forced to officially leave the fishing industry. For example in Valle Gran Rey (La Gomera) in the 1990s, the number of legally licensed fishing boats dropped by more than 50%, which "led to a rise in part-time and non-legal fishing activities by some of the people who left the activity professionally, but continue to fish and sell their catches through different channels" (Pascual 2004). This trend was and remains true for all the islands (Castro and Santana-Ortega 2008). Retired fishers occasionally fish 'recreationally' and then sell their catches to restaurants and local fishmongers as a way to supplement their low retirement pension. In some secondary ports on smaller islands, there are more retired fishers than active ones. Nonetheless, considering all ports and islands, this proportion is significantly less, perhaps less than 10%. This trend has increased over time (Pascual-Fernandez and De la Cruz Modino 2011), which is logical as the number of active artisanal boats and fishers continually decline.

Hence, after the number of boats began to decline in 1989, we assumed that a certain proportion continued to stay active in fishing, averaging approximately 10% of retired artisanal boats. This proportion was assumed because many boats were destroyed (or sold to other countries) as a means of obtaining government-funded subsidies. Of the 10% of boats still in operation, we assumed that retired artisanal fishers only used them for fishing a sixth of the level of artisanal fishers, as they are likely also involved part-time in other activities like tourism, or only fish on free days, frequently the weekends. We assume they have the same catch composition as other artisanal fishers, excluding tuna and purse seine gears targeting other pelagic fish.

**Population**

Data on resident and non-resident population were useful in estimating non-commercial fishery catch for the subsistence and recreational sectors.

**Resident**

Data on resident population in the Canary Islands were obtained from the Canarian Government (2004) for the years 1940, 1960, and 1981, and from the Canarian Government Statistics Institute, Instituto Canario de Estadística (ISTAC), for the years 1999-2000. For all other years the population figures were interpolated between the nearest anchor points (Figure 8).

**Tourist**

Data on the tourist population were available from 1990 – 2010 from ISTAC's publicly available data (http://www.gobiernodecanarias.org/istac/). The expansion of tourism dates back to the 1960s and has been steadily increasing up until the 1990s (Pascual 2004). Thus we interpolated between zero tourists from 1950 – 1959 to over 4.87 million tourists in 1990 (Figure 8).

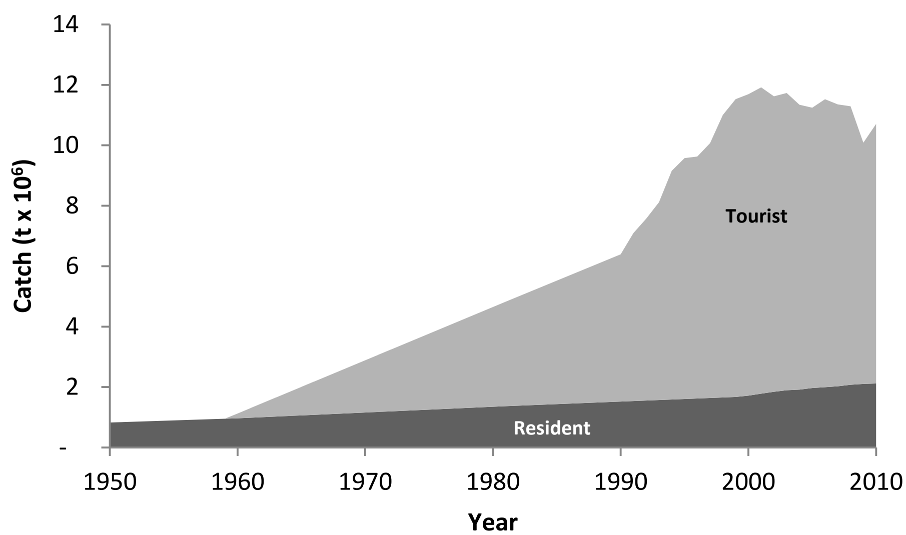


**Figure 8**. Resident and annual tourist population in the Canary Islands, 1950 – 2010.

**Recreational catch**

Recreational catch was calculated by creating a time series of the number of active anglers and multiplying it by an appropriate variable catch rate per fisher.

Number of active anglers

In 2005, 16,247 fishing licenses were issued, each valid for three years (MAPyA 2006). This implies that in 2005 the number of active anglers was approximately three times the amount of fishing licenses issued (including those who got their licenses in 2003 and 2004), or approximately 49,000 active anglers. In 2007, the number of valid fishing licenses grew to approximately 60,000, then to 120,000 in 2009 (Pascual-Fernandez and De la Cruz Modino 2011), and then slightly declined to 116,000 in 2011 (MAAyMA 2013).

These recreational licenses included those issued to private individuals and those issued to charter boat captains who take tourists and other individuals without a recreational license to fish. Additionally, Jiménez-Alvarado (2010) reported that approximately 10% of recreational fishers fish without licenses, which is equivalent to unreported fishing licenses at 11.1% of reported ones. It is reasonable to assume those fishing without licenses are individual anglers rather than charter boat captains. Ultimately, we created separate time series for recreational anglers and charter vessels, which would have different catch rates because charter vessels take many passengers at a time and fish all year round.

According to the number of recreational fishing boats registered in the Canary Islands in 2005, MAPyA (2006) indicated that 827 of them where under the "sixth list", or recreational vessels which are for-profit, i.e. charter vessels, and 22,619 vessels were personal recreational fishing craft under the "seventh list". It was reasonable to assume that each charter boat would own one license, while there are likely more recreational licenses active than boats, as one boat may belong to a family or some fish without boats on piers. Hence, we assumed that of the 48,741 active anglers in 2005, 827 were charter licenses for taking tourists, and the rest were generally for residents.

We extended this division through time by creating a proxy variable: the number of charter licenses divided by the tourist population, which in 2005 was .009%. We used tourist population because the number of recreational fishers upon charters depends on the influx of tourism and assumedly varies according to the rate of tourist population. We assumed this ratio would be 0% from 1950 to 1959 when tourism had not yet expanded, and interpolated to .009% in 2005 and then continued the linear trend to 2010. This time series of the proxy ratio was multiplied by the tourist population from 1950 – 2010 to obtain an estimated time series of the number of charter boats in operation.

Next we estimated the total number of active recreational anglers, excluding anglers upon charter boats yet including recreational fishers without a license. Since we have data on the total number of active licenses from 2005 – 2010 (with any gap year interpolated) we subtracted the number of charter licenses to obtain the number of (assumedly resident) recreational licenses. For the years prior to 2005, we utilized a similar strategy as that for charter licenses, except we used resident rather than tourist population, obtaining a ratio of resident licenses in 2005 to resident population in 2005 at 2.7%. Since 1950 to 1959 was a time of food shortage (Palmero 2001), implying that subsistence fishing was more likely than recreational fishing among residents, we interpolated between 0% from 1950 – 1959 to the 2005 value. Also, the development of the touristic industry in the 1960s facilitated a better economic position for the local population and, according to this, facilitated the inversions in equipment for recreational fishing, particularly fiberglass boats. This ratio from 1950 – 2004 was multiplied by the resident population to generate a complete time series of reported licenses. Finally, we adjusted this time series to account for the 10% of recreational anglers fishing without a fishing license by multiplying the reported resident licenses (not charter) by 11.1%.

From comparing boat capacity on recreational charters (from an internet search), it appears that on average, each charter takes between 3 and 4 people at a time. We assumed a very conservative number of trips at two per year per charter, resulting in each charter license accommodating the equivalent of seven private license holders. It is likely that fishing is far more common among charters, who fish all year long to accommodate the waves of tourists; nonetheless, we assume this conservative estimate.

<u>Catch rate per angler</u>

According to interviews of anglers, MAPyA (2006) reported a catch rate of 0.085 t·fisher$^{-1}$·trip$^{-1}$ when fishing from a boat and 0.0085 t·fisher$^{-1}$·trip$^{-1}$ when fishing from the shore. Furthermore, of the new licence holders in 2005, 301 were for fishers fishing from a boat while 16,202 were for those fishing from shore. We weighted these rates by the number of fishers in each category to obtain one representative rate of 0.0099 t·fisher$^{-1}$·trip$^{-1}$. Furthermore, the average number of trips taken was 43 trips annually (MAPyA 2006) so we adjusted this rate obtain a total annual catch rate of 0.425 t·fisher$^{-1}$·year$^{-1}$ in 2005.

While this catch rate is appropriate for 2005, we varied catch rates over time using some simple assumptions about changes in the CPUE and technological advancements. Regarding technological advancements, these changes came first for artisanal fishers and then recreational fishers, and we assumed there was a lag of about five years. Throughout the 1970s, most of the artisanal fleet became equipped with onboard engines and hydraulic fishing winches, and in the 1980s and 1990s other technological advancements were also incorporated such as radio, GPS, synthetic nets, echo sounders, etc. Accounting for the five year lag, we assumed a constant level of technology until 1975, thereafter increasing by a factor of four to 100% in 2005, and then remaining constant (Figure 9a). CPUE was modelled in Figure 9b, where the 2005 value was normalized to 100% as well. The merging of the two trends created a variable trend line of the catch rate before and after the 2005 catch rate (Figure 9c).

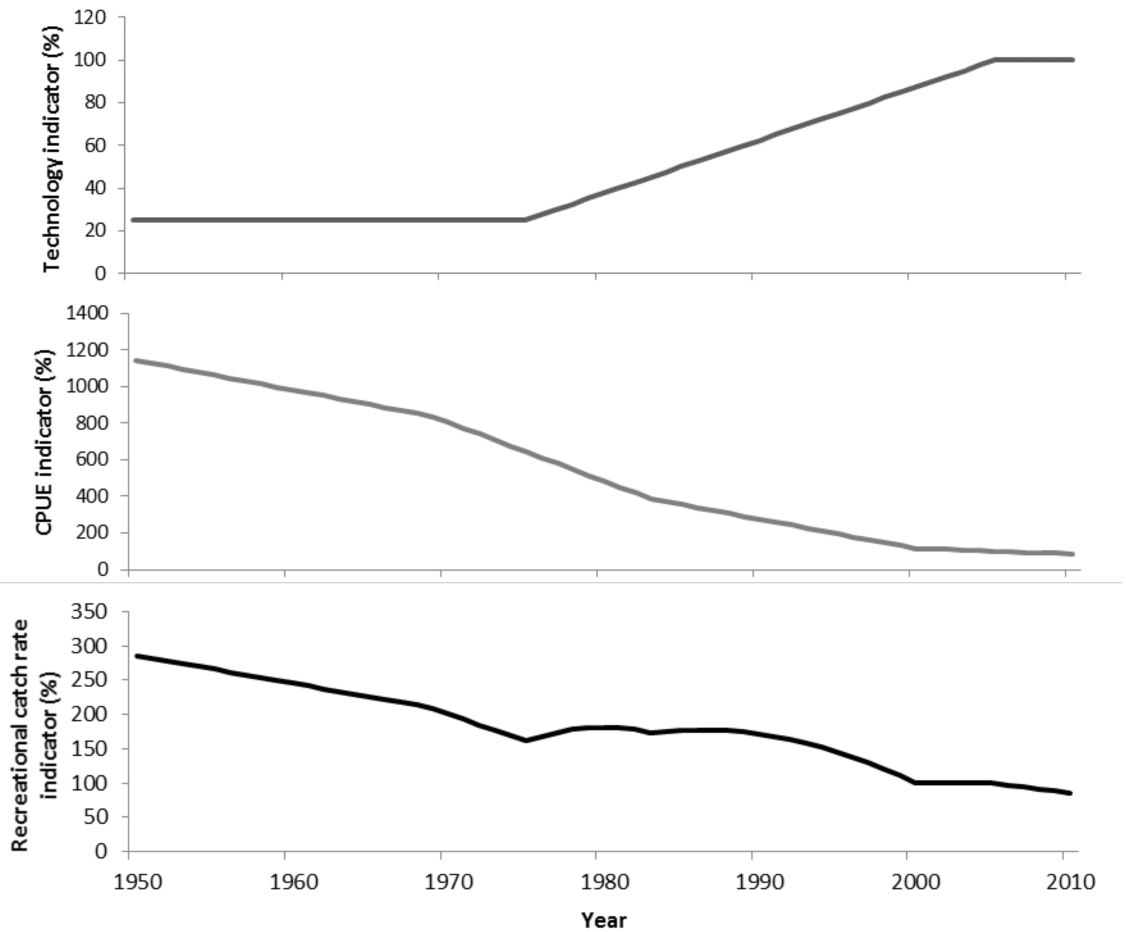


**Figure 9**. Data for recreational fisheries in the Canary Islands, showing a) the technological indicator; b) the CPUE indicator ; and c) the cumulative indicator for 1950 – 2010. The base year is 2005 with 100%,

The time series of catch rate was adjusted accordingly, and this time series was multiplied by the total amount of recreational anglers, counting seven anglers per charter license to obtain the entire time series of recreational catches. For the species composition, we used the percentage of fishers who target certain species as a representative sample of catch (MAPyA 2006). A comprehensive list of species and their contribution to catch is available in Appendix 2.

**Subsistence catch**

Subsistence catch is defined as 'take-home' catch for personal consumption, as opposed to artisanal catch which is sold in local markets. We assumed there were two sectors of the Canarian population who catch fish for subsistence: (i) fishers and their families, and (ii) non-fishers during times of food shortage.

Fishing households

Since most fishers belong to fishing households, we assumed that fishers would take home catch for personal consumption for themselves and their families prior to selling their catch. Hence, we multiplied the time series of the number of artisanal fishers by four, making the assumption that an average household has four members.

Non-fishers during food shortages

After the Spanish Civil War and WWII, Spain, and by extension the Canaries, suffered a severe economic recession due in part to their isolation from the international community (Palmero 2001). Characteristic of this time period was serious food shortages, which brought about the development of a black market in the 1940s, until the 1950s when it diminished as Spain joined the UN in 1955 and had mostly ended by 1959 when the economy had revived (Palmero 2001). This black marketeering was all pervasive and created a general climate of corruption; average prices of the products on the black market were two to three times higher than the official market (Palmero 2001). Thus, it is reasonable to assume that some of the poorer resident population would look to the sea for survival due to lack of other alternatives for food. This mostly took the form of gathering shellfish on foot, as poor non-fishers were not able to afford boats or fishing gear.

We assumed 5% of the total population subsisted on fish in 1950, declined to 4% of the population in 1955, and then furthermore decreased to 0% in 1960 when the economy had substantially revived (Palmero 2001). The number of residents, both fishers and non-fishers, subsisting on fish from 1950 to 2010 can be seen in Figure 10.

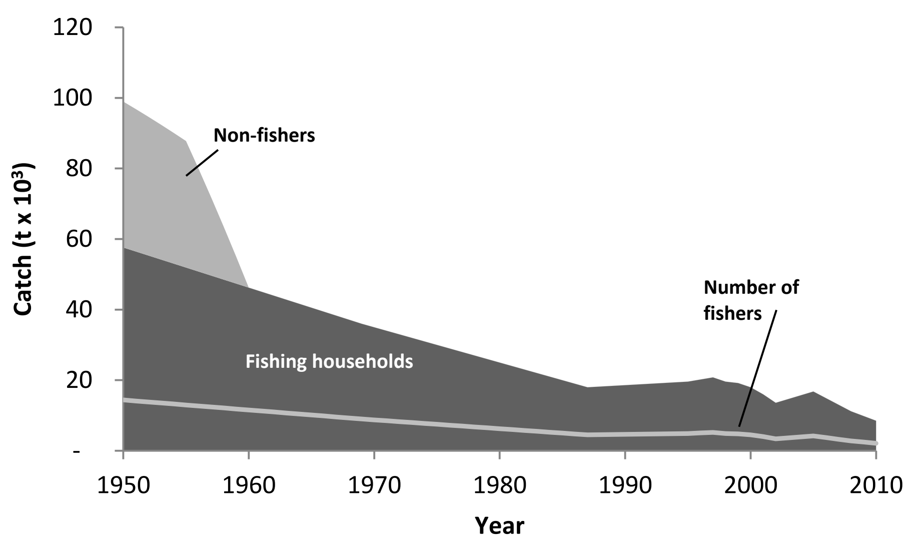


**Figure 10**. Number of residents consuming fish for personal subsistence, 1950 – 2010.

Per capita rate of fish consumption

Per capita fish consumption was estimated at 21 kg·fisher$^{-1}$·year$^{-1}$ by the Food Consumption Panel of the Spanish Ministry of Agriculture, which did not include food consumption outside the home or the consumption of food not bought through markets. Although this estimate is not complete, we assumed this amount is representative of the cultural norm of food consumption in the Canary Islands. Due to the omission of subsistence catch and consumption of fish in restaurants, it is a conservative estimate, especially since fisher families likely eat more fish on average than other households. Nonetheless, due to lack of more suitable data we utilized this rate as an acceptable proxy for how much a fisher and his family may consume from their own small-scale catch in 2010. We assumed this amount was twice as high in 1950 and interpolated between the two values.

This per capita rate was multiplied by the total number of fishing household members and the estimated proportion of non-fishers during times of food shortage from 1950 to 2010. For catch consumed by fishers and their families, we utilized the same species composition as artisanal catch while for non-fishers we assumed they mostly consumed shellfish.

**Discards**

Few studies of discards at sea for the small-scale fisheries of the Canary Islands have been undertaken, complicated by the fact that the artisanal fishers utilize about 30 different gears targeting over 200 different species (Santamaría *et al.* 2013). One of the few discard studies undertaken for the Canary Islands waters is for the artisanal shrimp trap fishery (Arrasate-López *et al.* 2012) which is a traditional fishery of the Canary Islands since the late 1980s (FAO CECAF-SC 2011b), although catches are quite small. The discard rate cited for the traditional bottom traps was 1.9%, which we cited in Table 7. Many other trap fisheries exist, especially for finfish and coastal morays (FAO CECAF-SC 2011a; Santamaría *et al.* 2013), and we believe this study can be used as a representative study on discards for bentho-demersal species (Popescu and Ortega Gras 2013). According to Kelleher (2005) amongst other sources, the bait boat fishery targeting tuna is highly selective and thus we assumed discards were zero (Table 7). For other pelagic species, in the 1990s the senior author observed a discard rate of over 50% of bogue (*Boops boops*). We conservatively assumed an average discard rate of 25% for the entire time period of all species.

**Table 7.** Discard rates of artisanal fisheries in the Canary Islands, 1950–2010.

| Gears | Percentage of total catch (%) | Percentage of total landings (%) | Applied to: |
|---|---|---|---|
| Artisanal trap, longlines, gillnets | 2 | 2 | Bentho-demersal species |
| Artisanal purse seine | 25 | 33 | Small pelagic species |
| Artisanal bait boats (tuna)* | 0 | 0 | Tunas and tuna-like species |

**Considered a "highly selective" gear*

For the bentho-demersal fishery we used the species composition from Saavedra (2011), assigning certain percentages based on the qualitative description used (Table 8).

**Table 8.** Species discarded in the artisanal fisheries targeting bentho-demersal species, 1950–2010.

| Species name | Common name | Percentage of discards (%) | |
|---|---|---|---|
| | | *1950 - 1979* | *1980 - 2010* |
| Tetraodontidae | Puffers | 9 | 10 |
| *Canthigaster rostrata* | Caribbean sharpnose-puffer | 9 | 10 |
| *Canthigaster capistrata* | Macaronesian sharpnose-puffer | 9 | 10 |
| *Sphoeroides marmoratus* | Guinean puffer | 9 | 10 |
| *Synodus* | Lizardfishes | 9 | 10 |
| Pomacentridae | Damselfishes | 9 | 10 |
| *Chromis limbata* | Azores chromis | 9 | 10 |
| *Abudefduf luridus* | Canary damsel | 9 | 10 |
| Echinoidea | Sea urchins | 3 | 3 |
| Holothuroidea | Sea cucumbers | 3 | 3 |
| Miscellaneous aquatic invertebrates | Aquatic invertebrates | 3 | 3 |
| *Dasyatis* | Stingrays | 2 | 3 |
| *Myliobatis aquila* | Common eagle ray | 2 | 3 |
| *Taeniura grabata* | Round stingray | 2 | 3 |
| *Squatina squatina* | Angelshark | 2 | 3 |
| *Stephanolepis hispidus* | Planehead filefish | 9 | 0 |

For the purse seine fisheries, we estimated that majority (90%) of species discarded were bogue and the minority (10%) was another common species caught, the Madeiran sardinella (*Sardinella maderensis*) as is depicted in Table 9. We assumed this was constant due to lack of changes in gear or target species by the artisanal fleet. Furthermore, this observation was supported by Saavedra (2011) who stated that discards at times exceed 50% of the catch and another common species discarded was the Madeiran sardinella (*Sardinella maderensis*).

**Table 9.** Species discarded in the artisanal purse seine fisheries targeting pelagic species (except tuna), 1950–2010.

| Species name | Common name | Percentage of discards (%) |
|---|---|---|
| *Boops boops* | Bogue | 90 |
| *Sardinella maderensis* | Madeiran sardinella | 10 |

## Results

### Reconstructed total catch

Reconstructed total catch increased from approximately 38,600 t in 1950 to 81,200 t in 1985 before declining to about 43,700 t·year$^{-1}$ in the early-2000s and then rebounding to 65,300 t·year$^{-1}$ by the late-2000s (Figure 11a). For the years when data were assumed to have been reported by Spain to the FAO (2006 – 2010), the reconstructed catch was seven times the reported catch. For the entire time period, artisanal landings comprised 66% of the total catch, recreational catch was 26%, discards were 6%, and subsistence catch was 2% of the total catch. This composition is not representative for the 2000s, however, and by 2010 artisanal landings had declined to 22% of catch, discards to 4% subsistence to 0.3%, and recreational catch increased to 74% of catch. A detailed time series can be seen in Appendix 3.

Taxonomically, approximately 30.5% of the catch was composed of species from the family Scombridae. Among scombrids, Atlantic chub mackerel, bigeye tuna and skipjack tuna were the most common, comprising 10%, 8% and 6% of the total catch by weight, respectively. Another 30.5% of the catch was composed of various species in the porgy family (Sparidae; Figure 11b), which included several dominant species like bogue (*Boops boops*; 7.4%), red porgy (*Pagrus pagrus*; 4.1%), salema (*Sarpa salpa*; 4.1%), black seabream (*Spondyliosoma cantharus*; 4.0%), Moroccan white seabream (*Diplodus sargus cadenati*; 3.5%), and twelve other species that contributed a smaller portion of the total catch. The two most dominant species each contributed 10% to total catch: Atlantic chub mackerel (*Scomber colias*) and parrotfish (*Sparisoma cretense*; Figure 11b). Besides the 28 species already considered above, 29% of the leftover catch was a mixture of 83 other taxonomic categories (Figure 11b). Please refer to Appendix 4 for a detailed time series of catch by taxon.

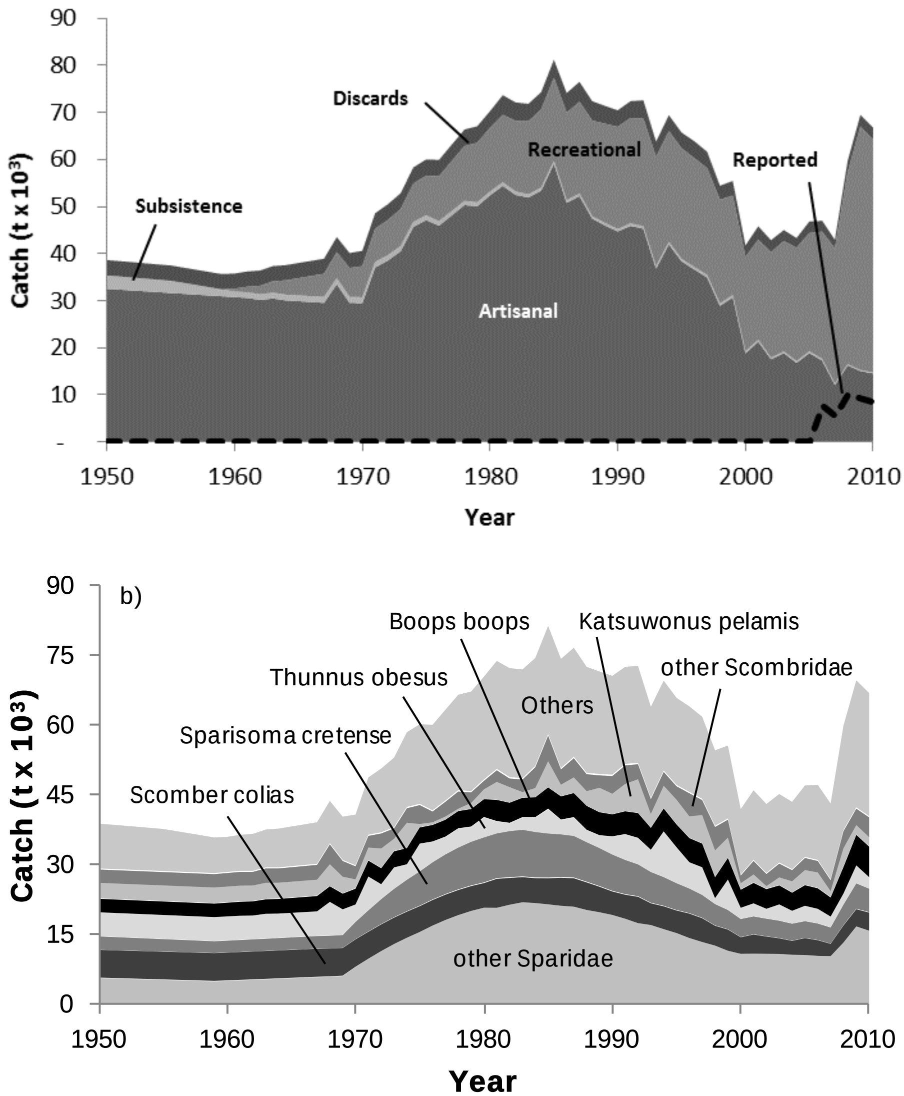


**Figure 11**. Reconstructed total catch for the Canary Islands for 1950 to 2010, by a) sector, with official reported data overlaid as line graph; and b) major taxa, with 'others' consisting of over 90 additional taxa.

## Discussion

Fishing in the Canary Islands consists of a large multi-gear polyvalent small-scale fleet, alternating the exploitation of different fish resources, in a process similar to that of other European small-scale fisheries (Maynou *et al.* 2011; Guyader *et al.* 2013; Maynou *et al.* 2013). Up until the start of the 21$^{st}$ century, most of the approximately 54,000 t·year$^{-1}$ of reconstructed catch was taken by this artisanal fishery, including its bait catch and discards, while the remaining 28% were from informal sectors such as recreational and subsistence fishing. Recreational fishing has generally been a larger proportion of catch than subsistence, which has a small catch yet is nonetheless culturally significant.

In 1970, García-Cabrera, faced with the depletion of and limited prospects offered by the bentho-demersal resources of the islands, suggested reorienting the fishing fleet to the exploitation of tuna species, particularly in the nearby, more profitable African fishing grounds (i.e., the Canary-Saharan Bank) (Balguerías 1995) as part of the future development strategy for fishing from the islands, and designing a fishing industry based on the manufacturing and processing of these species. However, it was this expansionist policy incorrectly applied to the islands, together with the subsequent loss of Western Sahara fishing grounds (Pérez-Labajos *et al.* 1996; Guénette *et al.* 2001) and the disappearance of the processing industry (Bas *et al.* 1995),which contributed to the exhaustion of fishery resources of the archipelago, while the small-scale fleet, recreational fleet, and onshore infrastructures expanded, resulting in fishing overcapacity. This is clearly seen in the present catch reconstruction, where the catch of this artisanal fleet increased in the 1970s, reaching over 59,000 t in 1985 before declining fourfold by 2010.

Target species have long shown signs of overfishing (García-Cabrera 1970; González 2008), and yet this fact has not motivated a significant change in management strategies. The management policy of this fishery has been based primarily on the establishment of regulations of fishing effort, limiting the type and quantity of certain fishing gear used by both professional and sports fishers, and on reducing the number of fishing boats. However, this policy failed to reduce overcapacity (ECOA 2011) and overfishing. On the contrary, it has led to the reduction of the available biomass of bentho-demersal stocks by approximately 93% over the entire 60 year period.

Paradoxically, at the same time that regulatory measures to reduce the "classical" fishing effort were taken, onshore infrastructures were developed to assist the artisanal and recreational fishing fleets along the entire archipelago, as secondary ports and support equipment (e.g., travel lifts, floating docks, etc.), producing a significant increase in the fishing capacity and effectively the fishing effort. Thus, the progressive investment in the construction and improvement of secondary ports, not only as refuges of the fleet and to facilitate docking, but also incorporating frozen systems, storing, cranes, naval repair, supplies, etc., has allowed boats, that until the late 1980s were stranded on the beaches from adverse environmental conditions, have easier access to fishing grounds and operate with less crew members, a fact that also increased fishing effort. Furthermore these secondary ports boosted the development of recreational boat fishing.

While in the second half of the 20$^{th}$ century most catch was taken by the artisanal fleet, by the late 2000s, this dynamic shifted from a large increase in recreational fishing, which comprised nearly 70% of total catch and averaged about 40,000 t·year$^{-1}$. This large amount also explains why, from 2006 to 2010 when data were assumedly reported, total reconstructed catch was nearly seven times the reported catch of the FAO. This is troubling for the fishery because in contrast to the artisanal fleet which faces many stringent guidelines limiting effort, there is still no formal management plan to control recreational catch, as can be seen by the abundant charter boat operations and the 10% of recreational fishers who fish without a license. Likewise, the number of recreational anglers grew 230% from 2005 to 2010, while the number of professional fishers decreased by 49% in the same time period. This is a key result for policy makers to attend to, as fish stocks are already depleted. Additionally, there is an increasing trend in recent years of recreational fishers poaching and selling their catches illegally (Pascual-Fernandez and De la Cruz Modino 2011).

Finally, there is no management plan for the baitboat fishery of the Canary Islands, similar to many other countries with such fisheries (Gillett 2012). Indeed, "the status of the major baitfish species is not known, but lack of problems reported by fishery stakeholders leads to the belief that there are no major resource issues" (Gillett 2012). This is furthered by the fact that baitfish demand and catches have declined substantially in recent decades so there is even less of a reason to manage the fishery than before. While this fishery has many positive attributes, such as little to no discards, the lack of data on bait catch is something that should be revisited. This is the first report that estimated the catch of baitfish in the Canary Islands and the results are rather striking at nearly 5,000 $t \cdot year^{-1}$, while the food fishery has averaged only 4,000 $t \cdot year^{-1}$ with catches drastically declining by the 2000s. Sources do point to fishers having difficulties at times obtaining sufficient catches of bait species and cite the reason for this as natural causes. While it is very possible that the stock is healthy and simply had lower catch from natural variations, assessing the stock of such species would still be useful in ensuring the future sustainability of the fishery. Additionally, bait catches of sand smelt (*Atherina presbyter*) are permitted but not for catch in the commercial fishery for food, which leaves some discrepancies (Gillett 2012).

From 1950 to 2010, many changes have taken place on the islands, only a mirror of the worldwide trends. Once, fishers passed down their craft to their family, educating them on the best fishing spots, which were considered proprietary and was often a barrier for those wishing to enter the market from non-fishing families (Pascual-Fernandez and De la Cruz Modino 2011). With the introduction of new technologies, e.g., the use of GPS (global positioning system), eco sound, etc., "small-scale fishers no longer have the same capacities to control their territories," as recreational fishing boats can simply pass by artisanal fishing boats while they fish and 'store' their GPS coordinates (Pascual-Fernandez and De la Cruz Modino 2011). Additionally, young people are no longer attracted to fishing industry and the prestige associated with being a good fisher has changed, as the benefits of continuing the family tradition do not seem to outweigh the time-consuming apprenticeship and stringent qualifications of the EU to be considered a professional fisher.

As the artisanal fleet declines, several economic alternatives have sprouted for fishing households, namely investment in fresh fish restaurants or renting their houses and apartments for complementary incomes (Pascual-Fernandez and De la Cruz Modino 2011). Such viable alternative livelihood options complement artisanal fishing and are particularly relevant for tourism, especially domestic tourism. The artisanal fishers are adapting, yet with the rapid increase in recreational fishing the question is whether management policy will adapt as well, or continue to overlook the problems of the fishery.

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**Appendix 1**

The following sources, in addition to what was already cited in the References, were used by the senior author, Dr. Castro, to develop bottom-up anchor points and a database of key information of the small-scale artisanal fishery for bentho-demersal species. These data points contributed to estimating total catch within the waters of the Canary Islands:


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**Appendix 2**. Species composition of recreational catch in the waters of the Canary Islands, 1950 – 2010.

| Species name | Spanish common name | English common name | Composition (%) |
|---|---|---|---|
| *Diplodus sargus cadenati* | Sargo | Moroccan white seabream | 10.2 |
| *Sparisoma cretense* | Vieja | Parrotfish | 10.1 |
| *Serranus* spp. | Cabrilla | Groupers | 8.4 |
| *Boops boops* | Boga | Bogue | 8 |
| *Sarpa salpa* | Salema | Salema | 5.8 |
| *Mycteroperca fusca* | Abade | Island grouper | 4.2 |
| *Acanthocybium solandri* | Peto | Wahoo | 3.6 |
| *Pagellus erythrinus* | Breca | Common pandora | 3.3 |
| *Trachinotus ovatus* | Palometa | Pompano | 2.6 |
| *Pagrus pagrus* | Bocinegro | Red porgy | 2.4 |
| *Makaira nigricans* | Marlin azul | Blue marlin | 2.4 |
| *Muraena augusti* | Morena | N/A | 2.3 |
| *Seriola dumerili* | Medregal | Greater amberjack | 1.7 |
| *Coryphaena hippurus* | Dorado | Common dolphinfish | 1.6 |
| *Thunnus obesus* | Atún patudo | Bigeye tuna | 1.5 |
| *Pagellus acarne* | Besugo | Axillary seabream | 1.5 |
| *Spondyliosoma cantharus* | Chopa | Black seabream | 1.5 |
| *Sparus aurata* | Dorada | Gilthead seabream | 1.5 |
| *Diplodus vulgaris* | Seifia | Common two-banded seabream | 1.5 |
| *Oblada melanura* | Galana | Saddled seabream | 1.5 |
| *Trachurus picturatus* | Chicharro | Blue jack mackerel | 1.4 |
| *Bodianus scrofa* | Pejeperro | Barred hogfish | 1.3 |
| *Thunnus alalunga* | Bonito del norte | Albacore | 1.2 |
| *Sphyraena viridensis* | Bicuda | Yellowmouth barracuda | 1.2 |
| *Katsuwonus pelamis* | Listado | Skipjack tuna | 1.2 |
| *Stephanolepis hispidus* | Gallo verde | Planehead filefish | 1.15 |
| *Balistes capriscus* | Gallo moruno | Grey triggerfish | 1.15 |
| *Helicolenus dactylopterus* | Bocanegra | Blackbelly rosefish | 1.1 |
| *Atherina presbyter* | Guelde blanco | Sand smelt | 1 |
| *Liza aurata* | Lisa | Golden grey mullet | 1 |
| *Lithognathus mormyrus* | Herrera | Sand steenbras | 0.8 |
| *Dicentrarchus labrax* | Lubina | European seabass | 0.8 |
| *Mugil cephalus* | Lebrancho | Flathead grey mullet | 0.7 |
| *Pomadasys incisus* | Roncador | Bastard grunt | 0.7 |
| *Dentex gibbosus* | Sama | Pink dentex | 0.6 |
| *Polyprion americanus* | Cherne | Wreckfish | 0.6 |
| *Thalassoma pavo* | Pejeverde | Ornate wrasse | 0.6 |
| *Sarda sarda* | Sierra | Atlantic bonito | 0.6 |
| *Beryx splendens* | Alfonsiño | Splendid alfonsino | 0.5 |
| *Tetrapturus albidus* | Marlin blanco | Atlantic white marlin | 0.5 |
| *Merluccius merluccius* | Merluza | European hake | 0.5 |
| *Belone belone* | Aguja | Garfish | 0.4 |
| *Plectorhinchus mediterraneus* | Burro | Rubberlip grunt | 0.4 |
| *Abudefduf luridus* | Fula negra | Canary damsel | 0.4 |
| *Thunnus albacares* | Rabil | Yellowfin tuna | 0.4 |
| *Trachinus draco* | Araña | Greater weever | 0.4 |
| *Scomber colias* | Caballa | Atlantic chub mackerel | 0.4 |
| *Sphoeroides marmoratus* | Tamboril | Guinean puffer | 0.4 |
| *Synodus saurus* | Lagarto | Atlantic lizardfish | 0.2 |
| *Mora moro* | Merluza canaria | Common mora | 0.2 |
| *Mullus surmuletus* | Salmonete | Surmullet | 0.2 |
| *Epinephelus marginatus* | Mero | Dusky grouper | 0.1 |
| *Diplodus annularis* | Mugarra | Annular seabream | 0.1 |
| *Schedophilus ovalis* | Pámpano | Imperial blackfish | 0.1 |
| *Xyrichtys novacula* | Pejepeine | Pearly razorfish | 0.1 |
| *Pagrus auriga* | Sama roquera | Redbanded seabream | 0.1 |
| *Loligo vulgaris* | Calamar | European squid | 0.1 |
| *Heteropriacanthus cruentatus* | Catalufa | Glasseye | 0.1 |
| *Dentex dentex* | Dentón | Common dentex | 0.1 |
| *Beryx splendens* | Palometa roja | Splendid alfonsino | 0.1 |
| *Dentex macrophthalmus* | Antoñito | Large-eye dentex | 0.1 |
| *Thunnus thynnus* | Atún rojo | Atlantic bluefin tuna | 0.1 |
| *Dicentrarchus punctatus* | Baila | Spotted seabass | 0.1 |
| *Phycis blennoides* | Briota | Greater forkbeard | 0.1 |
| *Mustelus mustelus* | Cazón | Smooth-hound | 0.1 |
| *Dasyatis pastinaca* | Chucho | Common stingray | 0.1 |
| *Promethichthys prometheus* | Conejo | Roudi escolar | 0.1 |
| *Conger conger* | Congrio | European conger | 0.1 |
| *Beryx decadactylus* | Fula roja | Alfonsino | 0.1 |
| *Ommastrephes bartramii* | Pota | Neon flying squid | 0.1 |
| *Octopus vulgaris* | Pulpo | Common octopus | 0.1 |
| *Brama brama* | Japuta | Atlantic pomfret | 0.1 |
| *Aphanopus carbo* | Sable negro | Black scabbardfish | 0.1 |
| *Sepia officinalis* | Sepia | Common cuttlefish | 0.1 |
| *Pontinus kuhlii* | Obispo | Offshore rockfish | 0.1 |
| | | | **100.0** |

**Appendix 3**. Total reported catch and total reconstructed catch for the Canary Islands by sector, 1950 – 2010.

| Year | Reported catch | Total reconstructed catch | Artisanal | Subsistence | Recreational | Discards |
|---|---|---|---|---|---|---|
| 1950 | 0 | 38,600 | 32,500 | 2,840 | 0 | 3,260 |
| 1951 | 0 | 38,400 | 32,400 | 2,790 | 0 | 3,260 |
| 1952 | 0 | 38,200 | 32,200 | 2,740 | 0 | 3,260 |
| 1953 | 0 | 37,900 | 32,000 | 2,690 | 0 | 3,250 |
| 1954 | 0 | 37,700 | 31,800 | 2,640 | 0 | 3,250 |
| 1955 | 0 | 37,500 | 31,600 | 2,580 | 0 | 3,250 |
| 1956 | 0 | 37,000 | 31,500 | 2,310 | 0 | 3,240 |
| 1957 | 0 | 36,600 | 31,300 | 2,030 | 0 | 3,240 |
| 1958 | 0 | 36,100 | 31,100 | 1,750 | 0 | 3,240 |
| 1959 | 0 | 35,600 | 30,900 | 1,470 | 0 | 3,230 |
| 1960 | 0 | 35,800 | 30,800 | 1,180 | 596 | 3,230 |
| 1961 | 0 | 36,200 | 30,600 | 1,190 | 1,200 | 3,230 |
| 1962 | 0 | 36,400 | 30,200 | 1,200 | 1,810 | 3,220 |
| 1963 | 0 | 37,300 | 30,500 | 1,210 | 2,430 | 3,220 |
| 1964 | 0 | 37,500 | 30,100 | 1,220 | 3,040 | 3,220 |
| 1965 | 0 | 38,000 | 29,900 | 1,230 | 3,670 | 3,210 |
| 1966 | 0 | 38,500 | 29,700 | 1,240 | 4,290 | 3,210 |
| 1967 | 0 | 38,900 | 29,500 | 1,250 | 4,910 | 3,210 |
| 1968 | 0 | 43,500 | 33,500 | 1,260 | 5,530 | 3,200 |
| 1969 | 0 | 40,100 | 29,500 | 1,270 | 6,150 | 3,170 |
| 1970 | 0 | 40,600 | 29,500 | 1,220 | 6,630 | 3,220 |
| 1971 | 0 | 48,600 | 37,100 | 1,180 | 7,080 | 3,280 |
| 1972 | 0 | 50,500 | 38,500 | 1,130 | 7,480 | 3,330 |
| 1973 | 0 | 52,800 | 40,500 | 1,090 | 7,850 | 3,370 |
| 1974 | 0 | 58,300 | 45,700 | 1,040 | 8,170 | 3,410 |
| 1975 | 0 | 60,000 | 47,100 | 1,000 | 8,450 | 3,440 |
| 1976 | 0 | 59,900 | 45,900 | 954 | 9,540 | 3,470 |
| 1977 | 0 | 63,200 | 48,100 | 911 | 10,620 | 3,490 |
| 1978 | 0 | 66,400 | 50,300 | 869 | 11,660 | 3,510 |
| 1979 | 0 | 67,100 | 50,100 | 828 | 12,640 | 3,520 |
| 1980 | 0 | 70,300 | 52,400 | 787 | 13,550 | 3,520 |
| 1981 | 0 | 73,700 | 54,400 | 748 | 14,360 | 4,160 |
| 1982 | 0 | 72,100 | 52,500 | 708 | 15,020 | 3,890 |
| 1983 | 0 | 71,800 | 51,900 | 670 | 15,530 | 3,700 |
| 1984 | 0 | 74,300 | 53,400 | 632 | 16,600 | 3,680 |
| 1985 | 0 | 81,200 | 59,100 | 595 | 17,620 | 3,860 |
| 1986 | 0 | 74,100 | 50,800 | 559 | 18,600 | 4,160 |
| 1987 | 0 | 76,500 | 52,200 | 523 | 19,500 | 4,230 |
| 1988 | 0 | 72,400 | 47,400 | 522 | 20,340 | 4,090 |
| 1989 | 0 | 71,400 | 46,000 | 522 | 21,080 | 3,800 |
| 1990 | 0 | 70,400 | 44,700 | 521 | 21,710 | 3,500 |
| 1991 | 0 | 72,400 | 45,900 | 520 | 22,390 | 3,570 |
| 1992 | 0 | 72,600 | 45,300 | 519 | 22,870 | 3,890 |
| 1993 | 0 | 63,800 | 36,800 | 517 | 23,220 | 3,220 |
| 1994 | 0 | 69,400 | 42,000 | 516 | 23,550 | 3,370 |
| 1995 | 0 | 65,700 | 38,400 | 514 | 23,510 | 3,330 |
| 1996 | 0 | 63,900 | 36,600 | 523 | 23,140 | 3,580 |
| 1997 | 0 | 61,600 | 35,000 | 531 | 22,670 | 3,480 |
| 1998 | 0 | 54,400 | 28,900 | 494 | 22,090 | 2,920 |
| 1999 | 0 | 55,400 | 30,700 | 477 | 21,120 | 3,110 |
| 2000 | 0 | 41,700 | 18,800 | 441 | 20,040 | 2,430 |
| 2001 | 0 | 45,800 | 21,300 | 386 | 21,300 | 2,820 |
| 2002 | 0 | 42,800 | 17,600 | 324 | 22,410 | 2,540 |
| 2003 | 0 | 45,000 | 18,900 | 344 | 23,490 | 2,300 |
| 2004 | 0 | 43,300 | 16,800 | 363 | 24,100 | 2,050 |
| 2005 | 0 | 46,800 | 18,900 | 382 | 25,110 | 2,480 |
| 2006 | 7,710 | 47,000 | 17,300 | 335 | 27,060 | 2,290 |
| 2007 | 5,603 | 43,000 | 12,100 | 288 | 28,740 | 1,840 |
| 2008 | 10,035 | 59,700 | 16,300 | 243 | 40,790 | 2,430 |
| 2009 | 9,253 | 69,500 | 15,100 | 210 | 51,760 | 2,440 |
| 2010 | 8,342 | 66,700 | 14,600 | 179 | 49,390 | 2,610 |

**Appendix 4**. Total reconstructed catch for the Canary Islands by taxon, 1950 – 2010.

| Year | Sparidae | *Sparisoma cretense* | *Scomber colias* | *Boops boops* | *Katsuwonus pelamis* | *Thunnus obesus* | Other |
|---|---|---|---|---|---|---|---|
| 1950 | 1,650 | 2,860 | 5,980 | 2,870 | 3,410 | 5,300 | 16,600 |
| 1951 | 1,620 | 2,820 | 5,990 | 2,870 | 3,410 | 5,310 | 16,400 |
| 1952 | 1,600 | 2,780 | 5,990 | 2,870 | 3,420 | 5,310 | 16,200 |
| 1953 | 1,580 | 2,740 | 5,990 | 2,870 | 3,420 | 5,310 | 16,000 |
| 1954 | 1,560 | 2,700 | 5,990 | 2,870 | 3,420 | 5,310 | 15,900 |
| 1955 | 1,530 | 2,660 | 6,000 | 2,870 | 3,420 | 5,320 | 15,700 |
| 1956 | 1,510 | 2,620 | 6,000 | 2,870 | 3,420 | 5,320 | 15,300 |
| 1957 | 1,490 | 2,580 | 6,000 | 2,870 | 3,420 | 5,320 | 14,900 |
| 1958 | 1,460 | 2,540 | 6,000 | 2,870 | 3,430 | 5,330 | 14,500 |
| 1959 | 1,440 | 2,500 | 6,000 | 2,870 | 3,430 | 5,330 | 14,100 |
| 1960 | 1,520 | 2,520 | 6,010 | 2,920 | 3,440 | 5,340 | 14,000 |
| 1961 | 1,600 | 2,540 | 6,010 | 2,970 | 3,450 | 5,350 | 14,300 |
| 1962 | 1,680 | 2,570 | 6,020 | 3,010 | 3,380 | 5,250 | 14,500 |
| 1963 | 1,770 | 2,590 | 6,020 | 3,060 | 3,540 | 5,490 | 14,900 |
| 1964 | 1,850 | 2,610 | 6,030 | 3,110 | 3,480 | 5,390 | 15,100 |
| 1965 | 1,940 | 2,630 | 6,040 | 3,160 | 3,490 | 5,400 | 15,300 |
| 1966 | 2,020 | 2,660 | 6,040 | 3,210 | 3,500 | 5,420 | 15,600 |
| 1967 | 2,100 | 2,680 | 6,050 | 3,260 | 3,510 | 5,430 | 15,900 |
| 1968 | 2,180 | 2,690 | 6,020 | 3,310 | 4,770 | 7,390 | 17,200 |
| 1969 | 2,270 | 2,730 | 5,980 | 3,330 | 3,650 | 5,650 | 16,500 |
| 1970 | 2,870 | 3,680 | 5,920 | 3,360 | 2,010 | 3,870 | 18,900 |
| 1971 | 3,420 | 4,530 | 5,820 | 3,380 | 2,900 | 7,340 | 21,200 |
| 1972 | 3,930 | 5,350 | 5,760 | 3,400 | 4,310 | 3,290 | 24,400 |
| 1973 | 4,400 | 6,090 | 5,690 | 3,420 | 2,810 | 4,670 | 25,800 |
| 1974 | 4,830 | 6,760 | 5,630 | 3,430 | 5,590 | 3,370 | 28,700 |
| 1975 | 5,210 | 7,380 | 5,570 | 3,440 | 895 | 5,980 | 31,600 |
| 1976 | 5,700 | 8,010 | 5,520 | 3,520 | 732 | 4,460 | 32,000 |
| 1977 | 6,140 | 8,570 | 5,460 | 3,590 | 871 | 3,790 | 34,700 |
| 1978 | 6,540 | 9,040 | 5,410 | 3,660 | 708 | 4,100 | 36,900 |
| 1979 | 6,880 | 9,440 | 5,360 | 3,730 | 1,510 | 3,220 | 36,900 |
| 1980 | 7,160 | 9,740 | 5,310 | 3,790 | 2,360 | 4,300 | 37,600 |
| 1981 | 7,220 | 9,690 | 6,250 | 4,510 | 4,110 | 2,560 | 39,300 |
| 1982 | 7,460 | 9,990 | 5,790 | 4,270 | 3,600 | 1,700 | 39,300 |
| 1983 | 7,660 | 10,100 | 5,420 | 4,120 | 1,460 | 2,620 | 40,400 |
| 1984 | 7,700 | 9,850 | 5,370 | 4,220 | 2,240 | 3,100 | 41,800 |
| 1985 | 7,700 | 9,550 | 5,620 | 4,530 | 5,930 | 5,240 | 42,600 |
| 1986 | 7,690 | 9,250 | 6,050 | 4,940 | 2,750 | 3,090 | 40,300 |
| 1987 | 7,710 | 9,020 | 6,140 | 5,120 | 3,640 | 3,950 | 40,900 |
| 1988 | 7,570 | 8,560 | 5,950 | 5,100 | 3,390 | 2,610 | 39,200 |
| 1989 | 7,490 | 8,210 | 5,510 | 4,900 | 5,480 | 2,730 | 37,100 |
| 1990 | 7,370 | 7,840 | 5,060 | 4,690 | 4,640 | 3,890 | 37,000 |
| 1991 | 7,190 | 7,380 | 5,180 | 4,860 | 6,110 | 5,530 | 36,200 |
| 1992 | 6,950 | 6,870 | 5,690 | 5,280 | 7,500 | 5,680 | 34,600 |
| 1993 | 6,860 | 6,630 | 4,680 | 4,660 | 3,170 | 4,800 | 33,000 |
| 1994 | 6,630 | 6,180 | 4,920 | 4,880 | 5,120 | 9,810 | 31,900 |
| 1995 | 6,380 | 5,780 | 4,860 | 4,870 | 5,510 | 7,740 | 30,600 |
| 1996 | 6,030 | 5,290 | 5,270 | 5,140 | 4,830 | 5,700 | 31,600 |
| 1997 | 5,750 | 4,910 | 5,130 | 5,040 | 6,270 | 6,010 | 28,500 |
| 1998 | 5,470 | 4,580 | 4,280 | 4,450 | 5,820 | 1,390 | 28,400 |
| 1999 | 5,070 | 4,120 | 4,580 | 4,600 | 4,450 | 6,630 | 26,000 |
| 2000 | 4,790 | 3,860 | 3,570 | 3,840 | 1,400 | 2,540 | 21,800 |
| 2001 | 4,900 | 3,820 | 4,130 | 4,350 | 1,830 | 2,930 | 23,800 |
| 2002 | 4,980 | 3,770 | 3,730 | 4,180 | 644 | 2,250 | 23,300 |
| 2003 | 5,060 | 3,720 | 3,360 | 4,040 | 1,730 | 3,620 | 23,500 |
| 2004 | 5,060 | 3,630 | 3,000 | 3,850 | 2,440 | 2,900 | 22,400 |
| 2005 | 5,130 | 3,580 | 3,640 | 4,390 | 3,270 | 3,420 | 23,400 |
| 2006 | 5,170 | 3,530 | 3,380 | 4,370 | 3,420 | 3,280 | 23,800 |
| 2007 | 5,290 | 3,450 | 2,650 | 4,060 | 1,340 | 2,490 | 23,700 |
| 2008 | 7,330 | 4,390 | 3,680 | 5,640 | 4,120 | 2,480 | 32,100 |
| 2009 | 9,180 | 5,460 | 3,700 | 6,510 | 2,250 | 3,910 | 38,500 |
| 2010 | 8,690 | 5,030 | 3,900 | 6,500 | 2,150 | 2,550 | 37,900 |