Introduction to the Red Sea ecosystem and its fisheries[1]

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Abstract

The Red Sea, characterized by a number of unique oceanographic and biological features, provided for humans for millennia, from the earliest record of human consumption of seafood to its current state as an important fishing ground for the seven countries along its shores. Contemporary fisheries need monitoring and management, and catch data are crucial for both. However, reliable time-series of catch data are lacking for most Red Sea Fisheries. Here, the catches of Red Sea fisheries are 'reconstructed' from 1950 to 2010 by country (i.e., Egypt, Sudan, Eritrea, Yemen, Saudi Arabia, Jordan and Israel) and sector (artisanal, subsistence, industrial and recreational), and in terms of their species composition. Historical documents, published and unpublished reports and other grey literature, databases, field surveys, anecdotal information, interviews, and information on processed seafood products were used as sources. When reliable data were available for a number of years, they were used as anchor points, and missing years were interpolated, based on assumptions of continuity, and given the best knowledge of the fisheries available. The reconstructed catches (which also include discards) were compared to the statistics submitted by the above-mentioned countries to the Food and Agricultural Organization (FAO) of the United Nations. Overall, the total Red Sea catch was low (around 50,000 t·year^{-1}) until 1960, increased to its peak (around 177,000 tonnes) in 1993, and is declining since. Overall, it was 1.5 times higher than the catch officially submitted to FAO by the countries bordering the Red Sea. Artisanal fisheries generally contributed about half of the total Red Sea catch, while the composition of the catch was extremely varied, with no single species or even family dominated. In addition to the national catch reconstructions, the local (Arabic) names of common commercial fishes and a brief reconstruction of the effort are also presented. The resulting catch trends provide crucial historical records and important guidance for the development of future fisheries management policies aiming at resource conservation and sustaining the livelihoods of the coastal communities.

Introduction

The Red Sea is an elongated narrow sea between Northeastern Africa and the Arabian Peninsula, ranging from 30°N to 12°30'N and from 32°E to 43°E with a length of 2,000 km and an average width of 208 km (Figure 1). The maximum width is 354 km in the southern part (Morcos 1970), and the total area is 4.51 x 10^5 km^2. The Red Sea is connected to the Indian Ocean in the south through the narrow strait of Bab al Mandab, the door of fortune. Bal al Mandab, which is only 29 km wide, has a sill 137 m below sea level, which limits the circulation of water between the Red Sea and the Gulf of Aden. The Red Sea is also connected to the Mediterranean Sea through the Suez Canal since its opening in 1869. The average depth of the Red Sea is 491 m, with a maximum of 2850 m. In the north, the Red Sea is divided into the Gulfs of Suez and Aqaba. The Gulf of Suez is generally wide, shallow and muddy, while the Gulf of Aqaba is narrow and deep.

Figure 1. The Red Sea and the surrounding countries, including their Exclusive Economic Zones (EEZs) and shelf areas.

Geological evolution

The Red Sea was formed by plate tectonics, i.e., by the African and Arabian plates drifting apart, and is part of a larger tear that includes the Dead Sea and the East African rift systems. Geologically, the Red Sea is a young ocean that is still growing or

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spreading (Braithwaite 1987). The zone was already structurally weak during the Pan-African orogeny 600 Ma. The separation of the Arabian and African plates is believed to have started in the Tertiary period, between the Eocene and Oligocene periods; it accelerated during the late Oligocene, with intense magmatic activity and the development of a continental rift (Makris and Rihm 1991). The Red Sea depression is believed to have been flooded by the Mediterranean as a result of extensive sinking in the early Miocene (Girdler and Southren 1987). Since its inception, the Red Sea went through a series of connections and disconnections with the Mediterranean in the North and the Indian Ocean in the south. At the end of Miocene, upheaval of land occurred and the Red Sea was disconnected from the Mediterranean to become a separated salty lake. At the beginning of the Pliocene, the Red Sea was reconnected with the Mediterranean, and for the first time, it was also connected with the Indian Ocean, but at the end of Pliocene, the northern connection with the Mediterranean was closed off due to crustal plate movement. The connection with the Indian Ocean was closed off during the Pleistocene, when the Red Sea again became an isolated sea. At the end of the Pleistocene, a glacial period, its connection with the Indian Ocean was re-established, whereas the connection with the Mediterranean remained closed until it was artificially opened via the Suez Canal in 1869 (Goren 1986; Getahun 1998). The Red Sea being young and still expanding is used as a case study to understand and explain plate tectonics, mid ocean ridges and formation of oceans.

Physical oceanography

The Red Sea area is generally arid, rainfall is very sparse with annual average ranging from 1 mm to 180 mm (Edwards 1987). Evaporation, with an annual average of 2 m (Morcos 1970), largely exceeds precipitation, and the deficiency is made up by the flow of water from the Indian Ocean through Bab al Mandab. In winter, warmer and less saline water flows into the Red Sea in the surface layer; while cooler and saltier water flows into the Gulf of Aden in the lower layer. In summer, there are three layers of water flow in the strait. In addition to the two flows of winter, warm water flows on the surface from the Red Sea to the Gulf of Aden (Smeed 2004). Sea and air temperatures are high in the Red Sea with mean annual sea surface temperature of 28°C. Additionally, the Red Sea is undergoing an intense and rapid increase in temperature, which is attributed to climate change (Raitsos *et al.* 2011). Another remarkable characteristics of the Red Sea is its high salinity, about 35 psu on average at the surface; readings as high as 40.5 psu are also reported. The high salinity of the Red Sea is due to the combination of its geological history and its location in dry and hot environment. Though originally the Red Sea depression was flooded with Mediterranean water, it soon started to become more saline due to high evaporation. Later during the glacial period, the Red Sea was an isolated salty lake with salinity higher than the present by a value of 10 psu. The highly saline water was diluted by water from Indian Ocean when the Red Sea was reconnected with the Indian Ocean (Thunell *et al.* 1988). However, it is still more saline than the Indian Ocean water due to high evaporation (Morcos 1970).

Biological oceanography and origin of the biota

The Red Sea is not very productive, mainly due to lack of nutrient-rich terrestrial run off; also, there is almost no upwelling to lift nutrient-rich deep water to the surface where photosynthesis can occur. Moreover, the vertical mixing of water is prevented by a permanent thermocline as the temperature of the sub-surface water is always lower than the warm surface temperature. The depth of the thermocline is deeper in winter than summer (Edwards 1987). Generally, the southern part of the Red Sea is more productive than the northern part due to the flow of nutrient rich water from the Indian Ocean, the main nutrient input, and the re-suspension of nutrients from the bottom sediments by turbulent mixing over shelf areas (Sheppard *et al.* 1992). The shallow Gulf of Suez is also productive and supports many exploited fish populations.

The high and relatively stable temperature of the Red Sea favours the formation of coral reefs, which are well developed in its northern part, starting from the tip of Sinai Peninsula. The longest continuous fringing reef in the Red Sea extends from Gubal, at the mouth of the Gulf of Suez, to Halaib, at the Egyptian border with Sudan (Pilcher and Alsuhaibany 2000). In the south, more patchy reefs are observed as the turbid waters of the shallow shelf prevent the formation of extensive reefs. Sanganeb Atoll, located in Sudan near the border with Egypt, is the only atoll in the Red Sea; it raises from 800 m depth to form a structure that has been recognized as regionally important conservation, and proposed to UNESCO as a World Heritage Site in the 1980s (Pilcher and Alsuhaibany 2000). Coral reefs recycle their nutrients, which enable them to maintain a high productivity, much like an oasis in a desert. They attract fisheries, mainly small-scale artisanal, and tourists.

The connections of the Red Sea with the Mediterranean in the north and the Indian Ocean in the south account for the kind of species that colonized it at different times. Though the Red Sea was first populated by Mediterranean species, its current biota resembles that of the Indian Ocean. When the Red Sea was disconnected from Mediterranean and for the first time connected with the Indian Ocean in the beginning of the Pliocene period (about 5 – 6 million years ago), it was populated by Indian Ocean fauna. Later during the glacial period of the Pleistocene, the level of the world's oceans was low. The Red Sea was isolated with high level of salinity (about 50 psu at the surface) and low temperature (about 2°C lower than the present) (Thunell *et al.* 1988). This resulted in the extinction of many species. Later, when it was reconnected with the Indian Ocean at the end of the glacial period, 10 – 12 thousand years ago, an opportunity was created for Indian Ocean species to re-populate the Red Sea (Goren 1986).

As a result of its connection to the speciose Indo-Pacific fauna, the Red Sea has a very high fish diversity, with more than 1,400 species of fishes are reported in FishBase (www.fishbase.org). It is also characterized by high degree of endemism, due to the closures alluded to above, with estimates of endemic fish species reaching 10–17% (Ormond and Edwards 1987). Because the Red Sea has very low nutrient input, as explained above, species that can survive its extreme environments have very good chance to dominate, as there are fewer competitors. One example is the phytoplankton *Trichodesmium erythraeum*, a blue-green alga (cynobacterium) that can overcome nitrate depletion by fixing atmospheric nitrogen dissolved in the water. In calm waters, its filaments float to the sea surface of the Red Sea and form a rather reddish scum, the likely origin of the name 'Red Sea' (and incidentally, of Eritrea's as well).

On the shores of coastal lagoons and sheltered bays mangroves are common. The most common species is *Avicennia marina*. *Bruguiera gymnorhiza* and *Ceriops tagal* also occur, though they are less common. The shallow waters of the lagoons and bays are home to seagrass beds. About 500 species of algae are reported from the Red Sea. Most algae in the north and central part are macroscopic, non-calcareous, brown, green and red algae. In the south, large brown algae such as *Sargassum* dominate (Walker 1987).

Five sea turtle species are reported from the Red Sea: hawksbill, green, olive ridley, loggerhead and leatherback. Hawksbill and green turtles are the most common, and are reported to nest along Red Sea beaches (Frazier *et al.* 1987). There is no active hunting for sea turtles in the Red Sea, but they are accidentally caught in fishing nets. The rich seagrass beds support dugongs, which are reported from Gulf of Suez in the north to Eritrea's Dahlak Archipelago in the south (Preen 1989). The reports of cetaceans from the Red Sea are sparse. Seven species of dolphins are commonly reported, as well as occasional spotting of killer whale and false killer whale. Frazier *et al.* (1987) suggested that the narrow strait of Bab al Mandab and the low productivity in the Red Sea as reasons for the scarcity of cetaceans. As far as seabirds are concerned, the enclosed nature of the Red Sea acts as a barrier for pelagic fishes on which many seabirds feed. As a result pelagic seabirds, such as shearwaters and petrels, are poorly represented. Because of its elongated shape, the Red Sea has high coast to sea area ratio and its seabird fauna is dominated by coastal species (Evans 1987).

Human settlements

According to archeological evidence, human settlement on the Red Sea coast started millennia ago (Horton 1987) and the Red Sea has the oldest records of human use of marine resources, in the form of giant clam and other shell middens (Walter *et al.* 2000). The Red Sea was also used as an important trade route between the Indian Ocean and the Mediterranean. However, in contrast with the rest of the world, where most of the population lives in a narrow strip of land along the coast (Edgren 1993), the population density on the Red Sea coast is still very low, except for very few major ports and cities. This is mainly due to the arid and hot climate, which resulted in most of the settlements being farther inland, in milder climate and where freshwater is less scarce. This has greatly limited the degree of coastal shoreline alteration, pollution and resource extraction. Thus, many Red Sea communities still depend on harvesting marine resources for subsistence using traditional methods of shell collection and fishing.

However, in the last few decades, the wider availability of technology coupled with cheap oil, at least for the oil producing countries, is changing the demography of the Red Sea coast. The major port cities are metropolitan hubs, with diverse economic activities, and fishing has become marginal. Egypt has a strong recreational and tourism industry, and its coast is quite populated, creating pressure on the coastal ecosystems. Air conditioners and desalination plants are making life easier. A typical example is the Saudi Arabia coast where vibrant cities, such as Jeddah, have grown fast and new cities (e.g., Yanbu) are developing. In such cities, coastal reclamation and dredging are becoming common for residential, commercial and industrial purposes. Pollution is prevalent around urban areas and ports, and lack of sewage treatment is a serious problem throughout the Red Sea, as is the pollution from oil refineries. Overall the impact of human activities is growing (Frihy *et al.* 1996).

Research expeditions

One of the earliest scientific expeditions to the Red Sea is the Danish Arabia Felix of 1761 – 1767, which spent October 1762 – August 1763 in the Red Sea area. It included the Swedish naturalist Peter Forsskål, a student of Linnaeus, who made an extensive collection of plants and animals, and particularly fish. His report was published posthumously by Carsten Niebuhr, the sole survivor (Forsskål 1775). There were many fragmented accounts of expeditions, most of them unsuccessful, to the Red Sea in the 18th and 19th centuries. One important and outstanding work in describing the Red Sea ecosystem and its organisms is that of Carl Benjamin Klunzinger, a German medical doctor who worked as a quarantine inspector in the Egyptian Red Sea port of Qusier from 1863 to 1869 and 1872 to 1875. His descriptions include coral fauna, fish, crustacea, hemichordates and also meteorological (Klunzinger 1870, 1872), and cultural observations (Klunzinger 1878). An Austrian research vessel, the Pola, conducted an expedition in 1895 – 1896 to the northern Red Sea (Luksch 1898) and 1897 – 1898 to the south (Luksch 1900), including the first oceanographic studies and sampling of deep sea life up to 2000 m (Head 1987a). The specimens from the expedition are kept in the Natural History Museum in Vienna (Stagl *et al.* 1996).

More recent expeditions include the John Murray expedition carried out using the Egyptian research vessel Mabahiss 1933 – 1934 (Tesfamichael 2005), which collected oceanographic and biological samples throughout the Red Sea and the Arabian Sea (Norman 1939). From 1959 to 1964, the International Indian Ocean Expedition brought some vessels to sample the Red Sea, whose oceanography was compiled by Morcos (1970). An Israeli expedition to the southern Red Sea in 1962 and 1965 (Ben-Tuvia 1968), and the Israeli Marine Biological Station at Eilat, which was opened in 1968, also contributed to the knowledge of the Red Sea. At present, a lot of initiatives are taken by the countries bordering the Red Sea and new information is collected.

Fisheries

The Red Sea has multiple uses, the major one being as a route from the Indian Ocean to Europe. Recently, interest in the tourism industry has been increasing, notably in Egypt, which has a well-developed marine tourism industry, especially along its northern coast. As far as resource extraction is concerned, however, fishery is still the most important sector in Red Sea. The Red Sea has a long history (and prehistory) of resource exploitation by humans. Archaeological studies of middle stone age middens from the Eritrean Red Sea coast indicate that humans were eating giant clams and other molluscs about 125,000 years ago, possibly the most ancient such practice on record in the world (Walter *et al.* 2000). The artisanal fisheries have traditionally operated in harmony with the ecosystem because of low population; non-destructive traditional fishing technology; and poor communication and infrastructure. However, recently, more advanced and destructive methods are being used. Currently, fishing operations in the Red Sea range from foot fishers catching fish mainly for their own consumption, to very large trawlers with freezing facilities.

The fisheries in the Red Sea are typical tropical fisheries, multi-gear and multi-species. Most fishing is performed from wooden boats ranging from 5 to 18 meters, locally called 'Sambuk' and 'Houris'. Sambuks are larger, and have inboard engines; Houris are smaller and use outboard engines. Both Sambuks and Houris use similar fishing gears, mostly handlining and gillnet. The main difference in the operation of Sambuk and Houri are length of the fishing trip, crew size and capacity (Tesfamichael and Pitcher 2006).

Total annual potential landings from the Red Sea were estimated once at 360,000 t·year^{-1} (Gulland 1971), but this value needs further scrutiny. Though the Red Sea accounts for 0.12% of the total world ocean area, its contribution to the world catch is only 0.07% (Head 1987b). Nevertheless, it is important to the countries in the region. Fishery produces a cheap source of animal protein and provides livelihood for the communities on the coast. Since the countries on the Red Sea coast are generally less industrialized, fisheries can provide multiple livelihoods.

Of the seven countries that border the Red Sea, Jordan and Israel have too small coastlines to support any major fishery. Of the other countries, Egypt and Yemen have well established fisheries and have been utilizing their resource for a long time. Egyptian and Yemen fishermen also fish in other countries' waters. Sudan is the country which utilize its fisheries resources the least, besides Jordan and Israel. Saudi Arabia has recently established an industrial fisheries, in addition to the artisanal fishery that has been active for many years. Eritrea had a strong small pelagic fishery in the past, then the fishery was dormant until it resumed after the country's independence in 1991.

Fishery data and assessment

A key part of documenting a fishery is reporting its catches. Given the catch level of a fishery, inferences can be drawn on the intensity of the pressure it exerts, and the approximate number of people involved in, and/or dependant on that fishery. Also, from additional information on the catch composition, inferences can be drawn on the technology that is deployed, the trade linkages that a fishing community has with its neighbours, its income from fishing, etc. In fact, reliable catch data are the most straightforward source of information for a variety of disciples, ranging from history and maritime anthropology to fisheries economics (Pauly 2006).

For fisheries scientists, the value of catch data is even greater. Indeed, catch data are crucial to their main task, which is to perform fish stock assessments in support of fisheries management. Herein, the key feature of stock assessments is to evaluate the status or level of fishing activity in relation to the productivity of the ecosystem, so that fish from a given stock can be caught in such a manner that the various components of the ecosystem and its regeneration potential are not compromised. If these conditions are met, the ecosystem will sustain fishing for a long time. To accomplish this task, there are two different subtasks to be considered: first establishing the potential of the ecosystem and second establishing where the fishery is relative to that potential. Many assessment tools have been developed to estimate the biological potential of a fishery system and use them as benchmarks for the level of exploitation. Maximum sustainable yield (MSY), and the ratio between the estimated original (un-fished) biomass and the current biomass are two of the many metrics used globally to establish levels beyond which the catch is not advised to go (Beverton and Holt 1957; Hilborn and Walters 1992). Of course, there are criticisms of those approaches, the assumptions they use and their applicability to different ecosystems, and they even share part of the blame for the decline of many fisheries (Larkin 1977; Punt and Smith 2001). However, until better alternatives are available to replace the traditional stock assessment tools, they will be used, despite their limitations. Moreover, while new approaches are being developed, many fisheries in the world do not even have estimates of those metrics and/or are not managed at all.

Overall, reliable catch data, jointly with the methods to estimate the biomass of fish and their productivity, are crucial components of effective assessment and management of fisheries. Time series of total catch, preferably by species, is thus the most basic and important information that can be gathered about a fishery (Caddy and Gulland 1983; Pauly and Zeller 2003). It is even more useful when coupled with fishing effort data. Notably, catch and effort data can help with preliminary assessment of the status of population upon which fisheries depend. However, this should be done with caution (Harley *et al.* 2001), because catch per unit of effort (CPUE), although an indicator of fish biomass, is not always proportional to abundance. CPUE can remain more or less stable while abundance is declining, a phenomenon called 'hyperstability', observed on schooling pelagic fish and spawning aggregations (Hilborn and Walters 1992; Pitcher 1995; Sadovy and Domeier 2005). On the other hand, CPUE can decline more than the actual decline of abundance called 'hyperdepletion' (Hilborn and Walters 1992). This can occur, for example, when only a portion of the population is vulnerable to the fishery (Walters and Bonfil 1999; Kleiber and Maunder 2008). However, for many fisheries, CPUE is the best type of information available for assessment, and not using it is short-sighted.

The rationale for catch reconstruction

There are many ways catch data can be collected. The most common are log books filled in by fishers, the records of observers onboard fishing vessels and data collection at the landing sites and on markets (e.g., auction and exports). For the Red Sea countries, many of these methods are very difficult to implement. Most of the local (artisanal) fishers are illiterate. The communities are predominantly based on oral traditions, thus logbooks are out of question. The majority of the boats are small, and on-board observers are impractical to deploy. Data recording at landing sites, although still arduous, is the most practical for routine catch and effort data collection. The challenge here is that the number of landing sites along the coast is quite large, and some of them are not even known to the fisheries administrations. Setting up proper data collection systems is thus not straightforward, given the complexity of fisheries and fish marketing.

There are many fates of a fish following its encounter with fishing gear (Figure 2). The actual effect of fishery in an ecosystem should be measured by the amount of fish killed (rather than fish landed). The actual measure of fishing mortality can be concealed by lack of data on the mortality of the fish at the different parts of Figure (2). For example, for some Red Sea countries, more than half of the fish catch does not go through fish market, where official recording occurs (Chakraborty 1983). If only the data from landing sites is used to calculate the fishing mortality, this will underestimate its actual magnitude. Thus, proper planning and systematic collection procedures are needed (Gulland 1975; Sparre 2000) and for the Red Sea, it is urgent (Tesfamichael 2012). Systematic data collection requires resources, and thus developed countries usually have better catch and related statistics than developing countries (Alder *et al.* 2010), while the latter also have to contend with a generally higher biodiversity, which makes the catch highly diverse, and hence comprehensive catch statistics difficult to produce (Pauly and Watson 2008). Note, however that even in developed countries with better statistics, overfishing is rampant, e.g., in the North Atlantic (see e.g., Christensen *et al.* 2003).

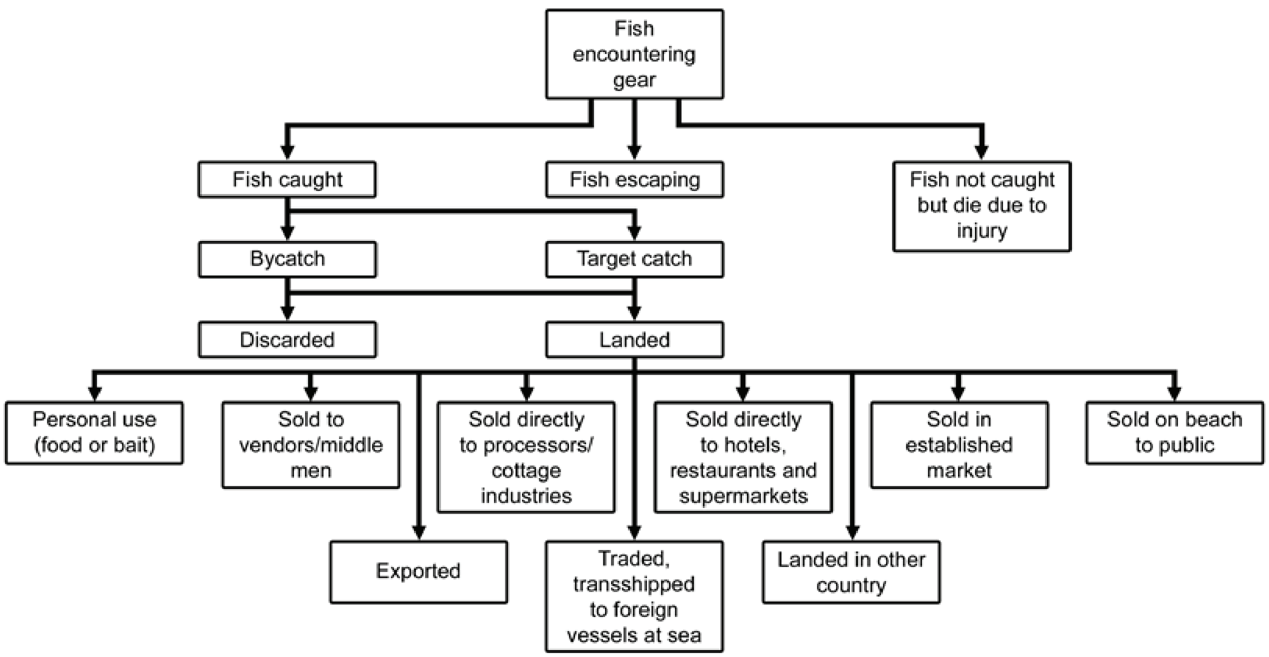

Figure 2. Possible fates of fish following an encounter with a fishing gear, based on Mohammed (2003).

The Food and Agricultural Organization (FAO) of the United Nations assembles annual catch data submitted by member countries and harmonizes and disseminates them since 1950 (Garibaldi 2012; Pauly and Froese 2012), and Garibaldi (2012) gives a comprehensive description of the FAO database and its evolution. Because it consists of continuous, long time series and is easy to access, the FAO database is used extensively for research and policy at regional or international scales. Thus, 600 articles in peer-reviewed journals cited the FAO database in the last 15 years, notably because its standardized data makes comparisons straightforward (Garibaldi 2012).

FAO's mandate is very broad, and when it comes to fishery data, it can only compile what is submitted to it. This is the main bottleneck to the quality of the data. Countries do not necessarily have the incentive to submit reliable data, except as moral obligation to contribute to a global system. Thus, it is not uncommon for countries to send incorrect or incomplete fishery data (Pauly and Froese 2012), and FAO does not have a legal or procedural mandate to refuse such data. Even more problematic, the technical reports produced by FAO staff or consultants are not reflected in the database. Thus, the global estimates of discards documented in successive Technical Papers and other FAO documents were never included in the FAO statistics (Zeller and Pauly 2005).

Another example, applying specifically to the Red Sea, is that most of the early fishery data for the Red Sea comes from national or regional projects executed by FAO, especially the project 'Development of fisheries in areas of the Red Sea and Gulf of Aden', which ran from the late 1970s to the mid-1980s under United Nations Development Programme (UNDP and FAO. Among other things, the projects surveyed the fisheries and estimated national catches (Chakraborty 1984), but they were not incorporated into the FAO catch database. Moreover, while the countries around the Red Sea are all members of FAO, and hence they send their fishery data to FAO, many suffer from political and institutional instability, which affects their fishery agencies, and thus there are gaps and inconsistencies in the data supplied to FAO.

FAO's mandate, while broad, does not include detailed analysis and review of the data supplied by member countries, which thus remain limited in their reliability and usefulness. It is assessed by FAO itself that the catch data it receives from over half of its developing country members, and one quarter of developed country members are unreliable (Garibaldi 2012). The following are the major constraints with the fishery statistics in the FAO database, and affect all countries, and not only those around the Red Sea:

1. The FAO database reports global marine catches spatially only to the extent that they are allocated to 19 giant 'statistical areas'. In the cases of Red Sea catches, this is area 51, the 'Western Indian Ocean', extending from the tip of the Gulf of Suez in the North to the Antarctic Convergence in the South, and from Sri Lanka in the East to South Africa in the West;
2. The level of taxonomic aggregation of the catch is usually very high, and a large part of the catch is reported as 'miscellaneous' or 'unidentified species', which masks qualitative changes occurring within the ecosystem;
3. FAO's member countries often send in catch data (usually emanating from a Department of Fisheries or similar institution) through their Ministry of Trade, or some central statistics office or other government agency not directly connected with fisheries, where they are often over-aggregated and/or otherwise modified before being sent off;
4. Some countries may have political reasons to misreport their catch, including over-reporting of catches as China did to FAO for at least two decades (Watson and Pauly 2001) and, gravest of all:
5. When data for certain fisheries are not available (because the fisheries in question were not monitored), no estimate for the missing catch data are submitted. Subsequently, absent catch data for a given year become an annual catch of precisely '0' tonne (Pitcher *et al.* 2002). Thus, the FAO database does not account for illegal, unreported and unregulated (IUU) catch (Alverson *et al.* 1994; Kelleher 2004), nor does it suggest where gaps in its coverage may occur.

FAO has taken initiatives to improve the content of its catch database, and indeed, it has improved over time. Also, there is a university-based research project, the Sea Around Us (www.seaaroundus.org), which aims to improve the quality of global marine fishery data. Being non-governmental, Sea Around Us is not limited by formal procedures. Hence, country catch reports can be critically examined, and when fisheries where omitted, their catch can be estimated using the best available knowledge. In effect, the major issues with the FAO database can be overcome through reconstructing historical catch time series (Pauly 1998; Pauly and Zeller 2003; Pauly and Froese 2012). Reconstructed time series of catch (and effort) data from the past are not merely useful for historical purposes. Rather, they provide a basis for overcoming the shifting baseline syndrome (Pauly 1995), i.e., for improved assessment of past and current impacts of fishing on marine ecosystems, and for ecological restoration (Scott Baker and Clapham 2004; Pitcher 2005). The lessons learned from catch reconstruction in different circumstances of the fisheries can be informative, similar to 'scenarios' in adaptive management of resources (Walters 1986).

Catch reconstruction involves quantifying the catch of each fishery known to have existed, based either on 'hard' catch data, or when such data are not available, on the 'shadow' that the fishery – a social activity–throws on the society in which it is embedded. This shadow may consist of household fish consumption figures, number and income of fishers, export figures, etc... (Pauly 1998). Estimates from catch reconstruction, while approximate, will generally be closer to reality than the misreported catches, e.g., the precise estimate of zero in the official databases alluded to in the above (Pitcher *et al.* 2002; Zeller *et al.* 2007).

The main objective of this report is to reconstruct catches of the Red Sea fisheries from 1950, the year FAO started to publish annual statistical reports on the fisheries of the world, up to 2010. . Included here are all the Red Sea countries: Egypt, Sudan, Eritrea, Yemen, Saudi Arabia, Jordan and Israel and all the fishing sectors of these countries. The major outputs are a time series of standardized fishery catch for the Red Sea, by sector and species or other groupings. We do not claim these catch reconstructions data to be final. Rather, we see them as the start of an iteration, and as a basis to kick start the discussion on how to improve fishery data for the Red Sea, and ultimately, the management of its fisheries resources.

Sources and catch reconstruction procedures

The main procedure in catch reconstruction is digging into different sources reporting the catches of the countries, critically analyzing them, and organizing them to a common standard, which can be used for comparison and carrying out analysis for the assessment of the resources (Mohammed 2003; Tesfamichael and Pauly 2011). The sources used here include peer-reviewed published papers, grey literature (mainly government, consultant, and FAO reports), and national databases, complemented by field trips by the first author to Egypt, Sudan, Eritrea, and Yemen from

December 2006 to September 2007. The information collected was enriched by the insights of local experts and colleagues who provided data through personal communications. The catch reconstruction for the whole Red Sea was first compiled in the form of individual country reports, co-authored by country experts: Egypt (Tesfamichael and Mehanna 2012), Sudan (Tesfamichael and Elawad 2012), Eritrea (Tesfamichael and Mohamud 2012), Yemen (Tesfamichael *et al.* 2012b), Saudi Arabia (Tesfamichael and Rossing 2012), and Jordan and Israel (Tesfamichael *et al.* 2012a), which give country-specific details (see also www.seaaroundus.org/eez/). Here, a summary of the general methodology and the procedure to establish one coherent data set for the whole Red Sea are described.

Sources

The earliest data sources for the Red Sea countries were technical reports of the assessments of the fishery resources for planning the development of the fishing industry, starting in the decades following WWII. The 1950s was also a period where several of these countries became independent and started to run their national economies, and food security became a critical issue. These assessments/surveys were made by foreign experts (except for Egypt), usually recruited through the FAO. The earliest sources available were for Saudi Arabia (El-Saby and Farina 1954), Sudan (Kristjonsson 1956), Eritrea (Ben-Yami 1964), Egypt (Al-Khol and El-Hawary 1970) and Yemen (Lisac 1971; Losse 1973). Other early assessments were performed through bilateral arrangements or consultants hired directly by the countries (e.g. see Ben-Yami 1964; Atkins 1965; Grofit 1971 for Eritrea). In the 1970s and 1980s, in part because of the Cold War and ensuing East-West competition, development aid was pouring into the Red Sea countries. A fraction of these funds were assigned to fisheries development projects, which led to an improvement in documented knowledge about the fisheries (catches, catch composition, gear, etc). A regional project for the Red Sea area, 'Development of fisheries in areas of the Red Sea and Gulf of Aden', was carried out from the end of the 1970s until the mid-1980s and led to an improvement of the quality (comprehensiveness and taxonomic resolution) of fishery catch data. Additional sources were also used, notably tax offices and export records. For example, the catch of the Eritrean beach seine small pelagic fishery was reconstructed from export figures for fish meal, which was the output of the fishery (Ben-Yami 1964).

Organized databases and/or annual fishery statistical reports are a relatively new development for the Red Sea countries. The oldest database is that of Egypt, which starts in 1979, while Saudi Arabia started publishing its annual fishery statistics in the 1980s. Eritrea has had annual reports since its independence in 1991, but its fishery database started only in 1996. Sporadic annual reports are available for Yemen and a database system is being established. Sudan does not have any fishery data reporting system yet; however, daily catch data are collected at the main fishing market of Port Sudan, which are stored, but not issued as annual reports. All these sources were accessed for the catch reconstruction of the respective countries.

Once the sources were accessed, their contents were analyzed for their spatial, temporal and sectoral coverage. Some reports were written only for a certain section of the countries or only a specific sector of the fisheries. Then, the sources were critically examined with regards to the method(s) and assumptions used in collecting their data. For some years, data were available from different sources, some simply regurgitating previously reported data. In such cases, an effort was made to locate the original reports. When there were multiple independent sources, the ones which have detailed explanations of the methodology and comprehensive coverage were selected. In a few cases, the information from one source was used to correct data from another.

Interviews

Field interviews were conducted by the first author with fishers ranging from 15 to 82 years of age, and with fishing village elders and the employees of fisheries administrations (Tesfamichael *et al.* in press). The main goal of the interviews was to assess long-term change in fisheries productivity by accessing fishers' memories, which provided two major inputs to the catch reconstructions. First, the interviews were very useful in filling data gaps. For some periods there were no records at all, so interviewees were asked to explain what occurred during those periods, i.e., whether the catches were higher or lower than, or about equal, to the adjacent periods with records. The other type of information supplied by the interviews was the unreported catch, i.e., the catch missed by official records. For many artisanal fisheries in the Red Sea, this included the catch given freely to some members of the community and the catch landed at remote landing places, away from data collectors. Regarding the former, there is a strong tradition, shared by the maritime cultures of Red Sea countries, that part of the catch is expected to be given freely to family, friends and people who need assistance (e.g., the elderly, disabled, and widows). The amount given freely is called '*kusar*' and is a form of food security social network. Not to give '*kusar*' leads to loss of prestige, which may have serious consequences, e.g., with regards to market transactions and eventual marriages. The amount was about half of the total catch in the 1950s and 1960s; however, as the catches started to decrease and the fish accrued market value, the proportion of the catch devoted to *kusar* started to decrease.

Another input from the interviews was explanations of discrepancies among reports. The insights from older fishers and people who have been involved in the management of fisheries helped resolve ambiguities in reports and/or records. Although they did not give specific quantitative values, their ability to give comparative qualitative information helped to base the assumptions used in quantifying the catch. In the absence of any other source, anecdotal information can be a good starting point (Pauly 1995) and quantitative data can be inferred from qualitative information, given some anchoring (Tesfamichael and Pitcher 2007).

Missing data

For the years data were missing, interpolations or extrapolations were made to fill in the data gaps. These were made on the basis of explicitly stated assumptions, given the best knowledge of the fisheries available at the time. Population size and per capita consumption were frequently used as a proxy for inferring catches. In a few instances, information from one country was used for another country with a similar fishery, particularly in the case of catch composition data.

Comparison and compilation

Using the different sources and procedures, the catches of each country were reconstructed by sector, and the catch compositions were inferred. Then, the reconstructed catches were compared to the catch data reported to FAO by the respective country. The FAO data is used a reference for comparison because it is a good source of time series catch data for the Red Sea countries and is used by many organization (local and foreign) for analysis and planning. Thus, the part of the reconstructed catch of a given taxon that was accounted for in the FAO data was assigned as 'reported' catch in our analysis and results. When the reported catch of a taxon was higher than what is reported for that taxon in the FAO database, the difference was assigned to the 'unreported' catch; in contrast, when the FAO catch for a taxon was higher than the reconstructed catch, it was assigned as 'over-reported' catch. As will be seen in the country chapters, reported and unreported catches are identified separately in the catch reconstruction. Note that if there was a part of the catch that was not reported (e.g., catches were sold outside landing sites where catch data recordings are carried out and we managed to get an estimate of the amount), then that part of the catch is referred as 'unreported' catch in our computations. This should not be confused with the reported and unreported catches of the results as compared to the FAO data. Once the catches were reconstructed for each country, by sector and the catch composition calculated, they added up to represent the catches of the Red Sea as a whole, i.e., as a Large Marine Ecosystem (see also www.seaaroundus.org/lme/33.aspx).

Summary results and discussion

The total reconstructed catch from the Red Sea from 1950 to 2010 was 6,333,000 tonnes, 1.5 times higher than what is reported to FAO by the surrounding countries for the same period. The total catch was low (around 50,000 t·year^{-1}) until 1960, when it started its first increase until a decline in the early 1970s (Figure 3, Appendix Table A1), due to the war between Israel and the Arab countries in the region. The catch increased again from the mid-1970s, until it reached its peak of 177,000 tonnes in 1993. This phase is characterised by massive boat motorization and the introduction of industrial fishing by several Red Sea countries. This increased the effort and also allowed the expansion of the fisheries to areas they did not access previously. The total catch remained high, with some fluctuations, until the mid-2000s when it started to decline. This decline is here interpreted as a sign of resource depletion, especially in Yemen (Tesfamichael *et al.* 2012b).

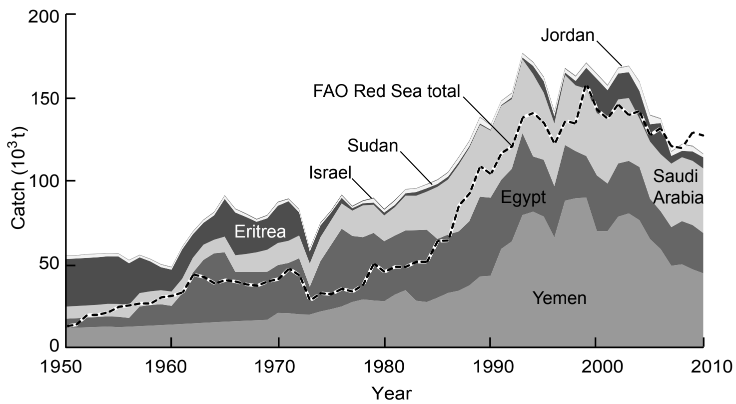

Figure 3. Reconstructed catch of the countries bordering the Red Sea from 1950 to 2010 and its comparison to the data reported to FAO.

The reconstructed catch was higher than the FAO data, except for the last few years. An obvious reason why the reconstructed catch is generally higher is that we included discards, subsistence and recreational fisheries, which are not usually included in FAO data for the Red Sea. The higher FAO catch in the last few years of our analysis was caused by double counting of some fishery catches in the FAO database. This is due mainly to Egypt fishing outside its EEZ in the waters of Sudan, Eritrea and Yemen, and reporting all their catches as Egyptian, while Sudan, Eritrea and Yemen report some of these same catches to FAO as well, as they are taken within their EEZ. One can argue this catch should be reported by area, i.e., by the EEZ it was taken from, or by the country that has taken it. Here, in view of the current emphasis on ecosystem-based fisheries management, we focused on the area, i.e., the EEZ from which the catch originates, as it provides the spatial context for fisheries management. For completeness, we also indicate, in the database, the country fishing. Presently, there is no a regional fishery management agency for the Red Sea LME, and whatever management there is extends only to national schemes, pertaining to single EEZ. By country, Yemen has the highest percentages of the Red Sea catch (36%), followed by Egypt (28%), Saudi Arabia (23%), Eritrea (11%) and Sudan (2%), while Jordan and Israel contribute less than 0.2% each.

The artisanal fisheries accounted for 49% of the total catch from 1950 to 2010 (Figure 4, Table A2). Their contribution was dominant throughout the whole period, unlike the industrial sector (22%), which is important only in the later part of the period covered here. This has major economic and social implications, as artisanal fisheries employ a higher number of fishers per tonne of catch (Pauly 2006), which translates to higher employment and livelihood in the communities. The discards (near exclusively from industrial fishing), which are usually ignored in official reports, represented 16% of the total catch. The subsistence catch was 12%, while the recreational fishery (1%), which started only recently, is still negligible. Egypt is the country with the most developed recreational fishery and even in that country, recreational catches are low.

Comparing the reconstructed catch with the FAO data at taxonomic level, only 42% of the reconstructed catch was accounted in the FAO data, i.e., the reported catch (Figure 5, Table A3). The remaining 58% was not accounted at all, which included 43% unreported, but landed catch and 15% discarded catch, which is not landed and thus unreported as well.

A total of 209 taxa or taxonomic group were identified as contributing to Red Sea catches, in addition to a group 'others' encompassing the minor taxa that were not represented separately. The taxa contributing most to the catch was Indian mackerel (*Rastrelliger kanagurta*; 8%), Spanish mackerel (*Scomberomorus commerson*; 7%), and jacks (Carangidae; 7%). Emperors (Lethrinidae) and ponyfishes (Leiognathidae) each accounted for 5% of the total catch, the former prized fishes, the latter the dominant taxon in the discarded catch of industrial trawlers. These percentages suggest that there is no a single taxon that is overly dominant in the Red Sea fisheries, a reflection of their multi-species nature, and one of the main challenges in managing the Red Sea fisheries. The major taxonomic groups of the total catch composition are presented in (Figure 6). Only few taxa are included here for better visual effect of the figure. Appendix Table (A4) has a large list of the taxonomic composition.

In the following, a brief per-country account is given, starting with Egypt and moving counter-clockwise along the Red Sea coast as the different chapters are introduced. For Egypt (Chapter 2), the reconstructed catch is higher than the fisheries catch statistics that Egypt submits to FAO from the beginning of 1960s until the beginning of 1990s, but the reverse occurs after the mid-1990s. This discrepancy is due to the fact that Egypt fishes outside its own waters (e.g., in Eritrean waters starting early 1990s (Tesfamichael and Mohamud 2012) and these catches are not included in the reconstruction (Tesfamichael and Mehanna 2012), as the focus of the reconstruction is to quantify the amount fished in the waters of various countries (also clearly identifying the fishing country) and not where they landed. The catch of Egyptian vessels from Eritrean waters is reported in the reconstruction of Eritrea.

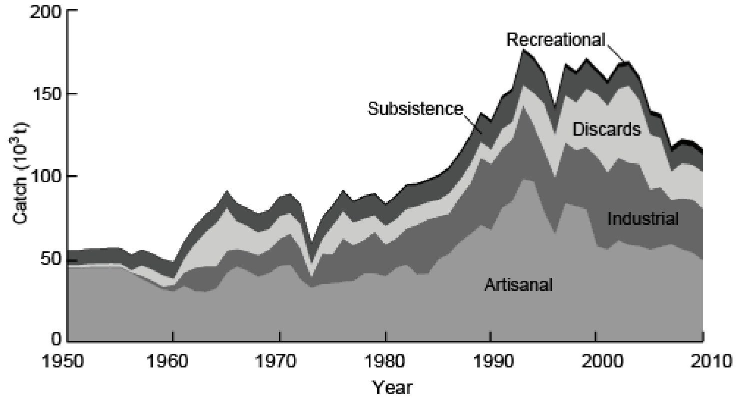

Figure 4. Reconstructed catch of the Red Sea fisheries by sector from 1950 to 2010.

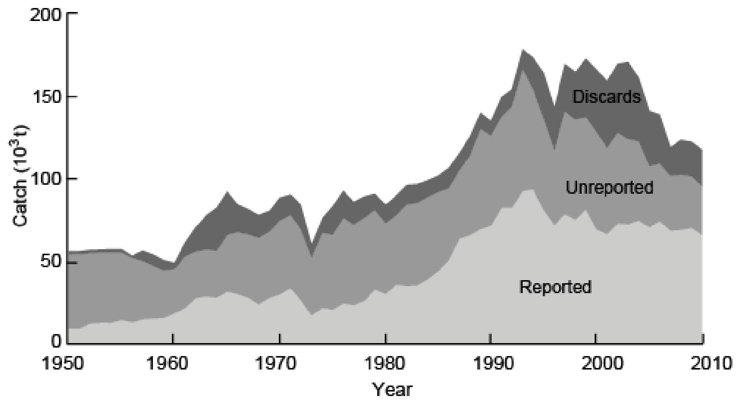

Figure 5. Reconstructed catch of the Red Sea fisheries by components from 1950 to 2010.

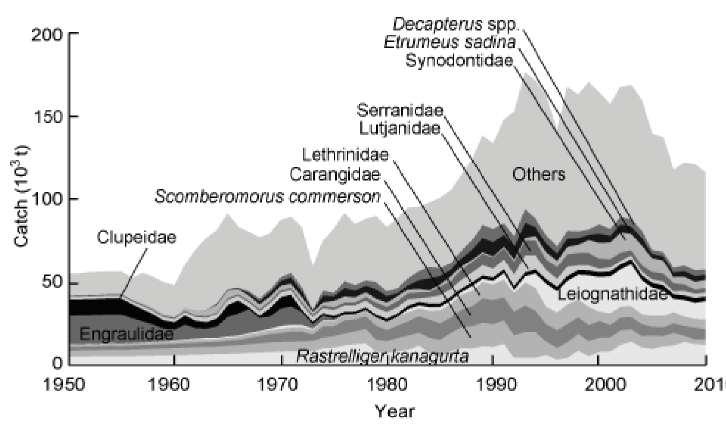

Figure 6. The major taxonomic composition of the total reconstructed catch of the Red Sea from 1950 to 2010.

The Sudanese data (Chapter 3) submitted to FAO does not include the catches of shells (trochus and mother-of-pearl) fishery, which was very important before 1980s. Generally, there is no large difference between the reconstructed data and data submitted to FAO for Sudan. The sudden spike of Sudanese catch reported to FAO in 1983, on the other hand, is likely due to a reporting error, as there was no major change in the fisheries likely to cause such a sudden jump for only one year. The higher catches reported to FAO after the 1990s are also suspicious, as they contradict locally available data (Tesfamichael and Elawad 2012).

For Eritrea (Chapter 4), Yemen (Chapter 5) and Saudi Arabia (Chapter 6), the reconstructed catches are higher than those reported to FAO, due to the latter not including various fisheries and omitting discards. The major discrepancies between the reconstructed data and data submitted to FAO for Eritrea are in the early decades (1950s and 1960s) and later, after 2000. Between those periods the fishery was largely inactive, hence catches were low (Tesfamichael and Mohamud 2012). For Yemen in the Red Sea, the reconstructed catch is higher than the reported catch, the difference being more consistent for Yemen than for any other country (Tesfamichael *et al.* 2012b). There is clear difference between the reconstructed and reported catch for Saudi Arabia in the Red Sea until the mid-1980s. After the mid-1980s, trawlers were introduced into the Saudi fishery, and hence the differences between the two data sets consist mainly of discard (Tesfamichael and Rossing 2012). The reconstructed catches of Israel and Jordan (Chapter 7) are negligible compared to those of the other countries (Tesfamichael *et al.* 2012a), which is understandable given their minuscule footholds in the inner Gulf of Aqaba. They also exhibited less fluctuation than the FAO data.

In addition to the catch reconstruction for each country bordering the Red Sea, a list is provided of common commercial fishes caught by the fisheries in the Red Sea and their corresponding local names (Chapter 8). The names include valid scientific names, common English names, local (Arabic) names written in both Arabic script and Roman characters. We believe this will helps researchers, resource users and managers. A brief reconstruction of the effort of the Red Sea fisheries is provided as an appendix, by country and split between the artisanal and industrial sector. Jointly, the information presented here can help in better understanding the Red Sea and provide a basis for the management schemes that the future will require (Tesfamichael 2012).

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Appendix Table A1: Reconstructed catch (in tonnes) of the countries bordering the Red Sea from 1950 to 2010 and its comparison to the data reported to FAO.

Year	FAO landings	Reconstructed total catch	Yemen	Egypt	Saudi Arabia	Eritrea	Sudan	Israel	Jordan
1950	12,194	55,071	11,458	5,535	7,326	28,599	1,946	66	142
1951	13,218	55,166	11,631	5,683	7,326	28,599	1,721	66	142
1952	18,771	55,937	11,841	5,831	7,326	28,599	2,133	66	142
1953	18,962	56,153	12,069	5,980	7,326	28,599	1,972	66	142
1954	20,427	56,509	12,316	6,129	7,509	28,599	1,749	66	142
1955	23,736	56,383	11,933	6,277	7,692	28,599	1,663	77	142
1956	24,467	52,402	12,239	5,247	7,875	25,051	1,761	88	142
1957	25,639	55,495	12,544	11,839	8,058	21,503	1,311	98	142
1958	25,583	53,105	12,852	12,397	8,241	18,054	1,309	109	142
1959	29,273	49,897	13,171	12,569	8,424	13,848	1,622	120	142
1960	30,129	48,235	13,500	11,270	8,608	13,166	1,418	131	142
1961	32,139	60,342	13,842	18,417	8,791	17,684	1,324	142	142
1962	42,712	69,555	14,201	30,454	8,974	14,157	1,475	153	142
1963	41,084	76,642	14,554	37,841	9,157	13,159	1,626	163	142
1964	37,392	81,296	14,899	41,475	8,167	14,661	1,777	174	142
1965	39,282	91,316	15,225	41,750	9,428	22,657	1,928	185	142
1966	38,426	83,324	15,525	29,647	10,039	25,695	2,080	196	142
1967	36,809	80,393	15,810	29,328	10,805	22,325	1,783	206	135
1968	36,041	77,079	16,086	29,087	11,803	18,365	1,393	217	129
1969	38,671	79,475	16,362	28,904	13,265	18,888	1,713	222	122
1970	40,010	87,412	20,510	28,776	13,293	22,406	2,085	227	116
1971	46,233	89,365	20,363	30,224	13,322	23,797	1,319	231	109
1972	41,963	82,974	19,679	33,699	13,699	13,886	1,672	236	102
1973	27,277	59,395	19,535	16,728	14,075	7,162	1,580	241	75
1974	31,644	74,843	21,380	30,235	14,450	7,027	1,367	279	105
1975	31,051	82,196	22,776	38,618	14,824	4,637	955	286	99
1976	34,349	91,687	24,410	46,756	15,196	3,393	1,562	292	78
1977	32,613	84,947	27,085	39,751	15,222	1,481	1,041	299	69
1978	36,728	88,218	28,647	37,422	19,160	1,258	1,355	305	70
1979	49,050	89,831	28,016	40,629	16,905	1,314	2,576	311	79
1980	44,233	83,142	27,530	36,123	15,516	1,758	1,781	346	88
1981	47,139	88,513	31,511	35,589	17,056	1,366	2,579	317	96
1982	47,100	95,047	34,218	35,868	20,950	1,455	2,328	122	105
1983	50,018	95,561	27,847	42,473	20,685	2,223	2,106	113	114
1984	50,104	98,079	27,068	43,490	22,916	2,036	2,262	151	156
1985	62,333	100,831	29,651	35,339	31,376	1,699	2,364	204	198
1986	62,597	105,332	32,528	35,118	33,141	1,724	2,420	206	196
1987	83,220	114,395	33,863	35,659	40,138	1,452	2,892	196	194
1988	90,283	124,165	37,033	38,649	44,163	980	2,959	187	193
1989	106,386	138,613	42,429	48,012	43,304	759	3,764	155	191
1990	101,623	133,641	42,859	46,970	40,401	533	2,567	122	189
1991	114,136	148,208	59,018	41,520	44,500	535	2,354	90	192
1992	118,048	152,994	63,539	43,715	41,921	1,058	2,408	158	194
1993	135,085	176,943	79,390	49,255	44,525	1,005	2,431	141	196
1994	137,648	171,632	81,409	33,231	49,503	5,017	2,080	175	218
1995	131,708	162,695	78,507	34,120	40,353	6,913	2,342	214	246
1996	119,382	141,913	65,977	30,834	37,766	4,346	2,457	296	238
1997	133,088	167,935	88,038	33,507	42,108	1,501	2,312	240	229
1998	131,384	163,244	89,499	28,347	39,500	2,714	2,758	206	220
1999	155,244	171,199	89,922	24,983	40,500	12,598	2,764	166	266
2000	139,742	164,542	69,768	33,454	37,485	20,626	2,762	190	257
2001	134,293	157,725	69,699	28,684	39,431	16,703	2,738	190	280
2002	142,696	168,085	78,402	32,044	38,497	15,570	3,189	95	288
2003	136,406	169,269	80,393	31,586	37,820	15,565	3,575	94	237
2004	138,811	159,861	76,315	31,993	29,180	16,545	5,410	168	250
2005	124,519	139,738	64,934	24,249	34,396	10,442	5,310	141	266
2006	128,752	137,630	58,872	22,783	34,329	18,769	2,486	140	251
2007	118,105	117,813	48,884	23,247	38,206	4,634	2,469	113	260
2008	117,069	122,244	49,752	26,002	38,406	3,853	3,864	112	255
2009	126,212	121,131	46,728	26,662	38,601	5,683	2,993	132	332
2010	124,397	116,368	44,358	24,279	38,796	6,721	1,873	99	242

Appendix Table A2: Reconstructed catch (in tonnes) of the Red Sea fisheries by sector from 1950 to 2010.

Year	Artisanal	Industrial	Discards	Subsistence	Recreational
1950	44,191	557	1,848	8,475	0
1951	44,132	580	1,895	8,559	0
1952	44,737	604	1,939	8,658	0
1953	44,781	627	1,980	8,765	0
1954	44,920	650	2,019	8,920	0
1955	44,758	674	2,055	8,896	0
1956	41,722	429	1,177	9,074	0
1957	38,137	1,940	6,165	9,253	0
1958	35,002	2,140	6,529	9,434	0
1959	31,533	2,195	6,551	9,619	0
1960	30,470	4,110	3,818	9,837	0
1961	34,061	7,909	8,343	10,028	0
1962	30,687	14,056	14,618	10,194	0
1963	30,029	15,718	20,507	10,388	0
1964	32,193	13,490	25,797	9,815	0
1965	41,715	13,282	26,175	10,144	0
1966	45,494	10,676	16,675	10,479	0
1967	42,821	11,786	15,077	10,709	0
1968	39,437	13,017	13,642	10,966	16
1969	41,503	14,325	12,330	11,287	32
1970	45,903	16,295	13,729	11,387	100
1971	46,799	18,667	12,309	11,422	168
1972	37,957	18,661	14,551	11,568	237
1973	32,847	6,485	7,853	11,903	306
1974	35,171	18,311	8,434	12,494	433
1975	35,474	17,527	17,036	11,654	505
1976	36,365	26,368	16,393	11,983	578
1977	37,008	21,520	13,596	12,172	651
1978	41,502	20,396	12,767	12,829	724
1979	41,372	25,207	9,855	12,600	797
1980	39,693	19,299	10,936	12,345	868
1981	44,670	17,901	11,713	13,290	940
1982	46,869	21,713	11,852	13,601	1,012
1983	40,683	29,898	11,279	12,616	1,084
1984	41,040	33,072	10,255	12,553	1,159
1985	50,073	25,793	9,883	13,848	1,234
1986	53,181	24,295	12,196	14,350	1,310
1987	60,350	27,211	10,191	15,257	1,386
1988	64,902	30,468	11,526	15,806	1,462
1989	70,480	40,661	9,580	16,354	1,538
1990	67,598	39,785	8,763	15,882	1,613
1991	80,908	35,848	11,792	17,969	1,691
1992	85,044	37,411	10,311	18,460	1,769
1993	98,486	44,686	11,931	19,994	1,846
1994	96,826	34,243	19,133	19,517	1,913
1995	78,686	37,507	27,580	16,940	1,982
1996	64,910	34,496	25,706	14,744	2,056
1997	83,682	36,776	28,343	17,005	2,129
1998	81,832	33,943	28,718	16,549	2,202
1999	80,120	37,625	35,097	16,108	2,247
2000	57,707	54,083	37,532	12,916	2,302
2001	55,678	46,683	40,219	12,775	2,370
2002	61,497	49,829	41,422	12,889	2,448
2003	58,511	49,622	46,478	12,128	2,530
2004	57,826	49,523	38,402	11,443	2,667
2005	55,588	36,492	33,241	11,619	2,798
2006	57,413	36,089	29,558	11,646	2,923
2007	58,976	26,884	17,140	11,769	3,043
2008	55,985	30,859	20,851	11,387	3,161
2009	53,946	32,144	20,771	10,994	3,276
2010	49,370	31,242	22,033	10,335	3,388

Appendix Table A3: Reconstructed catch (in tonnes) of the Red Sea fisheries by components from 1950 to 2010.

Year	Reported	Unreported	Discards
1950	8,726	44,497	1,848
1951	8,777	44,495	1,895
1952	11,647	42,352	1,939
1953	12,262	41,911	1,980
1954	12,211	42,279	2,019
1955	13,829	40,500	2,055
1956	12,464	38,761	1,177
1957	14,181	35,150	6,165
1958	14,646	31,929	6,529
1959	15,102	28,245	6,551
1960	17,742	26,675	3,818
1961	20,988	31,010	8,343
1962	26,939	27,998	14,618
1963	27,939	28,195	20,507
1964	27,251	28,248	25,797
1965	30,967	34,174	26,175
1966	29,328	37,322	16,675
1967	27,232	38,084	15,077
1968	23,336	40,101	13,642
1969	27,195	39,950	12,330
1970	29,201	44,483	13,729
1971	32,952	44,104	12,309
1972	25,712	42,711	14,551
1973	16,654	34,888	7,853
1974	21,105	45,304	8,434
1975	20,075	45,085	17,036
1976	23,836	51,458	16,393
1977	22,863	48,488	13,596
1978	25,477	49,974	12,767
1979	32,113	47,863	9,855
1980	29,472	42,733	10,936
1981	35,103	41,697	11,713
1982	34,361	48,834	11,852
1983	34,717	49,564	11,279
1984	38,327	49,497	10,255
1985	43,253	47,695	9,883
1986	49,825	43,312	12,196
1987	62,967	41,236	10,191
1988	64,919	47,720	11,526
1989	68,540	60,493	9,580
1990	70,569	54,308	8,763
1991	81,425	54,991	11,792
1992	81,272	61,412	10,311
1993	91,608	73,403	11,931
1994	92,412	60,088	19,133
1995	80,086	55,028	27,580
1996	71,143	45,064	25,706
1997	77,540	62,051	28,343
1998	74,258	60,268	28,718
1999	80,412	55,690	35,097
2000	68,325	58,684	37,532
2001	65,586	51,920	40,219
2002	71,814	54,849	41,422
2003	71,503	51,288	46,478
2004	73,658	47,801	38,402
2005	69,711	36,786	33,241
2006	73,326	34,745	29,558
2007	67,674	32,999	17,140
2008	68,070	33,323	20,851
2009	69,231	31,128	20,771
2010	65,161	29,174	22,033

Appendix Table A4: The major taxonomic composition of the total reconstructed catch (in tonnes) of the Red Sea from 1950 to 2010.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1950	4,975	3,616	2,203	1,376	84	17,500	9,663	1,556	795	190	0	8	414	628
1951	5,048	3,647	2,215	1,395	84	17,500	9,677	1,565	795	201	0	9	427	637
1952	5,136	3,684	2,228	1,416	84	17,500	9,693	1,574	795	212	0	9	438	649
1953	5,232	3,725	2,242	1,438	84	17,500	9,711	1,584	795	224	0	10	449	661
1954	5,339	3,809	2,285	1,475	84	17,500	9,731	1,617	812	235	0	11	459	675
1955	5,183	3,784	2,319	1,487	84	17,500	9,701	1,646	830	246	0	11	468	654
1956	5,315	3,877	2,354	1,502	84	15,173	8,562	1,652	848	128	0	6	238	671
1957	5,447	3,971	2,430	1,539	84	12,846	7,422	1,877	866	856	0	38	1,547	688
1958	5,581	4,066	2,474	1,576	199	10,519	6,285	1,931	884	946	0	41	1,631	704
1959	5,719	4,163	2,520	1,614	199	7,731	4,916	1,975	902	973	0	43	1,637	722
1960	5,861	4,261	2,535	1,673	361	6,681	4,420	1,893	920	646	0	23	853	740
1961	6,009	4,362	2,606	1,712	719	8,951	5,589	2,096	938	1,554	0	52	1,892	759
1962	6,164	4,466	2,698	1,731	854	6,366	4,326	2,399	956	2,676	0	97	3,483	778
1963	6,316	4,569	2,787	1,770	926	5,505	3,925	2,700	974	3,752	0	143	4,999	798
1964	6,532	4,403	2,980	1,712	791	6,869	4,632	2,854	882	4,678	395	479	6,443	817
1965	6,682	4,742	3,172	1,883	787	11,803	7,125	3,072	998	4,842	333	441	6,544	834
1966	6,840	4,926	3,236	1,989	811	13,312	7,904	2,730	1,055	3,241	413	428	4,040	851
1967	7,230	5,145	4,083	2,069	789	14,466	1,271	2,746	1,126	3,000	1,490	1,209	3,631	866
1968	7,476	5,413	4,604	2,169	827	8,006	1,294	2,835	1,221	2,804	1,951	1,537	3,238	882
1969	7,732	5,784	5,199	2,307	905	7,350	4,993	2,979	1,357	2,636	2,412	1,866	2,861	897
1970	7,962	5,835	5,612	2,409	1,726	10,675	6,692	2,953	1,379	2,762	2,872	2,194	2,500	913
1971	8,158	5,831	6,221	2,444	1,617	11,200	6,977	2,915	1,401	2,509	3,705	2,797	2,194	913
1972	8,216	5,954	6,082	2,518	1,337	8,006	1,398	3,146	1,455	3,048	3,400	2,603	3,001	929
1973	8,113	6,238	4,151	2,619	884	2,691	1,418	2,927	1,508	1,709	758	613	1,564	996
1974	9,903	6,723	6,685	2,809	611	3,084	1,450	3,087	1,574	1,822	4,080	3,066	1,870	1,126
1975	10,358	7,112	5,851	2,948	487	1,411	1,483	3,681	1,628	3,756	2,724	2,159	4,215	1,226
1976	11,617	7,444	7,789	3,026	554	250	1,520	3,783	1,757	3,663	5,291	4,040	4,013	1,310
1977	12,423	7,869	7,103	3,034	339	0	1,552	3,675	1,753	3,045	4,302	3,291	3,344	1,446
1978	12,883	8,900	7,552	3,430	477	0	1,573	4,116	2,132	2,841	4,101	3,134	3,021	1,501
1979	7,920	7,381	8,476	4,876	192	0	1,598	4,172	3,127	2,316	5,789	4,355	2,507	1,458
1980	7,276	6,962	6,853	4,810	58	289	1,659	4,150	3,108	2,491	3,907	2,987	2,847	1,418
1981	8,076	8,300	7,379	5,281	128	198	1,843	3,941	3,556	2,973	1,788	3,154	3,021	1,627
1982	9,039	8,685	8,515	5,731	1,742	200	1,881	3,859	3,618	2,443	2,579	4,154	2,388	1,773
1983	11,636	7,979	9,782	4,842	1,703	200	1,904	2,156	3,646	2,261	5,177	5,448	2,254	1,762
1984	7,257	9,159	10,975	5,505	1,970	300	1,918	3,766	3,195	1,149	7,169	6,841	1,874	617
1985	4,653	10,502	9,920	7,940	1,954	250	1,941	4,874	5,388	1,350	5,012	4,788	1,784	1,813
1986	8,245	11,215	9,130	8,281	1,985	300	1,985	4,804	4,933	2,829	4,021	3,873	2,378	1,324
1987	9,871	12,756	10,745	8,864	1,626	250	2,026	5,337	5,954	2,055	4,796	4,616	2,000	1,175
1988	9,814	13,529	12,119	9,345	3,151	0	2,035	5,939	6,417	1,219	6,058	5,796	1,718	883
1989	11,205	14,271	14,771	9,972	1,886	0	2,050	6,286	6,845	955	8,460	7,993	1,732	900
1990	10,807	13,819	14,566	9,593	2,108	0	2,076	5,258	6,751	683	8,568	8,084	1,426	798
1991	12,592	14,262	13,892	10,905	3,939	0	2,222	6,043	6,689	962	7,241	6,869	1,461	3,789
1992	4,282	13,880	14,118	11,396	2,057	0	2,252	6,907	7,689	1,431	7,278	6,853	1,853	8,389
1993	4,351	15,527	16,120	13,998	3,670	0	2,290	10,282	9,104	1,494	9,087	8,568	1,596	10,331
1994	4,413	15,597	12,807	13,743	8,881	0	2,400	8,454	8,836	2,860	5,240	5,054	1,312	9,953
1995	6,048	8,002	10,590	10,689	13,903	0	2,714	5,557	6,249	4,453	5,280	5,025	1,433	6,744
1996	3,304	6,959	10,775	10,846	12,869	0	2,677	4,861	6,937	3,803	4,457	4,268	1,357	5,395
1997	4,332	9,210	11,194	11,908	14,271	0	2,805	5,768	7,411	4,462	4,953	4,797	1,455	7,127
1998	8,591	10,366	9,768	10,763	15,135	0	2,780	2,782	7,503	4,892	4,162	4,041	1,182	6,036
1999	5,285	8,945	9,776	11,169	19,075	0	2,875	3,087	7,613	7,697	3,279	3,169	1,213	7,152
2000	7,816	8,723	9,954	5,801	20,922	0	2,908	2,026	6,018	9,511	5,804	5,533	1,078	2,341
2001	8,067	8,642	7,479	7,092	22,351	0	2,964	2,348	5,110	9,950	4,216	4,106	1,222	1,494
2002	12,019	8,905	7,572	6,787	22,496	0	2,963	2,195	4,929	12,325	4,721	4,555	1,442	465
2003	13,971	7,560	7,387	6,659	25,394	0	3,007	2,224	3,148	10,034	4,388	4,256	1,553	853
2004	10,414	7,112	7,091	6,134	20,567	0	2,859	2,256	3,786	11,891	4,728	4,465	1,423	970
2005	9,687	8,106	5,244	6,587	17,300	0	2,832	1,983	4,484	8,327	2,520	2,439	1,455	1,459
2006	11,065	6,436	5,277	6,846	15,546	0	3,132	2,222	4,805	7,813	2,541	2,585	1,239	1,594
2007	11,631	7,836	5,704	6,853	7,891	0	2,776	1,772	5,076	3,650	2,760	2,838	1,192	1,606
2008	13,772	3,907	5,815	5,713	9,976	0	2,781	2,680	4,150	4,580	3,316	3,367	1,284	2,074
2009	12,487	2,983	6,990	5,222	9,879	0	2,786	2,663	2,750	4,578	3,433	3,497	1,306	1,853
2010	11,917	3,593	6,084	5,818	11,030	0	2,807	2,428	2,944	4,842	3,079	3,118	1,150	1,184

1: *Rastrelliger kanagurta*; 2: *Scomberomorus commerson*; 3: Carangidae; 4: Lethrinidae; 5: Leiognathidae; 6: Engraulidae; 7: Clupeidae; 8: Lutjanidae; 9: Serranidae; 10: Synodontidae; 11: *Etrumeus sadina*; 12: *Decapterus* spp.; 13: *Leiognathus berbis*; 14: Carcharhinidae

A4 continued

Year	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1950	292	341	317	854	296	541	0	374	27	773	0	0	336	318
1951	294	346	321	863	305	541	0	380	27	774	0	0	336	324
1952	296	352	327	872	313	541	0	386	27	775	0	0	337	330
1953	298	357	333	881	321	541	0	394	27	775	0	0	337	338
1954	300	363	340	892	328	554	0	402	27	784	0	0	345	345
1955	303	370	330	903	335	571	0	389	27	794	0	0	353	336
1956	305	348	338	914	170	587	0	399	27	802	0	0	361	343
1957	308	508	346	926	1,105	604	0	409	27	811	0	0	369	352
1958	310	527	353	954	1,165	620	0	419	27	820	0	0	377	361
1959	313	537	362	966	1,169	636	0	430	27	829	0	0	385	371
1960	2,629	443	376	1,061	609	653	0	441	27	838	0	0	393	381
1961	3,756	584	397	1,274	1,351	669	0	452	27	847	0	0	400	391
1962	7,616	808	411	1,365	2,488	686	0	463	27	856	0	0	409	401
1963	7,368	1,030	423	1,417	3,571	702	0	475	27	865	0	0	417	412
1964	2,524	1,251	428	1,347	4,602	633	0	486	27	831	0	0	379	422
1965	2,163	1,297	437	1,375	4,674	726	0	497	27	1,441	0	0	431	435
1966	2,634	946	446	1,373	2,886	772	0	507	27	1,680	0	0	456	441
1967	1,144	876	453	1,296	2,593	830	0	516	27	3,748	0	0	494	529
1968	1,448	841	462	1,356	2,313	904	0	525	27	6,134	0	0	541	538
1969	1,752	808	472	1,443	2,044	1,008	0	534	27	2,602	0	0	607	466
1970	2,058	1,741	506	1,449	1,786	1,008	347	543	27	2,207	0	0	613	479
1971	2,593	1,648	503	1,430	1,567	1,008	328	543	65	3,009	0	0	621	480
1972	2,399	1,537	502	1,418	2,144	1,032	237	553	103	1,828	0	0	631	569
1973	707	970	521	1,347	1,117	1,057	117	593	142	1,148	0	0	618	601
1974	2,837	928	578	1,257	1,336	1,081	81	671	180	1,268	0	0	664	665
1975	1,969	1,267	625	1,243	3,010	1,105	49	730	218	818	0	0	664	714
1976	3,613	1,271	667	1,259	2,867	1,129	55	780	357	914	0	0	703	750
1977	2,982	1,210	731	1,169	2,389	1,129	75	861	496	826	0	0	692	821
1978	2,853	1,300	761	1,146	2,158	1,405	121	894	635	1,030	0	0	847	848
1979	3,937	1,144	1,397	1,924	1,791	2,260	2	1,027	774	947	0	583	771	96
1980	2,731	1,279	1,359	1,877	2,033	2,141	0	999	913	865	0	567	694	71
1981	3,365	1,330	1,557	2,047	2,158	2,264	3	1,146	1,172	1,118	0	651	926	94
1982	3,560	1,514	1,697	2,093	1,706	2,310	7	1,248	1,298	1,128	0	709	963	76
1983	5,356	1,378	672	1,321	1,610	1,841	454	1,062	1,425	1,065	0	0	1,164	75
1984	1,452	2,080	1,615	2,447	1,339	1,611	7	656	1,551	773	3,171	0	1,260	65
1985	1,086	2,078	1,786	1,775	1,274	1,637	1,519	1,247	1,678	511	2,217	1,657	1,883	73
1986	917	2,064	1,352	3,321	1,699	977	1,579	998	1,746	528	1,779	1,717	1,985	69
1987	1,050	1,808	1,508	1,593	1,429	1,179	1,116	816	1,907	648	2,122	3,613	2,502	473
1988	1,264	2,308	1,423	1,581	1,227	1,293	2,202	1,198	2,067	682	2,680	3,761	2,616	419
1989	1,673	1,943	1,925	1,567	1,237	1,878	3,652	1,652	2,228	694	3,742	3,561	2,684	1,263
1990	1,690	1,932	2,260	1,826	1,018	2,322	2,461	1,950	2,389	712	3,790	2,851	2,468	2,072
1991	1,463	2,507	2,599	1,863	1,044	1,423	2,754	3,189	2,550	715	3,203	4,674	2,484	2,285
1992	1,468	1,829	3,742	1,461	1,324	2,574	4,973	3,286	2,710	717	3,219	4,540	2,523	2,295
1993	1,773	2,415	5,235	1,408	1,140	3,484	346	3,282	2,871	756	4,019	8,686	2,690	861
1994	1,116	3,257	4,373	1,389	937	4,301	681	3,211	3,032	754	2,318	6,733	2,694	1,855
1995	1,101	4,735	3,856	1,325	1,023	3,764	1,017	2,842	3,193	468	2,335	4,826	1,053	1,974
1996	978	3,993	2,923	1,433	969	2,999	1,353	2,678	3,353	484	1,971	3,684	1,079	1,494
1997	1,060	3,973	3,597	1,304	1,039	4,079	1,688	3,805	3,514	500	2,191	5,350	1,235	2,589
1998	920	3,581	3,791	3,169	844	2,896	6,018	3,067	3,675	502	1,841	0	1,188	2,044
1999	760	3,421	3,605	2,195	866	4,149	7,079	3,649	3,836	685	1,450	0	1,527	2,239
2000	1,171	4,319	2,060	1,499	770	2,387	4,781	1,556	4,001	761	2,567	0	1,131	2,218
2001	913	4,289	2,420	1,999	873	1,373	5,821	1,637	902	786	1,865	0	468	1,494
2002	1,426	3,303	2,244	1,698	1,030	1,267	6,844	1,834	1,340	784	2,088	0	535	1,047
2003	1,678	4,284	4,253	1,415	1,109	545	5,507	1,777	3,616	743	1,941	0	996	1,752
2004	2,443	3,010	2,953	1,543	1,017	521	4,869	1,673	6,422	556	2,091	0	435	1,107
2005	1,923	3,149	2,809	1,787	1,039	362	3,508	1,796	1,468	674	1,114	0	644	1,911
2006	603	3,370	3,239	1,568	885	728	2,803	1,621	1,370	918	1,124	0	466	1,600
2007	633	2,636	2,834	1,637	851	462	2,331	1,815	1,407	968	1,221	0	576	1,974
2008	737	1,985	2,591	1,653	917	2,936	1,624	1,116	271	959	1,467	0	604	2,660
2009	1,050	2,641	569	1,546	933	1,751	1,639	3,540	144	1,020	1,519	0	500	2,728
2010	686	1,629	718	1,431	821	1,345	1,740	2,120	74	1,181	1,362	0	563	1,875

15: *Sardinella* spp.; 16: Penaeidae; 17: Sphyraenidae; 18: Mugilidae; 19: *Champsodon capensis*; 20: Scombridae; 21: *Nemipterus* spp.; 22: *Trachurus* spp.; 23: Holothuroidea; 24: Elasmobranchii; 25: *Scomber japonicus*; 26: *Chrysoblephus* spp.; 27: *Sphyraena* spp.; 28: *Euthynnus affinis*

A4 continued

Year	29	30	31	32	33	34	35	36	37	38	39	40	41	42
1950	305	178	89	369	594	1,365	65	118	374	150	0	105	446	79
1951	308	183	90	374	594	1,033	67	122	376	150	0	106	446	81
1952	312	188	92	379	594	1,530	68	125	378	150	0	108	446	83
1953	316	192	94	385	594	1,364	70	128	380	150	0	110	446	86
1954	320	197	97	391	609	1,159	72	131	391	150	0	112	446	87
1955	314	201	95	397	624	1,097	74	134	403	150	0	109	446	89
1956	319	102	90	401	639	1,129	54	68	410	150	0	112	446	45
1957	325	663	134	408	654	750	178	442	420	150	0	115	446	295
1958	330	699	139	414	669	761	173	466	431	150	0	117	446	311
1959	336	702	143	421	683	1,070	178	468	442	150	0	120	446	312
1960	342	365	119	422	698	848	198	244	453	150	0	123	521	162
1961	348	811	158	427	713	781	519	541	464	150	0	126	521	360
1962	354	1,493	220	435	728	932	772	995	474	150	0	130	446	663
1963	361	2,142	281	440	743	1,083	988	1,428	485	150	0	133	446	952
1964	367	2,761	343	445	660	1,234	1,083	1,841	436	150	0	136	446	1,227
1965	373	2,805	355	463	762	1,385	1,108	1,870	508	150	0	139	446	1,247
1966	378	1,732	262	453	811	1,536	848	1,154	532	150	0	142	744	770
1967	383	1,556	250	424	873	1,270	797	1,037	572	150	0	144	744	692
1968	388	1,388	239	442	953	866	784	925	623	150	0	147	744	617
1969	393	1,226	228	463	1,071	1,130	794	817	697	150	0	149	744	545
1970	398	1,072	232	507	1,069	1,542	713	714	707	150	130	152	744	476
1971	398	940	222	526	1,067	751	653	627	708	150	123	152	744	418
1972	403	1,286	259	545	1,094	1,073	750	857	726	150	89	155	744	572
1973	423	670	192	564	1,120	931	486	447	744	150	44	166	744	298
1974	463	801	209	600	1,146	725	436	534	762	150	30	188	744	356
1975	493	1,806	326	620	1,172	276	757	1,204	780	150	19	204	744	803
1976	518	1,720	323	631	1,197	442	739	1,147	785	150	20	218	744	764
1977	560	1,433	297	652	1,195	141	553	956	786	0	28	241	302	637
1978	576	1,295	289	671	1,509	257	489	863	979	0	45	250	308	575
1979	538	1,075	264	692	1,322	1,223	441	716	867	0	76	540	313	478
1980	510	1,220	275	710	1,206	520	576	813	800	0	74	526	445	542
1981	569	1,295	344	733	1,031	209	478	863	741	0	85	603	395	575
1982	624	1,023	329	743	1,029	345	422	682	747	0	110	657	455	455
1983	81	966	384	761	688	114	475	644	574	0	36	56	838	429
1984	557	803	528	798	530	172	457	536	413	0	53	252	717	357
1985	959	764	513	839	484	298	465	510	322	0	289	1,245	597	340
1986	958	1,019	589	859	503	81	448	679	322	0	288	733	603	453
1987	652	857	727	882	639	543	369	572	384	0	135	526	510	381
1988	1,184	736	549	886	689	601	309	491	403	0	167	478	417	327
1989	1,413	742	686	923	687	1,398	336	495	422	0	216	491	325	330
1990	1,446	611	663	939	635	115	266	407	412	0	197	440	53	272
1991	2,925	626	686	938	634	115	314	417	372	0	550	760	53	278
1992	2,081	794	812	951	633	442	397	529	352	0	919	1,262	106	353
1993	1,846	684	927	973	682	613	371	456	397	0	1,325	1,965	100	304
1994	3,742	562	1,049	984	681	277	716	375	393	0	2,056	1,927	98	250
1995	4,247	614	1,019	1,169	370	396	998	409	626	0	3,091	1,700	113	273
1996	3,321	581	1,072	1,224	368	319	494	388	500	0	2,492	1,383	255	258
1997	4,952	623	1,214	1,280	415	600	724	416	567	0	3,166	1,786	57	277
1998	3,219	507	1,239	1,268	413	750	734	338	544	3	4,636	1,854	39	225
1999	4,934	520	1,432	1,263	365	379	2,378	347	569	0	3,859	1,721	153	231
2000	299	462	1,250	923	351	500	2,133	308	313	115	577	204	157	205
2001	404	524	1,397	978	384	417	1,632	349	422	792	469	1,248	165	233
2002	435	618	1,188	918	357	335	1,239	412	397	4,439	394	84	154	275
2003	611	665	2,748	940	339	364	1,168	444	324	2,786	182	113	56	296
2004	505	610	4,300	953	198	336	1,361	407	198	3,732	369	90	98	271
2005	492	624	4,042	986	216	367	1,280	416	339	2,732	343	222	76	277
2006	760	531	4,063	992	185	301	1,590	354	373	2,375	658	373	93	236
2007	648	511	1,247	987	259	280	658	340	322	2,375	400	307	105	227
2008	185	550	1,552	1,027	261	312	641	367	472	2,375	819	117	108	245
2009	122	560	1,520	1,022	262	42	789	373	385	2,375	383	475	125	249
2010	95	493	1,541	1,032	263	13	825	329	357	2,375	1,385	36	112	219

29: *Scomberoides* spp.; 30: *Equulites elongatus*; 31: Sepiidae; 32: Sparidae; 33: *Valamugil seheli*; 34: *Trochus* spp.; 35: Nemipteridae; 36: *Pseudorhombus arsius*; 37: Scaridae; 38: Holothuriidae; 39: Haemulidae; 40: *Rachycentron canadum*; 41: Lutjanidae <Snappers>; 42: *Charybdis hellerii*

A4 continued

Year	43	44	45	46	47	48	49	50	51	52	53	54	55
1950	9	21	17	5	0	67	170	314	209	0	39	39	0
1951	9	21	18	5	0	83	172	319	212	0	41	41	0
1952	9	21	19	5	0	98	174	325	216	0	42	42	0
1953	9	22	20	5	0	113	176	331	220	0	43	43	0
1954	9	22	21	5	0	128	178	338	225	0	44	44	0
1955	9	22	21	5	0	143	181	327	218	0	45	45	0
1956	9	140	12	5	0	127	183	336	224	0	23	23	0
1957	9	152	70	5	0	140	186	344	229	0	147	147	0
1958	22	164	77	0	0	152	188	353	235	0	155	155	0
1959	22	176	79	0	0	164	191	361	241	0	156	156	0
1960	41	229	47	0	0	176	191	370	247	0	81	81	0
1961	81	255	104	0	0	188	193	380	253	0	180	180	0
1962	96	259	187	0	0	201	196	390	259	0	332	332	0
1963	105	278	269	0	0	213	199	399	266	0	476	476	0
1964	89	305	348	0	0	225	211	409	272	0	614	614	0
1965	89	28	361	0	0	294	216	418	278	0	623	623	0
1966	92	360	233	0	0	249	214	426	284	0	385	385	1
1967	89	654	215	0	0	261	228	434	289	0	346	346	1
1968	93	559	198	0	0	274	249	441	294	0	308	308	1
1969	102	444	182	0	0	286	270	449	299	0	272	272	1
1970	195	30	177	58	58	369	293	457	304	0	238	238	1
1971	183	31	160	55	55	384	316	457	304	0	209	209	1
1972	151	31	208	39	39	400	309	465	310	0	286	286	1
1973	100	32	114	20	20	415	241	498	332	0	149	149	1
1974	69	33	131	13	13	430	329	564	375	0	178	178	1
1975	55	34	287	8	8	445	294	614	409	0	401	401	1
1976	54	399	281	9	14	371	361	656	437	0	382	382	1
1977	38	403	237	22	13	383	337	724	482	0	319	319	1
1978	43	423	222	29	26	395	332	752	500	0	288	288	1
1979	10	421	185	71	7	408	379	1	0	0	239	239	1
1980	7	477	173	73	0	406	329	1	0	0	271	271	1
1981	0	453	178	80	8	496	242	2	0	0	288	288	2
1982	0	581	321	88	112	399	255	3	0	0	227	227	197
1983	0	581	174	126	110	364	319	6	0	0	215	215	195
1984	0	544	145	21	127	358	232	7	0	0	179	179	228
1985	0	233	161	91	126	526	233	10	0	0	170	170	226
1986	0	267	226	722	128	448	233	11	1	0	226	226	228
1987	0	293	263	663	105	388	233	14	1	0	191	191	188
1988	0	288	416	546	203	367	233	12	2	0	164	164	354
1989	0	313	373	444	122	482	233	15	2	0	165	165	213
1990	0	291	345	273	136	609	232	13	2	1	136	136	232
1991	0	378	408	747	254	319	230	14	2	1	139	139	457
1992	0	358	638	1,923	133	165	229	16	2	3	176	176	247
1993	171	367	547	2,267	237	311	227	16	2	3	152	152	258
1994	467	468	524	1,720	502	284	224	17	3	3	125	125	551
1995	692	1,091	687	2,719	795	210	203	21	115	3	136	136	896
1996	736	785	608	9	800	266	219	18	65	1	129	129	733
1997	859	905	602	2	918	314	216	28	76	10	139	139	779
1998	1,069	749	534	1,388	951	175	212	22	82	8	113	113	653
1999	1,622	736	637	504	1,016	81	202	26	106	7	116	116	542
2000	1,975	990	676	1,230	1,059	90	183	26	89	1,203	103	103	395
2001	2,141	718	743	753	1,176	119	196	27	115	1,264	116	116	377
2002	2,102	644	849	472	1,338	115	171	26	116	1,066	137	137	436
2003	2,395	990	977	412	1,412	111	167	25	211	1,118	148	148	469
2004	1,986	601	854	745	1,134	96	164	20	219	715	136	136	281
2005	1,495	655	809	215	996	122	175	101	147	1,020	139	139	455
2006	1,373	560	703	472	747	86	171	114	96	1,122	118	118	393
2007	488	468	503	235	492	65	163	135	205	1,202	113	113	399
2008	668	488	582	504	644	59	173	43	929	1,107	122	122	419
2009	688	620	562	149	610	61	164	46	1,036	1,287	124	124	420
2010	848	566	509	150	666	54	161	40	618	1,150	110	110	421

43: *Terapon* spp.; 44: Brachyura; 45: Mullidae; 46: Ariidae; 47: Trichiuridae; 48: *Epinephelus* spp.; 49: *Encrasicholina punctifer*; 50: Dasyatidae; 51: *Thunnus tonggol*; 52: *Lethrinus lentjan*; 53: *Clypeaster reticulatus*; 54: *Jacksonaster depressum*; 55: Balistidae

A4 continued

Year	56	57	58	59	60	61	62	63	64	65	66	67	68	69
1950	0	7	140	3	3	0	0	132	0	1	209	28	6	1,937
1951	0	7	141	3	3	0	0	132	0	1	212	28	6	2,072
1952	0	7	143	3	3	0	0	132	0	1	216	29	6	2,017
1953	0	7	145	3	3	0	0	132	0	1	220	30	6	2,051
1954	0	7	146	3	3	0	0	132	0	1	225	31	6	2,066
1955	0	7	148	3	3	0	0	132	0	1	218	31	6	2,062
1956	0	7	150	3	3	0	0	132	0	1	224	16	6	1,808
1957	0	7	152	3	3	0	0	132	0	1	229	103	7	3,071
1958	0	8	155	6	6	0	0	132	0	1	235	109	7	3,063
1959	0	8	157	6	6	0	0	132	0	1	241	109	7	3,074
1960	0	8	157	12	12	0	0	154	0	1	247	57	7	2,757
1961	0	8	158	23	23	0	0	154	0	1	253	126	7	4,469
1962	0	8	161	28	28	0	0	132	0	1	259	232	7	6,131
1963	0	8	163	30	30	0	0	132	0	1	266	333	7	7,487
1964	0	7	164	26	26	0	0	132	0	1	272	430	7	8,619
1965	0	9	169	25	25	0	0	132	0	1	278	436	8	8,930
1966	0	9	166	26	26	0	0	220	0	1	284	269	8	6,230
1967	0	10	155	25	25	0	0	220	0	1	289	242	9	6,038
1968	0	11	162	27	27	0	0	220	0	1	294	216	10	5,776
1969	0	12	169	29	29	0	0	220	0	1	299	191	11	6,488
1970	58	12	177	56	56	0	29	220	0	1	304	167	11	6,048
1971	55	12	178	52	52	0	27	220	0	1	304	146	11	5,788
1972	39	12	179	43	43	0	20	220	0	1	310	200	11	6,622
1973	20	13	179	29	29	0	10	220	0	1	332	104	11	4,275
1974	13	13	180	20	20	0	7	220	0	1	375	125	12	4,962
1975	8	13	180	16	16	0	4	220	0	1	409	281	12	7,274
1976	14	14	179	18	18	0	7	220	0	1	437	268	12	7,332
1977	13	14	180	11	11	0	6	86	0	1	482	223	12	6,293
1978	26	17	181	15	15	0	13	88	0	1	500	201	15	6,083
1979	7	15	183	6	6	0	3	90	0	1	0	167	13	8,016
1980	0	14	183	2	2	0	0	127	0	1	0	190	12	8,041
1981	8	34	185	4	4	0	4	113	0	3	0	201	30	8,867
1982	2	160	185	56	56	0	56	130	0	5	0	159	51	9,235
1983	2	190	182	55	55	0	55	239	0	9	0	150	88	8,007
1984	2	222	188	64	64	0	64	205	0	11	0	125	108	9,116
1985	4	253	192	63	63	0	63	171	0	15	0	119	147	7,585
1986	6	272	193	64	64	0	64	172	0	17	0	159	171	7,865
1987	7	285	195	52	52	0	52	146	0	22	0	133	214	9,695
1988	9	361	196	102	102	0	102	119	0	18	0	115	182	10,127
1989	11	311	197	61	61	0	61	92	0	23	0	115	228	9,436
1990	13	301	197	68	68	0	68	43	0	20	0	95	200	9,428
1991	3	438	196	127	127	0	127	43	0	22	0	97	213	11,440
1992	3	336	194	66	66	0	66	86	0	25	0	124	240	13,045
1993	101	347	192	118	118	0	118	81	0	25	0	106	243	14,751
1994	199	518	192	307	286	0	251	79	0	25	0	87	249	15,115
1995	296	788	177	465	448	0	397	90	0	797	0	96	311	15,899
1996	394	639	190	415	415	3	400	195	0	695	0	90	262	13,164
1997	492	820	187	461	460	3	459	98	0	1,012	0	97	418	16,751
1998	593	659	182	488	488	2	476	84	0	598	0	79	326	15,899
1999	724	642	176	636	615	0	508	213	0	636	0	81	311	17,000
2000	851	256	159	679	674	282	530	345	721	614	0	72	311	25,473
2001	979	197	170	729	716	670	588	103	636	669	0	81	327	24,703
2002	1,107	363	146	724	722	817	669	228	896	623	1	96	310	25,714
2003	1,161	295	133	816	816	339	706	226	801	593	1	104	299	23,311
2004	978	163	137	665	663	575	567	115	596	272	0	95	211	21,975
2005	769	228	147	558	558	958	498	47	855	263	0	97	218	21,059
2006	529	218	141	502	501	1,108	373	87	801	306	0	83	250	22,375
2007	267	234	135	254	254	1,052	246	59	847	299	0	79	545	19,364
2008	418	236	142	322	322	1,006	322	11	824	293	1	86	449	19,988
2009	383	239	143	319	319	1,160	305	16	860	295	1	87	451	21,975
2010	439	239	136	356	356	1,104	333	6	718	296	1	77	452	21,841

56: Gerreidae; 57: *Gerres* spp.; 58: Siganidae; 59: Platycephalidae; 60: Soleidae; 61: *Sphyraena barracuda*; 62: Tetraodontidae; 63: Serranidae; 64: *Penaeus semisulcatus*; 65: *Siganus* spp.; 66: Rhinobatidae; 67: *Callyspongia monilata*; 68: *Netuma thalassina*; 69: Others