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RECONSTRUCTION OF PAKISTAN'S MARINE FISHERIES CATCHES 1950-2010

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Abstract

The Islamic Republic of Pakistan is a South Asian country that shares borders with Iran, India, Afghanistan and China. Located on the Arabian Sea, the coastal zone is divided into two areas: the Sindh coastline and the Balochistan coastline. The rich sediment flow of the Indus Delta, combined with a subtropical environment, has resulted in a highly productive coastal zone and commercially important fisheries established throughout the waters of Pakistan's Exclusive Economic Zone. Political instability, environmental degradation and poverty are prominent issues for the Pakistani people, and like in many developing countries no concerted effort has been made to effectively manage the small-scale fisheries sector. In this study, we reconstructed the total catch of Pakistan's marine fisheries for 1950-2010, and found that total extractions were over 38 million tonnes, which is 2.6 times the official data reported by FAO on behalf of Pakistan. Instances of illegal fishing, high amounts of discarding and by-catch, along with discrepancies in the statistical data collection system, all contributed to this mismatch. This study illustrates the need for improved estimating and reporting of catches for all fisheries sectors and greater consideration of small-scale (artisanal and subsistence) sector, which is crucial for providing food security and employment to the fast growing population of Pakistan.

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Introduction

The Islamic Republic of Pakistan is part of South Asia, and has borders with India in the east, Afghanistan in the north and northwest, Iran in the west and China in the far northeast. The relatively small coastline touches both the Arabian Sea and the Gulf of Oman (Figure 1). At the time of independence in 1947, Pakistan's population was 32.5 million and has grown since by 2.6 percent per year, reaching approximately 173.6 million in 2010.[1] The country's capital is Islamabad and the national language is Urdu. Prior to 1971, Pakistan consisted of two parts: East Pakistan and West Pakistan. By the end of 1971, former East Pakistan established itself as the independent country of Bangladesh (Folsom 1974). The history of Pakistan has been marred by natural disasters, recurrent drought, civil conflict and on-going political strife with neighboring countries, notably India and Afghanistan (McCauley and Shaikh 2001). Combined with other problems, such as environmental degradation, loss of biodiversity and declining fisheries, the impacts of food insecurity are felt across the country. The fishing sector is a crucial food security provider in coastal areas, but a minor sector overall. To date, it has received little attention or prioritization and many local communities that live near the coastline are among the poorest and most food insecure.

Pakistan has a wealth of marine fisheries and freshwater resources, and the marine fishery sector accounts for approximately 80% of the country's total fish production. The country's coastline can be split into two maritime provinces or 'fishing areas', Sindh to the east and Balochistan (Makran) to the west (Figure 1). The coastal zone, with the exception of Pakistan's largest industrial city of Karachi, is sparsely populated with socio-economic conditions that are poor (UNEP 1986). About 70% of Pakistan's population lives in rural areas, with the remainder concentrated in large urban areas such as Karachi, Lahore, Faisaland, Multan, Hyderabad, Peshawar, Islamabad and Rawalpindi (UNEP 1986). The River Indus, which is one of the largest river system of the world, flows southward until it drains into the Arabian Sea in Sindh and forms the Indus Delta (FAO 2003). This area is rich in fish and invertebrates, and local fisheries provide multiple livelihoods for coastal people (MSA 2009).

There are approximately one million fishers in Pakistan and the most popular fishing grounds are located in coastal areas, including the Indus Delta (Khan 2011). The Balochistan coastal shelf (approximately 14,500 km^2) is rocky and narrower than that of Sindh (approximately 35,700 km^2), and has no major freshwater in-flows or estuaries. In contrast, the Sindh coastline has a sandy, mud bottom and sheltered bays, with mangroves that provide habitat and nursery grounds for a variety of fishes and invertebrates. Territorial waters extend from the coastline to 12 nautical miles. Pakistan claimed its 200

[1] http://data.worldbank.org/country/pakistan

nm Exclusive Economic Zone (EEZ) in 1976 (approximately 221,400 km^2)[2] and access to these fishing zones and valuable resources have historically been controversial (Khan 2006; Wijeratna 2007).

Shortly after independence (1947), the marine fishery was entirely small-scale, consisting of locally made non-mechanized vessels. The first landing center was constructed in Karachi in 1958 and development of the fishing industry was relatively slow. Until 1976, the fleet off the coast of Balochistan consisted of traditional un-motorized fishing boats. In comparison, fishers along the Sindh coast began mechanization of their traditional fishing vessels in 1958, signaling the start of the industrial shrimp fishery. At this time, the country inherited one used trawler, which was supposed to increase Pakistan's involvement in the expanding global fishing industry (Ahmed 1985). Marine fish catches in 1947 were close to 33,000 tonnes. At this time, fish was either sold fresh close to the landing sites (which until 1958 were generally limited to beaches) or dried and exported to Sri Lanka, Myanmar and other countries in Southeast Asia (FAO 1977). Total marine catches doubled from 1955-1975, due to the development of mechanized (industrial) fishing fleets, which were thought to contribute approximately 60% to the total marine landings, the rest being contributed by small-scale (artisanal) fisheries. In 1977, out of a total of 98,000 fishers operating in the marine sector, some 61,000 fishers were involved in small-scale fisheries (FAO 1977); yet by 2002, only 62,100 fishers were actively fishing (Khan 2006).

Today, fleets are largely mechanized and reported landings have increased to around 522,000 t·year^{-1}, of which approximately 26,000 t are shrimp (Khan 2006). In 2005, it was estimated that more than 300,000 fishers were engaged directly in the fishing sector, whose industrial part is export driven and has the marine shrimp fishery as its backbone. This rapid growth of the fishing industry was the result of increased mechanization of the fleet, technological improvements and a greater demand for fish products by the local population (Hussain *et al.* 1972). There are now four main harbors and nine primary landing sites along the coast of Pakistan. The largest is Karachi fish harbor, which is used by approximately 80-90% of the industrial fishing fleet, almost exclusively shrimp trawlers and larger gillnetters. The rest of the fishing fleet and landing sites are located along the Balochistan coast; Pasni and Gwader handle more than 30,000 t (2004), whereas landings at all other sites combined account for less than 10,000 t (WWF 2005). Gillnets, cast-nets, handlines and longlines are still the traditional gears that are used by fishers in the small-scale fishing industry. About 150 species of fish are commercially landed in Pakistan; among these sardinellas (*Sardinella* spp.), white pomfrets (*Pampus argenteus*), snappers (*Lutjanus* spp.), emperors (Lethrinidae), seabreams (Sparidae), narrow-barred Spanish mackerel (*Scomberomorus commerson*), Indian mackerel (*Rastrelliger kanagurta*), catfishes (*Arius* spp.) and sharks (Carcharhinidae) are dominant (WWF 2005).

[2] www.seaaroundus.org

There is no traditional 'seafood-eating' culture in Pakistan; historically, chicken is preferred as a source of protein over globally popular seafood such as shrimp, lobster, crabs, and mussels. Also, many species of marine fish have been exploited for animal feed, specifically for fishmeal (Ahmed 1985). Despite this, much of the fish landed is intended for domestic consumption, which is highest in the coastal towns and cities with a landing site. Karachi's main market distributes most fish products; however, fish consumption is higher in the Balochistan and Sindh coastal regions than the rest of the country. Fresh seafood is a highly perishable commodity, therefore many Pakistani people still associate fish with disease and sickness, which is emphasized by the often unhygienic state in which fish reaches many consumers (Ahmed 1985; Feidi 1995). In general, fish is not consumed in Pakistan during the summer months (April to October) due to the belief that fish is not suitable food during warm periods. Despite this, local consumption of marine fish has been slowly increasing. From 1973 to 1977, consumption increased from 11% to 20% and by 1985, 30% of the fish catch was locally consumed (50-60,000 t). The rest of the catch was salt-cured or sundried for export or ground up and used for manure or fishmeal (Anon 1977; Ahmed 1985). The country's *per capita* fish consumption in the early 1960s was only 2.3 $kg \cdot person^{-1} \cdot year^{-1}$(Qureshi 1961), and has remained low (e.g., 2.0 $kg \cdot person^{-1} \cdot year^{-1}$ in 1998) in recent years (Shakir and Bano 1999). The World Wildlife Fund (WWF) estimated that 50% of the total fish catch is consumed in the country, 10% of which is used for subsistence purposes (WWF 2005).

Artisanal fisheries

In Pakistan, the traditions and knowledge of the 'art of fishing' is passed down from father to son, generation after generation (Riaz 2010). Despite a lack of formal training, fishers in Pakistan are experienced and accustomed to coastal and offshore operations, which has resulted in successful fishing techniques, based on simple technology and fishing gear (Khan and Khan 2011). Thus, the small-scale fishing communities have maintained their traditional methods of fishing, production and marketing (Siddiqi 1992). Fishers engage in traditional fishing practices within the 12 nm coastal zone (no deeper than 50 meters), from small wooden-vessels, using cast nets, gillnets, stake nets and line gears (Khan 2006). Many of the local gears used are non-selective and unsustainable, with trammel nest and fine mesh gillnets used widely in coastal areas. The fishery is still subsistence-oriented, with a few commercially important species such as croaker, catfish, grouper (*Epinephelus* spp.), ribbonfish, eel, sole, sharks, sardines, threadfin bream and snapper, caught for export or sold in the market. These fishing activities are managed by the provincial fisheries departments of Sindh and Balochistan (FAO 2003). It is difficult to estimate the total artisanal and subsistence fishery production in Pakistan, as there is no routine registration required for village fishers. Still, it is estimated that artisanal fishing contributes approximately 40% to total annual marine catch (Siddiqi 1992).

The two main small-scale gear types in Pakistan are artisanal gillnets, which targets mainly demersals, and 'katra' nets (purse-seine), which catch small pelagics (Table 1). The commercial fishery for small pelagics targets sardines, anchovies (*Thryssa* spp.) and Indian mackerel in the shallow coastal waters. The fishery uses open-decked wooden boats known as 'hora', with long-shaft outboard motors and fish with a 'katra' net (Ahmed 1985; Shakir and Bano 1999). Trips are no longer than 14-16 hours, as there is no means of preserving the catch on board. A portion of the catch from this sector is sold fresh for local consumption, but more commonly, fish is frozen or cured for export (Javaid *et al.* 1975; FAO 1977).

Most of the small pelagic catch, specifically Indian oil sardine (*Sardinella longiceps*) and anchovies (*Thryssa* spp.), is landed and then sent directly for reduction to fishmeal (FAO 2003). Historically, most small pelagic forage fish around the world are caught for the purpose of non-food use, such as reduction and/or direct animal feeding (Tacon and Metian 2009). More recently, the bulk of fishmeal production globally is consumed by the aquaculture sector. However, in Pakistan most of the fishmeal is used as poultry feed. Until 1971, fishmeal was mostly exported, but by the mid-1980s, a local demand had been generated from the poultry industry. Over 50% of the marine catch in Pakistan is used for fishmeal, and production is estimated at 36,000 t·year^{-1} (Pritchard *et al.* 1996). According to FAO's Processed Products database,[3] Pakistan is in the top 20 countries of fishmeal production, being highlighted as a major producer, but not a consumer (Campbell and Alder 2006).

Coastal fishing is characterized by gillnet, trawl and 'doonda' fisheries. Gillnets are primarily used for catching demersal species, such as emperors, croakers (Sciaenidae), grunts, snappers and groupers (FAO 2003). 'Doonda' is the local name for fiberglass lifeboats obtained from scrapped ships, an approach that began in the late 1980s. These boats usually make trips lasting 8-14 days, often targeting demersal fish. Shrimp is caught either by medium sized trawlers, from small boats with drag nets or sometimes gillnetters. This fishery is concentrated in shallow territorial waters (max. 30 m), where shrimp is caught and categorized by body size, color and texture (Zupanovic and Mohiuddin 1973; Sami 1994). There are at least 30 species that occur regularly in the commercial landings, but only five or six species make up the bulk of catches (Van Zalinge *et al.* 1986).

The fishery for lobster is only of minor importance in Pakistan; however the Handbook of Fisheries Statistics (1973-83) reports annual catches of lobsters ranging from 48 t (1980) to 805 t (1983). Three species are of commercial importance: *Panulirus polyphagus*, *P. homarus* and *P. ornatus*. The official

[3] http://faostat.fao.org/default.aspx

statistics report spiny lobster from 1971-2010, with an increasing catch from 1984 (517 t·year^{-1}) to a peak of 1,077 t·year^{-1} in 1999; thereafter, catch decreased to 511 t·year^{-1} by 2010.

Shrimp fisheries

The Indus Delta estuary is about 140 miles wide and about 40 miles deep (Sami 1994). Every monsoon season, the Indus River deposits sediment rich in organic matter into the delta, which sometimes leads to plankton blooms throughout the network of mangrove creeks (Folsom 1974). These mangrove creeks provide critical habitats for some marine food webs, specifically providing nurseries for over 30 species of shrimp (Sami 1994; Hayat 2003). These conditions are ideal for productive growth and have propelled Pakistan into one of the major shrimp producing countries in the world. As the demand for large size shrimp from Japan, USA and West European countries increased, Pakistan began mechanization and expansion of their commercial fleet. The trawling fleet expanded from 3 vessels in 1958 to 897 vessels in 1980 and 1,631 vessels in 1985 (Van Zalinge *et al.* 1986; Sami 1994; Khan 2006). In the early 1990s, there were also 1,090 gillnet vessels catching large shrimp. By the year 2001, 2,415 trawlers were in operation, and at present the number of trawlers is still around this number. Catches are divided into three categories: 'Jaira' (white shrimp), the largest, highest priced and once the commercially most important shrimp, 'Kalri' (pink-brown shrimp), the second most harvested and 'Kiddi, which comprises the smallest shrimps. The shrimp fishery remains the most important fishery in Pakistan, providing substantial foreign exchange (Table 1).

As with most trawl fisheries, Pakistan's shrimp fishery produces a large portion of by-catch and discards. Substantial quantities of non-target fish are caught, which consist of a mixture of fish species, including fish of commercial importance, and a significant portion of small, unmarketable fish. The trawl feet can be at sea for approximately 7-15 days and the by-catch can be retained each day depending on the capacity of the vessel and is usually caught in the last few hauls (Shakir and Bano 1999). Approximately 60-90% of all by-catch is retained for the purpose of fish meal production. Discard rates have been estimated by region for the trawl fishery (Shakir and Bano 1999; Kelleher 2005; Davies *et al.* 2009). However, estimates are assumed to be conservative and not reflective of fleet size and total discard rates. Because of the increased price, and hence value, of by-catch utilized for fishmeal, the discarding at sea has drastically declined.

Tuna fisheries

Tuna support some of the more important fisheries in Pakistan (Table 1). There are eight known species of tuna landed in Pakistan. However, only five species contribute significantly to commercial catches (Khan 2012b): longtail tuna (*Thunnus tonggol*), yellowfin (*Thunnus albacares*), skipjack (*Katsuwanus pelamis*), frigate tuna (*Auxis thazard*), and Kawakawa (*Euthynnus affinis*). The official reported data does not include any landings of bigeye tuna (*Thunnus obesus*). According to Fonteneau (2009), vessels of Pakistan and Iran's oceanic gillnet fisheries operating in central Western Indian Ocean waters may have greatly underreported catches of bigeye tuna. It has been predicted that in some cases, bigeye catches have been misclassified as yellowfin tuna catches, something that has also been documented in Iran and the Maldives.[4] However, as bigetye tuna are rare in northern parts of the Western Indian Ocean, this does not apply to Pakistan's tuna catches in EEZ waters or near-EEZ high seas waters (i.e., northwest Indian Ocean).

The fishery operates as both an artisanal and industrial activity, using locally made wooden-hulled gillnet vessels. It is estimated that more than 500 gillnet fishing vessels are engaged in the inshore and offshore fishery for tuna (Khan 2012c), with most vessels ranging from 10-20 m. Only about 30 vessels are between 20 to 30 m LOA and have on board freezing compartments and dual registration to fish in Pakistan and Iran's EEZ (Khan 2012c). In 1990, the Government of Pakistan permitted four foreign companies to operate in the EEZ for an experimental resource survey of tuna and tuna-like species (Majid 1995). These survey vessels operated until 1993, but in that same year, 12 Taiwanese longliners were licensed to fish under the Pakistani flag, paying fixed royalties and annual license fees (Anon 1995; Majid 1995; Khan 2006). These joint-ventures drastically depleted the tuna resources in the area, specifically yellowfin tuna, with catches reaching a peak of 30,817 t in 1993 and then dropping to 4,604 t in 1994. The stock of yellowfin was thought to have recovered 12 years later, when in 2005 and 2006, another 25 Taiwanese tuna longliners obtained licenses to fish in Pakistan's EEZ. During this period, a total of 7,870 t of yellowfin tuna was caught by these vessels, which again depleted the stocks.

Shark fisheries

The elasmobranch fisheries of Pakistan, which target sharks, sawfish, guitarfish and rays, are a declining fishery. Pakistan's landings, in the early 1990s, contributed 5% of the world's elasmobranch production (Bonfil 1994), and Pakistan became one of the 30 top shark fin exporters to Hong Kong in 2008 (Maslam 2010). Elasmobranch species have historically been caught by Pakistan for meat and fins. Traditionally, landings were small and shark meat was eaten locally, either fresh or salted. Sharks are targeted

[4] Juvenile bigeye tuna frequently school at the surface in shallower waters with yellowfin tuna (IOTC 2011). It is difficult to distinguish between juvenile bigeye and adult yellowfin tuna, which is why it is thought large quantities of bigeye tuna have been miss-reported as yellowfin tuna in the Indian Ocean tuna fisheries.

primarily by pelagic gillnet fleets, which have the capacity to fish as far as Somalia, the Yemen and Oman (Bonfil 1994). As the Chinese demand for shark fins increased, the profit that could be made from fins may have also encouraged fishers in Pakistan to increasingly target sharks. However, locally consumed shark meat has traditionally been the driver of Pakistan's shark fisheries. According to the FAO, Pakistan was the world's leading producer of shark meat in 1997. Of the 31,200 t landed, 19,000 t were processed into dried, salted and in-brine shark products (Vannuccini 1999). As in many regions of the world, 'fishing down' (Pauly *et al.* 1998) has altered entire marine ecosystems in the waters of Pakistan, and sharks in particular have been substantially reduced (Khan 2011).

Foreign fisheries

Foreign fishing in the EEZ of Pakistan has been conducted by fleets from Korea, Taiwan and China since 1982. Offshore fishing is primarily undertaken by 'joint ventures' and is divided into Zone I (12-35 nm) and Zone II activities (35-200 nm). As many local traditional fishers do not have the means to fish beyond 12 nm, this inshore zone has been off-limits to foreign as well as Pakistani flag trawlers and tuna longliners. In 1982, foreign-flag fishing trawlers of 300-350 GRT were allowed to fish beyond 35 nm from shore, under joint venture schemes (FAO 2003). These 'joint ventures' have historically been a source of controversy, and local inshore fishers have repeatedly accused foreign vessels of illegally fishing within territorial waters, or of performing offshore transshipments of catch, and thus underreporting (Ahmed 1985; Wijeratna 2007). After protests from fishing communities, foreign access was stopped in 1986 and only 'Pakistani-flag'[5] vessels were permitted to operate in the EEZ.

In 1995, the desire to expand the country's fish trade resulted in the 're-opening' of Pakistan's EEZ to foreign trawlers (Wijeratna 2007). In 2000, the Federal government again banned 'deep-sea fishing', but after only a few months, the policy was amended. The new Fishing Policy (2001), allowed large factory trawlers to fish within the 35-200 nm zone, and mid-size trawlers to extract resources from the 13-35 nm zone, which was previously used as a 'buffer zone' for traditional local fishers. According to the Government of Pakistan, 19 midsized and 13 large trawler licenses were issued in 2002, and 20 stern trawlers and 10 tuna longliners were permitted to operate beyond 35 nm in 2003 (Hayat 2003; Wijeratna 2007). Licensed vessels are not permitted to transship catch at sea, and are required to land and export their catch from Korangi Fisheries Harbour in Karachi (Hayat 2003).

[5] It has been noted by the MFD that trawlers operating between 1986 and 1995 were flying Pakistani flags, but were actually owned and operated by South Korea or Taiwanese companies, and were therefore treated as foreign operations.

Foreign trawlers have been accused of encroaching on inshore fishing grounds, discarding large amounts of fish, and claims have been made against vessels that were licensed as joint-venture or as foreign operation, but have deliberately re-flagged as Pakistan (Wijeratna 2007). Efforts were made to address growing fishing capacity, by not allocating new licenses to additional foreign trawlers in Pakistan's EEZ, requiring all vessels to be correctly licensed and prohibiting harmful fishing practices (FAO 2007). However, these efforts were likely of very limited success, since there is no comprehensive data collection or enforcement in place. Since 2005, no foreign trawlers, and since 2009, no foreign tuna longliners appear to have operated in Pakistan's waters, mainly due to the high price of fuel and fears of Somali piracy.

Objectives

The Food and Agriculture Organization's (FAO) FishStat database[6] provides marine landings records for Pakistan from 1950-2010. The data provided by the FAO are based on national fisheries statistics supplied by its member countries (Garibaldi 2012), therefore the quality and accuracy of the data depend on the method and capacity of the statistical collection and reporting system within FAO member countries. According to the FAO, Pakistan is endowed with an "immense wealth" of marine resources (FAO 2003), although tragically, no comprehensive data collection system has been put in place to inform management. In many cases, data are merely extrapolated from the previous year, and lack reliability, traceability, transparency and coherence. For many developing countries, official fisheries statistics for small-scale artisanal and subsistence catches are either missing or underestimated (Zeller *et al.* 2007), and therefore undervalued in terms of their economic and social importance (Zeller *et al.* 2006; Watson *et al.* 2011). In Pakistan, the combination of Illegal, Unreported and Unregulated (IUU) fishing, poor regulation, surveillance and estimation of catches, discarding and high amounts of unreported by-catch for fishmeal production, continues to deplete valuable fish stocks and fishers' livelihoods. The purpose of this study is to reconstruct the total marine catch of Pakistan for the 1950-2010 time period. This may serve as a scientific baseline; for a better understanding and potential first-order assessment (e.g., Kleisner *et al.* 2012) of resource availability and food security in Pakistan.

[6] www.fao.org/fishery/statistics/en

Materials and methods

Fisheries statistical data reported by Pakistan have historically remained debatable and unreliable. It is the responsibility of the Federal government and the Marine Fisheries Department (MFD) to report fisheries statistics to international agencies such as the FAO. The data collected and reported to the FAO are compiled by the MFD after receiving them from various fishery agencies and departments in Pakistan. In the past, national landings data were intermittently recorded from the eight most important landing sites along the Balochistan coast. However, this system quickly deteriorated (M.M. Khan, pers. obs.) and it is not known if these sampled data were scaled up to account for un-sampled landing sites. Landings were at times recorded at Karachi harbor; yet separate data are not available for a number of landing centers along the Sindh coast. The major issue lies in the lack of effective communication and cooperation between the statistical collectors, management, enforcement personnel and stakeholders. This non-integrative management system, combined with a lack of standardized and formalized routine reporting, data collection and simple expansion, is likely due to inadequate resources.

Fisheries statistical data in Pakistan have been reviewed for 1970-2001 by Garibaldi (2002) and Khan (2002), and they found that the commercial catch more than tripled from 1970 (173,500 t) to 2001 (614,800 t). According to the Central Fisheries Department in Karachi, total marine catches for Pakistan from 1957-1959 increased from 82,300 t to 96,500 t, which is almost twice the reported FAO catch for those years. However, this reported catch did not include catches from subsistence fishing, as the fisheries department did not estimate catches from this sector (Qureshi 1961). In 1973, it was suggested that catch increases were due more to improvements in the reporting system than fisheries increases. The peak from 1977-1979, it was suggested, was the product of domestic fleets being able to fish further offshore, which resulted in the identification of more fishing areas. From 1992-1993 and 1999-2000, peaks in catch were the result of extensive fishing by foreign tuna longliners and deep-sea trawlers operating under joint-ventures (Majid 1995). Recent increases in fish catches are likely the result of improvements in fishing technology (Khan 2006).

Here we follow the principles of 'catch reconstruction' as described in Zeller *et al*. (2007), which broadly consists of six steps that are used to estimate catches missing from officially reported data:

1) Identification of existing reported catch time series, e.g., local reports and data presented by the Marine Fisheries Department and by FAO;
2) Identification of sectors, time periods, species, gears etc. not covered by (1), i.e., missing catch data, via literatures searches and consultations;
3) Search for available alternative information sources relating to the missing catch data in (2), through extensive literature searches and consultations with local experts;

4) Development of data anchor points in time for missing data items, and their expansion to country -wide catch estimates;
5) Interpolation for time periods between data anchor points for total catch, often with *per capita* or per fisher catch rates; and
6) Estimation of final total catch time series for total catch, combining reported catches (1) and interpolated and expanded missing data series (5).

We apply this conceptual approach to Pakistan's fisheries, by major sectors and components.

Industrial fisheries

Shrimp fisheries

The shrimp fishery is one of the economically leading fisheries sector for Pakistan, based on gross value (Table 1). Shrimp landings gradually increased from 2,900 t in 1950 to 9,170 t in 1963. In 1964, they rapidly increased to over 16,000 t, and since 1980 have fluctuated between 25,000-30,000 $t \cdot year^{-1}$ (Anon 2006). However, declining shrimp catch from 1988-2007 raised serious concerns within the industry. It has been suggested that overfishing, poor quality and distribution, declining markets, and bans by the European Union (EU) due to poor quality of the final product, could be reasons behind the decline (CSF 2009). There is also an apparent discrepancy between the reported catch and a decline in the value of exports. A substantial decline of 60% in the export value of shrimp catch from $100 million USD (1994) to $40 million USD (2005), suggest poor catch statistics that do not reflect the true decline (ADB 2006; CSF 2009). Interestingly, official reported landings of shrimp have shown an increasing trend from 2008-2010. The reported landings of *Penaeus*, *Parapenaeopsis* and *Metapenaeus* shrimp from 1958-2010 were defined as industrial catch, while from 1950-1957 they were assumed to be entirely artisanal, as no industrial trawlers were operating at that time.

Shrimp fishery discards

Shrimp landings make up the bulk of fisheries exports. However, besides shrimp, the trawl fleet incidentally catches a mixture of fish species as by-catch; either deemed edible or considered non-marketable. Much of the commercially important species are landed, however, large quantities of low-value catch is discarded at sea. Karachi fish harbour handles up to 90% of Pakistan's marine catch and more than 60% of the landings consist of by-catch, which is due to a three-fold increase in incidental by-

catch from the shrimp trawl fishery (Davies *et al.* 2009). An accurate record of the amount of by-catch that is being discarded or landed is scarce and almost impossible to obtain. None of the fishery departments collect data on by-catch and portions of the incidental catch can only be traced through small pelagic landings and fish destined for fish meal factories. Of the landed by-catch, over 50% is sent to fishmeal factories, wile the remaining valuable fish is sold in markets. However, Siddiqi (1992) suggested that processors may reject more than 30% of the catch for quality reasons.

Zupanovic and Mohiuddin (1973) reported an average 6.4:1 by-catch: shrimp ratio during trawl surveys for stock assessment of shrimp off the coast of Pakistan from 1966-1969. This catch ratio was used to calculate assumed by-catch of the industrial shrimp fishery from 1950-1973. A by-catch to shrimp ratio of 5.3:1 by Shakir and Bano (1999) was used to estimate total by-catch from 1990-2010. A liner interpolation between the 1973 and 1990 ratios was used to estimate by-catch from 1973-1990. We used the total catch by shrimp trawlers (i.e., total shrimp catch plus assumed by-catch), to calculate the amount of discards associated with this industry. A discard rate of 21.1% from Kelleher (2005) was applied to the total catch from 1975-2010, to estimate the amount of discards. The fishery for small pelagics has only been carried out since the early-1960s (first fishmeal factory was built in 1957) and demand for fishmeal was growing during that time within the country (MFD 1974; Pritchard *et al.* 1996). To represent the shift from predominately discarding unwanted by-catch to retaining a growing proportion for fishmeal production, we assumed that discards would be higher in early years, i.e., representing 65% of the total catch from 1950-1965. We then gradually decrease this rate to 21.1% by 1970. Inversely, the retained by-catch would be 21.1% of the total catch from 1950-1965 and would increase to 65% by 1970. The percentage of retained by-catch in the total catch decreased to 63% in 1990 and was held constant to 2002. Since 2003, the prices for by-catch destined for fishmeal plants have risen sufficiently to ensure substantially increased retention of by-catch. Thus, retention of by-catch of shrimp trawlers reached 95% by 2010.

Shark fisheries

Elasmobranch landings in Pakistan are significant and are among the highest in the world (Bonfil 1994). However, detailed data on this fishery are unreliable and contain serious discrepancies. There are approximately 134 species of elasmobranchs in Pakistan's waters, 64 of those being shark species (Shahid 2012). Landings are dominated by blacktip (*Carcharhinus limbatus*), silvertip (*Carcharhinus albimarginatus*), spot-tail shark (*Carcharhinus sorrah*), milk shark (*Rhizoprionodon acutus*), spadenose shark (*Scoliodon laticaudus*), thresher (Alopiidae) and short-fin mako shark (*Isurus oxyrhincus*). It is estimated that 55% of the total shark landings originate from gillnet vessels targeting tuna and other large pelagics (Shahid 2012). It has been documented that sharks are landed with their fins attached and little is wasted. However, Taiwanese shark 'finning' operations were observed fishing in the offshore Pakistani waters from 2004-2005 (IOTC 2005).

Landings of sharks in 1950 were 4,800 t, although during this time the fishery was minor and fishers were catching substantial quantities of rays, guitarfishes and sawfishes, which were not reflected in the data. Landings reached approximately 74,000 t in 1973, but still no records of rays or guitarfishes were reflected in the reported landings. The landings data then show sudden decreases in 1974 and 1975 (34,800 t), as well as again in 1983 (18,200 t; Figure 2). The reasons for these declines were not documented at the time of reporting. However, it was later revealed that in 1974, the person responsible for data 'reporting' (Assistant Director Statistics), was on leave and one of his sub-ordinates 'prepared' the data without taking into consideration the previous level of landings (M.M. Khan, pers. obs.). In 1982, the person responsible for data 'reporting' (promoted to level of Deputy Director of Statistics) retired from government service and a new Assistant Director of Statistics was appointed. Since he was not familiar with the statistical data compilation process, he used his own judgment to process the data, which subsequently resulted in catch data much lower than the previous years' data (M.M. Khan, pers. obs.). These are clear cases of 'loss of institutional knowledge' and also reflect poor documentation and standardization of data processes. Sharks, rays, guitarfishes and sawfishes were only reported separately as of 1987.

In order to account for the institutional under-reporting of elasmobranch catches in the mid-1970s and mid-late 1980s, linear interpolations were applied (Figure 2). It is apparent that those data should be considered a minimum, since no additional landings data were available. Pakistan only reported 'requiem sharks' (Carcharhinidae) in the official reported data; however, is known that many species of sharks are caught as by-catch in the tuna fishery (Khan 2012b). All unreported by-catch of sharks and rays, by the tuna gillnet fishery, the artisanal sector and the shrimp trawlers as retained by-catch, were summed to generate the total reconstructed catch for elasmobranchs from 1950-2010.

Tuna fisheries

Landings of tuna reported by FAO on behalf of Pakistan have fluctuated from 1950-1990, primarily due to changes in the method of collecting and compiling data (Majid 1995). Yellowfin tuna does not appear in the FAO data as a separate category until 1986, nor do kawakawa, frigate and bullet tunas. Reported catch of skipjack tuna was included in 1970. Longtail tuna appears to have the most accurate time series, and has been reported in the FAO data since 1961. Updated catch data was supplied by the MFD for tuna species from 1987-2010 (M.M. Khan, pers. obs). Data supplied by the Indian Ocean Tuna Commission (IOTC) regarding catches of yellowfin tuna by Pakistan was used from 1952-1985 (IPTP 1992). Skipjack catch data from the IOTC was also used from 1959-1981 and for kawakawa from 1959-1987 (IOTC 2009b), as catches for these species were either missing from the FAO data or lacked an accurate trend. Other landings data for tuna species were taken from the Handbook of Fisheries Statistics of Pakistan (1973-1982), to either verify the reported FAO data or improve the taxonomic disaggregation of the catch. To estimate catches for longtail and kawakawa from 1950-1961, and skipjack from 1950-1958, a proportion was calculated for each species in relation to the data for yellowfin tuna from the earliest year available (i.e., 1961 for longtail and kawakawa), and then applied to all earlier catches. Interpolations were used in years where catch data were unavailable.

Landings of tuna, specifically yellowfin, peaked between 1991-1994 when the Pakistani government approved an experimental resource survey, allowing more than 50 Taiwanese longliners to fish within Pakistan's EEZ (IPTP 1991; Majid 1995; Khan 2012c). Tuna landings attributed by Taiwanese (and assumed Chinese, Pauly *et al.* 2013) industrial longliners, fishing in the EEZ from 1991-2009, were subtracted from the total tuna catch for all species and reallocated as Taiwanese (and Chinese) catch. The remaining catches were assumed to be domestic catch from inshore and offshore gillnet operations, fishing within the EEZ. Little information is available on catches by the gillnet fishery. However, it is estimated that the inshore gillnet fishery takes 30-40 % of the skipjack catch. Based on information given by the IOTC and FAO (Gillett 2011), it was assumed that 10% of the gillnet catches were made by inshore artisanal fishing operations and the remaining 90% by offshore fleets, which for the purpose of this report, were categorized as industrial catch. Pakistani gillnetters are known to also fish in the EEZ of Iran, Somalia and the high seas (Khan 2012c); however, estimates of catches outside the EEZ were not available.[7]

[7] Spatial data pertaining to tuna catches outside the EEZ were not calculated at this time. However, such data will be found on the *Sea Around Us* project website once they become available (www.seaaroundus.org).

By-catch in this fishery is significant, and consists of commercially valuable species such as sharks, rays, barracudas (*Sphyraena* spp.), Spanish mackerel, as well as, turtles, cetaceans and marine birds (Khan 2012b). According to the IOTC, from 2006-2008, gillnet vessels produced an annual average of 6,858 t of tuna and 29,919 t of non-tuna catch (Gillett 2011). This 1:4.4 ratio of tuna to non-tuna catch was used to calculate total by-catch from tuna gillnetters from 1950-2010.Due to the high commercial value of most by-catch taxa in this fishery, most are retained and discards were considered to be low to negligible (Gillett 2011). The by-catch has never been recorded separately; therefore, it has not been possible to determine any historical change in proportion of by-catch species (Khan 2012b).

It has been documented that an estimated 2-5 whale sharks (*Rhinocodon typus*) are entangled in tuna gillnets per year. Fishers generally do not release the entangled sharks, and rarely bring the sharks into designated landing centres. Instead the liver is extracted and the oil used for lining vessel hulls. The remaining meat is sold to fishmeal factories (Khan 2012b).

Artisanal fisheries

The artisanal (i.e., small-scale commercial) fisheries in Pakistan play a crucial role in providing employment and food for the coastal population. All fishing vessels, with the exception of shrimp trawlers and large mechanized gillnetters, are involved in the small-scale fishery. The artisanal sector is estimated to contribute 40% to total marine catch (FAO 1977; WRI 1987; Siddiqi 1992). However, before mechanization of the traditional fishing fleet in Sindh, all marine catches prior would have been generated by the artisanal fishing sector alone. Balochistan also began mechanization of their fleet gradually between 1959 and 1976, and contributions from the industrial fishing sector increased. To accommodate this shift, an interpolation from 100% artisanal (1950) to 40% artisanal (1976) was applied to derive the artisanal sector component of the reported landings. From 1976 onwards, catches by the artisanal sector were assumed to contribute 40% until 2010.

Throughout the Sindh coast and Indus Delta of Sindh, small-scale fishers regularly land their catch in remote fishing villages and settlements. The Balochistan coast hosts eight significant landing sites and more than 25 fisher settlements (WWF 2005). In Sindh, besides Karachi Harbour, there are approximately 10 major sites where fishers can land their catch and an unknown number of small settlements. Along both coasts, where no landing facilities exist, fish is landed on the beach and either sold onsite, sent to be auctioned or transferred directly to processing facilities (WWF 2005). Since reliable and separate data do not exist for many of these 'unofficial' landing sites, it is assumed much is being landed and not officially recorded (WWF 2005; CSF 2009). To account for under-reporting at secondary landing sites, we raised artisanal catches (minus inshore tuna and catch of small pelagics) by

30% from 1950-1990. As there would have been a gradual increase in resources to record landings at more sites, as well as improved transportation to and from rural markets, we raised catches by 20% from 1990-2010 to account for this underreporting.

Seine (Katra) fishery

Small pelagics, such as sardinella and anchovies, are targeted by the seine (locally known as 'katra') fishery, as well as through incidental by-catch from the shrimp trawl fishery. More than half of the total landings of this fishery are used for fishmeal, although some commercial species, such as Indian mackerel, are sold for direct human consumption. The scale of the fishmeal industry (Shakir and Bano 1999), combined with a large proportion of the catch being landed in rural areas and not being recorded, allows the inference that the small pelagic catch could be at least three times as high as figures suggest (CSF 2009). Abildgaard and Khan (1986) describe the methods in which small pelagics are transported to the fishmeal factories in trucks that must pass through designated weigh stations. At these stations, the weights of the catches are recorded. However, it is known that at times these trucks bypass the weighing stations and are delivered directly to the fishmeal factories. Thus, it is not known what proportion of small pelagics is actually recorded at these weigh stations. Shakir and Bano (1999) also make reference to the discrepancies in data reporting of small pelagics. Taking all this into consideration, it is clear that official catch data for small pelagics should be considered a minimum value (Abildgaard and Khan 1986). To account for all potential sources of underreporting, the total reported catch of small pelagics was multiplied by a factor of three from 1950-2010.

Recreational fishery

A sizable recreational fishery exists in Pakistan that targets fish in three different zones of the EEZ: billfish and tuna fishing out of Karachi, sport fishing in coastal waters, and hand-line (bottom) fishing in near-shore waters (FAO 2009). The only available information on this sector evaluated the fishery at about 900 participants, catching approximately 130 t in 2002 in all activities, and by 2009 it was estimated that 1000 participants were involved in the sector, operating approximately 120-150 non-licensed vessels (Khan 2006; FAO 2009). Despite this information, the total contribution from this sector remains unknown and no official records of catch can be found. We were able to obtain estimates of total catch from 1983-2010 (M.M. Khan, pers. obs.) provided by the Agha Sport Fishing and Angling Headquarters[8], the largest organized recreational fishing company in Pakistan. As these data only

[8] http://www.aghasportfishing.org [Accessed January 2, 2013]

represent catches by one organization, 20% was added to all catches to account for other sports fishing companies in operation, such as the prominent Pakistan Game Fish Association (PGFA).[9] As no records of a recreational fishery exists prior to 1983, a linear interpolation from a catch of zero in 1950 to the first estimate provided by the MFD in 1983, was completed to account for the growth of the recreational sector.

Subsistence fisheries

Poverty is a central issue for coastal rural communities in Pakistan. In Sindh province, many families rely fully on the resources within the mangroves, and the livelihoods of these communities are intimately connected to their environment (Anon 2006). According to the Government of Pakistan Handbook of Fisheries Statistics (1973-1983), national marine catch data for 1972-1983 and 1987-1999 included some estimates for subsistence fishing (Ahmed 1985; Raza and Khan 2001). These subsistence estimates were collected from the early 1970s by fisheries officers and inspectors from fishing vessels and fishers returning with their days catch. Unfortunately, such data were not collected in recent years (M.M. Khan, pers. obs.). The 'subsistence' estimates referred to by the handbooks, likely represent the 'take home' catch of commercial artisanal fishers and greatly underestimate catches by those living in rural areas fishing solely for subsistence purposes (i.e., true subsistence catch). As most fisheries in Pakistan are poorly managed and much is landed in rural areas, it is not surprising that estimates for subsistence fishing are limited or unavailable. Despite this, it is assumed that only a small amount of subsistence catch was unreported, likely 3-5% of the total catch in recent years and about 5-8% in previous years (M. M. Khan, pers. obs.).

The WWF estimated that in 2003, about 50% of fish catch was locally marketed and consumed, and 10% was used for subsistence purposes (WWF 2005). This estimate was likely derived from the subsistence totals provided by the MFD, as explained above. However, since this was the only information available, we linearly interpolated from the catch in 1999 to the 10% subsistence catch estimate (about 40,000 t) to calculate the missing subsistence catch for years where no data were available. We assumed in the 'early years', from 1972-1990, 8% of subsistence catch was unreported. From 1990-2000, it was assumed 6% was unreported and that this would decline to 5% from 2000-2003 (i.e., recent years). These percentages of unreported catch were applied to all reported subsistence catch from 1972-2003.

As we had subsistence estimates for some years, in order to determine a *per capita* subsistence catch rate and an estimate for total subsistence catch from 1950-2010, we required historical human

[9] http://www.pgfa.org [Accessed January 2, 2013]

population data. Pakistan's population data from 1960-2010 were obtained from the World Bank[10] database and information provided by the population statistics historical demography website[11] was used from 1950-1960 (Figure 3). Coastal population data were taken from NASA's Socioeconomic Data and Applications Centre (SEDAC) (CIESIN 2012). The data were presented by both coastal, rural and coastal, urban locations, for the years 1990, 2005, and 2010, and calculated for a distance from the coast of between 5 and 200 km. In order to calculate Pakistan's *per capita* subsistence catch rates, the number of people living within 100 km from the coastline was used. To determine coastal, rural and coastal, urban populations from 1990-2010, a linear interpolation between years of missing data was used. To estimate the coastal population from 1950-1990, rural and urban population growth rates from 1960-1990, obtained from the World Bank, were applied to the coastal, rural and coastal, urban population in 1990 as determined above, and applied back to 1960. The 1960 rate was held constant from 1950-1960.

Using this estimated subsistence catch, divided by the estimated coastal rural and urban population, we were able to derive a *per capita* subsistence catch rate from 1972-2003. No estimate was made for the inland population, as most of the fish consumed by this region is supplied by the freshwater fishing sector (Javaid *et al.* 1975). The rates increased from 13 kg·person^{-1}·year^{-1} in 1972 to a peak of 27 kg·person^{-1}·year^{-1} in 1992. The subsistence catch rate in 2003 was estimated to be 19 kg·person^{-1}·year^{-1}. To estimate the *per capita* subsistence catch rate in 1950, we assumed that the rate would have been twice the assumed rate in 2003 (i.e., 38 kg·person^{-1}·year^{-1}), as it is expected that due to increased economic development, improved infrastructure such as roads and processing facilities, the Pakistani people gained better access to commercially caught fish at the main markets.

These rates were taken to represent coastal and rural rates only. Compared to many other areas in the world where people are heavily dependent on subsistence for marine resources (e.g., the Pacific, Zeller *et al.* 2006, 2007), the *per capita* subsistence catch rates estimated here seem low. However, one has to consider that these rates were based on the total population within 100 km from the coast. Thus, these rates do not represent a catch rate of a true subsistence fisher, but rather a population-level averaged rate.

To account for the fluctuating rates, likely due to changes in the data collection system, the coastal, rural *per capita* subsistence catch rate in 1950 (38 kg·person^{-1}·year^{-1}) was linearly interpolated to the catch rate in 2003 (19 kg·person^{-1}·year^{-1}), to show a more consistent and gradual trend over time. The *per capita* subsistence catch rate in 2003 was held constant to 2010. The subsistence rates for the coastal, urban population from 1950 to 2010 were assumed to be half of the rural *per capita* rate (i.e., 19

[10] http://data.worldbank.org/ [Accessed March. 19, 2013]
[11] http://www.populstat.info/ [Accessed March 19, 2013]

kg·person^{-1}·year^{-1} to 9.5 kg·person^{-1}·year^{-1} for 1950 and 2010, respectively), as people living close to the main markets would always have better access to commercially caught fish. The subsistence catch contributed by the coastal rural and coastal urban population were combined to estimate total catch by subsistence fishers from 1950-2010 The subsistence estimates provided by the MFD from 1972-1999 were assumed to be included in the data and all remaining subsistence catch estimates for 1950-2010 were therefore treated as unreported.

Foreign fisheries

The MFD have regularly collected data from foreign licensed vessels operating in the EEZ of Pakistan. However, the accuracy of these data is questionable, since it has been observed that the data collected by the observers on board often match the data given by the captain. In addition, there are no specific records of discards from these vessels. Legal offshore fishing by foreign trawlers in Pakistan's EEZ was stopped in 2005, followed by foreign tuna longliners in 2009 (M.M. Khan, pers. obs.).

Catch data from within the EEZ can be found in Pakistan's Handbook of Fisheries Statistics (1973-1983). The number of foreign vessels in operation, along with the species breakdown from 1982-2009, was provided by the MFD. A total of 15 Taiwanese pair trawlers operated from 1982-1988 and more than 200 Taiwanese longliners from 1992-2009. South Korean stern trawlers were consistently present in Pakistan's EEZ from 1982-2005. North Korea had two stern trawlers in operation in 1984. China has been mentioned as a key contributor to industrial offshore (Khan 2006; Wijeratna 2007), and the MFD recorded longliners operating in Pakistan EEZ from 1998-2005. Also, it has been documented that 20 trawlers, belonging to China and South Korea, fished in Pakistan's EEZ in 2001 (Niaz 2001). In 2009, unconfirmed reports suggest that 10 Chinese fishing vessels may have operated in Pakistan's waters (Anon. 2009). Based on these observations, it was assumed that a few Chinese vessels may have continued to fish in Pakistan's EEZ towards the end of the time period of interest here (see also Pauly *et al.* 2013).

National data sent to the FAO included catches by joint-venture operations fishing within Pakistan's EEZ. Using the estimated catch data from foreign operations in the EEZ and vessel breakdown provided by the MFD, the catches were proportioned based on the vessel type (i.e., trawl or longline) and by the number of vessels operating from each country. Taiwanese longliners fishing from 1992-2009 were assigned catches of large pelagic taxa (e.g. tunas and sailfish), as well as 50% of the foreign shark catch. The remaining trawler operations were assigned catches of small pelagics, demersals (including the

remaining 50% of shark catches) and shellfish (shrimp, crabs and cephalopods). Catch by Taiwanese and South Korean operations in 1982 was extended back to 1976, the establishment year of the EEZ, as South Korea was known to fish in FAO area 51 from 1965-2010. Although data are not available, it is likely that Taiwan was also fishing in Pakistan's EEZ during these earlier years.

Foreign discards

Discards are reported to be high (15-35%), specifically during Korean operations from 1982-1986 (M.M. Khan, pers. obs.). Since 1986, most foreign operations landed a major portion of their catch for local sale; however, it was found that discarding stayed on average as high as 15-20% of the commercial catch (M.M. Khan, pers. obs.). A discard rate of 35% was applied to Taiwanese catch from 1982-1988 and Korean (South and North) catch from 1982-1986. Thereafter, a 20% discard rate was applied until 2010. A discard rate of 20% was also applied to Chinese catch from 1998-2005. A discard rate of 40% (Kelleher 2005) was applied to all longline catches from 1992-2009.

Taxonomic breakdown

Commercial fisheries

The taxonomic breakdown for the reported landings for the artisanal and industrial sectors was derived from the reported FAO data. Since most groups reported to FAO contained commercially important species targeted by both the artisanal and industrial gillnet fishery, the same taxonomic information was applied to both sectors. This applies to all groups except spiral babylon (Buccinidae) and 'clams nei', which were assumed to be collected exclusively by artisanal fishers.

The composition of unreported artisanal catch was derived from local knowledge of taxonomic composition supplied for 1972-1973 (M.M. Khan, pers. obs.), national landing statistics from 1999-2010, as well as information from the Handbook of Fisheries Statistics (1973-1983) to identify taxonomic groups not found in the official FAO data, with all compositions retained at family level (Table 2). The proportions derived for the 1970 time period were extended back to 1950, as no addition information was available. Interpolations from 1970-1990, 1990-2000 and 2000-2010 were used to represent the change in species composition over time. From 1990-2000, increases in commercially important families such as Ariidae, Carangidae and Scombridae were observed. Since the year 2000, a large decrease in the landings of large pelagics, specifically sharks, was observed (Table 2). Catches of

ribbonfish (Trichiuridae) have increased considerably since 2000, and in 2010 represented 10% of the unreported artisanal catch (Table 2).

'Miscellaneous' marine fishes

The FAO yearbook made reference to misreporting for Pakistan, stating that "the quantities of individual species for the years 1983-1987 refer to partially recorded catches at main landing sites only. The remaining not recorded quantities are included in marine fishes nei" (FAO 1989). When examining the data, it was evident that catches within the 'marine fishes nei' category were much larger from 1983-1990 (Table 3). In order to reduce the ecologically un-informative pooled group 'marine fishes nei', we calculated the average proportion for all species reported five years prior to 1983 (i.e., 1978-1982), and applied these average proportions to 'marine fishes nei' catches from 1983-1990 (Table 3).

The 'marine fishes nei' category in the FAO data was reported from 1970-2010. The FAO yearbook notes make reference to incomplete taxonomic detail, indicating that "the 1970-77 catch data for 'marine fishes nei' include quantities of several species shown separately in subsequent years" (FAO 1982). To improve the species composition for the reported 'marine fishes nei' category from 1970-2010 (Table 4), we used the taxonomic composition from the unreported artisanal catch component (Table 2), as well as major families of sharks and rays described in Khan (2012b). Pakistan only reported 'requiem sharks' from 1950-2010, and since sharks are an important component of the by-catch from tuna gillnet operations, six major families of sharks (Alopiidae, Echinorhinidae, Gingymostomatidae, Lamnidae, Sphyrindae and Triakidae) were included in this taxonomic breakdown (Table 4). Since a large decrease in sharks was observed in later years, this was reflected in the proportions from 2000-2010 (Table 4). Artisanal fishers operate traditional gillnet vessels in the coastal area of Pakistan's EEZ, catching demersals and some pelagic species, such as mackerel. There was no target fishery for Indian mackerel prior to 2001, although a frozen export sector for Malaysia and Thailand has developed since (M.M. Khan, pers. obs.). As this species is also used for production of fishmeal, a small proportion was applied to the 'marine fish nei' breakdown from 1970-2010 (Table 4).

Small pelagic fisheries

The taxonomic breakdown for small pelagics from 1950-2010 (Table 5) was derived using the Handbook of Fisheries Statistics (1973-1982) as well as landing statistics from 1999-2010 supplied by the MFD (M.M. Khan pers. obs.). Catches of small pelagics in 1970 were dominated by sardinella species; specifically Indian oil sardine and Sindh sardine (50% of the catch). Eight other species of sardinella and shads (Clupeidae) were also identified, and contributed 10% to the total catch. *Thryssa* spp.

(Engraulidae) contributed 30% to overall small pelagic catch. The 1970 species breakdown was extended back to 1950, as no other information was available. The species composition remained relatively stable from 1970-1990 (Table 5), however, from 2000-2010 a decrease in Indian oil sardine and *Thryssa* spp. was observed. Indian mackerel was not included in the species composition of small pelagics from 1950-2000, however by 2010, it represented 33% of the total catch (Table 5).

Subsistence fisheries

The taxonomic composition for the subsistence fisheries for 1970, 1990 and 2010 was derived from the artisanal breakdown indicated in the commercial fishery section above. However, through cross-referencing with Fishbase (www.fishbase.org), all taxa that occurred primarily in deeper water (>20 m) or offshore habitats were removed, since most local inhabitants engage in subsistence fishing from shore or within the near shore areas. Penaeid and non-penaeid shrimp, along with certain taxa of molluscs, are also harvested by subsistence fishers in the Indus Delta region (Qureshi 1956; Akhter 1995), and were included in the subsistence catch composition (Table 6). The 1970 taxonomic composition was extended back to 1950, and interpolations were done for 1970-1990 and 1990-2010, to account for a change in taxonomic composition over time (Table 6).

Recreational fishery

Catch composition for the sports and recreational fishing sector from 1983-2010 was provided by the Agha Sport Fishing and Angling Headquarters in Pakistan. Since total catch of the target family was provided from 1983-2010, the proportion of catch observed in 1983 was extended back to 1950. The taxonomic composition of recreational catch was proportioned into five families (Carangidae, Scombridae, Serranidae, Sparidae and Sphyraenidae) and a 'marine fishes nei' category (Table 7).

Shrimp fisheries by-catch and discards

The taxonomic composition of by-catch resulting from the shrimp trawl fishery was derived using landed by-catch data sampled from landing centres (Shakir and Bano 1999). The data recorded provided average size (cm) of each taxon collected and the number of specimens. Using the life-history tool in Fishbase (www.fishbase.org), a representative average weight was estimated using the average length provided by Shakir and Bano (1999). By multiplying this weight by the number of specimen sampled in the trawl survey, we generated an assumed proportion for each species within the by-catch (Table 8). These proportions were then applied to the total retained by-catch from 1950-2010.

The taxonomic breakdown for by-catch was also applied to discards associated with the shrimp trawl fishery (Table 8). However, Brachyura (crabs) was included in the discarded by-catch with an overall contribution of 1%; thus all proportions were re-adjusted to account for the addition (Table 8).

Tuna fisheries

Landings of tuna are noticeably different for vessels operating offshore in waters of Pakistan and neighboring countries such as Somalia and those operating in inshore waters. Those operating in inshore waters have longtail (33%) and skipjack (32%) dominating, with kawakawa (19%), yellowfin (14%) and frigate tuna (2%) also contributing to landings. In offshore operations, skipjack alone contributes 83 %, followed by yellowfin (12 %), whereas other tuna species only contribute about 5% (Khan 2012c). These percentages were applied to the inshore and offshore tuna landings in Pakistan's EEZ from 1950-2010. Catch composition for joint-venture or foreign operated vessels from 1991-2010 was determined to consist in equal proportions of skipjack and yellowfin (35% each), with the remaining percentage of landings consisting of longtail (25%) and kawakawa (5%) (Khan 2012c). These compositions were based on analysis of data from 2005-2008. However, landings of tuna species have likely fluctuated since 1950, due to changes in the fleet size, type of gear and presence of industrial tuna longlining fleets in Pakistan's EEZ (Majid 1995).

The taxonomic composition of the by-catch associated with the inshore and offshore tuna gillnet fishery was presented in Khan (2012b). By-catch composition was split into the Karachi and Balochistan regions; therefore, the percentages were averaged to generate a breakdown for the whole EEZ. In inshore waters, the by-catch consists predominantly of Talang queenfish (*Scomberoides commersonianus*), followed by narrow-barred Spanish mackerel, barracuda (*Sphyraena* spp.), dolphinfish (*Coryphaena hippurus*), Indo-Pacific sailfish (*Istiophorus platypterus*), bigeye thresher shark (*Alopias superciliosus*), silky shark (*Carcharhinus falciformis*), other requiem sharks (Caracharinidae) and mantas (Dasytidae and Myliobatidae) (Table 9). Offshore by-catch typically consists of Indo-Pacific sailfish, black marlin (*Istiompax indica*), striped marlin (*Tetrapturus audax*), dolphinfish, bigeye thresher shark, shortfin mako shark (*Isurus oxyrinchus*) and other requiem sharks (Table 9).

Results

Industrial fisheries

Shrimp fisheries

Reported shrimp landings totaled over 1 million tonnes from 1958-2010 (Figure 4) and reached a peak of over 46,000 t·year^{-1} in 1984 before decreasing to less than 20,000 t·year^{-1} by the late 2000s. Shrimp landed prior to 1958, when trawlers began operating, were assumed to have been caught by the artisanal fishery sector (see below).

Shrimp discards

The shrimp trawl fishery produced high quantities of discards from 1950-2010; however, in a country where poultry is the primary source of protein, retained by-catch landings were larger as they are used for the production of fishmeal. Total discards by the shrimp fishery amounted to over 1.9 million tonnes from 1950-2010 and retained by-catch totaled about 5.2 million tonnes for the same time period (Figure 4). In the early stages of the fishery, discards were approximately 21,700 t·year^{-1} and increased to a peak of 87,200 t·year^{-1} in 1964, as a result of almost a doubling of shrimp catch in that year. Discards increased again gradually to a peak of almost 65,400 t·year^{-1} by 1984. Thereafter, the average discards from 1985-2010 were approximately 31,300 t·year^{-1}. The by-catch was low in 1958, with only about 7,000 t·year^{-1} retained, as there was little use for inedible species at this time. By 1973, retained by-catch increased to over 100,000 t·year^{-1}, and reached a peak of almost 200,000 t·year^{-1} in 1984. Retained by-catch remained consistently high until 2010.

The noticeably large increase in by-catch observed in 1964 is due to an increase in shrimp landings from 9,170 t in 1963 to 16,059 t in 1964, which magnified the estimated total by-catch once the shrimp to by-catch ratio was applied in 1964. This could also suggest a sudden and relatively rapid increase in fishing effort or capacity from 1963 to 1964.

Shark fisheries

The reconstructed catch of the elasmobranch fisheries was estimated to be over 5 million tonnes from 1950-2010 (Figure 2), while Pakistan reported to FAO 1,970,800 t for the same time period. Catches of sharks were relatively minor in 1950, with only 4,800 t·year^{-1} reported and no reported catches of rays. Reported landings gradually increase to 38,000 t·year^{-1} in 1968, once species of rays were reported, and

peaked in 1973 and again in 1983 (Figure 2). An observed decline in shark species has been observed from the mid-1980s to 2010.

Tuna fisheries

The total reconstructed domestic catch of tuna species amounted to over 1 million tonnes from 1950-2010 (Figure 5). The inshore artisanal fishery for tuna was estimated to be 108,280 t with about 125,730 t of unreported by-catch from 1950-2010 (Figure 5). The offshore (industrial) fishery was estimated to catch approximately 974,500 t of tuna, with over 3 million tonnes of unreported by-catch from 1950-2010 (Figure 5).

Artisanal fisheries

Total catch by the artisanal sector in Pakistan was estimated to be about 15 million tonnes from 1950-2010 (Figure 6). Catches contributed by the artisanal sector, excluding catch of small pelagics, amounted to over 4 million tonnes, with the unreported catch approximately 1.4 million tonnes from 1950-2010. The reported landings for small pelagics were over 3.1 million tonnes and the total unreported portion was estimated to be approximately 6.2 million tonnes, as catches for small pelagics were estimated to be two times larger than what was reported to the FAO on behalf of Pakistan from 1950-2010.

Total landings from the artisanal sector increased rapidly from 29,500 t·year^{-1} in 1950 to over 100,000 t·year^{-1} by 1953, as inshore fleets expanded and the fishery for small pelagics took shape. Catches decreased slightly from 1957-1963, and then subsequently increase in 1966 (Figure 6). Catch continued to increase gradually and reached an observed peak in 1993 (due to an increase in landings of small pelagic species, Figure 6). From 1994-2010 catches showed a steady but gradually declining trend to 310,200 t·year^{-1} by 2010.

Subsistence fisheries

Estimated total catch by the subsistence sector (only 'take home' catch of artisanal fishers) amounted to over 6.8 million tonnes from 1950-2010 (Figure 7). Subsistence fishers in the rural coastal regions were estimated to catch around 23,400 t in 1950. Catch steadily increased to 39,000 t·year^{-1} in 1992, thereafter, approximately 43,000 t·year^{-1} was caught from 1993-2010 (Figure 7). 'Take-home' catch from fishers in urban areas amounted to 29,750 t·year^{-1} in 1950. Catches increased steadily with an increasing urban coastal population and were estimated to be about 136,700 t·year^{-1} in 2010 (Figure 7). In should

be noted that this estimate for total subsistence catch remains conservative since reported landings were based on information collected from commercial sites and largely underestimates the amounts caught by fishers living in rural areas along the coastline, who are fishing exclusively for subsistence purposes.

Recreational fishery

The recreational sector contributed slightly over 8,000 t from 1950-2010 (Figure 8). Catches were approximately 160 t·year^{-1} in 1983, increasing to 277 t·year^{-1} in 1995. Catches then decreased gradually to 120 t·year^{-1} in 2010. Catch was dominated by five families and an 'others' category (Figure 8).

Foreign fisheries

Total catch by Taiwanese trawlers (1982-2010) and longliners (1992-2010) fishing in Pakistan's EEZ was estimated to be approximately 74,340 t, with approximately 28,800 t of discards associated with the fishery (Figure 9). During the time of the resource survey (1992-1993), approximately 47,300 t of tuna, specifically yellowfin, was caught.

South Korean trawlers operating in Pakistan's EEZ from 1982-2010, were estimated to catch approximately 71,700 t and an estimated 16,400 t of discards for the same time period (Figure 9). According to national data, North Korea only fished in Pakistan's EEZ in 1984, and was estimated to catch over 1,600 t and discarded approximately 600 t in the same year (Figure 9).

China contributed approximately 34,700 t to the total catch by foreign offshore ventures from 1998-2005 (Figure 9). The discards associated with these trawlers were estimated to be 6,950 t for the same time period.

Total reconstructed catch

The total reconstructed catch of Pakistan marine fisheries was estimated to be approximately 38 million tonnes from 1950-2010 (Figure 10a, Appendix A1). This total catch (including discards) by all sectors is 2.6 times the official landings of about 14.7 million tonnes reported by FAO on behalf of Pakistan for the same time period. The subsistence and artisanal sectors were found to contain substantial under-reported catches, as well as the discarding from the industrial shrimp trawlers. The artisanal sector contributed 37% to the total reconstructed catch from 1950-2010, with more than 7 million tonnes of unreported catch, primarily contributed by the tuna gillnet operations and small pelagics. The

unreported by-catch within this sector totaled to over 125,700 t. An estimate of catch for the subsistence fishery was included in the national data for some years. However, these are likely conservative estimates as they were collected from major landing centres only. The total contribution by this sector was estimated at 6.8 million tonnes, representing 18% of the total reconstructed catch from 1950-2010 Thus, small-scale fisheries (artisanal plus subsistence) accounted for 55% of total catches (Figure 10a).

The industrial sector represented 40% of the total reconstructed catch from 1950-2010 and was found to also have high unreported by-catch from the industrial shrimp and offshore tuna gillnet operations (over 7.5 million tonnes). Instances of misreporting of catch data and a lack of comprehensive system of data collection contributed to major discrepancies within the reported commercial catch data, as in the case of the elasmobranch and tuna gillnet fishery. Due to the high levels of by-catch retention for fish-meal production in Pakistan, industrial discards (including foreign operations) were relatively low and represented only 5% of the total reconstructed catch from 1950-2010 (Figure 10a).

The total reconstructed catch from 1950-2010 was dominated by nine families: Clupeidae, Scombridae, Ariidae, Carangidae, Sciaenidae, Carcharhinidae, Istiophoridae, Engraulidae and Penaeidae (Figure 10b, Appendix A2). Total catch from Pakistan's EEZ contributed by foreign distant water fleet, which were reported on behalf of Pakistan, was estimated to be approximately 182,400 t from 1982-2010 and about 52,700 t of discards estimated for the same time period.

Discussion

Pakistan's total reconstructed catch was estimated at 2.6 times the official landings reported by FAO on behalf of Pakistan for the 1950-2010 time period. Since a peak in landings in 1993, a decline in catch can is apparent in both reported landings as well as total catches (see Figure 10a). One should note that the peak of reconstructed catches in 1992-93 were driven by assumed unreported catches of small-pelagics (Clupeidae, Figure 10b), mainly derived from unreported artisanal catches (Figure 6). Due to the estimation method used for unreported artisanal catches, as applied here, this peak may represent a slight overestimate.

The reported data, while accounting for a portion of commercial catches of Pakistan's marine fisheries, fail to account for catches by the recreational and subsistence fishing sector, which very conservatively represents 21% of the total reconstructed catch from the same time period. The industrial sector contributed 41% to the total reconstructed catch and has generated over 7 million tonnes of unreported by-catch from 1950-2010. The total artisanal sector (i.e., all small scale commercial) represents 37% of the total reconstructed catch, which due to a lack of routine reporting at unofficial landing sites, contained substantial under-reported catches (about 7 million tonnes), including the fishery for small pelagics. There are also several cases of 'human error' that occurred while compiling data that were sent to the FAO. For example, the major discrepancies found within the landings data for elasmobranchs suggests that inadequate processes are in place to guard against loss of institutional memory and ensure clear documentation of methods of data analysis and collection.

An important issue that was also examined in this report was the poor taxonomic breakdown reported to the FAO. Particularly, the poor taxonomic reports from 1970 to mid-1980s, which is apparent in the large increase in the 'marine fishes nei' category. After applying a more accurate breakdown to the 'marine fishes nei' category, 55 taxa were identified to contribute to this category. The reported artisanal breakdown contained 44 FAO categories. However, after applying a more detailed taxonomic composition to the unreported artisanal and small pelagic catch, 80 different taxa were identified. The contribution of small pelagics to total catch has increased throughout our study period, while large pelagics such as sharks, billfish and tuna show a decreasing trend in the past 10 years. Major groups that contributed to the total reconstructed catch were small pelagics, specifically *Sardinella longiceps*, as well as *Arius* spp., carangids and species of tuna and sharks.

Small-scale tuna fisheries are well developed in many coastal countries of the Indian Ocean, and it is estimated that in the late 1980s, these fisheries landed 58% of the total world catch (UNEP 1986). The reconstructed catch for tuna species for Pakistan, including by-catch, represents 15% of the total

reconstructed catch from 1950-2010. This estimate is conservative and possibly a substantial underestimate, as there is known under-reporting by tuna gillnet and driftnet fisheries in the Indian Ocean (Fonteneau 2009; Le Roux 2011). However, to date no in-depth studies or estimates on this activity have been completed. In most cases, landing statistics collected by the IOTC lack accurate information on nominal catch and catch per unit effort for many important fleets, specifically Pakistan's gillnet and driftnet operations (IOTC 2009a).

The gillnet fishery is typically non-selective and the high quantities of by-catch associated with this fishery is an area of concern (Gillett 2011; Le Roux 2011; MRAG 2012). Effective management systems should be enforced to mitigate unwanted by-catch, and appropriate mechanisms (i.e., observer programmes) provided to give fishers incentives to reduce their by-catch (MRAG 2012). Pakistan's contribution to gillnet fisheries in the Indian Ocean ranks 13th overall, however, when shark catches were considered separately, Pakistan ranked fourth (MRAG 2012). The quality of data reporting for gillnet fisheries is poor in Pakistan, and available data are inconsistent (IOTC 2011). Pakistan needs to improve and standardize its data collection and reporting system and with the support of other governing agencies such as the IOTC, to engage with fishers to improve landing statistics and by-catch reporting.

Catch by foreign offshore trawlers and longliners were reported to the FAO on behalf of Pakistan from 1982-2010. To date, there are no notes in the official data to indicate what country was fishing in the EEZ or how the data were interpreted by FAO. Furthermore, estimates regarding the number of vessels in operation should be taken as a minimum. In comparison to domestic fisheries, foreign catch was not a significant contributor to the total reconstructed catch. However, it is known that vessels from neighboring countries are illegally fishing within Pakistan's waters. Indian fishers are violating international boundaries and poaching within Pakistan's EEZ, specifically offshore of the Indus Delta. From 1987-2008, there were approximately 660 Indian fishing boats arrested in Sindh province alone (Ganapathiraju 2010). We did not produce estimates for the illegal fish catch by Indian vessels. However, it is expected that the overall resource extraction could be substantial and more often this illegal activity is not an isolated case. Given that popular commercial species such as tuna, billfish and sharks and are shared resources with other neighboring countries (Khan 2011), it is likely that some illegal fishing is occurring undetected within Pakistan's EEZ.

In the early decades (1970-1980) there were high hopes that the fishing industry would contribute food and wealth to the people. The establishment of Pakistan's EEZ was expected to help the country better control its waters and allow for further assessment of unexploited resources. The goal was to develop its marine fisheries industry, as it would not only increase food production, but also generate employment, earn foreign exchange and bridge the protein gap (Ahmed 1985). Unfortunately, not much has changed

since the early 1980s. As the fishing industry began its expansion, the livelihoods of the fishing communities in the coastal areas was challenged by overexploitation of resources, poor handling techniques, an inefficient marketing system, and inaccessibility to markets (WWF 2005). There are currently about one million people engaged in the fishing sector in Pakistan and with no formal system of data collection or responsive and effective management in place, most fisheries remain essentially unmanaged and unregulated.

In a country with food security problems, there is a profound need to examine the utility of the fishing sector as a source of food and income. Pakistan has a high population growth rate, about 2.6 % annually from 1988-1998, which dropped to an estimated 1.8% in 2010.[12] According to the World Bank, 22.6% of the population lives below the poverty line and earns less than USD 1.25 per day. With an expanding population and beset by various socioeconomic and environmental problems, the country has been faced with a shortage of protein for human consumption. Catches made by the small-scale fishery sector, which historically have been marginalized (Pauly 2006), could be capable of supplying coastal and inland populations with valuable fish. Despite the known nutritional and health benefits gained from the consumption of fish by rural communities, a large portion of the catch in Pakistan is diverted into nonfood commodities, specifically fishmeal (Tacon and Metian 2009). In many cases, fish is improperly handled, resulting in poor quality, and rejection by consumers (Feidi 1995). This highlights the immediate need for improved quality control, proper handling and preservation practices during distribution and transportation.

Historically, data on landings have not been systematically and regularly collected. Pakistan's MFD should urgently initiate a consistent, reliable, transparent and clearly documented statistical data collection system, and regularly make and report estimates for non-monitored sectors to ensure comprehensive accounts of all fishing sector and components (Zeller *et al.* 2007; Khan 2012a). Other recommendations include making serious efforts to improve species identification, through improved port sampling and implementation of logbook systems, as well as, collecting catch and effort data routinely (IOTC 2009b). To date, very few long-term stock assessments have been completed for Pakistan's EEZ. Thus, accurate data on the status of pelagic and demersal stocks is limited (Siddiqi 1992). The reconstruction of Pakistan's catches reveals that without accounting for catches from all sectors, it is not possible to effectively understand how to manage the country's fisheries.

[12] http://data.worldbank.org/

Acknowledgments

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Tables:

Table 1. Total landings and gross value of catch in 2002 of the major fisheries in Pakistan (Khan 2006).

Fishery	Total landings (t)	Gross value of catch (US$ million)
Industrial shrimp	22,377	105.0
Commercial tuna	34,917	27.1
Industrial deep sea	4,270	3.8
Artisanal gillnet	270,893	327.0
Small pelagic	84,294	7.3
Total	416,751	470.2

Table 2. Percentage composition of unreported artisanal catch.

Taxon	1950-1970	1990	2000	2010
	% composition			
Ariidae	13	14	12	15
Brachyura	3	1	2	2
Carangidae	8	10	11	11
Carcharhinidae	20	10	8	2
Chirocentridae	1	1	1	1
Dasyatidae	4	3	3	1
Haemulidae	1	3	3	1
Lactariidae	2	3	3	2
Lethrinidae	2	3	3	2
Mugilidae	2	8	3	4
Rachycentridae	1	1	1	1
Sciaenidae	9	8	8	10
Scombridae	4	4	5	4
Sepiidae	3	2	3	5
Serranidae	2	4	5	6
Sparidae	6	4	5	2
Sphyraenidae	2	1	1	4
Stromateidae	2	3	2	2
Synodontidae	2	0	1	2
Trichiuridae	2	4	8	10
Others[a]	11	13	12	13
Total	100	100	100	100

[a] The 'others' category contains 'marine fishes nei' and an additional 14 families with minor contributions.

Table 3. The reported FAO taxonomic breakdown (1978-1982) used to account for 'partially recorded catches' (FAO 1989) and adjustment of the 'marine fishes nei' category (1983-1990).

FAO category	1978-1982	1983-1990
	% Composition	
Barracudas nei	1.1	0.4
Barramundi (giant seaperch)	0.7	0.2
Black pomfret	2.1	0.6
Carangids nei	3.9	2.3
Cobia	0.7	0.3
Croakers, drums nei	8.3	3.7
Dorab wolf-herring	3.6	0.3
False trevally	0.1	0.0
Fourfinger threadfin	0.6	0.1
Giant tiger prawn	0.1	0.0
Groupers nei	1.3	0.7
Grunts, sweetlips nei	1.7	1.3
Hairtails, scabbardfishes nei	0.2	0.1
Hilsa shad	3.0	0.5
Indian oil sardine	27.5	5.6
Jacks, crevalles nei	0.9	1.1
Largehead hairtail	1.3	0.8
Longtail tuna	4.1	1.2
Mangrove red snapper	1.3	0.3
Marine fishes nei	3.4	45.0
Marlins, sailfishes etc. nei	0.4	0.2
Metapenaeus shrimps nei	3.1	2.9
Mullets nei	3.6	0.6
Narrow-barred Spanish mackerel	3.4	2.4
Parapenaeopsis shrimps nei	6.9	3.4
Penaeus shrimps nei	3.3	2.1
Pike-congers nei	0.9	0.4
Porgies, seabreams nei	1.6	1.1
Sea catfishes nei	9.5	3.1
Sillago-whitings	0.2	0.1
Skipjack tuna	0.6	0.7
Tonguefishes	0.5	0.4
Tropical spiny lobsters nei	0.1	0.1
Others[a]	0.0	18.1
Total	100.0	100.0

[a] The 'others' group contains the remaining 27 FAO categories in which no changes to the species composition were made.

Table 4. Taxonomic composition of reported 'marine fishes nei' category.

Taxon	1970-1990	2000	2010
Alopiidae	6.0	6.0	2.0
Brachyura	3.0	3.0	3.0
Bramidae			
Taractichthys steindachneri	2.0	2.0	2.0
Carangidae	12.0	11.0	9.0
Coryphaenidae			
Coryphaena hippurus	2.0	2.0	2.0
Echinorhinidae	0.4	0.3	0.2
Gingymostomatidae	0.4	0.3	0.2
Lamnidae	8.0	6.0	4.0
Leiognathidae	9.0	6.0	6.0
Lethrinidae	5.0	2.0	2.0
Lutjanidae	6.0	9.0	9.0
Mugilidae			
Liza subviridis	2.0	4.0	4.0
Mullidae	2.0	2.0	2.0
Muraenesocidae	2.0	4.0	2.0
Palinuridae	4.0	4.0	2.0
Polynemidae	2.2	1.3	1.3
Scombridae	2.4	4.8	12.0
Sepiidae	3.0	5.0	6.0
Soleidae			
Solea elongata	1.0	2.0	2.0
Sphyrnidae	3.0	2.0	0.5
Stromateidae	2.0	2.0	2.0
Synodontidae	2.0	2.0	2.0
Triakidae	2.0	2.0	1.0
Trichiuridae	4.0	4.0	12.0
Others[a]	15.0	13.0	12.0
Total	100	100	100

[a] The 'others' category contains 28 taxa with lower percentages and 'marine fishes nei'.

Table 5. Species composition of the small pelagic catch.

Taxon	1950-1970	1990	2000	2010
	% composition			
Clupeidae				
Anodontostoma chacunda	1	3	3	4.0
Dussumieria acuta	1	3	3	4.0
Nematalosa nasus	1	3	3	4.0
Sardinella albella	1	3	3	4.0
Sardinella gibbosa	1	3	3	4.0
Sardinella longiceps	40	40	40	30.0
Sardinella sindensis	13	10	10	8.0
Spardinella fimbriata	1	3	3	4.0
Tenualosa ilisha	6	3	1	0.4
Tenualosa toli	4	1	1	0.2
Engraulidae				
Thryssa dussumieri	16	14	10	2.2
Thryssa mystax	16	14	10	2.2
Scombridae				
Rastelliger kanagurta	0	0	10	33.0
Total	100	100	100	100.0

Table 6. Species composition of subsistence catches (1950-2010).

Taxon	1950-1970	1990	2010
Ariidae	14	13	14
Brachyura	3	2	2
Carangidae	10	11	11
Chirocentridae	1	1	1
Clams nei	5	3	4
Coryphaenidae	1	1	1
Dasyatidae	4	4	2
Haemulidae	1	2	2
Latidae	1	1	1
Lethrinidae	2	1	2
Lutjanidae	1	6	8
Mullidae	1	1	1
Muraenesocidae	2	4	4
Myliobatidae	3	3	2
Penaeidae	4	4	2
Rhinobatidae	2	3	1
Sciaenidae	9	9	10
Scombridae	3	3	2
Sepiidae	5	3	3
Serranidae	2	2	3
Sparidae	10	6	4
Sphyraenidae	5	4	4
Stromateidae	2	3	3
Synodontidae	1	1	2
Trichiuridae	2	4	6
Others[a]	6	5	5
Total	100	100	100

[a] The 'others' category contains 'marine fishes nei' and 7 minor families.

Table 7. Derived taxonomic breakdown for recreational catches (1950-2010).

Taxon	1950-1983	1984	1995	2010
	Composition (%)			
Carangidae	4	4	3	6
Serranidae	30	35	23	26
Sparidae	8	8	5	6
Sphyraenidae	15	14	10	18
Marine fishes nei	8	8	10	14
Total	100	100	100	100

Table 8. Derived taxonomic composition of shrimp trawl by-catch and discards based on Shakir and Bano (1999).

Taxon	By-catch (%)	Discards (%)
Ariidae		
Arius thalassinus	3.0	3.0
Brachyura	0.0	1.0
Carangidae	13.0	13.0
Clupeidae	18.9	18.9
Dasyatidae		
Himantura uarnak	4.1	4.1
Engraulidae		
Thryssa malabarica	2.0	2.0
Harpadontidae		
Harpodon nehereus	1.8	1.8
Lactariidae		
Lactarius lactarius	5.0	5.0
Leiognathidae	7.0	6.0
Mugilidae	7.3	7.3
Mullidae		
Upeneus vittatus	4.3	4.3
Nemipteridae		
Nemipterus japonicus	1.9	1.9
Rhinobatidae		
Rhinobatos granulatus	3.2	3.2
Sciaenidae		
Otolithus ruber	9.8	9.8
Scombridae	7.0	7.0
Sillaginidae		
Sillago sihama	3.2	3.2
Soleidae	3.0	3.0
Sphyraenidae		
Sphyraena barracuda	0.3	0.3
Synodontidae		
Saurida tumbil	1.3	1.3
Terapontidae		
Terapon jarbua	3.8	3.8
Trichiuridae		
Lepturacanthus savala	0.1	0.1
Total	100.0	100.0

Table 9. Species composition of by-catch from the inshore and offshore gillnet tuna fishery (Khan 2012b).

Inshore		Offshore	
Taxon	**%**	**Taxon**	**%**
Alopiidae		Alopiidae	
Alopias superciliosus	3	*Alopias superciliosus*	15
Carangidae		Istiophoridae	
Scomberoides commersonianus	33	*Istiophorus platypterus*	13
Carcharhinidae	6	*Istiompax indica*	13
Corphaenidae		*Tetrapturus audax*	13
Coryphaena hippurus	12	Corphaenidae	
Dasytidae	2	*Coryphaena hippurus*	13
Istiophoridae		Lamnidae	
Istiophorus platypterus	11	*Isurus oxyrinchus*	15
Myliobatidae		Other Requiem sharks	14
Scombridae	2	Marine fishes nei	4
Scomberomorus commerson	12		
Sphyaenidae			
Sphyraena spp.	16		
Marine fishes nei	3		
Total	100		100

Figures:

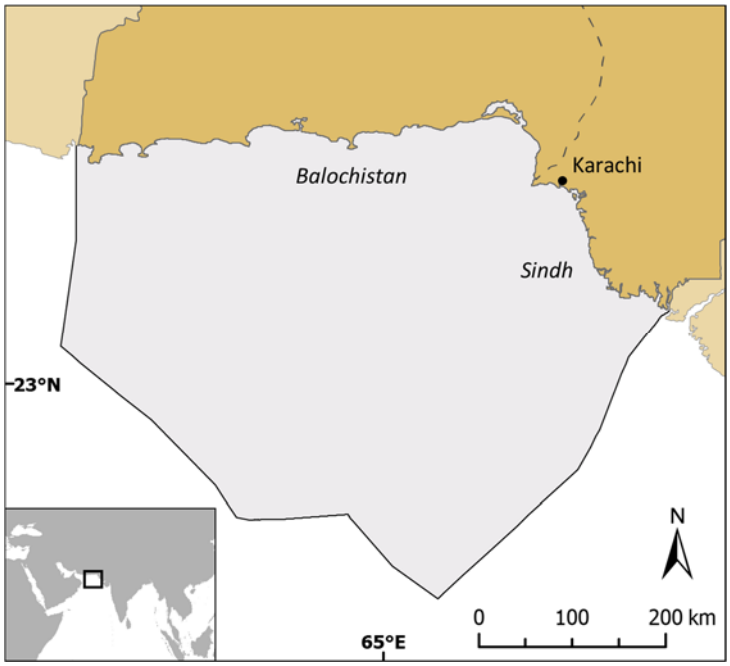

Figure 1. Map of Pakistan's coast and Exclusive Economic Zone (solid line).

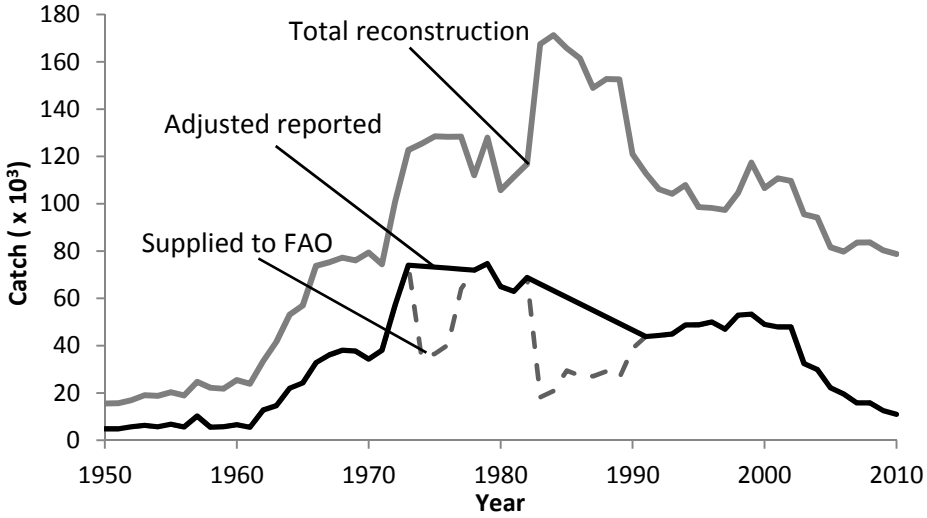

Figure 2. Reported and reconstructed landings of elasmobranchs in Pakistan from 1950-2010.

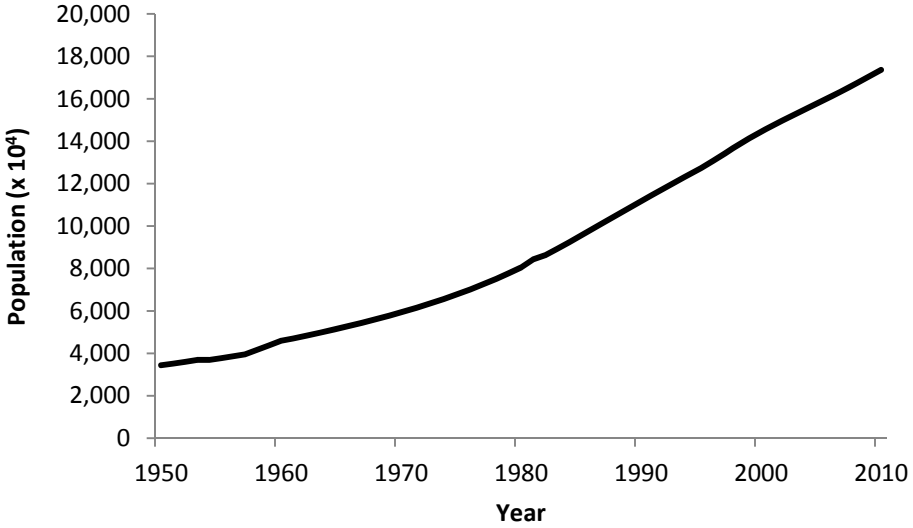

Figure 3. Human population data for Pakistan from 1950-2010.

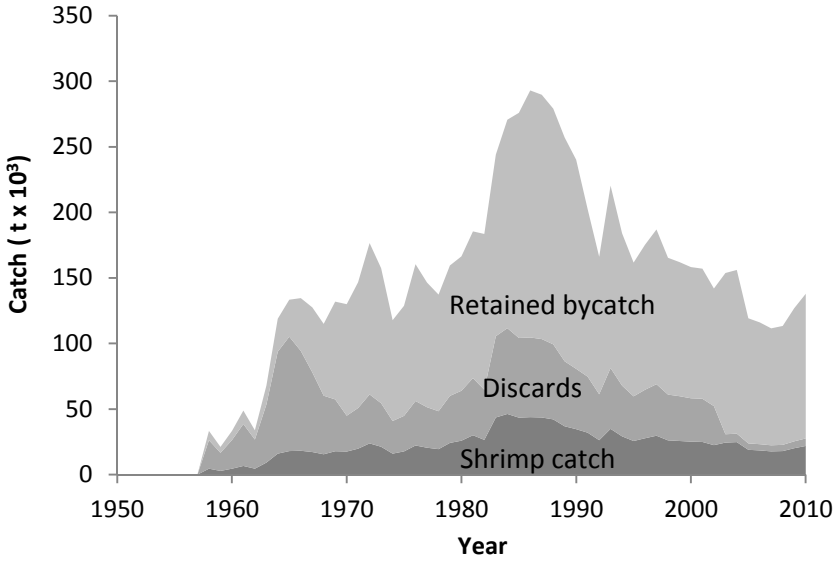

Figure 4. Total catch, discards and retained by-catch by industrial shrimp trawlers from 1950-2010.

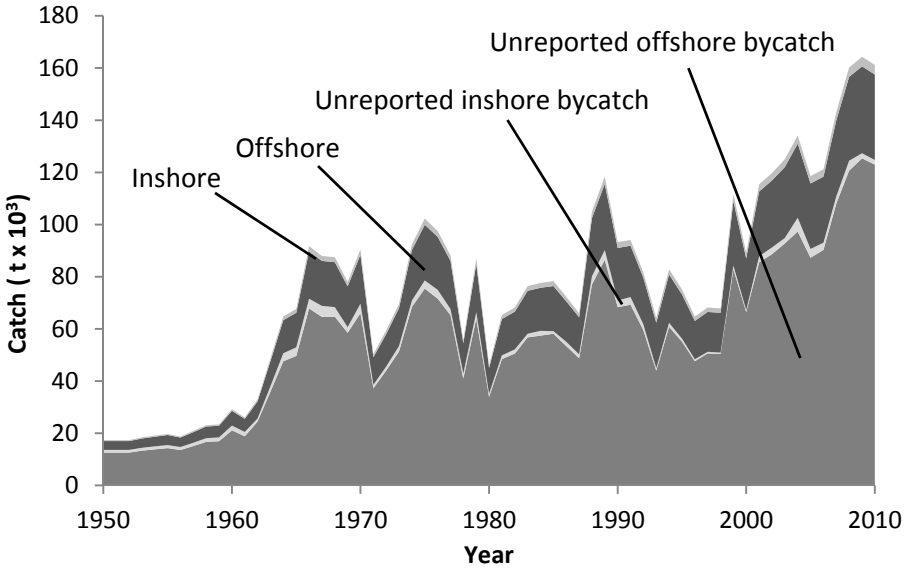

Figure 5. Total catch of tuna from the inshore (artisanal) and offshore (industrial) fishery, including unreported by-catch, from 1950-2010.

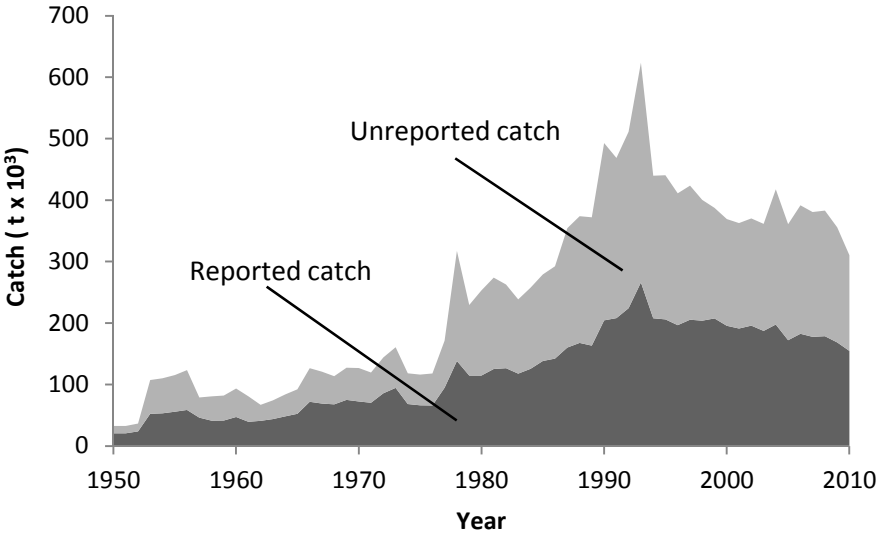

Figure 6. The reported and unreported catch (including reconstructed catch of small pelagics) of Pakistan's artisanal fishing sector (1950-2010).

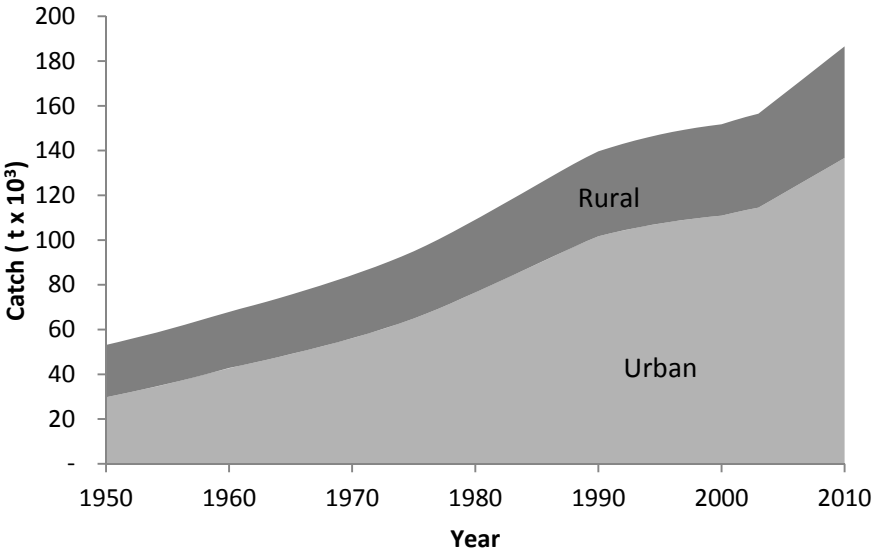

Figure 7. Estimated subsistence catch for Pakistan's rural and urban population from 1950-2010.

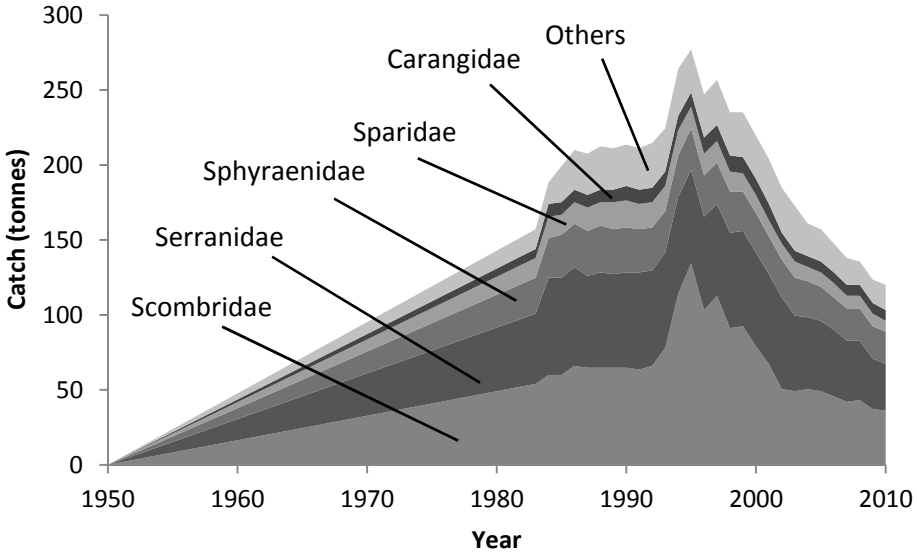

Figure 8. Pakistan's recreational catch by main taxa from 1950-2010. The 'others' category includes 'marine fishes nei'.

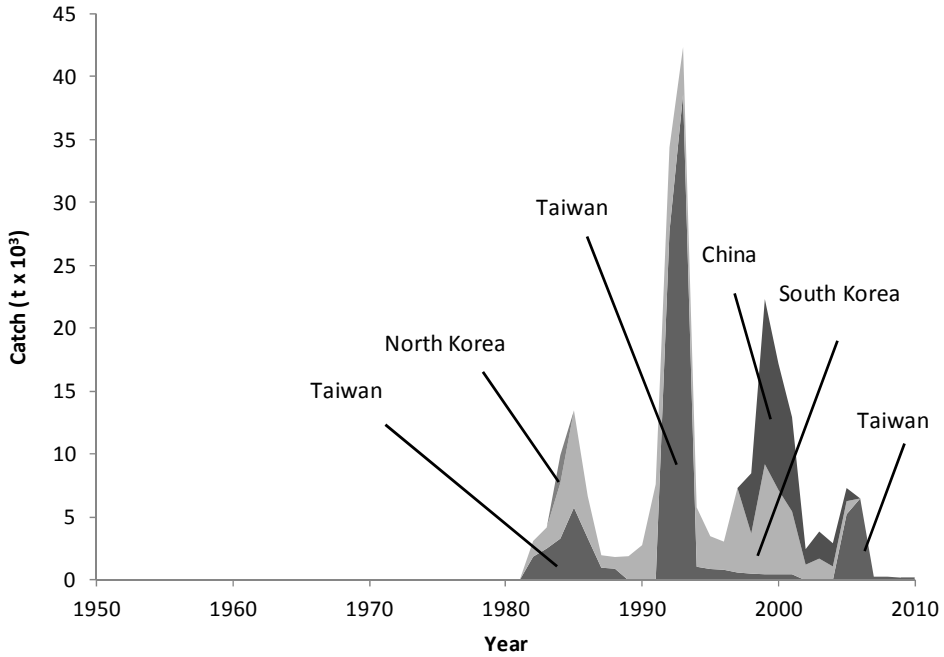

Figure 9. Total extractions (including discards) by foreign fleets operating in Pakistan's EEZ from 1982-2010.

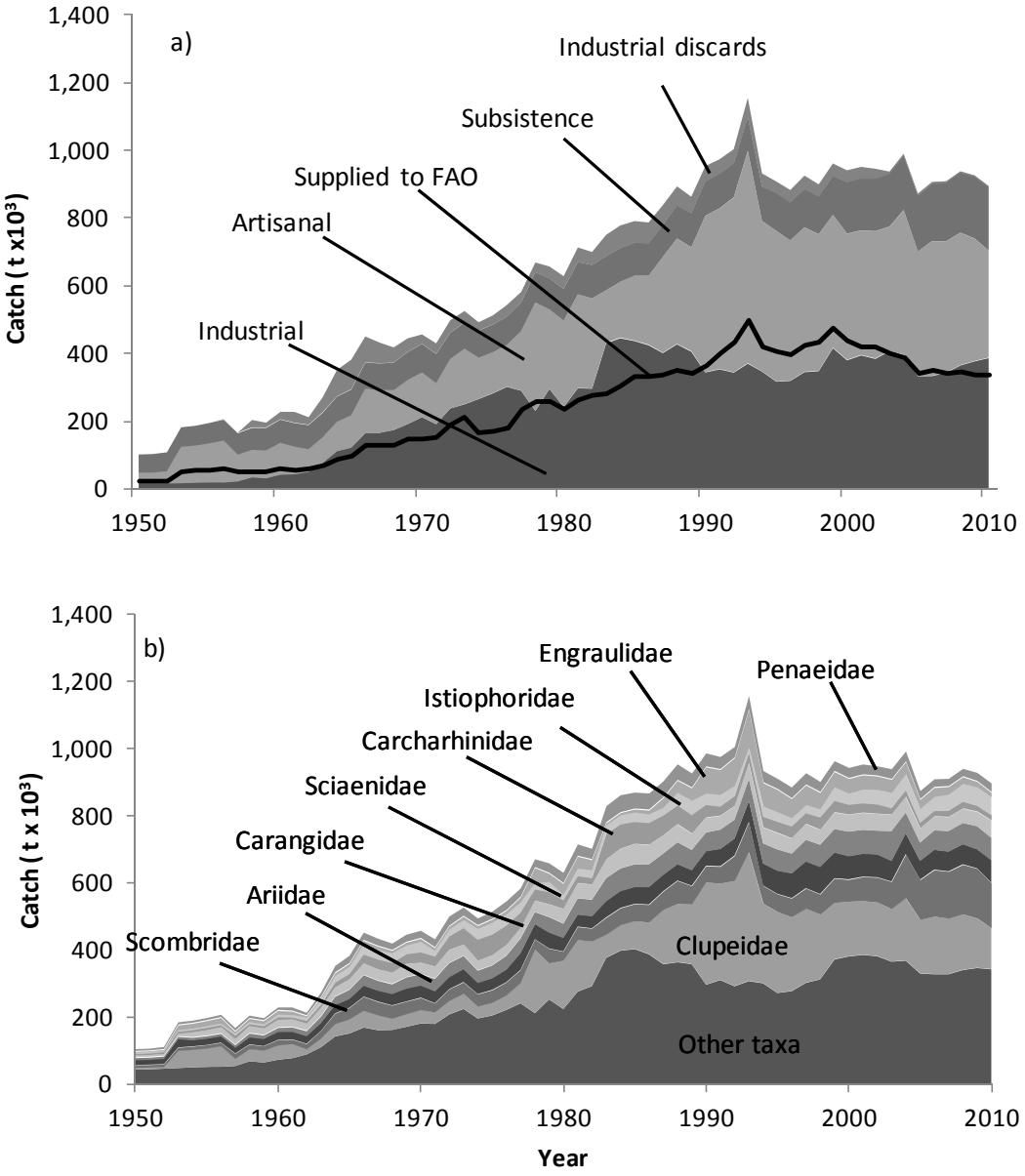

Figure 10. Total reconstructed catches for Pakistan's marine fisheries from 1950-2010, a) by sector plus discards, with data reported by FAO on behalf of Pakistan overlaid as line graph. Note that FAO data have been adjusted by exclusion of large pelagic (tuna) catches taken outside the EEZ in the Indian Ocean. Recreational catch is included but too low to be visible; and b) by major taxa, with the 'other taxa' category consisting of 51 additional families and a 'marine fishes nei' category.

References

Abildgaard NL and Khan W (1986) Production statistics of the small pelagic fish in Pakistan waters. Marine fisheries development project Karachi. 7 p.

ADB (2006) Proposed loan Islamic Republic of Pakistan: Sindh coastal community development project. Report and recommendation of the President to the Board of Directors, Asian Development Bank. 70 p.

Ahmed M (1985) Marine fisheries of Pakistan. Status Paper. Centre of Excellence in Marine Biology University of Karachi, Islamabad. 150 p.

Akhter N (1995) Sustainable fisheries. A Pakistan national conservation strategy sector paper, IUCN, Karachi. 31 p.

Anon (1977) General description of marine small-scale fishereis, Pakistan. Development of small-scale fisheries in the southwest Asia Working paper No. 4Colombo. 47 p.

Anon (1995) Report of the 6th expert consultation on Indian Ocean Tunas, Colombo, Sri Lanka, 25-29 September 1995. Indian Ocean Tuna Commision (IOTC), Colombo. 62 p.

Anon (2006) Proposed loan Islamic Republic of Pakistan: Sindh coastal community development project. Report and recommendation of the President to the Board of Directors, Asian Development Bank. 70 p.

Anon. (2009) Fishing trawlers' activities to be monitored closely. The News, Pakistan Available at: www.illegal-fishing.info/item_single.php?item=news&item_id=3710&approach_id= [Accessed: May 3, 2012].

Bonfil R (1994) Characterization of elasmobranch fisheries. Overview of world elasmobranch fisheries, FAO Fisheries technical paper No. 341, Rome. 119 p.

Campbell B and Alder J (2006) Fishmeal and fish oil: production and consumption. *In* Alder J and Pauly D (eds.), On the multiple uses of forage fish: from ecosystem to markets. Fisheries Centre Research Reports 14 (3). Univeristy of British Columbia, Fisheries Centre.

CIESIN (2012) National Aggregates of Geospatial Data Collection: Population, Landscape, And Climate Estimates, Version 3 (PLACE III). Center for International Earth Science Information Network (CIESIN)/Columbia University, Palisades, NY. Available at: http://sedac.ciesin.columbia.edu/data/set/nagdc-population-landscape-climate-estimates-v3. [Accessed: Nov 21, 2012].

CSF (2009) Action plan for the fish quality and value added at Karachi fisheries harbour. Competitive Support Fund (Pakistan), USAID, Ministry of Finance, Islamabad. 61 p.

Davies RWD, Cripps SJ, Nickson A and Porter G (2009) Defining and estimating global marine fisheries bycatch. Marine Policy 33: 661-672.

FAO (1977) General description of marine small-scale fisheries, Pakistan. Development of small-scale fisheries in Southwest Asia RAS/74/031, UNDP. 47 p.

FAO (1982) 1981 Fishery statistics catches and landings. FAO Yearbook 52, FAO, Rome. 38 p.

FAO (1989) Fishery statistics catches and landings. FAO Yearbook Vol. 68, FAO, Rome. 516 p.

FAO (2003) Information of the fisheries managment in the Islamic Republic of Pakistan. 15 p. Available at: http://www.fao.org/fi/oldsite/FCP/en/pak/body.htm [Accessed: 20 March 2012].

FAO (2007) Current status in capacity reduction and control of IUU fishing. APFIC regional consultative workshop, managing fishing capacity and IUU fishing in the Asian region. Phuket, Thailand, 13-15 June 2007, FAO, Bangkok. 11-12 p.

FAO (2009) The Islamic Republic of Pakistan. Fishery and aquaculture country profile, Food and Agriculture Organization of the United Nations, Rome. 18 p.

Feidi IH (1995) Proposed programme for small-scale fisheries development in Pakistan. FAO, Cairo. 29 p.

Folsom WB (1974) Fisheries of Pakistan, 1972. Foreign fisheries leaflet No. 74-1. US Department of Commerce, Washington, D.C. 22 p.

Fonteneau A (2009) On the statistical uncertainties of the Indian Ocean drift net fisheries? The Iranian case. Indian Ocean Tuna Commision (IOTC). 8 p.

Ganapathiraju P (2010) Illegal, Unreported and Unregulated marine fish catches in the Indian Exclusive Economic Zone, field report. Policy and ecosystem restoration in fisheries, Fisheries Centre, University of British Columbia, Vancouver. 30 p.

Garibaldi L (2002) Review of the fishery statistics collected by the FAO in the Asian region. Building awareness in aspects of fishery statistics, stock assessment and managment. Proceedings of the FAO/SEAFDEC regional workshop on use of statistics and other information for stock assessment Bangkok. 100 p.

Garibaldi L (2012) The FAO global capture database: a six-decade effort to catch the trend. Marine Policy 36: 760-768.

Gillett R (2011) Bycatch in small-scale tuna fisheries: a global study. FAO Fisheries and Aquaculture Technical Paper No. 560, Rome. 116 p.

Hayat M (2003) Fishing capacity and fisheries in Pakistan. pp. 121-126 *In* Pascoe S and Greboval D (eds.), Measuring capcity in Fisheries445. Food and Agriculture Organization of the United Nations, Rome.

Hussain AG, Burney MA, Mohiuddin SQ and Zupanovic S (1972) Analysis of demersal catches taken from the exploratory fishing off the coast of west Pakistan. pp. 61-84 *In* Indo-Pacific Fisheries Council Proceedings: Section III symposium on demeral fisheriesBangkok.

IOTC (2005) Information on shark finning fisheries. Report of the ninth session of Indian Ocean Tuna Commission (IOTC), Victoria, Seychelles, May 30th - June 3rd 2005, IOTC.

IOTC (2009a) Report of the sixth session of the working party on data collection and statistics. Indian Ocean Tuna Commision (IOTC). 34 p.

IOTC (2009b) Report of the twelfth session of the scientific committee. Victoria, Seychelles, 30 November-4 December. Indian Ocean Tuna Commission (IOTC). 190 p.

IOTC (2011) Executive summary: status of the Indian Ocean bigeye tuna (*Thunnus obesus*) resource. Scientific Committee, IOTC-2011-SC14-09, Indian Ocean Tuna Commision, Victoria, Seychelles. 1-9 p.

IPTP (1991) Tuna sampling programme in Karachi, Pakistan. Indo-Pacific Tuna Development and management progamme (IPTP), Colombo. 45 p.

IPTP (1992) Review of the national yellowfin tuna fisheries in the Indian Ocean. Report of the workshop on stock assessment of yellowfin tuna in the Indian Ocean, Indo-Pacific Tuna Development and Management Programme (IPTP), Colombo. 93 p.

Javaid MY, Naveed SA and Safdar MR (1975) Fisheries of Pakistan. Workshop on fish handling, plant sanitation, quality control and fish inspection. Bangkok,Thailand, 20 Oct 1975, FAO, Rome. 9 p.

Kelleher K (2005) Discards in the world's marine fisheries. An update. FAO Fisheries Techincal Paper, FAO, Rome. 131 p.

Khan MM (2011) Fisheries and shared recources of Pakistan. FAO workshop on the status of shared fisheries resources in the northern Arabian Sea- Iran (Islamic Republic of), Omen and Pakistan. Muscat. Oman. 13-15 December 2010, FAO Fisheries and Aquaculture Report No. 971, Karachi. 58 p.

Khan MM (2012a) Status of fisheries of neritic tuna in Pakistan. Second session of the working party on neritic tuna, Malaysia, 19-21 Novemeber 2012, Indian Ocean Tuna Commision (IOTC). 11 p.

Khan MM (2012b) Status report on bycatch of tuna gillnet operations in Pakistan. IOTC 8th session of the working party on ecosystems and bycatch (WPEB), Indian Ocean Tuna Commision (IOTC), WWF, Karachi. 12 p.

Khan MM (2012c) Tuna situation analysis-Pakistan. World Wildlife Fund (WWF), Karachi. 43 p.

Khan RS and Khan RS (2011) Fishery degredation in Pakistan: a poverty-environment nexus? Canadian Journal of Development Studies 32(1): 32-47.

Khan WM (2006) Country Review: Pakistan. pp. 281-296 *In* De Young C (ed.) Review of the state of world marine capture fisheries management: Indian Ocean. FAO Fisheries Technical Paper No. 488, Rome.

Kleisner K, Zeller D, Froese R and Pauly D (2012) Using global catch data for inferences on the world's marine fisheries. Fish and Fisheries: 19.

Le Roux S (2011) Océan Indien: des murs de filets maillants dérivants. Le Marin: 1-3.

Majid A (1995) Tuna production in Pakistan in recent years. Indian Ocean Tuna Commision (IOTC). 7 p. Available at: http://www.iotc.org/files/proceedings/1995/ec/IOTC-1995-EC601-20.pdf [Accessed: July 10 2012].

Maslam S (2010) Pakistan becomes an unwitting contributor to "shark finning". All Voices. Available at: http://www.allvoices.com/contributed-news/5590035-pakistan-becomes-an-unwitting-contributor-to-shark-finning [Accessed: June 22, 2012].

McCauley D and Shaikh A (2001) Environmental and natural resources management in South Asia: an assessment of issues and opportunitues. International Resources Group, Ltd. Region: Asia and the Near East Task order: South Asia Environmental Profile Technical area: Biodiversity Conservation, Washington, DC. 54 p.

MFD (1974) Handbook of fisheries statistics of Pakistan 19732. Survey and Statistics Section Marine Fisheries Department, Karachi.

MRAG (2012) A review of bycatch in the Indian Ocean gillnet tuna fleet focussing on India and Sri Lanka. ISSF Technical Report 2012-05, International Seafood Sustainability Foundation, Washington, D.C. 60 p.

Niaz S, M (2001) Status of fisheries and aquaculture in Pakistan. Proceedings of national seminar on strategic planning for fisheries and aquaculture to face the challenges of New Millennium, FAO, Karachi. 6-10 p.

Pauly D (2006) Major trends in small-scale marine fisheries, with emphasis on developing countries, and some implications for the social sciences. Maritime Studies 4(2): 7-22.

Pauly D, Belhabib D, Blomeyer R, Cheung W, Cisneros-Montemayor A, Copeland D, Harper S, Lam V, Mai Y, Le Manach F, Österblom H, Mok KM, van der Meer L, Sanz Antonio A, Shon S, Sumaila UR, Swartz W, Watson R, Zhai Y and Zeller D (2013) China's distant-water fisheries in the 21st century. Fish and Fisheries DOI: 10.1111/faf.12032

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

Pritchard M, Gordon A, Patterson G and Gray A (1996) Utilization of small pelagic fish species in Asia. Natural Resources Institute, Chatham, UK. 27 p.

Qureshi RM (1956) Shrimp fisheries of Pakistan. Ipfc proceedings 6th meeting FAO, Bangkok. 359-362 p.

Qureshi RM (1961) Pakistan's fisheries. Central Fisheries Department (Pakistan). Goverment of Pakistan Press, Karachi. 70 p.

Raza S, Qamar and Khan M, Wasim (2001) Avenues for imporving marine fish and handling. Proceedings of national seminar on strategic planning for fisheries and aquaculture to face the challenges of new millennium, FAO, Karachi. 40-70 p.

Riaz AM (2010) Ecology and by-catches of tuna with respect to the conservation and managment measures taken by government of Pakistan.22, IOTC. 10 p.

Sami MA (1994) Wild shrimps and shrimping in Pakistan territorial water. Economic Review: 8.

Shahid U (2012) An overview of shark fishing in Pakistan: interaction with tuna fisheries. Indian Ocean Tuna Commision (IOTC), WWF-Pakistan, Karachi. 25 p.

Shakir S and Bano A (1999) Bycatch utilization in Pakistan. pp. 179-190 *In* Clucas I and Teutscher F (eds.), Report and proceedings of FAO/DFID expert consultation on bycatch utilization in tropical fisheries, Beijing, China, 21-28 September 1998. FAO, Rome.

Siddiqi AH (1992) Fishery resources and development policy in Pakistan. GeoJournal 26(3): 395-411.

Tacon AGJ and Metian M (2009) Fishing for feed or fishing for food: increasing global competition for small pelagic forage fish. Ambio: A Journal of the Human Environment 38(6): 294-302.

UNEP (1986) Environmental problems of the marine and coastal area of Pakistan. National Report, UNEP Regional Seas Reports and Studies 77. 59 p.

Van Zalinge NP, Khaliluddin M and Khan W (1986) Draft report to the government of Pakistan on Pakistan's shimp fishery. FAO/UNDP Marine Fisheries Development Project, FAO, Karachi. 65 p.

Vannuccini S (1999) Shark utilization, marketing and trade. FAO fisheries technical paper No. 389, Rome. 470 p.

Watson R, Sumaila R and Zeller D (2011) How much fish is being extracted from the oceans and what is it worth? pp. 55-71 *In* Christensen V and Maclean J (eds.), Ecosystem Approaches to Fisheries: A Global Perspective. Cambridge University Press, Cambridge.

Wijeratna A (2007) Taking the fish-fishing communities lose out to big trawlers in Pakistan. Actionaid International. Available at: www.actionaid.org [Accessed: 30 January 2012].

WRI (1987) World resources 1987: An assessment of the resource base that supports the global economy. International Institute for Environmental and Development and World Resources Institute (WRI), New York. 369 p.

WWF (2005) Study on value added to the catch of fisher folk (fisheries development for sustainable livelihood). World Wide Fund for Nature, Karachi. 35 p.

Zeller D, Booth A and Pauly D (2006) Fisheries contributions to GDP: understanding small-scale fisheries in the Pacific. Marine Resource Economics 21: 21.

Zeller D, Booth S, Davis G and Pauly D (2007) Re-estimation of small-scale fisheries catches for U.S. flag island areas in the Western Pacific: the last 50 years. Fisheries Bulletin 105: 266-277.

Zupanovic S and Mohiuddin SQ (1973) A survey of the fishery resources in the northeastern part of the Arabian Sea. Journal of Marine Biologists Association of India 15(2): 496-537.

Appendices

Appendix Table A1: FAO landings vs. total reconstructed catch (in tonnes), also by sectors for Pakistan's marine fisheries 1950-2010.

Year	FAO landings	Reconstructed catch	Industrial	Artisanal	Subsistence	Recreational	Discards
1950	20,500	102,987	20,652	29,188	53,146	0	0
1951	20,500	104,288	20,652	29,188	54,443	5	0
1952	23,600	109,628	21,552	32,288	55,778	10	0
1953	52,300	182,824	23,067	102,591	57,152	14	0
1954	53,200	187,627	23,076	105,964	58,567	19	0
1955	56,500	195,775	25,119	110,609	60,023	24	0
1956	60,100	205,380	23,981	119,848	61,523	29	0
1957	49,000	165,584	31,241	71,244	63,066	33	0
1958	48,900	203,087	38,781	77,840	64,654	38	21,774
1959	48,453	195,163	36,000	79,026	66,289	43	13,805
1960	57,613	227,309	46,963	90,484	67,978	48	21,837
1961	53,800	227,318	47,517	78,416	69,397	52	31,935
1962	58,977	211,504	54,855	63,574	70,872	57	22,146
1963	69,770	270,796	82,308	71,656	72,399	62	44,370
1964	85,859	351,264	119,514	80,004	73,976	67	77,703
1965	96,024	381,221	130,903	87,435	75,601	71	87,211
1966	128,797	450,063	179,267	117,361	77,238	76	76,121
1967	126,732	432,017	181,675	110,545	78,926	81	60,790
1968	128,734	417,909	189,035	103,505	80,666	86	44,618
1969	145,124	444,439	205,570	116,812	82,454	91	39,513
1970	147,270	456,015	226,394	117,801	84,292	95	27,432
1971	150,322	430,092	204,701	108,077	86,266	100	30,949
1972	190,768	498,336	255,430	128,965	76,570	105	37,266
1973	209,485	525,372	270,493	143,586	77,950	110	33,233
1974	163,532	492,450	274,587	113,547	79,361	114	24,841
1975	168,074	512,707	291,524	112,501	81,395	119	27,167
1976	177,448	543,338	310,283	115,297	83,767	124	33,866
1977	235,436	581,942	303,350	162,585	84,967	129	30,912
1978	258,028	668,951	242,424	308,482	88,946	133	28,965
1979	259,737	657,205	309,088	220,716	91,434	138	35,829
1980	232,991	628,564	251,364	245,624	93,405	143	38,028
1981	261,539	713,558	304,847	269,586	95,412	148	43,565
1982	278,149	700,276	302,582	259,860	98,690	152	38,991
1983	283,043	751,038	428,519	231,344	101,090	157	66,250
1984	302,551	778,571	443,398	249,435	99,198	188	67,948
1985	333,316	791,292	438,051	268,148	97,312	199	64,287
1986	331,739	787,527	424,656	282,482	95,403	210	62,440
1987	336,105	838,773	402,709	345,140	93,478	208	60,129
1988	348,897	894,125	430,128	366,998	97,362	212	57,537
1989	341,222	863,549	408,145	365,670	100,717	211	49,831
1990	365,878	954,175	351,288	485,273	101,536	214	46,511
1991	399,590	974,365	365,111	462,853	102,300	211	43,889
1992	431,267	1,003,963	355,736	504,157	99,833	215	44,021
1993	499,159	1,155,782	382,839	614,667	99,990	224	58,062
1994	418,574	932,181	360,111	430,712	101,234	264	39,860
1995	404,444	908,846	330,938	430,154	112,727	277	34,750
1996	395,397	883,298	334,154	399,140	112,229	247	37,528
1997	422,265	925,719	358,901	412,991	112,879	257	40,692
1998	433,456	899,881	363,447	388,168	111,720	235	36,311
1999	474,665	961,747	430,161	378,489	114,932	235	37,930
2000	437,601	941,505	392,859	360,619	151,734	220	36,073
2001	420,698	952,003	406,135	357,072	153,482	204	35,110
2002	418,104	946,252	395,864	365,000	155,068	185	30,135
2003	399,040	937,729	414,827	359,246	156,492	173	6,992
2004	386,653	990,463	403,825	418,758	160,787	161	6,933
2005	340,206	872,641	338,907	361,730	165,083	157	6,763
2006	349,421	907,500	338,910	392,417	169,378	148	6,648
2007	340,056	909,147	347,756	382,893	173,674	138	4,687
2008	343,414	938,865	369,485	386,512	177,969	136	4,764
2009	334,007	926,831	379,759	359,385	182,265	124	5,298
2010	337,916	895,648	388,631	314,585	186,560	120	5,752

Appendix Table A2: Total reconstructed catch (tonnes) for Pakistan (1950-2010) by major taxa. 'Others' category includes 'marine fishes nei' and 51 additional taxa.

Year	Clupeidae	Scombridae	Ariidae	Carangidae	Scianenidae	Carcharhinidae	Istiophoridae	Engraulidae	Others
1950	6,609	7,679	16,065	6,299	5,354	6,069	5,889	1,792	47,230
1951	6,614	7,720	16,247	6,428	5,471	6,069	5,889	1,787	48,064
1952	6,620	7,798	17,650	6,631	5,672	7,149	5,889	1,781	50,438
1953	51,579	9,320	26,278	7,124	6,166	8,571	6,229	13,821	53,736
1954	53,517	9,616	19,704	7,301	14,112	8,014	6,455	14,283	54,623
1955	56,169	9,926	19,975	7,507	15,090	9,218	6,682	14,931	56,277
1956	62,858	9,554	20,172	7,617	17,316	7,999	6,342	16,642	56,879
1957	22,553	15,131	18,594	7,963	14,898	12,915	7,078	5,947	60,505
1958	37,379	13,364	22,186	11,668	19,605	7,821	7,814	9,171	74,077
1959	37,090	12,749	22,487	10,415	18,674	8,002	7,928	9,295	68,524
1960	43,635	15,694	24,894	12,201	21,960	9,217	9,888	10,729	79,092
1961	43,195	12,962	23,917	13,771	21,148	7,525	8,829	10,279	85,692
1962	17,059	15,274	23,874	15,040	20,428	9,836	11,454	3,769	94,770
1963	26,520	22,531	24,217	19,550	23,468	11,085	16,841	5,554	121,031
1964	37,611	31,355	25,340	25,295	26,217	15,304	22,267	7,429	160,447
1965	42,773	33,412	27,194	27,301	29,704	17,546	23,228	8,454	171,608
1966	50,506	41,166	33,681	31,422	33,555	27,667	31,724	10,703	189,640
1967	45,245	39,608	33,603	29,650	32,540	30,808	30,219	9,760	180,585
1968	34,070	39,036	34,825	28,970	32,759	30,885	30,255	7,355	179,754
1969	38,162	37,138	39,355	33,428	38,491	30,328	27,366	8,496	191,674
1970	40,465	35,809	37,437	33,693	33,334	31,752	32,789	9,369	201,367
1971	35,151	26,809	36,114	37,039	35,251	31,246	18,496	7,905	202,081
1972	40,213	34,739	36,502	42,168	37,705	41,641	21,862	8,948	234,557
1973	45,489	33,692	39,509	39,519	32,905	50,000	25,509	10,308	248,441
1974	36,244	36,076	34,348	36,638	28,186	64,329	33,997	8,214	214,419
1975	38,429	37,403	35,342	38,403	29,057	62,909	37,477	8,642	225,044
1976	43,247	38,634	37,874	41,792	31,445	58,457	35,557	9,591	246,741
1977	60,990	38,142	50,442	44,077	29,724	47,636	32,411	13,885	264,636
1978	189,399	30,281	45,457	36,337	33,096	35,175	20,348	44,580	234,279
1979	107,940	43,142	48,137	46,410	37,179	37,512	31,884	24,784	280,216
1980	144,402	26,502	41,175	42,312	43,149	27,465	16,939	33,220	253,400
1981	154,073	38,731	36,160	48,697	44,832	22,235	24,115	35,176	309,538
1982	133,372	38,041	36,722	49,824	44,279	20,055	25,161	30,251	322,570
1983	81,469	53,539	52,986	71,853	59,167	60,136	28,678	5,836	337,374
1984	90,379	54,247	55,089	71,414	62,199	56,468	28,889	6,430	353,456
1985	96,902	53,956	55,284	70,636	64,446	50,743	29,617	8,896	360,811
1986	108,473	55,997	56,785	71,408	61,869	49,564	27,400	11,231	344,801
1987	172,319	58,085	53,005	66,405	56,969	47,046	25,045	28,028	331,870
1988	184,256	70,762	52,536	68,470	55,990	45,018	39,269	35,815	342,010
1989	188,726	57,408	50,214	63,460	51,892	43,058	44,598	36,525	327,668
1990	310,780	49,631	45,627	57,768	45,369	32,604	35,331	77,951	299,114
1991	287,689	50,042	51,886	58,275	41,005	28,516	36,309	74,102	346,541
1992	312,925	73,353	50,580	55,913	40,264	29,985	32,291	82,881	325,769
1993	382,585	87,536	62,640	64,618	46,771	31,128	16,767	112,653	351,084
1994	237,437	52,564	65,718	60,894	47,286	32,637	32,572	69,289	333,783
1995	241,773	52,726	69,382	63,878	48,786	34,567	29,729	66,808	301,197
1996	220,937	55,257	74,046	59,361	44,892	36,693	25,890	57,181	309,040
1997	221,003	59,819	79,870	65,315	46,626	33,546	25,968	58,089	335,484
1998	194,023	59,577	80,635	66,810	44,324	37,885	25,983	48,558	342,085
1999	167,714	72,396	76,821	70,615	49,472	35,287	42,322	45,197	401,923
2000	162,860	64,894	69,227	73,728	50,657	30,726	33,787	44,453	411,173
2001	160,190	71,218	68,447	72,176	50,482	29,345	43,134	41,767	415,245
2002	160,192	73,705	68,404	70,972	50,505	29,109	44,680	40,200	408,485
2003	156,837	80,461	61,661	89,541	48,622	20,467	47,255	38,482	394,403
2004	185,965	129,603	62,362	62,695	46,742	20,257	49,323	35,937	397,579
2005	159,670	118,137	56,335	54,604	42,192	17,188	42,815	27,607	354,093
2006	171,435	138,410	59,274	58,547	41,381	17,184	43,239	26,918	351,112
2007	166,336	139,110	59,123	61,889	41,473	19,491	49,657	22,591	349,478
2008	165,703	147,516	60,272	63,945	42,691	21,318	55,000	19,821	362,597
2009	147,953	147,497	57,146	69,471	43,043	18,512	56,714	16,040	370,455
2010	122,319	134,613	66,880	67,493	51,045	16,892	55,780	12,102	368,524