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From bonito to anchovy: a reconstruction of Turkey's marine fisheries catches (1950-2010)

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Abstract

Turkey's marine fisheries catches were estimated for the 1950-2010 time period using a reconstruction approach, which estimated all fisheries removals, including unreported landings, recreational landings and discards. We added these estimates to the 'official' data, as reported in TURKSTAT, which are also available from the United Nations' Food and Agriculture Organization (FAO). The total reconstructed catch for the 1950-2010 time period (inclusive of the reported data) is approximately 30 million t, or 63% more than the 18.4 million t of reported data. This added 11.6 million t to the reported data, consisting of 7.4 million t of unreported landings, nearly 2.6 million t of discards, and 1.45 million t of recreational catches and 1.15 million t of subsistence catches. In 2010, total reported marine landings for Turkey were 445,617 t and the total reconstructed catch was 726,272 t, or 63% more than the reported data. The main unreported taxon by tonnage was European anchovy (*Engraulis encrasicolus*) due to its sheer high proportion of catch. The major reasons for underreporting include a general distrust fishers have towards the system combined with inefficient fisheries monitoring and surveillance capabilities. Accounting for all fisheries components is crucial in understanding the development of fisheries resources, improving management, and reducing threats to the domestic food security of Turkey.

Keywords: Turkey, fisheries, statistics, discards, recreational, unreported.

Introduction

Within the last few decades, global fishing effort has severely extended its reach and has dramatically altered the dynamics of marine ecosystems (Swartz *et al.*, 2010). Given the growing emphasis on ecosystem-based management, it is important to have a comprehensive understanding of total fishery removals in order to assess long-term trends and make more informed decisions regarding resource use.

Turkey is a country spanning Europe and west Asia, whose shoreline touches three major seas: the Black Sea, the Aegean Sea and the Levantine Sea in the eastern Mediterranean, and one territorial sea, the Sea of Marmara (Fig. 1).

The United Nations, Food and Agriculture Organization (FAO) includes these areas in FAO statistical area 37 (Mediterranean and Black Seas), which is further divided into sub-areas: 37.3.1 ('Aegean Sea'); 37.3.2 (eastern portion of the Mediterranean Sea**,** here referred to as the 'Levantine Sea'); 37.4 ('Black Sea') which is further divided into 37.4.1 ('Marmara Sea'), 37.4.2 (the 'Black Sea' proper), and 37.4.3 (the 'Sea of Azov', not discussed here).

Study Area

The Black Sea, called *Karadeniz* in Turkish, is one of the youngest seas on the planet. It was an enclosed freshwater lake until sea levels rose around the world (5,000-8,000 years ago), and water from the Mediterranean Sea inundated the depression that is now the bottom of the Black Sea. At present, it has a low average salinity of 18 psu. There are many large rivers that flow into the Black Sea (such as the Danube), but only one way for the water to exit, and that is southwards via the Bosphorus Strait.

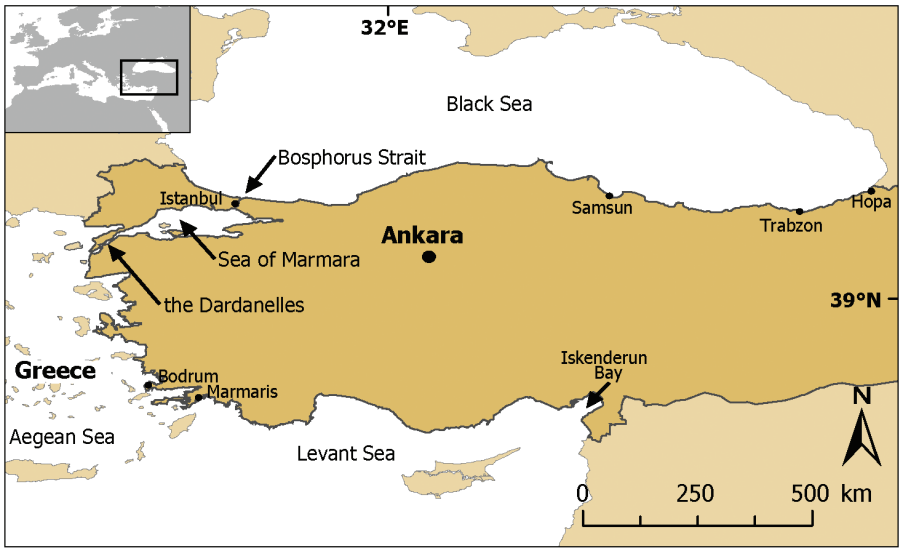

Fig. 1: Turkey and its four surrounding seas: the Black Sea, the Sea of Marmara, the Aegean Sea and the Levantine Sea. Also shown are cities and straits discussed in the paper.

The Bosphorus Strait (*İstanbul Bogazi* in Turkish) connects the Black Sea with the Sea of Marmara. It is a natural strait, which connects 'East' to 'West', but also can be seen as separating Europe from Asia, with Asia in the 'East' and Europe in the 'West'. Turkey, whose territory covers both sides of the Bosphorus is thus, with Russia, the only country that straddles both Europe and Asia. The 30 km long Bosphorus has always been of strategic and economic interest, due to its unique position on an important maritime trade route. The Bosphorus is the world's most narrow strait, and is used intensely for shipping. The city of İstanbul, bustling with 17 million inhabitants, spans the southern half of the strait. The Bosphorus most likely also formed the same time as the Black Sea, between 5,000 and 8,000 years ago, due to rising sea levels (Zaitsev & Mamaev, 1997).

The Bosphorus connects southwards to the Sea of Marmara, which is linked to the Aegean Sea – a part of the Mediterranean - by the Dardanelles (also called the Çanakkale Strait). The south-western end of the Dardanelles is the southern boundary for the Sea of Marmara; from there the Aegean Sea starts and encompasses the west coast of Turkey to the Turkish city of Marmaris, on Turkey's south-western coast. Finally, the southern coast of Turkey, in the easternmost part of the Mediterranean, also called the 'Levantine Sea', which is roughly parallel to the Greek Dodecanese Islands (Fig. 1). The Turkish portion of this sea spans from the city of Marmaris in the west to the Syrian border in the east.

Thus, for the purpose of documenting Turkey's marine fisheries catches, we will distinguish four different marine regions of Turkey: (1) the Black Sea coast, from which about 75% of Turkey's total fishery landings originate; (2) the Sea of Marmara, (which includes the Dardanelles, and also İstanbul and the Bosphorus Strait, which is the site of a large recreational/subsistence fishery); (3) the Aegean Sea to the city of Marmaris; (4) and the Levantine Sea. We will also briefly discuss fishing in waters outside the national jurisdiction of Turkey. This study focuses only on wild marine fish and invertebrate capture fisheries.

For a detailed introduction to the main commercially fished species in Turkey, please see the supplementary guide available online. An extensive detailed technical report of this reconstruction will be published in 2013 as a University of British Columbia, Fisheries Centre Research Report (FCRR), available at [http://www.fisheries.ubc.ca/publications/fcrrs].

Fishing history

The first detailed description of Turkish fish and fisheries is *Balık ve Balıkcılık* (Deveciyan, 1915). In this book, republished in 1923 and 2006, species composition in relation to their sales was recorded from 1909 to 1923 from the İstanbul fish market, including weight and price. Mean annual marine catches were approximately 9,500 metric tonnes (t) annually, estimated from the İstanbul fish market. The fish most abundantly caught and sold during this period were bonito (*Sarda sarda*) and Atlantic mackerel (*Scomber scombrus*). Please see Appendix Tables 1a (fish) and 1b (invertebrates) for a complete list of taxa used in this study, which includes the current English names (validated in Fishbase, www.fishbase.org), the scientific names, and the Turkish names.

In the 1930s, total annual national reported catches were between 25,000 and 30,000 t (Üstündağ, 2010). The main species caught at this time throughout the Aegean, Marmara and Levantine Seas were primarily bonito and Atlantic mackerel, and secondly, anchovy, European

pilchard (*Sardina pilchardus*) and turbot (*Scopthalmus maximus*). Bonito was such a staple, that in 1937, they comprised 18,000 of Turkey's 26,000 t of marine landings (Üstündağ, 2010), or over two thirds of total catches. Anchovy was the most important catch from the Black Sea region at this time; one author estimates annual anchovy catches at around 1,500 t from one among many cities along the Black Sea coast (Sayilir & Babuçoğlu, 1972). Excess anchovy catches from years with high abundance were utilized as manure and fertilizer. Catch capacity for all species was under-developed, as fishing gear was very simple; it consisted of rowboats, fish traps and cotton fishing nets (Knudsen, 1995). According to an early fisheries report from İstanbul from the 1940s (İstanbul Belediyesi, undated), about half of the total marine landings from 1944-1948 consisted of bonito. In the 1950s, coastal small-scale fishing typically involved nets and lines, purse seining for anchovy, beach-netting and the shooting of dolphins [Delphinidae; for blubber, see supplementary guide for more information on the past dolphin fishery] (Knudsen, 2009).

From 1953-1958, total national reported fishery landings varied between 100,000 and 110,000 t · year^{-1} and peaked in 1956, with 140,000 t (Üstündağ, 2010). In this period, fisheries statistics were notoriously inaccurate since reported landings were derived from estimates based on sales records of some fish markets, and after that they were based on sub-sampling surveys, rule of thumb and 'guesstimates' as described in the section on 'Unreported and under-reported catches'.

Many fisheries soon became over-exploited due to the development of industrial practices (Swartz *et al.*, 2010), which initially developed in parts of Turkey in the 1950s, such as in Iskenderun Bay where a drop in catch per unit of effort (CPUE) was noticed along with the increasing effort by the bottom trawling fleet (Gücü & Bingel, 2011), although the majority of industrial effort commenced in the 1970s and 1980s. With the aid of new technologies, subsidies and tax credits to the fishing industry, the rapid growth of fishing capacity was encouraged. Due to overfishing in the early 1960s and 1970s, the structure of catches shifted significantly from larger, valuable fish species (bonito, Atlantic mackerel, large bluefish *Pomatomus saltatrix*) to smaller, less valuable ones (such as anchovy and sprat *Sprattus sprattus,* see supplementary guide for further details on each of these fisheries). Consequently, fishing fleets started targeting smaller species, resulting in by-catch of the larger, less abundant fish species (BSERP, 2007).

The late 1970s saw a huge increase of anchovy catches, with demand following suit in the 1980s. This was largely influenced by the economy of Turkey changing from a state-led to a market-based economy during the 1980s (Zengin & Knudsen, 2006). The year with the highest reported marine fish and invertebrate catches in Turkey was 1988 with 623,404 t, not 676,000 t, as stated in "The present status of fisheries in Turkey" (Harlioğlu, 2011). State-led investments in the fisheries increased dramatically during this time, for example, credit to the fisheries sector totalled around U.S.$4 million in 1976 and peaked at around U.S.$30 million annually by the late 1980s (Knudsen, 2009). Many anchovy processing plants were quickly constructed along the Black Sea coast to deal with this 'new', highly abundant fish resource, many of which received a 40% investment grant from the government (Knudsen, 2009). In 1983, there were just two anchovy factories, which increased to 25 by 1995 (Üstündağ, 2010).

The late 1980s saw a collapse of fish catches in the Black Sea, which decreased from almost 500,000 t in 1988 to 190,000 t by 1991 (TÜİK, 1988-1991), due to the overcapacity of Turkish fishing vessels, increased eutrophication and also an alien jellyfish invasion (see supplementary guide for further details). This was deemed a national 'fishery crisis' that changed people's perception of the status of fisheries resources, which they began to regard as fragile, rather than inexhaustible. However, the crisis also resulted in a shift in target fisheries from small pelagics (purse seiners) to demersal fish (bottom trawlers) in the Black Sea (Knudsen, 2009), and then subsequently to a decline in catches of demersal fish species. Details of the anchovy collapse from the 'fishery crisis' are discussed in the 'anchovy' section in the supplementary guide.

Many bottom trawl vessels, after experiencing low catches throughout the 1990s, switched their target fishery again from demersal fish to small pelagics such as sprat. While more abundant yet much less valuable, they are not used for direct human consumption but rather for fish meal/oil production (European Commission, 2007; Zengin *et al.*, 2010).

Species composition has dramatically changed in the last fifty years. In the 1950s and 1960s, most fisheries landings were composed of larger, valuable species such as Atlantic bonito, Atlantic mackerel, bluefish (see supplementary guide for further details), grey mullet (Mugilidae), turbot, red mullet (*Mullus barbatus barbatus*), pike-perch (*Sander lucioperca*), and seabream (*Diplodus* spp.) (Hinrichson, 1998), and around 35% of total catches consisted of smaller forage fish such as anchovy or sprat. The situation is now reversed as most of the larger fish species have been removed from the system; while anchovy, sprat and pilchard together accounted for 78.5% of total fish catches in 2010 (TÜİK, 2010). Bluefin tuna (*Thunnus thynnus*) and Atlantic mackerel ceased their annual migrations to the Black Sea roughly 20-30 years ago (Knudsen *et al.*, 2007), but can still be found, albeit in drastically reduced numbers. This loss of biodiversity and especially top predators has substantially reduced the stability of the marine ecosystem. The amount of com-

monly caught commercially valuable species has also declined; for example in the 2000s, over 90% of the total catch consisted of only eight species; European anchovy, horse mackerel (*Trachurus* spp.), bonito, grey mullet, twaite shad (*Alosa fallax*), whiting (*Merlangius merlangus*), red mullet and turbot. This number decreased from 21 species in the 1980s (Harlioğlu, 2011) and 26 during 1960- 1970 (Zengin *et al.*, 1998).

Turkey shares the Mediterranean and Black Seas with many other countries, which poses challenges to the management of trans-boundary resources. Accurate baseline catch data are fundamental for assessing the current and future amounts and uses of fisheries resources. Publicly available national data sources and those provided to the United Nations' Food and Agriculture Organization (FAO), account only for a portion of what is removed from the marine environment (see section on unreported and under-reported catches). The aim of this study is to provide a time series of catches for all of Turkey's marine fisheries sectors and components since 1950. This will help provide the foundation necessary for sustainable management of this important national resource. The data are presented here by the four marine regions associated with Turkey's coastline, beginning with a brief synopsis of the fishing structure in each region. The methods and total reconstructed catches are then presented by region and then country as a whole. Turkish distant-water fisheries are only discussed for the Black Sea.

Black Sea

The Black Sea is thought to be named either for its great depths (over 2,200 meters) leading to its low visibility, an old connotation from the Ottoman language for either great or terrible (the latter possibly due to its roughness), or from ancient maps from the European steppe people because the north compass which points to the sea, was black (King, 2004). Aside from Turkey, Bulgaria, Romania, Ukraine, Russia and Georgia, also border the Black Sea. The uppermost 150 meters of the water column represent an area of great biological productivity, while the lower 90% of the basin, or depths below 100-150 m are naturally anoxic (very little or no dissolved oxygen), and have likely been anoxic since the Bosphorus (or possibly spillover from the Caspian Sea) inundated this basin. The influx of large amounts of freshwater from rivers (Danube, Dnieper, Dniester, etc.), raised the water level about 150 meters and created a lower density surface layer which inhibits mixing. The Bosphorus Strait has a two-layer flow: seawater enters from the Mediterranean along the bottom layer to the Black Sea, while brackish water at the surface flows into the Mediterranean.

During the 1980s, the anoxic layer, the largest in the world, increased due to massive agricultural runoff from the eastern bloc countries (Kideys, 2002) and due to increased eutrophication from the many European rivers that drain Europe, particularly the Danube, which drain into the Black Sea. Nutrient input levels have decreased since the mid-1980s and the ecosystem has been showing some signs of recovery since the early 1990s.

Another important feature of the Black Sea is the presence of a sharp thermocline; surface temperature is 15°C and decreases to 7°C in the mid-thermocline layer (Zengin, 2006). This thermocline layer exists in summer at depths of 40-70 m and is beneficial in enhancing the growth of many small pelagic species such as anchovy, sprat and whiting (Zengin, 2006). This thermocline is, in part, responsible for making this Large Marine Ecosystem (LME) so productive for small pelagics.

The fishing operations of the Black Sea are primarily industrial and operated by purse seines and pelagic trawlers. Demersal species in the Black Sea only occur to depths above the anoxic layer, due to the presence of H_2S gas, lower salinity and absence of oxygen levels (Zengin, 2006). The Black Sea previously hosted very healthy demersal and pelagic fish populations and was considered a highly productive ecosystem at all trophic levels until the mid-1980s, but conditions have rapidly deteriorated (Sahin *et al.*, 2009). There is an account of one large trap (or weir; *dalyan*) in operation in the Turkish Black Sea area in the 1840s that used to catch immense quantities of fish; as many as 20,000 bonito and 500 swordfish were often caught within 24 hours (Knudsen, 2004).

Major fisheries of the Black Sea include purse seining, trawling, set nets and dredging. The purse seine fleet began in Turkey in the early 1930s (Gücü, 2001). Since the 1950s, growth of this fleet accelerated due to technological advancements, state-sponsored credit and infrastructure improvements (Knudsen, 2003; 2009). Consequently, purse seines have dominated the fisheries of the Black Sea since the 1960s. Net size and engine power have continually increased. In 1998, a typical purse seiner had two 700 hp (or more) engines and carried two different nets each 1,000 fathoms long (1.8 km) (Knudsen, 2003). The industrial sector operates mainly in the Turkish portion of the Black Sea, although some boats will venture seasonally to Georgian waters and the Mediterranean Sea in order to turn a profit. Many Black Sea purse-seiners are actively involved in the bluefin tuna fishery in the Mediterranean, which is very profitable. Juvenile bluefin are caught in the eastern Mediterranean and sent to 'tuna ranches' where they are fattened for export to eastern markets (Stergiou *et al.*, 2009). Industrial fisheries can fish at sea for months at a time and use the following gear types for their target species: bottom trawls target whiting, red mullet, turbot, bluefish, horse mackerel, thornback ray (*Raja clavata*) and shark (Selachiimorpha); pelagic trawls target sprat; mid-water trawls target anchovy and sprat; and purse seines target

anchovy, horse mackerel, bonito, bluefish and large tuna species.

The small-scale fisheries operate closer to shore and use the following gear types for their target species: bottom gillnets target whiting, red mullet and turbot; surface gillnets target bonito, grey mullets, bluefish and garfish (*Belone belone*); and dredges target sea snail (*Rapana venosa*). Bottom trawling, despite being illegal in the eastern Black Sea, continues to occur (Knudsen, 2009). Although small-boat fishers oppose illegal trawling, corruption and bribes allow these destructive business practices to continue (Knudsen, 2009). A recent study on Atlantic horse mackerel *Trachurus trachurus* (Kalayci *et al.*, 2010), suggested that purse-seines and bottom trawls are the fishing methods which are the source of most undersize fish in markets. Many species of fish are caught as juveniles, before they have had a chance to grow and reproduce, thus leading to both growth and recruitment overfishing (Ricker, 1975; Pauly, 1984). The percentage of Atlantic horse mackerel caught under the minimum legal landing size (MLLS) of 13 cm was 61% by purse seine, 65% by bottom trawl, 10% by gillnet, 39% by midwater trawl and 20% by fishing line. These under-sized fish, are then either discarded or marketed illegally, and most likely not included in the catch data (V. Ünal, pers. obs.).The Black Sea coast had the lowest reported annual marine catches in 1968 with 82,245 t, and the highest in 1988 with 480,400 t. From a 2010 report (S. Bekişoğlu, unpublished data), during the 1967-2009 reporting period, the Black Sea was responsible for 77.5% of the catches of Turkey, although in terms of average productivity, the Black Sea was second to the Sea of Marmara, until recently. Illegal fishing in this sea has resulted in undersized fish being dominant in catches (i.e. growth overfishing). The dominant fishery catches from 1950-2010 in the Turkish Black Sea were anchovy, bonito, whiting, bluefish, horse mackerel and sprat while the important invertebrate landings were sea snail, cockle, and striped Venus clam.

Marmara Sea

Traditionally, the fisheries of this sea have mainly targeted pelagic and migratory species. Bottom trawling has been banned in the Sea of Marmara since 1971, but illegal bottom trawling for shrimp is prevalent to this day. Commercial fishing is technically banned during the summer months; however, before re-opening in 2010, 50 bottom trawlers were seen actively fishing (H.T. Çinarçiğil, pers. comm.). Consequently, many demersal stocks are over-exploited, and these overall catches are unknown. The shrimp fishing fleet consists of over 200 medium-sized boats, including illegal trawlers and beach seiners targeting deepwater rose-shrimp, *Parapenaeus longirostris* (Zengin & Akyol, 2009). Beam trawls are forbidden in the Aegean and Mediterranean Seas (ICES, 2006); although they are commonly used to catch shrimp and sea cucumber in the Sea of Marmara and sea snail in the Black Sea.

When bottom trawling became prohibited in 1971, bottom trawl nets were to be phased out eventually and replaced by alternative types of fishing gear. However, trawlers in fact stayed in the Marmara Sea as, once at sea, they were difficult to catch (A. Ç. Gücü, pers. comm.). The bottom trawl sector took off during the 1980s, when seafood demand increased and infrastructure improved (Knudsen *et al.*, 2010), until the mid-1990s, when catches and profits ceased to increase. Bottom trawl catches of shrimp in Marmara Sea where highest from 1988 to 1990, with 4,000-6,000 t landed annually (TÜİK, 1967-2010). Large-scale trawlers and the small-scale artisanal sector often compete for the same species, as trawlers operate close to shore. The low selectivity of bottom trawl gear has caused radical changes in the species composition of fish in the areas trawled. Fish that were once plentiful included swordfish, tuna, bluefish, mackerel and sea bream; however, now anchovy and sprat are the dominant catches.

Landings as a whole have declined in the Sea of Marmara. For instance, in 2006 total landings were 70,000 t and in 2010 total landings were 36,000 t, i.e. half the quantity. The Sea of Marmara's portion of Turkey's total marine catches has also been declining; in the late 1960s, it contributed 18.7% to the nation's total catches, but declined to 13.7% by 1980 and 8.8% by 2010. The Sea of Marmara's lowest reported landings (over the 1967- 2010 period) were in 1968, with 7,143 t, and highest in 1999 with 81,005 t. Overall, the Sea of Marmara is sick and its health is rapidly deteriorating, mainly due to pollution (notably, domestic waste), while declining fisheries are due to overfishing and illegal fishing [TUDAV, 2012. http://www.tudav.org/index.php?option=com_content&view=article&id=71:marmara-denizi-2000&catid=34:marmara-denizi&Itemid=37&lang=en].

In this report as well as in the official statistics, the catches of the Bosphorus Strait (İstanbul) and the Dardanelles are included in the catches of the Sea of Marmara. The Marmara Sea is the smallest of Turkey's four seas, occupying only 4.5% of Turkey's total fishing area. The Sea of Marmara differs from Turkey's other seas in that it is entirely surrounded by heavily populated areas of Turkey. Boat traffic is also an issue since as many as 50,000 ships each year travel through this sea to or from the Bosphorus.

Aegean Sea

The Aegean Sea is located in the north-eastern Mediterranean (Fig. 1). In contrast to the Black Sea, the Mediterranean is known as the 'White Sea' in Turkish, i.e., '*Ak*

Deniz' (King, 2004). Greece lies to the north and west; and Turkey to the east. It includes over 1,400 islands, most of them belonging to Greece. The Turkish zone in the Aegean Sea, for statistical purposes, extends from the southern end of the Dardanelles in the north, to the coastal city of Marmaris in the south. The Turkish sector of the Aegean is very small and narrow, and its width varies from approximately 50 km in the north, to around 10- 15 km for the remainder. The Aegean Sea is known for its turquoise and clear waters due to its extremely low nutrient levels and, consequently, its low marine fishery catches. In 2010, the catches of the Aegean Sea represented less than 9% of Turkey's total commercial fish catches.

The fisheries of the Aegean are dominated by the small-scale (artisanal) sector that uses small wooden boats, 5-12 m in length (Ünal & Franquesa, 2010), and are crewed by one to two fishers. Their daily fish catches range from 2.0 – 7.2 kg · day^{-1}. These small-scale vessels primarily deploy gill nets, trammel nets, long lines and lift nets (Ünal *et al.*, 2009a) and target horse mackerel, bluefish, grouper (Serranidae), common dentex (*Dentex dentex*), chub mackerel (*Scomber japonicus*) and swordfish (*Xiphias gladius*).

There is also a minor industrial sector operating in the Aegean Sea, which includes trawlers and purse seiners. Most of these industrial vessels are not indigenous to the area, but rather come from the Black Sea to fish opportunistically in the Aegean. Fishing with coastal seines was popular, until a 2001 ban prohibited their use in Turkish Aegean waters (Anonymus, 1999), demanded by local artisanal fishers. Driftnets were also popular in this sea. The industrial sector targets small pelagics such as anchovy and European pilchard as well as some larger pelagics such as bonito.

Levantine Sea

The Turkish section of the Levantine Sea consists of a narrow coastal strip, which runs from the Turkish town of Marmaris in the west (where it meets the Aegean Sea) to the Syrian border in the east. The continental shelf is between 50-200 m deep and only 10-20 km wide, which is suitable for demersal fishing. From the Turkish city of Mersin, eastwards, the continental shelf widens to 80 km, and is called Iskenderun Bay, which is a popular fishing ground for bottom trawlers. The remainder of Turkey's national waters in this area are very deep and only suitable for pelagic fisheries. Due to three rivers bringing terrigenous nutrients to the continental shelf area in southeastern Turkey (the Seyhan, Ceyhan and Goksü), this portion of the basin used to be very abundant in terms of marine life (Kosswig, 1953); and Iskenderun Bay was perceived as having very productive fishing grounds in the early 1950s.

The small-scale sector here uses predominantly trammel nets, gill nets and longlines. Fishers often use two different size mesh trammel nets to target a wider range of species, i.e., a small mesh for small species such as mullet, and a larger mesh net for others (Berkes, 1986); many demersal species such as seabreams, bass, mullet and grouper are landed. Longlines are used to target swordfish and large tuna species; stingrays are often caught as by-catch and then discarded since there is no local consumption of these species (M. Ulman, pers. comm.).

Industrial operations in the Levant Sea include trawlers, purse seiners and beach seiners. Iskenderun Bay is approximately 80 km wide and it is illegal for trawlers to operate within three miles from the coast; however, this is not enforced. Trawlers often ignore this rule and invade the small continental shelf area shared with the small-scale sector, further aggravating relations between the two sectors. The industrial boats operating here have the ability to be away from port for weeks. The Levantine coast has the lowest reported landings out of the four seas and represented 6.2% of Turkey's total commercial landings in 2010.

Materials and Methods

Here, we present a reconstruction of Turkey's fisheries for the years 1950-2010, using the methodology as described in Zeller *et al.* (2007).

Reported landings

The FAO's Fishstat Plus database is the only publically available resource presenting Turkish marine landings for the entire 1950-2010 period. National 'Turkstat', data are only available from 1967 onwards (TÜİK, 1967-2010), although Turkey has been reporting landings data to the FAO since 1950. We compared the reported landings from 1950-2010 between the two available sets (national and FAO data), and found that the data sets were almost identical, thus implying a good transfer of data from the Turkish government to the FAO (Fig. 2).

Annual totals from the FAO database were used as the reported baseline from 1950-1966, since national data were unavailable for this period. During this period, the reported FAO catches were presented as one total sum for the country. The Turkish Ministry of Commerce collected statistics at that time (Üstündağ, 2010); however, the species composition, and allocation to corresponding sea is no longer available. Catches were disaggregated by region (i.e., by sea) and by species using average proportions from the closest available national landing statistics (the 1967 to 1971 period). The geographic allocation of catches used for the reported data during the 1950-1966 period was Aegean Sea (2.7%), Black Sea (75.4%),

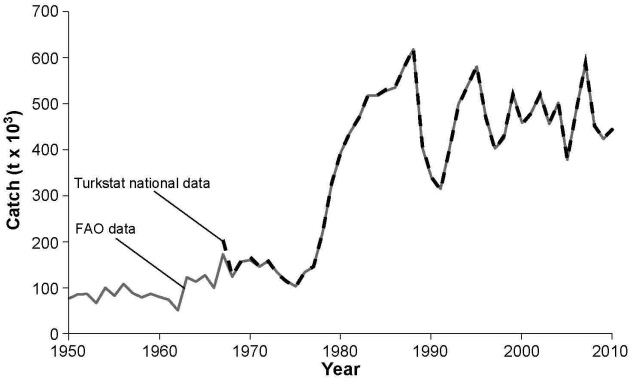

Fig. 2: Reported FAO data compared to national TURKSTAT data, 1950-2010.

Levant Sea (3.2%), and Marmara Sea (18.7%). All national Turkstat catch statistics (www.turkstat.gov.tr) for the 1967 to 2010 time period were made available to us and were used as the reported baseline, since they contained better spatial detail than the FAO data.

From 1950 to 2010, Turkey's population grew from 21 million (www.turkstat.gov.tr) to 74 million people (www.tradingeconomics.com/turkey). Along with this massive population growth, an urbanization trend has also occurred since the 1950s. In 1950, 18.7% of the population lived in cities (Keles, 1982); by 2010, this grew to 70% of the total population. The bulk of Turkey's population lives in the coastal area, in İstanbul (18% of the population), and the rest mainly along the western coast (www.citypopulation.de/Turkey-İstanbul.html).

Turkey's fisheries catches in 2007, based on the reported data, represent approximately 0.6% of world fishery landings (Diffey, 2007). According to the latest published statistics in 2010 (TÜİK, 2010), anchovy dominated total reported marine catches (51%), followed by sprat (13%), European pilchard (6%), cockle (*Chamelea gallina* 6%), Mediterranean horse mackerel (*Trachurus mediterraneus* 3.3%), whiting (3%), and sea snail.

Catches outside Turkish national waters

Some Black Sea turbot catches were taken outside Turkey's Exclusive Economic Zone (EEZ), which is 200 nautical miles in the Black Sea (www.blacksea-commission.org). These catches, although not caught in Turkish waters, are recorded as Turkish landings and therefore do not accurately represent Turkish catches from a spatial point of view. These turbot catches, which were recorded as Turkish catches in national statistics, were re-allocated here to the waters of the countries from which they were caught, i.e. Romania, Bulgaria, and Ukraine (www.blacksea-commission.org/_publ-SOE2009-CH9.asp). The reconstructed total catch for turbot will therefore reflect only catches attributed to Turkey fishing within its own exclusive national fishing grounds in the Black Sea, allowing inferences to be made regarding national fisheries catches and resource trends. Turkish fisheries in areas other than those mentioned here, e.g. in the western Mediterranean, are not considered here.

Taxonomic breakdown

Based on 'Turkstat' national reported data, the catches from the eastern and western Black Sea were combined to represent 'the Black Sea'. Turkstat data were used as a baseline rather than FAO data since it contained a more detailed spatial allocation of catches, i.e., according to sea.

In Turkey, catches are recorded using common names. For most years the English equivalent was given, but these were not always consistent (See Appendix Tables 1a and 1b for a lists of fish and invertebrates used in this report). For instance, *istavrit karagöz* corresponds to Atlantic horse mackerel (*Trachurus trachurus*) and *istavrit kraça* corresponds to Mediterranean horse mackerel (*Trachurus mediterraneus)*.

We know that *mezgit* corresponds to whiting (*Merlangius merlangus*); and *bakalorya* and *berlam* correspond to European hake (*Merluccius merluccius*, see also www.fishbase.org). The catches for *bakalorya* and *berlam* were combined in the reported data from 2001 onwards; and these catches were assigned to European hake.

The various fish species of mullet (*Mugil cephalus, Mugil soiuy, Liza saliens, Chelon labrosus, Moolgarda seheli*, etc.) belong to the family Mugilidae, while *barbunya* is the red mullet (*Mullus barbatus*) and *tekir* is the striped red mullet (*Mullus surmuletus*), both of the family Mullidae.

For the Turkish *köpek baliği,* the provided English translation is 'smooth-hound sharks'; we have mostly classified these fish as picked dogfish sharks (*Squalus acanthias*), since they are the major shark species caught [FLMONH, 2012. www.flmnh.ufl.edu/fish/organizations/ssg/sharknews/sn11/shark11news12.html]. Some species of tuna including bullet tuna (*Auxis rochei rochei*), little tunny (*Euthynnus alletteratus*) and albacore tuna (*Thunnus alalunga*) were only added to the data collection process as of 2004, so their previous catches remain unknown.

It is most likely that the catches of round sardinella (*Sardinella aurita*) and European pilchard are grouped together in the reported data and therefore make it difficult to detect catch trends of either species. However, some local experts have explained that round sardinella populations are expanding northwards in the Aegean Sea and their catches are increasing. Only marine fish and invertebrates were used in this report, excluding jellyfish, sponges, turtles and dolphins where applicable.

Large-scale vs. small-scale catch

Complete enumeration was carried out covering all registered professional fishers between 1967 and 1969 and again from 1972 until 1980. From then on, the State Institute of Statistics (SIS) gathered data on fishery landings, fishing fleets, equipment and the status of those engaged in the industry. After 1980, the Ministry of Agriculture and Rural Affairs (MARA) took over data collection (although both of the above-mentioned bodies did have some corresponding collection of data until recently) and the statistical collection methods remained the same, to cover large-scale fishers (boats over 10 meters in length or with more than five crew members) by full enumeration, but changed from covering small-scale (artisanal) fishers by full enumeration to a 'sub-sampling' procedure (TÜİK, 1989).

The majority of the registered fishing boats are from the artisanal sector; for example in 2010, 85% of the registered Turkish fleet were small boats under 10 m in length (TÜİK, 2010). The Aegean and Levant coasts are mainly exploited by artisanal fishers, whilst the Black Sea and Marmara Sea are dominated by both industrial and small-scale operations (www.oecd.org/dataoecd/9/29/34431494.pdf).

The standard small-scale operation uses trammel net, gillnet, longline, and dredgers, or some variation of these. Larger-scale operations include trawlers, purse seiners and carrier vessels (to transport anchovy catches from the seiner to the processing plant). Beach seiners (Anonymus, 1985) were important until the most recent decades. Beam trawlers are used mainly for sea snail and hydraulic dredges are used to gather cockle in the inshore Black Sea. The Black Sea hosts most of Turkey's industrial fishing due to its large stocks of small pelagic fish, which are caught mainly by purse seine.

The activities of the large-scale (industrial) sector within Turkey are defined here as trawlers, purse seiners, and any other registered fishing boat greater than 10 m in length. While 12 m is the required minimum length a boat must be to apply for a trawling license, the national data categorizes boats as 5-9.9 m in length and 10 m-19.9 m in length (among other length classes), making it difficult to separate for the 12 m length class. As national statistics do not relate catches to a particular fishing sector, this was performed by assigning species (or more precisely percentages of species) to either the artisanal or large-scale sub-sectors, and the percentages are based on expert knowledge and experience (see Appendix Tables 2 and 3 for details).

Unreported and under-reported catches

Illicit fishing activities are problematic for management, as they combine issues of criminal activity with fisheries management. For the past decade, the term IUU (Illegal, Unreported and Unregulated) fishing has often been used to represent illegal fishing (Bray, 2000). Due to the complexity of the legalities which surround fishing enforcement accountability, from now on the suggested approach to illegal fishing, as proposed by the United Nations Office on Drugs and Crime (UNODC), is to separate the components of the term IUU; to have illegal fishing handled directly by law enforcement, and unreported and unregulated fishing to be dealt with by the fisheries management sector, as they both relate to fishery mandates (UNODC, 2011). Several fishing activities in Turkey can be regarded as IUU fishing: fishing with an unlicensed vessel, fishing in closed areas/seasons, catching prohibited species, using forbidden equipment, and catches or revenue that are not reported may all be considered IUU practices (Ünal & Erdem, 2009). Here we are concerned with unreported catches.

There seems to be a consensus between scientists, the government and people employed by the fishery industry in Turkey that unreported catches account for somewhere between 30-100% in addition to the reported landings (see below). In this section, we address the unreported catches of the commercial small-scale and large-scale sectors. Unreported recreational and subsistence sector catches will be estimated in subsequent sections.

The following is a compilation of available accounts of misreporting, including scientific papers and interviews/consultations with key fishery experts and fishers:

- "Fishery landing statistics may represent only 30-50% of actual catch, while the non-reported catch is likely to include more undersized, 'out of season' and/or prohibited species." (Diffey, 2007);
- "The EU Fishery Commission and mostly all fishers share the opinion that at least 30% of total fishery catches are not declared to the government"(pers. comm. to Ş. Bekişoğlu);
- R. Özkaya, the president of the Turkish fishery cooperatives, estimates that the unreported amount of fish is much more than 30%, and probably closer to or greater than 50% (pers. comm. to Ş. Bekişoğlu);
- From 1950-1966, the national statistics sent to the FAO were based on inquiries to provincial government officials, and on the sales records of provincial fish markets. It explicitly states that the true catch of fish could not be reflected by the data collected by the Ministry of Commerce during this period due to insufficient coverage (TÜİK, 1968). Unfortunately, the details of how these data were calculated are no longer available (U. Türkoğlu, Turkstat employee, pers. comm., March 18, 2011). Sales have, undoubtedly, occurred directly from boats and piers; and directly to restaurants throughout this period, all unreported. Given all the above evidence, we considered the official Turkish fisheries statistics to be an underestimate of total commercial catches. Based on a syn-

thesis of the above information, 40% was added to total catches reported for the period 1950-2010, in order to account for a significant unreported/underreported commercial catch component. The motivation to underreport catches may be attributed to the heavy taxes and levies imposed on fish sales and income of fishers and the way in which fish is marketed. Evidence of this includes:

- Brokers impose an 8-10% sales tax (depending on the species) on catches sold through the fish hall/bazaar. Fishers often avoid this method of sale in order to avoid the tax;
- Income tax, varies according to annual income and profit margin; the maximum rate of income tax that can be applied is 30%;
- Fish agents and wholesalers do not declare the 'true' amount of wholesale and retail fish sales to the government (Ministry of Finance). The Turkish government is lacking an effective control system. Government officials and some economists suggest that at least 40-50% of the nation's products and income have not been accurately declared (Ş. Bekişoğlu, pers. obs.); and
- An additional 10% tax is imposed on a commercial fisher's total catches (referred to as 'resource rent'), and is to be paid directly to the Ministry of Finance upon returning to shore. This tax is supposed to be collected at landing sites. Most fishers evade this tax by under-reporting their catches by about 30% on average, for fear of being taxed on their total landings (S. Bekişoğlu, pers. obs.; M. Ulman[1] pers. comm.).

While there is clearly some incentive to under-report catches, inadequacies in catch data may also be attributed to data collection methods. Data collection methods that may negatively influence the quality of the data include:

- For the 1950–1966 period, only fish sold through select markets were used in the national catch data; fish sold at places other than those select fish markets are not accounted for here;
- Total catches are often simply a memory-based reflection on the previous year's catch. Additionally, catches made out of season, using illegal gears, in prohibited areas, under legal size or sold directly by the fisher, are likely never declared;
- Small-scale fisheries catches from 1970 and 1971, and 1980 to the present are estimated by an annual sub-sampling method. This method of data collection, unless scaled-upward to account for the entire year and all fishers, results in underreporting; and
- Discrepancies also exist between reported landings and exports of the same species. For instance, sea snail, according to export records are vastly underreported by as much as 50% during the 1985-2004 time period, and around 1000% in 1995 alone (Knudsen *et al.*, 2010).

According to a report from Ünal & Erdem (2009), authorities reported that 2.5 t of grouper, 1 t of common dentex and 1.5-2.0 t of European seabass were caught annually in Turkey's first designated 'Marine Protected Area' and 'No Take Fishing Zone' (as of 2009), at night by illegal recreational spear fishers, where up to a hundred of illegal spearfishers likely operate. It is also worth mentioning, based on a study done on managing grouper catches from the same region (Ünal *et al.*, 2009b), that the illegal catch amounts of the above-mentioned species are equal or larger than the local fishery co-operative's annual legal catch of the same species. There are many layers of illegal fishing which occur at times simultaneously in Turkey; illegal fishing stems mostly from a lack of monitoring, control and enforcement, which all negatively affect the resource.

Recreational and Subsistence catches

Recreational catches have never been included in the collection of fishery statistics for Turkey. The first study of recreational fisheries activities in Turkey by Ünal *et al*. (2010), from the Çanakkale region, provided valuable insight and data; specifically, the number of recreational fishers, catch rates, and species composition.

At a recent workshop of the General Fisheries Commission for the Mediterranean (GFCM) on recreational fisheries (GFCM, 2011), a standardized definition of recreational fishing was produced. In this definition recreational fisheries are: "Fishing activities exploiting marine living aquatic resources from which it is prohibited to sell or trade the catches obtained." Subsistence fishing is generally understood as the exploitation of marine aquatic resources for personal consumption (stats.oecd.org/glossary). Subsistence and recreational fishing are not easily separated into distinct categories but rather form part of a continuum. Here we estimate these components separately but recognize that catches from one sector may encompass some catches of the other. Subsistence fishing (for necessity) developed into recreational fishing (for leisure and to supplement the diet) as social and economic conditions evolved. Although the legal framework for these sectors is defined in 'Fisheries Law No. 1380 Aquaculture and Fisheries Communiqué', the majority of fishers in these sectors are unaware of these rules. Anyone can obtain an Amateur Fishing Certificate, although it is not legally required in order to fish, which

1. One important advisor for this paper was the father of the first author, Metin Ulman, who is very knowledgeable about Turkish fish species, fish catches and the state of three of Turkey's seas (excluding the Black Sea); he grew up fishing along the Bosphorus Strait in the 1950s and is now a recreational fisher in the Aegean Sea.

leads to incapacity of monitoring this sector (M. Zengin, unpublished data). Here we estimate recreational and subsistence fisheries catches for Turkey using a detailed account of fishing in Çanakkale (Ünal *et al.*, 2010) in combination with assumption-based estimates to expand this estimate to the entire country.

Çanakkale

Çanakkale, with a population of 70,000, is increasingly becoming a popular coastal city for both recreational and commercial fisheries. In the Ünal *et al*. (2010) study, 190 recreational fishers were surveyed, and then total catches were scaled up to reflect total catches of the recreational fishers in the region. The percentage of recreational fishers from this region was found to represent 9.9% of the population and their average number of recreational fishing days was 77 per year. Their catch rate resulted in an average of 0.645 t · fisher^{-1} · year^{-1}. The study also suggested that most recreational fishers are neither subsistence nor 'true sport' fishers, since 45% of shore-based, 73% of underwater fishers and 75% of boat-based recreational fishers sell their catches. Conflicts often arise between commercial and recreational fishers for this reason (ICES, 2006). The total number of recreational fishers estimated for this study was greater than the reported number of commercial fishers (6,922 and 5,987, respectively).

The total human population of the region was obtained from Populstat data (www.populstat.info) for the period 1950-2010, and the data were interpolated between the closest available years. The annual population amount was divided by 9.9%, to represent the percentage of fishers in the study (Ünal *et al.*, 2010), which was then multiplied by the calculated catch rate to get annual recreational catch totals. The catch rate per fisher for 1950 was obtained by doubling the catch rate for 2010, which yielded 1.29 t ·year^{-1}, the intermediate values were then obtained by interpolating linearly to the 2010 values (o.645 t · year^{-1}, see above). This higher catch rate in the past was attributable to higher fish abundances and also larger mean fish sizes resulting from less competition in 1950. Recreational catches were assigned taxonomically using the same species composition as the Ünal *et al.* (2010) study.

İstanbul

İstanbul is, by far, the most populated city in the country. From 1950 to 2010, the city of İstanbul has grown in population from 1.18 million people to 13.3 million people (www.turkstat.gov.tr), and it is now the 22nd largest city in the world.

İstanbul has thousands of anglers fishing daily on the Bosphorus Strait, which is a very prominent fishing corridor. Many pelagic stocks make their annual migrations from the Aegean Sea, through the Sea of Marmara and then the Bosphorus Strait, to the Black Sea, and return via the same route back to the Mediterranean Sea. To calculate the number of recreational fishers for this area, the assumption that 1% of the population fishes recreationally was used (S. Bekişoğlu, pers. obs.), changing with population trends over time so that in 1950, İstanbul had an estimated 11,665 recreational fishers, and in 2010 an estimated 129,000 recreational fishers.

In earlier years, fishers in İstanbul were richly rewarded for their efforts. An angler could finish a fishing 'day' in one hour in the 1960s, and each fish weighed between 4-6 kg (M. Ulman, pers. comm.). The average catch rate at present is about 1 kg · fisher^{-1} · day^{-1}, although considerable day-to-day variation occurs (A. Safahi, pers. comm., recreational angler from İstanbul). In 1950, we conservatively assumed a catch rate of 2 kg · day^{-1} (due to more abundant fish stocks, and less overall fishing pressure). A linear interpolation was used to derive a time series of catch rates from the 1950 rate of 2 kg · person^{-1} · day^{-1} and the rate in 1999 of 1 kg · person^{-1} · day^{-1}. The 1999 catch rate was held constant to 2010. The increasing population of İstanbul and associated increase in fishing effort likely resulted in lower catch rates per person, due to lowered abundance and the availability of smaller-sized fish, which is reflected in our assumption-based estimated catch rate. We assumed the same number of fishing days per year as presented in Ünal *et al.* (2010) of 77 fishing days · year^{-1}. Although higher catch rates (5 kg · day^{-1}) are presented for recreational anglers catching horse mackerel from a Galata Bridge survey (Zengin, 2011), experience of fishers and timing of survey likely influenced these high catch rates and, thus, our estimation remains conservative in comparison.

The Çanakkale species breakdown (based on Ünal *et al.*, 2010) was also used to disaggregate the recreational catches of the İstanbul (Bosphorus) fishing area, since both areas share similar taxa.

The entire Turkish coast

Recreational catches

To estimate the number of recreational fishers in Turkey (excluding the Çanakkale and İstanbul provinces, which have been estimated separately), human population data from Populstat data's provincial dataset was used. The population of the coastal provinces in each of the four regions considered here (Black Sea, Marmara Sea, Aegean Sea, and Levantine Sea) was calculated based on census data (as presented by Populstat) for the period 1950-2000. For 2001-2010, the total known population trend was inferred to each coastal region. The percentages of the population living coastally (Çanakkale and İstanbul provinces excluded) ranged from 40.2% in 1997 to 45.0% in 1950.

To account for the number of recreational fishers in the coastal population, we assumed that 2% of the coastal population fishes recreationally in both the Aegean Sea and Levant Sea, to account for less productive seas than the study area, which equals 1/5th the percentage of recreational fishers of the Ünal *et* al. (2010) study on recreational fishers. For the Sea of Marmara, we assumed 3.3% of the coastal population fished recreationally; and for the Black Sea region, 1% of the coastal population was assumed to recreationally fish since subsistence/ recreational fisheries are known to be much lower in this region. The amount of recreational fishers varied over time along with population trends for each of the provinces.

The recreational catch rates applied to the coastal populations of the Black Sea, Aegean Sea and Levant Sea were one fifth that of the Çanakkale study site, or 0.129 t · fisher^{-1} · year^{-1} in 2010. The catch rate was doubled to 0.258 t · fisher^{-1} · year^{-1} in 1950. A linear interpolation between catch rates of 0.258 t · fisher^{-1} · year^{-1} in 1950 and 0.129 t · fisher^{-1} · year^{-1} in 2010 was applied.

The catch rate applied to the Marmara Sea was three quarters that of the study site, since the productivity of these regions are more similar, or 0.483 t · fisher^{-1} · year^{-1} in 1950 (to remain conservative), which was reduced by half in 2010 to 0.241 t · fisher^{-1} · year^{-1} and the catch rate was interpolated between 1950-2010.

Subsistence catches

To distinguish the recreational and subsistence sectors for accounting purposes, it was assumed that in 1950, this sector was dominated by people fishing exclusively for subsistence purposes. Therefore, in 1950, we estimate the ratio of subsistence to recreational fisheries catches to be 9:1 for all regions. Given the substantial developments in the economy of Turkey since 1950 (GDP *per capita* was $1,299 in 1950, www.nationmaster.com), and the fact that GDP had risen to $13,800 by 2010 (www.indexmundi.com), we assumed a subsistence to recreational catch ratio of 1:9 in 2010. We interpolated linearly between these two ratios to derive a sub-sector breakdown for the entire 1950-2010 time period.

Taxonomic allocation of recreational/subsistence catches

To allocate recreational/subsistence catches to individual fish species/groups for the Aegean, Marmara and Levant Seas, the species composition from the reported TURKSTAT 1980 commercial catch data was used as a baseline to assign catches to the same percentage of occurrence per species.

Some of these individual species ratios were slightly adjusted after consultation with local experts, fishers and analyzing all the peer-reviewed literature to account for different target species between commercial and recreational fisheries. For example, anchovy and other small pelagics are not caught by the recreational sector (S. Knudsen, pers. obs.), so these were excluded from recreational catches for all seas. For the Black Sea, annual trends in the catch data as well as expert knowledge were used. For the years between 1950 and 1966, the species composition was averaged from the closest available statistical years (1967-1971). Select popular recreationally-caught taxa were given a higher allocation percentage for recreational catches (Table 1).

Table 1. Taxonomic allocation of recreational/subsistence catches (%) in Turkey, from 1950-2010.

Taxa	1950-1980	1981-2010
Aegean & Levantine Sea:[a]		
Grouper (Serranidae)	20	10
European seabass (*Dicentrarchus labrax*)	20	10
Common dentex (*Dentex dentex*)	5	10
BlackSea:[b]		
Bonito (*Sarda sarda*)	40 (1950-1968)	3-49 (1969-2010)

[a)] From Ünal and Erdem (2009); [b)] From S. Knudsen, unpublished data.

Discards

Discards were separated into three components: 1) discards from bottom trawl fisheries; 2) discards from highgrading; and 3) all 'other' discards.

Turkey has reported some discard amounts in their annual statistical reports (as fish that are 'not processed or consumed') from 1998-2008. The reported discard rate was calculated from 1998-2008, and the discard rate ranged from 0.5% in 2000 to 3.24% in 2006, averaging 1.6% for the 11 year period. Due to the random process of the statistical sampling programme, and the annual form that commercial fishers are required to fill out (normally from memory alone), it is highly unlikely that these figures represent actual discard rates.

According to Kelleher (2005), fisheries around Turkey have the following discard rates: trawl fisheries (45-50%), artisanal fisheries (<15%), mid-water trawlers targeting small pelagics (5.1%), sea snail dredge fishery (11.5%), and coastal encircling nets (7.4%). Additionally, we found the following discard rates for Turkey: 35.5% discards from the coastal shrimp beam trawl fishery in Turkey (Zengin & Akyol, 2009), 77% discards from the commercial prawn trammel net fishery in the Aegean (Gökçe & Metin, 2007), 77.8% discard rate for monofilament nets, 22.8% for multifilament net fishing in the gillnet fishery in the Turkish Aegean Sea (İlker *et al.*, 2008), 38% discards from bottom trawl fishing in the Turkish Aegean Sea (A.Ç. Gücü, unpublished data), 37% discards from demersal trawling in Turkish waters (Özbilgin *et al.*, 2006), and 36% discards from Black Sea bottom trawling (Özdemir *et al.*, 2006). Available discard information was converted into discard rates for each of the discard components.

Table 2. Discard rates applied to taxa from bottom trawling on the Turkish Black Sea coast, 1950-2010.

Taxon	Discard rate (%)
Whiting (*Merlangius merlangus*)[a]	45.3
Red mullet (*Mullus barbatus*)[a]	25.7
Turbot (*Scopthalmus maximus*)[a]	27.5
Med. horse mackerel (*Trachurus mediterraneus*)[a]	25.8
Atl. Horse mackerel (*Trachurus trachurus*)[a]	22.2
Piked dogfish (*Squalus acanthias*)[a]	16.6
Sea snail (*Rapana venosa*)[b]	11.5

[a)] From Zengin and Knudsen (2006);[b)] From Kelleher, (2005).

Bottom trawling discards

Bottom trawling is one of the most destructive gear-types. Some of the well-documented impacts of bottom trawling include damage to benthic habitat, destruction of essential fish habitat, increased siltation, reduced biodiversity and reduced species richness over a short time period (Thrush & Dayton, 2002). Unfortunately, no such study on bottom trawling impact on the benthic system has been completed for Turkey; but this type of research is urgently needed.

Black Sea: Bottom trawling is illegal in the eastern Black Sea; but legal in the western Black Sea region. For all bottom trawling operations in the Black Sea, there are specific 'target' fisheries. From fieldwork on discard rates in the Black Sea (2004-2006), the following discard percentages were applied (Table 2, Zengin & Knudsen, 2006). These percentages mostly represent the ratio of under-sized fish that are discarded due to minimum legal landing size, fishing season, and market price.

The Black Sea does not have a 'target' shrimp (Penaeidae) fishery, but shrimps are caught as by-catch in bottom trawlers (Zengin & Knudsen, 2006). The Black Sea's shrimp contribution is negligible and had zero catches in 2010. No additional discards for shrimp have been calculated for the Black Sea region.

Marmara Sea: Discards from bottom trawling were calculated as 37% of the reported catches for five specific target species (Table 3, Özbilgin *et al.*, 2006). Shrimp are fished in the Sea of Marmara using trammel nets and bottom trawls. The discard rate used for the shrimp fisheries in this sea was averaged from two published discard rates for shrimp fishing in Turkey (Gökçe & Metin, 2007; Zengin & Akyol, 2009); the resulting discard rate of 56% was then applied to shrimp catches to get a total discarded amount, which was then allocated to the following species (Table 3, Metin *et al.*, 2009): swimming crabs (Portunidae 29%); blue crab (*Callinectes sapidus* 17%); annular seabream (*Diplodus annularis* 15%); angular crab (*Goneplax rhomboides* 15%); mantis shrimp (*Squilla mantis* 12%); and purple-dye murex (*Bolinus brandaris*, 12%).

Table 3. Discard rates (%) applied to taxa from bottom trawling in the Sea of Marmara and Aegean Seas, 1950-2010.

Taxon	Marmara Sea %	Aegean Sea %
Mullet (Mugilidae and Mullidae)[a]	37	38
Turbot (*Scopthalmus maximus*)[a]	37	38
Mackerel (*Scomber scombrus*)[a]	37	38
Smooth-hound (*Mustelus mustelus*)[a]	37	38
Sea snail (*Rapana venosa*)[a]	37	38
Shrimp fishery discard rate 56%, applied to following taxa:		
Swimming crab (Portunidae)[b]	29	29
Blue crab (*Callinectes sapidus*)[b]	17	17
Mantis shrimp (*Squilla mantis*)[bd]	12	12
Annular seabream (*Diplodus annularis*)[bd]	15	15
Angular crab (*Goneplax rhomboides*)[bd]	15	15
Purple-dye murex (*Bolinus brandaris*)[bd]	12	14

[a)] From Özbilgin *et al.* (2006); [b)] From Gökçe and Metin (2007); [c)] From Zengin (2009); [d)] From Metin *et al.* (2009).

Aegean Sea: Trawlers fish in their 'home' fishing grounds (the western Black Sea), and as the fishing season finishes their fishing grounds expand to the Aegean and Levant Seas. The trawling discard rate for this sea is a little lower than for the Levant Sea, at 38% (Stergiou *et al.*, 1998; A.Ç. Gücü, unpublished data). This 38% discard rate was applied to the same target species listed above in the Marmara Sea section. In addition, the shrimp trawling discards have been allocated to the same taxa and percentage (56% of shrimp fisheries) as in the previous section on the Sea of Marmara (Table 3).

Levant Sea: Bottom trawl data for this region were recently evaluated for the past 40 years (A.Ç. Gücü, unpublished data; Table 4) to establish trends in discard rates over time. In the 1980s, the discard rate from bottom trawling was 40.9%, on average, which increased to 48.3% by 2007-2010. We assumed a constant discard rate of 40.9% for the 1950 to 2006 time period, which increased to 48.3% from 2007-2010. In the recent period, discarding has increased in the Levant and Aegean Seas as evidenced by the increasing availability of undersized fish; and a maximum discard rate of 93.5% was even sometimes reached (A.Ç. Gücü, unpublished data). The shrimp trawl fishery had a higher discard rate in this sea with 71% (Duruer *et al.*, 2008), which was applied to the taxa in Table 4 for the 1950-2010 period.

Discards due to highgrading

Highgrading is defined as the discarding of a marketable species in order to retain the same species at a larger size and price, *or* to retain another species of higher value *or* the retention of only those species with the great-

Table 4. Discard rates (%) applied to bottom trawling in the Turkish Levantine coast, 1950-2010.

Taxon	1950-2006	2007-2010
Red mullet (*Mullus barbatus*)[a)]	40.9	48.3
Atl. horse mackerel (*Trachurus trachurus*)[a)]	40.9	48.3
Med. horse mackerel (*Trachurus mediterraneus*)[a)]	40.9	48.3
Shrimp fishery discard rate 71%[b)], applied to following species:		
Swimming crab (Portunidae)	50	50
Blue crab (*Callinectes sapidus*)	35	35
Mantis shrimp (*Squilla mantis*)	15	15

[a)] From Dr. Ali Çemal Gücü, unpublished data; [b)] From Duruer *et al.* (2008).

Table 5. Discard rates applied to highgrading for all seas, 1950-2010.[a] (%)

Taxon	1950-1995	1996-2010
Scorpionfish (Scorpaenidae)	900	200
Goby (Gobiidae)	900	200
Ray (Myliobatidae)	900	200
Sprat (*Sprattus sprattus*)	900	15

[a)] From M. Zengin, pers. obs.

est market value (Alverson, 1994). Until very recently, some non-target fish species have been almost entirely discarded (Zengin *et al.*, 2011). After the Turkish fishery 'resource crisis' of the late 1980s, some previously discarded species became target species and have only recently become marketable due to a marked decline in the catches of larger, more valuable fish.

From 1950-1995, nine times the reported amount of the following species were likely discarded (M. Zengin, pers. obs.): scorpionfish (Scorpaenidae), gobies (Gobiidae), stingrays (Dasyatidae) and sprat. From 1996-2010, at least two times the reported amount of these select species were discarded (Zengin & Knudsen, 2006; Zengin *et al.*, 2011), since a portion of these are now landed, but the majority continue to be discarded at sea (Table 5). Sprat is the exception, which has now shifted to being a 'target' fishery; sprat has a 15% discard rate post-1996 (M. Zengin, pers. obs.). Although a targeted fishery now exists for sprat, their geographical range overlaps for about one month during the year with that of anchovy and sprat is therefore caught incidentally, and then discarded at the market.

In a recent study by A. Ç. Gücü, based on anchovy size comparisons between landed sizes and sampled- at-sea sizes, it has been estimated that in fact 41% of anchovy by weight, and 76% by number were likely discarded at sea due to small sizes resulting from highgrading in the 2012-2013 fishing season (Anonymus, 2013). Since anchovy are the largest Turkish fishery, we feel this high amount has been covered through our estimations of unreported catches and discards.

'Other' discards

Kelleher (2005) suggested that the anchovy fishery, the largest fishery in Turkey, has no discards as the fish are caught by purse-seines and anything not sold is sent to one of 25 fish meal and fish oil processing plants. However, on closer inspection, fish processing plants occasionally refuse to process small pelagic catches when the facility is at capacity, resulting in the spoiling and discard of excess catches. Therefore, for anchovy and all 'other' commercial marine species that have not yet been mentioned, a discard rate of 5% was applied. This rate was guided by taking the weighted average global discard rate of 8%, and deducting Turkey's average reported discard rate (1.6%). The resulting rate of 6.4% was conservatively reduced to 5%. Mid-water trawlers targeting small pelagic fish have a weighted discard rate of 5.1% (Kelleher, 2005), which is suitable for the discards of all 'other' species, most of which are small pelagics. Although it may seem that discarded species are not of general importance, they may have an important role in the ecosystem (Akyol, 2003).

Adjustments

Sea cucumber

There are some minor discrepancies concerning the data collection that need mentioning. Sea cucumbers (Holothuridae) are commercially harvested, but have not been included in the national landing statistics. It is highly unlikely that sea cucumbers were included in the 'Miscellaneous marine invertebrates' category in the reported Turkstat data, since for most years there is a discrepancy, there is not a great enough amount in the miscellaneous category to cover these commercial activities. They generated between 19 to 77 t of processed product annually between 1996 and 2007 (Aydin, 2008); their weight was assessed mostly while the animals were fresh. Processing involves a combination of freezing, drying and salting; the final product is then exported to the Asian seafood market.

Sea snail

The Rapa whelk (*Rapana venosa*) is an invasive sea snail species that was first recorded in the Black Sea during the 1940s (Sağlam *et al.*, 2009). They are top predators with a ferocious appetite, and bivalve diversity in the Black Sea declined two-fold since their introduction (Vershinin, 2007). This sea snail is associated with a decline in range and density of native mussel settlements,

near both the Anatolian and Caucasus coasts on the Black Sea, originally biologically rich areas (Ozturk, 2010).

Rapa whelk has been fished either by dredging or by diving since the 1980s, mostly by small-scale fisheries. Dredging for sea snails most likely damages benthic habitats. This species was first included in the national fisheries statistics in 1988, under the 'others' column for invertebrates some years before that (Rad, 2002). This animal is not consumed in Turkey, but instead is exported to Asian markets.

In the Black Sea, illegal fishing for this species is common: "Although illegal, most boats use two (or even three) dredges simultaneously and often operate at night (which is also illegal); although dredging is illegal in the summer, this is when the fishery is most intense, when catches are best" (Knudsen *et al.*, 2010). The months with the highest sea snail catches are also the summer months when dredging (and trawling) activities are supposedly banned (M. Zengin, unpublished data). Formal state regulations to a large extent are circumvented with regards to the sea snail fishery of the Black Sea.

In the easternmost Black Sea, sea snail fisheries ceased operating from 2005 until recently due to the diminishing mean size of the animal, which decreased from 62 mm in 1991 to 47 mm in 2005 (Knudsen *et al.*, 2010). In 2008, the owners of three of the largest sea snail processing plants in Samsun (Black Sea coast), all complained about the hardships of finding buyers for sea snails for the last two to three years, due to their declining mean size; the fishers also complained that the reduced mean sizes meant they increasingly found themselves returning many smaller sized individuals to the sea (Knudsen *et al.*, 2010).

Sea snail exports were found to be higher than reported landings over a twelve year period in between 1986-1988 and 1993-2003, but not including the years between 1989 and 1992 because the export statistics could not be verified (Knudsen *et al.*, 2010). Unfortunately, export data from 2004 onwards group sea snails with a larger taxonomic category, so the export amounts for this species could not be verified. The year with the highest discrepancy was 1995, as exports were almost eleven times higher than the reported landings (12,988 t and 1,198 t, respectively). Data collection for this fishery should be more precise given the limited amount of snail-processing plants on the Black Sea coast.

Turbot in the Black Sea

There is a notable decline in reported Turkish turbot catches from the Black Sea starting in 2002. It is widely acknowledged that Turkish fishers were illegally fishing for turbot in the north-western Black Sea, in Bulgarian, Romanian and Ukrainian waters (where between 1,000 and 2,000 t were taken annually) in the period 1993-2001 and also 2009-2010. Some (fatal) accidents involving the maritime police and illegal Turkish fishers temporarily stopped this illegal fishing problem. The catches were sold on the Turkish market and reported as Turkish catch. Turkish fishers also catch turbot in the Abkhazian region of Georgia (a run-away Georgian state) (S. Knudsen, pers. obs.). After 2001, Turkish fishers have had to rely exclusively on their own 'narrow and exhausted' Black Sea continental shelf for turbot, hence the reduction of Turkish reported turbot catches after 2001 (Daskalov & Ratz, 2010).

Turbot catches caught by Turks in waters other than their own were estimated to be about 2.4 times higher than the reported landings averaged for the 2002-2010 period (Zengin *et al.*, 2011). For each of the eleven years (1993-2001, 2009-2010), the reported catch data was adjusted with the minimum estimated amount (1,000 t · year^{-1}) of foreign-caught turbot catches (since these catches were not caught in Turkish waters), and the catches must be allocated to the waters of the countries in which they were caught.

Tuna in the Mediterranean

Since the national fishery crisis occurred, many purse-seiners have switched their target catch species from anchovy to tuna and other scombrids in the Aegean and Mediterranean Seas (Karakulak, 2004); although anchovy stocks have somewhat recovered since the 'crisis', many purse-seiners have continued to target the much more highly-valued bluefin tuna.

Turkey fishes for bluefin both close to the Turkish coastline and also 30-40 miles offshore (Karakulak, 2004). ICCAT has been allocating catch quotas to different member countries since 2003. Turkey has not directly received a quota, but is allowed to fish jointly for bluefin tuna under the 'Others' country allocation, which in 2006 was 823 t. Turkey shares this 'Others' section with Cyprus and Malta (Anon, 2006). Turkey's reported exported processed bluefin in 2006 was 1,566 t and ICCAT estimates the amount of Turkey's under-reporting for 2006 to be 1,384 t. This under-reporting estimate from ICCAT for 2006 was added to Turkish catches in the Levant Sea in this reconstruction.

Turkey reported 806 t of bluefin tuna catches for the same year, of which 600 t was from the Levant Sea (TÜİK, 2010). In 2004, Korea declared 700 t of purse seined bluefin tuna in the Mediterranean under the cover of Turkish purse seiner charter agreements (Anonymus, 2006). All 700 t were caught and ranched in Turkey (Stergiou *et al.*, 2009).

The first bluefin tuna spawning area in the eastern Mediterranean was discovered in 2004 (Oray & Karakulak, 2005), and larvae were most heavily concentrated in the Levant Sea between northern Cyprus and Turkey.

According to a study carried out by the World Wildlife Fund, in just five years, from 2002 to 2007, the breed-

ing population of bluefin tuna was halved, implying a possible local extinction unless the fishery is strongly reduced or closed [Mongabay, 2012. http://news.mongabay.com/2009/0512-hance_turkeytuna.html].

Anchovy in the Black Sea

Turkish purse seiners have fished extensively in Georgian waters for anchovy under private deals between Turkish and Georgian companies since the dissolution of the Soviet Union; they have even established a fish processing plant in Abkhazia. This arrangement is not framed by any bilateral government agreement (Knudsen *et al.*, 2007). Also, contacts within the fish-buying sector suggest that more anchovy is sold through the economy than is recorded in the catch data (C. Mathews, pers. obs.), and this amount may total around 50,000 t · year^{-1}, and is most likely not reported. This portion of anchovy caught in foreign waters is most likely misreported as Turkish catches. Turkish authorities consider only anchovy catches landed in the Turkish Black Sea town of Hopa to be caught in foreign waters of Georgia/Abkhazia (Anonymus, pers. comm. to S. Knudsen). Anchovy purse seine employees who regularly fish in foreign waters have confirmed that their anchovy catches are landed in many Black Sea ports, aside from Hopa. This is the same anchovy stock as Turkey fishes, which migrates in a counter-clockwise pattern around the Black Sea. These migrating anchovy are easier to catch once they reach Abkhazia since they form dense shoals there. Fishers consider that due to increased fishing effort, these stocks are moving quicker eastward and offshore (out of Turkish waters). Fishers are able to locate and exploit the entire stock easily, using modern fishing technologies and by expanding their fishing range.

A contact directly working in this fishery has provided some estimates of Turkish anchovy landings caught in Georgian waters (Anon. pers. comm. to S. Knudsen). A contact working directly in this fishery explained that his carrier vessel, working for a purse-seine boat in Abkhazia, personally delivered 2,300 t of anchovy over a three month season (100 t · trip^{-1} · 23 trips). There is normally one carrier vessel working per two purse seiners, and it is thought that approximately 20-50 purse seiners actively fish in distant waters. These distant water catches will be addressed in a separate catch reconstruction on Georgia.

Distant Water Fisheries

Foreign vessels are prohibited to fish for commercial purposes in Turkish waters, i.e., Art. 21 of law No. 1380 of 1971 (Cacaud, 2005), but may be authorized to fish within their exclusive waters under Turkish jurisdiction for other purposes, such as scientific research.

In recent years, Turkey has extended a few big purse seine vessels to fish in the Mediterranean, off the shores of Egypt, Algeria, Morocco and Italy where they have special agreements to catch migratory small and big pelagics (Sağlam & Duzguneş, 2010); unfortunately, no data could be found regarding these agreements or the catches. Any fish catches caught with a vessel flying the Turkish flag should be reported by the same country, as stated by the United Nations Statistical Commission in 1954 (FAO, 2002-2012).

National waters in this report refers to waters equivalent to the Exclusive Economic Zone declared by most other countries (Turkey itself has only declared an EEZ in the Black Sea), which extends 200 nautical miles or the median line between two national coastlines, which lie closer than 200 nautical miles.

Results

The total reconstructed results will first be presented by sea and component, followed by adjustments, and then the total reconstructed catch for the nation as a whole, by component.

Black Sea

Reconstructed catch

Large scale vs. small-scale

For the 1950-2010 period, total reported landings for the large-scale fishing sector were ~13.1 million t (93.3%) from the Black Sea, while the small-scale sector landed a total of ~950,000 t (6.7%).

The major taxa landed by the large-scale sector for the 1950-2010 period include anchovy (69%); Mediterranean horse mackerel (9%); bonito (4%); whiting (3%); Atlantic horse mackerel (2%); cockle (2%); and bluefish (2%). Anchovy catches from the Black Sea region were exclusively caught by purse seiners from the large-scale sector.

The major taxa landed by the small-scale sector for the 1950-2010 period are grey mullet (10%); bonito (9%); whiting (8%); Mediterranean mussel (*Mytilus galloprovincialis* 8%); turbot (6%); bluefish (5%); and Mediterranean horse mackerel (4%).

Unreported

The total unreported component for the Turkish Black Sea amounted to approximately 5.6 million t for the 1950-2010 period. Of this total, 94% was allocated to the large-scale sector and 6% was allocated to the small-scale sector. The taxonomic allocation for the unreported catches is the same as the large-scale and small-scale reported components above.

Recreational & subsistence

Total estimated Black Sea recreational and subsistence catches totaled slightly over 77,500 t, or specifically ~39,300 t for the recreational and ~38,200 for the subsistence sectors, for the 1950-2010 period. The portion of this attributed to the subsistence sector was much higher (90%) at the beginning of the study period than at the end (10% in 2010). Recreational catches had the opposite trend, whereby in 1950, they accounted for 10% which increased to 90% by 2010. The dominant species caught in the Black Sea by the recreational sector over the 1950-2010 time period were: bonito (28%); Mediterranean horse mackerel (16%); Atlantic horse mackerel (12%); bluefish (7%); grey mullet (7%); and seabream (4%).

Discards

Total discards for the Black Sea amounted to 2.14 million t for the 1950-2010 period. Total discards from bottom trawling in the Black Sea (for the 1950-2010 period) totaled ~740,600 t. The taxonomic composition of discards included Mediterranean horse mackerel (65%), Atlantic horse mackerel (14%), red mullet (8%), turbot (5%), sharks (4%), sea snail (3%), and shrimp (1%).

The total discards from highgrading in the Black Sea (for the 1950-2010 period) totaled approximately 590,500 t and had the following composition: rays (56%); scorpionfish (20%); gobies (13%); and sprat (11%).

The total discards from all of the 'other' fisheries in the Black Sea for the 1950-2010 period, totaled around 558,300 t; of which 80% were from the anchovy fishery; 5% were from the bonito fishery; 3% were from the bluefish fishery; 3% were from the cockle fishery; 2% were from the red mullet fishery; and the remaining 7% were from 'other' fisheries.

Marmara Sea

Reconstructed catch

Large scale vs. small-scale

For the 1950-2010 period, large-scale fishing operations landed approximately 738,000 t of total reported catches (70%) from the Sea of Marmara, while the small-scale sector landed more than 323,500 t (30%).

The major species landed by the large-scale sector for the 1950-2010 period include anchovy (~140,300 t); grey mullets (~84,400 t); European pilchard (~78,000 t); silversides (~Atherinidae, 45,000 t); chub mackerel (~31,000 t); bonito (~26,000 t); and bluefish (~17,700 t).

The major species landed by the small-scale sector for the 1950-2010 period include cockle (~46,000 t); mussel (~40,400 t); shrimp (~33,350 t); chub mackerel (~33,000 t); mullets (~31,300 t); bonito (~24,300 t); and bluefish (~20,200 t).

Unreported

The total unreported component for the Sea of Marmara amounted to ~872,000 t for the 1950-2010 period. Of this total, 63% was allocated to the large-scale sector and 37% was allocated to the small-scale sector. The taxonomic allocations for the unreported catches are the same as the large-scale and small-scale reported components above.

Recreational and subsistence

The total reconstructed catch for the entire Marmara Sea region for the recreational and subsistence sectors for the 1950-2010 period was ~2.28 million t, or specifically, ~1.28 million t for the recreational and ~1 million for the subsistence sector, for the 1950-2010 period.

The catch is distributed between the three different sub-areas in the following manner: the total reconstructed catch for the recreational sector in the Marmara Sea region (excluding İstanbul and Çanakkale) for the 1950-2010 period totalled ~1.7 million t (75% of the regions total catch); the recreational/subsistence catches for the Çanakkale region for the entire 1950-2010 period totalled nearly ~233,500 t; and the recreational/subsistence catches for the İstanbul region for the same period totalled ~328,300 t.

Recreational catches for the Çanakkale region were dominated by bluefish (15%), picarel (*Spicara smaris* 12%), sea snail (10%), mussel (6.8%), sea cucumber (6.7%), axillary seabream (*Pagellus acarne*; 6.2%), grey mullet (4.6%), horse mackerel (3.6%), gilthead seabream (*Sparus aurata*; 3.35%), Atlantic mackerel (3%), and smooth-hound shark (*Mustelus mustelus*; 2.92%).

The dominant recreationally-caught species in the rest of the Marmara Sea region by the recreational for the 1950-2010 period were (Fig. 9): bluefish (15.9%); bonito (7%); Mediterranean horse mackerel (6.9%); picarel (6.5%); chub mackerel (5.9%); mullet (5.4%); sea snail (5.4%); horse mackerel (4.9%); mussel (3.8%); and 'other' marine species (38.3%).

Discards

Total discards from bottom trawling for the 1950-2010 period were estimated to be ~87,000 t (on average, ~5,100 t · year^{-1} for the 2000s). Discards had the following taxonomic composition: Mediterranean horse mackerel (41.2%); shrimp fishery discards (24.7%); Atlantic horse mackerel (21.6%); red mullet (6.5%); shark (3.3%); turbot (2.5%); and sea snail (0.2%).

Total discards from high-grading in Marmara Sea (for the 1950-2010 period) totaled ~127,000 t and had the following taxonomic composition: rays (42%); scorpionfish (35%); gobies (21%); and sprat (2%).

Total discards from 'other fisheries' in the Marmara Sea (for the 1950-2010 period) totaled just over 98,000 t, and had the following taxonomic composition: 37% an-

chovy; 9% bonito; 8% European pilchard; 8% bluefish; 5% whiting; and 33% from all 'other' fisheries.

Aegean Sea

Reconstructed catch

Large-scale vs. small-scale

For the 1950-2010 period, large-scale fishing operations landed just over 1 million t (75%) of total reported commercial catches from the Aegean Sea while the small-scale sector landed ~337,300 t (25%).

The major taxa landed by the industrial or large-scale sector for the 1950-2010 period are: European pilchard (~335,000 t); anchovy (~164,000 t); grey mullet (~89,000 t); blue whiting (~63,150 t); chub mackerel (~54,000 t); bogue (*Boops boops* ~40,000 t); and bonito (~24,150 t).

The major taxa landed by the small-scale sector for the 1950-2010 period are grey mullet (~48,000 t); seabream (~30,100 t); mussel (~30,050 t); European seabass (~20,750 t); bogue (~15,550 t); twaite shad (~11,100 t); and common octopus (*Octopus vulgaris* 8,750 t).

Unreported

The total unreported component for the Aegean Sea amounted to nearly 553,000 t for the 1950-2010 period. Of this total, 75% was allocated to the large-scale sector and 25% was allocated to the small-scale sector. The taxonomic allocations for the unreported catches are the same as the large-scale and small-scale reported components above.

Recreational and subsistence

The total reconstructed catch for the recreational and subsistence sectors from the Aegean Sea for the entire 1950-2010 period was ~143,450 t, (on average, 3,700 t · year^{-1} in the 2000s). Total recreational catches amounted to ~79,900 t (59%) over the 1950-2010 period, while subsistence catches accounted for ~63,550 t (41%).

The dominant taxa caught in the Aegean Sea by the recreational and subsistence sectors were groupers (13%); grey mullet (11%); seabream (12%); horse mackerel (12%); European seabass (12%); common dentex (11%); bogue (6%); and Mediterranean horse mackerel (5%).

Discards

Discards from bottom trawling in the Aegean Sea (for the 1950-2010 period) totaled nearly 70,000 t. The discards had the following composition: Mediterranean horse mackerel (30%); red mullet (25%); Atlantic horse mackerel (20%); shrimp fishery discards (20%); sharks (5%); sea snail (1%); and turbot (0.1%).

Total discards from the shrimp fishery totaled just over 8,900 t and specifically had the following taxonomic composition: swimming crabs (29%); blue crab (17%); annular seabream (15%); angular crab (15%); mantis shrimp (12%); and purple-dye murex (12%).

The total discards from highgrading in the Aegean Sea (for the 1950-2010 period) totaled nearly 86,000 t. The discards had the following taxonomic composition: scorpionfish (49%); gobies (29%); rays (20%); and sprat (2%).

The total discards from 'other fisheries' in the Aegean Sea (for the 1950-2010 period) totaled just over 58,400 t. Discards had the following taxonomic composition: European pilchard (29%); anchovy (12%); mullets (11%); European seabass (7%); shi drum (*Umbrina cirrosa*, 6%); and the remaining 35% were from other taxa.

The Levantine Sea

Reconstructed Catch

Large-scale vs. small-scale

For the 1950-2010 period, large-scale fishing operations landed nearly 483,000 t (64%) of reported catches from the Levantine Sea, while the small-scale sector landed nearly 270,000 t (36%).

The major reported taxa landed by the large-scale sector in the Levantine Sea during the 1950-2010 period were European pilchard (15%); mullets (7%); silversides (7%); chub mackerel (6%); anchovy (5%); picarel (3%); and bluefin tuna (3%).

The major reported taxa landed by the small-scale sector in the Aegean Sea during the 1950-2010 period were European barracuda (15%); seabream (11%); grey mullet (11%); leerfish (*Lichia amia* 7%); European seabass (5%); shrimp (4%); and common cuttlefish (*Sepia officinalis* 4%). Annual marine reported landings were highest in the Levantine Sea in 1993 with ~50,000 t and lowest in 2001 with ~11,800 t (TÜİK 2010).

Unreported

The total unreported component for the Levantine Sea amounted to ~306,000 t for the 1950-2010 period. Of this total, 75% was allocated to the large-scale sector and 25% was allocated to the small-scale sector. The taxonomic allocation for the unreported catches is the same as the large-scale and small-scale reported components above.

Recreational & subsistence

The reconstructed catch for the recreational and subsistence sectors from the Levantine Sea region for the entire 1950-2010 period was ~95,750 t (on average, just over 2,000 t · year^{-1} in the 2000s). Total recreational catches amounted to just above 53,500 t over the 1950-2010 study period, while subsistence catches accounted for ~43,600 t.

The major taxa caught in the Levantine Sea by the recreational and subsistence sectors through the 1950-2010 period were European barracuda (~14,250 t); grou-

per (nearly 13,200 t); picarel (just over 12,400 t); common dentex (~9,550 t); European seabass (~9,550); gobies (~7,200 t); shark (~6,150 t): and leerfish (~2,100 t).

Discards

Discards from bottom trawling in the Levantine Sea (for the 1950-2010 period) totaled nearly 44,500 t (on average, 810 t · year^{-1} for the 2000s). The discards had the following taxonomic allocation: red mullet (33%); Atlantic horse mackerel (13%); crabs (13%); Mediterranean horse mackerel (10%); shark (9%); and the shrimp trawl fishery (22%). The discards from the shrimp fishery (included in the above bottom trawling estimations) amounted to ~8,250 t.

The total discards from high-grading in the Levantine Sea (for the 1950-2010 period) totaled nearly 247,000 t. The discards had the following taxonomic allocation: gobies (72.8%); rays (15%); scorpionfish (12%) and sprat (0.2%).

The total discards from 'other' fisheries in the Levantine Sea (for the 1950-2010 period) totaled 32,240 t. The majority of discards had the following taxonomic allocation: European pilchard (16%); European barracuda (7%); mullets (6%); swordfish (5%); picarel (5%); cuttlefish (5%); and the remaining 56% were from other taxa.

Adjustments

Sea cucumber

The total adjustment for sea cucumbers contributed 228.6 t to the reconstruction.

Sea snail

The total adjustment for the discrepancy in sea snail reported landings in comparison to the export data amounted to 61,592 t for the years between 1985-1987, and 1994-2003.

Bluefin tuna

The total adjustment for bluefin tuna due to the ICCAT estimation was 1,384 t for 2006 only which was added to the Levantine Sea landings.

Turbot in the Black Sea

The amount of turbot caught by Turkey in distant waters in the Black Sea, outside its own national waters has been estimated from 1993-2001 and from 2009-2010. This equals an adjustment total of 11,000 t for the 11 year period which has been re-allocated equally to the EEZ's of Romania, Bulgaria and the Ukraine.

Turkey as a Whole

The total reconstructed catch for the 1950-2010 time period is approximately 30 million t, adding 11.6 million t to the total reported landings of around 18.4 million t (Fig. 3, Appendix Table 4). Thus, reconstructed total catches were 63% more than the officially reported data. Our reconstruction of Turkey's total catch from 1950 to 2010 combines the reported landings presented in the national data submitted to the FAO with our best estimates of additional unreported and under-reported catches (Fig. 3, Appendix Table 4). It is realized that some of these estimations may not be totally accurate, but they are preferred to the alternative method, which is ignoring these sectors and catches, as is often the case. Each following component comprised the following tonnages of total catch reconstruction: reported FAO data, 18.4 million t; unreported catches ~7.4 million t; discards ~2.6 million t, recreational catches ~1.45 million t; and subsistence catches of ~1.15 million t.

From the total reconstructed catches (inclusive of the reported data) for the 1950-2010 period (Fig. 5, Appendix Table 5), anchovy was the largest single-taxonomic contribution to total marine landings with 14 million t; horse mackerel contributed 3.7 million t; bonito 1.6 million t; whiting 1.1 million t; bluefish 1.1 million t; European pilchard nearly 1 million t; and sprat around 330,000 t (included in data from 1996-2010 only). It is clear from Figure 6 that the catches of small pelagics have increased dramatically since around 1980 (sprat, whiting, European pilchard and anchovy), while the larger pelagics (bonito, mullet, horse mackerel and bluefish) have been on a declining trend since around 1980. Marine landings for Turkey, when plotted as a time-series, appear to be semi-stable (Fig. 6). Once anchovy catches are excluded, it becomes apparent that the majority of catches, other than anchovy have been on a downward declining trend since 1989 (Fig. 6).

As of 2010, out of a total of 16,650 registered fishing vessels, only 2,583 (15%) were large-scale fishing vessels, i.e., over 10 m in length. However, the large-scale sector was estimated to land 90% of the total reported fishery landings for the 1950-2010 period (Fig. 4, Appendix Table 4).

Unreported landings

Of the contributed adjustments, unreported catches were the largest component. Illegal, unreported, unregulated fishing presents one of the biggest problems affecting fisheries management. The unreported and unregulated catches should be addressed by fishery managers, while illegal fishing should be addressed by law enforcement. This 40% unreported adjustment totalled to approximately 7.4 million t for the 1950–2010 period (Appendix, Table 4). The major unreported species throughout the 1950-2010 period were anchovy (~3.6 million t); Mediterranean horse mackerel (~520,000 t); bonito (~266,000 t); European pilchard (~220,000 t); and whiting (~200,000 t). Overall, unreported landings as a frac-

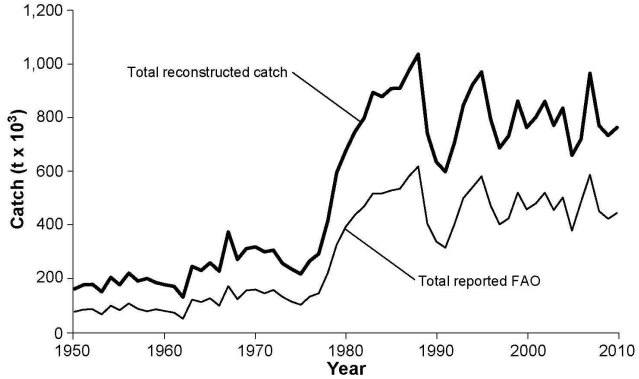

Fig. 3: Total reconstructed catch compared to total reported catch, 1950-2010.

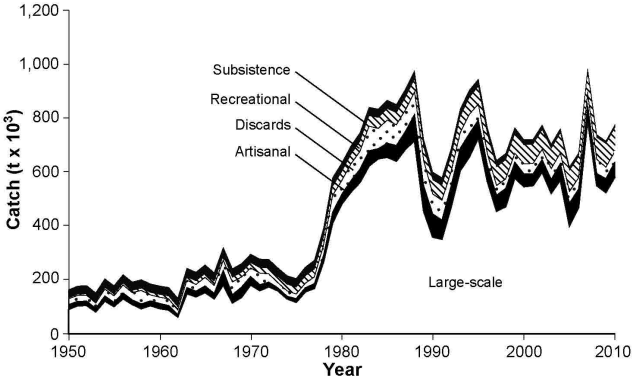

Fig. 4: Total reconstructed catch by sector, from 1950-2010.

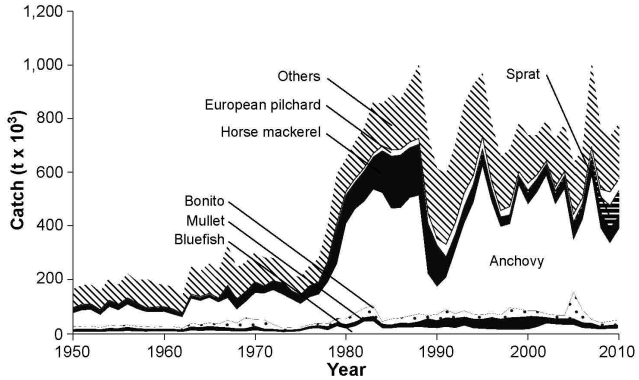

Fig. 5: Total reconstructed catch by major species or taxa, from 1950-2010.

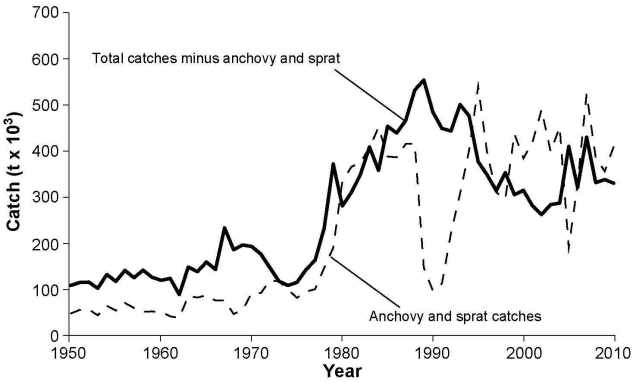

Fig. 6: Total reported catches (t) in Turkey, anchovy and sprat, and all other species, 1950-2010.

tion of total reconstructed catches accounted for 22.1% of total reconstructed catches.

Recreational/Subsistence Catches

The estimated recreational and subsistence catches for the 1950-2010 period were just over 2.6 million t (Appendix Tables 4 and 6). Of this amount 1.45 million tonnes was from the recreational sector and 1.15 million tonnes was from the subsistence sector. Of the total reconstructed catch, the Marmara Sea region (including both İstanbul and Çanakkale regions) accounted for ~2.3 million tonnes (88%); the Aegean Sea accounted for ~139,000 t (5%); the Levantine Sea accounted for ~251,000 t (10%); and the Black Sea region accounted for ~76,000 t (2%).

The major species caught by the recreational sector throughout the 1950-2010 period were bluefish (~590,000 t); bonito (~288,000 t); Mediterranean horse mackerel (~272,000 t); picarel (~239,000 t); and chub mackerel (~229,000 t). Overall, recreational and subsistence catches as a fraction of total reconstructed catches accounted for nearly 9% of the total reconstructed catch (Fig. 5).

Discards

Total discards for all components (Fig. 7, Appendix Table 7) estimated was approximately 2.7 million t over the 1950-2010 time period. Discards from highgrading were most substantial, totalling 1.27 million t for the entire study period. Discards due to bottom trawling represented the second largest discard component totalling 730,000 t, and discards came third for all 'other' fisheries which totalled nearly 800,000 t for the same period. The major species discarded throughout the 1950-2010 period were rays (587,000 t); anchovy (472,000 t); Mediterranean horse mackerel (399,000 t); scorpionfish (267,000 t); and Atlantic horse mackerel (118,000 t). Overall, discards as a fraction of total reconstructed catches accounted for 9% of total reconstructed catches (Fig. 4, Appendix Table 4).

Discussion

Turkey's total reconstructed catches over the 1950-2010 time period were estimated to be approximately 30 million tonnes, adding 11.6 million tonnes to the officially reported landings presented by the FAO on behalf of Turkey. The discrepancy between the reported and reconstructed data was largely due to unreported catches, which accounted for just over 7.4 million t, discards accounted for 2.6 million t, recreational catches accounted for 1.45 million t, and subsistence catches accounted for 1.15 million.This study highlights the need for improved data collection procedures for Turkish fisheries statistics.

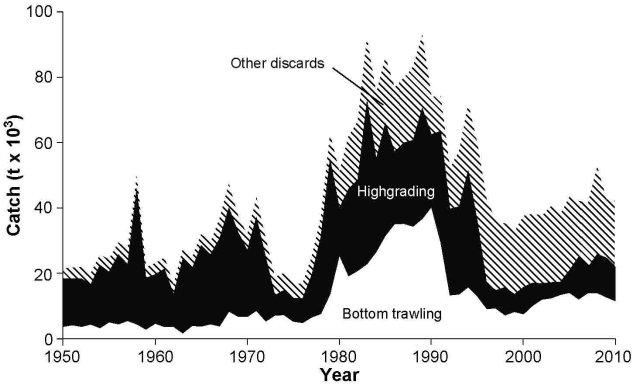

Fig. 7: Discard components for Turkey, 1950-2010.

Current and past methods of data collection have not accounted for total fisheries removals, which are urgently needed in order to assess fisheries impacts on marine ecosystems. Successful fisheries management plans depend, in large part, on the accuracy of the available data (Ünal, 2010). As Turkey aspires to become a member of the EU, addressing missing catch data must be a priority. An overhaul of the statistical data collection system is already under way. However, understanding past catches is important to understanding Turkey's fisheries. Since the fisheries represent less than 1% of the GDP, the Turkish government has not given these natural resources the special attention they require. However, such measures as GDP undervalue the true value of marine resources to a country especially when they fail to incorporate the unreported, recreational and discarded components, i.e., the three main components of this reconstruction. Below are some recommendations to enhance the accuracy for each component.

Of the contributed adjustments, unreported catches were the largest component. The substantial unreported landings estimated during this study appear to be the result of inefficient monitoring, control and surveillance (MCS) systems in Turkey. Furthermore, fishers may under-report their catches due to the present taxation system. It would be a worthwhile government investment to address the loopholes in the reporting system, by making sure that fishers only land their catches at the specific ports offices equipped to verify catches against logbook data, and correcting current issues in the Vessel Monitoring System. To improve the accuracy of reporting, 100% observer coverage on all commercial vessels should also be implemented (INTERPOL, 2010; Zeller *et al.,* 2011). If Turkey was granted entry into the European Union (EU), these discrepancies would likely be resolved the quickest, as Turkey would have to align their policies with the Common Fisheries Policy of the EU. Illegal fishing, on the other hand, should not be a matter of fisheries management, but of law enforcement (UNODC, 2011).

Currently, unreported and mostly unregulated, Turkey's recreational sector was found here to have significant catch amounts, particularly in the recent period in the Sea of Marmara and the Bosphorus Strait. Recreational catches, for some species, were comparable in magnitude to commercial landings (i.e. picarel catches in the Sea of Marmara). Management measures urgently needed for this sector include surveys to estimate catch and a licensing system, which could improve regulation effort in this sector. Long-term monitoring of the recreational sector can be accomplished in as little as once every 4-5 years (for cost-effectiveness) by completing roving surveys such as creel or angling surveys, or aerial surveys to provide necessary baseline data on fishing effort and catch per unit effort (see Brouwer *et al.,* 1997).

We feel that the İstanbul recreational/subsistence sector estimation is low compared to the Çanakkale study (Ünal *et al.* 2010), since the population of the study site is only about 6.4% that of İstanbul's, and yet the total estimated catches of Çanakkale are 377% that of İstanbul's. This is partly because only 1% of the population of İstanbul was estimated to fish recreationally while the study found 9.9% of the population in the Çanakkale region to be recreational fishers, and a much lower catch rate was used for the İstanbul region than the Çanakkale region to account for the fact that fishers generally use simple fishing rods and handlines in İstanbul, but more sophisticated boats and nets in the Çanakkale region. Also, it is understood that the study region is a much more biologically productive corridor than the Bosphorus Strait, since many species have discontinued their migration routes to the latter for various reasons.

Discards represent the third main component in this reconstruction. It has been estimated that 2.6 million t of marine life have been discarded in Turkey for the 1950-2010 period, which is close to five years' worth of total marine catches. Bottom trawling for shrimp and other species had the highest studied percentages of discards, and is also known to be highly destructive of the benthic fauna and flora composition. Mixed-species fisheries are considered wasteful as they catch substantial amounts of non-target species, which are often discarded. Most fishing methods in Turkey are mixed-species fisheries, which have high levels of associated discards, especially of under-sized commercial species. These factors have undoubtedly contributed to the nation-wide 'growth overfishing' dilemma. Putting an end to illegal trawling in the nation should significantly aid the many perilous marine stocks.

Previous studies conducted on pelagic and demersal fish stocks around the coasts of Turkey indeed show that catches are comprised mainly of juvenile and sub-adult fish (Lök *et al.*, 2002). Fish markets sampled along the Black Sea coast from 1990-1995 (Zengin *et al.,* 1998) found that one third of the anchovy for sale in the region were below the minimum legal catch size of 9 cm; and

in the Black Sea, 90% of bluefish are caught before they have a chance to reproduce. The minimum landing size (MLS) for bluefish was 14 cm (Ceyhan *et al.*, 2007), but this species does not begin to reproduce until it is between 20-25 cm in length. Local fishers were worried about this 'growth overfishing' problem and started a national campaign (with the aid of Greenpeace) to raise public awareness regarding under-sized fish (Ceyhan *et al.*, 2007). Due to this highly-publicized campaign (which provided rulers to measure fish length), the minimum legal landing size was increased to 20 cm for bluefish, but public pressure is mounting for the minimum legal landing length to be increased further to 25 cm. Since most fishers barely turn a profit, they instead try to 'think outside the rules'; Knudsen (1995) reported that in Samsun, on the Black Sea coast, "most trawlers use an additional inner trawl bag that is 2 mm less than the legal mesh size of 18 mm. Consequently, there is heavy overfishing of undersized fish". If the species has commercial value, even though it is under-sized, it may still sell at the market (V. Ünal, pers. obs.). The shrimp fishery would also benefit from having minimum landing sizes, so that individuals could be targeted which have already had a chance to reproduce, enhancing sustainability of the stock.

Minimum landing sizes would be more effective if the regulations coincided with fishing net mesh restrictions that would exclude catching juveniles of the target species to avoid waste in the fishery. Of course, there would have to be sufficient monitoring and control to enforce minimum mesh sizes, and also control measures are needed in fish markets, to prevent the sale of juvenile species.

It should underlined that although marine fish landings in Turkey appear relatively stable (reported landings around 500,000 $t \cdot year^{-1}$ since the early 1990s), during the 2005-2010 period, small pelagics averaged to contribute 80% of total landings, while the larger-sized pelagics made up less than 20%. It should be emphasized that much of this anchovy and sprat caught is processed into fish flour and fish meal and is not made accessible to the growing population to help address food security concerns. Another important issue is that many of these larger pelagics have substantially decreased in size and in the most recent decades, so that they themselves have almost become small pelagics, especially as in Mediterranean horse mackerel, Atlantic horse mackerel, and bluefish.

In Turkey, large and small-scale fleets often fish in the same areas and target the same species, aside from small pelagics such as anchovy and sprat (which are taken exclusively by large-scale fleets). The small-scale sector, however, represents most of the employment. Overcapacity in Turkey's seas needs to be addressed as almost all catches (aside from anchovy and sprat) are declining. Until fishing capacity is restricted, the well-being and resilience of Turkish marine ecosystems will continue to be compromised.

The industrial fishing fleet has continued to grow uncontrollably (most notably after the 1980s; Fig. 8 in Supplementary file, in electronic form), which has been detrimental to the declining stocks of target species (Gücü, 2001). The combined landings of all demersal species from the Levantine region drastically declined from 10,000 $t \cdot year^{-1}$ in 1992 to 2,000 $t \cdot year^{-1}$ from 2001 onwards. This is most likely due to decades of intense trawling combined with increased fishing effort.

The data collection system must account for all species caught. For example dolphinfish (*Coryphaena hippurus*) are known to migrate through the Levantine basin in the summer months; and palometa (*Orcynopsis unicolor*) are known to exist in the Aegean and Mediterranean Seas, both of which can be found for sale in İstanbul fish markets. Also, sea cucumbers are caught, processed and then exported to Asia. Yet, all these taxa are not included the official data collection system.

The larger, more valuable species such as grouper, turbot, and red mullet have been overfished and many traditional fisheries such as Atlantic mackerel have collapsed. Both the Black and Marmara Seas have experienced dramatic shifts in the composition of species and the quality of their ecosystems has declined within the last 30 years. Fishers are now targeting smaller, less valuable species such as sprat, whiting and gurnards, which were not consumed by Turks in the past, but which have now found their way to fish markets. In addition to declining fish stocks, mean fish sizes are getting smaller, as demonstrated with turbot, bluefish and anchovy. The health of Turkish fisheries is declining and will continue to do so until issues such as overcapacity, destructive fishing techniques (bottom trawling) and pollution are seriously addressed.

Exclusive economic zone

Turkey, along with less than a handful of other countries (Israel, Syria, United States and Venezuela), chose not to sign and ratify the 1982 United Nations Convention on the Law of the Sea (UNCLOS). UNCLOS granted each country exclusive rights over the marine resources within their Exclusive Economic Zone (up to 200 nautical miles from their coasts). However, Turkey's potential membership to the EU would be contingent upon signing. Turkey's issues with this law are primarily related the Aegean and Mediterranean coastal waters, since many Greek islands are situated very close to Turkish lands (for example the Greek Dodecanese island of Kastelorizo is only 2 km away from the Turkish mainland). Greece on the other hand, ratified UNCLOS in 1995.

Turkey's concerns about UNCLOS include the definition of the Exclusive Economic Zone, the range of its territorial sea, and the delimitation of the continental shelf (Oral, 2009). Turkey is also concerned that signing

may block some of the country's traditional and physical access to the sea, and to its resources. While Turkey continues to struggle with the UNCLOS framework, it has signed the Convention on International Trade for Endangered Species (CITES) of Wild Fauna and Flora (Knudsen *et al.*, 2007).

Conclusion

This study highlighted the shifting state of Turkey's marine fisheries, and then established our best estimation of total national marine fisheries removals. Many species have been intensively exploited and may never recover to their previous levels of abundance, even if effort is severely reduced. To prevent further decline in the fisheries, both ecologically and economically, improving fisheries management should be a national priority.

Key to improving management and moving towards more sustainable fisheries is an understanding of the history of fishing in an area. The current lack of adequate and reliable fisheries catch data, and the uncertainties associated with the available data have been major obstacles in the development of effective management plans (Koşar, 2009). Over the period from 1930 to 1980, Turkey's main fisheries catches changed from primarily bonito (a high trophic level, large fish), to primarily anchovy (a low trophic level, small fish), in the İstanbul and Marmara regions, which is an exemplary case of 'fishing down marine food webs' (Pauly *et al.*, 1998). Now it is also probable that much of Turkey's anchovy catches are not even coming from their own waters, as the anchovy are being driven out due to the highly–efficient technologies. Bonito had been the staple resource responsible for supplying İstanbul and the Marmara region with considerable wealth and food security for millennia, but its portion of total catch, along with many other larger fish such as swordfish, bluefin tuna and Atlantic mackerel have all but disappeared. A comprehensive time series of fisheries catches, such as presented in this report, is therefore essential to understand, and to help improve, the state of Turkey's fisheries.

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Appendix Table 1a. List of english names, scientific names and Turkish names used in this report for fish species. (Note that the symbols ı, ö, ü , İ, ç, ğ, ş are special Turkish characters which correspond to the English uh, o, u, ee, ch, soft gh, sh sounds respectively).

English name	Scientific Name	Turkish name (additional name)
Albacore	*Thunnus alalunga*	Albakor (irigöz)
Anglerfish	*Lophius piscatorius*	Fener baliği
Angel shark	*Squatina squatina*	Keler
Annular seabream	*Diplodus annularis*	İsparoz (ispari)
Atlantic horse mackerel	*Trachurus trachurus*	Karagöz İstavrit
Atlantic mackerel	*Scomber scombrus*	Uskumru
Atlantic saury	*Scomberesox saurus*	Zurna
Axillary seabream	*Pagellus acarne*	Kırma Mercan
Black scorpionfish	*Scorpaena porcus*	Lipsöz
Black goby	*Gobius niger*	Siyah Kayabalığı
Black grouper	*Mycteroperca bonaci*	Siyah Orfoz
Bogue	*Boops boops*	Kupez (kupa)
Bluefish	*Pomatomus saltatrix*	Lüfer (big çinekop)
Bluefin tuna	*Thunnus thynnus*	Orkinoz
Blue jack mackerel	*Trachurus picturatus*	Istavrit
Bonito	*Sarda sarda*	Palamut (torik)
Brown meagre	*Sciaena umbra*	Işkine (mavraşgil)
Bullet tuna	*Auxis rochei*	Yazılı orkinoz
Blue whiting	*Micromesistius poutassou*	Bakalorya
Chub mackerel	*Scomber japonicus*	Kolyoz (kolyozvonozu balığı)
Common dentex	*Dentex dentex*	Sinağrit
Common dolphinfish	*Coryphaena hippurus*	Lambuka
Dusky grouper	*Epinephelus marginatus*	Orfoz
European anchovy	*Engraulis encrasicolus*	Hamsi
European barracuda	*Sphyraena sphyraena*	İskarmoz (baraküda)
European conger	*Conger conger*	Miğri
European pilchard	*Sardina pilchardus*	Saradalya (çiroz)
European plaice	*Pleuronectes platessa*	Pisi
European seabass	*Dicentrarchus labrax*	Levrek
European sprat	*Sprattus sprattus*	Çaça
Frigate tuna	*Auxis thazard*	Gobene
Garfish	*Belone belone*	Zargana
Gilthead seabream	*Sparus aurata*	Çipura
Goatfishes	Mullidae	Paşa barbunu
Gobies	Gobiidae	Kaya baliği
Grey mullet	Mugilidae	Kefal
Groupers	Serranidae	Orfoz
Greater amberjack	*Seriola dumerili*	Avci (sarikuyruk)
Gurnards	*Trigla* spp.	Kirlangiç
Hake	*Merluccius merluccius*	Berlam
John dory	*Zeus faber*	Dülger

(continued)

(continued)

English name	Scientific Name	Turkish name (additional name)
Leerfish	*Lichia amia*	Akya
Little tunny	*Euthynnus alletteratus*	Yazili orkinoz
Meagre	*Argyrosomus regius*	Sariağiz
Medit. horse mackerel	*Trachurus mediterraneus*	Sarıkuyruk istavrit
Pacific mullet	*Mugil soiuy*	Rus kefali
Painted comber	*Serranus cabrilla*	Asıl hani
Pandora	*Pagellus erythrinus*	Kırma mercan
Picarel	*Spicara smaris*	İzmarit
Piper gurnard	*Trigla lyra*	Öksüz
Red mullet	*Mullus barbatus barbatus*	Barbunya
Round sardinella	*Sardinella aurita*	Sardalya
Saddled seabream	*Oblada melanura*	Melanurya
Salema	*Sarpa salpa*	Sarpa (çitari)
Scorpionfishes	Scorpaenidae	İskorpit
Seabream	Diplodus spp.	Fangri (fanri)
Shad	*Alosa fallax*	Tirsi
Sharpsnout seabream	*Diplodus puntazzo*	Sivriburun karakgöz
Shore rockling	*Gaidropsarus mediterraneus*	Gelincik
Sharks	Selachiimorpha	Köpek baliği
Shi drum	*Umbrina cirrosa*	Minekop
Silversides	Atherinidae	Gümüş (çumuka)
Sole	*Solea solea*	Dil
Sprat	*Sprattus sprattus*	Çaça
Striped red mullet	*Mullus surmuletus*	Tekir
Swordfish	*Xiphias gladius*	Kiliç
Thicklip grey mullet	*Chelon labrosus*	Kefal
Thornback ray	*Raja clavata*	Vatoz
Tub gurnard	*Trigla lucerna*	Kırlangiç
Turbot	*Scopthalmus maximus*	Kalkan (saç)
Twaite shad	*Alosa fallax*	Tirsi
White grouper	*Epinephelus aeneus*	Lahoz
White seabream	*Diplodus vulgaris*	Karagöz
Whiting	*Merlangius merlangus*	Mezgit

Appendix Table 1b. List of English names, scientific names and Turkish names used in this report for invertebrate species. (Note that the symbols ı, ö, ü , ı, ç, ğ, ş are special Turkish characters which correspond to the English uh, o, u, ee, ch, soft gh, sh sounds, respectively).

English name	Scientific name	Turkish name
Angular crab	*Goneplax rhomboides*	Yengeç
Blue crab	*Callinectes sapidus*	Mavi yengeç
Brown comb jelly	*Beroe ovata*	Deniz anasi (medüz)
Caramote prawn	*Melicertus kerathurus*	Karabiga
Carpet shell	*Ruditapes decussatus*	Akıvades (kum midyesi)
Comb jelly	Ctenophora	Deniz anasi (medüz)
Common octopus	*Octopus vulgaris*	Ahtapot
Common squid	*Loligo vulgaris*	Kalemerya
Deepwater rose shrimp	*Parapenaeus longirostris*	Pembe karides (çimçim)
Edible crab	*Cancer pagurus*	Pavurya
European flat oyster	*Ostrea edulis*	İstiridye
European lobster	*Homarus gammarus*	İstakoz
Giant gamba prawn	*Aristaeomorpha foliacea*	Kırmızi karides
Green tiger prawn	*Penaeus semisulcatus*	Jumbo karides
Great Mediterranean scallop	*Pecten jacobaeus*	Tarak
Horse mussel	*Modiolus barbatus*	Kıllı midye
Mantis shrimp	*Squilla mantis*	Böcek yiyen
Mediterranean mussel	*Mytilus galloprovincialis*	Kara midye
Norway lobster	*Nephrops norvegicus*	Deniz kereviti
Rapa whelk	*Rapana venosa*	Deniz salyangozu
Sea cucumber	Holothuridea	Deniz hıyarı
Sepia	*Sepia officinalis*	Mürekkep
Shrimp	Penaeidae	Karides
Speckled shrimp	*Metapenaeus monoceros*	Erkek karides
Spiny lobster	*Palinurus vulgaris*	Böcek
Striped venus clam	*Chamelea gallina*	Beyaz kum midyesi
Swimming crab	Portunidae	Çalpara
Tun snail	*Tonna galea*	Deniz salyangozu
Warty comb jelly	*Mnemiopsis leidyi*	Deniz anasi

Appendix Table 2. Fish catch allocation by sector. Percentage of fish caught by small-scale sector, remaining percentage caught by large-scale sector. Source: Percentages estimated from collaborative experience of authors and one additional person.

Fish species (or group)	Small-scale (%)	Large-scale (%)
Albacore tuna (*Thunnus alalunga*)	20	80
Anchovy (*Engraulis encrasicolus*)	-	100
Angelshark (*Squatina squatina*)	10	90
Atlantic bonito (*Sarda sarda*)	15	85
Atlantic horse mackerel (*Trachurus trachurus*)	2	98
Atlantic mackerel (*Scomber scombrus*)	25	75
Bluefin tuna (*Thunnus thynnus*)	10	90
Bluefish (*Pomatomus saltatrix*)	15	85
Blue whiting (*Micromesistius poutassou*)	-	100
Bogue (*Boops boops*)	25	75
Bullet tuna (*Auxis rochei rochei*)	20	80
Chub mackerel (*Scomber japonicus*)	25	75
Common dentex (*Dentex dentex*)	100	-
Dusky grouper (*Epinephelus marginatus*)	100	-
European barracuda (*Sphyraena sphyraena*)	100	-
European conger (*Conger conger*)	20	80
European pilchard (*Sardina pilchardus*)	5	95
European seabass (*Dicentrarchus labrax*)	100	-
European sprat (*Sprattus sprattus*)	-	100
Frigate tuna (*Auxis thazard thazard*)	20	80
Garfish (*Belone belone*)	50	50
Gobies (Gobiidae)	10	90
Greater amberjack (*Seriola dumerili*)	10	90
Hake (*Merluccius merluccius*)	25	75
John dory (*Zeus faber*)	50	50
Leerfish (*Lichia amia*)	100	-
Lizardfish (*Synodus saurus*)	70	30
Meagre (*Argyrosomus regius*)	100	-
Mediterranean horse mackerel (*Trachurus mediterraneus*)	2	98
Mullets (Mugil spp.)	30	70
Painted comber (*Serranus scriba*)	40	60
Picarel (*Spicara smaris*)	35	65
Salema (*Sarpa salpa*)	100	-
Sand smelt (Atherinidae)	-	100
Scorpionfishes (Scorpaeniformes)	10	90
Seabreams (Diplodus spp.)	75	25
Sharks (Selachiimorpha)	10	90
Shi drum (*Umbrina cirrosa*)	100	-
Shore rockling (*Gaidropsarus mediterraneus*)	100	-
Sole (*Solea solea*)	20	80
Swordfish (*Xiphias gladius*)	50	50
Thornback ray (*Raja clavata*)	25	75
Twaite shad (*Alosa fallax*)	78	22
Turbot (*Scopthalmus maximus*)	72	28
Whiting (*Merlangius merlangus*)	15	85

Appendix Table 3. Invertebrate catch allocation by sector. Percentage of invertebrates caught by small-scale sector.

Invertebrate species (or group)	Small-scale (%)	Large-scale (%)
Comb jellies (Ctenophora)	-	100
Common octopus (*Octopus vulgaris*)	50	50
Common squid (*Loligo vulgaris*)	50	50
Crabs (Brachyura)	50	50
European flat oyster (*Ostrea edulis*)	100	-
European lobster (*Homarus gammarus*)	90	10
Great Mediterranean scallop (*Pecten jacobaeus*)	100	-
Mediterranean mussel (*Mytilus galloprovincialis*)	100	-
Rapa whelk (*Rapana venosa*)	100	-
Sepia (*Sepia officinalis*)	50	50
Shrimps (Penaeidae)	45	55
Spiny lobsters (Palinuridae)	90	10
Striped Venus clam (*Chamelea gallina*)	10	90

Appendix Table 4. Time series of reported marine fisheries catches (t) for Turkey by sub-sector (reported FAO and national data where used), and the estimated unreported, recreational, subsistence, discarded and total reconstructed amounts.

Year	FAO	National	Unreported	Discard	Recreational	Subsistence	Total
1950	77,000	-	30,800	20,467	2,838	25,544	156,649
1951	86,000	-	34,400	22,859	3,194	25,025	171,479
1952	86,600	-	34,640	23,019	3,546	24,509	172,314
1953	67,100	-	26,840	17,835	3,894	24,000	139,669
1954	100,100	-	40,040	26,607	4,263	23,636	194,646
1955	83,000	-	33,200	22,062	4,418	22,197	164,877
1956	108,100	-	43,240	28,733	4,876	22,333	207,283
1957	89,400	-	35,760	23,763	5,312	22,298	176,533
1958	79,401	-	31,760	21,105	5,759	22,252	160,278
1959	87,402	-	34,961	23,232	6,212	22,180	173,987
1960	80,503	-	32,201	21,398	6,675	22,096	162,873
1961	74,602	-	29,841	19,829	7,178	22,095	153,544
1962	51,402	-	20,561	13,663	7,688	22,063	115,376
1963	122,602	-	49,041	32,588	8,209	22,015	234,455
1964	113,302	-	45,321	30,116	8,737	21,942	219,418
1965	127,502	-	51,001	33,890	9,276	21,852	243,521
1966	107,938	-	43,175	28,690	9,829	21,756	211,388
1967	-	204,069	81,628	47,922	10,391	21,640	365,649
1968	-	126,493	50,597	45,380	10,960	21,505	254,934
1969	-	158,679	63,472	40,624	11,536	21,348	295,658
1970	-	167,030	66,812	39,452	12,119	21,175	306,589
1971	-	146,207	58,483	41,701	12,810	21,151	280,353
1972	-	157,491	62,996	34,416	13,516	21,105	289,524
1973	-	130,367	52,147	18,698	14,226	21,022	236,460
1974	-	113,722	45,489	19,839	14,951	20,920	214,922
1975	-	102,024	40,810	17,776	15,681	20,787	197,078
1976	-	133,882	53,553	20,975	16,761	21,058	246,229
1977	-	146,270	58,508	27,405	17,865	21,278	271,326

(continued)

(continued)

Year	FAO	National	Unreported	Discard	Recreational	Subsistence	Total
1978	-	222,302	88,921	51,385	18,994	21,453	403,055
1979	-	328,342	131,337	81,615	20,146	21,582	583,022
1980	-	394,432	157,773	49,687	20,325	20,653	642,870
1981	-	438,284	175,314	62,773	21,345	20,573	718,289
1982	-	469,931	187,972	68,557	22,342	20,426	769,228
1983	-	518,561	207,424	98,667	23,355	20,250	868,258
1984	-	518,546	207,419	81,589	24,372	20,038	851,964
1985	-	531,095	212,438	93,243	25,388	19,787	881,952
1986	-	536,797	214,719	84,925	26,622	19,661	882,724
1987	-	580,453	232,181	94,068	27,867	19,493	954,063
1988	-	620,063	248,025	100,869	29,114	19,281	1,017,352
1989	-	409,316	163,726	90,441	30,366	19,026	712,875
1990	-	340,316	136,126	69,050	31,614	18,727	595,833
1991	-	312,845	125,138	66,143	33,071	18,506	555,702
1992	-	402,176	160,870	64,712	34,524	18,233	680,515
1993	-	496,555	198,622	68,710	35,955	17,902	817,745
1994	-	539,609	215,844	77,717	37,425	17,547	888,142
1995	-	582,150	232,860	69,276	38,876	17,141	940,303
1996	-	470,880	188,352	43,652	43,089	17,840	763,813
1997	-	400,672	160,269	35,215	39,831	15,459	651,445
1998	-	430,223	172,089	40,260	40,956	14,873	698,401
1999	-	520,499	208,200	42,707	41,470	14,060	826,935
2000	-	455,709	182,284	43,111	43,260	13,661	738,025
2001	-	479,649	191,860	41,746	44,329	13,003	770,586
2002	-	520,267	208,107	39,908	45,396	12,330	826,009
2003	-	458,079	183,232	37,063	46,445	11,640	736,458
2004	-	502,544	201,018	39,818	47,484	10,936	801,799
2005	-	378,759	151,504	36,370	48,512	10,219	625,365
2006	-	486,403	194,561	38,819	49,538	9,492	778,813
2007	-	588,548	235,419	44,944	50,544	8,752	928,207
2008	-	452,383	180,953	43,639	51,379	7,977	736,332
2009	-	424,606	169,842	41,424	52,831	7,286	695,990
2010	-	445,617	178,247	41,329	54,360	6,719	726,272

Appendix Table 5: Total reconstructed catch (t) by major taxa for Turkey, 1950-2010. 'Others' grouping includes 66 taxa.

Year	Anchovy	Horse mackerel	Bonito	Whiting	Bluefish	Sprat	Others
1950	38,704	20,718	24,137	5,203	7,961	-	59,925
1951	43,228	22,309	26,484	5,765	8,323		65,371
1952	43,530	22,303	26,584	5,794	8,283	-	65,820
1953	33,728	18,475	21,304	4,551	7,284	-	54,326
1954	50,316	24,636	30,079	6,633	8,798	-	74,184
1955	41,720	21,212	25,420	5,542	7,910	-	63,073
1956	54,337	26,047	32,177	7,134	9,169	-	78,419
1957	44,937	22,547	27,206	5,953	8,331	-	67,559
1958	39,911	20,700	24,563	5,322	7,907	-	61,873
1959	43,933	22,275	26,737	5,831	8,343	-	66,868
1960	40,465	21,014	24,921	5,397	8,064	-	63,011
1961	37,499	19,969	23,388	5,027	7,853	-	59,808
1962	25,837	15,631	17,223	3,561	6,814	-	46,309
1963	61,626	29,246	36,322	8,074	10,285	-	88,902
1964	56,952	27,547	33,875	7,488	9,906	-	83,651
1965	64,089	30,315	37,715	8,390	10,649	-	92,362
1966	54,255	26,661	32,516	7,155	9,779	-	81,021
1967	82,705	49,106	53,616	5,820	13,630	-	160,772
1968	50,137	33,425	34,640	9,249	11,338	-	116,145
1969	62,213	35,377	76,319	9,399	11,218	-	101,133
1970	103,745	42,574	28,931	17,561	14,651	-	99,128
1971	102,117	26,081	38,758	11,066	11,340	-	90,992
1972	133,045	37,234	21,375	10,137	10,755	-	76,979
1973	126,099	41,283	9,074	4,722	5,671	-	49,611
1974	109,842	29,396	11,443	5,621	6,550	-	52,070
1975	85,988	30,544	8,509	7,617	9,521	-	54,898
1976	112,802	40,622	8,465	8,312	18,356	-	57,672
1977	115,216	43,450	10,571	11,501	20,462	-	70,126
1978	168,110	75,793	12,133	40,167	12,145	-	94,707
1979	202,764	142,814	17,465	39,484	28,081	-	152,413
1980	365,212	104,702	26,023	13,507	20,984	-	112,443
1981	395,879	105,928	39,807	9,541	32,927	-	134,207
1982	399,258	119,463	42,228	8,757	53,144	-	146,379
1983	435,539	127,300	47,355	23,482	51,355	-	183,227
1984	479,902	164,288	16,007	23,017	23,716	-	145,034
1985	412,635	201,358	23,780	32,148	18,807	-	193,225
1986	417,752	197,441	21,540	35,623	24,591	-	185,776
1987	449,932	186,643	30,112	51,539	22,736	-	213,101

(continued)

(continued)

Year	Anchovy	Horse mackerel	Bonito	Whiting	Bluefish	Sprat	Others
1988	450,396	189,110	31,410	53,599	24,312	-	268,526
1989	142,999	194,092	12,451	36,806	23,394	-	303,133
1990	107,351	150,299	26,521	31,562	21,210	-	258,891
1991	131,424	64,394	33,815	36,214	25,567	-	264,289
1992	253,208	57,534	18,264	35,779	22,004	18	293,707
1993	329,339	66,232	33,721	34,827	32,136	170	321,320
1994	426,906	61,698	20,140	29,921	20,048	7,280	322,149
1995	561,982	41,108	18,123	33,310	16,341	16,328	253,110
1996	421,486	44,149	20,216	38,618	14,741	1,466	223,136
1997	349,450	34,042	16,505	24,505	12,725	758	213,461
1998	330,600	34,195	40,388	22,822	13,237	1,916	255,244
1999	507,500	31,494	31,661	24,208	12,653	656	218,764
2000	406,000	46,258	23,214	29,297	14,697	9,672	208,887
2001	464,000	52,289	25,249	15,402	27,504	227	185,916
2002	540,850	51,341	14,935	16,475	44,920	3,178	154,310
2003	427,750	53,396	14,482	15,014	40,680	9,373	175,763
2004	493,000	52,580	14,042	15,382	37,581	8,477	180,738
2005	200,925	54,796	108,418	15,286	35,386	8,596	201,958
2006	391,500	51,245	49,091	16,915	20,904	11,332	237,826
2007	558,250	60,997	14,446	23,788	18,627	18,478	233,622
2008	364,929	61,963	15,168	22,717	14,516	61,015	196,023
2009	296,814	55,356	15,845	20,332	17,426	83,196	207,021
2010	332,083	43,599	19,353	25,014	15,649	88,842	201,732

Appendix Table 6. Time series of estimated recreational catches (t), by sea. Marmara Sea includes catches for both Istanbul and the Dardanelles.

Year	Aegean Sea	Black Sea	Levantine Sea	Marmara Sea
1950	1,406	972	928	25,076
1951	1,598	996	948	24,677
1952	1,787	1,020	965	24,284
1953	1,968	1,042	988	23,895
1954	2,145	1,065	1,178	23,512
1955	1,540	1,086	855	23,134
1956	1,577	1,105	1,052	23,476
1957	1,608	1,122	1,070	23,810
1958	1,641	1,139	1,095	24,137
1959	1,667	1,155	1,115	24,456
1960	1,697	1,171	1,138	24,766
1961	1,729	1,190	1,161	25,193
1962	1,750	1,207	1,183	25,610
1963	1,775	1,225	1,206	26,018
1964	1,797	1,242	1,228	26,412
1965	1,820	1,258	1,250	26,801
1966	1,845	1,268	1,273	27,200
1967	1,866	1,276	1,300	27,588
1968	1,888	1,285	1,326	27,966
1969	1,907	1,293	1,351	28,333
1970	1,927	1,300	1,373	28,695
1971	1,951	1,304	1,373	29,334
1972	1,982	1,307	1,374	29,958
1973	2,006	1,311	1,366	30,565
1974	2,030	1,314	1,371	31,157
1975	2,052	1,316	1,366	31,734
1976	2,085	1,320	1,426	32,988
1977	2,110	1,324	1,484	34,225
1978	2,138	1,327	1,539	35,443
1979	2,161	1,330	1,595	36,642
1980	2,164	1,332	1,650	35,832
1981	2,250	1,335	1,690	36,644
1982	2,262	1,355	1,720	37,431
1983	2,294	1,358	1,759	38,194
1984	2,325	1,359	1,795	38,932
1985	2,355	1,346	1,830	39,645
1986	2,384	1,332	1,866	40,702
1987	2,410	1,318	1,907	41,725
1988	2,437	1,305	1,941	42,712
1989	2,462	1,290	1,975	43,664
1990	2,485	1,267	2,008	44,580
1991	2,489	1,243	1,997	45,846
1992	2,492	1,212	1,987	47,066
1993	2,494	1,159	1,967	48,238
1994	2,495	1,159	1,956	49,363
1995	2,495	1,136	1,946	50,441
1996	2,494	5,032	1,933	51,471
1997	2,491	1,122	1,911	49,766
1998	2,512	1,127	1,973	50,217
1999	2,531	1,133	2,030	49,836
2000	2,550	1,130	2,071	51,171
2001	2,787	1,126	2,069	51,349
2002	3,016	1,137	2,060	51,514
2003	3,236	1,133	2,051	51,665
2004	3,448	1,128	2,042	51,802
2005	3,652	1,123	2,031	51,926
2006	3,848	1,117	2,029	52,036
2007	4,036	1,111	2,017	52,133
2008	4,215	1,111	2,012	52,019
2009	4,413	1,096	2,006	52,602
2010	4,483	1,113	2,038	53,444

Appendix Table 7. Time series of discards (t) for Turkey by sea.

Year	Aegean Sea	Black Sea	Levantine Sea	Marmara Sea
1950	525	15,646	672	3,624
1951	586	17,475	750	4,047
1952	590	17,597	756	4,076
1953	457	13,635	585	3,158
1954	682	20,340	873	4,711
1955	566	16,866	724	3,906
1956	737	21,966	943	5,087
1957	609	18,166	780	4,207
1958	541	16,134	693	3,737
1959	596	17,760	763	4,113
1960	549	16,358	702	3,789
1961	509	15,159	651	3,511
1962	350	10,445	449	2,419
1963	836	24,913	1,070	5,770
1964	772	23,023	989	5,332
1965	869	25,908	1,113	6,000
1966	736	21,933	942	5,080
1967	3,837	34,333	1,525	8,226
1968	3,313	28,708	6,946	6,413
1969	2,698	29,028	3,480	5,417
1970	3,028	27,638	4,527	4,259
1971	850	31,925	4,895	4,031
1972	557	25,419	4,646	3,794
1973	433	14,721	2,559	984
1974	826	11,060	4,011	3,942
1975	1,279	9,856	5,488	1,153
1976	1,622	12,650	5,533	1,170
1977	1,732	15,473	8,587	1,614
1978	2,043	34,333	13,636	1,373
1979	1,966	71,588	7,193	868
1980	2,664	36,766	8,317	1,940
1981	3,742	42,279	13,181	3,572
1982	2,640	49,845	12,616	3,456
1983	4,048	70,954	18,197	5,469
1984	6,810	56,641	12,776	5,362
1985	7,835	65,630	9,756	10,022
1986	5,579	60,732	7,424	11,191
1987	6,593	65,690	8,808	12,977
1988	9,102	68,249	8,955	14,564
1989	7,305	58,879	15,154	9,102
1990	7,258	40,688	12,431	8,673
1991	7,619	31,177	23,085	4,262
1992	9,505	36,853	13,120	5,233
1993	9,551	35,178	16,047	7,934
1994	10,416	46,152	13,181	7,969
1995	7,736	51,287	5,569	4,683
1996	4,998	31,249	2,692	4,712
1997	5,621	22,238	2,681	4,675
1998	8,212	23,900	2,452	5,696
1999	6,495	27,394	2,550	6,268
2000	6,108	31,143	1,572	4,288
2001	7,510	26,150	1,996	6,090
2002	5,823	26,463	1,921	5,702
2003	4,750	23,583	1,981	6,749
2004	4,831	26,491	1,937	6,558
2005	5,345	21,095	3,281	6,649
2006	5,560	25,205	2,347	5,706
2007	3,966	34,607	2,175	4,197
2008	3,362	31,452	3,972	4,854
2009	4,070	29,113	3,817	4,424
2010	3,262	31,802	3,004	3,262