Fisheries catch reconstruction for Iran, 1950-2010[1]

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Abstract

Total marine fisheries catches were estimated for the Iranian Exclusive Economic Zone (EEZ) waters from 1950 to 2010. All fisheries sectors, i.e., industrial (large-scale, commercial), artisanal (small-scale, commercial), subsistence and recreational, as well as foreign catches were reconstructed to recalculate total catches. Overall, total catches in Iran's EEZ waters from 1950-2010 were approximately 18.2 million tonnes, of which 14.9 million tonnes were taken by Iranian fishers. It is evident that the data reported by FAO on behalf of Iran (around 5.7 million tonnes in EEZ waters only) represent mainly the large-scale fisheries in this region. Thus, management of artisanal and recreational fisheries is hampered by lack of key data, as is the prevention of illegal fishing.

Introduction

The Persian Gulf, which separates Iran in the Northeast from the neighbouring countries of Iraq, Saudi Arabia, Bahrain, Kuwait, Qatar and the United Arab Emirates in the southwest, extends from the Shatt al'Arab delta in the west to the Strait of Hormuz in the east (Walters and Sjoberg 1988; Esmaeili 2006; Figure 1). The average depth of this shallow water body is approximately 50 m, and its maximum depth is about 90 m near the Strait of Hormuz (Walters and Sjoberg 1988). The biodiversity in the Gulf is greatly influenced by the high salinity and seasonal temperature fluctuations. In winter, the water temperature can go as low as 3°C; conversely, during the summer, the temperature can rise to 50°C (Anon. 2013d).

The main shipping lanes of the world's largest oil fields pass through the Gulf's exit, the Strait of Hormuz, and thus, its ecology has been impacted by the pollution caused by multiple oil spills, to which, unfortunately, the effects of mining, a land reclamation project, and largely unregulated fishing must be added (Anon. 2013e).

In addition to oil production, fishing plays an important role in many of the economies or societies of the countries surrounding the Gulf region, including in Iran. Khozestan (western coast of Iran), Boushehr (central coast) and Hormozgan (eastern coast) are the three most important Iranian coastal provinces in terms of their contribution to the fishing industry (Esmaeili 2006). Reports show that over 54% of the fish caught in 2003 in Iranian coastal waters of the Gulf originated from the largest province, Hormozgan (Esmaeili 2006). Over 700 species of fish occur in the Persian Gulf (see FishBase; www.fishbase.org), and over 80% are either directly or indirectly associated with coral reefs (Anon. 2013a). Although their catch is declining, mackerels and shrimp are still among the most important target species (Peighambari and Daliri 2012). It seems that overfishing as a consequence of lack of proper management, together with environmental degradation, can explain the observed decline of fish stocks in the Gulf region (Anon. 2013c). Here, we provide re-estimated total marine catches by Iran in the EEZ waters from 1950-2010, using a catch reconstruction approach (Zeller *et al.* 2007), with the hope of providing a more accurate and comprehensive baseline for the management of the Gulf fisheries of Iran.

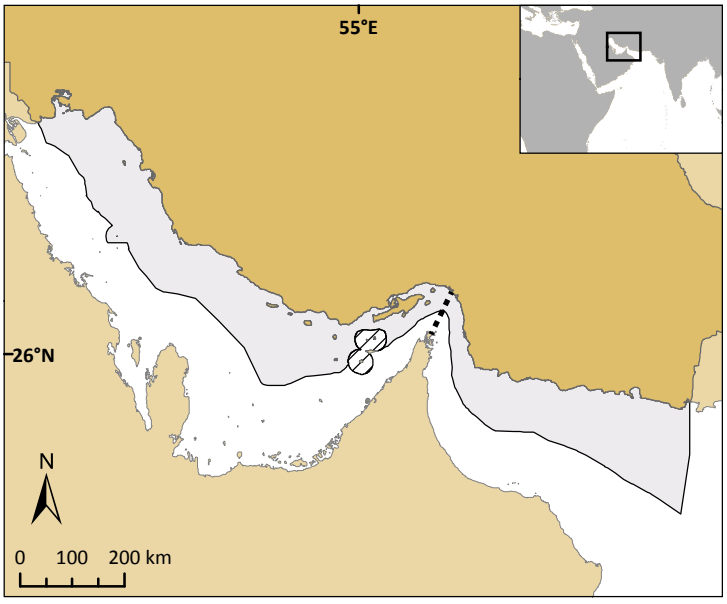

Figure 1. Map of Iran showing the extent of its EEZ (in grey), including the contested zone with the United Arab Emirates (stripped area). The 'Gulf' ends at the Strait of Hormuz (dotted line).

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Methods

Fisheries catch data were obtained from the FAO FishStat database, independent studies and government related fisheries websites. As Iran has a substantial and very active tuna fleet operating in the Indian Ocean, we assumed that nine large pelagic species are mainly being caught primarily outside Iranian waters, i.e., albacore tuna (*Thunnus alalunga*), bigeye tuna (*T. obesus*), black marlin (*Istiompax indica*), Indo-Pacific sailfish (*Istiophorus platypterus*), kawakawa (*Euthynnus affinis*), longtail tuna (*T. tonggol*), skipjack tuna (*Katsuwonus pelamis*), swordfish (*Xiphias gladius*) and yellowfin tuna (*T. albacares*). Thus, in order to separate catches from within the EEZ from offshore catches in the Indian Ocean, we filtered out reported landings of these nine species from the FAO dataset and used these adjusted data as the reported landings baseline.

We identified four sectors of Iranian fisheries, i.e., industrial (large-scale, commercial), artisanal (small-scale, commercial), subsistence (small-scale, non-commercial), and recreational. In addition, we identified discarding and illegal catches as items to be estimated. Data 'anchor points' (*sensu* Zeller *et al.* 2007) for each of these components were derived and linear interpolations were used between anchor points to provide a complete time series of total catches for 1950-2010.

To estimate likely Iranian catches within the Persian Gulf as opposed to outside (i.e., along the coast of the Iranian provinces of Sistan and Balochestan), a complete reconstruction of the six components was produced for both portions of the Iranian Exclusive Economic Zone (EEZ): within and outside the Persian Gulf (see Figure 1). The reconstruction of marine catches in the Sistan and Baluchestan provinces was facilitated through data provided by the Sistan and Baluchestan province portals (Anon. 2012c).

Artisanal catches

The official data on Iranian artisanal fishing effort distinguish two components: 'fibreglass' and 'wooden' vessels. In 1991, there were 3,176 fibreglass fishing vessels (Everett 2000). Due to the non-availability of fibreglass vessels in the 1950s and 1960s, we assumed that this represented small wooden crafts during the earlier decades and that there were 60% fewer such fishing vessels in 1950 compared to 1991. (Table 1). Furthermore, we assumed that total capacity (i.e., vessel numbers) would have been 50% higher in 1977, before the Islamic revolution, than in 1950. We also assumed that vessel capacity was halved during the 1980-1988 Iran-Iraq war. For 2001-2010, we were able to obtain capacity information from the official Iranian Fisheries website (Anon. 2012b). We performed a series of linear interpolations to complete the capacity time series from 1950 to 2001.

The number of wooden fishing vessels (here interpreted as larger crafts) was reported for 1991 and from 2001 to 2010 by Esmaeili (2006). We assumed the number of wooden vessels in 1950 was 20% lower than in 1991. In 1977 before the Islamic revolution, we assumed capacity was 20% higher than the capacity in 1950. Wooden vessel capacity was also assumed to be halved during the 1980-1988 Iran-Iraq war. We interpolated linearly between 1950 and 2001.

Table 1. Artisanal fishing vessels (small craft/ fibreglass and larger wooden) and catch per unit of effort (CPUE) data and derived anchor points. Values between anchor points were interpolated.

Year	small craft/ fibreglass (No. of vessels)	Larger wooden (No. of vessels)	CPUE ($t \cdot vessel^{-1} \cdot year^{-1}$)
1950	1,270 [a]	2,053 [a]	50
1977	1,906 [a]	2,464 [a]	41
1991	3,176 [b]	2,567 [d]	36 [d]
2001	2,817 [c]	7,086 [d]	27
2002	2,954 [c]	6,933 [d]	24
2003	2,945 [c]	7,356 [d]	20 [d]
2004	3,047 [c]	7,559 [d]	20
2005	3,210 [c]	7,496 [d]	20
2006	3,250 [c]	7,563 [d]	19
2007	3,257 [c]	7,663 [d]	19
2008	2,999 [c]	7,847 [d]	19
2009	3,033 [c]	7,970 [d]	19
2010	3,066 [c]	7,932 [d]	18

[a] 1950: 60% lower than 1991; 1977: 50% higher than 1950.
[b] Everett (2000).
[c] Iranian Fisheries website (Anon. 2012b).
[d] Esmaeili (2006).

Esmaeili (2006) lists catch per unit of effort (CPUE) for 1991 and 2003 as 36 $t \cdot vessel^{-1} \cdot year^{-1}$ and 20 $t \cdot vessel^{-1} \cdot year^{-1}$, respectively, with a peak of 50 $t \cdot vessel^{-1} \cdot year^{-1}$ in 1997. Given the high variability of these CPUE estimates, we interpolated them from 1999 to 2003 to smooth the data. We assumed that CPUE in 1950 was equivalent to the peak reported CPUE in 1997 (i.e., 50 $t \cdot vessel^{-1} \cdot year^{-1}$). Given the known overexploitation of marine resources in coastal waters of Iran (Esmaeili 2006), we reduced CPUE for 2010 by 10% compared to the 2003 value (Table 1). Intervening years were interpolated linearly.

Combining the derived capacity time series with the estimated CPUE time series allowed us to estimate a likely catch time series for the artisanal fleet from 1950-2010 in the Iranian EEZ. Then, we multiplied the total estimated artisanal catch by the percentage of catches from the provinces of Sistan and Baluchestan. To obtain these percentages, we divided the reported catch of these provinces (Anon. 2012c) by the reported total landings by Iran to FAO (from FAO Fishstat). This amounted to 42,650 $t \cdot year^{-1}$ for a total of 236,717 $t \cdot year^{-1}$ reported by FAO (excluding large migratory species) for 1996 (18%) and 104,665 $t \cdot year^{-1}$ compared to a total of 291,305 $t \cdot year^{-1}$ reported by FAO (35%) for 2003. We assumed that the 18% ratio was constant between 1950 and 1996 and that the 35% ratio was constant between 2003 and 2010, then interpolated linearly between 18 and 35% for the years 1997 to 2002. The resulting percentage time series was then used to allocate the total estimated Iranian artisanal catch within and outside the Gulf.

Using Google Earth, Al-Abdulrazzak and Pauly (2013) estimate 726 ± 28 weirs were operating in the Persian Gulf waters of Iran in 2005, generating an annual catch of 12,240 ± 4,223 t. Since Iran does not report their weir catches and because

the number is not known to have substantially fluctuated in the last five decades, we assume the catch is constant and apply 12,240 t·year^{-1} from 1950 to 2010. Species composition was estimated from Al-Abdulrazzak and Pauly (2013).

Subsistence catches

We extracted an estimate of the human population of Iran from the historical population demography website Populstat (www.populstat.info/), and used linear interpolations between census years to determine a complete population time series for 1950 to 2010. We then assumed that only the coastal population of Iran consumes domestically caught marine fish, and assumed that this would be the population within 10 km of the coast (CIESIN 2007). The fraction of coastal population for years prior to the years covered by the data source (pre-1990s, CIESIN 2007) was assumed to be a constant fraction of the total Iranian population. However, during the Iran-Iraq war (1980-1988), we assumed the coastal population used for estimating consumption was one fourth to reflect the severe military restrictions and high migrations towards northern areas (Figure 2).

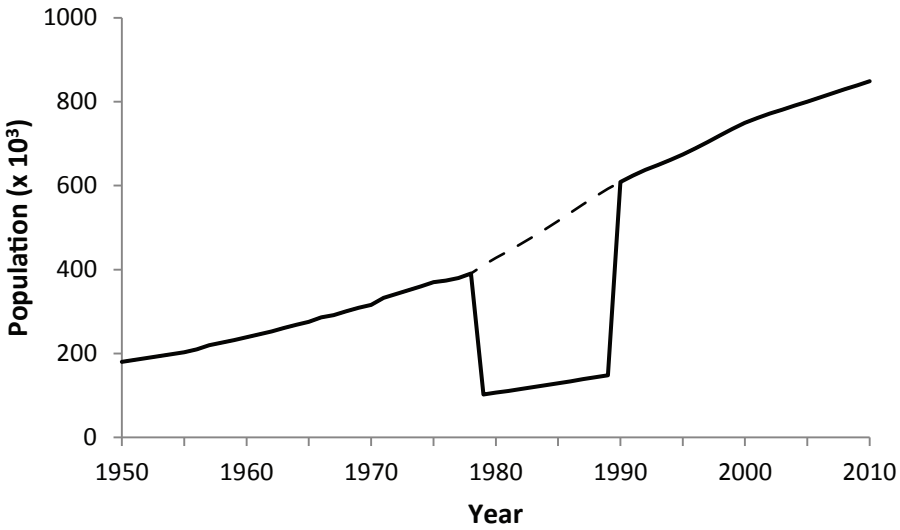

Figure 2. Human population data used for the subsistence calculation, 1950-2010 (solid line). An adjustment was made to the coastal population time series (dotted line) during the Iran-Iraq war years (1980-1988) to reflect severe restrictions imposed during that time.

Estimates of the coastal population were then combined a derived consumption rate time series. The average fish consumption of the population of Bandar Abbas, a coastal city of Iran was estimated at 3.4 meals·person^{-1}·month^{-1}, i.e., 41 meals·person^{-1}·year^{-1} (Adeli *et al.* 2011). We assumed each person consumed 500 g of fish per meal (i.e., 20.5 kg·person^{-1}·year^{-1}). After adjusting as best as possible for the international seafood trade, i.e., exports and import (Everett 2000; Anon. 2007), we derived the difference between the trade adjusted consumption and the landings as reported by FAO on behalf of Iran. This difference was deemed to represent unreported catches. This estimated difference, divided by the total population of Iran (Figure 2), was assumed to represent an estimate of per capita subsistence catch of 17 kg·person^{-1}·year^{-1}. We assumed this rate applies to the year 2010, but assumed a rate nearly 50% higher (i.e., 25.5 kg·person^{-1}·year^{-1}) for 1950, and interpolated the rate between these two years. We then multiplied this assumed subsistence catch rate by the adjusted southern coastal population, i.e., living within 10 km of the coast (Figure 2), to derive an estimated total subsistence catch in southern Iran.

Recreational catches

We assumed recreational fishing existed throughout the rule of the Shah, from 1950 to 1979, and after the Iran-Iraq war from 1989 to 2010. We assumed that any personal fishing that occurred during the war years was subsistence fishing and thus we estimated that there was zero recreational fishing during the war years (1980-1988); also, recreational fishing is popular primarily in the Persian Gulf, and hence, we assumed that no recreational fishing occurred in Sistan and Baluchestan. For 2010, it was estimated that around 0.12% of the population in Oman participated in recreational fishing (Cisneros-Montemayor and Sumaila 2010). We assumed this same rate applied to the coastal Iranian population in 2010. We then assumed half of this rate for the pre-war time period (1950-1979), i.e., 0.06%. Participation was set to zero for the years 1980-1988, and then we interpolated from zero in 1988 to 0.12% in 2010. To estimate recreational catches, we assumed that recreational fishers catch 5 kg·trip^{-1} and fish for one day per week (i.e., 52 days·year^{-1}). Therefore, we multiplied the number of fishers by the number of the fishing days (52 days) and the assumed catch rate (5 kg·trip^{-1}) to obtain an approximate time series of recreational catches.

Industrial (large-scale, commercial) catches

Data for the large-scale fisheries in the EEZ waters of Iran were largely based on information provided by the FAO and a variety of literature resources, as well as the Iranian official fisheries website. Given the absence of historic information on fishing effort by large-scale vessels, we considered the first anchor point for 1950 to be zero vessels. In 1957, there were three large vessels contributing to the fisheries in the Persian Gulf, while by 1961 there were 12

(Keddie 1971). By 1968, 50 large vessels operated in Iranian waters (Keddie 1971). We assumed effort was 20% higher before the Islamic revolution and the Iran-Iraq war. Furthermore, we assumed that the effort was halved by 1980 due to the start of Iran-Iraq war. For 1991, Everett (2000) reports 120 vessels. Anon. (2012b) provided data for years 2001-2010. We performed a series of interpolations to fill in the gaps throughout the time period (Table 2).

To estimate the CPUE for the large-scale fishing, we used information from Esmaeili (2006) for 2003 (i.e., 202.9 t·vessel^{-1}·year^{-1}, Table 2) and assumed that the CPUE would be 10% higher in 1950 and 2% higher in 1991. We also assumed that the CPUE in 2010 was 10% lower than in 2003 given the general over-exploitation of stocks (Esmaeili 2006). Lastly, we multiplied the interpolated effort time series with the interpolated CPUE time series to estimated large-scale catches in the waters of Iran for 1950-2010. To separate out the industrial catches taken in Sistan and Baluchestan from those of the Gulf, we applied the same method as for artisanal catches (see above) and information provided by Anon. (2012c).

Table 2. Industrial fishing vessels and catch per unit of effort (CPUE) data and derived anchor points. Values between anchor points were interpolated.

Year	No. of trawlers	CPUE (t·vessel^{-1}·year^{-1})
1950	0	227.7
1957	3 [a]	224.2 [e]
1961	12 [a]	222.7
1968	50 [a]	218.7
1980	25 [b]	212.6
1991	120 [c]	207.0 [f]
2001	74 [d]	203.6
2002	73 [d]	203.3
2003	75 [d]	202.9 [g]
2004	76 [d]	200.0
2005	77 [d]	197.1
2006	78 [d]	194.2
2007	47 [d]	191.3
2008	45 [d]	188.4
2009	44 [d]	185.5
2010	47 [d]	182.6 [h]

[a] Keddie (1971).
[b] Assumed 50% of 1968 capacity due to war.
[c] Everett (2000).
[d] Anon. (2012b).
[e] Assumed 10% higher than in 2003.
[f] Assumed 2% higher than in 2003.
[g] Esmaeili (2006).
[h] Assumed 10% lower than in 2003.

Foreign fishing

Reports on illegal fishing in Iranian waters are rare. The only source with some information regarding this issue was available via a website on illegal fishing (Anon. 2012a). The information obtained from this website was based on news reports of foreign fishing from 2006 to 2008. It appears that the bulk of foreign fishing in the Persian Gulf was conducted by Asian fleets (from China, South Korea and India), as well as some by vessels from neighbouring countries (Saudi Arabia, Bahrain and UAE), and from Pakistan in a few instances (Anon. 2012). Asian vessels were reported to catch around 100 tonnes per week during an average of 6 month operations in the Gulf in 2007 and 2008, while the number of Chinese vessels was given as 12 (Anon, 2012). Similarly, four Indian vessels flagged to Saudi Arabia were operating in Iranian waters in 2007 and 2008, catching around 50 t·week^{-1} over a 12 month period. Around 336 other vessels, including vessels from South Korea, Saudi Arabia, Bahrain, and the UAE were trawling for shrimp in Iranian waters, and caught 100 t·vessel^{-1}·year^{-1} in 2007 and 2008. We multiplied this CPUE by the total number of boats (n = 336) to estimate the foreign catch for 2007 and 2008, and distributed this evenly among South Korea, Saudi Arabia, UAE and Bahrain flags. We assumed foreign catches decreased by 20% in 2010 because of more efficient Iranian monitoring, and because of the international sanctions imposed on Iran, resulting in higher maritime scrutiny and security. We also assumed foreign catches were twice as high before the end of the war, given lower monitoring levels. Therefore we interpolated from zero in 1974 at the declaration of the Iranian EEZ, and performed a series of linear interpolations to fill in the gaps. Note that China did not start fishing in Iran waters until 1986.

Table 3. Species composition for unreported artisanal and industrial catches, reported "marine fishes nei", and illegal catches, modified from Paighambari and Daliri (2012).

Taxon name	Common name	% of catch
Penaeus semisulcatus	Green tiger prawn	11.1
Portunus pelagicus	Blue swimming crab	7.8
Pomadasys stridens	Striped piggy	5.2
Scyphozoa	Jellyfish	4.8
Arius gagora	Gagora catfish	4.1
Photopectoralis bindus	Orangefin ponyfish	3.5
Leiognathus equulus	Common ponyfish	3.5
Leiognathus lineolatus	Ornate ponyfish	3.5
Ilisha megaloptera	Bigeye ilisha	2.8
Ilisha melastoma	Indian ilisha	2.2
Psettodes erumei	Indian halibut	1.9
Platycephalus indicus	Bartail flathead	1.8
Metapenaeus affinis	Jinga shrimp	1.8
Saurida tumbil	Greater lizardfish	1.8
Otolithes ruber	Tigertooth croaker	1.7
Chiloscyllium arabicum	Arabian carpetshark	1.7
Chiloscyllium punctatum	Brownbanded bambooshark	1.7
Nemipterus japonicus	Japanese threadfin bream	1.7
Trichiurus lepturus	Largehead hairtail	1.5
Parapenaeopsis stylifera	Kiddi shrimp	1.5
Scomberomorus guttatus	Indo-Pacific king mackerel	1.5
Scomberomorus commerson	Narrow-barred Spanish mackerel	1.3
Dasyatis bennetti	Bennett's stingray	1.2
Himantura uarnak	Honeycomb stingray	1.2
Himantura walga	Dwarf whipray	1.2
Pastinachus sephen	Cowtail stingray	1.2
Aetobatus narinari	Spotted eagle ray	1.2
Aetomylaeus maculatus	Mottled eagle ray	1.2
Aetomylaeus nichofii	Banded eagle ray	1.2
Grammoplites suppositus	Spotfin flathead	1.1
Others [a]	—	22.1

[a] 92 species accounting for less than 1% of the catch make up this category.

Discarding

Here, we assumed the majority of discarding is associated with large trawlers (i.e., large-scale fishing). We used the ratio of 4.17 kg discards per kg of landed targeted species (i.e., shrimp and demersal fishes) for large trawlers as per Alverson *et al.* (1996). We did not estimate discarding by the artisanal fleet, which may also exist for certain gear types. Thus, our estimate of discarding is likely a conservative under-estimate.

Taxonomic breakdown

Data concerning the species composition of catches in Iranian waters are very limited. Paighambari and Daliri (2012) provide a percentage breakdown of species

captured in the Persian Gulf. Their catch composition (minus 12 taxa not caught within Iranian waters) was applied to the unreported artisanal (excluding the weir catches), unreported industrial, and illegal fisheries of Iran (Table 3). The reported data contained large amounts of catch in the category "marine fishes nei" and therefore the same species breakdown used for the unreported catch (minus the three shrimp species) was used to disaggregate that category. Recreational and subsistence catches were disaggregated using anecdotal data from pictures posted on web-logs of Iranians engaged in recreational fishing (www.fishingir.blogfa.com). The eight most commonly observed taxa by recreational activities are *Sphyraena* spp., *Seriphus* spp., *Chanos chanos*, *Hyporthodus* spp., *Caranx* spp., Sparidae, *Elops* spp. and *Myliobatis* spp., and we allocated recreational and subsistence catches in equal proportions to these taxa.

Results

Artisanal catches

Artisanal catches increased gradually from 1950-1977, with an average catch of around 186,600 t·year^{-1}, of which just under 156,000 t·year^{-1} were taken inside the Persian Gulf (Figure 3). During the Islamic revolution and subsequent Iran-Iraq war, the estimated artisanal catches dropped to a low of 117,900 t·year^{-1} in 1985. Catches slowly increased after the war and reached a peak of almost 426,700 t·year^{-1} in 1997, before declining sharply to around 220,000-230,000 t·year^{-1} by the end of the time period (Figure 3).

Subsistence catches

The estimated subsistence catch increased steadily from 4,600 t·year^{-1} in 1950 to around 9,000 t·year^{-1} by 1979 (Figure 4). Subsistence catches decreased to less than 3,000 t·year^{-1} during the civil war, and then increased steadily from around 3,000 t·year^{-1} in 1988 to over 14,000 t·year^{-1} by 2010 (Figure 4). Subsistence fishing appears more dominant in Persian Gulf waters, accounting for nearly 80% of total subsistence catches (Figure 4).

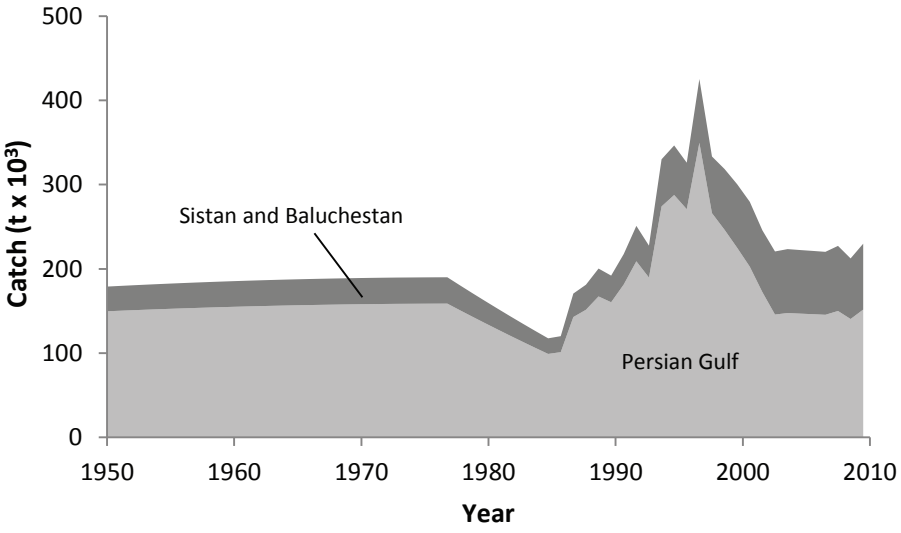

Figure 3. Iran's artisanal catches in the Persian Gulf and Sistan and Baluchestan, 1950-2010.

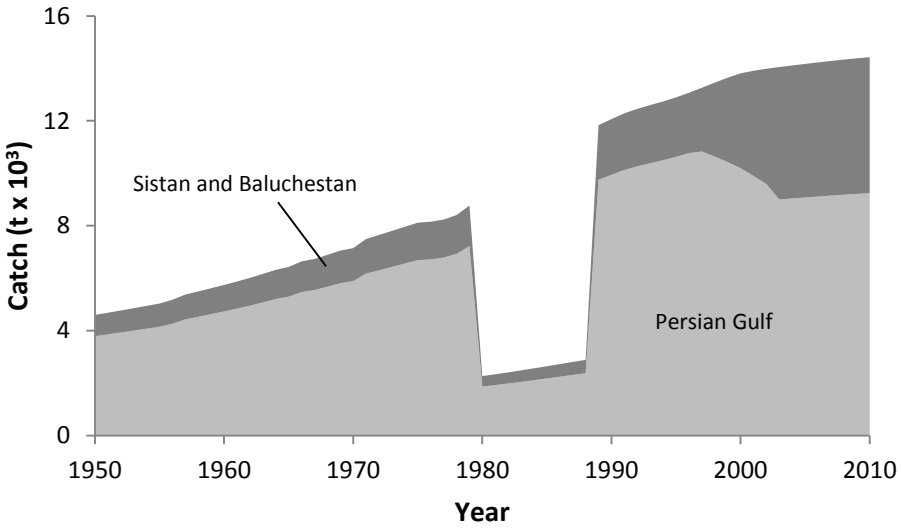

Figure 4. Iran's estimated subsistence catches in the Persian Gulf and Sistan and Baluchestan, 1950-2010.

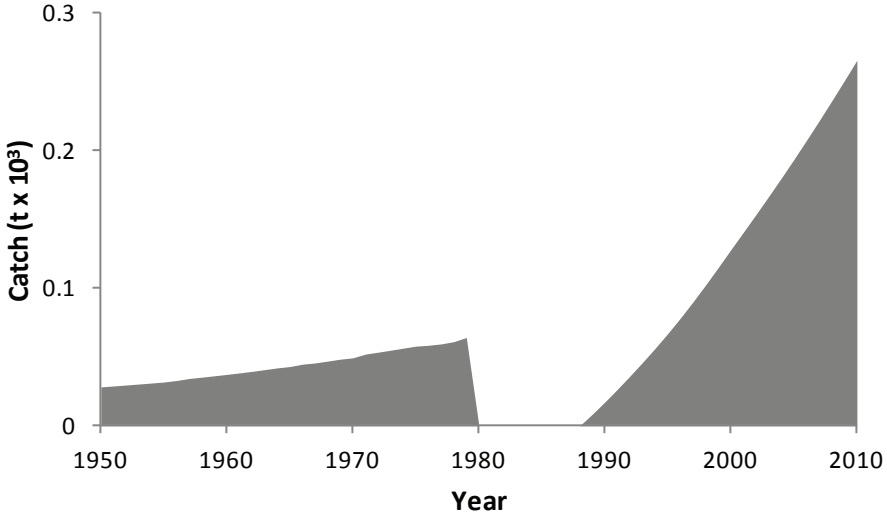

Figure 5. Recreational fishery catches in Iran, 1950-2010.

Recreational catches

Recreational catches (for the Persian Gulf waters only) were estimated at around 28 t·year^{-1} in 1950, increasing gradually to 64 t·year^{-1} by 1979. After the war years catches steadily increased from 8 t·year^{-1} to reach a peak of 265 t·year^{-1} in 2010 (Figure 5).

Industrial catches

Large-scale, industrial catches were considered to be zero in 1950. Initially, landings increased slowly to just under 500 t·year^{-1} by the mid-1950s, before increasing rapidly to around 13,000 t·year^{-1} by the late 1970s (Figure 6). During the war years, industrial catches declined to a low of around 6,000 t·year^{-1} before increasingly rapidly post-war to a peak of almost 25,000 t·year^{-1} by 1991. Thereafter, industrial catches declined to around 8,600 t·year^{-1} by 2010. Catches in Persian Gulf waters dominated total industrial catches, accounting for around 79% of total industrial catches by Iran (Figure 6).

Foreign fishing

Our estimates of foreign catches in Iranian waters are approximate, and suggest an increase from around 11,000 t·year^{-1} in the mid-1970s, to a peak of over 140,000 t·year^{-1} in the late 1980s (Figure 7). More recently, foreign catches appear to have declined to around 60,000 t·year^{-1}. Foreign catches appear to have been dominated by China and, to a lesser extent by India (Figure 7).

Discards

Discards appeared to be low throughout the 1950s, but increased with the expansion of industrial fishing (i.e., trawlers) to reach a pre-war high of just under 19,000 t·year^{-1} (Figure 8). Discards increased again after the war, reaching an all-time peak of over 36,000 t·year^{-1} in 1991, before declining to around 12,000 t·year^{-1} by the end of the time period (Figure 8).

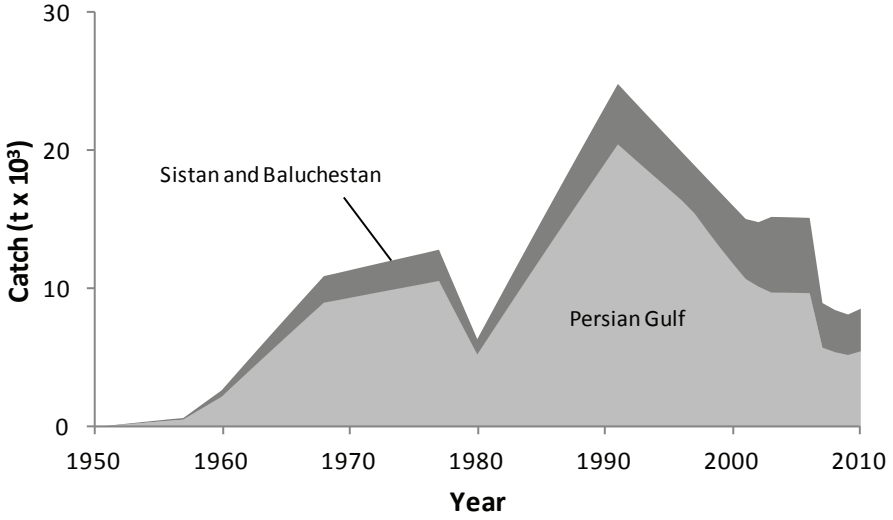

Figure 6. Iranian landings by the industrial sector, 1950-2010. (Discards not included on this graph).

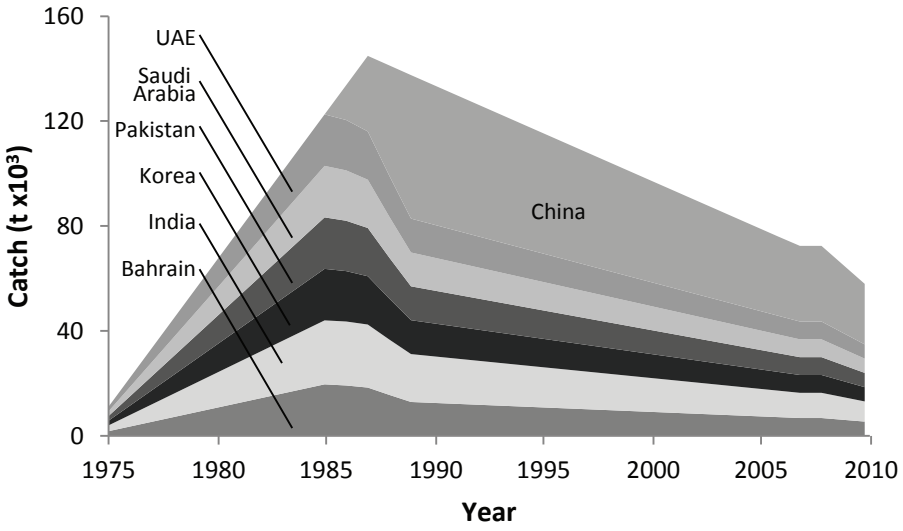

Figure 7. Foreign catches estimated as being taken from the waters of Iran, by the major foreign fishing countries. Note that the time-scale starts in 1975 as opposed to 1950.

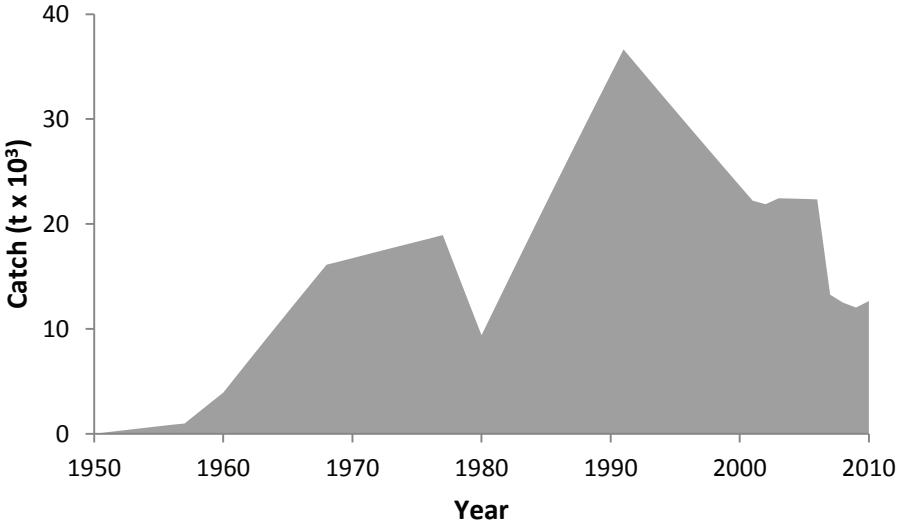

Figure 8. Estimated discards by the Iranian fisheries within their EEZ, 1950-2010.

Total reconstructed catch

Our reconstruction of the total marine fisheries catches for Iran was estimated at almost 14.9 million tonnes for 1950-2010, i.e., 2.6 times the 5.7 million tonnes reported by FAO on behalf of Iran (adjusted to account for catches taken by Iran outside its own waters, Figure 9a). Catches were heavily dominated by the artisanal sector, which accounted for nearly 12.7 million tonnes over the full time period. Overall, the majority of catches were taken within the Persian Gulf waters of Iran (i.e., 11.9 million tonnes), while only 3 million tonnes appear to have been caught in EEZ waters outside the Persian Gulf.

Reconstructed catches were derived for 145 taxa, compared to the 50 taxa reported by FAO on behalf of Iran. Catches were dominated by shrimps (family Penaeidae) with 1.3 million tonnes caught over the 1950-2010 time period (8.8% of the total catch; Figure 9b). Shrimps' contribution to the total catch has been decreasing over the time period, averaging 13% of the total catch from 1950-1970, and then declining to under 3% in 2010. Other important families include Leiognathidae (7.4%), Portunidae (6.8%), Clupeidae (5.5%), Haemulidae (5.0%), Carangidae (4.4%) and Scombridae (3.8%). Leiognathidae, Portunidae and Haemulidae have also decreased in their contribution to the total catch over the time period. Conversely, Clupeidae, Carangidae and Scombridae have all had in increase in their contribution to the total catch over the time period.

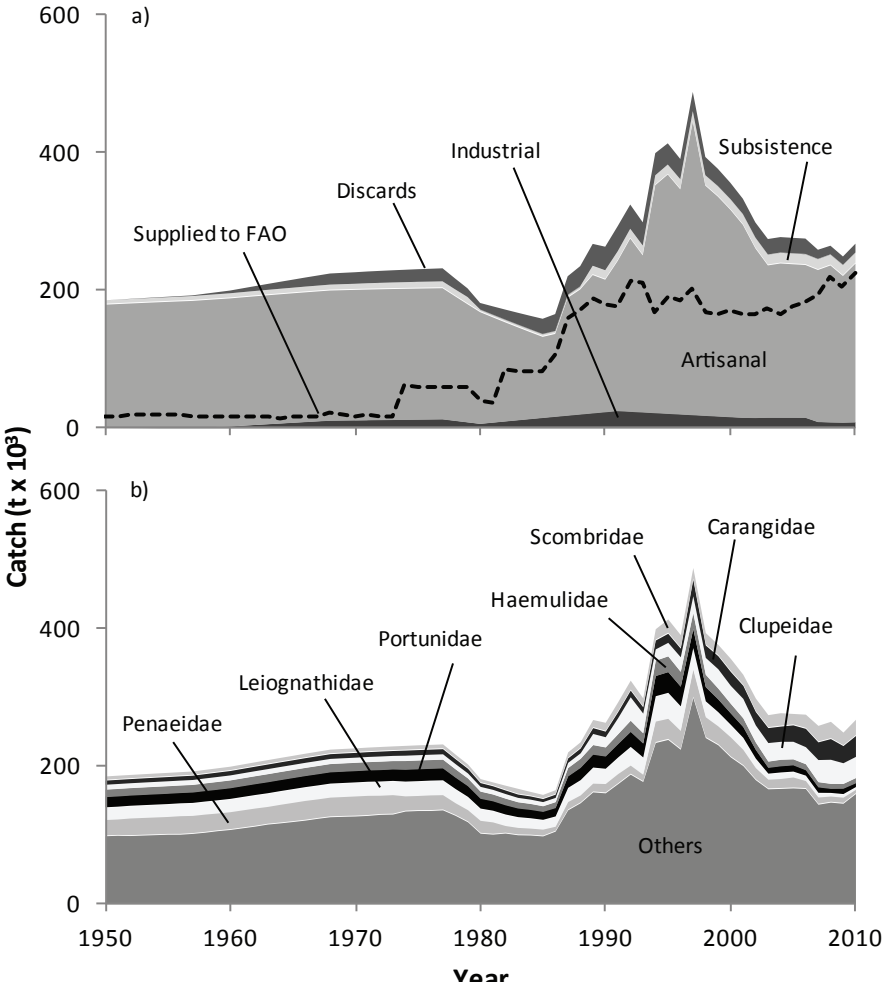

Figure 9. Total reconstructed catches for Iran for 1950-2010 by a) fishing sector plus discards (with comparison to FAO data, adjusted for large pelagic catches taken in offshore Indian Ocean waters); and b) by major taxonomic groups. Note that the recreational sector catches were included but are not visible on the sector graph (a) and that reconstructed catches consist of 145 individual taxonomic groups, here pooled into the 7 largest families plus 'others'.

Discussion

We reconstructed the best estimates of total marine fisheries catches taken by Iran in their own EEZ waters over the 1950-2010 time period. These estimates account for under-reported commercial catches and discards, as well as unreported recreational and subsistence catches. Overall, Iranian fishers caught almost 14.9 million tonnes, which is 2.6 times the 5.7 million tonnes FAO reports on behalf of Iran. While the major differences between reconstructed and reported catches occurred in the early time period, even in the most recent years, around 20% of likely total catches appear to be unreported. Both domestic consumption and export of seafood play a role in Iran's food security, therefore, a more comprehensive historic baseline of past total catches is important for our understanding of fisheries development and trends in Iran.

Unfortunately, our data suggest that marine fisheries in Iran have been poorly documented and assessed over time. It is likely that any data that have been supplied to the FAO are, for the most part, values of large-scale industrial fisheries together with some components of market sales.

Unsustainable fishing practices and pressures and ecological changes in the Persian Gulf have led to a reduction of catch rates over time. The abundance of target species such as shrimp, mackerels and major fish species has declined over the years. Unfortunately, despite this observed reduction in the abundance of various species in the Persian Gulf, fisheries continue to operate at unsustainable rates. This is also exemplified by the pearl fisheries occurring in the Persian Gulf (Anon. 2013b, 2013f).

The oil and gas industry is the major export earner for Iran. Over the last few decades, this emphasis on the oil and gas industry has eroded the traditional dominance of the fishing sector in coastal regions. With approximately 25,000 tankers passing through the Strait of Hormuz annually, the Persian Gulf plays a strategic role in the Middle East. With the ever increasing development of the oil industry in the region, oil pollution from offshore installations, oil tankers, tanker terminals and petrochemical plants has become a major threat to the ecology of the Persian Gulf, but its effect on the fisheries cannot be assessed.

Our data and study suggest the need for a transparent and more comprehensive data collection and reporting system, accounting for large-scale, small-scale, subsistence, recreational and foreign fishing be developed and implemented. This would help toward the establishment of a management plan for the fisheries of Iran, which should also include assessing and mitigating the impact of oil pollution on these fisheries.

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Appendix Table A1. FAO landings vs. total reconstructed catch (t) for Iran, 1950-2010, as well as catch by sector.

Year	FAO	Total reconstructed catch	Industrial	Artisanal	Subsistence	Recreational	Discards
1950	16,000	184,000	0	179,000	4,600	28	0
1951	16,000	185,000	110	180,000	4,690	29	160
1952	18,000	186,000	210	181,000	4,770	30	310
1953	18,000	187,000	300	182,000	4,860	30	450
1954	18,000	188,000	400	182,000	4,950	31	590
1955	18,000	189,000	500	183,000	5,040	32	730
1956	18,000	190,000	590	184,000	5,180	33	870
1957	17,000	191,000	670	184,000	5,380	34	990
1958	17,000	194,000	1,340	185,000	5,500	35	1,980
1959	16,000	196,000	2,010	185,000	5,620	36	2,960
1960	16,000	198,000	2,670	186,000	5,750	37	3,940
1961	16,000	202,000	3,720	186,000	5,880	38	5,490
1962	16,000	205,000	4,770	187,000	6,020	39	7,030
1963	15,000	208,000	5,810	187,000	6,170	41	8,570
1964	14,200	211,000	6,850	188,000	6,320	42	10,090
1965	15,900	214,000	7,880	188,000	6,430	43	11,610
1966	16,700	217,000	8,900	188,000	6,640	45	13,120
1967	17,100	220,000	9,920	189,000	6,740	46	14,630
1968	20,700	223,000	10,940	189,000	6,890	47	16,130
1969	18,300	224,000	11,150	189,000	7,060	48	16,430
1970	17,300	225,000	11,360	190,000	7,150	49	16,750
1971	17,800	226,000	11,580	190,000	7,500	52	17,070
1972	15,700	227,000	11,790	190,000	7,650	53	17,380
1973	15,800	228,000	12,000	190,000	7,810	55	17,700
1974	60,665	229,000	12,210	190,000	7,960	56	18,010
1975	60,270	229,000	12,420	190,000	8,120	58	18,320
1976	59,475	230,000	12,630	191,000	8,160	58	18,630
1977	58,836	231,000	12,850	191,000	8,240	59	18,950
1978	59,330	216,000	10,690	181,000	8,410	61	15,760
1979	58,729	202,000	8,530	172,000	8,770	64	12,580
1980	38,375	180,000	6,380	162,000	2,270	0	9,410
1981	37,326	176,000	8,100	153,000	2,340	0	11,940
1982	83,724	171,000	9,810	144,000	2,410	0	14,460
1983	81,765	166,000	11,510	135,000	2,490	0	16,970
1984	82,648	162,000	13,210	126,000	2,570	0	19,480
1985	82,804	157,000	14,890	118,000	2,650	0	21,970
1986	108,188	164,000	16,570	120,000	2,730	0	24,440
1987	158,940	219,000	18,240	171,000	2,810	0	26,910
1988	169,443	234,000	19,900	182,000	2,890	0	29,360
1989	188,688	266,000	21,560	201,000	11,840	8	31,800
1990	180,299	262,000	23,200	193,000	12,070	17	34,230
1991	175,238	292,000	24,840	218,000	12,290	27	36,640
1992	214,463	323,000	23,850	252,000	12,460	36	35,180
1993	211,588	297,000	22,860	228,000	12,600	46	33,720
1994	169,097	398,000	21,880	331,000	12,740	56	32,270
1995	189,284	412,000	20,900	348,000	12,900	67	30,820
1996	183,672	389,000	19,920	327,000	13,070	78	29,380
1997	202,556	487,000	18,950	427,000	13,260	90	27,940
1998	168,410	392,000	17,970	334,000	13,460	102	26,500
1999	163,525	375,000	17,000	319,000	13,650	115	25,070
2000	169,226	355,000	16,030	301,000	13,810	128	23,650
2001	165,634	332,000	15,070	280,000	13,910	140	22,230
2002	164,472	297,000	14,840	246,000	13,990	153	21,890
2003	173,725	273,000	15,220	221,000	14,050	166	22,450
2004	165,695	276,000	15,210	224,000	14,110	179	22,430
2005	176,360	275,000	15,180	223,000	14,170	193	22,390
2006	182,741	274,000	15,150	222,000	14,230	207	22,350
2007	193,739	258,000	8,990	221,000	14,280	221	13,270
2008	219,881	264,000	8,480	228,000	14,340	235	12,510
2009	205,441	248,000	8,160	213,000	14,380	250	12,040
2010	224,740	266,000	8,580	231,000	14,430	265	12,660

Appendix Table A2. Total reconstructed catch (t) for Iran by major taxa, 1950-2010.

Year	Penaeidae	Leiognathidae	Portunidae	Haemulidae	Clupeidae	Carangidae	Scombridae	Others[a]
1950	23,900	17,400	15,700	10,800	6,530	6,020	4,720	98,900
1951	24,100	17,500	15,800	10,900	6,560	6,060	4,740	99,600
1952	25,900	17,400	15,700	10,800	6,520	6,030	4,710	99,200
1953	26,000	17,500	15,800	10,900	6,550	6,070	4,730	99,900
1954	26,100	17,600	15,800	10,900	6,570	6,110	4,760	100,500
1955	26,200	17,700	15,900	11,000	6,590	6,140	4,780	101,100
1956	27,300	17,600	15,900	10,900	6,580	6,150	4,760	101,100
1957	26,600	17,800	16,000	11,000	6,630	6,230	4,810	102,300
1958	26,800	17,900	16,100	11,100	6,660	6,280	4,850	104,000
1959	26,100	18,100	16,300	11,300	6,730	6,370	4,910	106,300
1960	26,200	18,300	16,400	11,300	6,760	6,420	4,940	108,000
1961	26,500	18,400	16,500	11,400	6,810	6,490	4,990	110,400
1962	26,700	18,600	16,600	11,500	6,850	6,560	5,030	112,900
1963	26,000	18,800	16,800	11,700	6,930	6,650	5,100	115,800
1964	27,400	18,900	16,800	11,700	6,930	6,680	5,100	117,600
1965	28,200	18,900	16,900	11,800	6,950	6,710	5,120	119,500
1966	29,000	19,000	16,900	11,800	6,970	6,760	5,140	121,600
1967	28,700	19,200	17,100	11,900	7,030	6,840	5,200	124,200
1968	28,900	19,300	17,200	12,000	7,070	6,900	5,230	126,500
1969	29,100	19,400	17,200	12,000	7,080	6,930	5,240	127,100
1970	29,600	19,400	17,200	12,000	7,080	6,940	5,240	127,500
1971	29,500	19,400	17,200	12,100	7,090	7,010	5,260	128,400
1972	28,200	19,600	17,400	12,200	7,150	7,090	5,310	129,900
1973	28,700	19,600	17,400	12,200	7,150	7,110	5,310	130,400
1974	22,500	20,400	18,000	12,700	7,370	7,370	5,520	134,700
1975	22,300	20,500	18,000	12,700	7,390	7,410	5,540	135,500
1976	23,100	20,400	18,000	12,700	7,370	7,400	5,520	135,500
1977	22,500	20,500	18,000	12,700	7,400	7,440	5,550	136,400
1978	18,700	19,600	17,300	12,100	7,130	7,160	5,290	128,600
1979	18,000	18,200	16,300	11,300	6,750	6,790	4,930	119,200
1980	19,100	16,700	15,200	10,400	6,320	5,500	4,520	102,600
1981	18,200	15,900	14,600	9,900	6,100	5,260	4,310	101,300
1982	11,400	15,600	14,400	9,700	6,010	5,170	5,720	102,800
1983	11,100	14,500	13,600	9,000	5,710	4,840	7,040	100,300
1984	10,500	13,900	13,100	8,700	5,540	4,670	5,320	100,000
1985	10,300	13,200	12,600	8,200	5,320	4,440	4,790	98,700
1986	7,500	13,900	13,100	8,600	5,520	4,670	5,240	105,600
1987	12,400	19,600	17,400	12,200	7,140	6,460	7,460	136,500
1988	11,800	21,200	18,600	13,200	7,590	6,970	7,750	146,800
1989	13,100	22,400	19,400	13,900	15,920	8,460	10,390	162,500
1990	14,000	21,200	18,500	13,100	14,580	8,110	11,430	161,200
1991	15,100	23,200	20,000	14,400	23,150	8,770	12,950	174,500
1992	13,600	26,200	22,300	16,300	34,010	9,730	12,930	188,300
1993	10,900	24,100	20,800	15,000	28,430	9,110	11,470	177,600
1994	31,600	35,900	29,600	22,300	16,760	12,800	14,870	234,200
1995	31,100	36,900	30,300	22,900	20,030	13,120	19,240	238,700
1996	27,700	34,900	28,800	21,600	21,460	12,520	18,090	224,400
1997	41,100	30,800	27,700	23,000	25,280	23,930	15,380	299,800
1998	30,700	22,200	20,900	18,000	24,790	18,040	16,480	241,400
1999	27,900	19,700	18,900	15,800	28,260	19,000	14,880	230,900
2000	29,600	17,300	16,900	14,100	26,180	20,200	17,460	213,300
2001	24,000	16,400	16,100	12,800	28,230	19,070	14,440	200,700
2002	18,000	12,800	13,200	10,900	24,570	19,540	18,140	180,300
2003	14,400	7,700	9,200	9,100	26,620	21,770	17,390	167,000
2004	14,800	8,500	9,700	9,400	25,760	22,140	18,050	167,600
2005	16,300	7,600	9,800	8,700	25,190	23,870	15,150	168,300
2006	12,100	6,800	8,600	8,800	24,390	26,670	19,180	167,400
2007	10,900	5,800	8,800	7,600	31,630	25,710	22,570	144,700
2008	9,300	4,200	6,800	7,300	34,510	30,100	23,680	147,700
2009	9,300	4,200	8,600	7,000	29,540	24,950	18,210	146,100
2010	6,500	3,000	6,300	7,600	30,300	30,390	22,160	160,200

[a] "Other" contains 68 additional additional families and 3 higher taxonomic groupings.