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Reconstruction of marine fisheries statistics in the Egyptian Mediterranean Sea, 1950-2010

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ABSTRACT

We reconstruct marine fisheries catches for Egypt in the Mediterranean from 1950-2010 to account for catches that are omitted from official statistics. Annual landings statistics reported by the FAO under-estimate actual catches from Egypt's industrial and small-scale fisheries, while catches from recreational fishing and discarded fish are absent. This reconstruction quantifies unreported and under-reported catch from Egypt's Exclusive Economic Zone in the Mediterranean. Reconstructed total catch was 3.7 million t from 1950-2010, which is 1.9 times the 1.97 million t reported by FAO on behalf of Egypt for the same time period. The industrial sector accounted for 83% of under-reported catch. While the magnitude of under-reported catch has decreased steadily since the 1990s, there remains much uncertainty over how much fish is taken from Egypt's Mediterranean waters. Basic fisheries statistics are essential to obtain a comprehensive understanding of Egypt's fisheries in the Mediterranean and to guide future informed decision-making.

INTRODUCTION

Egypt is situated in the eastern corner of North Africa. The country is bordered by the Mediterranean Sea between Libya and the Gaza Strip, and the Red Sea north of Sudan. Fisheries play a minor role in Egypt's economy, making up less than 0.5% of Egypt's total GDP in 2008 (FAO 2010). Nonetheless, fishery products are important locally both as a source of affordable protein and as part of the traditional diet. Marine capture fisheries have a long history in Egypt, but their importance has decreased relative to freshwater fisheries and aquaculture, with the latter accounting for 74% of total fish production in Egypt in 2012 (GAFRD 2013). Egypt's Red Sea fisheries are documented, and their catch reconstructed in Tesfamichael and Mehanna (2012) and thus, this account deals only with Egypt's Mediterranean fisheries, i.e., within the part of its Exclusive Economic Zone (EEZ) identified in Figure 1.

Egypt's Mediterranean fisheries are multi-species and the bulk of the fleet is made up of wooden hulled boats that fish mainly in inshore waters. Most of the fish catch is sold and consumed locally, where the preference is for fresh fish over more expensive poultry and red meat (FAO 2010). About half of Egypt's population of 82 million is concentrated along the Nile delta on the Mediterranean coast¹. This growing population exerts pressure on fisheries not only through increased demand for fresh fish, but also through anthropogenic pollution that have negative impacts on the coastal and marine ecosystems in which fisheries are embedded.

Motorised fishing boats were first introduced to Egypt in 1930, when there were 30, most of them trawlers operating out of Alexandria. In the next 30 years this number increased rapidly so that by 1961 there were over 600 motorised boats (Faouzi 1930; Anon 1962). At the same time, Mediterranean Sea fish catches grew from contributing 13% of total fisheries catches (inland and marine) in 1928 to 58% in 1960 (El-Zarka and Koura 1965). Due to the continued and extensive growth of the fishing fleet, in 1992 the government issued a resolution that prohibited further granting of licenses for trawling in both the Red Sea and Mediterranean. Nonetheless, Egypt's fishing effort in the marine fisheries continued to grow, spurred by development oriented fisheries policies. Predictably, this led to the current poor status of the fish stocks along Egypt's Mediterranean coast, which are considered to be overfished (Alsayes *et al.* 2010; Charbel 2010). The situation is compounded by general scarcity of research on the biological (but see Abdel Razeq *et al.* 2006; Mahmoud *et al.* 2010a, 2010b) and socio-economic² aspects of Egypt's Mediterranean fisheries. Compiling reliable catch statistics is a first step towards understanding local fisheries, allowing sources of pressure to be identified and quantified, and trends in species abundance to be inferred.

¹ Wikipedia URL: http://en.wikipedia.org/wiki/Nile_Delta. Accessed 7 January 2015.

² See FAO (2014) for a general overview of socio-economics of Egyptian fisheries.

Background

The fishing grounds along the Egyptian Mediterranean coast are divided into four regions which are served by 9 fishing ports, most of which are located along the Nile River Delta. The continental shelf is narrow in the western region, toward Libya, where the productivity of the fisheries is generally low. The fishing ground most used by Egyptian vessels is the continental shelf off the Nile delta, which is flat, mostly muddy to sandy and suitable for trawling. Inshore fisheries are widespread along the coastline and dominated by artisanal fishers using small boats and a variety of gears including hand lines, long lines, gill nets, and trammel nets to target demersal and pelagic species.

Fisheries in the Eastern Mediterranean have been affected by two major events – the construction of the Suez Canal in 1869 and that of the Aswan High Dam in 1965. The Suez canal, which connects the Mediterranean, via the Red Sea, to the highly diverse Indo-Pacific marine fauna became a major route for species invasions, mainly from the Red Sea to the Mediterranean, and which are called ‘Lessepsian’, after the name of its architect, Ferdinand de Lesseps (Por 1978). These invasions, which were limited at first, have massively increased as global warming intensified, which drives fish and marine invertebrates away from the warming waters of the Red Sea (Cheung *et al.* 2013), and into the Mediterranean.

The construction of the Aswan High Dam, on the other hand, disturbed the flow of the Nile, preventing annual floods from transporting nutrients downstream to the coastal zone and into the Mediterranean Sea (Nixon 2004). This led from 1964 to a short-term decrease in primary productivity and subsequent decrease in fish catch (Nixon 2004), which may also have provided invasive species from the Red Sea a chance to thrive. The decline in fish catch was apparently overcome a decade later, by an increase in fishing effort and gains in fishing technology, and possibly by anthropogenic nutrients (Nixon 2003), all of which driven by population and economic growth in Egypt.

The main fishing gears used by larger boats in the Mediterranean are trawl nets, purse-seines, and longlines. The trawl fishery contributes about one third of total fish catch from the Mediterranean (Mehanna 2014), and trawl licenses comprised about 36% of total Egyptian vessel licenses in 2012, while longlines made up 40% and purse-seines 8%. Trammel and gill nets, which are mainly used by small boats (less than 15 m length overall) comprised the remaining 16% of vessel licenses (GAFRD 2013). Commercially important fish species caught by trawlers include red mullet (Mullidae), soles (Soleidae), porgies (Sparidae), hakes (Merlucciidae), lizardfish (Synodontidae), snappers (Lutjanidae), elasmobranchs and barracuda (*Sphyraena* spp.), as well as invertebrates (Mehanna 2014). Purse-seine vessels target mainly small pelagic fish species, notably sardinella (*Sardinella* spp.), a major species, comprising on average 15% of total landings in the period 1950 to 2010. Also important commercially are shrimp (Penaeidae), contributing 10% of total landings. There is also an important recreational fishery that is not monitored. Recreational fishing is widespread along the Mediterranean coast, but there is virtually no information about fishing effort and catch so the impact of this activity is unknown. Subsistence fishing is also carried out by many coastal households, and is depended on for meeting nutritional needs.

Fisheries management

Fisheries management in Egypt falls under the authority of the General Authority for Fish Resources Development (GAFRD), which is responsible for administering the Fisheries Act. The GAFRD also collects statistics and undertakes research. Fisheries statistics on landings and fishing fleets are collected but are inconsistent in terms of coverage and quality (FAO 2010), while statistics on fishing effort and socio-economic parameters are limited. Stock assessments of several species, including bogue (*Boops boops*) (Mehanna 2014), barracuda (*Sphyraena*) (Allam *et al.* 2005), and lizard fish (*Saurida undosquamis*) (Mahmoud *et al.* 2014) have been conducted in Egypt’s Mediterranean coast, but there is breadth for more comprehensive assessments to inform fisheries management.

The Fisheries Act mainly provides for the administration of fisheries resources in Egypt, but is insufficient as a tool for effective marine fisheries management (De Young 2006). The few regulations that pertain to fisheries management include temporal and spatial restrictions on trawling and a ban on issuing new trawl licenses. Aside from the weak regulatory framework, there is also a lack of capacity for enforcement such that marine fisheries in Egypt can essentially be considered as being unregulated. The consequence of this has been uncontrolled fishing effort, both by Egyptian fishers and illegal fishers from neighbouring countries (FAO 2004), which has contributed to the decline and overexploitation of fisheries resources in Egypt’s Mediterranean.

METHODS

Reported landings

Annual reported marine fisheries landings from 1950-2010 were extracted from FishStat³ and represent the reported baseline as used here. Catch statistics reported by the FAO were allocated to sector by species based primarily on the distribution from the Egyptian Red Sea marine fish catch reconstruction (Tesfamichael and Mehanna 2012). Here, a species that was caught by a certain gear type was allocated to the sector to which that gear was typically used (e.g., Bogue caught by trawl nets is allocated to the industrial sector). The fractions contributed by various species to the catch of artisanal, subsistence, and industrial fisheries are listed on Table 1, and the resulting proportion of total landings allocated to each of the three sectors on Table 2.

Egyptian fishing vessels are known to fish illegally in neighbouring Mediterranean countries, and therefore a portion of Egypt's reported landings will originate from outside its EEZ. In this reconstruction, we are concerned with quantifying domestic marine fisheries catch in Egypt's EEZ, and thus we had to account for potential over-reporting. Besides the Mediterranean, the FAO also reports Egyptian catch in the Atlantic. From 1950 to 2010, total Egyptian landings from fishing grounds in the Atlantic were 3.1% of total landings from the Egyptian Mediterranean. As we had no data on how much fish Egyptian fishers catch outside Egypt's EEZ in the Mediterranean, we assumed that the amount was at least equivalent to that caught in the Atlantic. Consequently 3.1% of annual reported landings from the industrial sector was reassigned as Egyptian catch in Mediterranean waters outside their own EEZ. We started this adjustment in 1990, the year Egyptian fishers in the Red Sea were reported to start their own expansion beyond their EEZ in search of more fish (Charbel 2010; Tesfamichael and Mehanna 2012).

Unreported catch

Unreported catches in Egypt originate from all sectors – industrial, artisanal, subsistence, and recreational fishing. We add unreported catch to reported landings to estimate total reconstructed marine fisheries catch in Egypt from 1950 to 2010.

Industrial catches

Landings from purse seines and trawlers are not fully reported in the Red Sea (Tesfamichael and Mehanna 2012), and it is reasonable to assume that the same situation exists in Egypt's Mediterranean fisheries. Landings of commercial fish from the Mediterranean Sea were available from national sources for the years 1958-1960 and 1962 (Faouzi 1930; Anon 1962; El-Zarka and Koura 1965), of which the amount taken by industrial vessels was derived by multiplying national landings statistics by the proportion of FAO reported landings allocated to the industrial sector (see Table 2). National industrial landings were higher than that reported by the FAO in the years for which we had national data, by 58%, 81%, 133%, and 3.4% in 1958, 1959, 1960, and 1962 respectively. The difference in industrial landings between national and FAO statistics was attributed to unreported catch. The data point in 1962 was treated as an outlier and omitted from the analysis. We assumed that the same level of under-reporting occurred from 1950-1958. In 2010 underreported catch was 70% that of reported catch in the Red Sea (Tesfamichael and Mehanna 2012). Due to lack of recent year data for the Mediterranean Sea, we used the Red Sea data as the anchor point for the proportion of unreported catch in 2010. Years with missing data were filled using interpolation.

Discards

A substantial amount of trawl catches are discarded and not landed. A review of fish discards in the Mediterranean suggested that about 14.7% to 26.6% (late 1990s-2000s) of total trawl catches in Egypt's Mediterranean waters were discarded (Tsagarakis *et al.* 2014). Shrimps are targeted by Egyptian trawlers and make up close to 25% of trawl catches in the Mediterranean (Alsayes *et al.* 2010). Shrimp trawlers are known to have particularly high discard rates that can range up to 96% of total catch, with a weighted average rate of 62.3% (Kelleher 2005). In 1950 the Egyptian trawl fishery was primarily for shrimp (Tesfamichael and Mehanna 2012); thus, we applied the shrimp trawl fishery average discard rate, 62.3%. We then assumed that discards gradually diminished through time as fishers started to retain more of the less valuable fish as more pricey, higher-trophic fish become scarcer. Discard rates were interpolated from 1950 to the second anchor point in 2000, which was set at a discard rate of 26.6%, and then held constant to 2010.

³ FAO. FIGIS. FishStat (Database). (Latest update: 31 Jan 2014) URL: <http://data.fao.org/ref/babf3346-ff2d-4e6c-9a40-ef6a50fcd422.html?version=1.0>. Accessed (22 Jan 2015).

Artisanal catches

Assuming that artisanal fishery characteristics in the Mediterranean Sea are similar to those in the Red Sea, unreported catch from artisanal fishers in the Red Sea was conservatively estimated at 10% of total catch (Tesfamichael and Mehanna 2012).

Subsistence catches

Subsistence fishing occurs throughout Egypt and an estimated 10-30% of this sector's catch is unreported (Tesfamichael and Mehanna 2012). Subsistence catches are primarily used to meet household nutritional needs and we assume that they are fully consumed locally. Thus, subsistence sector catch was estimated based on the fish consumption rate of Egypt's population living by Mediterranean coastal governorates. Per capita consumption in Egypt was 6.5 kg·person⁻¹·year⁻¹ in 1986 and 13.7 kg·person⁻¹·year⁻¹ in 2000 (Dawoud 2005), of which half of the increase in fish consumption since 1992 has been supplied by aquaculture (Dawoud 2005). We assumed that the portion of consumed fish that is of marine origin (as opposed to aquaculture and freshwater) is proportional to that of fish catch from marine sources in Egypt's total fisheries production. In the 1980s, Mediterranean sea catches made up 12% of Egypt's total fisheries catches, then dropped to 5.1% by 2008. In comparison, aquaculture production increased from 17% in the 1980s to 67.3% in 2008⁴. Thus, consumption of seafood was calculated by multiplying annual fish consumption by the proportion of fish from marine waters; yielded rates of 0.8 and 0.7 kg·person⁻¹·year⁻¹ in 1986 and 2000 respectively. We then linearly interpolated between these two anchor points to fill in missing data from 1950 to 2010.

Data on Egypt's population by governorate were available for 2006 and 2012; Mediterranean coastal population was approximated by summing the population of 8 governorates that border the Mediterranean- Alexandria, Beheira, Dakahlia, Damietta, North Sinai, and Port Said. Of these, Alexandria and Port Said had 100% urban rates, while at other governorates the urban rate ranged from 19% (Beheira) to 60% (North Sinai). We assumed that most urban dwellers likely do not participate in subsistence fishing as they have other sources of food; thus, we halved the population of Alexandria and Port Said. In 2006, the population on Egypt's Mediterranean coast was approximately 16.1 million. In the absence of earlier coastal population data, we estimated this parameter by multiplying Egypt's total population⁵ by the proportion that lived by the Mediterranean coast, which in 2006 was 22%. As we had no data on coastal population in 1950, we made the assumption that more people lived closer to the coast to be closer to the resource base. A coastal population rate 30% was thus assumed for 1950, and linearly decreased to the 2006 anchor point then maintained constant until 2010.

The total annual fish catch by subsistence fishers was then calculated by multiplying fish consumption rate by Mediterranean coastal population. From this quantity we subtracted subsistence landings to derive unreported subsistence fish catch. The quantity of unreported subsistence fish catch was then calculated by subtracting landed subsistence catch from that caught for consumption. From 2008 to 2010, total subsistence catch estimated by the fish consumption method was less than landed subsistence catch, implying zero unreported catch from the subsistence sector. As this was not realistic, we used the proportion of unreported subsistence catch in the Red Sea as the basis for our estimation. Unreported subsistence catch in the Red Sea made up 14%, 23%, and 27% of total reconstructed subsistence catch in 2008, 2009, and 2010 respectively. From 1950 to 2007 unreported subsistence catches averaged 59% of total reconstructed subsistence catch in Egypt's Red Sea and 60% in the Mediterranean. We thus assumed that unreported subsistence catch proportions in the Red Sea from 2008 to 2010 were of those in the Mediterranean, and applied the Red Sea rates to calculate unreported subsistence catch in the Mediterranean from 2008 to 2010.

Recreational catches

Recreational fishing is a traditional leisure past-time in coastal cities in Egypt. Fishing is shore- or boat- based and the catch is not sold. Recreational fishing is overseen by a set of regulations, among them the stipulation of a license and gear limitation. Nonetheless, the licensing system is apparently not enforced, and it is estimated that thousands of people along the Mediterranean participate in recreational fishing without a license⁶. The only data

⁴ Mehanna, S. Stock assessment of red mullet and hake in the Egyptian Mediterranean waters. PowerPoint presentation.

⁵ United Nations, The Demographic Profile of Egypt. URL: <http://www.escwa.un.org/popin/members/egypt.pdf>. Accessed 7 January 2015.

⁶ Transversal workshop on the monitoring recreational fisheries in the GFCM area. Palma de Majorca, Spain, 20-22 October 2010. URL: http://151.1.154.86/GfcmWebSite/SAC/2010/Recreational_Fisheries/ppt/ReviewRecreationalFisheriesMediterraneanCoastEgypt.pdf Accessed 12 December 2014

on this sector available to us were the number of recreational fishers in Egypt in 2003 and 2008, which were 3013 and 5,079 respectively (FAO 2004, 2010), and 5,349 recreational licenses in 2013 (GAFRD 2013). Further, about 3,500 people had recreational licenses along the Mediterranean coast in 2010⁵.

We assumed that recreational fishing started in 1968, after Egypt's war with Israel in 1967 (Tesfamichael and Mehanna 2012). We estimated the total number of recreational fishers through two methods. First, a global study on recreational fishing indicated that the participation rate in recreational fishing in Africa was 0.28%. Applying this rate to the Mediterranean coastal population resulted in an average of 34,000 recreational fishers annually from 1968-2010. Second, we assumed that the 3,500 licensed recreational fishers in 2010 represented 21% of total recreational fishers (Ünal *et al.* 2010), i.e., there were a total of 16,667 recreational fishers, representing less than 0.01% of Egypt's population by the Mediterranean coast in 2010. Due to lack of other data, we assumed that the number of recreational fishers in 1968 was half that in 2010 as fishing for leisure was likely still an emerging activity (fishing for food would have been more prevalent and is captured under subsistence fishing in this reconstruction). The proportion of recreational fishers between 1968 and 2010 was then linearly interpolated between the two anchor points. The first method yielded 21,000 recreational fishers in 1968 and 48,720 in 2010, while the second method resulted in 3,590 and 16,670 recreational fishers in 1968 and 2010 respectively. Given the lack of knowledge on the magnitude of recreational fishing in Egypt, we selected the more conservative method to estimate the total number of recreational fishers.

We assumed that recreational fishers fished at least twice per month for 10 months in a year. As recreational fisheries are not monitored there was a lack of Egyptian recreational catch data. We thus applied information from a study of recreational fisheries in the Çannakale Strait in Turkey, for which catch and effort data were available (Ünal *et al.* 2010). Since Turkey also borders the Mediterranean Sea, and recreational fishers in Egypt and Turkey use similar gears, we made the assumption that recreational fish catch in Turkey was a valid representation of that in Egypt. The survey of recreational fishers in Turkey found that 75% of all recreational fishers fished from shore and 25% from boats, catching 4.6 kg and 16.8 kg of fish per fishing day, respectively (Ünal *et al.* 2010). Weighting the fish catch by type of fishing resulted in an annual catch per unit effort (CPUE) of 153 kg-person-year⁻¹. Given the absence of CPUE data for earlier time periods, we set the catch rate in 1968 at 1.5 times the 2010 level on the assumption that fish were more abundant in the past.

Species composition

Trawling generates a high level of discards that includes finfish and invertebrates. In a series of bottom trawl surveys along the Mediterranean coast of Egypt (Alsayes *et al.* 2010), European hake (*Merluccius merluccius*), penaeid prawns (Penaeidae), sea breams and porgies (Sparidae) made up 21%, 19%, and 17% of total discards, respectively (Table 3). We applied this composition to break down discards from the industrial sector from 1950-2010.

Popular fishes that are targeted by recreational fishers in Egypt include groupers (*Epinephelus* spp.), kawakawa (*Euthynnus* spp.), Scombridae, and blue fish (*Pomatomus saltatrix*). A detailed breakdown of recreational catch in Egypt was based on that of shore and boat based recreational fishing in Turkey (Ünal *et al.* 2010). The final catch composition was calculated by weighting species composition of shore and boat catches by the proportion of recreational fishers who engaged in each type of fishing (Table 4). As we had no detailed information on the characteristics of recreational fishing in Egypt, we assumed a 50/50 split in the proportion of shore and boat based fishers.

RESULTS

Egypt's total reconstructed domestic catch in the Mediterranean summed to 3.7 million t from 1950-2010, which is 1.9 times the 1.97 million t reported by FAO on behalf of Egypt for the same time period. Reconstructed catches were on average 2.2 times that reported by the FAO on behalf of Egypt in the early 1950s and reached a maximum of 3.8 times in 1975. The unreported catch component declined through time and in the late 2000s, reconstructed catches were on average 1.5 times that of FAO data. Unreported catches were primarily from the industrial sector, where discards and under-reported landings made up 75% of the total from 1950 to 2010 (Figure 2). In comparison, the small-scale sector and recreational fisheries contributed 22% and 4% to total unreported catch from Egypt's Mediterranean Sea respectively. Reconstructed total catch averaged 41,000 t-year⁻¹ in the 1950s, peaked at 150,000 t in 1999, and has been about 120,000 t-year⁻¹ in the late 2000s. Industrial fishing contributed 71% to total reconstructed catch, of which 9% was attributed to fish discards. Subsistence catches made up 17% of

total reconstructed catch, while catch from artisanal fishers comprised 10% and that from recreational fishers was just under 2% (Figure 3a). Sardinella, at 15%, was the largest taxonomic group in total reconstructed catch, followed by shrimps at 9% (Figure 3b). Cuttlefish have remained constant in the catch, averaging 4% of total reconstructed catch from 1950-2010, while the contribution of mullets (Mugilidae) and Sparidae has increased from 5% and 6% in the 1950s respectively to 9% in the 2000s. On the other hand, 'other marine fishes' dropped from comprising 24% of reconstructed catch in the 1950s to 8% in the late 2000s (Figure 3b).

DISCUSSION

This reconstruction estimates Egypt's domestic marine fisheries catches in the Mediterranean Sea from 1950-2010. During this period Egypt reported 2 million t of marine fish to the FAO, whereas 3.7 million t was estimated by this reconstruction, which excludes 25,000 t of fish that were assumed to have been taken outside of Egypt's EEZ.

This reconstruction provided a first attempt at quantifying recreational fishing in the Egyptian Mediterranean, which is acknowledged to be widespread but unmonitored by authorities. Estimated catch from recreational fishing constituted just under 2% of total reconstructed catch and 4% of all unreported catch, and is likely an underestimate given the conservative approach we took. Nonetheless, putting a number on recreational catch may be the needed catalyst for better understanding and future management of this sector.

Egypt's fisheries in the Mediterranean were impacted by the construction of the Aswan Dam, which, when completed in 1965, blocked the flow of fertile floodwaters from the Nile to the coastal zone. Fish landings decreased by 40% in the first year from 1965 to 1966 and remained depressed until the late 1970s. Sardinella catches in particular declined sharply in the mid-1960s, both in quantity and proportionately out of total reconstructed catch (see Figure 3b), a trend that may be linked to reduced primary production from the blockage of floodwater (El-Mor *et al.* 2002). The downward trend in fish landings started to recover in the mid-1980s, a reversal that has been attributed to nutrient loading from anthropogenic sources such as fertilizers and sewage, a result of concentrated human population and agriculture along the Nile (Nixon 2003; Oczkowski *et al.* 2009).

Fish caught in the waters of European and northern African countries in the Mediterranean, including Egypt, are all classified by the FAO as coming from the same fishing area (Mediterranean and Black Sea, major fishing area 37) regardless of territorial waters. Egyptian fishing vessels and their crew have been detained for illegally fishing in neighbouring countries including Libya⁷, Tunisia⁸, and Turkey⁹. This suggests that the observed increase in fish landings commencing in the mid-1980s may be due in part to spatial expansion of Egyptian fishing vessels beyond their country's EEZ and not to higher fisheries productivity alone. In the Red Sea, stagnating fish catch and an excess of fishing boats by 1990 drove Egyptian fishers to encroach into the EEZ of neighbouring countries (De Young 2006), and a similar situation evolved in the Mediterranean (Charbel 2010). Although we have no data on the quantity of Egyptian landings that are taken from outside Egyptian waters in the Mediterranean, we accommodated potential over-reporting by assigning a portion of landings to other Mediterranean waters outside Egypt's EEZ. The point is that spatial expansion of Egypt's fishing fleet outside Egypt's EEZ may be masking a more severe fisheries decline in domestic waters. The fact that landings have decreased steadily from 2008 to 2012 (GAFRD 2013) may be a reflection of this scenario. Thus, Egyptian fisheries in the Mediterranean may be in worse shape than assumed, and will likely continue to degrade without diligent monitoring, management, and enforcement of fishing effort.

CONCLUSION

Fisheries play a small role in Egypt's economy but are significant locally as an integral part of traditional diet and for supporting food security. The current overexploited status of Egypt's Mediterranean fisheries is a result of

⁷ Anon, 2014. Libya releases 15 detained Egyptian fishermen. Daily News Egypt. 22 January 2014. URL: <http://www.thedailynewsegypt.com/?p=223792>. Accessed 7 January 2015.

⁸ Anon, 2012. Seven Egyptian fishermen detained off Tunisian coast. Egypt Independent. 8 October 2012. URL: <http://www.egyptindependent.com/news/seven-egyptian-fishermen-detained-tunisian-coast>. Accessed 7 January 2015.

⁹ Anon, 2010. Turkey detains 6 Egyptians for illegal fishing. Egypt Independent. 29 December 2010. URL: <http://www.egyptindependent.com/news/turkey-detains-6-egyptians-illegal-fishing>. Accessed 7 January 2015.

existing weak institution and out dated policies that are focussed on resource development rather than sustainable use and stock rebuilding. This has negatively impacted Egypt's fishers, who, since the 1990s, have felt compelled to encroach into the waters of neighbouring countries, where they fish illegally. Marine fisheries can no longer support the growing demand for fish from Egypt's population, and aquaculture now supplies the bulk of fish consumption needs. The rise in importance of aquaculture may detract from the needs of the marine fishery sector, but it is at this time that most attention is required to rethink marine fisheries management in Egypt. It is essential to secure the viability of the marine ecosystem in Egypt's EEZ.

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Table 1. Allocation of landings to fishing sector, by species. Species are allocated according to sector-specific gear type (e.g., species caught by trawl and purse-seine nets are allocated to the industrial sector), as derived from Tesfamichael and Mehanna (2012) and others.

Common name	Scientific name	Artisanal	Industrial	Subsistence
Meagre	<i>Argyrosomus regius</i>	0.00	0.00	1.00
European seabass	<i>Dicentrarchus labrax</i>	1.00	0.00	0.00
Red-eye round herring	<i>Etrumeus teres</i>	0.00	1.00	0.00
Bluefish	<i>Pomatomus saltatrix</i>	1.00	0.00	0.00
Little tunny(=Atl.black skipj	<i>Euthynnus alletteratus</i>	1.00	0.00	0.00
Tuna-like fishes nei	Scombrids	1.00	0.00	0.00
Red porgy	<i>Pagrus pagrus</i>	0.33	0.34	0.33
Natantian decapods nei	Shrimps and prawns	0.00	0.80	0.20
Mediterranean horse mackerel	<i>Trachurus mediterraneus</i>	0.01	0.87	0.13
Largehead hairtail	<i>Trichiurus lepturus</i>	0.00	1.00	0.00
Salema	<i>Sarpa salpa</i>	0.03	0.00	0.97
Mulletts nei	<i>Mugil</i> spp.	0.32	0.33	0.35
Marine crabs nei	Brachyura	0.41	0.00	0.59
Surmulletts(=Red mullets) nei	<i>Mullus barbatus barbatus</i>	0.00	1.00	0.00
Bogue	<i>Boops boops</i>	0.00	1.00	0.00
Gilthead seabream	<i>Sparus aurata</i>	0.33	0.34	0.33
Lizardfishes nei	Synodontidae	0.00	1.00	0.00
European anchovy	<i>Engraulis encrasicolus</i>	0.00	1.00	0.00
Sharks, rays, skates, etc.	Elasmobranchii	1.00	0.00	0.00
Groupers nei	Serranidae	1.00	0.00	0.00
Grey gurnard	<i>Eutrigla gurnardus</i>	0.00	1.00	0.00
Blue swimming crab	<i>Portunus pelagicus</i>	0.41	0.00	0.59
Sardinellas nei	<i>Sardinella</i> spp.	0.00	1.00	0.00
European hake	<i>Merluccius merluccius</i>	0.00	1.00	0.00
Barracudas nei	<i>Sphyraena</i>	0.00	0.50	0.50
Common sole	<i>Solea solea</i>	0.50	0.50	0.00
Flathead grey mullet	<i>Mugil cephalus</i>	0.00	0.00	1.00
Marine molluscs nei	Misc. marine molluscs	0.50	0.00	0.50
Cuttlefish, bobtail squids nei	Sepiida	0.00	0.92	0.08
Red sea mantis shrimp	Stomatopoda	0.00	0.57	0.43
Annular seabream	<i>Diplodus annularis</i>	0.32	0.33	0.35
Marine fishes nei	Misc. marine fishes	0.03	0.86	0.12
Silversides(=Sand smelts) nei	<i>Atherina boyeri</i>	1.00	0.00	0.00
Spinefeet(=Rabbitfishes) nei	Siganidae	0.00	0.75	0.25
Spotted seabass	<i>Dicentrarchus punctatus</i>	1.00	0.00	0.00
White seabream	<i>Diplodus sargus sargus</i>	0.32	0.33	0.35
Common dentex	<i>Dentex dentex</i>	0.03	0.00	0.97

Table 2. Proportion of landings allocated to sectors, 1950-2010.

Year	Artisanal	Industrial	Subsistence
1950	0.03	0.83	0.13
1951	0.03	0.84	0.13
1952	0.03	0.84	0.13
1953	0.04	0.81	0.15
1954	0.04	0.81	0.15
1955	0.04	0.81	0.15
1956	0.03	0.82	0.15
1957	0.03	0.82	0.15
1958	0.03	0.81	0.16
1959	0.03	0.81	0.16
1960	0.04	0.79	0.17
1961	0.04	0.79	0.17
1962	0.04	0.81	0.16
1963	0.04	0.81	0.16
1964	0.06	0.75	0.19
1965	0.07	0.77	0.16
1966	0.09	0.72	0.19
1967	0.08	0.69	0.23
1968	0.09	0.68	0.23
1969	0.11	0.65	0.24
1970	0.17	0.68	0.15
1971	0.14	0.73	0.13
1972	0.09	0.63	0.28
1973	0.10	0.57	0.33
1974	0.15	0.68	0.17
1975	0.17	0.70	0.13
1976	0.17	0.67	0.16
1977	0.16	0.72	0.12
1978	0.15	0.75	0.10
1979	0.11	0.78	0.11
1980	0.12	0.74	0.13
1981	0.11	0.79	0.10
1982	0.19	0.65	0.17
1983	0.14	0.70	0.17
1984	0.15	0.74	0.11
1985	0.09	0.78	0.13
1986	0.14	0.73	0.13
1987	0.13	0.76	0.11
1988	0.16	0.75	0.10
1989	0.19	0.70	0.11
1990	0.30	0.62	0.08
1991	0.21	0.67	0.11
1992	0.15	0.72	0.13
1993	0.15	0.73	0.12
1994	0.21	0.68	0.12
1995	0.20	0.67	0.13
1996	0.27	0.61	0.12
1997	0.21	0.68	0.11
1998	0.17	0.73	0.10
1999	0.17	0.73	0.10
2000	0.21	0.69	0.10
2001	0.24	0.63	0.12
2002	0.30	0.54	0.16
2003	0.32	0.52	0.16
2004	0.28	0.56	0.16
2005	0.26	0.60	0.14
2006	0.22	0.63	0.14
2007	0.19	0.67	0.14
2008	0.20	0.66	0.14
2009	0.22	0.62	0.17
2010	0.22	0.61	0.17

Table 3. Species composition (%) of discarded catch, 1950-2010.
Derived from Alsayes et al. (2010).

<i>Merluccius merluccius</i>	21.0
Penaeidae	19.0
Sparidae	17.0
<i>Mullus surmulatus</i>	9.4
<i>Sepia</i> spp.	7.1
<i>Gobius niger</i>	4.8
<i>Teropon puta</i>	4.1
<i>Bothus podas</i>	2.1
<i>Arisoma balearicum</i>	1.9
<i>Synodus saurus</i>	1.7
<i>Trigla cavillone</i>	1.6

Table 4. Species composition (%) of recreational catch, 1950-2010.
Derived from Ünal et al. (2010).

Sparidae	25.0
Pomatomidae	23.0
Centracanthidae	18.0
Scombridae	13.0
Carangidae	7.0
Triakidae	4.4
Rajidae	3.5
Moronidae	1.9
Octopodidae	1.1
Clupeidae	0.7
Mugilidae	0.7
Belonidae	0.6
Squatinae	0.5
Serranidae	0.4
Atherinidae	0.4
Triglidae	0.3
Scorpaenidae	0.1
Congridae	0.1
Scophthalmidae	0.1



Figure 1. The Exclusive Economic Zone (EEZ) and shelf area of Egypt Mediterranean

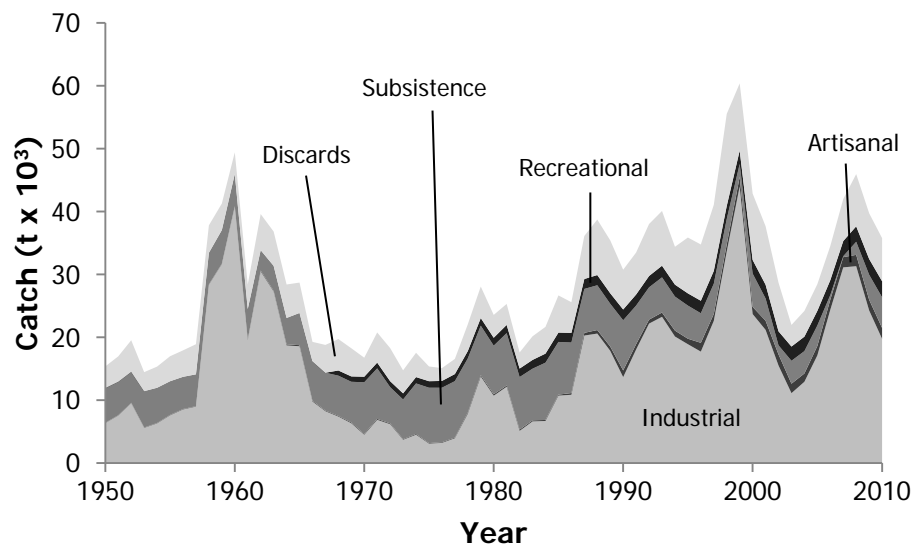


Figure 2. Unreported catch by sector, with discards shown separately for Egypt's Mediterranean from 1950-2010.

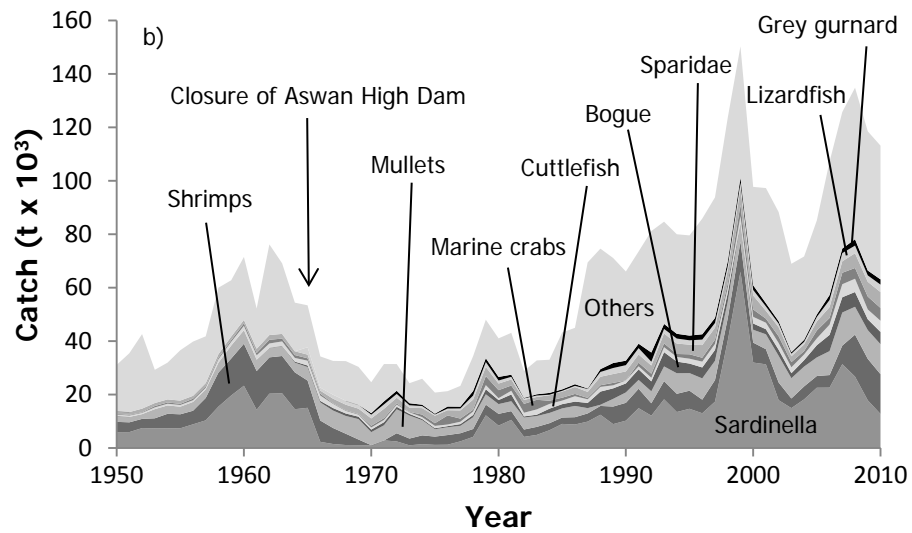
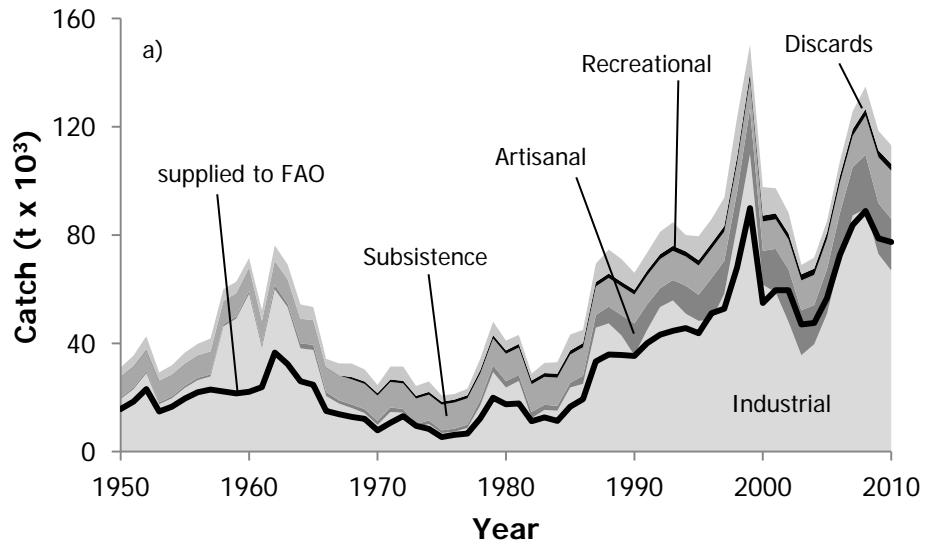


Figure 3. Reconstructed total catch for Egypt's Mediterranean for 1950 to 2010, by a) sector with official reported data overlaid as solid line; and b) by major taxa, with 'others' consisting of 40 other taxa. Note the decline of sardinella in response to the closure of the Aswan High Dam, which led to Lake Nasser beginning to fill in 1964 with Nile water and sediment, the latter thus ceasing to fertilize Egypt's coastal waters (see text).

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

Year	FAO landings	Reconstructed total catch	Industrial	Artisanal	Subsistence	Recreational	Discards
1950	15,700	31,073	19,400	558	7,660	0	3,410
1951	18,500	35,471	23,000	635	7,800	0	4,010
1952	23,100	42,628	28,900	764	7,930	0	4,990
1953	14,800	29,256	17,500	672	8,050	0	3,020
1954	16,600	31,940	19,700	694	8,170	0	3,360
1955	19,600	36,583	23,600	776	8,290	0	3,970
1956	21,900	39,818	26,400	812	8,400	0	4,200
1957	22,900	41,798	27,800	757	8,500	0	4,790
1958	22,200	60,000	46,200	794	8,600	0	4,360
1959	21,500	62,768	49,100	739	8,690	0	4,220
1960	22,100	71,499	58,200	1,048	8,780	0	3,430
1961	23,800	52,190	38,300	1,094	8,860	0	3,900
1962	36,600	76,189	59,900	1,566	8,940	0	5,740
1963	32,300	69,113	53,300	1,321	9,010	0	5,450
1964	26,000	54,394	38,200	1,849	9,080	0	5,320
1965	24,700	53,397	37,500	1,895	9,140	0	4,830
1966	15,000	34,271	20,600	1,444	9,200	0	3,080
1967	13,800	32,586	17,800	1,160	9,250	0	4,420
1968	12,800	32,518	16,100	1,289	9,300	825	5,000
1969	12,100	30,356	14,200	1,473	9,340	855	4,470
1970	7,858	24,610	9,900	1,441	9,380	885	3,020
1971	10,657	31,421	14,700	1,648	9,420	915	4,790
1972	13,129	31,413	14,400	1,357	9,450	945	5,260
1973	9,508	24,251	9,100	1,002	9,470	976	3,660
1974	8,379	25,912	10,200	1,390	9,500	1,006	3,860
1975	5,380	20,742	6,900	984	9,510	1,037	2,340
1976	6,176	21,275	7,300	1,164	9,640	1,080	2,040
1977	6,677	23,237	8,700	1,206	9,760	1,124	2,410
1978	12,260	34,328	17,000	1,990	9,880	1,169	4,250
1979	19,937	48,004	29,400	2,437	9,980	1,213	5,010
1980	17,470	41,027	23,700	2,391	10,080	1,258	3,630
1981	17,788	43,094	26,100	2,169	10,170	1,303	3,340
1982	11,232	28,820	12,400	2,290	10,260	1,349	2,560
1983	12,613	32,769	15,400	1,883	10,330	1,394	3,750
1984	11,365	33,026	15,100	1,819	10,400	1,440	4,260
1985	16,591	43,248	23,700	1,721	10,460	1,486	5,910
1986	19,384	44,963	25,000	3,020	10,520	1,531	4,880
1987	33,351	69,463	45,800	4,707	10,560	1,577	6,840
1988	35,883	74,605	47,400	6,179	10,610	1,623	8,820
1989	35,695	71,108	42,900	7,514	10,640	1,669	8,410
1990	35,310	66,052	35,600	11,778	10,670	1,715	6,320
1991	40,062	73,536	45,000	9,380	10,710	1,761	6,670
1992	43,169	81,181	53,400	6,972	10,750	1,806	8,260
1993	44,616	84,700	55,800	7,525	10,780	1,852	8,700
1994	45,600	79,991	50,900	10,335	10,800	1,897	6,020
1995	43,700	79,563	48,300	9,623	10,820	1,942	8,880
1996	51,100	85,853	48,700	15,411	10,840	1,987	8,940
1997	52,748	93,801	58,300	12,094	10,840	2,031	10,500
1998	68,000	123,512	83,400	12,576	10,850	2,075	14,630
1999	89,943	150,310	109,800	16,848	10,840	2,119	10,690
2000	54,872	97,722	61,700	12,510	10,840	2,163	10,550
2001	59,624	97,280	58,800	16,062	10,910	2,197	9,290
2002	59,619	88,293	47,900	19,445	10,990	2,232	7,730
2003	46,973	68,938	35,600	16,564	11,060	2,265	3,430
2004	47,481	71,673	39,700	14,504	11,130	2,299	4,090
2005	56,721	85,168	51,000	16,442	11,200	2,331	4,240
2006	72,666	107,180	70,400	17,773	11,260	2,364	5,430
2007	83,762	125,742	87,200	17,925	11,480	2,412	6,670
2008	88,882	134,825	89,700	19,880	14,510	2,460	8,300
2009	78,790	118,515	73,000	18,764	17,000	2,507	7,270
2010	77,388	113,154	66,900	19,107	17,760	2,553	6,860

Appendix Table A2. Reconstructed total catch (in tonnes) for Egypt's Mediterranean, by major taxa, 1950-2010. 'Others' contain 40 additional taxonomic categories.

Year	<i>Sardinellas</i> nei	Shrimps	Mullets	Bogue	Cuttlefish	Marine crabs nei	Sparidae	Lizardfishes nei	<i>Eutrigla</i> <i>gurnardus</i>	Others
1950	5,940	3,830	2,260	0	495	260	999	0	0	17,300
1951	5,950	3,660	2,040	0	486	234	1,073	0	0	22,000
1952	7,450	3,450	1,780	0	474	202	1,383	0	0	27,900
1953	7,350	3,770	3,420	0	652	509	1,129	0	0	12,400
1954	7,350	5,440	3,130	0	641	466	1,152	0	0	13,800
1955	7,380	5,240	2,850	0	632	425	1,222	0	0	18,800
1956	8,860	5,080	3,300	0	624	590	1,065	0	0	20,300
1957	10,350	8,390	3,210	0	622	574	1,160	0	0	17,500
1958	15,500	12,740	3,700	0	1,285	562	1,361	0	0	24,900
1959	19,660	13,840	4,850	0	1,396	597	1,379	0	0	21,000
1960	23,310	15,720	5,070	0	1,629	935	1,276	0	0	23,600
1961	14,290	14,510	4,240	0	1,643	876	1,563	0	0	15,100
1962	20,340	13,580	3,600	0	1,598	1,377	1,773	0	0	33,900
1963	20,470	13,960	3,830	0	1,621	1,055	1,761	0	0	26,400
1964	14,520	13,790	3,630	392	1,368	1,085	1,408	0	0	18,200
1965	15,050	10,190	5,050	594	1,802	898	1,366	2,772	0	15,700
1966	2,290	7,980	6,780	573	2,004	694	1,145	1,145	0	11,700
1967	1,490	5,990	6,540	933	1,554	215	1,732	1,492	0	12,600
1968	1,110	4,230	6,640	924	976	234	2,088	1,478	0	14,800
1969	1,080	2,090	7,640	902	766	237	2,006	1,443	0	14,200
1970	1,060	0	4,870	957	800	645	2,740	1,411	551	11,600
1971	2,840	0	5,670	1,140	869	667	3,489	1,645	1,131	14,000
1972	2,460	3,060	8,970	939	802	421	2,176	1,402	1,200	10,000
1973	1,010	2,530	8,600	634	602	162	1,557	903	755	7,500
1974	1,440	3,290	5,700	458	656	964	2,429	763	514	9,700
1975	1,170	3,100	2,760	380	872	996	2,811	453	295	7,900
1976	1,230	3,610	2,920	415	611	3,403	1,951	619	751	5,800
1977	2,490	3,030	2,770	652	888	1,176	3,064	725	667	7,800
1978	4,160	2,940	4,400	843	1,297	695	3,776	1,513	1,686	13,000
1979	12,230	3,990	3,880	1,868	1,560	3,370	3,447	1,823	1,421	14,400
1980	8,370	4,410	3,650	1,504	718	2,997	2,471	1,137	1,343	14,400
1981	10,530	3,260	3,710	2,522	1,385	1,970	2,269	986	792	15,700
1982	4,170	2,740	4,490	430	1,375	3,317	1,466	568	188	10,100
1983	4,900	3,010	4,040	519	1,974	3,598	1,063	535	465	12,700
1984	6,660	2,630	3,830	1,596	1,775	1,188	2,053	205	680	12,400
1985	9,010	2,380	3,430	1,591	1,328	1,095	2,280	278	549	21,300
1986	8,790	2,740	4,210	1,612	2,016	863	2,572	436	633	21,100
1987	9,880	3,060	1,980	1,948	1,364	520	2,248	1,083	185	47,200
1988	12,440	3,300	440	4,938	1,757	615	3,179	1,788	1,052	45,100
1989	8,940	6,580	2,870	3,936	1,132	920	3,318	2,249	1,859	39,300
1990	10,230	6,670	3,900	3,366	1,107	0	3,387	2,346	1,679	33,400
1991	14,910	7,270	3,310	3,955	1,134	1,350	3,075	2,379	1,655	34,500
1992	12,100	4,650	4,460	3,723	1,358	1,501	3,093	1,406	3,446	45,400
1993	18,220	6,820	5,490	5,343	1,858	1,424	3,721	1,679	1,883	38,300
1994	13,470	6,820	7,690	4,360	1,732	1,119	3,901	1,874	1,780	37,200
1995	14,680	6,770	6,580	3,570	1,828	1,644	3,609	1,631	1,758	37,500
1996	13,000	5,100	7,950	4,102	2,167	1,466	4,736	2,055	1,987	43,300
1997	17,340	8,080	7,190	4,080	2,254	1,609	4,467	1,755	1,891	45,100
1998	40,080	8,410	6,190	3,278	1,923	1,739	4,828	1,577	1,788	53,700
1999	65,990	11,220	7,210	0	2,369	4,154	6,356	1,938	1,933	49,100
2000	31,980	7,450	4,810	2,355	2,480	2,774	5,238	2,055	1,751	36,800
2001	31,310	5,670	5,570	1,910	2,418	1,536	2,940	1,621	1,216	43,100
2002	17,900	6,620	9,970	2,278	2,520	2,512	3,419	1,331	903	40,800
2003	14,930	3,610	7,580	1,872	2,208	1,939	2,178	981	551	33,100
2004	18,200	4,850	7,410	2,407	2,136	1,253	2,502	957	754	31,200
2005	22,560	4,390	6,960	4,577	2,543	2,961	3,392	1,675	922	35,200
2006	22,590	4,710	8,950	6,090	3,828	2,495	4,067	2,672	1,847	49,900
2007	31,380	6,950	12,370	5,715	4,877	4,294	4,289	3,064	1,716	51,100
2008	26,710	15,710	10,420	5,526	4,977	4,017	5,519	2,860	2,366	56,700
2009	17,850	15,520	10,750	4,062	3,668	4,824	5,525	2,397	1,814	52,100
2010	12,730	14,900	11,210	4,584	4,187	4,794	5,954	2,781	1,963	50,000