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Soohyun Shon, Sarah Harper and Dirk Zeller

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Email: d.zeller@fisheries.ubc.ca

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Soohyun Shon, Sarah Harper, and Dirk Zeller

Sea Around Us, Fisheries Centre, University of British Columbia,
2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada
d.shon@fisheries.ubc.ca; s.harper@fisheries.ubc.ca; d.zeller@fisheries.ubc.ca

Abstract

The Democratic People's Republic of Korea (DPRK or North Korea) is located on the northern portion of the Korean Peninsula. Unlike most coastal countries in the world, North Korea does not report its annual marine fisheries catches to the United Nations Food and Agriculture Organization (FAO) although it is a member country of FAO. We independently reconstructed North Korea's total marine catches within its EEZ for the 1950-2010 time period. The reconstructed catch estimate is the sum of an estimate of subsistence catches based on information on consumption and a re-estimated commercial fisheries catch from the FAO and the South Korean government statistics department. Total reconstructed catches were estimated to be 38.3 million t for the 1950-2010 period, increasing from 0.43 million t·year^{-1} in 1950 to a peak of 1.28 million t·year^{-1} in 1978, before declining to 0.2 million t·year^{-1} by 2010. In comparison, landings data presented by FAO amount to 24.4 million tonnes for the same period, resulting in estimated total catches being 60% larger than presented landings. Since the early 1990s, North Korea has relied heavily on international food aid. Thus, marine resources and fisheries production in North Korean waters are crucial to food security and the economy of the country.

Introduction

The Democratic People's Republic of Korea (DPRK or North Korea) is located between 38°-43°N and 124°-131°E on the northern portion of the Korean Peninsula, within Food and Agriculture Organization (FAO) statistical area 61, the Northwestern Pacific (Figure 1). The neighboring countries are the Republic of Korea (ROK or South Korea), China, Japan and Russia. The country's mainland and islands comprise a land area of around 120,000 km^2, with a total population of approximately 24 million in 2009 (www.kosis.kr). The Exclusive Economic Zone (EEZ) comprises a sea area of approximately 115,000 km^2 (www.seaaroundus.org) where both commercial and subsistence fishing activities take place.

History

After WWII, the Korean peninsula was divided geographically and politically, with a socialist regime in the north and a democracy in the south. North Korea, backed by the Soviet Union, invaded South Korea, thus igniting the Korean War from 1950-53. Kim Il Sung, the founding president of North Korea, isolated the country by creating a philosophy called 'Juche'. Although 'Juche' is originally based on the belief that "man is the master of everything and decides everything", Kim Il Sung re-directed this to 'independent stand' or 'spirit of self-reliance' and used this philosophy to justify its political decisions against outside influence. As a result, North Korea became one of the most closed socialist regimes in the world. In 1991, when the Soviet Union collapsed and eliminated oil and food exports at subsidized prices, North Korea's fisheries and agriculture production began to decline (Meditz *et al.* 2008). Furthermore, China started to decrease exports of food, fertilizer and oil. With these economic crises, several decades of resource and economic mismanagement have resulted in a heavy reliance on international assistance to feed an increasingly impoverished North Korean population[1]. For example, Ae Ran Lee (2009) examined 353 North Korean defectors to study the changes in the North Korean diet before and after the 1990s, and suggested that the amount of food distributed started to decrease after 1973, and the frequency of food distribution decreased considerably as of 1990. By the end of the 1990s, the distribution of food stopped in most areas of North Korea (Anon. 2011).

Figure 1. Map of Democratic People's Republic of Korea (DPRK or North Korea), showing the country's EEZ claim (solid line) within FAO statistical area 61 (inset).

[1] https://www.cia.gov/library/publications/the-world-factbook/geos/kn.html [accessed: August 05, 2011]

Although people have started buying food on the black market, malnutrition is still prevalent (Lee 2009). Even the military forces that have priority in food rations have not received adequate food rations and are becoming increasingly malnourished.[2]

Fisheries

North Korea's EEZ is separated into two seas: the East Sea and the western Yellow Sea (Figure 1), both of which have distinct marine geography and ecosystems. The eastern sea has a simple coastline with very few islands and a steep slope dropping to a mean depth of 1,700 meters (Kim 1994). Within this area, both the warm Kuroshio current and the cold Oyashio current intersect, creating favorable fishing conditions for both warmer water species such as Alaska pollock (*Theragra chalcogramma*), Pacific herring (*Clupea pallasii pallasii*), yellow striped flounder (*Pseudopleuronectes herzensteini*), and Ayu sweetfish (*Plecoglossus altivelis altivelis*), as well as colder water species such as Japanese pilchard (*Sardinops sagax*), Japanese anchovy (*Engraulis japonicas*), and Pacific saury (*Cololabis saira*) (Nam 2006; en.wikipedia.org/wiki/Ocean_current). In contrast, the western sea has a complex coastline with many islands (Kim 1994). The western sea gently slopes to a mean depth of 44 meters (Hong and Im 2002). This continental shelf area is an excellent fishing ground for Yellow croaker (*Larimichthys polyactis*), Hommibe croaker (*Nibea mitsukurii*), Japanese Spanish mackerel (*Scomberomorus niphonius*), Silver pomfret (*Pampus argenteus*), and righteye flounders (Family Pleuronectidae) (Kim 1994; Hong and Im 2002). The 6-7 meter tidal range provides for large intertidal areas where people collect marine species such as crabs and clams (Kim 1994; Nam 2006).

The number of marine species in the North Korean EEZ is estimated to be around 530, while the number of freshwater species is estimated to be around 120 (Kim 1994). Around 120 marine species, including 75 fish species and 20 mollusk species are commercially targeted (Hong and Im 2002). North Korea's fishing fleets are either small, unpowered wooden boats, less than 8 meters in length that operate near shore, or iron vessels, more than 4 tonnes in weight with powerful motors, which operate offshore (Hong and Im 2002). All fishing fleets are registered and their access to the sea is controlled by the government (Hong and Im 2002). In 1988, there were an estimated 30,600 fishing vessels, 64% being motorized and the remaining 36% being wooden boats (Kim 1994). The main commercial fishing gears used in North Korea are stow net in the western sea and trawl in the eastern sea (Kim 1994; Um and Heo 2010).

North Korea started a distant-water fishery in the northern Pacific ocean in 1962 and sent trawlers to Pakistan for fishing in 1984 (Hornby *et al.* 2014); however, due to a fuel crisis that began in the late 1980s, North Korea has virtually given up distant-water fishing and has focused on artisanal fisheries and aquaculture of seaweed and clams (Nam 2006; Um and Heo 2010). The amount of imported fuel decreased from 3.02 billion L (19 million barrels) in 1989 to 1.53 billion L (9.6 million barrels) by 1992 (Chang 1993).

FAO relies on data supplied by its member countries (Garibaldi 2012); thus, the quality of the data largely depends on each country's ability to collect comprehensive marine fisheries catch data. However, national statistics supplied to FAO have been found to generally underestimate total catches, as they mainly consist of commercial, large-scale or industrial fisheries landings (Zeller *et al.* 2007; Zeller and Pauly 2007). 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. Thus, total marine fisheries catches taken by South Korea within its EEZ for the 1950-2010 time period were estimated to be 64% larger than reported data suggest (Shon *et al.*, in Prep.).

With limited food supplies, marine resources and fisheries productions are particularly crucial food sources for the people of North Korea. In fact, fish supplies almost 56 percent of the animal protein intake in the diet (Anon. 2000a). North Korea does not seem to formally report its fisheries landings to FAO. Thus, FAO has to rely on approximations or indirect reports. Underestimating total removals from the marine environment compromises sustainable fisheries management and may contribute to over fishing and further food insecurity. Thus, it is important to know how much is being caught each year, both past and present, and it is necessary to determine the status of North Korean fisheries in order to establish a baseline time series of historical catches.

The objective of this study is to collect all available information regarding unreported commercial and non-commercial catches, and to provide a more comprehensive estimate of North Korea's likely total marine fisheries catches from 1950-2010. This estimate of total marine fisheries catches can serve as a baseline for understanding issues such as resource depletion and food insecurity in North Korea.

Materials and Methods

Total marine fisheries catches taken by North Korean within its EEZ were reconstructed from 1950-2010 using a combination of landings data reported by FAO and the estimates of total North Korean fisheries catches assessed by the Ministry of Unification in South Korea. The FAO statistics were taken as representing only reported commercial landings, to which we added estimates of unreported commercial catches and estimates of small-scale non-commercial catches (i.e., subsistence catches). Commercial catch data from other sources deemed reliable were used in place of the FAO commercial landings data for some years.

[2] http://www.asiapress.org/rimjingang/english/release001/index.html [accessed: August 23, 2011]

Commercial landings

Reported landings

The commercial data used in this study were taken from the FAO landings database. Reported commercial landings data consist of fishery products that are sold in the domestic market or exported, and these are what the FAO typically represents in their landings statistics on behalf of a particular country.

These reported landings are catches of two fisheries operating within North Korean EEZ, artisanal (i.e., small-scale commercial) and industrial (i.e., large-scale commercial) fisheries. The definitions of these two fisheries in North Korea were not available, but we assumed that artisanal fishing vessels would be non-motorized wooden boats and industrial fishing vessels would be motorized boats which can operate more than one day per trip. Since the industrial fisheries use motorized boats and require fuel, their catches must have been affected more severely than the artisanal fisheries by the sudden fuel crisis which began in 1991. Thus, we assumed that the catch percentage of the industrial sector was higher than the artisanal sector for years prior to 1990 (70%), and rapidly decreased to 20% by 1996 and afterwards. We used linear interpolation to derived the annual catch percentages from 1950-2010 and applied these to individual species reported landings in order to derive the species landings by sector.

FAO statistical area 61 includes North Korea's EEZ and part of EEZs of Russia and Japan. Thus, we assumed that North Korea's distant water catches (estimated below) would be included in the miscellaneous marine fish category ('marine fishes nei') of FAO data. We subtracted the estimated catches of distant-water fisheries from the reported landings of 'marine fishes nei' and derived the catch percentages of artisanal and industrial sectors for the remaining reported 'marine fishes nei' landings. Also, we used the species composition of unreported landings (estimated below) to derive a breakdown for the remaining reported 'marine fishes nei'.

Distant-water (outside EEZ within FAO area 61)

North Korea started a distant-water fishery in the northern Pacific ocean in 1962 and sent trawlers to Pakistan for fishing in 1984 (Hornby *et al.* In prep). However, these distant-water fisheries catch data are not easily available; thus, the distant-water fisheries catches are only estimated for areas outside North Korea's EEZ, and still within FAO area 61. North Korea has had access to Russia's EEZ, within FAO area 61, since 1961 (Anon. 2000b). Although North Korea was allowed to catch between 18,000 – 200,000 t·year^{-1}, North Korean fisheries were only able to catch around 7,800 t·year^{-1} from 1995-1998 (Anon. 2000b; Um and Heo 2010). Therefore, we allocated 7,800 t·year^{-1} to the areas outside North Korea's EEZ (but within FAO area 61) from North Korea's catch for area 61 for the period from 1962-2010.

Unreported landings

North Korea does not normally release their fisheries catch data. Even in the few cases when North Korea released their data, these estimates were thought to be an exaggerated misrepresentation of their real catches. Thus, according to the FAO Yearbook of Fisheries Statistics (FAO 2005), FAO revised North Korea's 1961-1993 capture data using "the information in a report to FAO on anomalies in global capture statistics", which suggested that previous estimates of fishery production by North Korea were "seriously overestimated" (Nowara *et al.* 2005; L. Garibaldi, FAO, pers. comm.). We assumed that FAO lowered North Korea's landings data for pre-1991 years (Table 1). However, other sources that document North Korea's total fisheries catches persistently suggest values higher than the FAO's "adjusted landings" prior to 1991 (Table 1). Thus, the landings data from these other sources were treated as unreported commercial landings when their value was higher than the reported FAO FishStat data. In fact, FAO data were higher than these other sources only between 1991 and 1999. From 2000-2010, other sources had higher estimate of total North Korean marine catches. We assumed that the low landings for 1950 would be maintained to 1953 due to the Korean War. We used linear interpolation to estimate the annual total fisheries catches from 1950-2010.

In order to calculate the EEZ landing portion of the estimated total North Korean marine catches, we used the ratio of North Korean FAO landings data (area 61 to all areas) with an assumption that the FAO area 61 landings without the estimated distant-water catches were all taken within the North Korean EEZ.

Table 1. Comparison of FAO landings and alternate catch estimates (in tonnes) obtained from a variety of sources for some years.

Year	FAO landings	Alternate catch estimate	Sources
1950-1953	100,621	344,940	Nam (2006) with assumption
1957	293,956	580,000	Nam (2006)
1960	304,426	690,000	Nam (2006)
1965	399,143	748,000	Statistics Korea[a]
1970	456,743	931,000	Statistics Korea[a]
1975	737,608	1,304,000	Statistics Korea[a]
1976	822,889	1,600,000	Nam (2006)
1979	1,211,961	1,700,000	Lee (1992)
1980	1,200,299	1,700,000	Statistics Korea[a]
1982	1,527,917	1,970,000	Lee (1992)
1984	1,446,800	2,230,000	Lee (1992)
1985	1,484,900	2,420,000	Statistics Korea[a]
1986	1,628,100	2,370,000	Lee (1992)
1987	2,034,000	2,123,000	Lee (1992)
1988	1,822,000	2,146,000	Lee (1992)
1989	1,967,000	2,190,000	Nam (2006)
1990	1,378,00	1,600,000	Kim (1994)
2000	680,550	698,000	Statistics Korea[a]
2001	714,495	746,000	Statistics Korea[a]
2002	712,995	805,000	Statistics Korea[a]
2003	712,995	835,000	Statistics Korea[a]
2004	713,005	1,169,000	Statistics Korea[a]
2005	713,075	909,000	Statistics Korea[a]
2006	713,080	923,000	Statistics Korea[a]
2007	713,150	861,000	Statistics Korea[a]
2008	713,250	830,000	Statistics Korea[a]

[a] http://kosis.kr/bukhan/ [accessed: October 31, 2012]

Data concerning the species composition of commercial catches were limited. Thus, we used several sources to come up with a reasonable estimate of annual species composition (Table 2). Hong and Im (2002) presented a list of commercial species catch which was not year specific. To this, we added any missing taxa and their catches that are present in FAO data, trade data (Anon. 2005, 2006, 2007, 2008, 2009, 2010), and other sources mentioned below.

Table 2. Taxonomic composition applied to unreported commercial landings and reported MMF for North Korea. Percentage data derived through assumption-based consideration of source materials (Kim 1994; Hong and Im 2002; Nam 2006).

Taxon	Common Name	Catch (%)			
		prior to 1970	1989	1991	after 1996
Clupea pallasii pallasii	Pacific herring	0.057	0.051	0.059	0.063
Sardinops sagax	Pacific sardine	0	0.103	0.117	0.126
Scomber japonicus	Chub mackerel	0.115	0.103	0.117	0.126
Todarodes pacificus	Japanese flying squid	0.287	0.257	0.293	0.316
Theragra chalcogramma	Alaska pollock	0.219	0.197	0.113	0.061
Others		0.827	0.743	0.706	0.685

Alaska pollock (*Theragra chalcogramma*) and Japanese pilchard (*Sardinops sagax*) have been major commercially targeted species in North Korea since the early 19th century (Kim 1994; Nam 2006). According to Kim (1994), the North Korean government reported that they caught 2 million t of Alaska Pollock, which is 80% of their reported marine landings in 1988. However, reported catches of these two species prior to 1994 were not present in FAO statistics. We assumed that both species must have been caught by commercial fisheries prior to 1994. Though Nam (2006) stated that the pilchard stock was depleted during the late 1940s to early 1970s, we did not assign any catches to 1970 and assumed that it gradually increased from zero t·year^{-1} in 1970 to 20,000 t·year^{-1} (Hong and Im 2002) by 1989 when the industrial fisheries began to decline.

According to FAO statistics, sea urchins are not cultured in North Korea; thus, we assumed that all reported landings and exports of sea urchins are derived from wild capture fisheries. Various products of sea urchins (i.e., live sea urchin, fresh roe, frozen roe, and other processed roe) are mainly exported to Japan, and the exported amounts range from 239-1,893 t·year^{-1} during 1975-2002 (Sonu 1995; Hirai 1996; Sonu 2003). FAO statistics present sea urchin landings of 100 t in 1993; however, the amount of sea urchins exported to Japan in the same year was 1,380 t in wet weight (Hirai 1996). Another report suggests that North Korea's sea urchin catches were in fact higher, estimated at 2,000 t (Hong and Im 2002). This suggests that sea urchin landings were highly underestimated and under-reported.

Since 1984, FAO statistics present landings of 'miscellaneous marine crustaceans', but provide no further taxonomic detail. However, South Korea estimated that the annual crab catches were around 5,200 t, being 3,000 t from the western sea[3] and 2,200 t from the eastern sea (Hong and Im 2002). Although crab catches from the western sea were not separated at species level, crab catches from the eastern sea consisted of 400 t of hair crab (*Erimacrus isenbeckii*), 800 t of snow crab (*Chionoecetes opilio*) and 1,000 t of strong elbow crab (*Platylambrus validus*). Thus, we used these tonnages to derive individual species catch percentages (Table 2).

We used linear interpolation between anchor points to derive the annual catch percentages from 1950-2010 (Table 2) and applied these to the estimated unreported commercial landings and the reported 'marine fishes nei' landings from FAO. The percentage breakdown by sector (artisanal and industrial) applied to unreported catches was the same as used for the reported landings.

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 North Korea does not usually release their fisheries landing statistics, we assumed that the FAO estimated data do not include any discards.

Kelleher (2005) assumed that discards are negligible in North Korea due to the severe food deficits, and assumed 0.5% of landings would be discards. Thus, we used the same discard rate and applied it to the annual estimated commercial landings of North Korea to estimate the annual discards for 1950-2010. As the species composition of the discards was not available, we assumed that it is miscellaneous marine fishes ('marine fishes nei').

Human population

Human population data were taken from the population division, population estimates and projections section of the United Nations[4]. Data are provided in five years increments from 1950 to 2010, and intervening years were interpolated to derive a complete time series of human population data from 1950-2010. North Korea's human population grew from 9.7 million in 1950 to 24.3 million by 2010 (Figure 2).

North Korea's coastal rural human population was required to estimate subsistence catches. To derive an estimate of the coastal rural population, we obtained urban and rural population ratio data for 1953-2008 (Kim *et al.* 2011; Table 3). In years without data, a linear interpolation between years of known data was done to estimate missing values. For years before 1953 and after 2008, we used the 1953 and 2008 values, respectively. As a subset of the rural

[3] http://www.unikorea.go.kr/CmsWeb/viewPage.req?idx=PG0000000345&boardDataId=BD0000183745&CP0000000002_BO0000000030_Action=boardView&CP0000000002_BO0000000030_ViewName=board/BoardView#none [accessed: August 30, 2011]

[4] http://esa.un.org/unpd/wpp/unpp/panel_population.htm [accessed: March 8, 2013]

population, the coastal rural population within 10 km coastal proximity were 2.48 million (31% of rural population), 2.87 million (32%) and 3.15 million (33.3%) for 1990, 2000, and 2010, respectively (Anon. 2012). Based on this increasing trend (approximately 1% increase in every decade), we assumed that there would be lower coastal rural population in 1950, i.e., 27% of rural population at that time. Linear interpolation between these anchor points was done to estimate the coastal rural population of North Korea from 1950-2010. North Korea's coastal rural population decreased from around 2.16 million in 1950 to 1.82 million in 1960, and subsequently increased to around 3.15 million by 2010 (Figure 2).

Table 3. North Korea's urban and rural human population ratios, 1953-2008 (Kim *et al.* 2011).

Years	Urban population (%)	Rural population (%)
1950-1952[a]	17.7	82.3
1953	17.7	82.3
1956	23.2	76.8
1960	40.6	59.4
1965	47.5	52.5
1970	54.2	45.8
1975	56.7	43.3
1980	56.9	43.1
1982	58.3	41.7
1985	59.0	41.0
1986	59.1	40.9
1987	59.6	40.4
1993	60.9	39.1
2008	60.6	39.4
2009-2010	60.6	39.4

[a]1953 ratios carried back unaltered
[b]2008 ratios carried forward unaltered

Subsistence catches

Subsistence fisheries are considered to be non-commercial catches of the small-scale sector. Catch data for this sector are neither collected nor reported in the official landings statistics. While subsistence catch data were not readily available, we approximated catches for this sector conservatively using coastal rural population data in combination with general seafood consumption habits.

We assumed that people living in urban areas obtain seafood from either government supplies or markets for their daily consumption, and the seafood available through markets is commercially caught. We also assumed that the urban population is not involved in subsistence fishing and that only the rural population meets some of their animal protein 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. Thus, we assumed that only the coastal rural population would meet some of their seafood demand through marine subsistence fishing. This may be a conservative assumption for North Korea, especially in the last two decades when there has been severe food supply crisis.

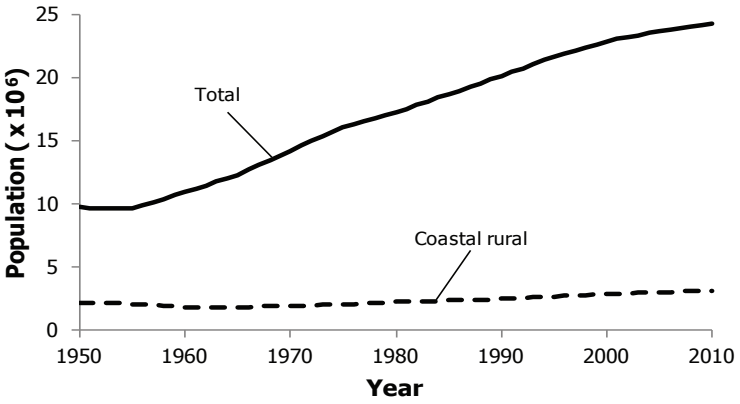

Figure 2. Total and coastal rural human population estimates for North Korea, 1950-2010.

For 1950, when the Korean War started, we assumed that North Korea and South Korea did not differ and that their coastal rural populations would have had a similar *per capita* subsistence consumption rate. Thus, we used the subsistence consumption rate of South Korea (47.6 kg·person^{-1}·year^{-1}; Shon *et al.*, this volume) and applied the same rate to North Korea.

In the 1960s, North Korea modernized their fishing vessels (Chang 1993). Thus, we assumed that the introduction of motorized vessels increased commercial catches and therefore we reduced the subsistence consumption rate by half for 1970 (23.8 kg·person^{-1}·year^{-1}).

Since the 1990s, substantial food distribution problems have caused serious food shortages in key organizations such as the military who have had to source their own food (Ishimaru 2011). More recently, military personnel stationed near the coast not only occupy all accessible beaches, but also seem to control available marine resources (Dr. S. Um, Korea Maritime Institute, pers. comm.). In fact, the "military-first" policy in North Korea allowed the military to monopolize fisheries production and isolated the benefits from most other North Koreans since 1998 (Park and Hong 2012). We assumed that these circumstances must have affected subsistence fishing opportunities in the coastal rural areas.

Since actual *per capita* seafood consumption data were not easily available, we used *per capita* seafood consumption supply data which are calculated by using commercial landings, imports, and exports data of fish, crustaceans and mollusks for 1991-2009 which range from 43.2 – 8.8 kg·person^{-1}·year^{-1} (Table 4; NOAA 1997, 1998, 2000, 2001, 2003, 2005, 2007, 2009, 2010, 2012). We used these supply rates to derive assumed marine subsistence rates by taking 35% in 1991, 30% in 1998, and 10% in 2009, with intervening years interpolated (Table 4). A linear interpolation between the 1991, 1998, and 2009 subsistence percentages was done, and applied to the supply rate to estimate the subsistence rate. Then, a linear interpolation between the 1950, 1970, and 1991 subsistence rate was done to obtain the annual subsistence rate for 1950-2009. The 2009 value was carried to 2010 to derive a complete time series of subsistence catch rates for coastal rural areas of North Korea. The total annual subsistence catch amounts were then estimated by multiplying the *per capita* subsistence catch rates by the population of coastal rural areas. As the species composition of the subsistence catches was not available, and North Korea would likely not have access to boats for subsistence fishing, we assumed that North Koreans would catch the same species that South Koreans catch or collect on the beach. We used the species composition of South Korean recreational mud flat collecting for subsistence catches of North Korea (Shon *et al.*, this volume).

Results

Commercial landings

Reported landings

The total reported commercial landings for North Korea within FAO statistical area 61 for the period 1950-2010 were 24.4 million tonnes, of which 24 million tonnes were deemed to come from inside the North Korean EEZ and 0.4 million tonnes were assumed to come from outside the EEZ but within FAO area 61 (Figure 3). In 1950, marine commercial landings from the North Korean EEZ were estimated to be 94,000 t, then peaked at about 990,000 t in 1982 and decreased very rapidly to around 329,000 t·year^{-1} by 1992. It declined further to approximately 190,000 t by 2002 (Figure 4a). Commercial landings were dominated by Japanese flying squids (*Todarodes pacificus*; 26%), Alaska pollock (*Theragra chalcogramma;* 22%), Chub mackerel (*Scomber japonicas;* 10%), Pacific herring (*Clupea pallasii pallasii;* 5%), and Pacific sardine (*Sardinops sagax;* 5%).

Table 4. Data sources for fish and shellfish consumption of the total population and estimated subsistence catch rate for coastal rural population. N/D: no data; '-' indicates interpolation.

Year	Consumption rate (kg/person/year)[a]	Source	Assumed subsistence proportion (%)	Subsistence rate (kg·person^{-1}·year^{-1})
1950	52.93	Shon *et al*. (in prep.)	90	47.36
1970	N/D		N/D	23.82[b]
1991	43.20	NOAA (1997)	35	15.12
1992	43.20	NOAA (1997)	-	14.81
1993	43.20	NOAA (1997)	-	14.50
1994	32.80	NOAA (1998, 2000)	-	10.76
1995	27.50	NOAA (1998, 2000, 2001)	-	8.83
1996	18.20	NOAA (2000, 2001)	-	5.72
1997	13.20	NOAA (2001, 2003)	30	4.04
1998	9.40	NOAA (2003)	-	2.82
1999	8.80	NOAA (2003, 2005)	-	2.48
2000	8.20	NOAA (2005)	-	2.16
2001	8.60	NOAA (2005, 2007)	-	2.11
2002	9.00	NOAA (2007)	-	2.05
2003	8.10	NOAA (2007, 2009)	-	1.69
2004	7.20	NOAA (2009)	-	1.37
2005	8.50	NOAA (2009, 2010)	-	1.46
2006	9.70	NOAA (2010)	-	1.50
2007	10.50	NOAA (2010, 2012)	-	1.43
2008	11.30	NOAA (2012)	-	1.34
2009	11.30	NOAA (2012)	10	1.13
2010	N/D	Assumed same as 2009	N/D	1.13

[a] Average consumption rate is used when there are two or more sources.
[b] Assigned 50% of 1950 subsistence rate.

Unreported commercial catches

The total unreported catches within the North Korean EEZ for the period 1950-2010 were estimated to be 11.5 million tonnes, of which 3.6 million tonnes were assumed to be artisanal and 7.8 million tonnes were deemed to be industrial (Figure 4a). From 1950 to 1976, the unreported catches increased from around 230,000 to 553,000 t·year^{-1}. By 1987 unreported catches fluctuated between 0 to 34,000 t·year^{-1}. The domestic unreported landings were dominated by Japanese flying squids (*Todarodes pacificus;* 28%), Alaska pollock (*Theragra chalcogramma;* 21%), Chub mackerel (*Scomber japonicas;* 11%), and Pacific herring (*Clupea pallasii pallasii;* 6%).

Discards

The total discards of commercial fisheries within the North Korean EEZ for the period 1950-2010 were estimated to be 177,000 t (Figure 4a). The annual discards gradually increased from around 1,600 t·year^{-1} in 1950 to around 6,100 t·year^{-1} by 1978 and decreased to around 1,000 t·year^{-1} by 2010.

Subsistence catches

The total estimated subsistence catch of North Korea for the entire study period was approximately 2.6 million tonnes (Figure 4a). In 1950, marine subsistence catches were estimated to be around 103,000 t·year^{-1} and gradually decreased to approximately 4,600 t·year^{-1} by 2010 (Figure 4a). These unreported catches were likely dominated by miscellaneous marine crustaceans (25%), octopus (10%), and species of Osteridae (10%), Portunidae (10%), and Holothuriidae (10%).

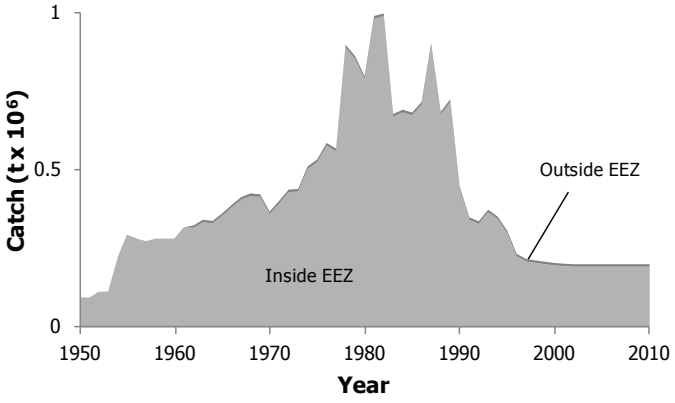

Figure 3. FAO landings data of North Korea within FAO statistical area 61 assigned to Korean EEZ and the remaining area 61. Source: FAO FishStat and (Anon. 2000b); Um and Heo (2010).

Reconstructed total catch

Reconstructed total marine catches by North Korea within its EEZ were estimated to be around 38.5 million tonnes over the 1950-2010 time period (Figure 4a). In 1950, the total reconstructed catches within North Korea's EEZ equivalent waters were 0.43 million t and gradually increased to just over 1.28 million t·year^{-1} by 1978. Catches fluctuated in the late 1970s and the early 1980s and decreased to 0.85 million t·year^{-1} by 1989. After this, there was a rapid decrease in catches to 0.2 million t·year^{-1} by the late 1990s. Thereafter, total marine catches within the EEZ have not recovered to previous catch levels and have remained around 0.2 million t·year^{-1} (Figure 4a).

Total reconstructed catches were dominated by 5 major taxa: Japanese flying squids (*Todarodes pacificus;* 22%), Alaska Pollock (*Theragra chalcogramma;* 22%), Chub mackerel (*Scomber japonicas;* 10%), Pacific herring (*Clupea pallasii pallasiii;* 5%), and Pacific sardine (*Sardinops sagax;* 4%), while an additional 42 taxa contributed 42% (Figure 4b).

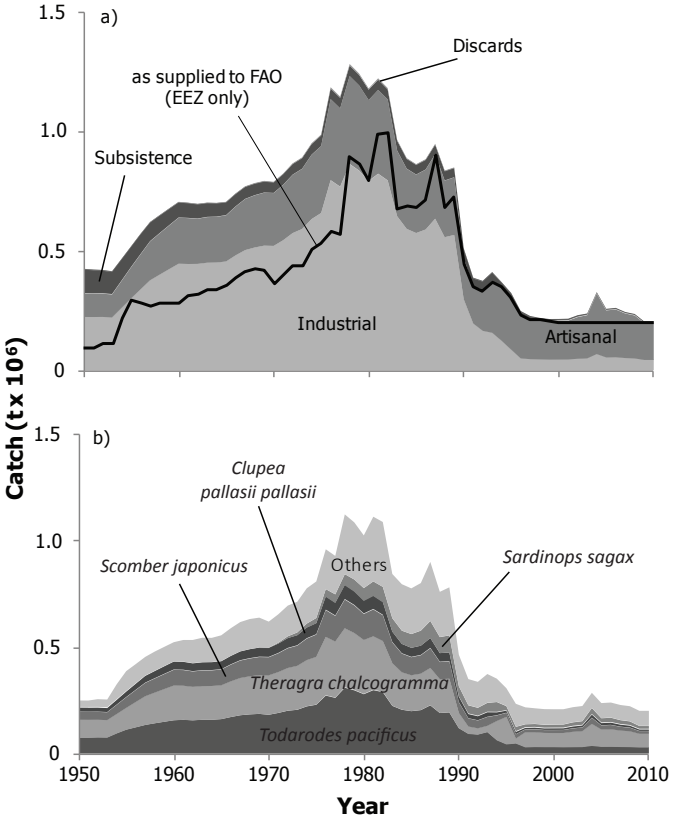

Figure 4. Total reconstructed catch for North Korea, 1950-2010, a) by sector compared to landings supplied to FAO (dotted line); and b) by major taxa with 'Others' consisting of 42 additional taxa.

Discussion

The reconstructed total marine catch for North Korea within its EEZ for the period 1950-2010 was approximately 38.3 million tonnes. In comparison, the FAO estimate for North Korea's marine commercial landings was approximately 24.4 million tonnes, resulting in reconstructed catches being nearly 60% larger than those presented by the FAO (Figure 4a). This discrepancy is largely due to the likely under-estimation of commercial landings prior to 1990. North Korea was actively supported by the former USSR until the late 1980s and therefore had substantial infrastructure (i.e., boats) and cheap oil to catch seafood. Some of the above difference is due to subsistence catches and discards being not accounted for in data reported by FAO.

Commercial catches declined rapidly during the late 1980s and early 1990s. The rapid decline was due to the shortage of subsidized fuel with the collapse of the former USSR. North Korea was suddenly left to search for other external economic support to save their economy and maintain their 'Juche' philosophy (Rhee 1991). For this reason, we assumed that catches after 1990 were mainly from inshore areas, accessible by less fuel intensive means.

Subsistence catches in North Korea showed a steady decline due to the gradual migration of the coastal rural population to urban areas and the increasing dominance and polarization of access to these resources by the military.

Unfortunately, there were no readily available catch data for other components of unreported fishing such as recreational fishing and unregulated fishing activities such as discarding. However, we assumed that no recreational marine fishing estimates exist in North Korea. Additionally, due to the food deficiency in North Korea, we assumed that discarding was also low, although some of the larger commercial vessel with export focus may engage in discarding.

Our study attempted to account more comprehensively for the total marine fisheries removals than the landings data currently presented and available for North Korea's marine fisheries, by adding estimates of non-commercial subsistence to the re-estimated commercial landings over the period 1950-2010. For developing countries, depletion of marine resources can further perpetuate economic hardships and issues of food insecurity (Kent 1997). We hope that the results of this study can help improving a historic baseline for North Korean fisheries' catch statistics.

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

Year	FAO landings	Reconstructed total catch	Industrial	Artisanal	Subsistence	Discard
1950	94,000	427,000	226,000	97,000	103,100	1,610
1951	94,000	424,000	225,000	97,000	100,600	1,610
1952	113,000	422,000	226,000	97,000	98,200	1,610
1953	114,000	417,000	224,000	96,000	95,800	1,600
1954	220,000	469,000	263,000	113,000	91,200	1,880
1955	293,300	521,000	303,000	130,000	86,800	2,160
1956	282,000	574,000	341,000	146,000	84,900	2,430
1957	274,000	623,000	378,000	162,000	80,100	2,700
1958	282,000	652,000	402,000	172,000	75,200	2,870
1959	282,000	680,000	425,000	182,000	70,100	3,030
1960	282,000	707,000	447,000	192,000	65,000	3,200
1961	318,000	704,000	446,000	191,000	63,200	3,190
1962	324,000	691,000	447,000	188,000	61,200	3,140
1963	342,000	696,000	452,000	190,000	59,200	3,170
1964	338,000	695,000	452,000	191,000	57,100	3,180
1965	362,000	700,000	457,000	192,000	54,900	3,210
1966	389,000	735,000	482,000	203,000	53,100	3,390
1967	414,000	764,000	504,000	213,000	51,300	3,550
1968	426,000	778,000	515,000	217,000	49,300	3,620
1969	423,000	787,000	523,000	221,000	47,200	3,680
1970	368,000	783,000	522,000	220,000	45,100	3,670
1971	402,000	817,000	545,000	230,000	45,100	3,840
1972	438,000	860,000	575,000	243,000	45,000	4,050
1973	440,000	885,000	593,000	251,000	44,900	4,180
1974	512,000	944,000	634,000	268,000	44,800	4,470
1975	534,000	980,000	659,000	279,000	44,600	4,650
1976	587,000	1,176,000	796,000	338,000	44,500	5,630
1977	569,000	1,137,000	769,000	326,000	44,400	5,440
1978	900,000	1,273,000	864,000	367,000	44,200	6,110
1979	864,000	1,233,000	836,000	355,000	44,100	5,920
1980	800,000	1,171,000	793,000	337,000	43,800	5,610
1981	992,000	1,214,000	823,000	349,000	43,100	5,820
1982	1,000,000	1,173,000	795,000	337,000	42,300	5,620
1983	679,000	957,000	645,000	273,000	42,000	4,550
1984	693,000	882,000	593,000	251,000	41,600	4,180
1985	684,000	856,000	576,000	243,000	41,200	4,060
1986	718,000	877,000	590,000	250,000	40,900	4,160
1987	904,000	941,000	635,000	269,000	40,100	4,480
1988	686,000	830,000	558,000	236,000	39,600	3,930
1989	726,000	843,000	568,000	240,000	39,100	4,000
1990	448,000	506,000	300,000	173,000	38,500	2,320
1991	350,000	382,000	198,000	152,000	38,000	1,710
1992	337,000	369,000	168,000	169,000	37,800	1,650
1993	374,000	405,000	160,000	214,000	37,500	1,830
1994	351,961	363,000	126,000	226,000	16,900	1,720
1995	307,083	318,000	89,000	218,000	16,800	1,500
1996	233,125	242,000	53,000	180,000	15,500	1,130
1997	216,462	221,000	50,000	167,000	11,100	1,040
1998	212,000	213,000	49,000	163,000	7,900	1,020
1999	208,000	208,000	48,000	160,000	7,000	1,000
2000	204,000	209,000	48,000	161,000	6,300	1,010
2001	201,572	210,000	48,000	162,000	6,200	1,010
2002	200,000	224,000	51,000	174,000	6,200	1,090
2003	200,000	231,000	53,000	180,000	5,200	1,130
2004	200,000	321,000	71,000	252,000	4,300	1,580
2005	200,000	251,000	57,000	196,000	4,700	1,230
2006	200,000	255,000	58,000	199,000	4,900	1,240
2007	200,000	238,000	54,000	186,000	4,500	1,160
2008	200,000	229,000	53,000	179,000	4,500	1,120
2009	200,000	198,000	46,000	154,000	4,500	960
2010	200,000	198,000	46,000	154,000	4,600	960

Appendix Table A2. Reconstructed total catches (in tonnes) by major taxa for North Korea, 1950-2010. 'Others' contain 42 additional taxanomic categories.

Year	*Todarodes pacificus*	*Theragra chalcogramma*	*Scomber japonicus*	*Clupea pallasii pallasii*	*Sardinops sagax*	Others
1950	77,000	86,100	37,000	18,500	-	30,200
1951	76,900	86,000	37,000	18,500	-	30,200
1952	78,300	84,900	37,000	18,500	-	36,300
1953	77,700	84,000	36,700	18,300	-	36,600
1954	97,300	92,900	43,200	21,600	-	70,700
1955	114,700	104,200	49,700	24,800	-	94,300
1956	125,800	120,600	55,900	28,000	-	90,600
1957	137,100	136,600	62,100	31,100	-	88,100
1958	144,900	145,600	65,900	33,000	-	90,600
1959	152,100	155,000	69,700	34,800	-	90,600
1960	159,200	164,400	73,400	36,700	-	90,600
1961	161,400	161,500	73,200	36,600	-	102,200
1962	158,900	158,600	72,000	36,000	-	109,400
1963	161,700	159,300	72,800	36,400	-	115,200
1964	161,600	159,900	73,000	36,500	-	113,900
1965	164,700	160,100	73,700	36,800	-	121,700
1966	174,500	168,800	77,900	38,900	-	130,300
1967	183,100	176,000	81,500	40,700	-	138,400
1968	187,300	179,600	83,200	41,600	-	142,200
1969	189,500	183,000	84,500	42,300	-	141,300
1970	185,400	186,300	84,300	42,200	-	123,600
1971	194,000	192,700	87,700	43,900	4,160	133,800
1972	204,600	201,300	92,100	46,000	8,780	144,600
1973	209,000	207,000	94,400	47,200	13,570	144,500
1974	225,200	217,600	100,500	50,200	19,370	166,400
1975	233,100	225,000	103,900	52,000	25,180	172,400
1976	276,800	274,700	125,100	62,500	36,580	188,000
1977	265,900	263,600	120,100	60,100	41,220	181,500
1978	314,200	277,800	134,300	67,100	52,960	282,400
1979	301,900	267,800	129,200	64,600	57,660	269,900
1980	283,400	253,700	121,800	60,900	60,750	248,900
1981	302,700	251,500	125,700	62,800	69,360	305,700
1982	293,300	238,900	120,700	60,300	73,090	306,400
1983	227,800	200,700	97,200	48,600	64,120	208,700
1984	209,200	176,500	87,500	43,700	62,520	219,400
1985	202,400	169,500	84,300	42,200	64,970	215,600
1986	207,500	171,900	86,000	43,000	71,110	224,600
1987	230,100	175,900	92,000	46,000	81,360	278,500
1988	193,700	159,700	80,100	40,100	75,420	213,600
1989	196,600	159,000	80,600	40,300	80,600	226,800
1990	121,800	73,300	49,900	25,000	47,180	148,200
1991	95,100	36,600	38,000	19,000	38,030	123,300
1992	91,800	31,600	36,700	18,400	36,700	121,900
1993	103,400	31,500	41,400	20,700	41,360	135,700
1994	65,100	92,400	26,000	13,000	45,740	109,700
1995	46,100	130,800	18,400	9,200	18,510	84,000
1996	50,000	25,000	20,000	10,000	20,020	108,000
1997	32,200	72,800	12,900	6,400	12,880	79,300
1998	33,600	71,500	13,400	6,700	13,430	73,300
1999	33,200	68,400	13,300	6,600	13,280	73,200
2000	33,200	67,900	13,800	6,900	13,790	71,900
2001	32,500	68,900	13,900	6,900	13,860	71,500
2002	33,000	73,900	15,700	7,900	15,730	70,900
2003	33,500	76,500	16,800	8,400	16,750	70,900
2004	39,000	104,900	28,100	14,100	28,120	70,900
2005	34,700	82,800	19,300	9,600	19,270	70,900
2006	35,000	83,900	19,700	9,900	19,750	70,900
2007	33,900	78,700	17,600	8,800	17,630	70,900
2008	33,400	76,000	16,600	8,300	16,570	70,900
2009	31,500	66,100	12,600	6,300	12,600	70,900
2010	31,500	66,100	12,600	6,300	12,600	70,900