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Reconstruction of Marine Fisheries Catches for the Republic of Korea (South Korea) from 1950-2010

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Abstract

The reconstruction of total marine fisheries catches of the Republic of Korea (South Korea) for the 1950-2010 time period added estimates of unreported subsistence, recreational and domestic illegal fisheries catches, and discards to the reported commercial fisheries landings obtained from the national government statistics and supplied to the FAO. Total estimated fisheries catches taken by Korea from the Republic of Korea EEZ were 95.1 million tonnes for the 1950-2010 period, increasing from 0.7 million t·year^{-1} in 1950 to a peak of 2.5 million t·year^{-1} in 1986, before declining to 1.4 million t·year^{-1} by 2010. In comparison, data reported to FAO amount to 58.1 million tonnes, resulting in estimated total catches being 64% larger than those reported. Due to the significance of marine resources to the economy and food security in the Republic of Korea, we hope that fisheries managers and policy makers recognize the need for improved catch recording systems and estimation approaches, especially for growing sectors such as recreational fisheries.

Introduction

The Republic of Korea is located between 33°-38°N and 125°-131°E on the southern portion of the Korean Peninsula, and is generally referred to as South Korea. The country's mainland and 3,400 islands comprise a land area of over 100,000 km^2, with an Exclusive Economic Zone (EEZ) of over 475,000 km^2, which is located in the Food and Agriculture Organization (FAO) statistical area 61 (Figure 1; www.seaaroundus.org). The neighboring countries are the Democratic People's Republic of Korea (North Korea), China and Japan.

Figure 1. Map of Republic of Korea (South Korea), showing the countries' EEZ (solid line) within FAO statistical area 61 (inset). EEZ subsection 1 is the national EEZ and subsection 2 is the EEZ disputed with Japan.

While fishing contributes less than 1% to the overall economy of South Korea, this figure is not indicative of the importance of fishing and seafood to South Koreans (Bowden 2006). In 2005, Korea ranked as the 15th largest marine fishery globally and aquaculture production was the 6th highest in the world (Bowden 2006). Over 200,000 people are employed in the fisheries sector.

The focus of this study is to estimate total marine fisheries catches taken by South Korea within its EEZ or EEZ equivalent waters from 1950 to 2010. However, for a more complete understanding of South Korea's marine fisheries, landings trends from earlier time periods are also considered (Figure 2). When South Korea's officially reported landings are compared to landings for Korea as a whole (both North and South together), an interesting picture of the history and development of fisheries in South Korea emerges. Korea's reported landings in the late 1930s, prior to the establishment of a distant-water fleet, are similar to South Korea's reported landings in the early 1980s when it had large distant-water fleets. The long period of low South Korean reported

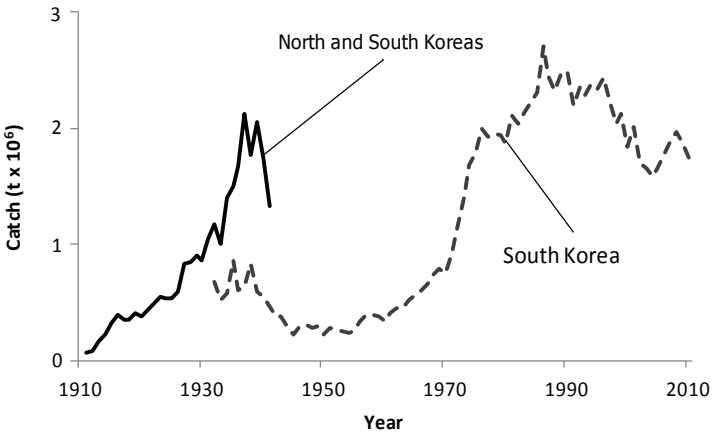

Figure 2. Reported marine fisheries landings for South Korea compared to the total landings of the two Koreas (North and South Korea) for the period 1911-2010. Source: FAO's FishStat and 1955 Yearbook of Fishery Statistics.

fisheries landings from the 1940s to the 1960s is a reflection of major historical events affecting fisheries and associated reporting infrastructures, namely the Japanese occupation, WWII, and the Korean War (1950-1953).

Following the Korean War, Typhoon Sarah in 1959 caused a further decline in the number of fishing boats from 49,000 in 1946 to 29,000 in 1959, which may have kept marine fisheries catches low over a long period (Jeong 1991). However, unreported catches are suspected to be high during the time period. The South Korean government revised its fishery policy 13 times between 1953 and 1990 in order to develop appropriate policies for managing a growing fishing industry (Ryu 1991).

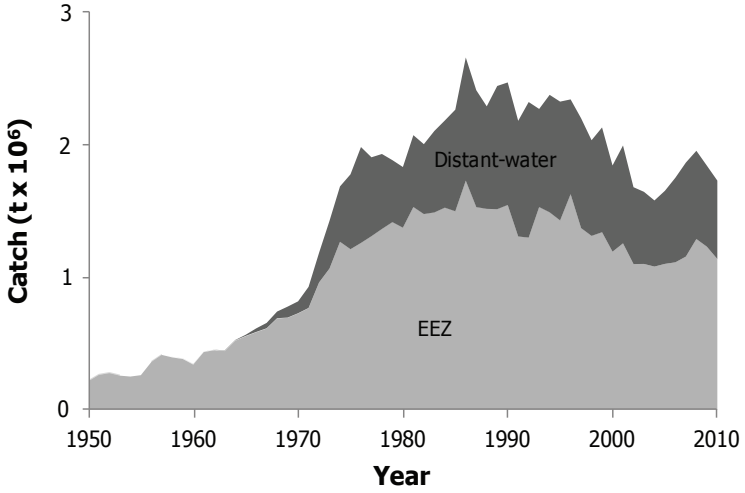

Figure 3. Landings by distant-water fleets compared to landings by vessels within EEZ for South Korea for the period 1950-2010. Source: 2011 Korean Fishery Yearbook.

Despite these revisions, the 1990s witnessed an increase in fishing effort. The number of fishing boats increased to 75,000 in 1996 and 81,000 in 1997, of which 70% were operating within Korean EEZ or EEZ-equivalent waters (Park 1999). The excess effort resulted in the overfishing of many commercially important species, especially coastal resources, and a reduction in the reported landings from South Korea since 1986 (Anon. 2011; Kang 2011). In response, in 1994, the government initiated a fishing boat reduction project and successfully decommissioned 16,800 boats by 2008, of which 10,400 were coastal boats (Kang 2011).

In the 1950s, the commercial fishing industry operated solely within South Korea's EEZ-equivalent waters. Reported landings from these waters were 216,000 t, or approximately 98% of the overall South Korean fisheries production at this time. As distant-water fishery and aquaculture production increased, the contribution from EEZ fishery decreased to just 36% by 2010 (Anon. 2011).

The major targeted species by the commercial fishing industry in South Korean waters has progressively changed over time. In the 1950s and 1960s, the most frequently caught species were largehead hairtail (*Trichiurus lepturus*) and squids (Jang and Lee 2002). This was replaced by large catches of chub mackerel (*Scomber japonicus*) and thread-sail filefish (*Stephanolepis cirrhifer*) catches in the 1970s, and the thread-sail filefish and Japanese pilchard (*Sardinops sagax*) in the 1980s, respectively. In the 1990s, Japanese anchovy (*Engraulis japonicus*) was the most caught species. Overall, the trophic level of major targeted species has been decreasing from 3.45 in the 1950s to 3.17 by 2000, suggests the occurrence of 'fishing down the food web' (Pauly *et al.* 1998; Jang and Lee 2002).

The South Korean government established the first five-year Economic Development Plan in 1962 and focused on development of fisheries, especially distant-water fisheries.[1] Although the distant-water fishery began with the tuna long-line test fishery in the Indian Ocean in 1957, the government officially added the distant-water fishery as a distinct sector in 1963 (Ryu 1991). The distant-water fishery expanded to all oceans of the world in a relatively short period of time[1,2], for example, there were South Korean stern trawlers fishing in Pakistani waters in the early 1980s (Hornby *et al.* 2013). However, the distant-water fishery catches were not substantial until the broad utilization of flash-freezers in 1968 (Anon. 2007). Thereafter, the increase of distant-water catches contributed to the large increase of the reported marine landings seen from the late 1950s onward (Figure 3; Anon. 2010). The distant-water fisheries reported 656 tonnes in 1962 and increased their reported landings to 1 million tonnes by 1992. The establishment of a 200 nautical mile EEZ by coastal countries starting from the late 1970s and the establishment of Regional Fisheries Management Organizations (RFMOs) restricting uncontrolled access to fishing grounds may have contributed to the decline in reported landings beginning in the 1990s (Figure 3).

Researchers and international agencies rely on FAO's database to examine global trends in fisheries (e.g., Grainger and Garcia 1996; Garcia and Moreno 2003; FAO 2010). Since FAO relies on data supplied by its member countries (Garibaldi 2012), the quality of the data depends, to a large part, on the country's ability to collect and report comprehensive marine fisheries catch data. However, national statistics supplied to FAO have been found to underestimate total catches, as generally only commercial, large-scale or industrial fisheries landings are reported (Zeller *et al.* 2007; Zeller and Pauly 2007; Zeller *et al.* 2011a; Zeller *et al.* 2011b). In the case of South Korea, unregulated commercial catches, discards and non-commercial catches such as subsistence and recreational catches, are unaccounted for in the official data. In order to comprehensively account for total catches in commercial fisheries, 100% observer coverage should be required (Zeller *et al.* 2011b). Currently, observers are present on only a few vessels and are thought to be not very effective (Varkey *et al.* 2006). In contrast to commercial sectors, accounting for non-commercial catches requires different survey and estimation approaches to be established and maintained (Zeller *et al.* 2007). Emphasis needs to be placed by the responsible government agency on incorporating such estimates in regular national fisheries statistics. Underestimating total removals from the marine environment potentially compromises sustainable fisheries management and may contribute to overfishing. The purpose of this study is to collect available information about unreported catches, to provide a more comprehensive estimate of

[1] http://www.doopedia.co.kr/doopedia/master/master.do?_method=view&MAS_IDX=101013000848587#MGROUP_101015000148852 [Accessed: March 17, 2010]

[2] http://www.kosfa.org/english/e_fish/e_fish1.asp [Accessed: January 17, 2011]

South Korea's total marine fisheries catches from 1950 to 2010 by combining estimates of discards, subsistence, recreational, and domestic illegal catches from South Korean waters with the reported commercial catches. Our aim is to also improve the data taxonomically by assigning aggregated catches to more specific taxa.

Materials and Methods

Commercial fisheries

Reported landings

The commercial data used in this study were taken from the FAO landings database. FAO commercial landings include the national reported landings within South Korea EEZ and the commercial landings from areas outside the EEZ within the FAO statistical area 61. Thus, the FAO landings data were divided into landings within the national EEZ and landings outside the EEZ within the FAO area 61 by considering national fisheries catch statistics that separate reported landing by EEZ and distant water (Anon. 2010, 2011). The national reported landings consist of the landings that are sold at markets that are registered with the national federation of fisheries cooperatives and at other non-registered markets such as fishers-owned markets (Yeom *et al.* 2002; Hwang and Choo 2004). Landings that are sold at the registered markets are recorded at the first point of sale. However, the landings that are sold at the non-registered markets are not fully recorded or reported (Hwang and Choo 2004), and are only estimated by sample survey (Yeom *et al.* 2002).

The reported landings within the South Korean EEZ are catches of two fisheries sectors, artisanal and industrial fisheries. Artisanal fishing vessels, which weigh less than 10 GRT, normally operate within 20 nautical miles from the shore, or within a one day trip, while industrial fishing vessels, which weigh more than 10 GRT, normally operate more than one day per trip (Jang *et al.* 1998). The national reported landing data by vessel type from 1970-2010 were available through the Korean Statistical Information Service website (www.kosis.kr). To disaggregate reported landing to sector (industrial versus artisanal), we assumed that any species which has a biological minimum depth of 200 m or more would be caught by industrial fishing vessels only, and all other species would be caught by both artisanal and industrial vessels. Thus, we subtracted the reported landings of the deep water species from the national industrial vessel catches and derived the catch percentage of artisanal and industrial sectors for the remaining reported landings. We assumed that artisanal catch percentages decreased from 59% in 1970 to 31% by 2010, while the industrial catch percentages increased from 41% in 1970 to 69% by 2010. We assumed that the catch percentage of industrial fisheries would have been lower for years prior to 1970. Thus, we assumed that the catches of industrial and artisanal fisheries would be 20% and 80% in 1950 and 25% and 75% in 1960, respectively. We used linear interpolation to derive the annual sectoral percentages from 1950-2010 and applied these to individual species reported landings in order to derive the species landings by sectors.

Unregulated landings

Although South Korea defines both domestic and foreign vessels fishing without government permission or license (or with banned gears) as illegal fishing, we distinguished 'unregulated' fishing as unlicensed domestic boats fishing in Korea's own EEZ and 'illegal' fishing as foreign vessels fishing without permission in Korea's EEZ. South Korea is well aware of the types of gear or vessels that are involved in domestic unregulated fishing activities and their impact on the marine ecosystem (Kim 2008c). The most common unregulated gear types are small otter trawl, large trawl, dredge nets, diving, gill nets and fish traps (Kim 2008c). The South Korean government recognized that small otter trawls are highly destructive to the benthic marine environment and banned the use of this gear within South Korean waters in 1953 (Cho 2012). However, fishers continued operations and maintained 4,000-5,000 unregulated small otter trawlers up to 1990, before stronger enforcement was established (Kim 2008a). While enforcement increased in the 1990s, it was not sufficient to stop all small otter trawlers. A large number of small otter trawlers fished at night or in poor weather to avoid detection, and 3,260 small otter trawls were estimated to be present by 2004 (Lee *et al.* 2007; Kim 2008a). The South Korean government substantially reduced the number of small otter trawlers by decommissioning 55% of the remaining fleet in 2005, 46% in 2006, and 15% in 2007 (Kim 2008a). As a result, there has been a steady decrease in the number of small otter trawlers from the 1990s to the mid-2000s, and we used 3,260 small otter trawlers in 2004, 1,473 in 2005, 793 in 2006 and 673 from 2007 onwards as anchor points. In the 1950s, when there were historical events such as the Korean War and Typhoon Sarah which maintained the total fishing vessel numbers low, we conservatively assumed that there were half of the 1990 number of unregulated small otter trawlers (i.e., 2000) and gradually increased this from 1960 to 4000 vessels by 1990. Thus, we used linear interpolations between 2,000 in 1960, 4,000 in 1990, and 3,260 in 2004 to derive the number of small otter trawlers for time periods when data were unavailable. Since these 'unregulated' small otter trawlers have not completely disappeared and were reported to be present in the Korean EEZ in 2012 (Kang 2012), we assumed that there has been no change in the number of unregulated small otter trawlers and maintain the 2007 estimate unaltered to 2010.

According to Oh (2006) and Kim (2008a), each small otter trawler annually catches approximately 60 tonnes, but only 15 tonnes (i.e., 25%) of the annual catch is retained. We combined the number of small otter trawlers operating with the retained catch per boat in order to estimate the retained domestic unregulated small otter trawler landings within South Korea's EEZ from 1950 to 2010. We similarly estimated discards by this vessel type as shown below.

Discards

We define discards as catches that are caught by fishing boats but are thrown back into the sea because of their non-edible condition or low commercial value. Since South Korea records only landings that are traded, we assumed that the national marine data supplied to FAO do not include any discards. Here, we were able to estimate the discards of five of the major gears operating in South Korean waters: small otter trawl, shrimp beam trawl, other non-shrimp bottom trawl, trap, and funnel net.

Small otter trawl

Each unregulated small otter trawl catches approximately 60 $t \cdot vessel^{-1} \cdot year^{-1}$ and around 70-80% of catches are discarded due to small size, damage or low-value (Oh 2006; Kim 2008a). We assumed that 45 $t \cdot vessel^{-1} \cdot year^{-1}$ (i.e., 75%) vessel are discarded. Then, we combined this discard rate with the number of small otter trawlers operating each year to calculate the total annual small otter trawl discards within South Korea EEZ from 1950 to 2010. We assumed 100% mortality of discards, due to the larger-scale nature of this gear type and likely longer-shot-times (bottom contact time) of bottom trawls.

Shrimp beam trawl

Oh and Ma (2004) estimated the average bycatch of the total shrimp beam trawl catch as being 84%, with 54% of this being discarded and the remaining 46% being landed. This implies that the landed targeted species catch (i.e., shrimp), the landed bycatch and the discarded bycatch percentages are 16%, 38.6% and 45.4% of the total catch, respectively. The reported data of this gear type include the landed components which are summed to 54.6% of the total catch, whereas the discarded component is unaccounted for.

The reported landings of shrimp beam trawl were obtained from the yearbooks of fisheries statistics of South Korea (1974, 2010) for 1963–1972 and 1990–2010. To derive the landings for missing years, we calculated the ratio of shrimp beam trawl landings to the total landings in South Korean waters in 1963, 1972 and 1990. We applied the 1963's ratio to the total landings for the years prior to 1963. We interpolated the ratios between 1972 and 1990 and applied each year's ratio to the total landings of the same year from 1973 to 1989.

We divided the annual reported landings of shrimp by the landing rate, 54.6%, to calculate the annual total catches of this gear type. Then, we multiplied these total catches by the discard rate of 45.4% to derive the estimate for the annual total discard. We assumed 100% mortality of discards, due to the larger-scale nature of this gear type and likely longer-shot-times (bottom contact time) of bottom trawls.

Non-shrimp bottom trawl

The discard rate for South Korean non-shrimp bottom trawls was not readily available. Thus, we assumed that the discard rate of Korea would be similar to neighboring countries' discard rates for the same gear type. Japan's non-shrimp trawl discard rate was reported as 60.5% of total catch in 1994 (Kelleher 2005). This suggests that the reported landings of the target species and retained bycatch by this gear type in South Korea represent 39.5% of total catch.

To derive an estimate for the annual discards of this gear type, we first calculated the annual reported landings from 1950 to 2010 using the same method as described for shrimp beam trawl. Then, we divided the annual reported landings by the reported landing rate, 39.5% and multiplied this by the discard rate, 60.5%. We assumed 100% mortality of discards, due to the larger-scale nature of this gear type and likely longer-shot-times (bottom contact time) of bottom trawls.

Funnel net fishery

The funnel net fishery in the coastal waters of Korea has discards which vary monthly from 0.2% to 18% of total catches, depending on locations (Shin *et al.* 2010). The average discard percentage was calculated to be 4.7% of total catches (Shin *et al.* 2010). To derive an estimate for the annual discards of this gear type, we first calculated the annual reported landings from 1950 to 2010 using the same method as described above. Then, we divided the annual reported landings by the reported landing rate, 95.3% and multiplied this by the discard rate, 4.7%. We assumed 100% mortality of discards.

Trap fishery

The trap fisheries on the coast of Korea use net-pots to catch eels and crabs. Cha *et al.* (2010) estimated that the discards of trap fishery using the spring-net-pot vary monthly, depending on regions, and reach up to 50% of total catches. During the 6 months of the experimental period, the commercial catches, self-consumed bycatch and discards were respectively 3,078 kg (i.e., 58%), 817 kg (i.e., 15.4%) and 1,413 kg (i.e., 26.6%) of the total catches of 5,308 kg (Cha *et al.* 2010). We assumed that the reported landings would include the commercial catches, while the self-consumed bycatch (which are included in subsistence catches, see below) and discards are not reported.

We know the reported landings from 1990 to 2010 (Anon. 2010). To estimate the trap fisheries' landings prior to 1990, we calculated the ratio of the trap fishery's reported landings to the total EEZ landings in 1990, and applied this ratio to the total landings from 1950 to 1989. To derive an estimate for the annual discards of this gear type, we calculated the annual total catches and applied the discard rate of 26.6%. Furthermore, we assumed 100% mortality of discards, an acceptable assumption for these traps, which are typically set in deeper waters.

Subsistence fisheries

Subsistence fisheries are the non-commercial portion of the small-scale marine fisheries. Catches from this sector are neither recorded nor reported. Subsistence catch data were not readily available; however, here we estimated catches for this sector by using coastal rural population and their general seafood consumption habits, as well as components of the catches of the trap fishery.

Human population

Korea's population is highly concentrated in urban areas, with the capital city, Seoul, accounting for 20% of the total human population, and there were 7 other cities with population of more than 1 million by 2005.[3] We conservatively assumed that people living in urban areas obtain seafood from markets for their daily consumption and the seafood sold at markets was commercially caught (Hwang and Choo 2004). We also conservatively assumed that the urban population was not involved in subsistence fishing and that only the rural population would meet some of their seafood demand through subsistence fishing. People living in inland rural areas would likely catch freshwater species and would not travel to the coast to catch marine species for subsistence.

Human population data were obtained from South Korean census data (www.census.go.kr). Census data are presented every 4 or 5 years from 1949 to 2010. A linear interpolation between the census years was necessary to derive a complete time series of population data. South Korea's total population grew from 20 million in 1950 to 48 million by 2010, with the population of rural areas decreasing as people moved to urban areas. To derive an estimate of the coastal rural population (including islands), we obtained population data for coastal towns, and considered rural towns as those with a population of less than 50,000 and where more than 40% of families are engaged in primary industries. Based on our assumptions and estimates, the coastal rural population decreased from 7 million in 1950 to 1.1 million by 2010. This is likely a conservative estimate of the population potentially engaging in subsistence fish.

Seafood consumption rate

According to Kim and Ahn (1988), Choi *et al.* (2005) and Park *et al.* (2008), seafood consumption rates for the coastal rural population were 117.1 g·person^{-1}·day^{-1} in 1987 (42.7 kg·person^{-1}·year^{-1}), 101.5 g·person^{-1}·day^{-1} in 2004 (37.1 kg·person^{-1}·year^{-1}), and 72.5 g·person^{-1}·day^{-1} in 2007 (26.5 kg·person^{-1}·year^{-1}), respectively (Table 1). As they had fewer protein alternatives, we assumed that the amount of seafood that the coastal rural population consumed in 1950 would be double the consumption rates of 2007, i.e., 53 kg·person^{-1}·year^{-1}. We used these four consumption rates as anchor points to derive assumed subsistence rates as described below.

First, we assumed that 90% of rural seafood consumption in 1950 was from subsistence fishing and this percentage decreased linearly to 65% by 1987 when EEZ catches level off and signs of stock depletion begin to appear. We assumed that the percentage of rural fish consumption supplied by subsistence fisheries eventually decreased to 20% in 2005 and 15% by 2007, as South Korea developed into an industrialized country and people living in coastal rural areas had increasing access to markets. Using these assumptions, we derived subsistence seafood catch rates which declined from 47.6 kg·person^{-1}·year^{-1} in 1950 to 4 kg·person^{-1}·year^{-1} by 2007 (Table 1). We used linear interpolation to estimate the subsistence catch rate for time periods when data were unavailable. The annual marine subsistence catch was estimated by multiplying the *per capita* subsistence catch rates by the population of coastal rural areas.

Recreational fisheries

Although recreational fishing has occurred in South Korea for more than a century, there is still no monitoring system for recreational fishing activities (Min 2008). Thus, recreational catch data for South Korea are not readily available. Recreational fisheries can be divided into two components, inland and marine; however, available data do not distinguish between these prior to 1970. According to Min (2008), people started to use boats for recreational fishing in 1971. Boats allowed recreational fishers to expand their fishing areas from shore-

Table 1. Data sources for fish and shellfish consumption of the coastal rural population.

Year	Consumption rate (g·person^{-1}·day^{-1})	Consumption rate (kg·person^{-1}·year^{-1})	Source	Assumed subsistence catch rate (%)	Catch rate (kg·person^{-1}·year^{-1})
1950	145.00	52.93	Assumed twice 2007	90	47.63
1987	117.05	42.72	Kim and Ahn (1988)	60	25.63
2004	101.50	37.05	Choi *et al.* (2005)	20	7.41
2007	72.50	26.46	Park *et al.* (2008)	15	3.97
2010	72.50	26.46	Assumed same as 2007	15	3.97

[3] http://kosis.kr/abroad/abroad_01List.jsp?parentId=A [Accessed: May 2, 2011]

bound activities. In addition, South Korea developed a highway system in the 1970s and ended the midnight curfew in 1982. These factors enabled more people to travel and engage in marine recreational fishing. Thus, we made a conservative assumption that marine recreational fishing (boat and shore-based) in South Korea started in 1971 and increased gradually thereafter. We also assumed that any 'recreational' fishery prior to 1971 was possibly more related to subsistence fishing, and hence assumed to be included in the subsistence catch estimates.

Table 2. Data sources for South Korea's recreational fisher population.

Year	Recreational Fishers	Recreational Sector	Source
1970	0[a]	Marine only	Min (2008)
1990	3,250,000	Inland and marine[b]	Bae (1992 in Lee *et al.* 2002)
1994	4,000,000	Inland (70%) and marine (30%)	Anon. (1995 in Lee *et al.* 2002)
1999	5,000,000	Inland (70%) and marine (30%)	Cho (2000 in Lee *et al.* 2002)
2004	5,730,000	Inland (66%) and marine (34%)	Anon. (2004 in Kim 2008b)
2008	6,524,000	Inland (37%), Marine (27%), and both (36%)	Lee (2010)

[a] Assumption base on Min (2008) who states that Korea started to use boats for recreational fishing in 1971. [b] Assumed 30% were marine recreational fisheries.

Although the number of people engaged in recreational fishing in South Korea was estimated by several studies with different methods, these estimates were not significantly different from each other and showed an increasing trend. Thus, they were used to estimate marine recreational fish catch (Table 2). According to these sources, approximately 30% of recreational fishers in South Korea are marine fishers prior to 2000 and this increased to 34% by 2004. In 2008, approximately 27% and 36% of recreational fishers are marine specific fishers and general fishers fishing both in inland and marine waters (Lee 2010). The marine specific recreational fishers make an average of 7.5 trips·person^{-1}·year^{-1}, while general recreational fishers make 4.1 trips·person^{-1}·year^{-1} for marine fishing.

Table 3. South Korea's recreational fishing catch estimates.

Sources	Average catch (kg·person^{-1}·trip^{-1})
Part *et al*. (2005)	2.20
Part *et al*. (2007)	2.45
Averages	2.33

Prior to 2008, we combined the number of marine recreational fishers with the marine specific *per capita* number of trips per year (7.5 trips·person^{-1}·year^{-1}) and the average catch per trip (2.33 kg·person^{-1}·trip^{-1}) (Table 3) to estimate the total marine recreational catch. In 2008, we first calculated the total number of trips per year for both marine specific and general fishers, and then combined the average catch per trip (2.33 kg·person^{-1}·trip^{-1}) to estimate the total marine recreational catch. Linear interpolations between data anchor points were used for time periods when data were unavailable, and the 2008 estimate was carried forward to 2010 to estimate the total annual marine recreational catch.

Recreational mud flat collecting

Recreational fishing in South Korea not only relates to catching marine fishes from shore or boat, but also to people who catch mud flat species such as clams and crabs during low tide. Recreational mud flat activities started as events to attract tourists to fishing villages 10 to 20 years ago, and the number of annual participants has increased steadily, reaching 40,000 in 2004 and 46,000 by 2005 (Ryu *et al*. 2005). Thus, we conservatively assumed that recreational mud flat collecting started in 1994. Since the number of people involved in marine recreational activities such as fishing is increasing, we assumed that the total number of participants in mud flat collecting would continue to grow at the rate observed from 2004-2005 until 2010. We used linear interpolations between 0 in 1994, 40,000 in 2004 and 77,900 in 2010 to obtain the annual number of participants from 1994 to 2010.

However, total participants in recreational mud flat activities do not represent the number of people who catch mud flat species, since the total number of participants includes people who engage in sport activities on mud such as soccer, wrestling and running marathons (Ryu *et al*. 2005). Thus, we conservatively assumed that only half of the number of total participants would be involved in some collection of marine species.

There were no data available for catch rates on mud flats. However, 3 out of 8 surveyed locations have catch limits of 1 kg per participant (Table 4). We applied this rate to half of the total annual participants to estimate the annual recreational catch of mud flat species.

Table 4. Surveyed recreational mud flat collecting locations in South Korea.

Locations	Sources	Catch limitation
Baekmiri fishing experience village 백미리 어촌체험마을 (Hwaseong-si화성시)	http://www.sugbag.net/j/baegmiri/enjoy.htm	not available
Doopo Village mud flat experience centre ⊠포마을갯벌체험장 (Buan-gun부안군)	http://www.dupotown.com/	1kg per person
Jundo mud flat experience centre 전도갯벌체험장 (Namhae-gun남해군)	http://cafe.naver.com/nengchun.cafe?iframe_url=/ArticleRead.nhn%3Farticleid=3134	not available
Mohang mud flat experience centre 모항갯벌체험장 (Buan-gun부안군)	http://www.mohangmud.com/sub1-1.htm	1kg per person
Nengchun mud flat experience center 냉천갯벌체험장 (Namhae-gun남해군)	http://www.getbeol.com/	not available
Taean ark, salt pan, mud flat experience centre 태안방주염전 갯벌체험장 (Taean-gun 태안군)	http://www.xn—vh3bv0ok3cluk.kr/index.html	not available
Tando fishing experience village 탄도어촌체험마을 (Ansan-si안산시)	http://www.tando.or.kr/04sea02.html	1kg per person
Walhaseong mud flat experience centre 월하성 갯벌체험마을 (Seochun-gun서천군)	http://cafe.naver.com/01054279292.cafe?iframe_url=/ArticleRead.nhn%3Farticleid=3	not available

Taxonomic breakdown

Data concerning the species composition of catches for subsistence, recreational and unregulated fisheries as well as discards were limited. Thus, we used reported catch data from coastal small-scale fisheries to derive a breakdown for subsistence catch estimates (Anon. 2010). The estimates were assigned taxonomically to a list of commonly caught species or families using their catch proportions. The marine recreational catch estimate was broken down using a list of coastal fish species that are commonly targeted by recreational fishers (Ryu *et al.* 2005) (Table 5). The estimated recreational mud flat catch was assigned to oysters, octopus, crabs, sea cucumbers, miscellaneous crustaceans and miscellaneous mollusks (Table 6). Both unregulated catch and discards by small otter gear were broken down to the eight most targeted species and miscellaneous marine fish, with a higher percentage of discards being assigned to the miscellaneous group (Kim 2008a) (Table 7). Oh and Ma (2004) had a list of species for the shrimp trawl bycatch with their appearance proportions. We used this information as a guide to produce an assumed representation of their catch proportions in weight to assign to the discards (Table 8). For non-shrimp bottom trawl, Kim *et al.* (2007) had a list of total species caught by a bottom trawl with their biomass (wet weight) and we used this information as a guide to produce an assumed species composition of the discards by eliminating the most-likely retained species (Table 9). We assigned all discards of trap and funnel net to miscellaneous marine species due to lack of usable data.

Table 5. Taxonomic composition applied to marine recreational fish catches for South Korea. Percentage data derived through assumption-based consideration of source material (Ryu *et al.* 2005).

Taxon	Common name	Catch (%)
Acanthopagrus schlegelii	Black porgy	10.0
Chanos chanos	Milkfish	2.5
Girella punctata	Girella punctata	10.0
Niphon spinosus	Ara	2.5
Oplegnathus fasciatus	Barred knifejaw	10.0
Pagrus major	Red seabream	10.0
Sebastes spp.	Redfishes	5.0
Clupeidae	Herrings, shads, sardines	5.0
Hemiramphidae	Halfbeaks	2.5
Lateolabracidae	Asian seaperches	2.5
Mugilidae	Mullets	5.0
Paralichthyidae	Large-tooth flounders	5.0
Serranidae	Sea basses, groupers	5.0
MMF	Misc. marine fishes	25.0

Table 6. Taxonomic composition applied to recreational mud flat collected catches for South Korea. Percentage data derived through assumption-based consideration of source material (Ryu *et al.* 2005).

Taxon	Common name	Catch (%)
Holothuriidae	Sea cucumbers	5
Octopus	Octopuses	10
Ostreidae	True oysters	10
Portunidae	Swimming crabs	10
MMC	Misc. marine crustaceans	25
MMF	Misc. marine fishes	40

Results

Commercial fisheries

Reported landings

The total reported landings for South Korea within FAO statistical area 61 for the period 1950-2010 were 66.5 million tonnes, of which 58.1 million tonnes were from inside the South Korean EEZ (or EEZ-equivalent waters) and 8.4 million tonnes were from areas outside the EEZ but within FAO area 61 (Figure 4). Among the reported landings within EEZ waters, 37.1 million and 21.1 million tonnes were from industrial and artisanal fisheries, respectively. Reported landings within the EEZ-equivalent waters increased from around 204,000 t·year^{-1} in 1950 to a peak of 1.66 million t·year^{-1} in 1986, before declining to around 1.09 million t·year^{-1} by 2010 (Figure 4).

Unreported catches

The total unreported catches by small otter trawls within the South Korean EEZ for the period 1950-2010 were estimated to be 2.5 million tonnes and included in the industrial catches (Figure 5a). From 1950 to 1959, the annual unregulated catches were estimated at 30,000 t·year^{-1}. The annual catch amount doubled by 1989, after which it slowly decreased to 48,900 t·year^{-1} by 2004, and then rapidly decreased to 10,100 t·year^{-1} by 2007. The domestic unreported landings were dominated by species of Lophiidae, Pleuronectidae, and Congridae (Table 7).

Table 7. Taxonomic composition applied to unregulated landings and discards of small otter trawls for South Korea. Percentage data derived through assumption-based consideration of source material (Oh 2006).

Taxon	Common name	Landings (%)	Discards (%)
Octopoda	Octopuses	5	10
Congridae	Conger and garden eels	10	10
Lophiidae	Goosefishes	40	10
Paralichthyidae	Large-tooth flounders	5	10
Pleuronectidae	Righteye flounders	30	10
Shrimps, prawns	Shrimps, prawns	5	10
MMF	Misc. marine fishes	5	40

Discards

The total discards by the five main discarding gear types within the South Korean EEZ for the period 1950-2010 were estimated to be 23 million tonnes (Figure 5a). The annual discards increased from around 155,000 t·year^{-1} in 1950 to around 608,000 t·year^{-1} by 1981, and gradually decreased to around 217,000 t·year^{-1} by 2010 (Figure 5a).

Small otter trawl

The discards of the unregulated small otter trawl fishery in the South Korean EEZ were estimated to be almost 7.6 million tonnes for the study period. Due to the constant discard rate used, the trend for the discards is similar to the landings by this gear type. From 1950 to 1959, the annual discards were estimated at around 90,000 t·year^{-1}. The annual discards doubled by 1989, slowly decreased to around 147,000 t·year^{-1} by 2004 and rapidly decreased to around 30,300 t·year^{-1} by 2007.

Shrimp trawl

The total discards by shrimp beam trawl within the South Korean EEZ for the study period were estimated to be 153,000 t. The annual discards increased from approximately 1,100 t·year^{-1} in 1950 to around 3,200 t·year^{-1} by 1974, and gradually decreased to about 120 t·year^{-1} by 1992. Since 1992, the discards fluctuated between 920 t·year^{-1} and 6,900 t·year^{-1}.

Non-shrimp bottom trawl

The total discards by the non-shrimp bottom trawl were estimated to be 14.5 million tonnes from 1950 to 2010. There was a steady increase of these discards from around 62,000 t·year^{-1} in 1950 to about 456,000 t·year^{-1} by 1974. Since then, it gradually decreased to around 161,000 t·year^{-1} by 2010.

Trap

The total discards by the trap fishery within the South Korean EEZ during 1950-2010 were estimated to be 568,000 t. The annual discards increased from around 1,400 t·year^{-1} in 1950 to 20,200 t·year^{-1} by 1997 and rapidly decreased to around 10,700 t·year^{-1} by 2001. Subsequently, the annual discards increased again to about 19,000 t·year^{-1} by 2010.

Funnel net

The total discards by the funnel net fishery within the South Korean EEZ during 1950-2010 were estimated to be 108,000 t. From the 1950s to the early 1990s, the annual discards fluctuated between 700 t·year^{-1} and 2,100 t·year^{-1}. The annual discards rapidly increased to around 4,300 t·year^{-1} by 1997, then decreased to around 1,900 t·year^{-1} by 2010.

Subsistence fisheries

The total estimated subsistence catch of South Korea for the entire 1950-2010 period was 10.6 million tonnes. Annual subsistence catches were established at around 342,000 t·year^{-1} in 1950 and decreased to just over 4,200 t·year^{-1} by 2010 (Figure 5a). The subsistence catches were dominated by species of Octopodidae, Ommastrephidae, Sciaenidae and Carangidae, and their catches in recent years (2000s) were, on average, 3,400 t·year^{-1}, 3,400 t·year^{-1}, 1,400 t·year^{-1} and 9,400 t·year^{-1}, respectively.

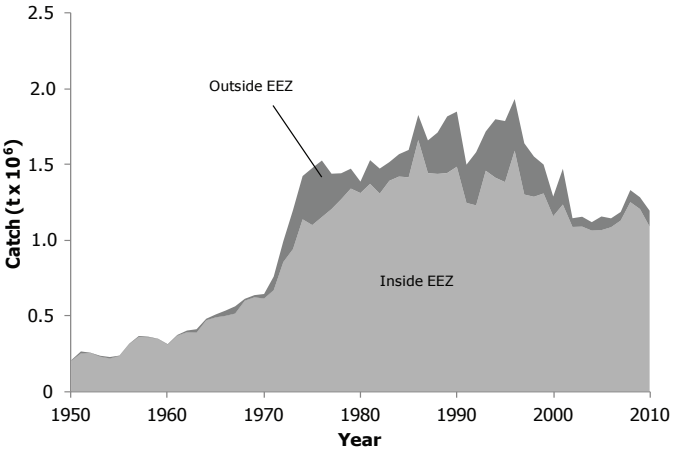

Figure 4. FAO landings data of South Korea within FAO statistical area 61 assigned to Korean EEZ and remaining area 61. Source: FAO Fishstat and Korean Fishery Yearbook 2011.

Table 8. Taxonomic composition applied to shrimp trawl discards for South Korea. Percentage data derived through assumption-based consideration of source material (Oh and Ma 2004).

Taxon name	Common name	Discards (%)
Sciaenidae	Drums or croakers	20
Gobiidae	Gobies	10
Pectinidae	Scallops	10
Rapana	Sea snails	5
Oratosquilla oratoria	Mantis shrimp	10
Charybdis	Japanese swimming crabs	15
Echinoidea	Sea urchins	10
MMF	Miscellaneous marine fishes	20

Table 9. Taxonomic composition applied to non-shrimp bottom trawl discards for South Korea. Percentage data derived through assumption-based consideration of source material (Kim *et al.* 2007).

Taxon name	Common name	Discards (%)
Asteroidea	Sea stars	72
Cynoglossidae	Tonguefishes	2
Trachysalambria curvirostris	Southern rough shrimp	2
Pleuronectidae	Righteye flounders	1
Portunus trituberculatus	Gazami crab	1
Pampus argenteus	Silver pomfret	1
Liparis tanakae	Tanaka's snailfish	1
Portunidae	Swimming crabs	1
Penaeidae	Penaeid shrimps	1
Lophiidae	Goosefishes	1
Engraulidae	anchovies	1
Platycephalus indicus	Bartail flathead	1
Tetraodontidae	Puffers	1
MMM	Miscellaneous marine molluscs	8
MMF	Miscellaneous marine fishes	4
MMC	Miscellaneous marine crustaceans	1
MAI	Miscellaneous aquatic invertebrates	1

Recreational fisheries

The estimated total marine recreational catches of South Korea for the 1970-2010 period were 820,000 t, while the estimated recreational mud flat collecting catches for 1994-2008 were 300 tonnes (Figure 5a). Total annual recreational catches were around 850 t·year^{-1} in 1971 and increased to just under 53,000 t·year^{-1} in 2010 (Figure 5a). The recreational catches were dominated by *Acanthopagrus schlegelii schlegelii, Girella punctata, Oplegnathus fasciatus* and *Pagrus major* (Tables 5, 6).

Reconstructed total catch

South Korea's reported marine landings as provided through the Korea Fishery Yearbook (2011) (excluding marine mammals and seaweed) and FAO FishStat matched nearly perfectly. It is apparent that there have been transparent data transfers between South Korea and FAO (Garibaldi 2012). Overall, the South Korea's total marine catches within EEZ waters as reconstructed here were estimated to be 95.1 million tonnes, which is 64% greater than the EEZ landings data (Figure 5a).

The total reconstructed catch within the EEZ was around 0.7 million t·year^{-1} in 1950 and gradually increased to about 1.3 million t·year^{-1} by 1970. Then, there was a rapid increase of catches reaching around 2 million t·year^{-1} by 1974 and total catches peaked at about 2.5 million t·year^{-1} in 1986. Thereafter, catches declined steadily to about 1.4 million t·year^{-1} in 2010 (Figure 5a).

The reconstructed catch was dominated by sea stars (Asteroidea), Japanese anchovy (*Engraulis japonicus*), Japanese flying squid (*Todarodes pacificus*), Chub mackerel (*Scomber japonicus*), croakers or drums (Sciaenidae), largehead hairtail (*Trichiurus lepturus*), and threadsail filefish (*Stephanolepis cirrhifer*) (Figure 5b). Overall, reconstructed catches could be assigned to 120 taxa.

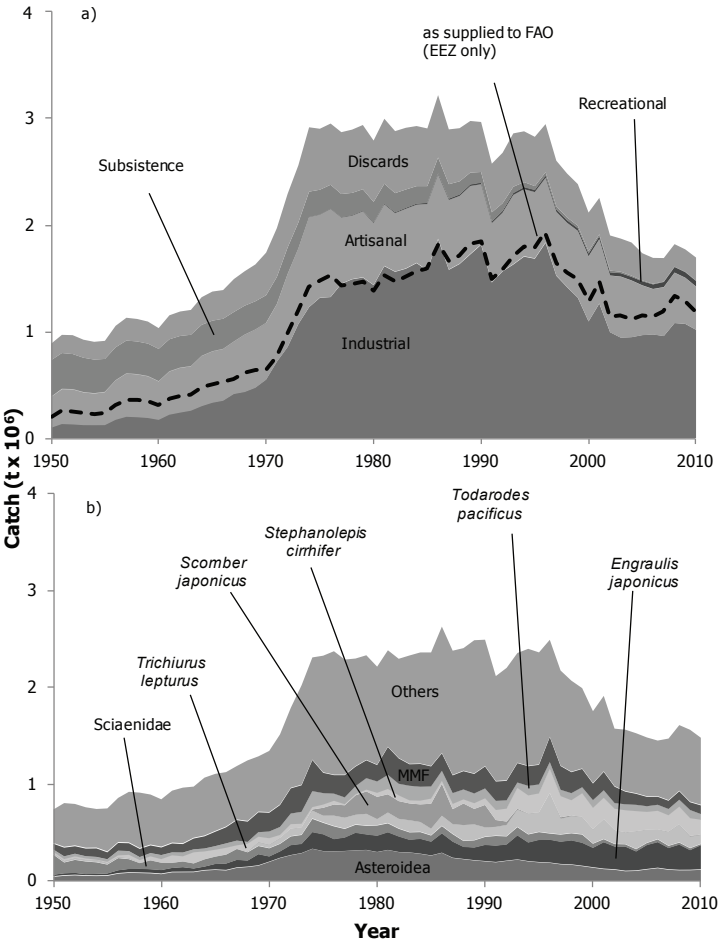

Figure 5. Reconstructed total catch for South Korea, 1950-2010, a) by sectors: from bottom to top, industrial, artisanal, discards, subsistence and recreational with landings supplied to FAO (dotted line); and b) by major taxa and 'Others' consisting of 113 additional taxonomic entities.

Discussion

The total reconstructed marine catch for the South Korean EEZ waters for the study period, 1950 – 2010, was estimated at 95.1 million tonnes, which was 64% greater than the reported landings for the South Korea EEZ. This discrepancy was largely due to unreported discards and subsistence catches. Discards represent close to 25% of the total reconstructed catch but it is still underestimated. We only estimated discards of five gear types: small otter trawl, shrimp beam trawl, other non-shrimp bottom trawl, trap, and funnel net. Thus, our discards estimate does not represent all discards. Subsistence catches in South Korea did not fluctuate much year to year but were steadily decreasing due to the gradual migration of coastal rural population to urban areas, and the increasing access to commercial markets and a cash-based economy. The rapid decline of the unregulated catches in the mid-2000s was due to increased enforcements. Unlike other sectors, recreational catches have been increasing since the early 1970s. In this study, we estimated unreported catches and discards only inside the EEZ, and we did not account for IUU catches from outside the EEZ. Therefore, a more focused study is required to address IUU catches outside the EEZ.

South Korea's fisheries catches supplied to FAO included only commercial fisheries landings and this data transfer seems comprehensive. Our study is the first to estimate the total removal of marine resources for the period from 1950 to 2010. As we took a conservative approach and were only able to account for parts of domestic illegal catches and discards, our estimates are most likely underestimates.

As mentioned previously, South Korea defines both domestic and foreign vessels fishing without government permission or license (or with banned gears) as illegal fishing. However, we distinguished 'unregulated' fishing as unlicensed domestic boats fishing in Korea's own EEZ and 'illegal' fishing as foreign vessels fishing without permission in Korea's EEZ. Unfortunately, there were no readily available catch data for other unregulated fishing activities aside from small otter trawlers within South Korea. Since we could not estimate and include the catches by

other common gear types involved in unregulated fishing activities, our estimates do not represent total unregulated removals. Beside the unregulated activities, there is also intense foreign illegal fishing by Chinese vessels in Korean waters since the Chinese portion of the Yellow Sea is overfished and depleted (Jia and Ce 2012). In the 2000s, South Korea's government increased its regulations and attempted to enforce illegal fishing activities. Although these have reduced illegal activities, they have not been entirely eliminated (Jia and Ce 2012). Unfortunately, catch data for the foreign illegal fishing activities within South Korea were unavailable. However, estimating and reporting on subsistence estimate should be undertaken by South Korean agencies.

Future research on legal and illegal fishing by Chinese or Japanese vessels in Korean waters and discards from these vessels are required to estimate true removals of marine resources from Korea's EEZ. The results of this study highlight the importance of better monitoring and reporting systems, for all marine removals, especially for the rapidly growing recreational sector and for the substantial discarded bycatch.

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

Year	FAO landings	Reconstructed total catch	Industrial	Artisanal	Subsistence	Recreational	Discard
1950	207,801	734,000	45,000	193,000	342,000	-	155,000
1951	265,301	801,000	65,000	230,800	335,000	-	171,000
1952	256,401	792,000	55,000	231,700	328,000	-	177,000
1953	236,601	757,000	56,000	210,900	322,000	-	169,000
1954	228,201	740,000	57,000	200,900	315,000	-	167,000
1955	237,701	746,000	55,000	212,600	308,000	-	170,000
1956	315,502	855,000	74,000	271,100	308,000	-	202,000
1957	367,102	918,000	91,000	306,300	307,000	-	214,000
1958	362,701	910,000	90,000	303,100	306,000	-	211,000
1959	349,001	890,000	87,000	292,400	304,000	-	207,000
1960	313,202	840,000	80,000	263,000	302,000	-	195,000
1961	374,191	930,000	103,000	302,300	300,000	-	225,000
1962	403,145	961,000	121,000	313,900	297,000	-	229,000
1963	412,044	972,000	138,000	307,300	294,000	-	233,000
1964	481,255	1,065,000	157,000	358,300	290,000	-	260,000
1965	510,004	1,105,000	180,000	364,800	286,000	-	273,000
1966	535,082	1,122,000	207,000	364,700	282,000	-	269,000
1967	563,341	1,186,000	233,000	367,600	276,000	-	309,000
1968	612,901	1,245,000	240,000	411,100	271,000	-	323,000
1969	637,201	1,286,000	260,000	416,300	265,000	-	345,000
1970	644,668	1,343,000	283,000	402,400	258,000	-	399,000
1971	760,087	1,514,000	395,000	406,500	254,000	850	458,000
1972	994,135	1,790,000	494,000	543,000	249,000	1,700	503,000
1973	1,198,898	2,024,000	679,000	562,900	243,000	2,550	536,000
1974	1,424,291	2,313,000	777,000	692,200	238,000	3,400	603,000
1975	1,477,223	2,331,000	897,000	625,500	233,000	4,250	571,000
1976	1,526,804	2,377,000	905,000	667,900	225,000	5,100	573,000
1977	1,439,668	2,291,000	1,027,000	460,100	218,000	5,950	579,000
1978	1,442,647	2,301,000	1,060,000	431,200	211,000	6,800	593,000
1979	1,472,989	2,335,000	1,071,000	451,300	203,000	7,650	602,000
1980	1,387,570	2,217,000	1,030,000	408,700	196,000	8,500	575,000
1981	1,529,211	2,387,000	1,178,000	403,000	189,000	9,350	608,000
1982	1,473,610	2,299,000	1,154,000	371,900	181,000	10,200	581,000
1983	1,516,387	2,333,000	1,190,000	380,400	174,000	11,050	578,000
1984	1,568,773	2,365,000	1,260,000	363,300	166,000	11,900	563,000
1985	1,596,827	2,365,000	1,216,000	437,000	159,000	12,750	540,000
1986	1,827,870	2,633,000	1,470,000	414,500	150,000	13,610	584,000
1987	1,659,644	2,383,000	1,255,000	462,100	138,000	14,460	513,000
1988	1,711,851	2,409,000	1,328,000	443,000	125,000	15,310	498,000
1989	1,818,320	2,491,000	1,436,000	442,600	113,000	16,160	484,000
1990	1,850,236	2,497,000	1,538,000	371,500	102,000	17,010	469,000
1991	1,499,318	2,119,000	1,197,000	360,400	87,000	17,990	456,000
1992	1,581,828	2,204,000	1,282,000	357,700	74,000	18,970	472,000
1993	1,718,865	2,359,000	1,329,000	448,900	61,000	19,950	500,000
1994	1,799,694	2,402,000	1,428,000	427,900	49,000	20,930	476,000
1995	1,787,770	2,365,000	1,422,000	421,700	38,000	21,980	461,000
1996	1,933,176	2,496,000	1,578,000	410,000	35,000	23,030	450,000
1997	1,640,712	2,177,000	1,289,000	405,700	32,000	24,080	426,000
1998	1,553,273	2,072,000	1,189,000	417,800	29,000	25,130	411,000
1999	1,500,272	1,994,000	1,109,000	444,300	26,000	26,180	389,000
2000	1,288,737	1,755,000	907,000	434,200	23,000	27,740	363,000
2001	1,472,349	1,914,000	1,096,000	427,900	20,000	29,310	341,000
2002	1,145,469	1,574,000	835,000	360,400	18,000	30,870	329,000
2003	1,155,395	1,563,000	805,000	399,900	15,000	32,440	310,000
2004	1,119,471	1,526,000	805,000	363,100	13,000	34,010	311,000
2005	1,157,083	1,482,000	804,000	374,900	10,000	38,710	254,000
2006	1,144,762	1,450,000	793,000	364,100	7,000	43,420	243,000
2007	1,186,858	1,471,000	800,000	397,100	5,000	48,130	220,000
2008	1,331,542	1,610,000	929,000	412,200	5,000	52,830	211,000
2009	1,284,070	1,562,000	921,000	373,400	5,000	52,810	210,000
2010	1,195,104	1,479,000	858,000	346,800	4,000	52,810	217,000

Appendix Table A2. Reconstructed total catch (in tonnes) by major taxa for South Korea, 1950-2010. 'Others' contain 129 additional taxonomic categories.

Year	Asteroidea	Marine fishes not identified	*Engraulis japonicus*	*Todarodes pacificus*	*Scomber japonicus*	Sciaenidae	*Trichiurus lepturus*	*Stephanolepis cirrhifer*	Others
1950	44,500	58,900	15,000	20,000	15,000	209,000	25,000	-	347,000
1951	55,300	89,200	19,000	24,000	19,000	113,000	28,000	-	453,000
1952	59,700	76,900	18,700	24,000	19,800	136,000	27,400	-	430,000
1953	54,300	78,300	11,600	18,300	21,000	132,000	22,700	-	419,000
1954	52,700	87,400	15,900	8,700	26,600	120,000	28,200	-	400,000
1955	54,800	70,800	17,600	18,300	18,500	93,000	26,100	-	446,000
1956	76,500	79,700	29,100	21,800	13,900	127,000	48,200	-	458,000
1957	84,900	80,600	34,700	39,500	12,800	102,000	38,600	-	525,000
1958	82,900	84,000	37,800	33,500	5,800	60,000	30,600	-	575,000
1959	79,900	78,800	36,800	46,800	1,600	93,000	33,700	-	519,000
1960	71,800	77,800	36,300	42,100	2,100	78,000	41,700	-	491,000
1961	90,300	92,000	39,700	83,000	1,800	54,000	30,000	-	539,000
1962	91,100	86,700	46,900	56,900	4,100	60,000	39,300	-	577,000
1963	91,700	111,700	32,400	117,100	5,400	53,000	30,500	-	530,000
1964	108,200	125,500	35,600	86,600	2,400	76,000	30,000	-	600,000
1965	114,600	148,200	56,800	70,600	7,300	77,000	37,700	-	592,000
1966	109,100	165,800	66,300	75,500	2,000	94,000	45,400	-	565,000
1967	135,400	211,200	78,500	41,700	2,800	114,000	48,700	-	554,000
1968	143,500	209,200	63,100	84,700	10,500	87,000	18,600	-	628,000
1969	157,200	204,600	115,100	59,900	42,100	86,000	47,900	-	573,000
1970	194,900	193,800	54,000	72,100	38,300	86,000	69,100	-	635,000
1971	234,400	225,400	66,900	37,600	60,600	79,000	82,900	-	727,000
1972	262,600	259,900	104,200	52,700	79,000	91,000	110,300	300	829,000
1973	283,400	274,000	95,600	44,200	74,200	94,000	124,200	2,000	1,032,000
1974	327,900	321,100	173,500	31,400	80,600	139,000	166,400	12,500	1,060,000
1975	303,700	209,300	175,500	40,300	70,100	120,000	120,100	81,400	1,210,000
1976	302,900	190,800	126,200	45,200	107,400	134,000	75,600	114,700	1,281,000
1977	304,700	229,400	140,800	18,100	113,100	90,000	72,000	128,100	1,194,000
1978	311,700	201,500	183,200	18,400	99,500	85,000	86,100	199,900	1,117,000
1979	315,700	183,400	161,900	26,100	120,300	91,000	120,700	230,300	1,086,000
1980	294,400	168,800	169,700	48,500	62,700	108,000	120,000	229,200	1,016,000
1981	315,700	287,400	184,400	62,400	108,100	94,000	147,700	187,600	1,000,000
1982	294,300	261,600	162,300	66,200	99,400	81,000	122,000	182,400	1,029,000
1983	289,900	221,500	131,900	38,800	122,900	78,000	152,600	172,700	1,124,000
1984	276,900	234,800	155,100	45,800	101,700	71,000	145,400	181,000	1,153,000
1985	259,000	206,300	143,500	59,900	68,500	65,000	127,600	256,500	1,178,000
1986	287,000	180,700	201,600	37,200	103,500	77,000	107,600	327,500	1,311,000
1987	235,300	182,600	167,700	60,900	101,300	79,000	113,400	153,600	1,289,000
1988	222,400	188,500	126,100	49,500	162,800	62,000	104,400	221,700	1,272,000
1989	209,900	201,200	131,900	65,900	163,600	75,000	102,400	159,100	1,382,000
1990	200,800	226,400	168,100	75,300	97,200	84,000	104,000	230,300	1,311,000
1991	191,200	199,700	170,300	109,900	91,500	102,000	95,700	70,500	1,088,000
1992	205,200	201,200	168,200	139,800	116,400	85,000	87,300	34,900	1,166,000
1993	217,800	199,700	249,200	222,000	174,700	88,000	58,000	11,400	1,138,000
1994	200,300	202,000	193,400	191,900	210,400	85,000	101,100	4,400	1,214,000
1995	190,500	202,400	230,700	200,900	200,500	82,000	94,600	1,800	1,162,000
1996	185,600	258,300	237,100	252,600	415,000	65,000	74,500	1,800	1,006,000
1997	170,700	244,900	230,900	225,000	160,400	75,000	67,200	16,300	986,000
1998	166,400	216,500	249,500	163,000	172,900	75,000	74,900	9,400	944,000
1999	152,500	188,700	238,500	249,300	177,500	87,000	64,400	3,000	834,000
2000	137,100	171,600	201,200	226,300	145,900	44,000	81,100	2,900	745,000
2001	122,500	190,200	273,900	225,600	203,700	33,000	79,900	1,600	783,000
2002	116,100	169,100	236,300	226,700	141,800	27,000	60,200	900	596,000
2003	101,100	130,100	250,100	233,300	122,000	25,000	62,900	1,400	637,000
2004	104,300	113,300	196,600	212,800	184,600	24,000	66,300	1,300	622,000
2005	118,900	96,000	249,000	189,100	135,600	22,000	60,100	1,100	610,000
2006	131,900	82,700	265,300	197,100	101,400	30,000	63,700	1,100	577,000
2007	116,000	84,800	221,100	174,500	143,800	23,000	66,000	3,000	639,000
2008	110,300	87,000	261,500	186,200	187,200	22,000	72,900	2,600	680,000
2009	110,900	80,000	203,700	189,200	118,000	21,000	85,500	8,300	745,000
2010	115,900	89,500	249,600	159,100	94,300	13,000	59,200	3,500	695,000