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The Wall Street of fisheries: the Russian Far East, a catch reconstruction from 1950 to 2010

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THE WALL STREET OF FISHERIES: THE RUSSIAN FAR EAST, A CATCH RECONSTRUCTION FROM 1950 TO 2010

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ABSTRACT

The Russian Far East (RFE), as defined here encompasses the Sea of Japan, the Western Bering Sea, and the Sea of Okhotsk south to the southern tip of Sakhalin Island and the Kuril Islands (but not the North Coast of Siberia), is extremely rich in fisheries resources, ranging from Alaska pollock (*Theragra chalcogramma*) to species of Pacific salmon (*Oncorhynchus*), and from squids (Teuthida) to king crab (*Paralithodes*). The present catch reconstruction has generated a 'baseline' of FAO reported Russian fisheries catch within the Russian Exclusive Economic Zone (EEZ) from 1950 - 2010. Furthermore, we estimated total marine fishery removals, resulting in total reconstructed catch at 1.8 times the reported baseline for the entire time period, and 2.4 times the reported baseline after the dissolution of the former Soviet Union. With the transition from the Soviet planned economy producing for the domestic market to the current export-orientated market-fisheries, the fisheries industry has become a free-for-all with high levels of unreported commercial catches averaging 1.5 million tonnes annually (over 62% the tonnage of reported catch) consisting predominantly of high-value species like Alaska pollock, wild salmon, and king crabs. The discards for these commercial fisheries amounted to approximately 50% the tonnage of the landed catch. Unreported small-scale catches were also reconstructed, together equating to 1.4% the magnitude of reported catch, with subsistence catch from the indigenous populations averaging 5,700 t annually, and subsistence and recreational fishing for non-indigenous populations averaging 5,300 t and 12,700 t annually, respectively. Lastly, foreign legal and illegal catches and their discards were estimated within the Russian EEZ. Key issues of the fisheries are discussed, including but not limited to market, wage, and legislature inefficiencies, the ecological state of stocks, and potential solutions to the unbridled poaching of the post-Soviet era.

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INTRODUCTION

The Exclusive Economic Zone (EEZ) of the Russian Far East (RFE), as defined here, which includes over 1 million km² of shelf, encompasses the northwest of the Sea of Japan, the Western Bering Sea, and the Sea of Okhotsk south to the southern tip of Sakhalin Island and the Kuril Islands (Figure 1). However, this definition does not include the Chukchi Sea, or other areas along the north coast of Siberia, whose fisheries are discussed in Pauly and Swartz (2007) and Zeller *et al.* (2011). The Administrative regions covered here include the Kamchatka Krai and the Koryak Autonomous Area (since 2007 a part of Kamchatka Krai), the Magadan Region, Khabarovsk Krai, Primorsky Krai, the Sakhalin Region, and a portion of the Chukotka Autonomous Okrug.

Figure 1. Exclusive Economic Zone of the Russian Far East (about 3,420,000 km²), as delineated by (VLIZ, see www.vliz.be and Claus *et al.* 2014).

The Exclusive Economic Zone of the Russian Far East includes all but a small part of the Sea of Okhotsk Sea Large Marine Ecosystem (LME; see Shuntov and Dulepova 1996; Sorokin and Sorokin 1999; Lapko and Radchenko 2000b; Lapko and Radchenko 2000a; Chaikina 2004; Heileman 2008b), the western half of the West Bering LME (Aquarone 2008) and a north-western sliver of the Sea of Japan/East Sea LME (Heileman 2008a). The oceanography and biology of these ecosystems have been relatively well studied, and the key reason for their high productivity - a high rate of surface and subsurface mixing, ensuring a high availability of nutrients during the summer (ice free) season - has been identified. These

conditions are favourable to the development of productive fisheries, which have indeed developed in each of these LMEs.

The creation of a fishing industry of the RFE as an independent branch of the national economy occurred in the 1930s, when the first factories were erected, and fishery 'kolkhoz' were formed. From this time until after WWII, small boats with the 40 hp engine power were used. In the 1950s, these small motor boats were replaced by more powerful seiners, which initiated a period of intensive exploitation of the marine resources (Беляев and Ерухимович 2005). The historical development of the RFE fishing industry reflects all peculiarities of the complex socio-economic and political processes that took place in the USSR and it successor, the Russian Federation from 1950 to 2010.

Until 1977, long-range fleets based in the RFE were mainly engaged in fishing Alaska pollock, herring (*Clupea pallasii*) and Pacific saury (*Cololabis saira*) in the North Pacific. Distant-water fishing by Soviet fleets, which had started in the 1960s (Беляев and Ерухимович 2005), was then straightforward as until that time, the 'freedom of the sea' concept was dominant, which enabled any country with a distant-water fleet to operate in the waters off another maritime country, except its 12 mile 'territorial' waters. From 1977 on, this changed, as the gradual acceptance of the concept of 200 miles Exclusive Economic Zones (EEZ), led to numerous countries claiming EEZs. While this took place before the United Nations' Convention on the Law of the Sea (UNCLOS) was ratified by a sufficient number of countries to become international law (which occurred in 1982), the industrial fleets operating from the RFE found it impossible to continue their long range operations, and instead concentrated on the previously underutilized resources within the RFE's waters (Беляев and Ерухимович 2005), notably the Sea of Okhotsk. At that time, the RFE's fishing industry generated 70% of the total catch of that of the Soviet Union (Johnson 1996, p. 131). Indeed, the RFE still has Russia's most important fishing ground, generating more than 60% of the total catches of the Russian Federation (Тупикина 2009).

During Soviet years, in exchange for the valuable fish products produced in the RFE, the Russian government supplied the isolated region with the same resources as its other territories, including but not limited to stable employment in a growing fisheries sector and access to produce whose transport was heavily subsidized (Newell 2004). With the collapse of the former Soviet Union also came the collapse of the former subsidized rural economy, leaving residents unemployed and residing in one of the regions with the highest cost of living in Russia, primarily due to the poor transportation network linking mainland Russia with the East. Additionally, the government no longer subsidized fuel and repairs for the fisheries, which provided the major source of employment to these regions. The fishery sector faced frequent reforms, leading to chaos in the sector with regards to jurisdictional territories, transfers of personnel and loss of qualified staff, and deterioration of equipment (The Wild Salmon Center 2009). In the 2000s, inept leadership caused the number of inspectors to drop in 2009 by 66%, leaving one inspector per 28 km of coastline, not including rivers (The Wild Salmon Center 2009). Experimentation with quota allocation in the early 2000s likewise caused great instabilities in the fisheries sector (FAO 2007).

While some poaching existed in the former Soviet Union in the form of a shadow economy, the years leading up to and after the dissolution of the Soviet Union led to an enormous, "terrifying" increase poaching (Dronova and Spiridonov 2008) as a result of the socio-economic position of residents. As described by Vaisman (2001), there is substantial evidence from varying levels of the government and media that "Russia's fishing industry has turned into powerful black-market sector". This has extended beyond only fishers, as poaching has operated with the "complicity of the militia, airport personnel, port personnel, maritime transport companies, phyto-sanitary inspectors, and various security officials" (The Wild Salmon Center 2009). Bribery and corruption is deeply ingrained in the culture

from Soviet years, and little has changed as seen by its poor corruption index, on par with many African countries (The Guardian 2011).

Poaching in the Russian Far East has become increasing criminalized and large-scale, often linked with industrial fisheries. Due to unique regulations which exempt fishers from landing catch captured outside 12 nautical miles from shore in Russian ports, most of this catch is exported to neighboring Asian countries like Japan, North Korea and South Korea. This may take the form of over-the side-sales, forged port clearances, and trade in cities like Pusan in South Korea, a common route for delivering fish abroad as no customs certification is required (Spiridonov and Nikolaeva 2004).

This reconstruction, which provides a current overview of the fisheries of the RFE, is an attempt to identify commercial catches and their discards, along with catch from small-scale sectors such as subsistence and recreational that have gone unreported in fisheries statistics. Of all the Russian markets, "the fish market is likely the least transparent" as "Russian fish companies are reluctant to disclose both production and trade volumes" (Spiridonov and Nikolaeva 2004). Hence the task at hand requires significant review of grey literature to obtain estimates. FAO landing data from Areas 61 and 67 are used as a starting point for this study.

The time period from 1950 – 2010 are divided into several sub-periods, each characterised by a set of political and socio-economic attributes that shaped the fisheries of the RFE, and which influenced its level of misreported landings and discards:

1. 1950-1961, the post-WWII period (beginning of the intensive exploitation of the marine resources due to the technical upgrade of fish factories, kolkhoz, large vessels, and massive capital investments by the state);
2. 1961-1977, the period when the RFE fishing fleet was mainly fishing in what became the EEZs of other maritime countries, then described as the "open ocean";
3. 1977-1991, when the catches by the distant-water fleets based in the RFE decreased dramatically due to the declaration of EEZs by countries in the North Pacific and elsewhere, leading to the exploitation of the previously untapped resources in the RFE, notably the Sea of Okhotsk;
4. 1991-1995, the period of serious crisis that hit all industries, caused by the dissolution of the Soviet Union in 1991, followed by major changes in the fishing industry due to the country's transition from centrally planned to a market economy;
5. Late 1995-2010, when the fishing industry gradually recovered, through a re-orientation toward export and concentrating on high-end product (pollock roe and fillet, salmon and salmon roe, crabs).

The sectors in focus are:

1. Industrial (large- and medium-scale fishing vessels) whose key issues are connected with unreported catches, unregulated catches (poaching), and discards;
2. Artisanal fisheries, including most salmon catch and sales by residents;
3. Subsistence fishing by indigenous peoples and non-indigenous people who rely on fish as the main source of food throughout the year;
4. Recreational fishing, i.e., fishing for fun;
5. Foreign catch within the Russian EEZ, both legally through access agreements or quotas and illegally.

In the following section, we highlight the methodology for reconstructing true fishery removals within the Russian Far East EEZ, beginning with establishing a baseline for domestic 'reported' landings.

METHODOLOGY

Reported baseline of catch

The Food and Agriculture Organization of the United Nations (FAO) maintains a publicly accessible database of reported fishery landings by country, species, major fishing area, and year from 1950 – 2010 (www.fao.org/fishery/statistics/en). The *Sea Around Us* refers to these landings as the 'baseline' catch, prior to any estimation of unreported catch. In the case of the Russian Far East, establishing a 'baseline' for catches within its Exclusive Economic Zone (EEZ) is complicated by the lack of specificity regarding where catches were taken in the FAO data.

The bulk of the Russian EEZ is in FAO Area 61 (although a small portion near the Bering strait falls within FAO Area 67). FAO Area 61 includes the Exclusive Economic Zones of the USA, Japan, China, South Korea, North Korea, as well as the high-seas. Russia has historically fished extensively in USA waters and Japanese waters prior to the declaration of the EEZs in 1977 and continues to fish in Japanese waters to this day with bilateral access agreements. Hence, Russian catch in FAO Area 61 include catch from Russian, Japanese, USA, and high seas waters without designation as to where they are from. Similarly, Russia's catch in FAO Area 67 includes catch in its own EEZ and the EEZ of the USA.

National Russian data do not provide greater detail because "catches are reported to regional rybvods not by area of catch, but by area of registration of the fishing company in question" (Vaisman 2001). Hence, we estimated catch by subtracting Russian catches in Japan (Swartz and Ishimura 2014) and in Alaska, USA (Doherty et al. 2014) from FAO catches in the appropriate fishing area.

FAO Fishing Area 61

Doherty *et al.* (2014) reconstructed Russian catches in Alaskan waters from 1958 – 1980 and 1984 – 1985, including the western portion of the Aleutian island chain that falls into FAO Area 61. We subtracted these catches by species and year from Russian FAO Area 61. When Russian catch of a particular species in Alaskan waters was lower than FAO data, we assumed that the remainder of FAO catch was caught in the Russian EEZ for that species and year. When Russian catch in Alaska was greater than FAO catch for a particular species and year, this indicated that the entirety of the FAO catch was caught in Alaskan waters *plus* an unreported portion of catch in Alaska. This was straightforward when the species matched exactly, e.g. Alaska pollock, red king crab (*Paralithodes camtschaticus*), etc., but more complex when dealing with broad classifications like flatfish or miscellaneous marine fishes. In those cases we made some adjustments to avoid data distortions that may amplify total catch.

For example, in 1965, there were 29,600 t more Pacific ocean perch (*Sebastes alutus*) caught by Russia in the FAO Area 61 Alaskan waters than in all FAO Area 61 catch, i.e. 29,600 t of unreported catch. Simultaneously, in both data sets, there was a catch designation of 'marine fishes not identified' which for 1965 was 95,500 t higher in FAO Area 61 data than in catch caught in Alaska FAO Area 61 waters. Rather than simply assuming 29,600 t of unreported ocean perch, we considered the possibility that some of the 95,500 t of miscellaneous marine species were in fact Pacific ocean perch, hence resulting in 0 t of unreported catch and 65,900 t more miscellaneous marine species in FAO area 61 than caught in Alaskan waters. Whether this is accurate is impossible to know but this adjustment is surely the more conservative approach. Rather than 'creating' an additional catch of 29,600 t we minimized

this possibility when appropriate, meaning it was only done when the species classification could have easily been transferrable. Sometimes the species classification was not transferrable, which was also seen in 1965 when the comparison of FAO data to Russian catch in Alaskan waters showed 395 t of unreported Tanner crabs caught in Alaskan waters over what was represented in the FAO data. There was no 'leftover' catch in categories that would be appropriate such as 'miscellaneous marine crustaceans; hence we left this designation without adjustment, resulting in 395 t of unreported tanner crab catch by Russia in Alaska's EEZ.

This methodology was done for all species and years for Alaska, and the portion designated as caught outside the Alaska's EEZ in FAO Area 61 was then compared with reconstructed Russian catch within Japanese waters as per (Swartz and Ishimura 2014). Relevant targeted species include anchovy (Engraulidae) and mackerels (Scombridae), longfin codling (*Laemonema longipes*), and Pacific saury (*Cololabis saira*) and due the specificity of the species names, the adjustments done for Alaska were not required. For the catch of 'anchovies and mackerels' in Japan, we combined the FAO catch of anchovies and chub mackerel (*Scomber japonicus*) and compared it to the data in (Swartz and Ishimura 2014).

Finally, FAO Area 61 included a circular portion of the Bering Sea designated as international waters outside the 200 nautical mile perimeter EEZ of any country, effectively named the 'Donut Hole'. After the declaration of the 1977 Exclusive Economic Zones, countries which previously freely fished the Bering Sea, began to focus their fishing efforts for the valuable Alaska pollock in the Donut Hole. Large-scale fishing only began in the mid-1980s, but by the early 1990s, the scale of catches was so extreme (1.7 million t of pollock caught in 1987 alone), the pollock stock plummeted and an international moratorium was placed on fishing pollock in the Donut Hole (Bailey 2011). Russia was also engaged in fishing in the Donut Hole and its catches were available in (Bonfil *et al.* 1998a) which included catch of Alaska pollock by country in the Donut Hole from 1983 to 1992. For the relevant years we separated the total Alaska pollock catch in FAO Area 61 between that caught in the high-seas 'Donut Hole', and the remainder assumed to be caught within the Russian EEZ.

FAO Fishing Area 67

A small portion of Russia's Exclusive Economic Zone is located in FAO Area 67, which also includes Alaska's EEZ, the latter of which was extensively fished by Russia in the 1950s – 1985 (Doherty et al. 2014). To dissect what was caught in the Russian EEZ from what was caught within Alaska's territory, we performed the same methodology as previously described for FAO Area 61.

Commercial fisheries

> "*Estimates of the scale of illegal activity vary widely, but all have one thing in common, which is their magnitude*" (Vaisman 2001).

Commercial fisheries in the Russian Far East are primarily industrial because in Russia there is no legal definition of an artisanal fishery, nor is it a prominent concept in the minds of the fishing community (FAO 2007). Nonetheless, by generalized characteristics of artisanal fishers, thousands of Far East residents would fall into this category, as they fish for a living, predominantly utilize gears that are artisanal in nature, e.g. fixed nets, kiddle (basketwork traps), channel spanning weir, etc., and they sell their catch to support themselves and their families (Dronova and Spiridonov 2008). The caveat is that since the Russian fishery does not technically recognize artisanal fishers, it so happens that most artisanal fishing is simultaneously unregulated. Nonetheless, the current depressed socioeconomic position of many fishers leaves them no choice but to poach. Hence, artisanal catch is composed of both

reported catch, i.e., salmon caught by all gears except driftnet, and unreported catch of salmon by locals, also known as poaching.

The industrial sector is by far the largest sector, employing various gears such as trawl (bottom and pelagic), drift net, bottom-net, bottom seine (snuurevaad), long line, seine, pots, traps, and poundnets, to name a few, which are used to catch major commercial species such as Alaska pollock, several salmon species, especially pink salmon (*Oncorhynchus gorbusha*), chum salmon (*Oncorhynchus keta*) and sockeye salmon (*Oncorhynchus nerka*), flatfishes (Pleuronectiformes), Pacific cod (*Gadus macrocephalus*), Pacific herring (*Clupea pallasii*) and red king crab. Poaching is also widespread, and will be discussed in greater detail in the section on industrial fisheries.

In the following sections we focus on major artisanal and industrial fisheries and present for each (i) its history and evolution from 1950 – 2010, (ii) an estimation of under-reported catch (if any) that is present in other reported data sources, and (iii) estimates of any unregulated catch (poaching). We accomplished (ii) by comparing FAO species-level data with other publications. Years where catch for a species were higher in alternate sources than in the FAO dataset highlighted that not all fisheries and regional collectives had reported data in full to the FAO, e.g. non-intentional misreporting. Then (iii), or intentional concealment of catches, was estimated using grey literature, accounts of fishers, expert assessment, and by comparing reported catch with comparable import and export data. The trend of intentional misreporting to reap profits, or poaching, exploded after the dissolution of the Soviet Union.

Artisanal fisheries

Salmon (coastal)

Pacific salmon of the genus *Oncorhychus*, including pink salmon, chum salmon, sockeye salmon, chinook salmon (*O. tchawytscha)*, coho salmon (*O. kisutsch)*, and masu salmon (*O. masou masou*) are major resources of the Russian Far East, with a mean annual catch second only to that of Alaska pollock (Радченко 2006). Their share in the catch of the main fishing grounds such as the Western Bering Sea and the Sea of Okhotsk constitutes 9.9 % and 15% respectively (Радченко 2006). Species composition of the Pacific salmon and their distribution vary depending on the geographical area. In addition to the six main types of the Pacific salmon listed above *Salmoniformes* also include Ussuri whitefish (*Coregonus ussuriensis*), Low Amur grayling (*Thymallus tugarinae*) and blunt-snouted lenok (*Brachymystax tumensis*) that are found in Sakhalin region, as well as the genus of *Salvelinus*: whitespotted char (*S. leucomaenis leucomaenis*), endemic species of Sakhalin char (*S. vasiljevae*) and South char (*S. curilus)* (Павлов and Глубоковский 2010). Although listed in the Red Book of the Russian Federation, rainbow trout (*Oncorhychus mykiss*) is relatively abundant in the northern rivers of western Kamchatka (Павлов and Глубоковский 2010). Masu salmon is generally not included in fisheries statistics as it is caught only in small amounts by amateur fishers and sometimes as by-catch in commercial fishing (Рассадников 2003).

Despite the fact that all species of Pacific salmon occur in the waters of the RFE, pink, sockeye and chum salmon are the most abundant species in the salmon fishery (Павлов and Глубоковский 2010). Masu salmon, coho and chinook salmon are less common, but are important in recreational fishing or may be caught as by-catch of commercial operations (Павлов and Глубоковский 2010). Kamchatka Krai among other administrative regions of the RFE is the main region for the reproduction of the wild Pacific salmon populations, as it provides, jointly with the Sakhalin-Kuril region, up to 90% of the total catches of the Pacific salmon in the Russian Federation (Павлов and Глубоковский 2010). This region is also

vital from a worldwide perspective, as "up to one fifth of the world stock of wild pacific salmon reproduces in Kamchatka" (Spiridonov and Nikolaeva 2004).

The social importance of fishing in Kamchatka cannot be understated either, as it provides employment and livelihood opportunities, albeit not always legal ones, to local residents. The ecological role of salmon is also vital to the ecosystem, especially for animals like the brown bear that rely on them during their fattening period. They also form an essential role in nutrient flow of organic material such as carbon, nitrogen, and phosphorous which they accumulate in their body tissues during their time at sea (Hilderbrand *et al.* 2004) . Once they return to their freshwater environments, through their eggs and also decomposing of their carcasses (either at sea or in the forest from the leftovers of a bear), they return these nutrients to the land and freshwater, allowing them to flourish.

Pacific salmon, in the RFE experienced a strong exploitation before WWII. Thus, during the period from 1932 to 1941, the mean annual catch of salmon in the waters of Kamchatka was 159,400 $t \cdot year^{-1}$, of which 69,200 $t \cdot year^{-1}$ were caught by Soviet enterprises, and 99,200 $t \cdot year^{-1}$ by Japanese ones (employing driftnets), with a similar Soviet/Japanese ratio in 1941, when the maximum catch of salmon was taken, i.e., 213,800 t (Ваняев 1956).

In the post-WWII period, exploitation of the salmon resources resumed and by the mid-1950s the exploitation was so heavy (especially of Japanese vessels) that it resulted in the "drift-net catastrophe" by the late 1950s, where the stock plummeted, taking over twenty years for the stocks to rebuild (Vakhrin 2008). However, even in the 1980s and 1990s, the state of salmon resources was characterized as unstable. The dissolution of the USSR exacerbated this situation through wide-spread poaching of Pacific salmon (Association 2006). Nonetheless, to this day, salmon fishing remains an important economic resource, especially as a source of exchange to foreign markets (Dronova and Spiridonov 2008).

Under-reported catch

We assumed that the data quality for salmon catch from the Soviet years, i.e. 1950 – 1991, was satisfactory as the planned economy heavily emphasized reporting. In the post-Soviet years however, data available through the NPAFC for 1993 - 2010 indicated that FAO data (both FAO Area 61 and 67) were only a subset of the coastal salmon data reported in the NPAFC Statistical Yearbook, averaging less than 60% of total catch, ranging from 28% to 87% depending on the year. Hence, we added the difference between NPAFC data and FAO data to our overall catch of salmon from 1993 – 2010, with the addition of a catch in 2004 of 10.98 t of masu salmon not reported in NPAFC data that was present in (Dronova and Spiridonov 2008). From 1993 to 1995, under-reported catch were approximately 20% of catch. Thus, for 1992, which was a transition year, we assumed that unreported catch was approximately 10% of FAO reported catch, varied by the unreported composition of each salmon species seen in the 1993 - 1995 data. While there were some catches of salmon in FAO Area 67 in the reported data, it was insignificant compared to the magnitude of catches caught in FAO Area 61. Therefore, we assumed all these unreported catches were taken in FAO Area 61.

Poaching

> *"Over the past 18 years, an entire generation has grown up in the illegal salmon fishery – in many places, it provides the highest local wages possible"* (The Wild Salmon Center 2009)

'Salmon poaching', in the present paper, incorporates unregulated and unreported commercial fishing in the amounts exceeding allocated quotas, either by commercial enterprises or the local population for sale or roe extraction (Dronova and Spiridonov 2008).

According to Шевляков (2013), unreported salmon catch can fall into several categories, including: commercial catch exceeding allocated quotas, organized criminal poaching, local poaching for profit, and subsistence catch by local inhabitants, and increasingly the indigenous peoples (Шевляков 2013). Subsistence catches (as well as recreational catch of salmon) will not be discussed here, rather in the section on subsistence and recreational fisheries.

In Soviet times, from the 1950s to the late-1980s, unreported salmon catch was primarily found in the subsistence sector by amateur fishers as well as by commercial vessels (Шевляков 2013). Nonetheless, the overall volume of unreported catch was relatively low compared to current levels, as finding a market for unregulated catch was more difficult to find, although still these markets existed as evidenced by the existence of the shadow economy (O'Hearn 1980).

This changed in the post-Soviet period, when state enterprises shutdown and employment plummeted, leading the local population to support themselves and their families through unregulated fishing activities (Максимов and Леман 2008). Particularly in Kamchatka, poaching in rivers significantly increased due to heightened economic incentives for illegal fishing, greater accessibility to spawning rivers and greater freedom of trade of salmon products (Dronova and Spiridonov 2008). Indeed, during salmon fishing season in Kamchatka, "virtually every Kamchatka settlement turns into a poachers' camp" (Dronova and Spiridonov 2008).

Enforcement has been poor, and corruption among those aiming to protect resources rampant. Additionally, persecution upon being caught rarely leads to punishment, as the current evidentiary process requires two eyewitnesses to confirm the unlawful fishing or sale of salmon or roe, and if not met the case is dropped (The Wild Salmon Center 2009).

Kamchatka

We estimated Kamchatka separately due to the plethora of data available on this dynamic, complex, and vital salmon fishery. First, we derived the proportion of reported salmon catch taken in Kamchatka using the following guideline: Kamchatka's average annual yield between 2000 – 2005 was about 47.3% of Far East catch, and more specifically 41.4% of the pink salmon catch, 40,1% chum, almost 100% sockeye and chinook, and 82.2% coho catch (Dronova and Spiridonov 2008). We applied these specific catch proportions by species to the entire time period from 1950 – 2010, obtaining a complete time series of Kamchatka catch by salmon species.

Next, we generated a time series outlining the progression of unregulated catch as a percentage of reported catch. Recent estimates (2002 – 2006) for the poaching of Pacific salmon in Kamchatka evaluated unregulated catch at 28 % of reported catch for pink salmon, 201 % of reported chum salmon catch, 61 % of sockeye, 376 % of coho, and 230% of chinook salmon (Максимов and Леман 2008). We assumed these rates represent the 'post-Soviet' period from 1991 to 2010.

For the earlier time period, as numerous grey literature suggests the "shadow economy" for fish was approximately 33% of reported catch (O'Hearn 1980; Sampson 1987). We assumed a more conservative estimate of 10% of reported catch for the early time period due to lack of specific data on the Far East and also that a portion of this unregulated catch would be in the form of roe, which was estimated separately.

This estimate of 10% during the Soviet period was applied to all species equally due to lack of species-specific data. From 1950 – 1953, we assumed poaching was at 0% due to the effects

of Stalin's regime, when any private activities were severely punished. Thereafter we assumed poaching increased to 5% in 1954 and to 10% of reported catch by 1955, remaining constant until 1979. From 1980 – 1988 the share of unregulated salmon catch grew at a slow pace, i.e. 1% per year (Максимов and Леман 2008). Thus, by 1988, catch from poaching reached 19% of the officially recorded salmon catch. From 1988 to 1991 we interpolated catch by species to its appropriate 'post-Soviet' rate cited earlier.

Other Far East territories

The level of poaching for all other federal subjects except Kamchatka, i.e. Sakhalin, Primorsky, Khabarovsk, Magadan, and Chukotka, were estimated as well. We first established the baseline of salmon catch for these regions by taking overall reported salmon catch and subtracting the previously estimated reported catch for Kamchatka. Then, we looked to grey literature to obtain estimates of unregulated catch as a percentage on reported catch. While species-specific data were available for Kamchatka, this level of detail was not available for all other Far East territories and hence a similar rate of poaching was applied to all salmon species and the poached catch was all allocated as species of the genus *Oncorhynchus*.

The remainder of Far East salmon catch for these regions amounted to slightly over half of total catch, and of this, approximately 85% of catch was caught in Sakhalin and 15% in the other territories (The Wild Salmon Center 2009). Furthermore, the rate of unreported catch differs for each region, varying from 42 – 67% for Sakhalin (average of 54.4%) to 60-92% (average of 76%) for all other territories (The Wild Salmon Center 2009). We took a weighted average for both Sakhalin and all other regions to obtain unregulated catch of salmon at 58% of reported catch. This 58% we assumed was representative for the 'post-Soviet' time period, while for the Soviet years we assumed the same poaching rates as calculated for Kamchatka, and then interpolated from 19% in 1988 to 58% in 1991, thereafter remaining constant until 2010.

Salmon roe

Salmon caviar, also known as 'red gold' to the Russian people is a symbol of luxury and "an almost obligatory dish at celebratory occasions for many Russians" (The Wild Salmon Center 2009). Salmon roe has historically been in high in demand in the Russian market, with a large share of the supply originating in the Russian Far East. It is well known that salmon roe is the "main source of income for residents of villages in Kamchatka" (Spiridonov and Nikolaeva 2004) as well as in Sakhalin (The Wild Salmon Center 2009). Unfortunately, the ramifications of this large-scale poaching is startling, as "roe-stripped carcasses" are strewn about rivers, bays, or sitting in piles in the forest rotting (The Wild Salmon Center 2009).

Furthermore, this multi-million dollar roe business has become increasingly criminalized and highly equipped, e.g. satellite phones, contacts within the enforcement establishment, and often overlap with the commercial fisheries although to what extent is not clear (The Wild Salmon Center 2009). Poaching brigades generally are "helicoptered to remote areas, left for several days to two weeks, and ferried out with several tons of caviar" (The Wild Salmon Center 2009). Furthermore, punishment is very small, "merely the cost of doing business for the criminal poaching sector"; an amount which can be earned by selling 45 kilos of roe (The Wild Salmon Center 2009).

Estimations of unregulated fishing generally report unregulated salmon catch separately from salmon fish discarded on site after roe stripping (Dronova and Spiridonov 2008), which we also do here. The two majors regions for roe-stripping are Kamchatka and Sakhalin, although other territories have marginal amounts as well.

Several recent estimates exist for the scale of unregulated and unreported caviar in Kamchatka and the corresponding whole weight of the salmon fish, as salmon caviar only weighs approximately 4% of the whole weight of the fish (Dronova and Spiridonov 2008). Recent estimates include 74,500 t whole weight of salmon in 2001, approximately 55,000 t annually from 2002 – 2005, 62,500 t in 2005 and 100,000 t in 2007 (Dronova and Spiridonov 2008). The geometric mean of these four estimates was taken and the resulting 71,138 t of salmon caught annually in Kamchatka was utilized for the years 1990 – 2010. The estimate for Sakhalin was at 80,000 t of salmon (Dronova and Spiridonov 2008) which we also used as a representative estimate for this period.

We assumed that unregulated catch for the time period from 1950 to 1979 was 1% of the estimated amount from 1990 – 2020. We then assumed that by 1987, the catch of salmon roe had increased to 50% of its estimated amount in 1990, then interpolated to the 1990 values previously cited. Sakhalin predominantly used pink salmon for caviar catch, and this was allocated as such, while Kamchatka used both pink salmon and chum salmon (The Wild Salmon Center 2009). For Kamchatka, to calculate the proportion allocated to each taxon, we compared the overall composition of catch (both reported and unreported as was calculated in the poaching sector for Kamchatka) and averaged the relative proportion of catch for the entire time period (1950 – 2010), obtaining 68% of pink salmon and 32% of chum salmon. This was applied to the entire time series of salmon caught as a result of roe-stripping activities.

Pseudo-indigenous communities

Unreported catch estimated from aboriginal communities in Kamchatka has increased nearly tenfold from an average of 1,000 t·year^{-1} between 1990 to 2009 to 10,000 t·year^{-1} in 2010 (Шевляков 2013). This strong increase was due mostly to the creation of 'pseudo-indigenous communities' created by organized criminal structures in order to claim salmon fishing quotas. In order to model the unregulated catch from these communities, first, we modelled the number of illegitimate indigenous communities that were present from 1950 to 2010. Data were only present for Kamchatka, so we only estimated the unregulated catch from these communities, understanding that there may be other illegitimate communities in other federal subjects and thus these catch estimates are a minimum.

In 2002 there were 10 registered communities in the Kamchatka region; in 2008, there were already 165, and in 2009 their numbers increased by 332 (Anon. 2008a, 2009). Therefore we assumed there were 10 communities from 1950 to 2002, interpolated to 165 in 2008, 332 in 2009, and for 2010 assumed the same number of communities as in 2009 due to lack of other data. It was implied that the 10 communities in 2002 were legitimate, and that the trend of illegitimate communities is very recent. Hence, we subtracted 10 from the entire time series in order to obtain the number of illegitimate communities.

Next, we estimated the catch rate per illegitimate community depending on the year. In 2008, the total tonnage of Pacific salmon quotas allocated to indigenous peoples amounted to nearly 6,400 t·year^{-1}. Since true indigenous communities caught approximately 1,000 t·year^{-1}, this resulted in 5,400 t·year^{1} of salmon quotas allocated to 155 'pseudo' communities in 2008, resulting in an average allocated quota to each illegitimate community of 41.3 t·year^{-1}. We applied this catch to the estimated number of pseudo communities from 1950 to 2008.

Unregulated 'indigenous' salmon catch in Kamchatka was cited at about 9,000 t in 2010. Since we estimated the number of communities as similar in 2009 as 2010, we extended this unreported catch in 2010 to 2009 as well. It is worth noting that there are additional quotas besides salmon for other species allocated for each administrative region where indigenous

people reside. Therefore, we added an additional 10% of catch for each year of other miscellaneous species.

Industrial fisheries

Industrial fisheries are the backbone of the Russian Far East fishery and supply a large percentage of the total Russian catch, as well as food supply for the world market. However, reported catch and export data are considered "unreliable and definitely gross underestimates of actual catch and export volumes" (Vaisman 2001) due to rampant poaching in the Far East fisheries.

Common violations include falsifying documents, as "almost all vessels had two fishing logs: an official log for the inspectors and a 'confidential' log for the owner" (Vaisman 2001). The surplus aboard commercial vessels is typically what is sold for cash, or "black bread", and several smart tactics have been developed to help make documentation of products declared on board comply with permitted catch (Vaisman 2001). One of the most impressive methods is called the Kuril Hokkutensen method, which masterfully maintains logs in a ways so that they can easily be adjusted in case of an onboard inspections, which itself happens rarely, about 3 – 4 times a year (Vaisman 2001). Another method is called "captain's trade" where illegal fish products are transferred from one ship to another to avoid detection (Vaisman 2001).

Indeed, the unrecorded cash deals, or "black break", are widespread and in fact expected from fishers to supplement their income. This is clearly seen by contracts issued to fishers by companies with catch quotas; the contracts pay for repairs, fuel, and water, but wages are not paid (Vaisman 2001). Rather, their income comes from what they sell over and above quotas obtained, which generally involves crew members involved in selling salmon roe and cooked king crab meat, either hiding cooked crab in freezer storage aboard the ship, or "if the ships lack freezing facilities have unregistered canning machines to seal crab and roe in tins" (Vaisman 2001). These products are generally funnelled through a small network of buyers from other crew members, who then sell to permanent trading partners in foreign ports (Vaisman 2001).

Up until recently, any catch harvested inside the Russian EEZ (200 miles from shore) yet outside its territorial waters (12 miles from shore) does not have to be landed with Customs so long as they are caught and sold without entering Russian waters (Vaisman 2001). This has made unregulated activities very easy and has encouraged trade with their Asian neighboring country ports, who Russians also prefer to trade with because they offer them cash on the spot (The Wild Salmon Center 2009) and because high and rising import and export duties by Russian customs cut into their profits even further (Vaisman 2001). Furthermore, since the Russian Federation is not equipped to build new and modern vessels as can be imported from abroad, the solution has been to purchase foreign vessels abroad, yet never bringing them into Russian territorial waters to avoid import duties on the ship itself or its catch (Vaisman 2001). This large fleet of foreign-bought vessels flying a Russian flag is floating between 12 miles to 200 miles from shore, selling fish to its foreign neighbors, and due to access agreement with countries like North Korea, South Korea, and Japan, are entitled to repairs abroad when their boats need it (Kravanja and Shapiro 1993) and hence can avoid "calling at Russian ports for years on end" (Spiridonov and Nikolaeva 2004).

These ventures have become increasingly criminalized in nature, ranging from forged port or cargo clearances in other countries (Spiridonov and Nikolaeva 2004) to criminal organizations literally overseeing illegal fishing on commercial vessels, at times issuing a document of 'provisional instruction' to guide captains step-by-step through dealings with law enforcement agents so as to avoid being caught (Vaisman 2001).

Alaska pollock

The Soviet fishing industry showed some interest in fishing for Alaska pollock (also known as 'walleye pollock') in the late 1940s, but it was declared inedible (Ruspelagic 2012). Russian fishers traded their catches of pollock to North Koreans in exchange for vegetables and fruits (Ruspelagic 2012). Alaska pollock was mainly seen as food for the poor; moreover many were convinced it could not be eaten because it was prone to nematode infestation (Ruspelagic 2012).

High catches from 1983-1984 (about 3.5 million t) are explained by strong class years from 1978-1981 (Улейский 2011). At the time, the catch of pollock was regulated by quotas, and in some areas, by temporary fishing bans (Улейский 2011). The bulk of the catch was processed into fish meal, as Alaska pollock at the time was considered of low nutritional value, essentially "fish for cats" (Ruspelagic 2012). Only one small part of adult pollock was processed for human consumption, 'pollock's loins', i.e., less than 40% of the whole fish (Ruspelagic 2012). However, the high demand for Alaska pollock products in Japan and Europe refocused the RFE's fleet from supplying the domestic to the export markets, and the exploitation of this fish became highly profitable and thus attractive for fishing companies in the late-1980s and early-1990s (Ruspelagic 2012).

The first product that had a very high value on Japanese market was frozen saccate roe of Alaska pollock (Ruspelagic 2012). The roe of Alaska pollock, which is a common ingredient in Japanese and Korean cuisine, can be eaten raw or salted, fermented, and seasoned. While it originated in Korea, once this dish was introduced to Japan in the first half of the 20th century it became popular and has been considered a delicacy since then. In 1990, the Soviet Union supplied over 6,000 t of Alaska pollock roe to Japan, and in 1993 and 1995, Russia supplied around 25,000 t and 40,000 t, respectively (Ruspelagic 2012). At about the same time, German and the US fish distributors experienced a severe shortage of Alaska pollock fillets and the RFE filled this demand. These events induced major changes in the fisheries and some of the fishing companies even modified their factory ships for filleting and pollock roe freezing (Ruspelagic 2012). In the early 1990s, the capacity of the fleet increased owing to foreign modern, well-equipped vessels that arrived to the RFE under chartered agreements, but by the 2009, nearly all of these vessels were returned due to the delays in payment and financial fraud (Ruspelagic 2012). In the 2000s, China became a processing hub of Russian-caught Alaska pollock, which it re-exported to European and American markets under the favourable tariff accorded to developing countries (Ruspelagic 2012). These profitable activities left little room for sustainable fishing and during the last decade of the twentieth century, the biomass of pollock strongly decreased (Улейский 2011).

<u>Under-reported catch</u>

Reported landings of Alaska pollock from various sources were compared with reported FAO data from FAO Areas 61 and 67 to gauge if there was any unreported catch. Table 1 depicts catch only for years where the catch from various sources (Мухин *et al.* 2000; Vaisman 2001; Булатов 2003; Бочаров 2010) exceeds FAO catch of Alaska pollock. Since data from (Бочаров 2010) from 2000 – 2010 were presented in graph form, we buffered against over-reporting catch by subtracting approximately 50,000 t of catch from final estimates of unreported catch.

Table 1. Compilation of years when various reported catch data of Alaska pollock in the Russian Far East (FAO Area 61 and 67) was higher than FAO data, 1950 – 2010.

	Reported catch by region (t)						Unreported catch (t)	
Year	Sea of Okhotsk (Булатов 2003)	West Bering Sea (Мухин et al. 2000)	(Vaisman 2001)	Russian Far East (Бочаров 2010)	Total	FAO data	Original	Adjusted[1]
1992	1,686,000		702,710		**2,388,710**	**2,340,700**	48,010	48,010
1996	2,030,000	753,000			**2,783,000**	**2,439,980**	343,020	343,020
1997	1,791,000	735,000			**2,526,000**	**2,252,742**	273,258	273,258
1998	1,351,000	720,000			**2,071,000**	**1,930,650**	140,350	140,350
1999	1,044,000	693,000			**1,737,000**	**1,500,450**	236,550	236,550
2000				1,400,000	**1,400,000**	**1,215,065**	184,935	134,935
2001				1,480,000	**1,480,000**	**1,145,016**	334,984	284,984
2002				900,000	**900,000**	**826,707**	73,293	23,293
2003				1,300,000	**1,300,000**	**1,055,886**	244,114	194,114
2004				900,000	**900,000**	**849,646**	50,354	354

[1] *From 2000 - 2010, source data were approximate, hence a buffer of approximately 50,000 was added to be conservative.*

Poaching

Alaska pollock, which accounts for approximately 60% of reported catch from the RFE since the mid-1970s, is one of the most valuable species of the North Pacific and is "plagued by illegal activity" (Vaisman 2001). There is ample evidence in the recent time period that the true catch of Alaska pollock is substantially higher than reported. According to the staff of the Kamchatka Regional Directorate for Protection and reproductions of Fish Stocks and Regulation of Fishery (Kamchatrybvod) staff, the actual volume of harvested stock is 50% higher than the quota, which is generally equivalent to the reported amounts (Vaisman 2001). Furthermore, individuals or companies involved in poaching engage in money laundering by elevating prices of goods declared to Customs in order to conceal any profits from illegal catch. In the case of Alaska pollock prices declared to Customs were on average 1.5 times higher than market price (Vaisman 2001), which interestingly matches the estimates from interviewees as to the share of illegal catch.

While this unregulated catch includes catch in excess of quotas, it is unclear whether this estimate includes catch that was processed onboard whose whole weight was not recorded, rather only the smaller weight of products like Alaska pollock fillets, paste, and roe. In addition, with the recent popularity of Alaska pollock roe and fillets, the fishery has seen increased discarding at sea of parts of the fish not needed for the final product, e.g. roe-stripping (Vaisman 2001), although this will be covered more in the section on discards. Due to lack of information on what is included in these estimates of 50% unreported catch in the post-Soviet time period, we conservatively assumed that our estimate included the whole weight from processed fish such as filets, paste, and roe.

We assumed unreported catch was 0% from 1950 – 1959 when Alaska pollock was not in high demand in Russia. Thereafter, we assumed the unreported portion was at 1% from 1960 – 1969 as interest began. For the 1970s, we assume that the unreported portion rose once more to 5% until 1979, at which point we interpolated catch to 50% in 1991 to mark the increase in unregulated activities in the 1980s up until the dissolution of the Soviet Union in 1991. Unregulated catch remained constant at 50% until 2010.

King 'crabs' and crabs

> *"We didn't till, didn't sow, but caught crabs – so there's money in our pockets" common saying by Kamchatka fisher[s]* (Vaisman 2001)

This section deal with both king 'crabs', which are crab-like, and with true crab (Brachyura), and both groups will be referred to as crabs, for simplicity's sake. Despite the fact that the RFE's seas are inhabited by 43 species of demersal and offshore crabs, just a few of them have commercial value and have been exploited since the beginning of the twentieth century (Алякринский 2003). The rest are either understudied or considered as promising commercial species for the future. Major commercial crab species include red king crab, blue king crab *(Paralithodes platypus),* golden king crab *(Lithodes aequispinus),* opilio snow crab *(Chionoecetes opilio),* tanner crab *(Chionoecetes bairdi),* Korean horsehair crab *(Erimacrus isenbeckii),* and triangle tanner crab *(Chionoecetes japonicus).*

Red king crab is distributed along the mainland coast of RFE from the northeast of Korean Peninsula in the south to the island of Karaginsky (off the east coast of Kamchatka), as well as on the Pacific coast and the Okhotsk Sea coast of Hokkaido island, around western and eastern Sakhalin and the Northern and Southern Kuril Islands (Ассоциация добытчиков краба 2013). The main fishing grounds of red king crab are Primorye subarea (to the north and south of the Golden Cape), Western Kamchatka subarea, the Kamchatka-Kurile subarea and Northern Okhotsk subarea. The largest concentrations of the red king crab are near the western coast of Kamchatka, where the major fishing operations occur (Ассоциация добытчиков краба 2013).

Blue king crab is found in the Japan Sea, Okhotsk and Bering Seas. The main fishing grounds of blue king crab are Western Kamchatka subarea, Western Bering Sea subarea, Primorye subarea, Northern Okhotsk subarea, Eastern Sakhalin subarea, and the Karaginskaya subarea (Ассоциация добытчиков краба 2013).

Golden king crab occurs in the Sea of Okhotsk and the Bering Sea, along the Kuril Islands, but is not found in the Sea of Japan (Ассоциация добытчиков краба 2013). The main fishing grounds of golden king crab are Northern Okhotsk subarea, Northern Kurile subarea, Western Kamchatka subarea (Ассоциация добытчиков краба 2013). Some brown king crab catches also exist in the FAO data, yet since this common name is not listed in SeaLifeBase (www.sealifebase.org), which is our reference point for crab species, we assumed that reference to brown king crab was actually a misidentification as golden king crab (*Lithodes aequispinus*).

Opilio snow crab is found in the Sea of Okhotsk, Bering Sea, in the southern part of the Chukchi Sea to the Sea of Japan and the Korean Strait (Ассоциация добытчиков краба 2013); it occurs on the shelf and continental slope of the northern and northeastern parts of the Sea of Okhotsk, where it is an important target species for commercial fishing. Major fishing grounds include North Okhotsk subarea, Primorye subarea, Western Bering Sea subarea and East Sakhalin subarea.

Tanner crab is found in the northwestern Pacific (Ассоциация добытчиков краба 2013). It is especially abundant in Olutorskiy Gulf, off the coast of eastern and southwestern Kamchatka, but not in northern and western part of the Okhotsk Sea. The main fishing grounds include the Kamchatka-Kurile subarea, the Western Bering Sea subarea and the Karaginskaya subarea (Ассоциация добытчиков краба 2013).

Fishing in the Russian EEZ fishing for the Korean horsehair crab is conducted off the coast of Primorye in the Tatar Strait, along southwestern cost of Sakhalin, in the Northern and Southern Kuriles, as well as in western Kamchatka (Ассоциация добытчиков краба 2013). This is highly valued on the Japanese market. The Japanese traditionally eat not only meat but also its 'liver' and gonad. It is mainly fished in Primorye subarea and Kamchatka-Kurile subarea (Ассоциация добытчиков краба 2013).

Triangle tanner crab is only found in the Japan Sea off the coasts of Primorye, Japan and the Korean peninsula, as well as in the central part of the sea on the banks of the Yamato and Quito-Yamato (Ассоциация добытчиков краба 2013). In the Russian EEZ it is fished in Primorye subarea and Western Sakhalin subarea.

The crab fisheries are among the most problem-ridden fisheries in the RFE, as these crabs have been subjected to poaching for a long time. Imperfect management practices and corruption (including during monitoring of crab fishing activities) are major reason for overfishing. Three species constitute the bulk of crab catches: red king crab accounted for 39 % of the total catch in 2000, opilio snow crab (32.2 %) and blue king crab (9.3%) (ФАС России 2010). The main fishing grounds are concentrated in Primorsky Krai, Kamchatka and Magadan regions. Red king crab constituted the major part of the catch from the 1960s until the late 1990s (Дупляков 2012).

Crab fishing in the coastal waters of Primorye has been in place for more than a hundred years. Intensive crab fishing began in 1908; by the 1930s, the total catches in Primorye varied between 750 and 4,500 t·year^{-1} (Кобликов and Мирошников 2002). In 1934-1937, in the southern areas of the region the first signs of the crab populations' decline appeared. Thus, the first temporary ban for crab fishing was imposed in 1938 and lasted until 1941 (Кобликов and Мирошников 2002; Кобликов *et al.* 2002). In 1942, the total catches of crabs in Primorye reached 1,700 t, and in 1943, it reached 11,500 t (Кобликов and Мирошников 2002). Due to the intensive exploitation of crab resources, the catches dropped in 1949 to 700 t (Кобликов and Мирошников 2002). The second ban was imposed on crabs fishing in 1955 which lasted until 1987 (Кобликов and Мирошников 2002). In 1988, exploitation resumed until minimum catches were reached in 2000 (Кобликов and Мирошников 2002). Excessive commercial fishing for crabs led to the third ban, from 2002 to the present (August 2014). The ban was justified by the widespread illegal fishing that nearly caused the total destruction of the crab populations (Шагинян 2012). While crab fishing was banned in some areas, it was permitted in others.

Exploitation of the red king crab in western Kamchatka area began in 1924 (Долженков et al. 2000). The periods of depression followed severe exploitation of crab with the average catches reaching 55,000-73,000 t·year^{-1} up to the 1970s (Долженков et al. 2000). A minimal catch - approximately 16,000 t occurred in 1978 (Долженков et al. 2000). Annual catches during 1979-1991 varied between 18,000 and 31,000 t·year^{-1} (Долженков et al. 2000).

Red king crab and blue king crab are exploited in the North Okhotsk subarea in smaller quantities comparing to Kamchatka region. These resources are also overfished. The catches of the red king crab during 2004-2009 increased from 438 t to 1626 t respectively (ЕСИМО 2012). Exploitation of the golden king crab resources began in the 1990s, and just in 5-6 years there were already signs of overexploitation. As a result, in some areas fishing for golden king crab was banned in 2000 (ЕСИМО 2012).

Demersal triangle tanner crab's *(Chionoecetes angulatus)* resources are currently understudied, thus its catches are limited (ЕСИМО 2012). Larger catches of the triangle tanner crab are also constrained by the need for special equipment allowing fishers to operate at greater depths.

Under-reported catch

Based on data from (Долженков *et al.* 2000) on red king crab catch, we were able to compare these catches to the FAO reported data of red king crab. Fishing areas within the Russian EEZ were primarily off Kamchatka in FAO Area 61 (Miles *et al.* 1982). Other commercial fishing areas were present off the coast of Alaska but we considered these within

the Alaskan EEZ (in FAO Area 67). We nonetheless included FAO Area 67 catches of crab in our comparison which may have been in Area 67 off the coast of Chukotka.

As was previously stated, up to the 1970s the average catch of red king crab reached 55,000-73,000 t·year^{-1} (Долженков *et al.* 2000) while the FAO data for the same time period amounted to 36,739 t·year^{-1}. We utilized the minimum estimate from this range (55,000 t·year^{-1}) revealing an underreporting of 50%. Hence, we multiplied this rate of 50% misreporting to all FAO red king crab landings from 1950 – 1969. In 1978, Долженков *et al.* (2000) states that catch of red king crab catch was at a minimum of 16,000 t, which was consistent with the FAO catch of 17,632 t. Hence for 1978, we assumed an underreporting of 0% and interpolated between 50% in 1969 to this 0% in 1978. The catches from 1979 to 1991 by (Долженков *et al.* 2000) were also within the appropriate range of FAO data, indicating that unreported catch according to this source was minimal after the 1970s.

Poaching

There are no references regarding poaching of red king crabs earlier than 1984, when a newspaper article was published which documented large-scale crab poaching by a Japanese sub-contractor and its local allies off the Kamchatka coast (Маренин 2007). This article, which sparked immediate public reaction, can be regarded as the beginning of the period of wide-scale unregulated crab catches. Since no indications have been found on poaching during 1950-1983, only 1% of the reported catches are considered unregulated for this early period. In fact, during Soviet times, the majority of the population did not even know how to prepare crab dishes, implying there was not a large market. Thus, the 1 % figure seems to be adequate.

In the late 1990s, in the western Kamchatka region, the actual catches of the red king crab, including illegal catches, sometimes exceeded official statistics 2-3 times (Долженков *et al.* 2000). In 1995, there were a number of indirect signs in western Kamchatka suggesting a deterioration of the resource of red king crab (Долженков *et al.* 2000). Scientists warned the industry and strongly advised them to take the situation under control. Updated versions of these studies suggest that illegal catches of red king crab in western Kamchatka outstripped official catches 2 times in the second half of the 1990s, and 3-7 times in the beginning of the 2000s (Долженков and Кобликов 2006)

Specific data by Glotov and Blinov (2005) support these assertions by comparing the imported data of king crab species into Japan and the US with the official TAC levels of king crabs. We substituted TAC levels with FAO reported catch and for years with available data obtained a ratio of Japanese and USA imports of Russian red king crab (Table 2). Any ratio greater than 1 indicated that official import data was higher than FAO data, clear evidence of poaching. This ratio is itself a minimum, as other markets for red king crab include domestic consumption in Russian market and exports of king crab to South Korea and other countries. In total, Glotov and Blinov (2005) estimated that the additional catch from these markets was in the order of 10%. Hence, we multiplied the calculated ratio for Russian and Japan data by 10% to obtain a more complete estimate of unreported catch, as can be seen in Table 2.

Table 2. Unregulated Russian catch of red king crab in the Far East for select years as a ratio to reported catch from Glotov and Blinov (2005).

	Reported catch (FAO)	Japan & USA imports : reported catch	Adjustment
Years	*FAO*	*Glotov and Blinov (2005)*	*Glotov and Blinov (2005)*
1994	38,068	1.05	1.16
1996	47,932	1.51	1.66
1999	45,529	1.67	1.83
2002	17,839	2.52	2.77
2003	12,041	4.15	4.57
2004	5,629	8.88	9.77
2005	7,969	6.02	6.63

These estimates served as anchor points for poaching from 1994 – 2005, with an interpolation done for any missing years. To reiterate, we applied a rate of poaching at 1% of reported catch from 1950 – 1983, interpolated to the 1994 rate of 16%, followed the data from (Glotov and Blinov 2005) from 1994 – 2005, and for 2006 – 2010 used the average rate of poaching from 2004 and 2005, or 720%.

Opilio snow crab has traditionally been the main target species of the Magadan region, generally caught in the Sea of Okhotsk (ЕСИМО 2012). The state of opilio crab stocks is relatively adequate in the North Okhotsk subarea (ЕСИМО 2012). However, during the period of 2006-2011, there has been evidence of increased poaching activities; according to some sources, opilio snow crab poaching exceeds TAC by more than 100% (ЕСИМО 2012). Currently, its stocks are estimated to be adequate due to the measures undertaken in order to regulate fishing activities (ЕСИМО 2012). Nevertheless, the pressure of the commercial fishing on the opilio snow crab resources remains considerable. Thus, we assumed that unreported catch of opilio and other tanner crabs was 0% from 1950 – 2005, increased to 50% in 2006, and to 100% from 2007 – 2010. For all other crabs catches, which were very minimal, we assumed no unreported catch due to lack of data.

Salmon (driftnet)

Driftnets are normally set along the salmon migration routes from the ocean to the river spawning grounds (WWF-Russia 2009). While traditionally, salmon driftnetting has been actively pursued by Japanese within the Russian waters, Russia has had several brief stretches of experimentation with this fishery, beginning in the mid-1960s until the late 1970s, where 1-12 boats obtained a seasonal catch of less than 160 t (Spiridonov and Nikolaeva 2004). After the dissolution of the Soviet Union in 1993, driftnetting resumed (Dronova and Spiridonov 2008) as an experimental fishery for research, soon after obtaining catches over 1,000 t (Spiridonov and Nikolaeva 2004). While originally the fishery was 100% financed for research, over time, the research integrity of these operations has been questioned as many consider the levels of extraction closer to large-scale driftnet fisheries and there is evidence of corruption (Spiridonov and Nikolaeva 2004; Dronova and Spiridonov 2008; Дронова and Спиридонова 2008; The Wild Salmon Center 2009). Furthermore, current driftnet operations violate the Russian Law on “Environmental expertise”, as TAC is set without environmental impact assessment (WWF 2011).

In order to remain economically profitable, salmon operations target mostly chum and sockeye salmon, which leads to significant high grading and discards, as driftnets are highly non-selective. Furthermore, the gear incurs high rates of injury on the target catch, which results in dumping damaged salmon species, and significant loss of catch from net tears. Please refer to the discards section for more information on this aspect of the fishery.

Poaching from driftnetting operations is also rampant, as these operations are the major route for illegal exports of sockeye and coho salmon to Japan, whose import data on sockeye and coho salmon from Russia in the late 1990s and early 2000s are higher than Russian reported catch (Dronova and Spiridonov 2008; The Wild Salmon Center 2009). This does not include the imports for China, South Korea, or the domestic market, hence giving concrete and alarming evidence to the scale of wide-spread poaching. The export to foreign markets, especially Japan, was facilitated by several means, one of which is that up until 2002, Russian driftnet vessels provided false port clearance documents due to Japanese law against buying fish directly from foreign vessels from fishing grounds (The Wild Salmon Center 2009).

Under-reported catch

While FAO data are supposed to include driftnet catches from the Russian "experimental" fishery, upon closer investigation it is clear that these catches were not included in FAO data. This became clear from comparing more detailed data on coho and sockeye catch, which distinguished between what was caught by coastal fishers and driftnets operations (Dronova and Spiridonov 2008). These more comprehensive catches of the coastal fishery match NPAFC catches (http://www.npafc.org) nearly perfectly – at most off by a few hundred t. It was clear from comparison that NPAFC catch only included the coastal fishery. Even though the FAO data were only a subset of NPAFC data, we nonetheless compared FAO catch with driftnet catch in order to be certain that driftnet catch was not reported in FAO data. Indeed, FAO data did not align or correlate with the magnitude or direction of driftnet catches, which reiterated once more that driftnet catches were not reported.

Hence we assumed catches increased from 0 t in 1954 to 150 t in 1967, remained at 150 t until 1977, and then subsided to 0 t of catch by 1980. Starting in the 1993, domestic driftnet operations resumed (Dronova and Spiridonov 2008), utilizing about 1-3 boats for research purposes and catching over 1000 t of salmon. We estimated a catch of 500 t in 1993 increasing to 1000 t in 1994 and remaining at this level until 1995. These catches were still considered minimal, and only in late 1999 did catches formidably started to increase (Spiridonov and Nikolaeva 2004). From 1998 to 2006, catches were available by specie (sockeye and coho salmon) and year for the Russian driftnetting fleet in (Dronova and Spiridonov 2008). The catch from 1995 of 1000t was interpolated to the 1998 value of 2,972 t. In addition, in (Spiridonov and Nikolaeva 2004) there was an additional level of data not available in any other source of catches by the driftnet vessels in the Russian EEZ of the Bering Sea from 1999 – 2003. As the driftnet fishery was only commencing in 1999, we did not assume any catches from the West Bering Sea prior to this. However after 2003, there is substantial reason to believe this fleet continues to operate and catch salmon; hence for 2004 – 2008 we assumed that catch from this fleet was the average of 2002 and 2003 data at 5,270 t. Catches from the North Pacific fleet (in the Russian EEZ) were also not available after 2006 so we assumed for 2006 and 2007 that catch was the average of catch from 2005 and 2006. In 2009, there were no Russian fishing vessels engaged in driftnetting (WWF-Russia 2009), however in 2010, the Russian driftnet fishery returned as a commercial fishery sharing the quota of 22,5oo t with Japan, resulting in approximately 10,225 t of salmon catch (WWF 2011).

Poaching

For the recent time period, official export data place misreported sockeye at 20% of reported catch and chum at 2%, implicating driftnet salmon fishing in this discrepancy (Dronova and Spiridonov 2008). However, the estimation from official export data is also an underestimate, as not all export data flow through official means nor does this comparison include salmon that goes to the domestic market. Indeed, according to questionnaire data on the driftnet fishery, fishers overfished their quota 1.5 - 2.5 times in 2005 (WWF 2011). We utilized the minimum of the latter estimate, that the rate of poaching was 50% of reported catch for sockeye salmon, less for chum catch.

Hence, we assumed that starting in 1999 to 2010, the proportion of reported catch that was poached and unreported was 50%. We assumed 0% misreporting from 1950 – 1990 when the research aims of the fishery were still considered reputable, thereafter increasing to 50% unreported in 1999 for sockeye, and 10% for chum. Export data indicated 2005 as a peak year for unreported catch with 9.7 excess tonnes of sockeye (Dronova and Spiridonov 2008). We included this one data point due to its magnitude.

Pacific herring

Pacific herring is one of the most important commercial species of the Russian Far East, targeted in industrial operations since the early 1900s (Науменко 2007). The first production peak of herring occurred from 1921–1936 when the Sakhalin-Hokkaido herring population contributed over 90 % of the total catch and annual yields reached 310,000 t (Науменко 2007). The time period after this from 1937–1955 period saw much lower catches, of 143,000 t·year^{-1} before another peak from 1956-1975 where maximum yield ranged from 377,000 to 472,000 t·year^{-1} (Association 2006; Науменко 2007). The third peak of herring production occurred in the period from 1996 to 2004 when the catch was about 290,000 t·year^{-1} (Науменко 2007).

Under-reported catch

We compared FAO catch data to data from other sources to see if there was any under-reported catch of Pacific herring. The outcome can be seen in Table 3, which depicts years when regional catch data were greater than reported FAO data. Data mostly came from (Науменко 2007) whose data include herring catch in Peter the Great Bay, Dekastrinskaya, Sakhalin-Hokkaido, Sea of Okhotsk, and Gizhiginsko-Kamchatskaya and Corfo-Karaginskaya populations. We only compared this catch to FAO data for Major Fishing Area 61 because the distribution of the commercial fishing areas was entirely within FAO Area 61 (Miles et al. 1982). For these time periods we multiplied the percentage difference between the two data sources by FAO reported catch for each year to obtain the under-reported portion of catch.

Table 3. Years when reported catch of Pacific herring by various sources exceeds FAO reported catch (t); Unreported catch as a percentage of FAO landings for the Russian Far East, 1950 – 2010.

Year(s)	Catch (t)	Source	FAO landings (t)	Unreported catch as a percentage of FAO data (%)
1956 – 1975	6,633,500	(Науменко 2007)	6,047,900	10%
1996 – 2004	2,617,200	(Науменко 2007)	2,468,308	6%
2010	232,370	(ТИНРО-центр 2011)	222,041	5%

Poaching

For all other species except Alaska pollock, salmon, and crab (for which there are very specific data available), we assumed unreported catch was 0% during Stalin's era (1950 – 1953), increased to 10% in 1955 and remained at this level up to the late 1970s, thereafter increasing to 30% in 1991 and remaining constant at 30% until 2010.

Pacific cod

Another important fishery of the Russian Far East is that of Pacific cod. In 2010, the total catch of Pacific cod in the RFE waters amounted 80,540 tonnes, i.e., 75,525 tonnes were caught by Russia and 5,015 t by Japan (ТИНРО-Центр 2010). However, the share of Pacific cod caught in Karaginsky and Olyutorsky Gulfs, as well as along the Pacific coast of Kamchatka and Northern Kuril Islands, constitutes just part of the total.

The exploitation of Pacific cod began in the early 1930s, when Soviet enterprises launched relatively successful fisheries using a combination of pole-and-line and long-line fishing (Золотов 2009). Large concentrations of Pacific cod in the northwestern part of the Bering Sea, near Cape Navarin, were discovered in 1950-1952 (Вершинин 1982). By the mid-1950s,

pole-and-line and long-line fishing methods were completely superseded by trawl and Danish seine (*snurrevaad*) fishing, yet the introduction of Danish seine in 1954-1955 did not bring about a sharp increase in catches (Золотов 2009).

Since 1968, one of the major fishing grounds for the Pacific cod trawl fishing was the Anadyr-Navarin region of the Bering Sea, but catches fluctuated strongly, and declined in the late 1970s, when Pacific cod became so scarce that it ceased to be targeted, and was caught only as by-catch in the Alaska pollock fishery (Вершинин 1982) . Then, a dramatic increase in cod catches occurred in the 1980s and 1990s due to exceptionally good recruitment in the late 1970s (Золотов 2009). From 1991-1995 Pacific cod catch shrank by half compared with the late 1980s and continued to decline until the mid-2000s (Золотов 2009).

Under-reported catch

The stock and commercial fishing areas of Pacific cod lie within FAO Area 61 and 67, hence we compared FAO data from both areas (excluding any catches within the USA territorial waters) with data from Золотов (2010), who reports on average catch in Eastern Kamchatka, Northern Kuril Islands and the Western Bering Sea. Table 4 depicts the time periods when catch from the regional data source was higher than FAO reported catch. For these time periods we multiplied the percentage difference between the two data sources by FAO reported catch for each year to obtain the under-reported portion of catch.

Table 4. Time periods when data by Золотов (2010) for Pacific cod catch (t) in the Russian Far East were higher than FAO reported data; adjustment applied (unreported as a percentage of FAO reported data).[1]

	Average catch (t)		Unreported catch (as % of FAO landings)
Period	*FAO*	*Золотов (2010)*	
1966-1970	27,800	31,976	15%
1971-1975	41,551	44,412	7%

[1] includes catches only from Eastern Kamchatka, Northern Kuril Islands and the Western Bering Sea

Poaching

We made the same assumptions as for Pacific herring.

Flatfishes

Flatfish are important in demersal resources for the Russian Far East fisheries. While there are a wide diversity of flatfish taxa, those abundant in fisheries catches are, in no particular order, flathead sole (*Hippoglossoides elassodon*), Bering flounder (*Hippoglossoides robustus*), northern rock sole (*Lepidopsetta polyxystra*), yellowfin sole (*Limanda aspera*), Sakhalin sole (*Limanda sakhalinensis*), longhead dab (*Myzopsetta proboscidea*), starry flounder (*Platichthys stellatus*) and Alaska plaice (*Pleuronectes quadrituberculatus*). Starry flounder and Alaska plaice are mainly found in Karaginsky and Olyutorsky Gulfs (Золотов 2010). Yellowfin sole and blackfin flounder (*Glyptocephalus stelleri*) were the most abundant species in the catches (up to 50-60%) during the period 1968–1998 in Peter the Great Bay (Иванкова 2000, p. 188).

Until the mid-1940s, flatfishes were mostly caught by coastal fisheries, or as by-catch of the salmon or herring fisheries (Золотов 2010). By the mid -1950s, with the introduction of the bottom trawls and Danish seines, the catches of flatfishes increased, peaked around Kamchatka 1955-1960, and decreased thereafter, mainly as a result over-exploitation (Золотов 2010).

Decreasing catches encouraged measures to regulate the demersal fisheries targeting flatfish, and by the mid-1980s the most of the populations showed signs of recovery (Золотов 2010). Currently, the general state of the stocks can be characterized as relatively stable, with some stocks strongly dependant on environmental fluctuation, notably yellowfin sole, whose contribution to total flatfish catches varies between 37 to 91% depending in the year, averaging 64% (Золотов 2010). It appears that flatfish population dynamics are strongly associated with regime shift changes in the northern Pacific. In the 2000s, the contribution of flatfishes in the catch from Karaginsky and Olutorskiy Gulfs was 7% of the total catch, while the contributions of Alaska plaice to the flatfish catch was about 15%, Sakhalin sole 4% and starry flounder 2% (Золотов 2010).

Under-reported catch

All data comparisons show FAO reported flatfish catch to be in line with other regional reported data, some sources include (Золотов and Захаров 2008) and (Шунтов 1985).

Poaching

We made the same assumptions as for Pacific herring.

Subsistence and recreational fisheries

Subsistence and recreational fisheries are small-scale sectors with effort exerted by non-professional fishers who fish for consumption or fun. Total catch is unreported and was reconstructed by modelling the number of anglers and their catch rate. Thus, in the following section we first estimated the population of the relevant Russian Far East regions and then use this information to assess the number of anglers.

Population

For the present paper, population data for the Russian Far East were only modelled for the six coastal federal subjects, as opposed to the ten federal subjects belonging to the RFE Federal District, four of which lie in the interior and have no access to the Sea of Okhotsk or the Bering Sea. The relevant coastal federal subjects are the Chukotka Autonomous Okrug, Kamchatka Oblast, Khabarovsk Krai, Magadan Oblast, Primorsky Krai, and Sakhalin Oblast.

Resident

Resident population data for the above mentioned subjects of the Russian Federation were obtained from the Soviet and Russian Federation censuses. The population of each federal subject was modelled separately using a compilation of 'anchor points' for years with population data. Between any years with missing population data, a series of interpolations were performed.

In 1989, the population of the relevant federal subject was made available by (Демоскоп Weekly 1989) and for the years 1991 (Magadan Oblast only), 2002, 2008 (Magadan Oblast only), and 2010, from the Russian Federal State Statistics Service (www.gks.ru). For the years prior to 1989, we obtained the population trend for the Russian Far East District as a whole, with census data present for the years 1939, 1959, 1970, and 1979 (Minakir and Freeze 1994). This trend was applied to scale back the 1989 data for each federal subject. The final population estimates can be seen in Figure 2a or for a complete tabular time series please refer to Appendix 1.

Urban and rural populations

The distinction between urban and rural populations was also modelled separately for each federal subject. As was done for the overall population, we compiled anchor points for years where data were available and interpolated between years with data. The final result was a comprehensive time series of urban and rural population for the six coastal federal subjects of the Russian Far East.

The earliest available data on the proportion of urban versus rural population were available for census years, i.e., 1939, 1959, 1970, 1979, and 1989 for the Russian Far East District as a whole (Minakir and Freeze 1994). Since the aim is to reconstruct the proportion of urban and rural separately for each federal subject, we first obtained such specific estimates for years where data were available, and then utilized the data from (Minakir and Freeze 1994) only as a trend for the unique composition of each subject.

Such specific data on the six relevant subjects were available for 2000 (Newell 2004) as well as for 2010 through the Russian Federal State Statistics Service (www.gks.ru). Additionally, there were data available on the change in urban population from 1989 and 1999 in major regional centers of the relevant subjects (Bradshaw 2013). With the dissolution of the Soviet Union, both rural and urban populations of the Russian Far East declined proportionally to their population share. On the federal subject scale, however, rural population in the Magadan Oblast declined more dramatically than urban population (Bradshaw 2013) and to this day “entire villages are disappearing as the countryside empties” (Scott Polar Research Institute 2014).

Hence, we utilized the data from 2000 and 2010 and estimated an additional data point for 1989 by assuming the change in population of the major regional centers from 1989 – 1999 was representative of the change in urban population from 1989 - 2000. With the 1989 unique composition for each federal subject, we then applied the trend implied in (Minakir and Freeze 1994) back to 1950. Through a series of interpolations for years where data were missing, we developed a comprehensive time series of urban and rural population for the six coastal federal subjects of the Russian Far East (Appendix 2 and 3), as well as the cumulative representation of urban and rural population in all six subjects (Figure 2b).

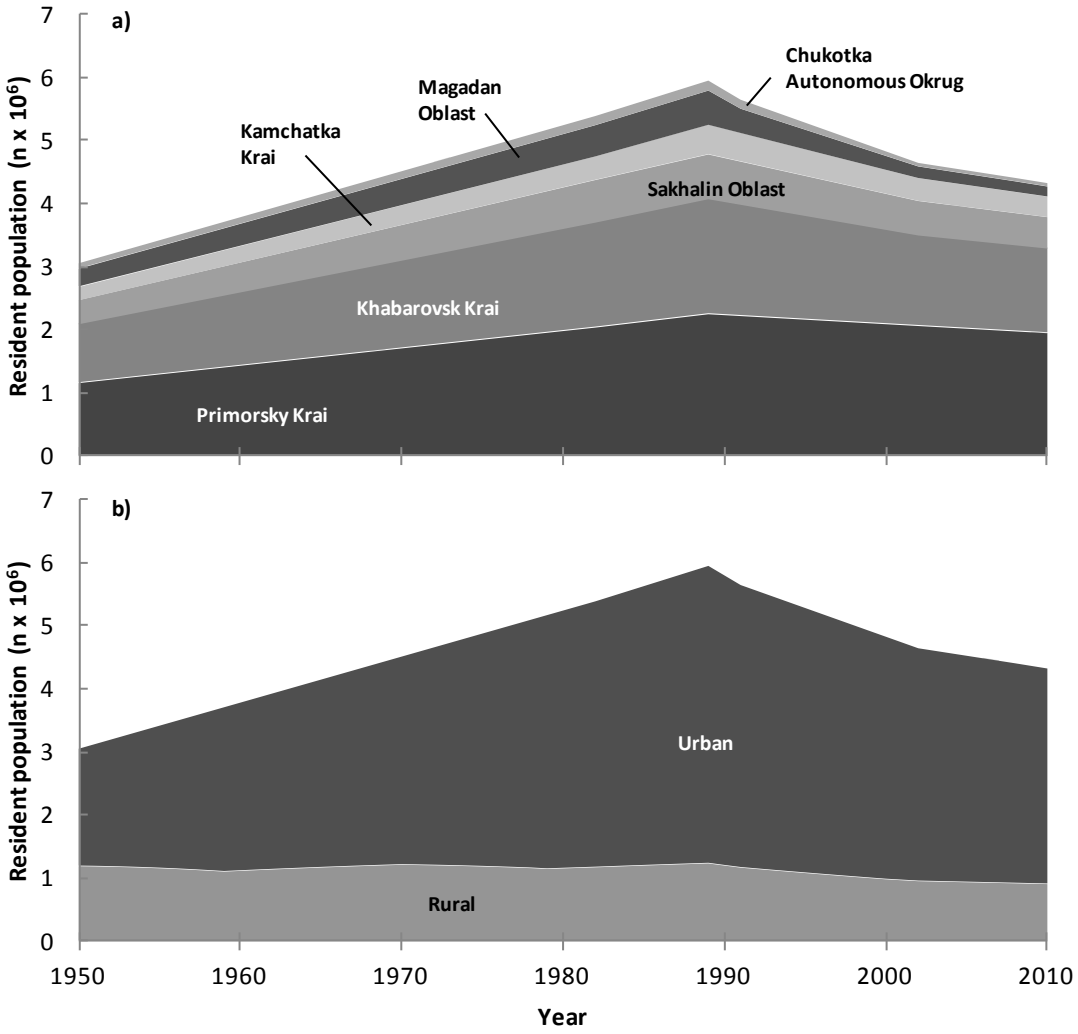

Figure 2. Estimated total population of the Russian Far East for a) six coastal federal subjects; and b) urban and rural population in all six coastal federal subjects.

Tourist

We estimated a time series of the (minimum) amount of foreign tourists who visit the Russian Far East in order to later estimate annual recreational fisheries catch by these tourists. The tourist industry of the Russian Far East has immense potential due to its rich resources, however due to certain factors, e.g., lack of infrastructure, it is presently under-developed. Nonetheless, tourism is present, especially for nature-lovers and those who enjoy hunting and fishing. Likewise, due to the proximity of Primorsky Krai and Khabarovsk Krai to heavily-populated countries like China, Japan, and South Korea, tourism in these two federal subjects is more developed than in others. In 2004, Primorsky Krai had 195,000 foreign tourists while the Khabarovsk Krai had 25,124, which would grow to 29,420 in 2005 (Anon. 2007).

Foreign travel was tightly restricted during the former-USSR, and hence we assumed the volume of tourists was zero in the Russian Far East from 1950 to 1991. We then interpolated to the tourist data available in 2004 for both Primorsky Krai and Khabarovsk Krai.

Thereafter, we assumed the number of tourists remained constant at 195,000 for Primorsky Krai and at 29,420 for the Khabarovsk Krai from 2005 to 2010.

Sakhalin Oblast is also a southern federal subject in close proximity to Japan, yet due to long-standing territorial disputes, most of the island is restricted to foreign tourists. Travelling to its capital city, Yuzhno-Sakhalinsk, has less restrictions, but since data were not present we conservatively assumed zero tourists in Sakhalin Oblast, especially as those visiting this larger city are not in rural environments where they can freely engage in recreational fishing.

For the northern federal subjects which are colder and even more remote, data on tourism only existed for Kamchatka. Some occasional tourists may visit Magadan and the Chukotka Autonomous Okrug, but as no data were available we assumed no foreign tourists for the entire time period. After 1991, the Kamchatka peninsula became 'open' for foreign tourists and began to attract amateur fishers from around the world. At the same time, the number of companies that provide services to fishing tourists grew steadily. In 2008, approximately 1,700 websites featured advertisements for recreational fishing in Kamchatka, 1,000 of them in Russian and 700 in English (Шатило and Леман 2008). While there is 'catch-release' scheme of fishing activities in place, it is unclear how well this is adhered to in terms of salmon fishing. Moreover, companies that provide services on fishing tourism often times act unlawfully, i.e. they do not obtain licenses that could authorise their activities (Шатило and Леман 2008).

Data were available on fishing tourism expressed as the number of fishers per day in Kamchatka from 1995 to 2007 (Шатило and Леман 2008). We converted these figures to the number of fishers present per year, and then assumed an average trip was 10 days for these tourists, so that we could obtain an estimated time series of the number of tourists who visited annually. Between 1991 to the 1995 data point we performed an interpolation, and after 2007 we assumed the number of fishers in persons per day remained constant at 1,421. Since this tourist data only reflect the number of tourists engaged in recreational fishing, the true number of tourists is undoubtedly higher.

Recreational fisheries

Catch by resident anglers

Amateur and sport fishing are, perhaps, ones of the most popular hobbies for Russian people. According to different sources, the number of amateur fishers in Russia is estimated between 20 and 25 million people (Демидов 2011), though this figure was not disaggregated by region; thus, the number of amateur fishers in the RFE is not known. However, the fact that seven of the nine of the RFE constituent entities that represent more than 90% of the territory and about 83% of the population in the Far East have direct access to the sea may would support the assumption that these numbers is high (ЕСИМО 2014).

Number of recreational fishers

The first data source available on this topic suggest that in the 1980s, there were 100,000 amateur fishers in Primorsky Region, 50,000-70,000 in Sakhalin, and 15,000-20,000 in Kamchatka, who caught 4000, 2000, and 1000 $t \cdot year^{-1}$, respectively (Фетинов 1982). Фетинов (1982) implied that amateur fishers include both recreational and subsistence fishers for whom fishing is a hobby, although catch of indigenous peoples was not included. With these numbers into account, it can be estimated that approximately 5% of the total population of Primorsky Region (where 2,046,000 persons resided in 1982) and Kamchatka (369,000 persons), and 9% of that of Sakhalin (676,000 persons) were engaged in fishing for

leisure and diet supplementation. For the three remaining federal subjects where data on the proportion of amateur fishers was not available, we assumed an average of the three federal subjects with available data (amounting to 6% of the resident population).

Based upon the total number of amateur fishers in the 1980s, we estimated that 80% of them were resident recreational fishers and the remaining 20% were subsistence fishers, as in the Soviet Union planned economy limited the need for a subsistence fishery, yet not entirely. We assumed that the resulting proportion of amateur fishers in each federal subjects resident population were representative for the entire period, from 1950 – 2010, as the popularity of recreational fishing among residents shows little change throughout time.

Catch rate per amateur fisher

The catch rate of amateur fishers in Primorsky Region, Sakhalin and Kamchatka in the 1980s was 40 kg, 33.3 kg and 57 kg·year^{-1} per fisher, respectively (Фетинов 1982). Since these are the earliest catch rates available and are also the only available benchmark during the Soviet years, we assumed these catch rates were representative up until the late 1980s, hence from 1950 – 1989.

According to interview with amateurs who fished during 2000-2010, their catches ranged between 70 and 80 kg·year^{-1} per person, with their increased catches are attributed to more advanced fishing gear and their greater affordability comparing to the previous times. Therefore, we assumed that the Kamchatka catch rate, which was the highest of the three other regions, increased to 80 kg·year^{-1} in 2000 from 57 kg·year^{-1} in 1989, while Sakhalin, which had the lowest catch rate in Soviet times increased to 70 kg·year^{-1} in 2000 from 33.3 kg·year^{-1} in 1989. Assuming that the ratio of catch rates in 1989 from each region remained constant, this implied that the catch rate for the Primorsky region increased to 73 kg·year^{-1} in 2000 from 40 kg·year^{-1} in 1989. From 2000 to 2010 we assumed the catch rates remained constant. For the three remaining federal subjects with no catch rate data, we took an average of the per capita catch rates for each year from 1950 to 2010.

Species composition

While the basic composition of the catches for recreational and subsistence fishing depends on the season and is divisible into few main species, their exact proportions of catch remain unclear. In Sakhalin, the Fisheries Agency of the region cites that winter catches mainly consists of smelts (Osmeridae), saffron cod (*Eleginus gracilis*) and white-spotted char (СахНИРО 2011). In spring, coastal flounders (Pleuronectidae), white-spotted char, Pacific redfin (*Tribolodon brandti*) and masu salmon dominate the catch (СахНИРО 2011). In summer season, pink salmon, white-spotted char, Pacific redfin, starry and smooth flounders (Pleuronectidae) make up the catch of amateur fishers (СахНИРО 2011). Finally, the main species in autumn catch are chum and coho salmon, white-spotted char, and Dolly Varden (*Salvelinus malma)* (СахНИРО 2011). Salmon species account for about 55% of all catches (СахНИРО 2011).

We used this description as a baseline, assuming that 55% of all recreational catch was various salmon species of the genus *Oncorhynchus*. For the other species we made several assumptions about the proportion of species caught in various seasons, as well as assigned 10% of catch to miscellaneous marine species which can be seen in Appendix 4.

Catch by foreign anglers (tourists)

Using the time series generated on the number of foreign tourists who visit each federal subject per year, we converted these estimates to the number of recreational fishers per year. For Kamchatka, 100% of the tourists were fishers, as the data were derived from a study on

fishing tourism. For the other federal subjects, we assumed 5% of the foreign tourist population engaged in recreational fishing. Furthermore, we assumed that a foreign recreational fisher fished only 25% of the total time that a resident recreational fisher would fish. This was based on the simplistic assumptions that while a foreign fisher may fish for 10 days in a row, the resident recreational fisher likely fishes 40 days sporadically throughout the year. This estimate is speculative and should be revised upon future data. Thus, we adjusted the recreational catch rate per fisher for residents for tourists by dividing it by four. Total catch was obtained by multiplying the adjusted recreational catch rates by the number of foreign fishers. The species distribution was assumed to be identical to that caught by resident recreational fishers.

Subsistence fisheries

Catch by non-indigenous rural populations

Subsistence fishing in the former Soviet Union planned economy was limited because the government subsidized food and its transport. With the dissolution of the USSR, the need for a subsistence fishery grew substantially as with the decline in subsidies of food and cost of transport the availability of food declined while its cost increased (Newell 2004). This trend was undoubtedly more severe in rural areas where employment opportunities were low and the regions more remote and more difficult to access. Additionally, while some of the southern federal districts like Primorsky Krai and Sakhalin were fertile enough for agriculture to supplement the people's daily intake of food, the harsh tundra climate in regions like Magadan and Chukotka meant that fish was at times one of the only means of subsistence in rural areas (Newell 2004).

As previously stated, we assumed that of the total number of amateur fishers from 1950 to 1985, 80% of them were recreational fishers and the remaining 20% were subsistence fishers. This assumption resulted in number of subsistence fishers at approximately 1.2% of the population, varying by region from 0.9% to 1.8%. As the Soviet Union began to slowly dissolve in the mid-1980s, we interpolated between these estimates of the population from each region, to a representative sample of the population engaging in subsistence fishing after the collapse of the Soviet Union in 1991.

This was calculated by comparing the proportion of the rural population in each federal subject and making an appropriate assumption for the proportion of the population residing on the coast and relying on subsistence fishing. For the Primorsky Krai and Khabarovsk where the interior was inhabitable and agriculture was present, we assumed that 10% of the rural population subsisted on fish (and none of the urban populations). For Sakhalin, which also has an agricultural sector, yet is an island with easy access to the waters, we assumed that 20% of the rural population subsisted on fish. In regions like Magadan, Kamchatka, and the Chukotka, agriculture was not well established and reliance on fish was heavy. Due to the lack of agriculture, we assumed greater proportions of the population lived on the coast and that half of the rural population subsisted on fish.

We applied this time series of the percentage of subsistence fishers on total population in each federal subject and then utilized the variable catch rate per amateur fisher (calculated in section on resident recreational fishers) to estimate catch.

Species

Species for subsistence were almost the same as for recreational fishing in that we allocated 55% to *Oncorhynchus* salmon species and 10 % as MMF. The difference is we also included 10% catch of various marine crustaceans (Decapoda) as these are also common species caught for subsistence by locals. The remaining species were the same as for recreational except scaled the proportion of each remaining species down by 10% total to compensate for addition of the Decapoda classification (Appendix 4).

Catch by indigenous peoples

Consumption of fish for indigenous peoples is not only a tradition, but is also a necessity to this day for some indigenous tribes of the Far East, who often inhabit lands not conducive to farming and store bought food may be unavailable to them either because of their remoteness, "unemployment, chronic non-payment of salaries, and very low incomes" (Spiridonov and Nikolaeva 2004). We reconstructed catch by looking at the change in indigenous population from 1950 – 2010 and appropriate per catch rates based on settlement region.

Census data for each tribe were available for the years 1939, 1959, 1970, 1979, 1989, and 2002 in (Petrov 2008) and for the year 2010 in (Демоскоп Weekly 2010). These population figures were adjusted to reflect the indigenous peoples living near the coast, and hence likely to have a fishing quota for various marine species. This was done by surveying their geographical distribution (ANSPIRA 2008) and estimating the proportion of the population living near the coast. Of the 40 indigenous ethnicities listed, 16 of them either entirely or partially resided on the Russian Far East coast. Please refer to Table 5 for a summary of the percentage assumed to reside on the coast for each indigenous community. These percentages were then applied to the corresponding community population figures. For years in between censuses the population was interpolated.

Table 5. Percentage of each Russian Far East indigenous population assumed to reside on the coast, 1950 – 2010.

Northern Indigenous Peoples	Coastal territories (%)
Koryak	100%
Nivkh	100%
Itelmen	100%
Ulchi	100%
Orochi	100%
Negidal	100%
Aleut	100%
Orok	100%
Taz	100%
Alutor	100%
Kerek	100%
Chukchi	50%
Even	40%
Udege	20%
Evenk	10%
Eskimo	5%
Other*	0%

**Other indigenous peoples with no territory adjacent to the sea include Nenets, Khant, Nanai, Mansi, Dolgan, Selkup, Saami, Ket, Yukagir, Chuvan, Nganasan, Enets, Shor, Veps, Soyot, Teleut, Kamchadal, Chelkan, and Chulym*

Furthermore, it has been estimated that in Kamchatka alone, the indigenous community caught approximately 1,000 t·year^{-1} of salmon from 1990 to 2009 (Шевляков 2013). While

there are additional quotas for other species allocated, salmon is by far the most common catch of indigenous populations. Therefore, we increased the total annual catch by 100 t to reflect other species which may have been caught from indigenous fishing (Appendix 4). We divided the estimate of 1,100 t by the average coastal indigenous population in Kamchatka from 1990 to 2009 and obtained a catch rate of 86.5 kg·person^{-1}·year^{-1}. As a side note, after 2009 the catch by indigenous peoples grew tenfold, but this this was due to the rising trend of "pseudo-indigenous communities" created by organized criminal structures in order to claim salmon quotas (Шевляков 2013). Please see the section on pseudo-indigenous communities for more details.

Within the Chukotka Autonomous Okrug, a news piece on the indigenous Chukchi people indicated that catch rate was over five times higher than Kamchatka. Titled "Chukchi: where the world ends" by RT (https://www.youtube.com/watch?v=rdeQz6TTBQ8), the reporter follows a couple fishing, an activity very common in Anadyr (their village) where "nearly all" inhabitants fish. Each indigenous inhabitant can legally set a net up during the season as long as it is no more than 10 m in length and they do not sell their catch. After setting up their net and waiting for 30 minutes, this one tow brought five pink salmon and five taimen (*Hucho taimen*). This catch was described as "not impressive by local standards", hence we believe this is a conservative catch per tow. Using the average length in the length-weight function in FishBase (www.fishbase.org), we derived the average weights and obtained an estimated weight of the catch at 64 kg. This catch from one tow is nearly as high as the per capita yearly catch in Kamchatka as derived above. Assuming that the fishing season for salmon is approximately 13 weeks (the summer), we made a conservative estimate that each person fishes approximately seven times, setting seven tows per year. This is especially conservative given that surplus was likely caught and cured or frozen for the winter months ahead. Therefore, the indigenous catch rate for peoples living in the Chukotka Autonomous Okrug was estimated at 450 kg·person^{-1}·year^{-1}.

This catch rate was applied to all indigenous coastal populations living in the Chukotka Autonomous Okrug, while for all other indigenous coastal communities we used the catch rate estimated for Kamchatka at 86.5 kg·person^{-1}·year^{-1}.

Cod and smelt (winter fishery)

Furthermore, a recent survey conducted in Sakhalin aimed at collecting and analyzing data in order to evaluate the approximate amount of fish extracted by amateur fishers in Sakhalin (СахНИРО 2013). The site chosen was a traditional place for winter fishing where from February to March, the target species for amateur fishers are smelts and saffron cod. The survey tracked the number of daily fishers and their catch in addition to interviewing more than a hundred fishers about their average catch and the researchers themselves engaging in fishing in order to obtain independent estimates of catch rate. Based on the quantity of catch, the average weight and length of smelt and saffron cod, and other relevant information, the authors of the study concluded that during the period from the 2nd of February to the 21st of March (2013), total catches of smelt amounted to 381 tonnes and 334.6 tonnes of saffron cod by amateur fishers (СахНИРО 2013). These catches are generally intended for self-consumption as well as for sale (large-scale purchase of fishers' catches is organized along the coast that in turn stimulates even greater catches).

Although the study covered only a small area and was conducted during the short period of time, it clearly demonstrates the scale of the catches for subsistence. Smelt catches just off the south-eastern coast of Sakhalin Island alone are estimated in hundreds of tonnes, while the official quota catch of these species along the whole East Sakhalin subzone is 590 t (СахНИРО 2013). The fact that this one site accounts for so much of the quota catch is troubling, especially as there are likely many more sites like this.

Hence, we estimated total catch of these species in the winter fishery in Sakhalin, compared them to what we reconstructed for recreational and subsistence fisheries, and then assumed the rest was sold, e.g. artisanal and unregulated catch. While the study in question was performed in 2013, i.e., beyond the time frame of the current reconstruction, its conclusions confirm the previous assumption with regards to the large subsistence catches in the RFE, and surely are also applicable to the 2000-2010 period in terms of catch composition and amount of fish caught.

At this one site, the maximum number of amateur fishers present in any day was 3,683 anglers, while all amateur fishers in Sakhalin number 58,500. While it is possible that there are more fishers than this in the region, this catch is only from a portion of the full winter season (48 days) and that this is only one fishing site among many. Using this estimate of about 3,683 fishers in the region, this implies that there are about 15 to 16 more sights like this on Sakhalin, which appears reasonable. We assumed similar productivity and then from this total catch subtracted catch previously calculated in the recreational and subsistence fisheries, i.e., 188 t of smelt and 188 t of saffron cod in 2010, leaving rest as what was sold. This leftover catch was considered artisanal in nature and was scaled with amateur fisher population in Sakhalin from 1950 – 2010. Additionally, we created a variable to account for the lower catch during the Soviet Union, assuming catch at 10% of the calculated value from 1950 – 1987 and then interpolating to 100% of the catch calculated by 1991 and remaining at 100% until 2010.

Foreign fisheries

Species that are strongly exploited, or exploited mainly by foreign fishers in the EEZ of the RFE are schoolmaster gonate squid (*Berryteuthis magister*), neon flying squid (*Ommastrephes bartramii*), Pacific saury, chub mackerel, capelin (*Mallotus villosus*), tuna-like fishes (Scombridae), Pacific sandlance (*Ammodytes personatus*), grenadiers (Macrouridae), sharks, rays and skates (Elasmobranchii), among others (Римская 2004, p. 138). Alaska pollock and other demersal species like cod and flatfish are also extensively fished by foreign fleets, predominantly in the Western Bering Sea (Vaisman 2001).

Prior to 1977, a year which marked the beginning for the establishment of 200 nautical mile EEZs, countries fished freely in each other's waters, so long as they respected other territorial waters located 12 nm from shore. With the convention moving to 200 nm from shore, foreign parties were able to fish in Russian waters either through fishing access agreements (often bilateral), buying a quota to fish in Russian waters, or, after the dissolution of the USSR, setting up joint ventures and other private enterprises with Russian partners. Any other activity not within these categories was considered illegal and will also be reconstructed in the present paper. Data regarding legal fishing by foreign parties are limited, as in some cases such data may even be considered proprietary. In order to remain conservative, we only reconstructed catch for years where there is clear data, both for legal and illegal catch

Illegal catch, especially for certain fisheries like the salmon driftnet fishery, have a bad reputation for overfishing their quota or other illegal activities, although the Russian propensity to engage in unlawful activities in their own waters is certainly greater in the post-Soviet era (Vaisman 2001). Nonetheless, clear data on illegal foreign catch are lacking, except in certain media outlets which document certain news-worthy cases of illegal fishing. The reasons for this trace to widespread corruption among observers aboard ships and weak enforcement capability of Russian enforcements staff. For example, being a permanent inspector aboard foreign vessels fishing in the Bering Sea is a lucrative job, where "inspectors are paid by the firms they are supposed to be monitoring" and have access to free food and alcohol among other perks. Furthermore, salaries aboard various country ships vary, with Japanese ships paying the best salary, followed by South Korea, Norwegian, Taiwanese,

Polish, and finally China, who has the worst reputations and whose salary is only approximately a fifth of what Japanese observers earn (Vaisman 2001). Those who disclose violations or in effect, do their job, are threatened to be "excluded from the on-board observers 'family', or at least assigned to Chinese vessels" (Vaisman 2001). Hence, 'loyalty', or keeping silent, are greatly rewarded in such fisheries.

Foreign legal catch

Foreign legal catch was reconstructed for the following countries: Japan, China, Tiawan, North Korea, South Korea, and the USA.

Japan

Japan has historically fished in Russian waters extensively with various fleets, including but not limited to the salmon driftnet fishery, northern longline fleet, snow crab fleet, Hokutsen trawl fleet, mother-ship (converted fleet), and other fleets conducting experimental fisheries.

Salmon driftnet fleet

Japan has historically had a substantial salmon fishery within Russian waters, a tradition which continues to this day, as Russia allots a quota to Japan (for a fee) to employ driftnet fishing targeting salmon. As mentioned previously, Japan had a large role to play in the "drift-net catastrophe" of the late 1960s and early 1960s. In the years prior to WWII, the ratio of Soviet to Japanese catch of Pacific salmon in the waters of Kamchatka was approximately 1:1.434. In the post-WWII period when exploitation of salmon resources resumed, we assumed a similar ratio of catch so that when Russia caught 110,100 t of salmon species, Japan caught an estimated 157,900 t of salmon in 1950.

In the beginning of the 1952, Japanese fleet intensified their Pacific salmon fishing activities, and by 1955 reached particularly large scale. In 1955, 2 mother ships and 58 of the Japanese drift-netters were sent to the west coast of Kamchatka in the Sea of Okhotsk for salmon fishing (Вахрин 2011). Each drift-netter set 300-350 nets daily with the length of 10-12 kilometers. According to some reports, the annual total catch of Pacific salmon by Japanese drift-netters fishing vessels amounted 280,000 t by 1956, which was three times more than the entire catches of the Pacific salmon by Soviet fishing fleet in the Far East (Вахрин 2011). We interpolated between the catch of 157,900 t in 1950 to 280,000 t in 1956, keeping the catch at this level in 1957 until the catastrophe broke out in 1958 and salmon catches in the western Kamchatka were reduced by a factor of 11 compared with catches in 1951 (Аров 2000). This resulted in approximately 16,200 t of catch in 1958 when the crisis broke out.

Japanese catch in Russian waters continued in the Russian EEZ after the driftnet catastrophe (yet at a much smaller scale). Data were only available from 1964 to 1992 in (MAFF Japan 2011), starting with 6,607 t of catch in 1964. We assumed all catches of salmon from this fleet were within the Russian EEZ as this was the traditional commercial fishing area. Hence we interpolated between 16,200 t of catch in 1958 to 6,667 t in 1964, thereafter following reported catch from this data source until the early 1990s. According to this data source, salmon catch declined significantly in 1988 and 1989 and was at 0 t from 1990 – 1992. It is not clear if this is true, as fishing quotas were allocated by the Russian Fishery Agency to Japanese vessels since 1991 (WWF 2011) although estimations of this quota are not given. Data appear to be contradictory, and due to lack of more concrete data we assumed catch began anew in 1993. This also aligns with the banning of directed fishing for salmon on the high-seas in 1992, were Japan fills a significant portion of its demand for wild salmon.

Starting in 1993, more accurate and comprehensive data were available from the North Pacific Anadromous Fish Commission, NPAFC (www.npafc.org) for salmon catches of foreign fleets in the Russian EEZ from 1993 - 2005. As stated by (Dronova and Spiridonov 2008), this catch is synonymous with reported catches of the Japanese driftnet fleet targeting salmon.

After 2005, we determined the salmon driftnet catch through various sources. In 2008, for example, Japan obtained a quota of 9,735 t of salmon in the Russian EEZ, which was over three times as high as the quota in its own waters of 3,005 t (Makino 2011). In 2009 there were reportedly less Japanese fishing salmon vessels inside the Russian EEZ – down by 11 ships, simultaneous with a temporary closure of Russian driftnet operations (WWF-Russia 2009). Without more information, we assumed the quota and catch reduced by half in this year. Since 2010, the Russian Federal Fishing Agency set Allowable Catch (TAC) for the driftnet fishing of salmon at 22,500 t annually, allocating half of the quota to Japan and the other half to Russian vessels (WWF 2011), amounting to an estimated catch of 10,225 t of salmon in 2010. Except from 1993 – 2005, when species-specific catch data were available, we labelled salmon catch as in the *Oncorhynchus* genus.

Northern longline

Data on the Japanese Northern longline fleet were available from (MAFF Japan 2011) from 1964 – 2001. Targeted species include Alaska pollock, Pacific cod, octopus (Octopodidae), largehead hairtail (*Trichiurus lepturus*), red seabream (*Pagrus major*), and other marine fishes.

Crab fleets

Data on the snow crab fleet were available from 1964 – 1984, presumably the end of this fishery. Likewise, data on Japanese catch of red king crab in Western Kamchatka were available from 1951 – 1974 (Долженков and Болдырев 2006). Catches by (Долженков and Болдырев 2006) for 1951 and 1952 were reported as "<200,000 t", while for 1953 and 1954 catches were reported at approximately 2,000 t. Given the wide range of possible catch we reported catch for 1951 and 1952 at 10,000 t each year.

Other fleets

Data on other fleets were available from 1950 – 1976 and 1985 – 2010, which we describe below. In between these two time periods, fishing activity was uninterrupted, and hence we interpolated catch between the two time periods.

Period from 1950 to 1976

Tsuji (1974) indicated that there was a small experimental Japanese fishery off eastern and western Kamchatka from 1957 to 1961, with catches beginning at about 1,830 t in 1957, and increasing several times to about 5,000 t from 1958 – 1960 and 4,500 t in 1961.

Furthermore, Hokutsen trawlers, also known as 'land-based' trawlers were launched in 1961 by Japan targeting halibut (Pleuronectidae) off east and western Kamchatka (Tsuji 1974). In winter they targeted Alaska pollock and in the summer they went after "higher class fish" like halibut, sablefish (*Anoplopoma fimbria*), and Pacific ocean perch. Catch and effort data were available from 1961 to 1967, climbing from under 21,000 t in 1961 to over 250,000 t in 1967 with 172 licenced vessels. It was stated that the number of vessels was constant at 182 vessels from 1968 - 1974. Hence, we applied the ratio of change in effort (182:172) to catch in 1967 and used this amount as representative from 1968 – 1974. The next anchor point of

catch for the Hokutsen fleet was a catch of 208,309 t in 1980 (Wildman 1993), and we interpolated between 264,993 t in 1974 to this amount in 1980.

In addition to the Hokutsen fleet, there was also a mothership-type fishery operating in the Bering sea and off western Kamchatka which began in 1954, targeting mainly flounders with refrigerator factory ships (Tsuji 1974). Data were available on catch of this mother-ship fleet from 1954 to 1976. While catch of the Bering Sea was enormous, climbing over 400,000 t in some years, catch of West Kamchatka was more moderate averaging about 20,000 t annually. Catch in West Kamchatka was clearly within the Russian EEZ, while catch from the Bering Sea could have also been from the US waters or the 'Donut Hole.' Hence, we made an assumption that 20% of catch from this Bering Sea fleet was within the Russian EEZ, as the rest would be from the high seas and the US EEZ. In 1966 there were 17 mother ships fishing, three off western Kamchatka and the other 14 in the Bering Sea. According to Wildman (1993) there were 16 mother ships in 1976, that later became the 'converted' fleet of the Japanese DWF that targeted mainly Alaska pollock and fished mostly in the Donut Hole in the 1980s, later declining in 1991 as a result of the Alaska pollock stock collapse.

We compiled data from the experimental fleet, Hokutsen fleet, and mothership-type fleet from 1950 - 1976 (year before EEZs were declared), obtaining approximately 350,000 t of catch in 1976. We allocated species based on the composition of catch from the Hokutsen fleet, with data from 1961 – 1967. Catch prior to 1961 was assumed to have the same catch distribution as 1961, and catch after 1967 was assumed to have the same catch composition as in 1967.

Period from 1985 to 2010

The next complete data source on catch by the Japanese fleet was in 1985, as this was the first year a reciprocal fishing agreement between Japan and the former USSR came into effect, as it was signed and brought into force in December 1984 (Smith 2014). Hence, to estimate the magnitude of Japanese catch, we utilized data on Russian catch in Japan (Swartz and Ishimura 2014), subtracted any catches by the longline and crab fleet (not the salmon fleet, whose quotas were negotiated separately for a fee, rather than reciprocally under a no-fee agreement) and obtained a catch of approximately 341,000 t of catch to be caught by the Hokutsen and mother-ship fleets in 1985, a value which we used for the interpolation between 1976 and 1985.

From 1986 – 1990 we followed the Russian catch in Japan as a baseline for the reciprocal fishing agreement and subtracted catch by the longline and crab fleet to obtain catch of the other fleets estimated here. In 1991 the Soviet Union dismantled and access agreements were considered null. However, fishing quotas were allocated by the Russian Fishery Agency to Japanese vessels since 1991 (WWF 2011) and so we used the catch of the Hokutsen fleet available in (Wildman 1993) as a baseline for 1991, or about 77,000 t of catch. Up until this point we used the same species distribution as in the Hokutsen fleet catch composition from 1967, but after this we no longer used this composition, with the logic that in the post-Soviet period the nature of fishing changed. For the following years we assigned all catch as miscellaneous marine fishes.

The access agreements were promptly re-established in 1992 and 1993, holding two major components: no fee mutual agreements and access agreements based in purchase. In 1992, the no fee access agreement was for 182,000 tonnes (171,000 tonnes in 1993) in addition to 30,000 tonnes purchased by Japan in 1992 and 18,000 t in 1993 plus 21,000 tonnes of salmon from Russian waters and 4,819 tonnes of salmon in Japanese waters in 1993. Hence, this once more confirms that salmon is not included in these reciprocal no fee access agreements, rather purchased at a fee by Japan. For the remaining years until 2010, we

followed the Russian catch in Japan as a baseline for total catch under the reciprocal fishing agreement and subtracted catch from the longline and crab fleet when applicable.

China

China and the former Soviet Union signed a fisheries agreement in 1988 which established cooperation between the Soviet Far Eastern Fisheries Administration and the CNFC. The agreement allows for China to fish in Russian waters with approximately 20 vessels, which it did in 1989 and assumedly 1990 until the Soviet Union devolved in 1991. Allocations were given in 1993 and 1994 but afterwards it is unclear (Wildman 1993).

While it is not explicitly stated, occurrences where Chinese vessels were apprehended for illegal activity indicate they were targeting Alaska pollock. Therefore, we made the assumption that China, like other nearby countries, target various groundfish resources with trawlers. According to Pauly *et al.* (2013), the mean catch per Chinese bottom trawler annually is 1256 t, and assuming a constant presence of 20 vessels, this implies a catch of 25,120 t for the years in question, in addition to a joint venture project with allocations of 1,000 t annually for 1993 and 1994, operated by the Russian scientific production company, Primakvaprom, and an unnamed Chinese fish processing company (Wildman 1993).

Taiwan

In August 1991 there were bilateral fishery talks and they were not renewed when they expired on November 25, 1992 (Kravanja and Shapiro 1993). The fishing regions agreed upon in the talks were Sakhalin Island, Kamchatka Peninsula, and south Kuril Island, targeting mainly squid, Pacific cod, and Pacific saury (Kravanja and Shapiro 1993). We assumed that the catch in 1991 and 1992 reached about 5,000 t, divided between the three aforementioned taxon.

North Korea

While exact figures and details are scant, Kravanja and Shapiro (1993) indicate that North Korea had a joint venture with Russia in 1989, and fishing quotas from 1990 - 1992. Details about specific catch indicated that due to frustration with North Korean behavior in 1990, Russia decreased their quota from 200,000 t (although the exact years they received this amount were not stated), to 30,000 t of Alaska pollock for a fee, and a quota of 30,000 t of Pacific sardines (*Sardinops sagax*) in 1991, and officially a quota of 60,000 t in 1992 (Kravanja and Shapiro 1993). We assumed the 200,000 t referred to 1990 only.

South Korea

The first ROK joint ventures with the former Soviet Union and then Russian Federation was in 1989 which allowed them “over-the-side purchases in Russian waters of Russian-caught fish” (Kravanja and Shapiro 1993). In 1991, there were about 23 vessels belonging to 12 ROK companies taking part in these joint ventures, having purchased 90,000 t of Alaska pollock (61,000 the year prior). In 1992, 25 ROK vessels were to be fishing in Russian waters with an annual quota of 110,000 t of fish, although this was not confirmed. Ultimately we assumed 31,500 t of Alaska pollock in 1989 (half of 1990), 61,000 t in 1990, 90,000 t in 1991, and 110,000 t in 1992. Additionally, 8,000 t per year was allocated for Samsung from 1991 to 1994.

The North Pacific ROK trawler fleet, which was in dire need of access to Russian waters after the closure of the Alaska pollock fishery in the Donut Hole, secured access to Russian water in 1992 and 1993, although the amount they actually caught of their 150,000 t quota was

"very little" in 1992 due to territorial disputes and "limited" in 1993 due to disagreement on fees. Hence we assumed they caught 7,000 t in 1992 and 10% of the 1993 quota, or 15,000 t in 1993.

Another bilateral fishing agreement was signed in February 1992 between the ROK and Russia concerning the fishery in the Sea of Okhotsk. South Korea was given access to 30,000 t of squid, pollock and saury caught in Russia, in exchange for Korea providing 30,000 t of mackerel, scad (*Decapterus*), and sardines or supplies (Kravanja and Shapiro 1993).

Data from South Korean quotas in the Bering Sea indicated a quota of 60 t of Alaska pollock, 1,600 t of Pacific cod, 60 t of halibut, and 33 t of other miscellaneous marine fishes. While the quota for the entire Far East EEZ may have been higher, we only considered these quotas in order to not over estimated catch.

In the 2000s, several data sources indicate that South Korea has continuously had access to Russian waters, starting with in 2000, a quota of 35,600 t of unspecified species and 110,000 t quota in 2001 for the Bering Sea. There was also a quota of 15,000 in the Kuril Islands that was disputed by Japan. Since it was not clear if any fishing actually took place we assumed that it did not.

Finally, a data source indicated that "as part of bilateral agreements with the Russian government, South Korean companies are actually allowed to catch up to 40,000 metric tonnes of pollock (in addition to some other marine resources) in 2013 without breaking any laws" (Anon. 2013). We assumed that the 40,000 t of Alaska pollock catch extended back to 2002, as South Korea appears, like Japan, to have had a constant presence in Russian waters since the dissolution of the Soviet Union.

USA

According to Vaisman (2001), the USA had a quota for 1,000 t of halibut in 1995 and 60 t of other species.

Foreign illegal catch

Illegal catch is defined as catch taken by vessels flying a foreign flag within the Russian EEZ who do not have a prior fishing access agreement, quota allocation, or participation in a private joint venture with Russian counterparts.

Japan

<u>Salmon driftnet fleet</u>

The reputation of the Japanese bilateral Agreement driftnet fishery is poor among the fishing community, with many Russians in favor of closing this fishery due to its history of misreporting, overfishing quotas, and high-grading (The Wild Salmon Center 2009). According to Spiridonov and Nikolaeva (2004), the inspectors on board fishing vessels used to be bribed, in addition to Japan paying the highest salaries for their inspectors (Vaisman 2001). Hence, there is a lack of clear data, so we assumed the same rate of poaching as the Russian fishery, or an underreporting of 50% of landed catch from 1988 – 2010. We assumed that from 1950 – 1976 unreported catch was at zero, as Japanese ships had no incentive to misreport. Once the EEZs were established, it was in the benefit of Japan to conceal some catch in order to maximize their quota allowance, so we assumed that unreported catch increased from 0 in 1976 to 50% in 1988, and that it remained at this level until 2010.

Other fleets

Due to lack of enforcement capabilities and that observers aboard foreign vessels are bribed, data on the foreign violations in Russian waters are limited. The extent to which the latter is true can be seen in 1999 when “a Japanese ship was detained in a marine nature reserve off the Commander Islands, where fishing is strictly prohibited” and “an observer was onboard at the time” (Vaisman 2001).

In 2000, there was substantial illegal activity by Japan of 18 violations, which can perhaps serve as a benchmark for other years where data are not as readily available. These case include 16 vessels poaching in Russian water, two of them were trawlers with each of them carrying 350 t of fish on board, two poaching salmon (one caught with 20 t illegally caught salon and the other vessels was driftnetter who was fishing in an illegal zone and with dangerous modifications to the gear), three fishing crab (total 15 t on board), and one fishing primarily squid (30 t of squid). Two other vessels were charged for leaving the Russian EEZZ without taking part in the mandatory inspected by Russian enforcement. In 1995, records of foreign fishing vessels in the Bering Sea show that the Japanese had 60 driftnetters, seven longliners, and two trawlers. The Japanese quota under bilateral agreements (not including salmon driftnet) in 1995 was 100,000 t, while in 2000 it was 66,400 t, which by logic would imply that Japan would have had less than nine vessels fishing for 66,400 t of fish in 2000. Nine legal vessels compared with 14 illegal vessels, even if it is a one-time occurrence is startling.

Nonetheless, it is possible that the list of reported vessels of Japan in Russian waters in 1995 is not complete as it i) only includes vessels in the Bering Sea ii) this would imply that seven longliners and two trawlers were supposed to catch the entire quota of 100,000 t, which is difficult to know without CPUE data of Japanese vessels in Russia waters. In contrast, violations of illegal vessels fishing in Russian waters were substantially lower from 1993 to 1998, higher in 1999 and 2000 due to increased organization of the enforcement agencies. Many assumptions would have to be made with data that are not available and severely clouded do to the lack of foreign vessels with unbiased observers who could report their findings. Hence, we assumed that from 1992 to 1997 the illegal, unreported catch of Japanese vessels was at 5% of reported catch, increased to 20 % by 2000, and then constant thereafter at 20%.

China

The first documented incidence of illegal Chinese catch cited was in 1998 where the *Tai ping* was apprehended carrying 200t of undocumented Alaska pollock in Sea of Okhotsk (Vaisman 2001). Another occurrence was in 2005 when the Russian Coast Guard, upon inspecting the Chinese cargo vessel *Kai Yuan* in the Russian part of the Bering Sea, found that fish products transferred to the cargo ships from three Chinese fishing vessels were registered as ‘round’, i.e. unprocessed, Alaska pollock, but in fact were fillets (Burnett *et al.* 2008). This amounts to 3,000 t of illegally caught fish needed to produce the quantity of illegal fillets. In 2010, 17 Chinese fishing vessels were apprehended and detained for illegal fishing, and in 2012 two Chinese fishing apprehended in a row, one leading to a violent shootout (Yu 2012).

To estimate the quantity of catch at sea, we first estimated an appropriate catch per unit effort of Chinese vessels fishing illegally. While the legal mean was 1256 t per vessel, the occurrence in 2005 suggests that each vessel fished 1,000 t before transferring their catch to a cargo ship, while the Tai ping indicates a catch of 200 t. Hence this annual mean of 1,256 t appears to be reasonable for vessels fishing illegally as well, and we applied this catch to the one boat fishing illegally in 1998, in 2005, and the 17 Chinese vessels caught illegally fishing

in 2010. It appears main products targeted at sea are Alaska pollock, so we allocated this catch as such.

Furthermore, many Chinese citizens slip the Russian-Chinese border on foot, as was described in a NY Times article in 2006, poaching salmon and their roe, often endangering the environment in the meantime (Wachter 2006). Coverage of this by various media outlets is growing, as "illegal fishing by Chinese fisher[s] is a long-standing problem for Russia," (Yu 2012). In 2009, 75 Chinese fishers were arrested on the Russian side of the Amur and Usuri rivers (Yu 2012).

For Chinese salmon poachers, we assumed that the illegal activity was present from 2000 until 2010, beginning at 10 Chinese fishers in 2000 and increasing to 75 in 2009, thereafter remaining constant at 75 for 2010. The figure of 75 is only a bare minimum, as it only considers the number of poachers who were detected, while the true amount is likely much higher. As was mentioned in (Wachter 2006), "a bucket of salmon roe will pay for a new house or car in China." Roughly, we assumed that a 'bucket' of salmon roe weight 10 kg, or the equivalent of 250 kg of whole weight salmon. We multiplied this rough estimate by the number of estimated Chinese illegal poachers from 2000 to 2010 to obtain an estimate of illegal catch of salmon. The species were classified within the *Oncorhynchus* genus.

North Korea

According to Kravanja and Shapiro (1993), in 1990 "Soviets became irritated by the fact that North Korean vessels not only fished illegally in the Sea of Okhotsk and off Kamchatka, but also sold a part of their catch quota ... to Japan." Earlier that year they had caught 12 Japanese vessels flying the North Korean flag, presumably fishing under this re-sold quota. While the Japanese activity was illegal, they were (presumably) not overfishing the quota, rather fulfilling the North Korean quota. Hence, we considered these catches legal, although we highlighted in the data that these catches were by the Japanese. The catches that were truly illegal were those of the North Koreans fishing in the Okhotsk and Kamchatka without a quota. We estimated that they sold approximately 25% of their 200,000 t quota to Japan, and simultaneously fished this amount illegally.

Furthermore, in 1998, 13 North Korean trawlers were caught illegally fishing in the Bering Sea (Bonfil et al. 1998b). Assuming a similar productivity as Chinese trawlers, this would imply an illegal catch of approximately 16,300 t.

South Korea

In 1996 the Pacific Kim was caught transporting illegal catch of crab at 64 t.

USA

In 2003, 4 crab boats were caught accidentally fishing in Russian waters due to an outdated NOAA chart that showed a Convention line from 1987 between Russia and the USA, obtaining crab at a value of $222,415 (NOAA 2003). Prices of crab from 1995 to 199 were decreasing, from about 12 USD / kg to 7 USD / kg (Vaisman 2001). Assuming prices did not decline further, this would imply that the amount of illegally caught crab was at approximately 32 t.

Ukraine

In 1999, a Ukrainian trawler was caught illegally transporting 3,800 t of mixed fish products in Russian waters (Vaisman 2001).

Discards

According to Kelleher (2005), "information on discards in the fisheries of the Russian Far East has proved particularly difficult to obtain and no estimates are included in the discard database". This is due in part to the lack of transparency in the fish industry and that information on catch and discards is considered proprietary (Spiridonov and Nikolaeva 2004).

Discarding of the target species occurs when either the target species is considered inadequate (too small for processing capabilities or damaged) or when high-grading occurs. High-grading is the dumping of acceptable fish in order to obtain more valuable species. This can be seen in the salmon driftnet fishery, where less valuable salmon species like pink salmon are dumped in order to amass greater amounts of sockeye salmon or in the Alaska pollock fishery where male and other non-roe-bearing females are dumped in order to augment production of roe.

Discarding of non-target species occurs in nearly every fishery, when commercially undesirable fish are caught as bycatch and then thrown overboard, often dead or injured. These numbers are especially high in the Russian Far East where nearly all bycatch is dumped because a company pays for the quota for 'target' species, while others caught as by-catch are normally discarded (Балыкин 2007).

Discard rates can be presented in two major formats; either discards as a percentage of total catch or discards as a percentage of retained catch (landings). In most literature, discards are presented as the former (as a percentage of total catch), which can cause confusion when actually calculating the number of discards from retained catch. Hence, all discard rates were converted from discards as a percentage of total catch to a percentage of landings, so that they could be standardized in comparison to retained landings. Below is a synthesis of the available data on major fisheries that was utilized to estimate the tonnage of fish discarded at sea from commercial operations.

Driftnet fisheries targeting salmon

According to the Russian Audit Chamber and the Kamchatka Parliament, analysis of official data indicates that in the 2000s there is effectively no control on driftnet fishing by-catch and non-target species is rarely reported, including seabirds and marine mammals whose incidental catch is on average 11 times underestimated (WWF 2011). While the *Sea Around Us* does not estimate catch and discards of marine animals or birds, in this section we will estimate discards at sea of marine species from the salmon driftnet fishery.

According to survey driftnet fishing data, fish loss due to tears in nets is estimated between 0.6% to 20% of catch (Spiridonov and Nikolaeva 2004). According to coastal Chukotka fisher reports, from 20 to 60% of sockeye salmon, the most valuable salmon species are injured by nets. Both data sources reflect how at-sea driftnet gear can seriously damage fish and lead to reduced value or waste. Hence, accidental discards of target species as well as dumping due to damage are significant in the salmon driftnet fishery. The minimum discard rate from damage and net tear (as a percentage of landings) is 25.6%, and the maximum is 210%. We conservatively assumed a loss rate of 30% of sockeye salmon (as a percentage of landed sockeye salmon).

In addition to loss of commercially valuable species from the gear itself, there is evidence of significant high-grading. The natural distribution of catch of various salmon species is grossly skewed, as sockeye salmon normally represents 5 – 10% of salmon catch, but in driftnet operations is represents over 90% for both Russian and Japanese vessels (WWF

2011). Simultaneously, the most abundant salmon species of pink salmon represents only 1.8% of driftnet catch, clear evidence that non-desirable salmon species are being discarded (WWF 2011). This implies that for every sockeye salmon caught, approximately nine pink salmon are discarded, or a discard rate of 900% of pink salmon (discards as a percentage of landings). Another source states that the amount of discarded fish estimated from driftnet operation in Russia was estimated at "no less than 60,000 tonnes per annum" (WWF-Russia 2009) which, if considering both Japanese and Russian reported catch corresponds to a discard rate of approximately 390%. We assumed the minimum of 390% in order to be conservative, assuming that the species composition of this was 300% pink salmon, 40% other less valuable salmon in the genus *Oncorhynchus*, and 50% miscellaneous marine fishes.

The 30% loss rate was applied for the entire time period as the gear itself has not changed, but the estimate of 390% discard rate was based on reference to the late-2000s. We assumed this rate for the 2000s from 2000 – 2010. Prior to this, we treated Russian discards and Japanese discards separately. Since the Russian driftnet fishery originally began as an experimental fishery from 1965 – 1979 followed by a research fishery starting in 1993, we believe discards from high-grading were substantially lower, but discards from the gear itself were still inescapably high. Hence, we estimated that from 1950 – 1998, discards were 50% of catch (composed entirely of miscellaneous marine fishes), interpolated to 390% in 2000 as the fishery quickly became corrupt.

For the Japanese salmon driftnet fishery, operations were commercial since the 1950s and hence the incentive to high-grade may have been high as in the 2000s. From 1993 to 2005 when data by species for Japanese catch were available, the proportion of catch of pink salmon slightly decreased over time, while the proportion of sockeye slightly increased. This shows a change in market conditions, but whether this shows a change in discards is not clear. We assumed that from 1950 – 1976, the discard rate was 100%, increased to 300% by 1991, and then further to 390% by 2000. During the time period when the discard rate was at 100%, the assumed species distribution slightly changed to reflect the lack of high-grading. Consistent with the proportion of MMF, 19.5% was assumed to be marine miscellaneous species, 50% was assumed to be pink salmon and the remained other salmon species of the genus *Oncorhynchus*.

For artisanal gears targeting salmon we assumed limited discards, as this is an artisanal gear placed mostly in salmon spawning areas where other species are not as abundant. Additionally, discards in this fishery are not studied and hence a discard rate of zero was assumed appropriate.

Fisheries targeting Pacific herring and other small pelagic species

While information on herring discards is very scarce, researchers note that "it is well-known that herring that does not meet certain technological requirements is not processed further and, as a rule, discarded" (Буслов *et al.* 2006). According to Буслов *et al.* (2006) the catch underestimation of Pacific herring are not limited to ignoring discards, but also suffer from the persistent underestimation of the retained catches because of erroneous processing ratios, i.e., ratios of raw material per unit of landed product. These two factors lead to considerable underestimation of actual herring catches.

Буслов *et al.* (2006) highlight the fact that the vast majority of vessels fishing for herring do not carry out advanced processing of the fish. Moreover, herring is of little use for fishmeal due to its high fat content (Буслов *et al.* 2006). The proportion of discards largely depends on whether the finished product is destined for domestic market or for export. It is worth noting that such approach is adopted by the large-scale fleet rather than medium tonnage

fleet as the latter does not carry out fish-processing on board. Instead they deliver the whole catch on processing ships (Буслов *et al.* 2006).

Буслов *et al.* (2006) present an example pertaining to large-scale fleet fishing activities in 2001, where the proportion of the discarded catch was 29% (41% of retained landings) when the catch was destined for domestic markets, and 48% (92% of retained landings) when the catch is destined to be exported. According to Буслов *et al.* (2006, p. 326), in 1999, some vessel discarded all herring weighing less than 300 grams, which constituted a shocking 77 % of the total catch (335% of retained landings), although this high estimate was not included in our estimate in order to remain conservative.

Overall, Буслов *et al.* (2006, p.328) suggested that discards of herring amounted 26.5% of their catch (36% of landings), which includes all vessel sizes and market destinations. We used this discard rate as representative for the recent time period from 1991 – 2010. There is no information on whether or not herring discards occurred during the Soviet period, i.e., from 1950 to 1991. However, considering the above observations, it can be assumed that they were lower, as the market shifted from being mostly domestic to largely exported.

To model the change in discards when the fishery moved from a domestic to a foreign market, we took the ratio of the discard rates when the product was destined for the domestic markets (41%) and foreign markets (92%). The resulting ratio of 2.26 indicates that the amount of discards increases by about 226% when the product shifts from being 100% for the domestic market to 100% exported. These particular discard rates are only representative on large boats, however the magnitude of change may be representative for the herring fishery as a whole.

Since the overall discard rate was 26.5% of catch (36% of landings) with a mixture of domestic and foreign markets for destination, applying the following ratio to the previous time period would be conservative. We assumed that from 1950 – 1988 the discard rate was 36% of landings divided by 2.26, resulting in a discard rate of 16%. We interpolated between 16% in 1988 to 36% in 1991 and kept this rate constant thereafter.

In addition to discards of target species, which are dictated by the quality requirements of the final product, there are also discards of non-target species caught as bycatch. Such discards can generally be assumed to be consistent for as long as the same fishing gear is used, as the gear itself is the source of the additional bycatch. In the Russian fishery, all bycatch caught that is not a target-species is discarded (Балыкин 2007).

Data on catch composition for the herring fishery (and we will assume by extension other fisheries targeting small pelagic fishes) are available in (Балыкин 2007), as can be seen in Table 6. These data originated from an overview of the catch composition of all fishing gears in the Far East by (Балыкин 2007), which can be seen in Appendix 5.

Table 6. Catch composition and discards of trawl fishing (at various depths) for Pacific herring in the Russian Far East, 1950 - 2010.

		Total catch			Discards
Common name	**Species name**	**Total catch (%)**	***Target* (%)**	***Bycatch* (%)**	**Percentage of target catch (%)**
Pacific herring	*Clupea pallasii pallasii*	**77**	77		0
Capelin	*Mallotus villosus*	**2**		2	3
Alaska pollock	*Theragra chalcogramma*	**21**		21	27
		100	77	23	30

The resulting discard rate as a percentage of target catch (30%) was applied to reported and unreported catch of small pelagic species from 1950 to 2010, as other small pelagic species more than likely were targeted by the same gear as herring.

Fisheries targeting Alaska pollock

Some authors point out that discards of pollock were common during the Soviet period (e.g., jammed and squashed fish), even though the control was stricter and corruption was nearly non-existent, compared to the current situation (Островский 2012). Others note that pollock is discarded even until today, often in order to maximize production output of the roe, i.e., young fish and males are simply thrown overboard (Маренин 2012). Indeed, the recent popularity of Alaska pollock roe and fillets has led to increased discarding at sea of parts of the fish not needed for the final product (Vaisman 2001). It was estimated in fact that in 2005, 120,000 metric tonnes of Alaska pollock were discarded in the Sea of Okhotsk alone (Glotov and Blinov 2005).

Until the mid-1980s, the mesh size in the cod end of the trawls was 40 mm and thus undersized fish constituted the bulk of the catch (Улейский 2011). According to Улейский (2011), in order to produce fillet and roe for export, the raw material should be no less than 35 cm in length. In order to reduce pressure on the stock, new rules and regulations were issued from 1998 to 2001, which increased the mesh sizes of nets, to 100-110 mm while only 20% of undersized fish (less than 35 cm) were allowed as by-catch. Also, a moratorium on fishing activities in the central part of the sea of Okhotsk was imposed and trawling was prohibited in the spawning grounds of Alaska pollock (Улейский 2011). In practice, however, the by-catch of undersized fish exceeded 20 % (sometimes up to 50 %) of the total catch of Alaska pollock, depending on the fishing ground and month (Улейский 2011). To determine the amount of discards of Alaska pollock, Улейский (2011) analyzed catches and outputs in the period from 1998-2009 (de-headed fish, roe and fishmeal). He found that when the target is Alaska pollock roe, the discards rate may be higher than 38 % in January and February when pollock has less of mature roe, comparing to March (Улейский 2011). Kelleher (2005), referring to the 1992-2001 period, states that discards of Alaska pollock may reach 47.5 %, particularly to the Sea of Okhotsk Alaska pollock fishery. In Soviet times, particularly in the 1960s and 1970s, discards occurred, but to a lesser extent than in the 1990s-2000s, when the whole industry became export-oriented. A discard rate of 5 % pollock for Alaska pollock is assumed for the former period, from 1950 – 1988, transitioning to 38% by 1991 to represent the post-Soviet period. This was applied to catch in the Russian EEZ for both foreign and domestic catch, assuming they had similar characteristics.

In addition to Alaska pollock catch, other species are also caught that are not the end goal of target operations. The company pays for the quota for 'target' species, while others caught as by-catch are normally discarded (Балыкин 2007). The composition of the catch by trawls targeting Alaska pollock at various depths can be seen in Table 7, taken from the original data by (Балыкин 2007), which can be seen in Appendix 5.

Table 7. Bycatch and discards in the Alaska pollock industrial fishery of the Russian Far East employing trawl gear of various depths, 1950 - 2010.

		Total catch			Discards
Common name	**Species name**	**Total catch (%)**	***Target* (%)**	***Bycatch* (%)**	**Percentage of Alaska pollock catch (%)**
Rays	Batoidea	**0.1**		0.10	0.10
Pacific herring	Clupea pallasii pallasii	**1.4**		1.40	1.44
Pacific cod	Gadus macrocephalus	**1.1**		1.10	1.13
Alaska pollock	Theragra chalcogramma	**97.2**	97.20		0.00
Flatfishes	Pleuronectiformes	**0.1**		0.10	0.10
Halibut	Pleuronectidae	**0.1**		0.10	0.10
		100.0	97.20	2.80	2.88

The discard rate of 2.88% of Alaska pollock landings was applied to all reported and unreported landings, as well as high-graded and discarded catch of Alaska pollock from 1950-2010, as this would represent the true proportion of other non-target species caught in fishing operations.

Fisheries targeting Pacific cod and various flatfish taxa

As can be seen by the data in Appendix 5, Pacific cod and various flatfish are often targeted in the same fisheries, notably fisheries employing bottom trawls, bottom seines (also known as Danish seine or 'snurrevaad'), and bottom longline. Generally, Pacific cod that do not meet market requirements are thrown overboard (Спиридонов 2001; Anon. 2008b). Since discards were minimal in Soviet times, and only squashed or jammed fish were discarded (similar to Alaska pollock), we assumed that 5% of landed catch of Pacific cod was discarded from 1950 to 1991. After 1991, higher standards for the final product have caused Pacific cod discarding to increase, we assumed to 10% of the landings by 1995, thereafter remaining constant at 10% until 2010. We assumed the same discarding of various flatfish, as they were targets of the same fisheries.

Regarding the discarding of non-target species, all other bycatch are generally discarded because the company only pays for the quota of target species (Балыкин 2007). Since Pacific cod and various flatfish are caught by numerous gears and in various regions, as is depicted in Appendix 5, we averaged the species compositions of bottom trawl, bottom seine, and bottom longline in the Western Bering Sea, with bottom seine and bottom longline in the Karaginskaya subzone. The result can be seen in column 1 of Table 8.

Table 8. By-catch and discards of bottom trawl, bottom seine, and bottom longline gears in industrial operations targeting cods and various flatfish in the Russian Far East, 1950 - 2010.

		Total catch			Bycatch				Discards
Common name	**Species name**	**Total catch (%)**	***Target (%)***	***Bycatch (%)***	**Retained (% of bycatch)**	**Discarded (% of bycatch)**	**Retained (% of total catch)**	**Discarded (% of total catch)**	**Percentage of target catch (%)**
Rays	Batoidea	**2.2**		2.2	0	100	0.0	2.2	4.4
Pacific herring	*Clupea pallasii pallasii*	**0.1**		0.1	0	100	0.0	0.1	0.2
Grenadiers	Macrouridae	**6.5**		6.5	0	100	0.0	6.5	12.8
Saffron cod	*Eleginus gracilis*	**1.9**	1.9		100	0	0.0	0.0	0.0
Pacific cod	*Gadus macrocephalus*	**30.5**	30.5		100	0	0.0	0.0	0.0
Alaska pollock	*Theragra chalcogramma*	**22.1**		22.1	0	100	0.0	22.1	43.8
Groupers	*Epinephelus*	**3.5**		3.5	0	100	0.0	3.5	7.0
Snappers	Lutjanidae	**1.1**		1.1	0	100	0.0	1.1	2.3
Okhotsk atka mackerel	*Pleurogrammus monopterygius*	**1.1**		1.1	0	100	0.0	1.1	2.1
Gobies	Gobiidae	**8.5**		8.5	0	100	0.0	8.5	16.8
Flatfishes	Pleuronectiformes	**12.2**	10.7	1.5	87	13	1.3	0.2	0.4
Halibut	Pleuronectidae	**7.8**	7.4	0.4	95	5	0.4	0.0	0.04
Other	Marine fishes not identified	**2.5**		2.5	0	100	0.0	2.5	4.9
		100.0	50.5	49.5			1.7	47.8	94.6

Thus, the final discard rate of 94.6% was applied to all reported and unreported landings, as well as discards of Pacific cod and various flatfish from 1950 – 2010.

RESULTS

Figure 3a and 3b present the reported and unreported portions (including discards) of total domestic reconstructed catch within the Exclusive Economic Zone of the Russian Far East

from 1950 to 2010 a) by sector and b) by species. As can be seen, total reconstructed catch were about 656,000 t·year^{-1} in the early 1950s, peaked at 9.08 million t in 1990 (and again to 8.52 million t in 1996) and declined to approximately 4.5 million t·year^{-1} in the mid-2000s before rising slightly in the late-2000s to 6.34 million t in 2010. Overall, reconstructed catch was 1.8 times the 'baseline' catch derived from the FAO landings in the Northwest Pacific (FAO Area 61 and 67). During the Soviet years, from 1950 to 1990, the reconstructed catch is 1.4 times the reported baseline catch, while from 1991 to 2010 it is 2.4 times, the increase due to both an increase in the rate of poaching and discards. The progression over time by sector can be seen in Figure 3a, and in tabular form in Appendix 6. Figure 3b presents the taxonomic composition of these caches, which are dominated by Alaska pollock, followed by Pacific herring, salmon, flatfish, cods, and Pacific sardines (please refer to Appendix 7 for tabular form by species).

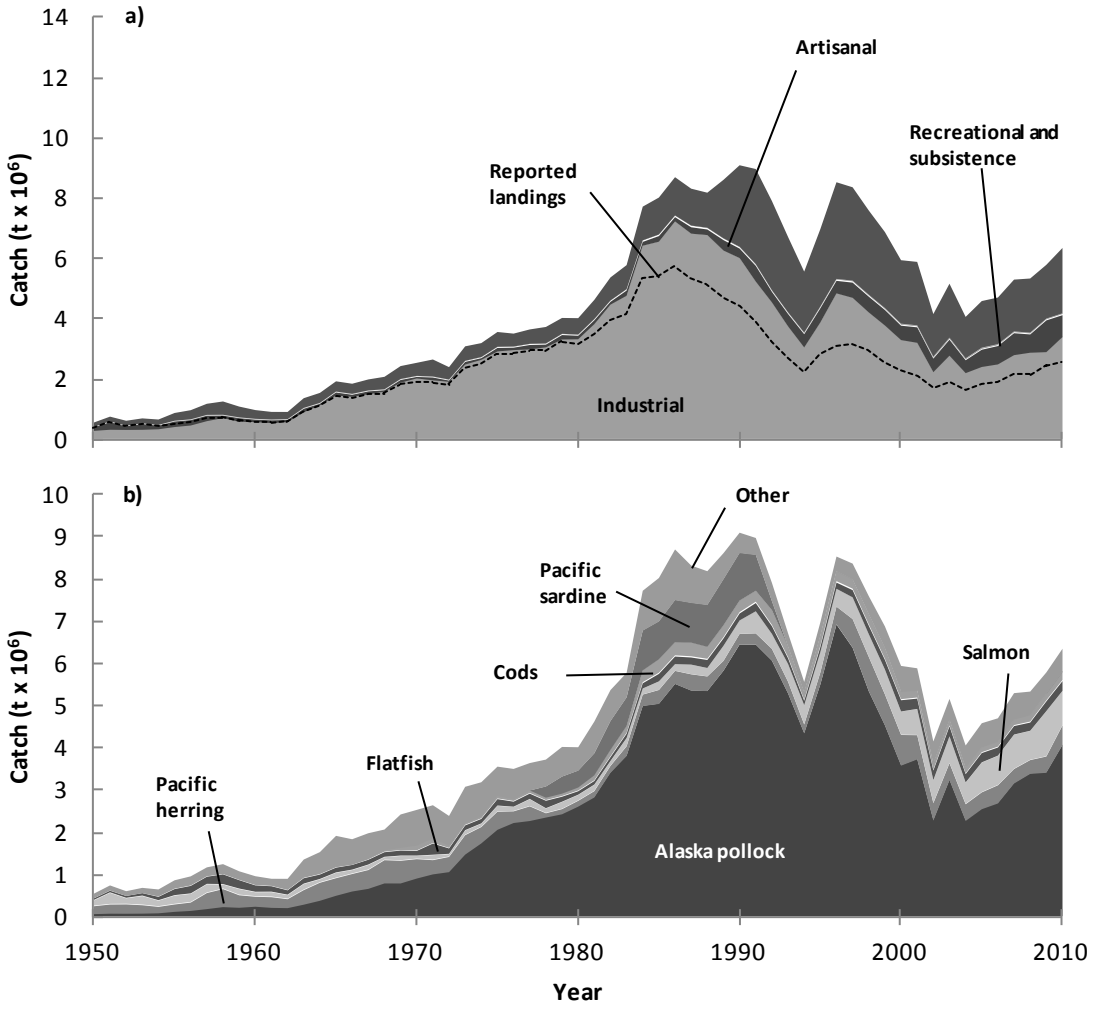

Figure 3. Total reconstructed catch of the Russian Far East from 1950 – 2010 by a) sector and b) species.

Due to the massive catches in the commercial sectors, subsistence and recreational catches are difficult to discern in Figure 3a and Figure 4 was created to more clearly depict the progression of the subsistence and recreational fisheries from 1950 to 2010. Recreational and subsistence catches began at 6,300 t and 6,000 t in 1950, respectively, both gradually increasing into the 1980s as a result of population growth. Subsistence catch grew substantially in the late-1980s to reach 16,750 t by 1991, which marked the dissolution of the Soviet Union. Thereafter, subsistence catches more or less plateaued at slightly over 17,000

t·year^{-1} in the 2000s. Recreational catch increased in the 1990s, peaking in 2003 with 29,300 t of catch and in 2005 with 29,800 t of catch before stabilizing at about 19,800 t·year^{-1} in the late-2000s.

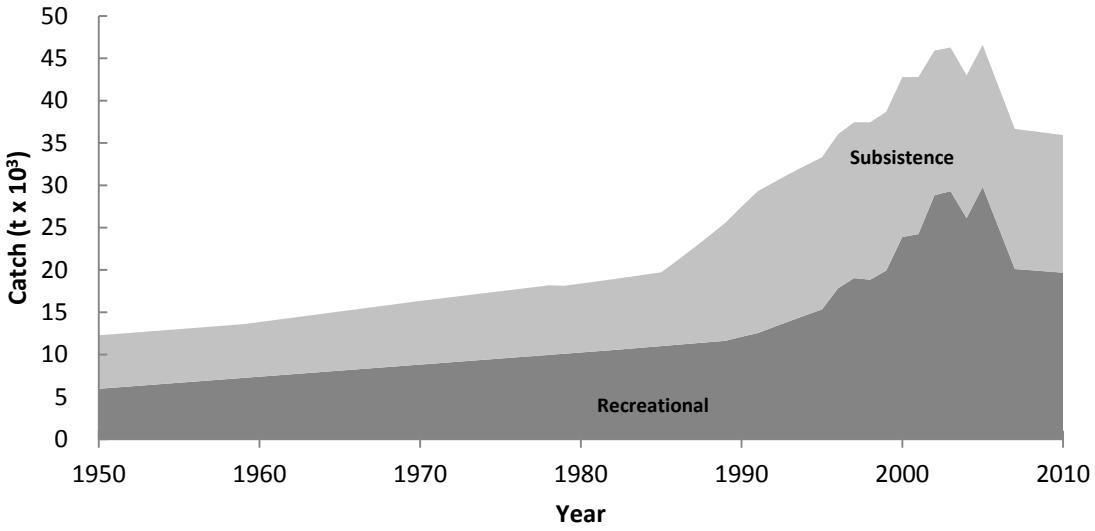

Figure 4. Reconstructed recreational and subsistence catch of the Russian Far East from 1950 to 2010.

Figures 3 and 4 only include domestic catch by Russia within its own EEZ, while Figure 5 depicts foreign catch with the Russian EEZ a) by country and b) by type of catch. As can be seen in Figure 5a, Japan was the major foreign fishing entity in Russian waters, with catch starting at 363,000 t in 1950 and increasing to 686,000 t in 1957 before plummeting dramatically seven fold due to the salmon 'drift-net catastrophe'. Catches rebounded, although mostly of species other than salmon, and over time declined, reaching about 145,000 t·year^{-1} in the 2000s. Catches of other countries were minimal, and total catches for all countries including South Korea, North Korea, China, Tiawan, USA, and Ukraine can be seen in more detail in Appendix 8.

Figure 5b depicts the distinction between reported and illegal catch as well as discards of the foreign fleet. Illegal catch is a relatively small proportion of total catch, with discards being a larger proportion averaging slightly under one third of total foreign catch. Catch (t) in tabular form can be seen in more detail in Appendix 9.

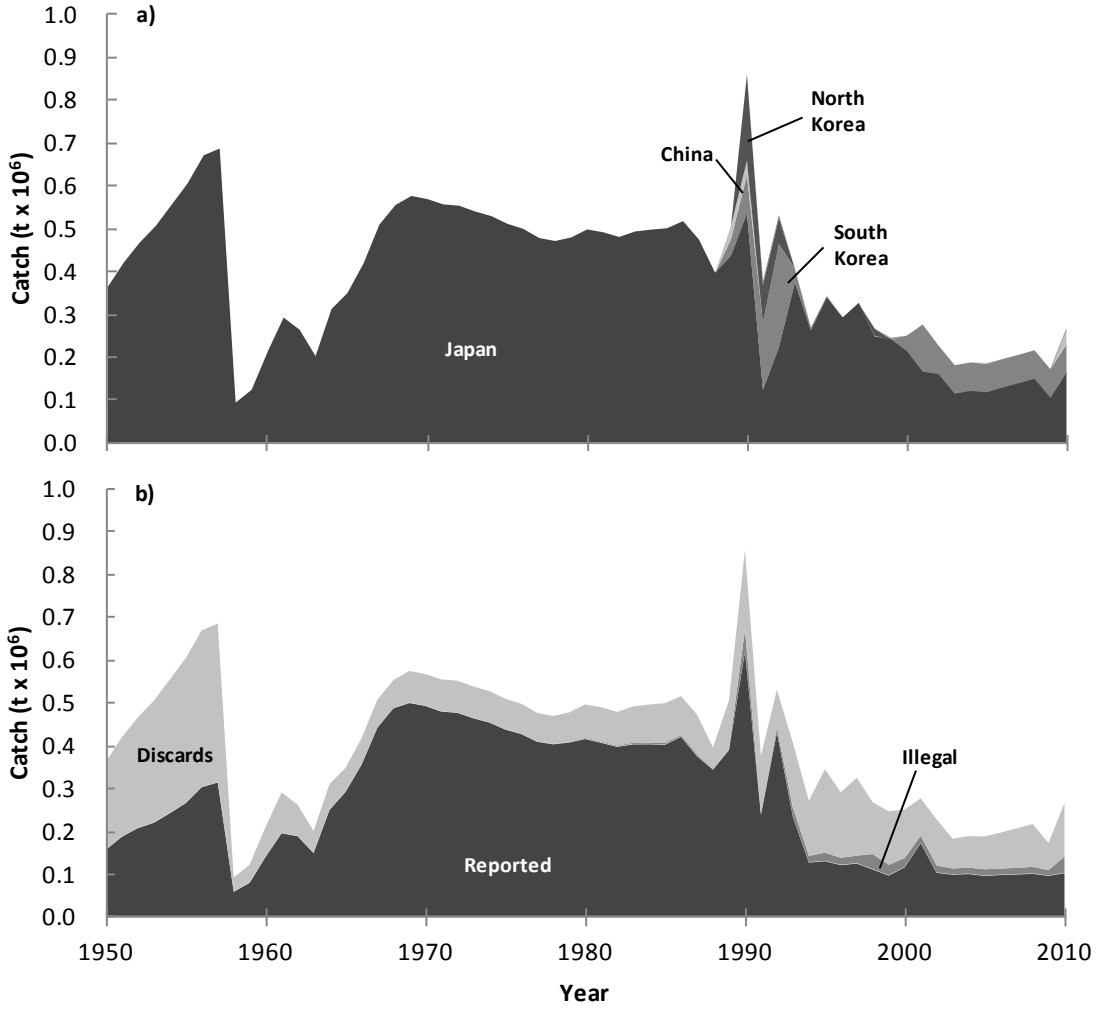

Figure 5. Total reconstructed foreign catch within the Russian Far East EEZ from 1950 to 2010 by a) country b) type of catch.

DISCUSSION

Total reconstructed catch was estimated at 1.4 times higher than the FAO reported catch in the Soviet period and 2.4 times higher in the post-Soviet period, depicting not only the magnitude of unreported catch, but also the impact of market liberalization on the fishery. A large portion of this was unreported, unregulated catch, also known as poaching, whose roots in were in the "collapse of formerly subsidized rural economies across the Russian Far East" that relied mainly on fisheries (The Wild Salmon Center 2009). The shift from the planned to private market economy was too overwhelming for the fishery to handle so that the industry lived on through "survival mechanisms" (Vaisman 2001) and not without significant illegal activity. This was reinforced in an interview with a salmon fisher from Magadan, who states that "there's no other job but selling fish" and that simultaneously "it's hardly possible to make a living through licenced fishing" (RT 2009).

Given the scale of other available estimates, the estimates presented here for unreported commercial catch (under-reporting or poaching) are relatively conservative, at

approximately 62% the magnitude of reported catch in the post-Soviet time period. For example, the WWF estimates that seafood exported from Russia untaxed and unregistered with Customs was approximately 3-5 times greater than the registered and reported amounts (Kalinicheva 2002). This translates to billions of dollars tied into the black market, in undocumented exports to Japan alone reaching $1B annually (WWF 2005). Regarding salmon catch, (Dronova and Spiridonov 2008) based their estimates of between 1.5 and 3 times more of the officially recorded catches. Our estimate falls within this range at 2 times more than reported catch. Ultimately, the lack of transparency in the fishery coupled with the rampant corruption and bribery conceals the true figures from the light.

Recreational and subsistence catch each account for 0.54% and 0.47% the magnitude of reported catch, respectively, which is quite small in proportion to commercial catch, but nonetheless of great social importance, especially for the indigenous populations. The collapse of the former Soviet Union resulted in increased activities in these sectors mainly due to the high prices of formerly subsidized food and their transport, as well as the influx of tourism that was previously restricted, which fueled recreational fishing activity. It is noteworthy that catch in these sectors is higher in the post-Soviet state *despite* the declining population of residents across the entire Far East, who moved away in great numbers due to the high cost of living, isolation, and dwindling employment opportunities of this region.

Discards also represent a major portion of unreported catch averaging 25% of the total reconstructed catch for the entire time period, mainly due to high-grading operations aimed at the most valuable catch, e.g. sockeye salmon, roe of salmon and pollock, as well as a quota fishery system where non-target bycatch species are discarded. The lack of studies on discards is due in part to the lack of transparency in the fishing industry where catch data are considered proprietary, let alone discards. Furthermore, the allocation of quotas after the shift to the private sector became increasingly non-transparent and financially-driven, as can be seen by the auctioning of quotas since 2001 (Newell 2004; FAO 2007). The process for allocating quotas has been far from scientific, rather a heavily politicized process with fishing companies lobbying extensively to secure their annual quotas along with occurrences of capital flight and bribery for quotas (Newell 2004). Even the TAC itself is seen by many fishers as a rough guideline rather than a maximum limit. For example, according to Dronova and Spiridonov (2008), it was estimated that officially reported catches of the Pacific salmon in the RFE exceeded TAC 10% on average from 1995 to 2005 (Dronova and Spiridonov 2008). If 10% above TAC of reported catch, then with unreported components with amounts to an excess above TAC of 240%. Although more scientific input in the setting of quotas would be an improvement from the current system, without accurate catch statistics such as the ones suggested in the present report, any stock assessments or models would be seriously biased.

Furthermore, such problems are amplified by the selling of quotas to foreign parties, whose ‘observers’ are paid handsome salaries by the companies that hire them to essentially keep quiet regarding any illegal activities they may see. Data on foreign catch are even more non-transparent than domestic catch, with a lack of public data on access agreements and quota allocations. Regarding the controversial driftnet fishery, Russia is the only country that allows a large-scale foreign driftnet fishery in its waters, an irony considering that “Russia simultaneously recognizes the inadmissibility of drift-netting at an international level while permitting its unlimited use in Russian waters” (Spiridonov and Nikolaeva 2004).

The impact of overfishing by domestic and foreign fisheries can be seen in the health of the fishery, which has suffered numerous stock collapses from the mid-20th century to the present day. The collapse of the Alaska pollock fishery in the Donut Hole was called the “the most spectacular fishery collapse in North American history, dwarfing the famous crashes of the northern cod and Pacific sardine” (Bailey 2011). Additionally, the valuable wild salmon population is also at risk and has been since the mid-20th century and in 2008, regional

sockeye population made the 2008 IUCN Red List (The Wild Salmon Center 2009). Moreover, grizzly bear sightings in settlements are increasing, a sign of bear hunger due to poor availability of salmon (The Wild Salmon Center 2009). These facts are troubling, as the Bering sea is one of the 61 priority eco-marine regions worldwide identified by the WWF, as it is one of the most productive and diverse seas in the world with over 450 species of fish and shellfish, as well as 50 species of seabirds and 26 species of marine mammals (Vaisman 2001). Hence, much is it stake in this unique region of the world.

Currently, the commercial fisheries are highly export driven, with most fishery products flowing to their Asian neighbors. The following simple remark of a Russian fisher summarized the situation well: "we give them fish and they give us a load of bucks" (Vaisman 2001). Ultimately, due to the poor socio-economic position of most residents of the Russian Far East and the economic benefits they receive from trade with Asian countries, the preference is clear-cut. First, the avoidance of reporting through Russian customs (which was legal until a law was passed in 2009) allowed fishers to avoid high import and export taxes. Furthermore, "shipping to Japan and the South Korea by sea is almost three times cheaper than shipping by train to central Russia" (Spiridonov and Nikolaeva 2004). This is due in part to the poor transportation infrastructure from the Far East Russia to its mainland, leaving the Far East isolated. So high are the transportation costs that they exceed 50% of the final value of the products (Dronova and Spiridonov 2008). Some other benefits include that "Japanese and Korean companies pay Russian fishers in advance of on a contract basis upon delivery, while the Russian system is much slower" (Dronova and Spiridonov 2008; The Wild Salmon Center 2009). Lastly, the Customs process itself is ridden with delays and hence significant product risk, and paired with the deterioration of ports in repairs and refueling; this leaves fishers with a clear economic incentive to not declare their catch in Russian customs (The Wild Salmon Center 2009).

While the current system seems profitable to most fisher, in fact, this is not the case. Over-the-side sales mean that Russian fish products are sold below market value, which depresses world market prices for fish. For example black market roe being traded in Pusan (South Korea) for $200,000 USD when the market prices in 1993 could have given them 500,000 for the same roe (Vaisman 2001). About the same ratio of underpricing was seen for trading crab with Japan in the 1990s, e.g. about 45% of market price (Vaisman 2001). Hence, the hurts fellow fishers most, as not only stocks decline, but also "supresses the market by low-bailing prices" so that honest fishing companies forced to patrol fishing areas along with enforcement agencies.

The legislation does not help either, as only the ship owner or fishing company staff can request criminal procedures be instituted by the police, yet most of the times these owners and staff are "the very perpetrators of the crime" (Vaisman 2001). Furthermore, the current laws only implicate the "foot soldiers", or the local poachers themselves, while "criminal and corporate bosses remain untouched, financially, legally, and in terms of reputation (The Wild Salmon Center 2009).

In recent years, there have been some improvements, such as in 2009 Russia earning its first MSC certificate (WWF-Russia 2009) and in 2010 signing the agreement on port state measures to prevent, deter, and illuminate illegal, unreported, and unregulated fishing (WWF-Russia 2010). While these measures are more symbolic, they still show a step in a positive direction. Additionally, an anti-poaching group was established with WWF's support in 2010, which spent 320 days in the territories of the Kronotsky Nature Reserve in southern Kamchatka, detecting 78 offenses to the conservation regime (WWF-Russia 2010). It is clear that these measures do not have the strength alone to shift the dynamic of poaching in this fishery; however the law regarding reporting to Customs in 2009 may have this power. This law declared that any fish caught within Russian EEZ must first be declared through Customs in Russian ports, which particularly concerns the fleet of ships remaining between

12 – 200 nautical miles at sea, up until 2009 legally exempt from reporting catch or answering to any government or regulatory agency.

Indeed, the passing of the 2009 law that requires fishers to land any catch caught in Russian waters on Russian soil has been met with severe resistance from fisher who argue (and rightfully so) that Russian ports are not equipped to handle this increase in traffic, and second, that this will cut into the profits of Russian fishers. The paradox is that while the short-term benefits seem scant, in the long-run it would be more profitable to land catch through Customs, because the current market undercuts the prices that cut into their own profits, as well as sink worldwide prices. The convention around the world in fisheries is that "everything harvested at sea is unloaded in ports, counted, checked, declared, and only then loaded on to cargo ships and transported elsewhere", that is, everywhere except Russia, "where most biological resources harvested in the exclusive economic zone are immediately shipped abroad" (Dronova and Spiridonov 2008). Furthermore, (Dronova and Spiridonov 2008) suggest that once "the supply of illegally harvested raw fish to foreign ports decreases, market prices will rise, and fisher[s] will not only compensate for their expenses, but also turn profits" (Dronova and Spiridonov 2008). Additionally, central and Far East Russia import Norwegian salmon that has been bred in captivity as a result of all the local salmon flowing out, an inefficient exchange that could be reversed with the success of this legislature (Dronova and Spiridonov 2008).

Some solutions to the current unwillingness to land catch though Customs and report catch may be to invest in the transportation system between the Far East and the rest of the country, which would also socially benefit the Far East as many residents feel isolated by the mainland. Additionally, high import and export tariffs (Vaisman 2001) discourage passage through Russia, so reform of these tariffs may also encourage this trend. Spiridonov and Nikolaeva (2004) advise that the government offer inhabitants alternatives to illegal harvest such as developing legal fish processing and fishing tourism, using satellite to track vessels fishing illegally, allow more stringent punishment for poaching than is currently in place, introduce mandatory labeling and branding for salmon products, among other recommendations.

Another area for improvement would be the current wage incentives in the fishery, as they also contradict the goals of a sustainable fishery. The average monthly wage of an enforcement officer is equivalent to the basic monthly cost of groceries for one person, hardly enough to support a family. Furthermore, enforcement is disorganized with no clear delineation of tasks, inspection ships are outdated and slow, offices do not have computerized systems, there are too new enforcement officers to effectively patrol the coastline, and corruption is common and as the Regional Director of the Interior stated, "bribery of government inspectors ... has become a widespread phenomenon" (Vaisman 2001). Hence, increasing wage along with better training would lower incentive for enforcement officers to accept bribes and properly do their job. This wage discrepancy is also seen for fishers who work under contract actually don't even receive a wage, meaning that it is expected of them to poach in order to make a living.

In contrast, observers aboard foreign vessels, who are paid by the very companies they are supposed to enforce, are paid handsome sums along with many other perks, making this position one of the most lucrative in fisheries. This juxtaposition between how inspectors are paid, versus Russian crew members and enforcement officers, highlights some of the contradictions of the Russian fishing industry.

The greatest irony perhaps lies in the fact that those with the most power to change something have the least incentives to. As a fish vendor Vadim Chernov aptly states, "the industry could easily be legalized, it's just that that would eat into authorities' profits from bribes and fines. Most of our fish goes abroad, so locals are forced to poach and we have no

choice but to buy fish from them. That's just not right" (The Wild Salmon Center 2009). The fisheries of the Russian Far East tell two different stories; the first is a story of desperate survival, poverty, and isolation, while the second is a story of complicity by the rest of the players, who earn a profit from this situation. Those in the second category includes all those who earn bribes, foreign buyers of significantly discounted fish products, and Russian companies who don't pay their employees' wages, etc. This multitude of small and big players, capitalizing on every opportunity, reminds one of a stock exchange, rushing hurriedly towards profit. Yet while the exchange trades stocks and futures, the question for this fishery is whether its stocks will a have future at all.

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Appendix Table A1. Estimated total population for six coastal federal subjects of the Russian Far East, 1950 – 2010.

Year	Primorskiy krai	Khabarovsk Krai	Kamchatka krai	Magadan Oblast	Sakhalin Oblast	Chukotka Autonomous Okrug
1950	1,161,589	937,858	209,495	279,053	383,790	80,975
1951	1,189,227	960,593	214,479	285,817	392,922	82,938
1952	1,216,865	983,327	219,464	292,582	402,053	84,901
1953	1,244,503	1,006,062	224,448	299,346	411,185	86,863
1954	1,272,141	1,028,796	229,433	306,111	420,316	88,826
1955	1,299,778	1,051,531	234,418	312,875	429,448	90,789
1956	1,327,416	1,074,265	239,402	319,640	438,579	92,752
1957	1,355,054	1,097,000	244,387	326,404	447,711	94,715
1958	1,382,692	1,119,735	249,371	333,169	456,842	96,678
1959	1,410,330	1,142,469	254,356	339,933	465,974	98,641
1960	1,437,968	1,165,204	259,340	346,698	475,106	100,604
1961	1,465,605	1,187,938	264,325	353,462	484,237	102,567
1962	1,493,243	1,210,673	269,309	360,227	493,369	104,530
1963	1,520,881	1,233,407	274,294	366,991	502,500	106,492
1964	1,548,519	1,256,142	279,278	373,756	511,632	108,455
1965	1,576,157	1,278,876	284,263	380,520	520,763	110,418
1966	1,603,795	1,301,611	289,247	387,285	529,895	112,381
1967	1,631,432	1,324,346	294,232	394,049	539,027	114,344
1968	1,659,070	1,347,080	299,216	400,814	548,158	116,307
1969	1,686,708	1,369,815	304,201	407,578	557,290	118,270
1970	1,714,346	1,392,549	309,186	414,343	566,421	120,233
1971	1,741,984	1,415,284	314,170	421,107	575,553	122,196
1972	1,769,622	1,438,018	319,155	427,872	584,684	124,159
1973	1,797,259	1,460,753	324,139	434,636	593,816	126,122
1974	1,824,897	1,483,488	329,124	441,401	602,947	128,084
1975	1,852,535	1,506,222	334,108	448,165	612,079	130,047
1976	1,880,173	1,528,957	339,093	454,930	621,211	132,010
1977	1,907,811	1,551,691	344,077	461,694	630,342	133,973
1978	1,935,449	1,574,426	349,062	468,459	639,474	135,936
1979	1,963,086	1,597,160	354,046	475,223	648,605	137,899
1980	1,990,724	1,619,895	359,031	481,988	657,737	139,862
1981	2,018,362	1,642,629	364,015	488,752	666,868	141,825
1982	2,046,000	1,665,364	369,000	495,517	676,000	143,788
1983	2,076,342	1,688,099	382,871	502,281	680,804	145,751
1984	2,106,683	1,710,833	396,742	509,046	685,608	147,713
1985	2,137,025	1,733,568	410,613	515,810	690,412	149,676
1986	2,167,366	1,756,302	424,483	522,575	695,217	151,639
1987	2,197,708	1,779,037	438,354	529,339	700,021	153,602
1988	2,228,049	1,801,771	452,225	536,104	704,825	155,565
1989	2,258,391	1,824,506	466,096	542,868	709,629	157,528
1990	2,243,992	1,794,665	457,843	463,697	697,096	149,551
1991	2,229,594	1,764,824	449,589	384,525	684,562	141,574
1992	2,215,195	1,734,982	441,336	366,180	672,029	133,596
1993	2,200,797	1,705,141	433,082	347,834	659,495	125,619
1994	2,186,398	1,675,300	424,829	329,489	646,962	117,642
1995	2,172,000	1,645,459	416,575	311,144	634,429	109,665
1996	2,157,601	1,615,617	408,322	292,798	621,895	101,687
1997	2,143,203	1,585,776	400,068	274,453	609,362	93,710
1998	2,128,804	1,555,935	391,815	256,107	596,829	85,733
1999	2,114,406	1,526,094	383,561	237,762	584,295	77,756
2000	2,100,007	1,496,252	375,308	219,417	571,762	69,778
2001	2,085,609	1,466,411	367,054	201,071	559,228	61,801
2002	2,071,210	1,436,570	358,801	182,726	546,695	53,824
2003	2,056,871	1,424,982	354,211	179,908	540,605	53,412
2004	2,042,532	1,413,395	349,621	177,091	534,515	53,000
2005	2,028,193	1,401,807	345,030	174,273	528,424	52,587
2006	2,013,854	1,390,220	340,440	171,455	522,334	52,175
2007	1,999,514	1,378,632	335,850	168,638	516,244	51,763
2008	1,985,175	1,367,044	331,260	165,820	510,154	51,351
2009	1,970,836	1,355,457	326,669	161,408	504,063	50,938
2010	1,956,497	1,343,869	322,079	156,996	497,973	50,526

Appendix Table A2. Estimated urban population for six coastal federal subjects of the Russian Far East, 1950 – 2010.

Year	Primorskiy kray	Khabarov kray	Kamchatka kray	Magadan oblast	Sakhalin oblast	Chukotka Autonomous Okrug
1950	696,555	592,367	130,457	176,043	219,173	42,920
1951	725,193	616,991	135,820	183,361	228,184	44,704
1952	754,391	642,100	141,289	190,823	237,371	46,523
1953	784,150	667,696	146,862	198,430	246,735	48,378
1954	814,469	693,777	152,541	206,181	256,275	50,267
1955	845,350	720,344	158,324	214,076	265,992	52,192
1956	876,791	747,397	164,213	222,116	275,885	54,152
1957	908,793	774,936	170,206	230,300	285,955	56,148
1958	941,356	802,960	176,305	238,629	296,201	58,178
1959	974,479	831,471	182,509	247,102	306,623	60,244
1960	997,333	851,223	186,789	252,972	313,814	61,675
1961	1,020,331	871,101	191,096	258,879	321,050	63,115
1962	1,043,474	891,104	195,431	264,824	328,332	64,565
1963	1,066,761	911,232	199,792	270,806	335,660	66,023
1964	1,090,192	931,485	204,181	276,825	343,032	67,490
1965	1,113,768	951,864	208,596	282,881	350,451	68,967
1966	1,137,489	972,367	213,039	288,974	357,914	70,453
1967	1,161,353	992,996	217,508	295,105	365,424	71,947
1968	1,185,363	1,013,749	222,005	301,273	372,978	73,451
1969	1,209,516	1,034,628	226,529	307,477	380,578	74,964
1970	1,233,814	1,055,632	231,079	313,720	388,224	76,485
1971	1,262,700	1,080,174	236,427	321,016	397,454	78,365
1972	1,291,871	1,104,951	241,826	328,382	406,779	80,265
1973	1,321,328	1,129,962	247,276	335,818	416,198	82,185
1974	1,351,070	1,155,209	252,778	343,323	425,712	84,126
1975	1,381,097	1,180,690	258,332	350,899	435,320	86,086
1976	1,411,410	1,206,406	263,937	358,544	445,022	88,067
1977	1,442,008	1,232,356	269,593	366,259	454,818	90,069
1978	1,472,891	1,258,541	275,301	374,045	464,709	92,090
1979	1,504,060	1,288,917	281,693	383,049	473,257	93,388
1980	1,527,989	1,309,624	286,175	389,202	480,786	94,888
1981	1,551,993	1,330,397	290,671	395,376	488,340	96,393
1982	1,576,074	1,351,235	295,181	401,569	495,917	97,903
1983	1,602,319	1,372,141	306,826	407,781	500,338	99,418
1984	1,628,646	1,393,112	318,512	414,014	504,771	100,937
1985	1,655,058	1,414,149	330,238	420,266	509,218	102,462
1986	1,681,554	1,435,253	342,003	426,538	513,677	103,991
1987	1,708,134	1,456,423	353,808	432,829	518,148	105,525
1988	1,734,797	1,477,660	365,653	439,140	522,632	107,063
1989	1,761,545	1,498,962	377,538	445,471	527,129	108,607
1990	1,750,314	1,472,557	370,852	385,116	519,541	102,979
1991	1,739,083	1,446,216	364,167	323,186	511,891	97,364
1992	1,727,852	1,419,937	357,482	311,409	504,180	91,763
1993	1,716,622	1,393,720	350,797	299,268	496,406	86,176
1994	1,705,391	1,367,567	344,111	286,761	488,571	80,602
1995	1,694,160	1,341,476	337,426	273,890	480,673	75,043
1996	1,682,929	1,315,448	330,741	260,653	472,714	69,497
1997	1,671,698	1,289,483	324,055	247,052	464,692	63,964
1998	1,660,467	1,263,581	317,370	233,085	456,609	58,446
1999	1,649,236	1,237,741	310,685	218,754	448,464	52,941
2000	1,638,006	1,211,964	303,999	204,058	440,257	47,449
2001	1,622,812	1,188,966	295,974	187,479	432,116	41,827
2002	1,607,673	1,165,920	288,010	170,812	423,907	36,256
2003	1,592,635	1,157,656	283,032	168,610	420,645	35,807
2004	1,577,652	1,149,373	278,088	166,394	417,349	35,361
2005	1,562,722	1,141,071	273,178	164,165	414,020	34,918
2006	1,547,848	1,132,751	268,301	161,922	410,659	34,477
2007	1,533,028	1,124,412	263,457	159,666	407,265	34,039
2008	1,518,262	1,116,055	258,647	157,396	403,838	33,604
2009	1,503,551	1,107,679	253,871	153,596	400,377	33,171
2010	1,488,894	1,099,285	249,128	149,774	396,884	32,741

Appendix Table A3. Estimated rural population for six coastal federal subjects of the Russian Far East, 1950 – 2010.

Year	Primorskiy kray	Khabarov kray	Kamchatka kray	Magadan oblast	Sakhalin oblast	Chukotka Autonomous Okrug
1950	465,034	345,491	79,038	103,009	164,617	38,055
1951	464,034	343,602	78,659	102,456	164,737	38,234
1952	462,474	341,227	78,175	101,758	164,682	38,377
1953	460,353	338,366	77,586	100,916	164,449	38,486
1954	457,671	335,019	76,892	99,930	164,041	38,559
1955	454,429	331,187	76,093	98,799	163,456	38,597
1956	450,625	326,869	75,189	97,523	162,694	38,600
1957	446,261	322,064	74,180	96,104	161,756	38,567
1958	441,336	316,774	73,066	94,540	160,642	38,500
1959	435,851	310,998	71,847	92,831	159,351	38,397
1960	440,635	313,980	72,551	93,726	161,292	38,929
1961	445,274	316,837	73,228	94,583	163,187	39,451
1962	449,770	319,569	73,879	95,403	165,036	39,965
1963	454,120	322,175	74,502	96,185	166,841	40,469
1964	458,327	324,657	75,098	96,931	168,599	40,965
1965	462,389	327,013	75,667	97,639	170,313	41,451
1966	466,306	329,244	76,209	98,310	171,981	41,929
1967	470,079	331,350	76,724	98,944	173,603	42,397
1968	473,708	333,331	77,212	99,541	175,180	42,856
1969	477,192	335,186	77,672	100,101	176,712	43,306
1970	480,531	336,917	78,106	100,623	178,198	43,747
1971	479,284	335,110	77,743	100,091	178,099	43,831
1972	477,750	333,067	77,329	99,490	177,905	43,894
1973	475,932	330,791	76,863	98,819	177,618	43,936
1974	473,828	328,279	76,345	98,077	177,236	43,959
1975	471,438	325,532	75,776	97,266	176,759	43,961
1976	468,763	322,551	75,156	96,385	176,189	43,943
1977	465,803	319,335	74,484	95,435	175,524	43,904
1978	462,557	315,884	73,761	94,414	174,765	43,846
1979	459,026	308,243	72,353	92,174	175,348	44,511
1980	462,736	310,271	72,856	92,785	176,950	44,973
1981	466,369	312,233	73,345	93,376	178,529	45,431
1982	469,926	314,129	73,819	93,948	180,083	45,884
1983	474,023	315,958	76,044	94,500	180,466	46,333
1984	478,037	317,721	78,230	95,032	180,837	46,776
1985	481,966	319,418	80,375	95,544	181,195	47,215
1986	485,812	321,049	82,481	96,037	181,540	47,648
1987	489,574	322,614	84,546	96,510	181,873	48,078
1988	493,252	324,112	86,572	96,963	182,193	48,502
1989	496,846	325,544	88,558	97,397	182,500	48,921
1990	493,678	322,107	86,990	78,580	177,554	46,572
1991	490,511	318,608	85,422	61,339	172,671	44,210
1992	487,343	315,046	83,854	54,770	167,849	41,833
1993	484,175	311,421	82,286	48,567	163,089	39,443
1994	481,008	307,733	80,717	42,728	158,392	37,039
1995	477,840	303,982	79,149	37,254	153,756	34,622
1996	474,672	300,169	77,581	32,145	149,182	32,191
1997	471,505	296,293	76,013	27,401	144,670	29,746
1998	468,337	292,354	74,445	23,022	140,220	27,287
1999	465,169	288,352	72,877	19,008	135,831	24,815
2000	462,002	284,288	71,309	15,359	131,505	22,329
2001	462,797	277,445	71,080	13,592	127,113	19,974
2002	463,537	270,650	70,791	11,914	122,788	17,568
2003	464,236	267,327	71,179	11,298	119,960	17,605
2004	464,880	264,022	71,532	10,696	117,166	17,638
2005	465,470	260,736	71,853	10,108	114,404	17,669
2006	466,006	257,469	72,139	9,533	111,675	17,698
2007	466,487	254,220	72,392	8,972	108,979	17,724
2008	466,913	250,989	72,612	8,424	106,316	17,747
2009	467,285	247,777	72,798	7,812	103,686	17,767
2010	467,603	244,584	72,951	7,222	101,089	17,785

Appendix Table A4. Species composition of Russian Far East recreational catch and subsistence catch (non-indigenous population and indigenous people) from 1950 - 2010.

Common name	Species name	Recreational (%)	Subsistence (%)	
			Non-indigenous	***Indigenous***
Salmon	Oncorhynchus	55	55	90
Marine fishes	Marine fishes not identified	10	10	10
Smelts	Osmeridae	5	4	0
Saffron cod	*Eleginus gracilis*	5	4	0
Whitespotted char	*Salvelinus leucomaenis leucomaenis*	10	7	0
Righteye flounders	Pleuronectidae	6	4	0
Pacific redfin	*Tribolodon brandtii*	5	4	0
Dolly varden	*Salvelinus malma malma*	3	2	0
Crabs, lobsters, and shrimps	Decapoda		10	0
	TOTAL	**100**	**100**	**100**

Appendix 5. Composition of catch by zone and gear (%) for the industrial fishery of the Russian Far East. Target species for each gear are highlighted.

		Western Bering Sea				Karaginskaya subzone		
Common name	**Species name**	**Trawls of varying depths (Alaska Pollock)**	**Bottom trawls**	**Bottom Seines**	**Bottom longline**	**Trawls of varying depths (Pacific herring)**	**Bottom Seines**	**Bottom longline**
Rays	Batoidea	0.1	3.7	1.2	0.1	0	0.7	5.5
Pacific herring	*Clupea pallasii pallasii*	1.4	0.3	0.2	0	**77**	0	0
Capelin	*Mallotus villosus*	0	0	0	0	2	0	0
Grenadiers	Macrouridae	0	14	0	3.1	0	0	15.2
Saffron cod	*Eleginus gracilis*	0	0	**2.1**	0	0	**7.5**	0
Pacific cod	*Gadus macrocephalus*	1.1	**14.1**	**11**	**57.7**	0	**21.1**	**48.6**
Alaska pollock	*Theragra chalcogramma*	**97.2**	34.5	54.1	1.5	21	17.8	2.6
Groupers	*Epinephelus*	0	0	0	0	0	0	17.6
Snappers	Lutjanidae	0	2.6	0	3.1	0	0	0
Okhotsk atka mackerel	*Pleurogrammus monopterygius*	0	0	0	0	0	3.2	2.1
Gobies	Gobiidae	0	9.1	15.1	9.6	0	5.5	3.1
Flatfishes	Pleuronectiformes	0.1	7.7	**12.2**	0	0	**41.3**	0
Halibut	Pleuronectidae	0.1	**8.5**	1.7	**24.9**	0	0.3	**3.5**
Other	Marine fishes not identified	0	5.5	2.4	0	0	2.6	1.8

Appendix Table A6. Total domestic reconstructed catch by sector and reported catch for the Russian Far East, 1950 - 2010.

Year	FAO landings	Reconstructed total catch	Industrial	Artisanal	Recreational	Subsistence	Discards
1950	392,700	558,027	294,018	112,251	5,959	6,317	139,481
1951	565,037	752,629	330,790	251,467	6,102	6,321	157,949
1952	426,212	616,395	324,972	118,782	6,245	6,324	160,072
1953	503,393	695,153	329,134	190,997	6,388	6,328	162,305
1954	426,700	657,504	347,009	119,812	6,531	6,331	177,820
1955	534,300	874,118	420,999	183,398	6,674	6,335	256,712
1956	577,400	967,234	472,003	179,343	6,817	6,338	302,732
1957	708,600	1,179,303	616,556	181,338	6,960	6,342	368,107
1958	717,250	1,255,666	718,796	83,123	7,103	6,345	440,298
1959	641,797	1,086,484	594,203	121,969	7,246	6,348	356,718
1960	601,264	970,476	586,569	80,404	7,389	6,455	289,658
1961	579,952	909,671	551,256	92,739	7,533	6,561	251,582
1962	589,674	908,422	585,956	70,314	7,676	6,668	237,809
1963	930,688	1,364,033	910,961	117,299	7,819	6,774	321,180
1964	1,087,390	1,539,627	1,140,163	53,955	7,962	6,881	330,667
1965	1,436,806	1,923,326	1,468,603	101,160	8,105	6,987	338,471
1966	1,374,736	1,843,633	1,425,750	68,065	8,248	7,093	334,477
1967	1,480,741	1,985,619	1,511,442	95,030	8,391	7,200	363,556
1968	1,520,266	2,072,508	1,597,968	45,656	8,534	7,306	413,044
1969	1,828,721	2,428,563	1,896,419	88,461	8,677	7,413	427,594
1970	1,904,921	2,536,791	2,037,957	49,426	8,820	7,519	433,069
1971	1,901,854	2,647,004	1,974,312	93,221	8,963	7,606	562,902
1972	1,815,595	2,394,052	1,926,381	39,227	9,106	7,693	411,645
1973	2,397,355	3,082,585	2,499,846	86,872	9,249	7,780	478,838
1974	2,515,239	3,190,062	2,655,639	55,317	9,392	7,867	461,847
1975	2,846,913	3,558,498	2,935,161	115,881	9,535	7,954	489,968
1976	2,863,768	3,504,661	2,980,030	80,037	9,678	8,041	426,875
1977	2,947,307	3,642,899	3,002,456	146,829	9,821	8,128	475,665
1978	2,960,043	3,725,153	3,072,001	89,254	9,964	8,215	545,719
1979	3,252,835	4,023,967	3,333,726	146,095	10,107	8,031	526,008
1980	3,141,033	4,016,709	3,340,024	116,248	10,250	8,144	542,043
1981	3,502,839	4,622,950	3,841,831	127,568	10,393	8,257	634,901
1982	3,936,876	5,366,606	4,491,943	92,824	10,536	8,370	762,934
1983	4,144,990	5,774,359	4,786,712	173,367	10,692	8,486	795,102
1984	5,366,161	7,713,190	6,452,050	125,936	10,849	8,602	1,115,753
1985	5,393,493	8,014,409	6,584,422	186,823	11,005	8,718	1,223,441
1986	5,750,200	8,688,670	7,257,438	142,959	11,161	9,965	1,267,148
1987	5,345,746	8,308,484	6,852,093	212,186	11,317	11,254	1,221,633
1988	5,134,646	8,174,972	6,805,358	185,168	11,474	12,586	1,160,386
1989	4,712,173	8,600,829	6,290,810	347,065	11,630	13,961	1,937,363
1990	4,412,983	9,084,387	6,040,644	314,527	12,106	15,377	2,701,734
1991	3,901,783	8,960,106	5,258,457	522,438	12,538	16,750	3,149,922
1992	3,202,843	7,899,960	4,565,797	350,352	13,257	17,097	2,953,457
1993	2,702,054	6,708,728	3,769,159	411,121	13,962	17,416	2,497,070
1994	2,233,418	5,559,406	3,068,155	440,338	14,655	17,706	2,018,552
1995	2,812,222	6,967,022	3,898,837	470,048	15,336	17,969	2,564,831
1996	3,087,116	8,521,052	4,866,258	416,220	17,833	18,205	3,202,536
1997	3,132,602	8,354,567	4,718,246	505,375	19,035	18,414	3,093,497
1998	2,966,404	7,585,922	4,232,898	523,379	18,847	18,597	2,792,201
1999	2,555,371	6,871,112	3,797,750	515,329	19,934	18,754	2,519,346
2000	2,326,347	5,937,917	3,312,831	478,131	23,894	18,886	2,104,175
2001	2,109,265	5,881,700	3,222,857	514,060	24,232	18,560	2,101,991
2002	1,676,319	4,152,748	2,246,239	450,668	28,822	17,088	1,409,932
2003	1,914,177	5,158,462	2,793,171	530,621	29,308	16,976	1,788,386
2004	1,637,239	4,058,736	2,213,584	428,752	26,126	16,867	1,373,407
2005	1,846,294	4,583,707	2,418,367	573,760	29,816	16,761	1,545,003
2006	1,924,919	4,700,834	2,503,660	610,417	24,970	16,656	1,545,132
2007	2,152,586	5,294,389	2,811,661	729,379	20,109	16,554	1,716,686
2008	2,148,112	5,331,285	2,892,519	607,894	19,970	16,454	1,794,448
2009	2,439,245	5,784,191	2,911,993	1,054,682	19,824	16,351	1,781,340
2010	2,547,237	6,343,477	3,413,622	727,518	19,679	16,252	2,166,406

Appendix Table A7. Total domestic reconstructed catch by species for the Russian Far East, 1950 - 2010.

Year	Alaska pollock	Pacific herring	Salmon	Flatfish	Cods	Pacific sardine	Other
1950	84,339	185,739	120,053	35,083	26,594	0	106,220
1951	94,577	215,768	259,322	37,029	29,529	0	116,403
1952	93,295	220,138	126,692	42,805	24,263	0	109,203
1953	95,797	198,396	198,961	56,723	21,277	0	123,998
1954	103,585	151,965	127,830	78,164	41,140	0	154,820
1955	138,070	173,840	191,469	142,725	43,606	0	184,407
1956	160,016	197,242	187,469	176,427	45,711	0	200,369
1957	203,150	378,724	189,518	167,803	41,342	0	198,766
1958	249,882	425,041	91,357	229,263	33,066	0	227,057
1959	234,208	295,353	130,256	197,998	34,706	0	193,963
1960	259,292	235,563	88,838	149,980	39,569	0	197,234
1961	232,542	252,003	101,320	127,870	38,397	0	157,538
1962	225,762	210,412	79,042	100,822	42,776	0	249,609
1963	307,546	343,568	126,174	126,073	44,528	0	416,145
1964	399,371	425,768	62,976	102,897	43,493	0	505,123
1965	518,000	414,900	110,378	111,563	34,614	0	733,872
1966	619,089	413,033	77,480	109,358	22,572	0	602,102
1967	681,692	443,918	104,642	111,954	32,217	0	611,196
1968	809,749	549,071	55,414	107,405	58,976	0	491,894
1969	809,139	535,684	98,366	117,733	81,079	0	786,563
1970	925,288	458,016	59,478	109,219	140,325	0	844,465
1971	1,023,801	335,837	103,402	264,691	138,294	0	780,979
1972	1,076,799	358,566	49,537	126,080	79,516	0	703,554
1973	1,491,068	459,064	97,311	110,426	63,636	0	861,080
1974	1,756,196	385,951	65,886	104,381	72,912	0	804,736
1975	2,077,897	427,159	126,579	150,792	85,690	0	690,383
1976	2,238,252	275,036	90,864	118,347	65,491	0	716,670
1977	2,285,441	345,485	157,785	124,067	80,271	0	649,850
1978	2,367,104	100,954	100,289	175,154	77,869	266,989	636,795
1979	2,444,600	121,359	156,965	117,023	76,737	405,374	701,909
1980	2,625,083	136,687	127,221	80,858	91,853	401,206	553,800
1981	2,841,626	149,109	138,694	83,149	136,749	522,467	751,156
1982	3,423,930	163,033	104,102	87,565	171,199	683,274	733,503
1983	3,820,804	230,061	184,814	100,470	179,903	676,566	581,741
1984	5,003,187	270,975	137,551	122,791	290,776	945,204	942,706
1985	5,053,263	329,038	198,608	176,726	329,478	897,790	1,029,507
1986	5,524,887	309,255	155,455	180,084	320,972	998,638	1,199,380
1987	5,367,429	385,773	225,418	168,888	332,967	943,114	884,895
1988	5,357,272	345,160	195,974	189,533	293,411	993,301	800,322
1989	5,837,815	232,911	355,064	173,819	290,464	1,091,108	619,648
1990	6,460,782	248,147	319,801	164,167	280,689	1,128,554	482,246
1991	6,459,713	261,456	524,734	194,068	264,274	852,504	403,357
1992	6,077,766	277,312	353,584	182,155	357,801	214,851	436,490
1993	5,299,743	277,893	415,779	135,495	260,234	5,608	313,975
1994	4,356,163	211,978	446,422	103,400	189,810	36	251,596
1995	5,512,172	284,014	477,024	120,712	251,521	0	321,578
1996	6,935,092	419,695	425,794	145,401	248,108	0	346,961
1997	6,383,626	676,262	516,853	170,961	230,380	0	376,485
1998	5,350,808	814,678	535,993	201,010	255,970	0	427,464
1999	4,543,379	734,861	584,247	225,970	266,924	4	515,728
2000	3,594,495	725,148	545,638	266,606	192,704	0	613,325
2001	3,741,296	572,720	612,945	243,772	179,558	0	531,409
2002	2,294,202	411,620	530,031	224,974	163,337	0	528,584
2003	3,249,001	401,847	624,321	235,648	152,560	0	495,085
2004	2,286,837	394,595	498,370	197,051	149,835	0	532,049
2005	2,564,408	397,378	695,513	219,663	135,267	0	571,478
2006	2,700,470	429,150	687,083	191,666	137,069	0	555,397
2007	3,171,848	342,802	803,402	200,057	151,903	0	624,375
2008	3,399,517	326,048	681,996	193,929	171,032	0	558,763
2009	3,425,306	384,337	1,065,678	228,705	174,127	0	506,038
2010	4,078,179	466,759	810,994	230,271	210,999	0	546,274

Appendix Table A8. Total foreign reconstructed catch by country for the Russian Far East, 1950 - 2010.

Year	Japan	South Korea	China	North Korea	Taiwan	Ukraine	USA
1950	363,170	0	0	0	0	0	0
1951	419,975	0	0	0	0	0	0
1952	466,780	0	0	0	0	0	0
1953	505,585	0	0	0	0	0	0
1954	555,319	0	0	0	0	0	0
1955	605,377	0	0	0	0	0	0
1956	670,608	0	0	0	0	0	0
1957	686,447	0	0	0	0	0	0
1958	92,229	0	0	0	0	0	0
1959	122,267	0	0	0	0	0	0
1960	211,011	0	0	0	0	0	0
1961	291,215	0	0	0	0	0	0
1962	262,725	0	0	0	0	0	0
1963	201,042	0	0	0	0	0	0
1964	311,188	0	0	0	0	0	0
1965	348,677	0	0	0	0	0	0
1966	417,549	0	0	0	0	0	0
1967	508,719	0	0	0	0	0	0
1968	554,198	0	0	0	0	0	0
1969	575,570	0	0	0	0	0	0
1970	568,171	0	0	0	0	0	0
1971	555,840	0	0	0	0	0	0
1972	552,604	0	0	0	0	0	0
1973	539,105	0	0	0	0	0	0
1974	528,413	0	0	0	0	0	0
1975	510,498	0	0	0	0	0	0
1976	498,614	0	0	0	0	0	0
1977	477,142	0	0	0	0	0	0
1978	470,181	0	0	0	0	0	0
1979	478,487	0	0	0	0	0	0
1980	497,229	0	0	0	0	0	0
1981	490,655	0	0	0	0	0	0
1982	479,599	0	0	0	0	0	0
1983	492,455	0	0	0	0	0	0
1984	496,815	0	0	0	0	0	0
1985	500,009	0	0	0	0	0	0
1986	516,630	0	0	0	0	0	0
1987	473,422	0	0	0	0	0	0
1988	396,588	0	0	0	0	0	0
1989	436,397	38,835	31,173	0	0	0	0
1990	535,691	89,446	33,598	200,000	0	0	0
1991	123,448	157,343	0	88,742	7,269	0	0
1992	222,600	241,726	0	60,000	7,302	0	0
1993	373,828	32,890	1,000	0	0	0	0
1994	262,525	8,000	1,000	0	0	0	0
1995	339,741	3,686	0	0	0	0	2,201
1996	291,630	64	0	0	0	0	0
1997	325,663	0	0	0	0	0	0
1998	249,308	0	2,084	16,328	0	0	0
1999	243,209	0	0	0	0	3,800	0
2000	215,763	35,600	3	0	0	0	0
2001	167,272	110,000	4	0	0	0	0
2002	161,662	66,375	6	0	0	0	0
2003	116,343	66,375	8	0	0	0	32
2004	122,750	66,375	10	0	0	0	0
2005	119,632	66,375	2,096	0	0	0	0
2006	130,700	66,375	13	0	0	0	0
2007	140,569	66,375	15	0	0	0	0
2008	151,037	66,375	17	0	0	0	0
2009	106,719	66,375	19	0	0	0	0
2010	164,831	66,375	35,450	0	0	0	0

Appendix Table A9. Total foreign reconstructed catch by type of catch for the Russian Far East, 1950 - 2010.

Year	Reported landings	Unreported landings	Discards
1950	157,900	0	205,270
1951	188,250	0	231,725
1952	208,600	0	258,180
1953	220,950	0	284,635
1954	243,325	0	311,994
1955	266,961	0	338,416
1956	304,398	0	366,210
1957	315,160	0	371,287
1958	59,652	0	32,577
1959	80,655	0	41,611
1960	141,469	0	69,542
1961	196,516	0	94,700
1962	189,674	0	73,051
1963	150,241	0	50,801
1964	251,066	0	60,121
1965	293,139	0	55,538
1966	356,595	0	60,954
1967	443,843	0	64,876
1968	488,915	0	65,283
1969	501,121	0	74,449
1970	494,310	0	73,861
1971	481,012	0	74,828
1972	478,231	0	74,372
1973	465,437	0	73,668
1974	455,524	0	72,889
1975	439,092	0	71,406
1976	428,535	0	70,078
1977	410,534	293	66,315
1978	404,584	497	65,101
1979	408,804	846	68,837
1980	417,003	1,556	78,670
1981	407,944	1,918	80,793
1982	398,720	1,996	78,883
1983	404,398	2,625	85,432
1984	404,598	3,064	89,153
1985	403,632	3,499	92,878
1986	422,128	3,137	91,365
1987	376,638	3,959	92,825
1988	345,483	191	50,914
1989	391,153	166	115,086
1990	621,220	50,000	187,515
1991	239,934	0	136,868
1992	432,000	10,600	89,028
1993	234,855	20,378	152,486
1994	127,982	14,491	129,052
1995	131,130	19,159	195,340
1996	122,042	16,085	153,567
1997	125,537	17,769	182,358
1998	111,616	35,392	120,713
1999	97,525	24,318	125,167
2000	116,946	20,756	113,664
2001	173,421	16,145	87,711
2002	103,857	16,005	108,182
2003	99,661	13,670	69,427
2004	101,146	14,113	73,875
2005	96,723	14,569	76,810
2006	98,894	14,070	84,124
2007	100,064	14,627	92,267
2008	101,735	15,284	100,409
2009	96,868	12,853	63,392
2010	103,250	37,396	126,010