Fisheries Centre

The University of British Columbia

Working Paper Series

Working Paper #2015 - 82

Reconstruction of marine fisheries catches for Subarctic Alaska, 1950-2010

Beau Doherty, Darah Gibson, Yunlei Zhai,
Ashley McCrea-Strub, Kyrstn Zylich, Dirk Zeller
and Daniel Pauly

Year: 2015

Email: b.doherty@fisheries.ubc.ca

RECONSTRUCTION OF MARINE FISHERIES CATCHES FOR SUBARCTIC ALASKA, 1950-2010

Beau Doherty, Darah Gibson, Yunlei Zhai, Ashley McCrea-Strub,
Kyrstn Zylich, Dirk Zeller and Daniel Pauly

Sea Around Us, Fisheries Centre, University of British Columbia,
2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada

b.doherty@fisheries.ubc.ca ; d.gibson@fisheries.ubc.ca ;
y.zhai@fisheries.ubc.ca; a.strub@fisheries.ubc.ca ; k.zylich@fisheries.ubc.ca ;
d.zeller@fisheries.ubc.ca ; d.pauly@fisheries.ubc.ca

ABSTRACT

This study aims to compile historic estimates of discarded and retained catches by domestic marine fisheries in the Alaskan EEZ and EEZ-equivalent waters from 1950-2010. Commercial, recreational, and foreign catch statistics were obtained from historical reports and databases from the National Oceanic and Atmospheric Administration (NOAA), Alaska Department of Fish and Game (ADFG) and the International Pacific Halibut Commission. Subsistence catches were estimated for coastal communities in Subarctic Alaska, using per capita catch rates and statewide estimates from ADFG surveys. The overall reconstructed total catches for U.S. fishing in the Alaskan EEZ and EEZ-equivalent waters increased from around 223,000 t in 1950 to 2 million tonnes by 2010 and are 1.1 times the reported landings from the National Marine Fisheries Service (NMFS) over this period, largely due to the inclusion of discards from domestic groundfish fisheries. Catches in the earlier period averaged around 200,000 $t \cdot year^{-1}$ from 1950-1975, more than half of which was composed of Pacific salmon (*Oncorhynchus* spp.) Catches increased sharply in the late 1970s and 1980s, coinciding with the establishment of joint-venture fisheries for groundfish and since 1985 have averaged around 2.4 million $t \cdot year^{-1}$, with Alaska pollock (*Theragra chalcogramma*) accounting for 43-63% of annual catch.

List of acronyms

ADFG	Alaska Department of Fish and Game
BSAI	Bering Sea and Aleutian Islands
CSIS	Community Subsistence Information System
D/L	Discards to landings ratio
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organization of the United Nations
GOA	Gulf of Alaska
IPHC	International Pacific Halibut Commission
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
RecFIN	Recreational Fisheries Information Network

TABLE OF CONTENTS

List of acronyms ii
Introduction 1
1.0 Sources of catch and reconstruction methods 2
1.1 Commercial fisheries 2
1.1.1 National statistics 2
1.1.2 Joint venture fishing 3
1.1.3 Landings reported to FAO 4
1.1.3 Foreign catches 4
1.2 Recreational fisheries 5
1.3 Commercial discards 6
1.4 Subsistence fisheries 8
1.5 Personal use 9
2.0 Results 10
2.1 Total reconstructed catch 10
2.2 Domestic commercial fisheries 10
2.3 Foreign fisheries 10
2.4 Discards from domestic commercial fisheries 10
2.5 Recreational fisheries 10
2.6 Subsistence fisheries 11
2.7 Reconstructed catch as defined by the Sea Around Us 11
3.0 Discussion 11
3.1 Limitations and recommendations 12
3.2 Conclusion 13
Acknowledgements 13
References 14
Figures 17
Appendices 27

INTRODUCTION

Alaska is the largest state in the United States by area. It is situated west of Canada and is not contiguous to the U.S. mainland (Figure 1). Purchased from Russia in 1867 (Bolkhovitinov 2003), Alaska attained statehood in 1959 and implemented its 200 nautical mile Exclusive Economic Zone (EEZ) of 3,770,000 km^2 in 1976 (Witherell and Pautzke 1997).

The marine ecosystems of Subarctic Alaska have been relatively well studied, one reason being the *Exxon Valdez* oil spill in 1989 in Prince William Sound (see contribution in Okey and Pauly (1999), and Peterson *et al.* (2003)). The other major reason is the enormous scale of the fisheries supported by these ecosystems. Thus, the commercial fisheries of Subarctic Alaska are among the largest in the world, supporting the world's largest whitefish catches (Kelleher 2005) and over 80% of U.S catches in the North Pacific over the last decade (www.st.nmfs.noaa.gov, accessed: August 24, 2013). Alaskan commercial and recreational fishing sectors generated over $4 billion in sales and provided 59,000 jobs in 2010 (NMFS 2011). Major commercially valuable species include salmon (*Oncorhynchus* spp.), crab, Alaska pollock (*Theragra chalcogramma*), Pacific halibut (*Hippoglossus stenolepsis*), king crab (*Paralithodes camtschaticus*) Pacific cod (*Gadus macrocephalus*), sablefish (*Anaplopoma fimbria*) and rockfish (*Sebastes* spp.)[1].

Due to its high-latitude location, growing seasons are short and food is generally shipped from outside. Food shipments can be expensive and sometimes difficult to obtain for more rural communities, making subsistence fishing and hunting for game an essential part of rural living (Buklis 2002). Subsistence fishing in Alaska is defined as 'non-commercial, customary, and traditional uses' (www.adfg.alaska.gov) and include catches used for take-home consumption, trade, and bartering[2]. The five species of Pacific salmon, in particular, play an important role in subsistence fisheries (Wertheimer 1997; Fall *et al.* 2013b).

Historically, Japan, Russia, South Korea, Poland, Canada, Germany and Taiwan have all fished in Alaskan waters, targeting mainly Alaska pollock and other groundfish species (e.g. flatfish, rockfish and Pacific cod). Japan and Russia, however, have had the greatest presence and Japanese vessels have fished off the Alaska coast as early as 1930 (Bakkala *et al.* 1979; Miles *et al.* 1982; Finley 2011). During World War II, Japan's once leading offshore fishery fleet was destroyed (Bakkala *et al.* 1979; Scheiber 1989). After the war, the U.S. subsidized fleet expansion for Japanese fleets, enabling greater access to the Pacific high seas as part of peace treaties (Scheiber 1989). Catches were highest during the 1970s with annual catches of 1-2 million tonnes (Miles *et al.* 1982; Queirolo *et al.* 1995). In addition, the Alaskan and Russian EEZs surround a high seas enclosure area known as the 'donut hole', where Alaska pollock was heavily fished by foreign fleets in the 1980s (Bonfil *et al.* 1998; Bailey 2011).

Although catch records exist for the various fisheries in Alaskan waters, there is no comprehensive report or database that encompasses all fisheries sectors from 1950-2010. The purpose of this report is to provide an estimate of the total marine fisheries catches for Alaska from 1950 to 2010; accounting for all sources of withdrawals from marine fisheries (e.g., retained catch and discards) and different subsectors (e.g., subsistence, recreational and commercial fisheries).

[1] In the following, we abstain from providing scientific names for all of the fish and other taxa we mention, as common names of fisheries resources in the U.S. are well standardized. If in doubt, see www.fishbase.org or www.sealifebase.org.

[2] See also www.afsc.noaa.gov/REFM/Socioeconomics/Projects/CPU.php

1.0 Sources of catch data and reconstruction methods

Total marine fisheries catches within Alaska's EEZ or EEZ-equivalent waters were estimated from 1950 to 2010 using commercial landings data from the National Marine Fisheries Service (NMFS) as a reporting baseline. Additional sources of catch in the form of recreational, subsistence, discards and joint venture catches were compiled from historical data from the National Oceanic and Atmospheric Administration (NOAA), the Alaska Department of Fish and Game (ADFG), the International Pacific Halibut Commission (IPHC) and other reports on Alaskan fisheries. The FAO data were assumed to represent only commercial landings, and estimates of other sectors (e.g., subsistence and recreational) and discards were added to create the total catch estimate from 1950 to 2010. We also compiled estimates of foreign catches in Alaska from 1953-1987 from historical reports (Forrester *et al.* 1978; Otto 1981; Miles *et al.* 1982; Berger *et al.* 1986; Berger *et al.* 1987; Berger *et al.* 1988; Berger and Weikart 1988, 1989; Queirolo *et al.* 1995).

1.1 Commercial fisheries

1.1.1 National statistics

Complete time series from 1950-2010 of commercial catches in Alaska by gear type are publicly available from NOAA's website (www.st.nmfs.noaa.gov, accessed: August 24, 2013) and were used to reconstruct commercial landings. We removed all freshwater taxa (including rainbow trout) as well as marine mammals, reptiles, amphibians, coral, roe and seaweeds, since these taxa are not included in the *Sea Around Us* global catch database. However, we do include all sea-run salmon catch. Additionally, Atlantic herring (*Clupea harengus*) and Atlantic jackknife clam (*Enis directus*) are listed in the NMFS landings database for earlier years for Alaska, although they do not occur in Pacific waters. Based on catch data reported in other years in the database, it was inferred that these catches were misidentified and were reassigned as Pacific herring (*Clupea pallasii*) and Pacific razor clam (*Siliqua patula*). Otherwise, commercial landings by Alaska's domestic fleet were assumed completely reported in the NMFS statistics and marine finfish catches were included in the reconstructed catch database without adjustment.

Data caveats from the NMFS website (www.st.nmfs.noaa.gov/commercial-fisheries/commercial-landings/data-caveats/index) indicate that catch statistics are reported in round weights, with the exception of univalve and bivalve molluscs, which are reported as "pounds of meat" (i.e., excluding the weight of the shells). An adjustment was made to commercial shellfish harvests to convert shellfish weights to 'wet weight'. We use the same conversion factors as Doherty *et al.* (2015) for adjustments to NMFS shellfish catches for reconstructed catches on the U.S. West Coast (Table 1). Conversion factors for snails were calculated from Crapo *et al.* (2004). For unidentified species (40% of NMFS shellfish catch) we assumed a conversion factor of 2, assuming a meat yield of 50%.

Table 1: Conversion factors for shellfish from meat weight to full wet weight, adapted from Crapo *et al.* (2004); Doherty *et al.* (2015).

Original NMFS name	Scientific name	Factor
Abalones	*Haliotis* spp.	2.5
Blue mussel	*Mytilus edulis*	3.8
Butter clam	*Saxidomus gigantean*	2.7
Pacific littleneck clam	*Leukoma staminea*	2.7
Nuttall cockle	*Clinocardium nuttallii*	2.4
Pacific oyster	*Crassostrea gigas*	7.1
Olympia oyster	*Ostrea conchaphila*	7.1
Pacific geoduck clam	*Panopea generosa*	3.0
Clams or bivalves	Bivalvia	2.7
Pacific razor clam	*Siliqua patula*	2.3
Weathervane scallop	*Patinopecten caurinus*	8.2
Atlantic jackknife clam	*Siliqua patula*	2.3
Sea scallop	Pectinidae	8.2
Shellfish	Miscellaneous marine molluscs	2.0
Snails	Gastropoda	3.6

1.1.2 Joint venture fishing and phase-out of foreign fishing

Following the establishment of the Alaskan EEZ along with the passing of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) in 1976 (Witherell and Pautzke 1997), foreign fishing was slowly phased out of Alaskan waters.

During this period, the U.S. did not yet have enough off-shore processing capacity to processfish caught in their EEZ and joint ventures between the U.S. and foreign countries (e.g., Japan, Russia, South Korea, Canada, Poland and China) were established (Table 2). Quotas for foreign countries participating in the joint venture fishery were decided based on each countries' role in the development of U.S. fisheries (Witherell and Pautzke 1997). Domestic vessels would catch the fish and transport it to foreign vessels for off-shore processing (Queirolo *et al.* 1995). These catches were considered domestic and included in the reconstructed commercial totals for Alaska.

Table 2: Joint venture catches (t) in the Bering Sea and Aleutian Islands (BSAI) and Gulf of Alaska (GOA) (Queirolo *et al.* 1995).

Year	BSAI	GOA
1978		49
1979		1,518
1980	33,390	1,988
1981	79,853	16,974
1982	109,422	74,456
1983	212,215	143,424
1984	358,679	220,431
1985	641,327	247,569
1986	1,162,743	65,435
1987	1,358,300	33,188
1988	1,304,648	4,023
1989	535,733	
1990	124,426	

1.1.3 Landings reported to FAO

We compared the NMFS domestic commercial landings and joint venture landings with the data reported to the FAO on behalf of the U.S. (FAO 2012) for areas in the Pacific Ocean. To our knowledge, the data reported to FAO represents only commercial landings and does not include catch from recreational fisheries or discards (Garibaldi 2012). FAO areas 77 (Pacific, Western Central) and 67 (Pacific, Northeast) include the EEZs of Hawaii, California, Oregon, Washington and Alaska and landings reported for these areas were assumed to consist of the data reported by NMFS for these states. These landings make up the majority of U.S. catch (96%) in the Pacific Ocean that are reported to FAO. The other 4% occur in FAO areas 71 (Pacific, Western Central), 81 (Pacific, Southwest) and 87 (Pacific, Southeast) and consist exclusively of tuna (mostly skipjack, yellowfin, albacore, and bigeye). As the current reconstruction focuses on domestic landings within the Alaskan EEZ, we excluded the landings from off-shore tuna fishing fleets (they are considered elsewhere).

FAO area 67 includes Northern California, Oregon, Washington and Alaska. Since we did not have landings for California separated by North and South, it is difficult to make a direct comparison of NMFS commercial landings by state with the data reported to FAO. This was attempted by comparing NMFS landings for Oregon, Washington and Alaska and joint venture catches in Alaska with FAO landings for area 67 (Figure 2). Based on this comparison, the sum of NMFS commercial landings and joint venture catches (Queirolo *et al.* 1995) are within 1% of what is reported by the FAO for most years (Table 3).

Table 3 - Comparison of FAO landings for Area 67 with NMFS commercial database and joint venture landings for years 1950-2010.

Data Source	Area/State	Total landings (10^6 t)	Annual % difference for years 1950-2010[a]			
			Min.	Max.	Average	Median
FAO	Area 67 - Northern California, Oregon Washington and Alaska	80.0	-35	14	-1	1
NMFS; Queirolo *et al.* (1995)	Oregon, Washington, and Alaska	78.4				

[a] Calculated as the difference between the two data sources, divided by the sum of NMFS and Joint Venture landings in a given year

1.1.3 Foreign catches

Japanese foreign vessels have fished in Alaskan territorial waters since the 1930s, however their deep-sea fishery was destroyed during WWII (Bakkala *et al.* 1979). The Japanese king crab and Alaska pollock fisheries returned to the Eastern Bering Sea in 1953 and 1954, respectively (Bakkala *et al.* 1979; Miles *et al.* 1982). Russia commercial groundfish fisheries in Alaska began in 1958, followed by South Korea (1968), Poland (1973), Taiwan (1974), Mexico (1979) and Germany (1980) (Bakkala *et al.* 1979; Berger *et al.* 1986). Canadian vessels also fished for Pacific halibut in Alaska waters starting in 1956 (Forrester *et al.* 1978; Miles *et al.* 1982).

Catch data were compiled from various reports to reconstruct foreign catches in the Bering Sea and Aleutian Islands (BSAI) and the Gulf of Alaska (GOA):

- 1954-1970 landings of groundfish, shrimp and herring in BSAI are from Forrester *et al.* (1978) and 1971 landings are from Miles *et al.* (1982)
- 1953-1974 landings of king crabs are from Otto (1981)
- 1960-1971 landings of all species in GOA and for South Korea in BSAI are from Miles *et al.* (1982)
- 1972-1987 landings for all other species in BSAI and GOA are compiled from Berger *et al.* (1986); Berger *et al.* (1987); Berger *et al.* (1988); Berger and Weikart (1988); Queirolo *et al.* (1995)

It should be noted that the reliability of some reported foreign data has been questioned, particularly prior to the 1980s when observer coverage was limited (Megrey and Wespestad 1990; Queirolo *et al.* 1995). We thus suggest that these are minimal catches.

Following the implementation of the Alaskan EEZ in 1976 (Witherell and Pautzke 1997), foreign fishing was phased out of Alaskan waters (Holland and Ginter 2001; Mansfield 2001). During this period, many foreign fisheries began fishing for pollock in a high seas area surrounded by the U.S. and Russian waters known as the 'donut hole' (Figure 1) (Ianelli *et al.* 2006; Bailey 2011).

Table 4. Pollock catches from the 'donut hole' by foreign vessels (Ianelli *et al.* 2006)

Year	Pollock catches and discards from the 'donut hole' (t)
1984	181,200
1985	363,400
1986	1,039,800
1987	1,326,300
1988	1,395,900
1989	1,447,600
1990	917,400
1991	293,400
1992	10,000
1993	1,957

These foreign catches are not included in the reconstructed domestic catches for Alaska, but are discussed throughout for completeness. It is assumed that landings by foreign countries are reported to FAO and thus these totals are not included in the Alaska reconstruction to avoid double-counting.

1.2 Recreational fisheries

The Alaska Department of Fish and Game has conducted statewide estimates of recreational "catch" (retained catch and discarded catch) and "harvest" (retained catch) since 1977; recorded as the number of individual fish for different species. Data from these statewide surveys were compiled from historical reports (Mills 1986; Howe *et al.* 1996) and data readily available on the ADFG website (www.adfg.alaska.gov/sf/sportfishingsurvey), and were converted into fish weights (Table 5). We included only marine species in our estimates and excluded species more commonly found in freshwater such as rainbow trout, arctic grayling, whitefish, sheefish, burbot, brook trout, lake trout, kokanee and other land-locked salmon. These data were used to reconstruct recreational catch from 1977-2010.

Table 5 – Conversion factors used to convert recreational catch from 1977-2010 ADFG surveys from numbers of individuals into weight.

Taxa	Kg·fish^{-1}	Source
Chinook salmon	13.6	1
Coho salmon	4.5	1
Sockeye salmon	2.7	1
Pink salmon	1.9	1
Chum salmon	5.2	1
Cutthroat trout	1.6	2
Dolly Varden	1.4	3
Smelt	0.2	4
Shark	2.2	4
Rockfish	1.1	4
Lingcod	3.7	4
Pacific cod	2.3	5
Sablefish	0.6	4
Razor clams	0.09	6
Other fish	1.0	4

Sources: 1. Average range from species information provided on ADFG website (www.adfg.alaska.gov/index.cfm?adfg=animals.listfish), 2. Behnke *et al.* (2002), 3. Estimated based on information from recreational fishing websites, 4. Estimated based on average weights recorded in the Recreational Fisheries Information Network (www.recfin.org) 5. Clark (1960), 6. Hirschhorn (1962)

Recreational catch estimates for Pacific halibut in Alaska are available from the International Pacific Halibut Commission since 1977 (Williams 2012) and were used to reconstruct recreational catch from 1977-2010, converting net weights into round weights using a conversion factor of 1.3. Skud (1975) provides estimates of

recreational catch for 1973-1975 in numbers of fish, which were converted into weights using a conversion of 7.1 kg·fish^{-1} (Skud 1975)

Due to the lack of data prior to 1977, the numbers of fishing licenses issued in Alaska from 1950-1976 (wsfrprograms.fws.gov) was used as a proxy for annual fishing effort. We calculated the average annual amount of fish caught per license per year from 1977-1981. This ratio was then used to estimate the recreational catch from 1950-1976. We used the average annual catch of halibut per license from 1973-1975 to estimate halibut catch from 1950-1972, and the average annual catch from 1975 and 1977 to estimate halibut catch in 1976.

1.3 Commercial discards

Discarded bycatch from Alaskan groundfish fisheries has been relatively well documented since 1990. Historical discard estimates for domestic groundfish fisheries are available on NOAA's website (alaskafisheries.noaa.gov/sustainablefisheries/catchstats.htm) from 1990-2010 (excluding 1992) and in Queirolo *et al.* (1995) from 1990-1994. These include discards from the Bering Sea and Aleutian Islands (BSAI) and Gulf of Alaska (GOA) groundfish fisheries. Discard estimates from Queirolo *et al.* (1995) since 1991 incorporate both observer data and vessel data in a 'blend' model. The data in Queirolo *et al.* (1995) are considered the best estimates of discards for domestic fisheries from 1990-1994 and were included in the reconstructed database. The historical reports from NOAA's website were used to reconstruct domestic discards from 1995-2010.

Total retained catch and discards are aggregated in Queirolo *et al.* (1995) data for joint venture fisheries. The focus of data collection for these fisheries was on estimating the total removals, and there is limited data to distinguish between the discarded and retained components (Queirolo *et al.* 1995). This exercise is attempted here in order to facilitate the comparison of commercial landings and discards in the *Sea Around Us* global catch database. The discard component of joint venture catch was estimated using the average annual discard rates and species composition for domestic fisheries in BSAI and GOA from 1990-1994 (Table 6). We also assumed that all catches of Pacific halibut, King crab, tanner crabs, and Pacific herring were discarded, as retention of these species was prohibited (Queirolo *et al.* 1995).

Table 6 – Average annual discard rates (100*discards/total catch) and species composition for domestic fisheries from 1990-1994 (Queirolo *et al.* 1995)

	GOA	BSAI
Discard rate:	**19.2**	**14.5**
Species Composition (%):		
Atka mackerel	0.5	3
Pacific cod	6.8	9
Pollock	20.8	45
Rockfish	10.5	2
Sablefish	1.6	0
Flatfish	51.1	33
Other species	8.9	9

The above data sources include estimates of discards for all joint venture fisheries and the majority of domestic catches by groundfish fisheries in Alaska. Discard data were unavailable for the smaller tonnages landed by the domestic fishery prior to 1990 and these discards were estimated using information from Queirolo *et al.* (1995) (Table 7).

Table 7 - Major fisheries in Alaska for which discard estimates were provided

Fishery	Target species	Gear types	Year	Source
Salmon	Chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), pink (*O. gorbuscha*) and sockeye salmon (*O.nerka*)	Trolling, gill nets	1989-2010	ADFG discard database, unpub data, provided by Cathy Tide
Groundfish trawl	Flatfishes (Pleuronectiformes), rockfishes (*Sebastes spp.*), Atka mackerel (*Pleurogrammus monopterygius),* Pacific cod (*Gadus macrocephalus*) and sablefish (*Anoplopoma fimbria*)	Bottom Trawls	1950 - 1989	Estimated using D/L ratios from Queirolo *et al.* (1995)
Pollock	Alaska pollock (*Theragra chalcogramma*)	Midwater trawls	1990-1994	Queirolo *et al.* (1995)
Pacific cod	Pacific cod (*Gadus macrocephalus*)	Hook and line	1995-2010	NOAA discard reports

Discard data were not readily available prior to 1990 for domestic groundfish fisheries in Alaska and historical discard data from NOAA were not available to us separated by gear type or by fishery for most years. We used NMFS discard data from 1991-1994 from Queirolo *et al.* (1995) that summarizes discards by gear types and fisheries to estimate discard to landing (D/L) ratios. D/L ratios were calculated as follows:

D/L ratio = Total discarded weight/Landed weight of target species

D/L ratios were calculated for the Alaska pollock trawl fishery, the groundfish trawl fishery and the Pacific cod hook and line fishery for 1991-1994 (Table 8). The average D/L ratio was then applied to NMFS commercial landings data of corresponding gear types for all applicable years from 1950-1989. Given that discard rates by groundfish fisheries have decreased over time (Witherell *et al.* 2000; AMCC 2009), this approach likely underestimates true discards. Species composition will also have changed over this period and estimates should be considered approximate.

Table 8: Discards to landings (D/L) ratios for major Alaskan fisheries from 1991-1994 (Queirolo *et al.* 1995)

Fishery	Alaska pollock trawl	Groundfish trawl	Pacific cod hook and line
Average D/L ratio	**0.05**	**0.46**	**0.18**
Average species composition of discards by weight (%)			
Alaska pollock	68.5	28.7	15.5
Arrowtooth Flounder	4.4	10.7	9.5
Greenland turbot	0.2	0.2	2.0
Rock sole	4.8	13.5	0.1
Yellowfin sole	1.0	14.5	0.3
Other flatfish	5.1	9.9	1.4
Atka Mackerel	0.1	4.2	0.1
Pacific cod	11.6	7.6	17.9
Rockfish	0.4	3.9	1.2
Sablefish	<0.1	0.2	0.2
Others	4.0	6.5	51.8

The Alaska pollock and Pacific cod fisheries target single species and thus calculations of discards were straightforward, multiplying D/L ratios by landings of Alaska pollock by midwater trawl and of Pacific cod by hook and line. Calculations for the groundfish trawl fishery were more complex as it is a multi-species fishery. Given the information available in NMFS landing database, it was not possible to differentiate between target landings and landed bycatch from the different target fisheries (e.g., shallow flatfish trawl, rockfish trawl, deepwater flatfish

trawl, etc.) defined by NMFS (Queirolo et al. 1995). Therefore, these fisheries were combined into a 'groundfish trawl fishery' to estimate discards for 1950-1989. We assumed all flatfish, rockfish, Pacific cod and sablefish that were landed by bottom trawling were targeted catch of the groundfish trawl fishery. The D/L ratio (Table 8) for the groundfish trawl fishery was then multiplied by NMFS commercial landings of these species by bottom trawl gear to estimate total discards prior to 1990.
Discards for Alaska's salmon fishery were obtained through a data request from ADFG, and kindly provided by Ms. Cathy Tide. These data include discarded, confiscated and forfeited fish and are almost exclusively salmon. We did not estimate salmon discards for the earlier period because ADFG discarded tonnages in the salmon targeted fishery were low most years. More detailed reports by the Pacific Salmon Commission (PSC 2011) estimate total mortality for Chinook salmon and may be considered in future investigation of Alaskan fisheries' discards.

1.4 Subsistence fisheries

Subsistence fisheries in Alaska are defined as non-commercial catch used for customary and traditional uses[3] (www.adfg.alaska.gov). Salmon subsistence estimates for the state of Alaska are available from 1994-2010, but there are very few annual estimates for other finfish and marine invertebrates (Fall *et al.* 2013b). Salmon catch estimates are presented as the total number of fish for different species of Pacific salmon: Chinook (*Oncorhynchus tshawytscha*), Chum (*O. keta*), Coho (*O. kisutch*), Pink (*O. gorbuscha*), Sockeye (*O. nerka*) and were converted into weights using conversions in Table 5

We also estimated catch of non-salmon fish, marine invertebrates and salmon from 1950-2010 using information from the Alaska Department of Fish and Game (ADFG) community subsistence information system (CSIS), with survey data for subsistence fisheries for 235 select rural communities since the 1960s.

We selected 124 communities (Appendix 1) which were deemed coastal and in FAO area 67[4] (see Figure 1). The CSIS data for these 124 communities were sorted into 3 hierarchal resource categories with data for select years between 1973 and 2011;

- Salmon – Catch estimates for 1973, 1980-1994, 1996-2000, 2003-2011;
- Non-salmon fish – Catch estimates for 1980-1994, 1996-2000, 2003-2008, 2010-2011; and
- Marine invertebrates - Catch estimates for 1982-1994, 1996-2000, 2003-2008, 2010-2011.

We reconstructed marine subsistence fisheries for these 124 communities using *per capita* catch rates for the 3 major resource categories, the methods of which are outlined in Table 9. These estimates are conservative given that many communities were excluded for reasons given in Table 9.

Table 9 - Methods used to estimate Subarctic Alaska subsistence catch from 1950-2010.

1) Compose list of coastal communities: Salt water subsistence catches were estimated for 124 coastal communities, which were selected based on the following criteria:

- At least one year of subsistence data for marine species were available in ADFG's CSIS, either as an estimated catch amount (edible pounds) or a household participation rate;
- Listed in the community index (ACMP 2011) of the former Alaska Coastal Management Program (ACMP)[a] and in close proximity to the coast[b];
- Had population data and a clearly defined geographic region;
- Located in FAO Area 67, South of 65^{0}35' N, 168^{0}06' W.

2) Develop population time series from 1950-2010: Population data were available for most of the 124 coastal communities for 1950, 1960, 1970, 1980, 1990, 2000 and 2010 (www.commerce.alaska.gov). Linear interpolations were used to fill in gaps and produce a complete time series (Figure 3).

[3] These uses include: "direct personal or family consumption as food, shelters, fuel, clothing, tools or transportation for the making and selling of handicraft articles out of nonedible by-products of fish and wildlife resources taken for personal or family consumption, and for the customary trade, barter, or sharing for personal or family consumption (AS 16.05.940[32]) " (www.adfg.alaska.gov).
[4] Subsistence fisheries for Arctic communities in FAO area 18 have been previously estimated by Booth and Zeller (2008); see also Booth *et al.* (2008) and Zeller *et al.* (2011a).

3) Removal of freshwater taxa and convert CSIS catch estimates to round weight: Freshwater taxa[c] were removed from estimated catches. Estimated catches in the CSIS data are given in pounds of edible weight, typically the weight of the resource once the head, viscera and bones are removed (Garret Zimpelman, ADFG, pers. comm.), and were converted back to round weights using average yields from (Crapo *et al.* 2004; see Appendix 2).

4) Estimate *per capita* subsistence rates: With the exception of 9 communities, salmon, non-salmon fish or marine invertebrates catch estimates were available for at least one year for each community between 1973 and 2011. Annual *per capita* catch rates for each community were estimated for the 1973-2010 period using interpolations to estimate *per capita* catch rates between years surveyed. The earliest *per capita* catch rate was kept constant for prior years dating back to 1950, while the most recent *per capita* catch rate was carried forward for later years up until 2010. A constant *per capita* catch rate was used for communities with only 1 year of catch estimates. We used the average *per capita* catch rates for major resource groups from communities with data to generate catch estimates for those communities without (Appendix 1).

5) Estimate annual subsistence catch for each community from 1950-2010: Annual *per capita* rates for salmon, non-salmon fish and marine invertebrates were multiplied by annual populations for each community to generate annual subsistence catch estimates.

6) Taxonomic breakdown: The subsistence catch estimates for salmon, non-salmon fish and marine invertebrates were further disaggregated into 64 taxonomic groups (5 for salmon, 36 for non-salmon fish, and 23 for marine invertebrates). Taxonomic breakdowns for marine invertebrates and non-salmon fish were estimated based on the average catch composition of taxa in the total CSIS subsistence catch, for all the coastal communities included in our analysis from 1973-2011. Salmon composition is based on the historic average from 1994-2010 Fall *et al.* (2013b) , after converting numbers of fish into weight (Appendix 2).

Notes:

[a] Exceptions to this included the census-designated places (CDPs) of Fritz creek, Game creek, Kenny Lake and the Kodiak Coast Guard Station. These communities are not listed in the ACMP, but do catch marine species.

[b] The majority of communities selected (103) were within 25 km of the coast. Another 21 communities were also included, ranging from 30-170 km from the coast, because the CSIS data indicated that salmon (*Oncorhynchus* spp.) composed a large component of their subsistence catch.

[c] For communities located within 25 km of the coast, we included all diadromous species. For communities located further then 25 km from the Alaskan coastline we included only the salmon resource category, as most salmon are from ocean-run populations (Appendix 1).

We compared our 1999-2010 subsistence estimates of salmon catches from these 124 communities with those for the same communities in ADFG annual reports (Fall *et al.* 2001; Fall *et al.* 2002; Fall *et al.* 2003a; Fall *et al.* 2003b; Brown *et al.* 2005; Fall *et al.* 2007a; Fall *et al.* 2007b; Fall *et al.* 2009a; Fall *et al.* 2009b; Fall *et al.* 2011; Fall *et al.* 2012; Fall *et al.* 2013a; Fall *et al.* 2013b) .Our annual salmon estimates for this period were on average about 10% higher than the more comprehensive estimates by ADFG for the same communities. To account for this, as well as additional communities not included in our estimate, we then compared our annual totals with total subsistence harvests by ADFG from 1999-2010 (Fall *et al.* 2013b), that include an additional 227 communities[5]. On average our estimates are about 50% of the total ADFG estimate and thus we increased our salmon estimates by a factor of 2 from 1950-1993 and used ADFG subsistence salmon estimates from 1994-2010.

1.5 Personal use

In Alaska, 'personal use' is defined as the "the taking of fish by Alaskan residents for personal use and not for sale or barter, with gill or dip net, seine, fish wheel, long line, or other means defined by the Board of Fisheries" (www.adfg.alaska.gov). Personal use fishing in Alaska requires the fisher to purchase a sport fishing license. Thus, we assume personal use catches are reported along with recreational statistics.

5 We exclude the 15 communities in the Arctic that were included in reconstructed estimates for Arctic Alaska by Booth and Zeller (2008): Wales, Shishmaref, Deering, Buckland, Selawik, Kotzebue, Noatak, Kivalina, Point Hope, Point Lay, Wainwright, Barrow, Atqasuk, Nuiqsut, Kaktovok.

2.0 RESULTS

2.1 Reconstructed total catch

The reconstructed total catch increases from nearly 223,000 t in 1950 to just over 2 million t in 2010 (Figure 4a). The catch averaged around 200,000 t·year^{-1} from 1950-1975 (Figure 4a). There is a sharp increase in catch in the mid-1980s, after which annual catches average around 2.4 million t·year^{-1} (Figure 4a), and peaked at nearly 3 million t in 1992. The increase in catch coincides with the beginning of joint ventures in the Alaska pollock fishery.

Strictly domestic commercial landings constitute 84% of the total reconstructed catch, with retained catches from joint ventures and commercial discards contributing an additional 7.75% each (Figure 4a). Reconstructed subsistence and recreational catches represented 0.4% and 0.3%, respectively, of the total reconstructed catch (Figure 4b).

Alaska pollock contributes nearly half of the total reconstructed Alaskan catch from 1950-2010 (Figure 5). However, the large presence of Alaska pollock does not begin until the mid-1980s, increasing from about 13,000 t in 1980 to over 666,000 t in 1985. Pacific cod, pink salmon and sockeye salmon also make a notable contribution to the reconstruction, comprising 9%, 7%, and 6%, respectively (Figure 5). Pacific salmon species make up a much larger portion of commercial catch in the earlier time period, comprising 55% of the reconstructed total catch from 1950-1975. Other prominent taxa in catches in the earlier time period include Pacific herring, king crab and Pacific halibut.

2.2 Domestic commercial fisheries

Domestic commercial fisheries, including catch from joint venture agreements, but excluding discards, were estimated to have landed catches of over 67.6 million t during the 1950-2010 period (Figure 6). Alaska pollock contributed 50% of the commercial catch during this time, followed by Pacific cod, with 9%. U.S. commercial catches in Alaska increased dramatically in the mid-1980s due to the replacement of foreign fleets following the establishment of the EEZ. The average annual commercial landings from 1950-1975 were less than 200,000 t·year^{-1}, after which catches increased rapidly, rising to nearly 1.3 million t by 1985 (Figure 6). Catches since 1987 have remained high, averaging about 2.3 million t·year^{-1} (Figure 6).

2.3 Foreign fisheries

Over the period of 1953-1987, we estimated that foreign vessels fishing in Alaskan waters removed nearly 38 million t (Figure 7), with 34.5 million t coming from the Bering Sea and Aleutian Islands and 3.5 million t from the Gulf of Alaska (Figure 8). The majority of catches were by Japanese and Russian fishing vessels, and Alaska pollock accounted for most of the catch, 66% of catches in Bering Sea and Aleutian Islands and 35% of catches in the Gulf of Alaska (Figure 8).

2.4 Discards from domestic commercial fisheries

We estimate 5.7 million t of fisheries discards between 1950-2010, 1 million t of which were from joint venture catches (Figure 9). Pollock comprises the largest portion of discards (34%) over the time period. A variety of flatfish species also make up a large portion of the discards and are common bycatch in the groundfish trawl fishery. Discards prior to 1980 are small compared to the later time period, as there was much less industrial trawling for groundfish at this time (Figure 9).

2.5 Recreational fisheries

Total estimated recreational catches from 1950-2010 were 207,000 t (Figure 10). The 3 species that contributed the most to these catches were Pacific halibut (*Hippoglossus stenolepis*) with 51% of total catch, coho (20%), and chinook salmon (16%). Recreational catches have steadily increased from about 160 t in 1950 to a peak of nearly 11,000 t in 2005 (Figure 10).

2.6 Subsistence fisheries

Total reconstructed subsistence catches from 1950-2010 are 294,000 t (Figure 11). Chinook contributed 32% of the catch, and chum, sockeye, coho and pink salmon 22%, 13%, 7% and 2%, respectively. Other important taxa included Pacific herring (8%), Pacific halibut (4%) and butter clams (2%). Subsistence catch estimates steadily increased from 2,600 t in 1950 to around 6,000 t·year^{-1} in the early 1990s and have remained at this level since (Figure 11).

2.7 Sectoral catch as defined by the Sea Around Us

The *Sea Around Us* uses the following fishing sectors in its global catch database: 'industrial' (i.e., large-scale commercial), 'artisanal' (i.e., small-scale commercial), 'subsistence' (i.e., small-scale non-commercial with primary purpose being self- or family-consumption), and 'recreational' (i.e., small-scale non-commercial with primary purpose being pleasure). As the reconstruction for Subarctic Alaska as outlined above used 'commercial' as a sectoral data label, a subsequent split of 'commercial' catches was required to assign these catches to one of the two commercial sectors as defined by the *Sea Around Us* (Figure 12), to allow for international comparisons. Commercial catch was divided into artisanal and industrial sectors based on gear types listed in the NMFS commercial landings data. Using the definitions of the *Sea Around Us*, catches from towed gears such as trawls, dredges and purse seines were labelled as industrial, while all other commercial landings were labeled artisanal. Thus, vessel size, which is commonly used for definition of 'artisanal' is not used here.

Note that this sectoral assignment of 'commercial fisheries' is approximate and indicative only, and non-binding in any form, as no legal definition of 'industrial' or 'artisanal' appears to exist in the U.S. These sectoral assignments suggest that 'industrial' retained catches accounted for 69% of total reconstructed catches from 1950-2010, 'artisanal' for 22%, discards for 8% and recreational and subsistence combined for 0.7% (Figure 12). Overall, the total reconstructed catches from 1950-2010 were 1.1 times the sum of the commercial landings reported by NMFS and joint venture catches.

3.0 DISCUSSION

The reconstructed total domestic catches for Alaska from 1950-2010 are 73 million t, i.e., 5 million t more than what is included in the NMFS commercial landings data and joint venture catches (Queirolo et al. 1995), which we assume are the basis for FAO Area 67 data for Alaska (Figure 2). The major part of this difference is due to the inclusion of discards from domestic groundfish fisheries, particularly since the operation of the industrial pollock fishery in the late 1980s.

Based on the comparison of NMFS, FAO and joint venture data (Figure 2), we suspect that discards from joint ventures may actually be included in the Alaska data for FAO, despite their database generally not including discards (Garibaldi 2012). Data collection for foreign and joint venture fisheries in Alaska has historically focussed on recording total catch and there is limited information to distinguish between their retained and discarded components (Queirolo et al. 1995).

Annual statewide surveys and catch estimates have been conducted by ADFG and the IPHC for recreational fisheries since 1977. We used these estimates and reconstructed recreational catch for earlier years, when there was much less recreational fishing effort (Mills 1980), adding an additional 10,000 t to what was estimated by the ADFG and IPHC for 1977-2010.

Alaska is one of the few areas in the world where detailed data collection of small-scale subsistence fisheries is performed; indeed, the ADFG has conducted surveys of subsistence fisheries in over 200 select rural communities since the 1960s. We used *per capita* catch rates and annual catch estimates from ADFG to estimate catch of fish and marine invertebrates from coastal communities in Subarctic Alaska. These estimates, along with those by Booth and Zeller (2008) for Arctic Alaska, are among the first to attempt estimating the extent of historic subsistence fisheries in coastal Alaska (see also Mathews *et al.* 1990; Zeller *et al.* 2011a).

Discards and retained catch from commercial groundfish fisheries are well-documented in Alaska and estimates of both are available since the 1980s. We included additional estimates of discards for a small amount of groundfish landings from domestic fisheries prior to 1990, before most groundfish trawl fisheries were in operation and where data was not available.

Similarly to the U.S. West Coast (Doherty *et al.* 2015), Alaska has extensive sources of data collection at the state and federal level, much of which is easily accessible online. Additional data were readily shared by ADFG, further adding to the transparency of official catch statistics in the U.S. For this transparency and openness, Alaska state and U.S. federal agencies deserve clear recognition, as this is not the case for many countries and associated data agencies around the world (e.g., see Zeller *et al.* (2011b). It is clear that recording and disseminating accurate catch data are a priority.

3.1 Limitations and recommendations

We were not able to provide estimates of uncertainty for the reconstructed totals, as error estimates are unavailable for most of the catch statistics used, including those reported by the FAO. Over 96% of the overall reconstructed domestic catches are from discard and landings estimates compiled from the NMFS commercial landings data (84%), Queirolo *et al.* (1995) Joint ventures and discards (9%) and NOAA discard reports from 1995-2010 (3%), for which we believe there is greater accuracy. There is greater uncertainty with recreational and subsistence catch estimates (0.7% of total catch) and domestic discards from 1950-1989 (0.6% of total catch).

Despite the low proportion of total catch, recreational and subsistence fisheries do account for important proportions of Pacific halibut and salmon catches in Alaska. Recreational catches (excluding halibut) from 1977-2010 and subsistence catches of salmon from 1994-2010 were compiled from statewide surveys from ADFG, believed to be reasonably accurate. There is, however, some uncertainty associated with converting these estimates from numbers of individuals into weights (Table 5). Future efforts might use specific annual weight conversions for different years and areas to better estimate the error associated with these conversions. Pacific halibut catches, in weights, were taken from IPHC estimates from 1977-2010. Estimates of recreational catches from 1950-1976 account for 5% of the total recreational catch and are approximate, given the limited data during this time. Alaska recreational estimates do not include any marine invertebrates (except for Pacific razor clams). Since recreational catches of molluscs and crustaceans are substantial on the U.S. West Coast (Doherty et al. 2014) and in Alaska's subsistence fisheries, these catches may warrant consideration in future improvements to this work.

The detail and precision of data quality for foreign, joint venture and domestic commercial fisheries has generally increased over time (Queirolo *et al.* 1995). Estimates of retained and discarded catches from joint ventures (since the 1980s) are based on a combination of observer estimates and vessel catch reports. The focus was on recording the total catch, and there is no data on the proportions that were discarded and retained prior to 1990 (Queirolo *et al.* 1995). Assumptions were used to estimate the portion that was discarded and retained during this period and are approximate. This accounted for discards from joint venture fisheries but we did not find discard data for domestic fisheries prior to 1990 and we estimated these based on discard rates for various fisheries in later years. These estimates should be taken as preliminary and are likely an underestimate given that significant reductions (Witherell *et al.* 2000) have occurred in the discard rates of Alaskan groundfish fisheries. Changes to these discard rates will not dramatically change our results, as the bulk of reconstructed discards (92%) were taken from existing estimates by Queirolo *et al.* (1995), NOAA and ADFG.

Future efforts to improve this work might consider more specific target fisheries when estimating discards for the earlier period. As it is difficult to ascertain the target fishery for some groundfish fisheries in the online NMFS commercial database, this was not possible in this study. Future revisions may also incorporate more detailed estimates of discards from the commercial and recreational salmon fishery, such as chinook mortality estimates in PSC (2011). Here, we included only the salmon discards that were available in the ADFG database since 1989. Discards from the salmon fishery are small in comparison to those by the groundfish trawl and Alaska pollock fisheries since the 1980s, but they would represent a much larger proportion of total catch in years prior to 1980, when salmon made up the majority of commercial landings.

3.2 Conclusion

This study attempts to compile all historic sources of catch, both retained and discarded, from the different fishing sectors (e.g., subsistence, recreational, domestic, joint venture and foreign commercial fisheries) that have operated in Alaska's subarctic Exclusive Economic Zone (or EEZ-equivalent waters) since 1950. The results from this study will help identify the sources of catch that are included in the FAO database and account for any unreported sources of catch in the *Sea Around Us* global database. We hope that these estimates will further increase the transparency of fisheries statistics in Alaska and worldwide and that they may be used as part of an ongoing global effort to improve catch statistics. The reconstructed catch database will be made freely available on the *Sea Around Us* website, and we welcome comments on this effort that will allow improvements to the quality of these data.

ACKNOWLEDGEMENTS

This is a contribution of the *Sea Around Us*, a scientific collaboration between the University of British Columbia and The Pew Charitable Trusts. The authors would also like to thank Dorothy Childers (AMCC), Cathy Tide (ADFG), and Garrett Zimpelman (ADFG) for their help in obtaining, compiling and interpreting historical data.

References

AMCC (2009) Discards in the North Pacific Groundfish Fisheries 2007. Alaska Marine Conservation Council (AMCC), Anchorage, Alaska. 104 p.

Bailey KM (2011) An empty donut hole: The great collapse of a North American fishery. Ecology and Society 16(2): 28.

Bakkala R, Hirschberger W and King K (1979) The groundfish resources of the Eastern Bering Sea and Aleutian Islands Region. Marine Fisheries Review 41(11): 1-24.

Behnke R, Tomelleri JR and Joseph R (2002) Cutthroat trout, *Oncoryhunchus clarki*. pp. 137-234 *In* Trout and salmon of North America. The Free Press.

Berger J, Nelson Jr. R, Wall J, Weikart H and Maier B (1988) Summary of U.S. observer sampling of foreign and joint venture fisheries in the Northeast Pacific Ocean and Eastern Bering Sea, 1986. Northwest and Alaska Fisheries Center, NMFS, NOAA. 167 p.

Berger J, Smoker J and King KA (1986) Foreign and joint venture catches and allocations in the Pacific Northwest and Alaska fishing area under the Magnuson Fishery Conservation and Management Act, 1977-84. Northwest and Alaska Fisheries Center, NMFS, NOAA. 53 p.

Berger J, Wall J and Nelson Jr. RE (1987) Summary of US observer sampling of foreign and joint venture fisheries in the Northeast Pacific Ocean and Eastern Bering Sea, 1985. Northwest and Alaska Fisheries Center, NMFS, NOAA. 169 p.

Berger J and Weikart H (1988) Summary of U.S. observer sampling of foreign and joint venture fisheries in the Northeast Pacific Ocean and Eastern Bering Sea, 1987. Northwest and Alaska Fisheries Center, NMFS, NOAA. 141 p.

Berger J and Weikart H (1989) Summary of U.S. observer sampling of foreign and joint venture fisheries in the Northeast Pacific Ocean and Eastern Bering Sea, 1988. Northwest and Alaska Fisheries Center, NMFS, NOAA. 118 p.

Bolkhovitinov NN (2003) The Sale of Alaska: A Russian Perspective. Polar Geography 27(3): 254-267.

Bonfil R, Munro G, Sumaila UR, Yaltysson H, Wright M, Pitcher T, Preikshot D, Haggan N and Pauly D (1998) Distant Water Fleets: An Ecological, Economic and Social Assessment.6, The Fisheries Centre, The University of British Columbia, Vancouver. 112 p.

Booth S and Zeller D (2008) Marine fisheries in Arctic Alaska. Fisheries Centre Research Reports 16, University of British Columbia, Vancouver. 59 p.

Booth S, Zeller D and Pauly D (2008) Baseline study of marine fisheries catches from Arctic Alaska: 1950-2006. Lenfest Ocean Program, Washington, D.C. Philadelphia. 15 p.

Brown C, Caylor D, Dizard J, Fall JA, Georgette S, Krauthoefer T and Turek MF (2005) Alaska Subsistence and Personal Use Salmon Fisheries 2003 Annual Report. ADFG, Alaska. 233 p.

Buklis LS (2002) Subsistence fisheries management on federal public lands in Alaska. Fisheries 27(7): 10-18.

Clark JR (1960) The 1960 salt-water angling survey. Fish and Wildlife Service, United States Department of the Interior. iv+36 p.

Crapo C, Paust B and Babbitt J (2004) Recoveries and yields from Pacific fish and shellfish. Marine Advisory Bulletin No. 37. School of fisheries & Ocean Sciences, University of Alaska Faribanks.

Doherty B, Harguth H, McCrea-Strub A, Jenkins K and Figueira W (2015) Reconstructing catches along Highway 101: Historic catch estimates for marine fisheries in California, Oregon and Washington from 1950-2010. Fisheries Centre Working Paper # 2015-81, University of British Columbia, Vancouver. 64 p.

Fall JA, Andersen DB, Caylor D, Coffing M, Georgette S and Turek M (2002) Alaska Subsistence and Personal Use Salmon Fisheries 2000 Annual Report. ADFG, Alaska. 154 p.

Fall JA, Balivet B, Brenner AR, Evans SS, Holen D, Hutchinson-Scarbrough L, Jones B, Kries TM, Lemons T, Marchioni MA, Mikow E, Sill LA and Trainor A (2013a) Alaska Subsistence and Personal Use Salmon Fisheries 2010 Annual Report. ADFG, Alaska. 246 p.

Fall JA, Braem N, Brown C, Evans SS, Holen D, Krieg T, La Vine R, Lemons T, Marchioni MA, Runfola D, Hutchinson-Scarbrough L, Sill LA, Trainor A and Van Lanen J (2012) Alaska Subsistence and Personal Use Salmon Fisheries 2009 Annual Report. ADFG, Alaska. 218 p.

Fall JA, Brenner AR, Evans SS, Holen D, Hutchinson-Scarbrough L, Jones B, La Vine R, Lemons T, Marchioni MA, Mikow E, Ream JT, Sill LA and Trainor A (2013b) Alaska Subsistence and Personal Use Salmon Fisheries 2011 Annual Report. ADFG, Alaska. 227 p.

Fall JA, Brown C, Braem N, Simon JJ, Simeone WE, Holen D, Naves L, Hutchinson-Scarbrough L, Lemons T and Krieg T (2011) Alaska Subsistence and Personal Use Salmon Fisheries 2008 Annual Report. ADFG, Alaska. 202 p.

Fall JA, Brown C, Caylor D, Coffing M, Georgette S, Paige AW and Rank L (2003a) Alaska Subsistence and Personal Use Salmon Fisheries 2001 Annual Report. ADFG, Alaska. 214 p.

Fall JA, Brown C, Caylor D, Georgette S, Krauthoefer T and Paige AW (2003b) Alaska Subsistence and Personal Use Salmon Fisheries 2002 Annual Report. ADFG, Alaska. 220 p.

Fall JA, Brown C, Turek MF, Braem N, Simon JJ, Russell A, Simeone WE, Holen D, Naves L, Hutchinson-Scarbrough L, Lemons T, Ciccone V, Krieg T and Koster D (2009a) Alaska Subsistence and Personal Use Salmon Fisheries 2006 Annual Report. ADFG, Alaska. 216 p.

Fall JA, Brown C, Turek MF, Braem N, Simon JJ, Simeone WE, Holen D, Naves L, Hutchinson-Scarbrough L, Lemons T, Ciccone V, Krieg T and Koster D (2009b) Alaska Subsistence and Personal Use Salmon Fisheries 2007 Annual Report. ADFG, Alaska. 206 p.

Fall JA, Caylor D, Coffing M, Davis B, Georgette S and Wheeler P (2001) Alaska Subsistence and Personal Use Salmon Fisheries 1999 Annual Report. ADFG, Alaska. 142 p.

Fall JA, Caylor D, Turek MF, Brown C, Krauthoefer T, Davis B and Koster D (2007a) Alaska Subsistence and Personal Use Salmon Fisheries 2004 Annual Report. ADFG, Alaska. 242 p.

Fall JA, Caylor D, Turek MF, Brown C, Magdanz J, Krauthoefer T, Heltzel J and Koster D (2007b) Alaska Subsistence and Personal Use Salmon Fisheries 2005 Annual Report. ADFG, Alaska. 207 p.

FAO (2012) FishstatJ. Food and Agriculture Organization of the United Nations (FAO), Rome.

Finley C (2011) All the fish in the sea: maximum sustainable yield and the failure of fisheries management. University of Chicago Press, Chicago. 224 p.

Forrester C, Beardsley AJ and Takahashi Y (1978) Groundfish, shrimp, and herring fisheries in the Bering Sea and Northeast Pacific: historical catch statistics through 1970. Bulletin # 37, International North Pacific Fisheries Commission. 147 p.

Garibaldi L (2012) The FAO global capture production database: a six-decade effort to catch the trend. Marine Policy 36(3): 760-768.

Hirschhorn G (1962) Growth and mortality rates of the razor clam (*siliqua patual*) on Clatsop beaches, Orgeon. Contribtuion No. 27, Fish Commission of Oregon, Portland, OR. 55 p.

Holland DS and Ginter JJC (2001) Common property institutions in the Alaskan groundfish fisheries. Marine Policy 25: 33-42.

Howe AL, Fidler G, Bingham AE and Mills MJ (1996) Harvest, Catch, and Participation in Alaska Sport Fisheries During 1995. ADFG, Alaska. 146 p.

Ianelli JN, Honkalehto T and Williamson N (2006) An age-structured assessment of pollock (*Theragra chalcogramma*) from the Bogoslof Island Region. Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. , North Pacific Fishery Management Council, Anchorage, Alaska. 201-236 p. Available at: http://www.afsc.noaa.gov/refm/docs/2006/BOGpollock.pdf. [Accessed: July 29, 2014].

Kelleher K (2005) Discards in the world's marine fisheries. FAO, Rome. 131 p.

Mansfield B (2001) Thinking through scale: the role of state governance in globalizing North Pacific fisheries. Environment and Planning A 33(10): 1807-1828.

Mathews V, Kookesh M and Bosworth R (1990) Subsistence Harvest and Use of Sea Cucumber in Southeast Alaska. Technical Paper No. 190, Division of Subsistence, ADFG. 43 p.

Megrey BA and Wespestad VG (1990) Alaskan groundfish resources: 10 years of management under the Magnuson Fishery Conservation and Management Act. North American Journal of Fisheries Management 10(2): 125-143.

Miles E, Sherman J, Fluharty D, Gibbs S, Tanaka S and Oda M (1982) Atlas of Marine Use in the North Pacific Region. University of California Press, Berkely.

Mills MJ (1980) Statewide Harvest Study - 1979 Data. Sport Fish Division, ADFG. 78 p.

Mills MJ (1986) Statewide Harvest Study - 1985 Data. Sport Fish Division, ADFG. 148 p.

NMFS (2011) North Pacific - Alaska. pp. 15-22 *In* Fisheries Economics of the United States, 2010. U.S. Department of Commerce, NOAA, Maryland.

Okey TA and Pauly D, editors (1999) Trophic mass-balance model of Alaska's Prince William Sound ecosystem, for the post-spill period 1994-1996, 2nd edition. Fisheries Centre Research Reports 7 (4). University of British Columbia, Vancouver, BC. xii + 137 p.

Otto RS (1981) Eastern Bering Sea crab fisheries. pp. 1037-1068 *In* Hood DW and Calder TA (eds.), The Eastern Bering Sea Shelf: Oceanography and Resources Vol. 2. Office of Marine Pollution Assessment, Juneau, AK.

Peterson CH, Rice SD, Short JW, Esler D, Bodkin JL, Ballachey BE and Irons DB (2003) Long-term ecosystem response to the Exxon Valdez oil spill. Science 302(5653): 2082-2086.

PSC (2011) Development of the technical basis for a chinook salmon total mortality management regime for the PSC AABM fisheries. Pacific salmon commission (PSC) - Joint chinook technical committee. xxi + 198 p.

Queirolo LE, Fritz LW, Livingston PA, Loefflad MR, Colpo DA and deReynier YL (1995) Bycatch, Utilization, and Discards in the Commercial Groundfish Fisheries of the Gulf of Alaska, Eastern Bering Sea, and Aleutian Islands. U.S. Department of Commerce. 148 p.

Scheiber HN (1989) Origins of the Abstention Doctrine in Ocean Law: Japanese - U.S. Relations and the Pacific Fisheries, 1937-1958. Ecology Law Quarterly 16: 23-100.

Skud BE (1975) The sport fishery for halibut: Development, recognition and regulation. Technical report No. 13, International Pacific Halibut Commission, Seattle, WA. 19 p.

Wertheimer AC (1997) Status of Alaska salmon. pp. 179-197 *In* Pacific Salmon & their Ecosystems. Springer.

Williams G (2012) 2011 Halibut sport fishery review. pp. 45-52 *In* IPHC report of assessment and research activities 2011. International Pacific Halibut Commission (IPHC), Seattle, WA.

Witherell D, Pautzke C and Fluharty D (2000) An ecosystem-based approach for Alaska groundfish fisheries. ICES Journal of Marine Science: Journal du Conseil 57(3): 771-777.

Witherell D and Pautzke Cq (1997) A Brief History of Bycatch Managment Measures for Eastern Bering Sea Groundfish Fisheries. Marine Fisheries Review 59(4): 15-22.

Zeller D, Booth S, Pakhomov E, Swartz W and Pauly D (2011a) Arctic fisheries catches in Russia, USA, and Canada: baselines for neglected ecosystems. Polar Biology 34(7): 955-973.

Zeller D, Rossing P, Harper S, Persson L, Booth S and Pauly D (2011b) The Baltic Sea: estimates of total fisheries removals 1950–2007. Fisheries Research 108(2): 356-363.

FIGURES

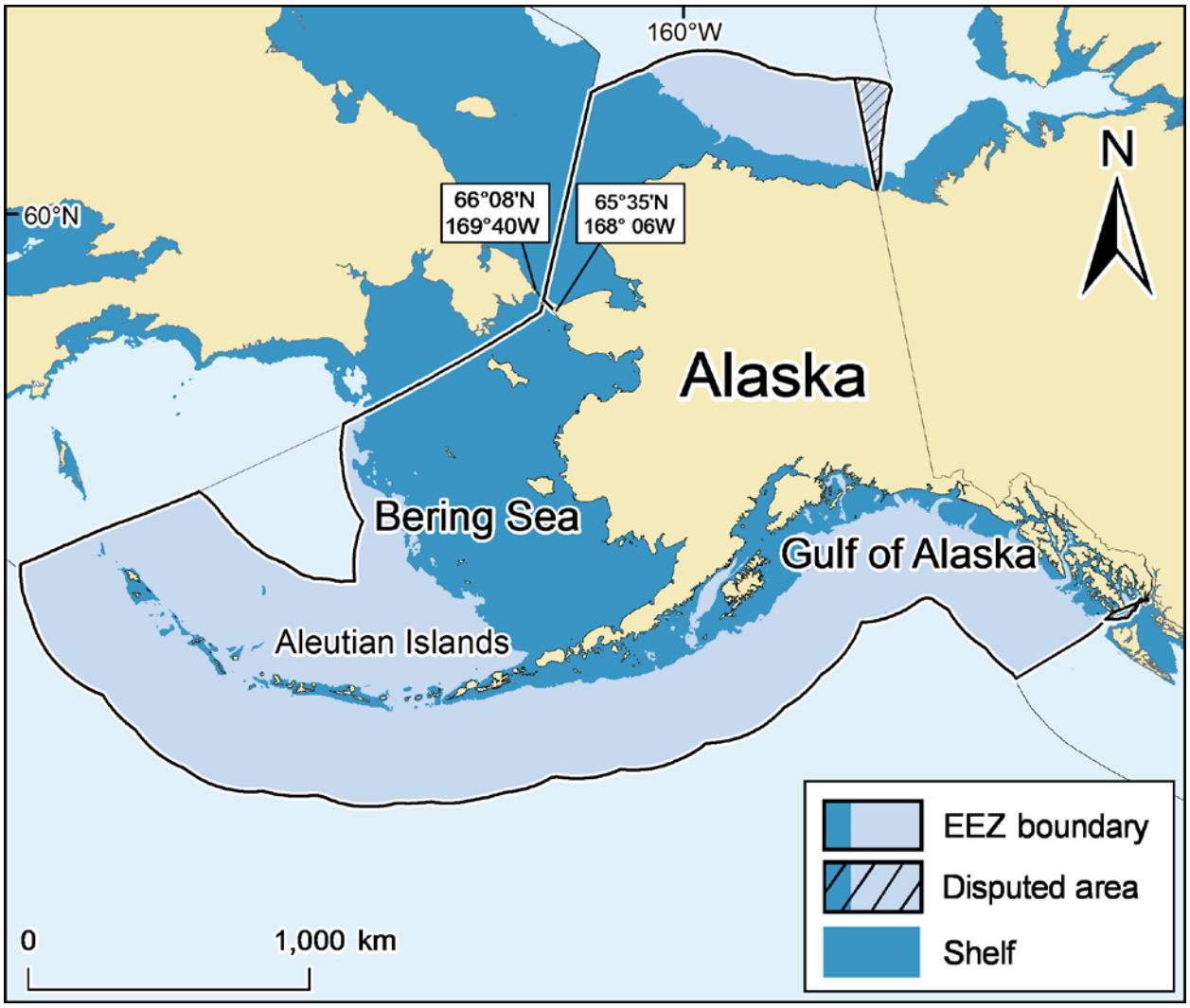

Figure 1. Map of Alaska showing its EEZ and continental shelf. Coordinates show the boundary between FAO area 67 (Pacific, Northeast) and FAO area 18 (Arctic).

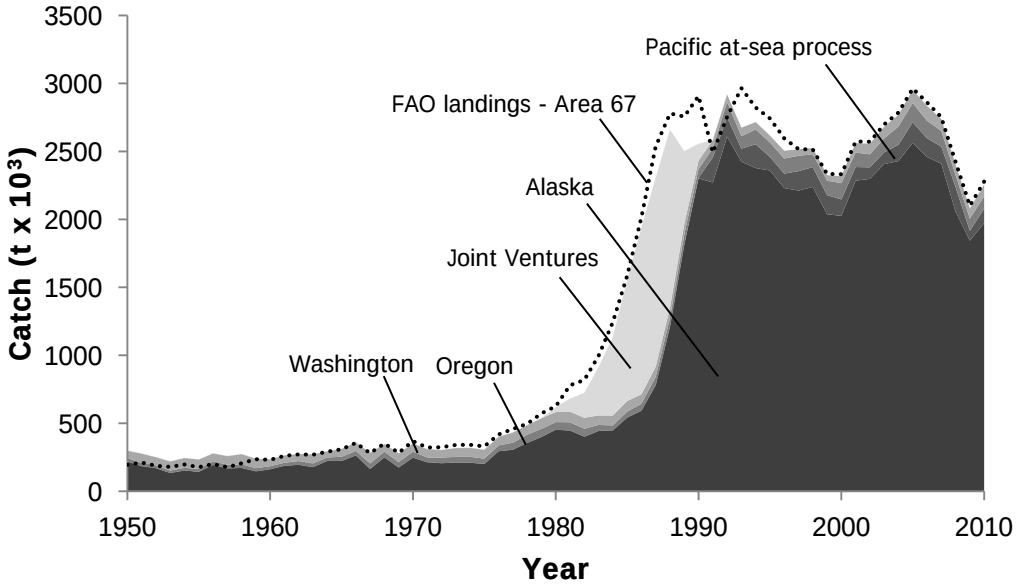

Figure 2. Comparing NMFS commercial landings data and joint ventures catches (Queirolo *et al.* 1995) with those reported to the FAO on behalf of the U.S. for FAO area 67 (Pacific, Northwest). NMFS landings exclude freshwater taxa (including rainbow trout) as well as aquatic mammals, reptiles, amphibians, coral, roe and seaweeds, as these taxa are not included in the *Sea Around Us* global catch database. Joint Venture catches include both retained catch and discards.

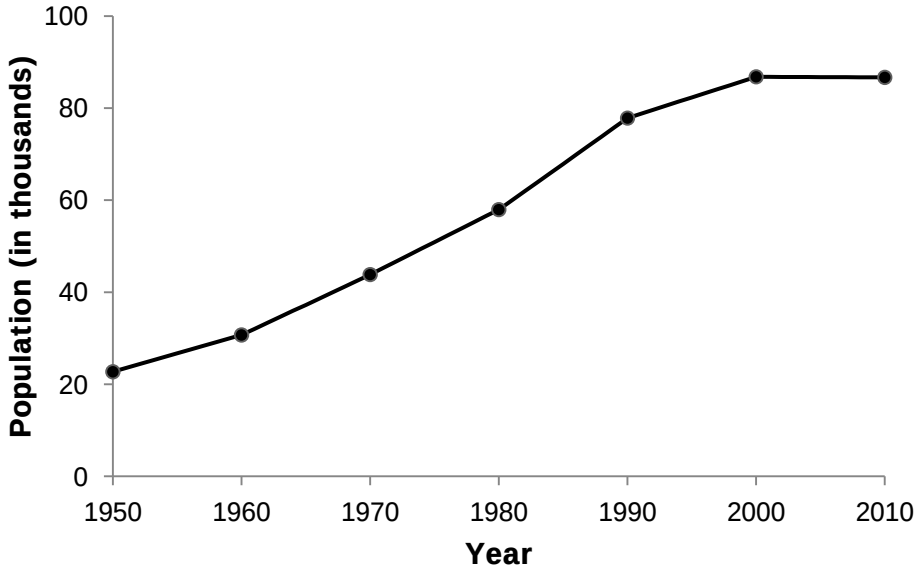

Figure 3. Total coastal population for 124 communities included in the subsistence estimates for Subarctic Alaska (See Appendix for complete list of communities).

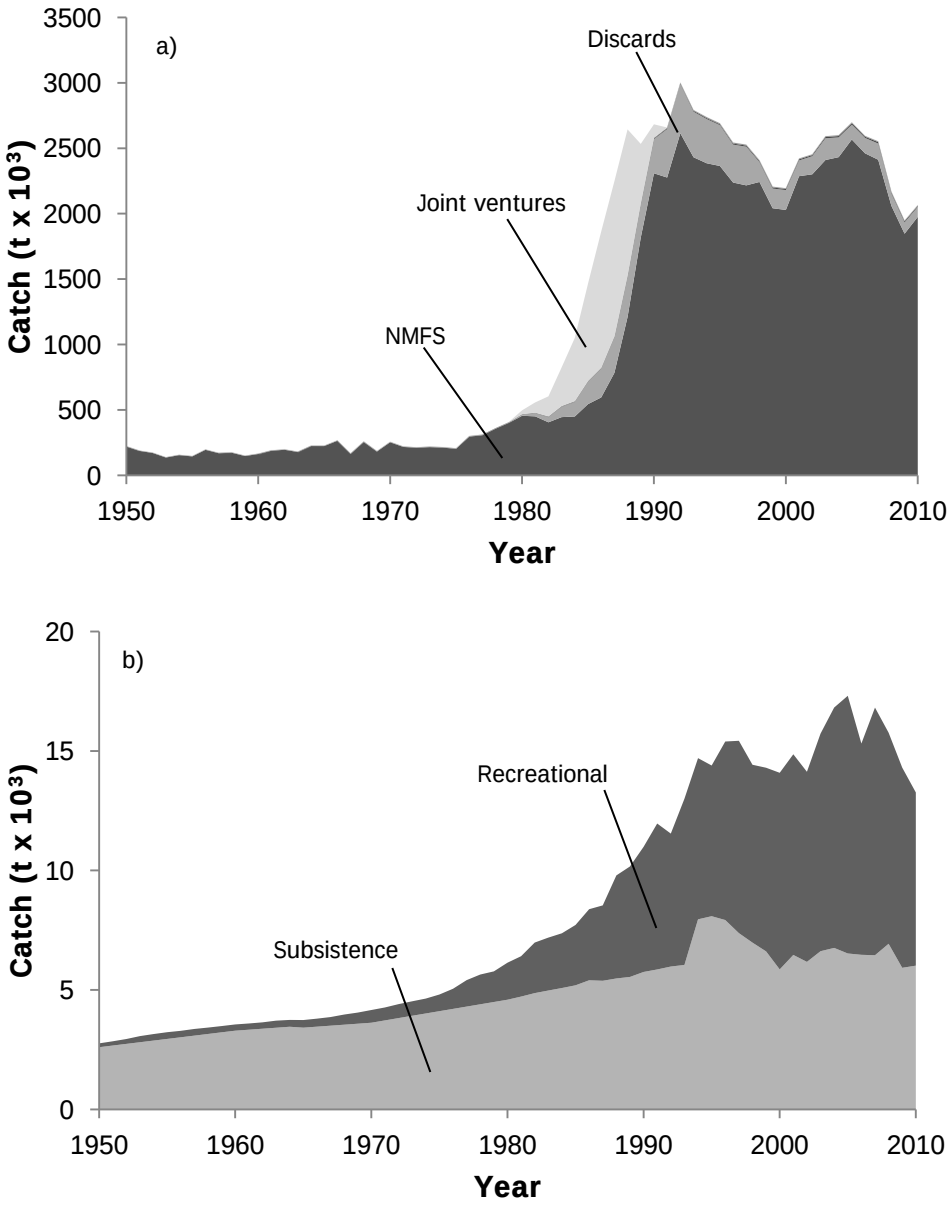

Figure 4. Total reconstructed catches for Alaska from 1950-2010 a) by major sectors; note that recreational and subsistence catches are included but not visible and b) for recreational and subsistence sectors.

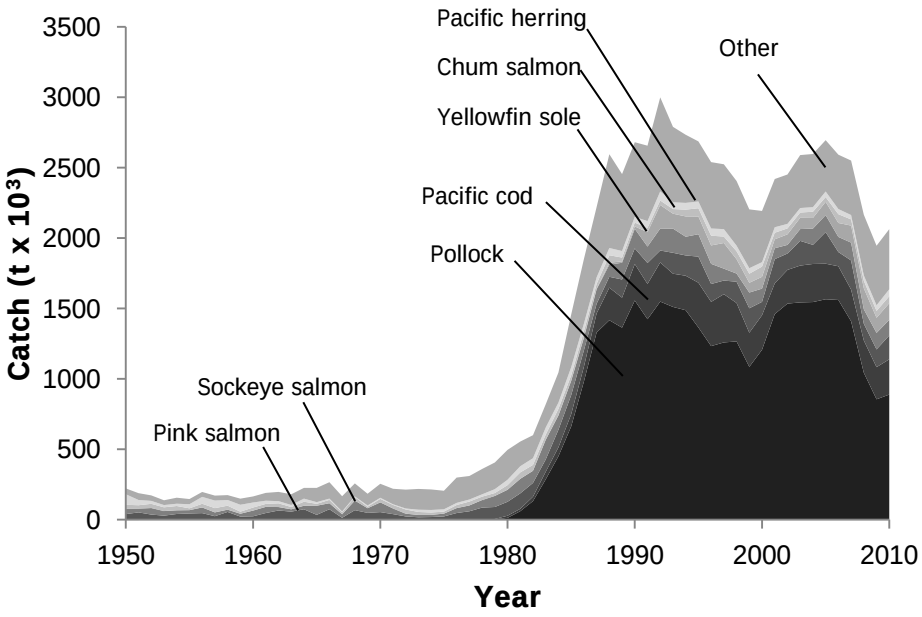

Figure 5. Total reconstructed domestic catch for all sectors (Domestic and Joint Venture commercial landings, discards, recreational and subsistence) within Alaska's EEZ equivalent waters from 1950-2010 by major taxa.

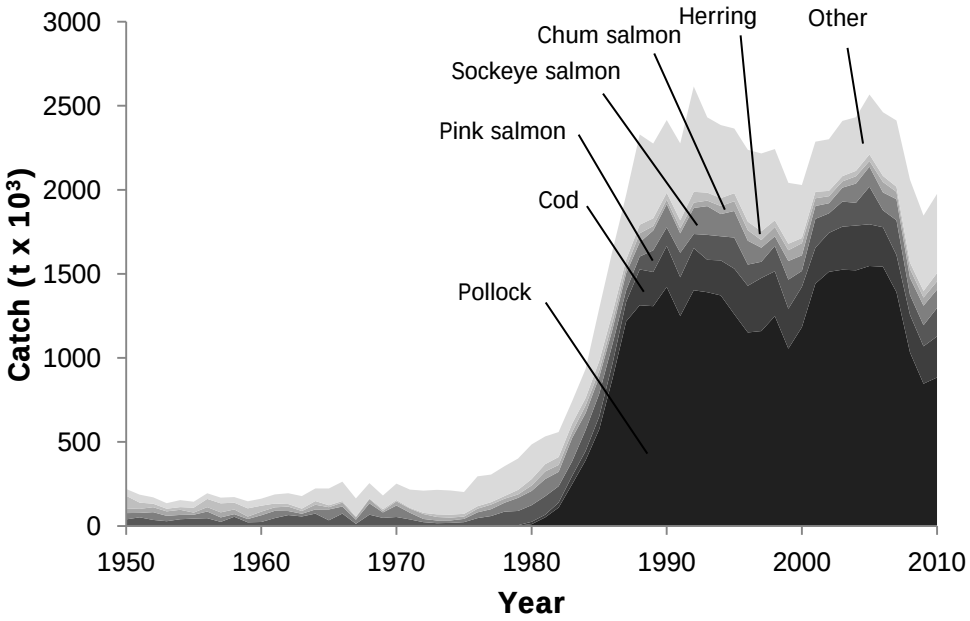

Figure 6. Total reconstructed domestic commercial catch in Alaska form 1950-2010 by major taxa. Includes commercial landings as reported by NMFS (with adjustments for shellfish wet weight) and catches from Joint Ventures as reported by Queirolo *et al.* (1995).

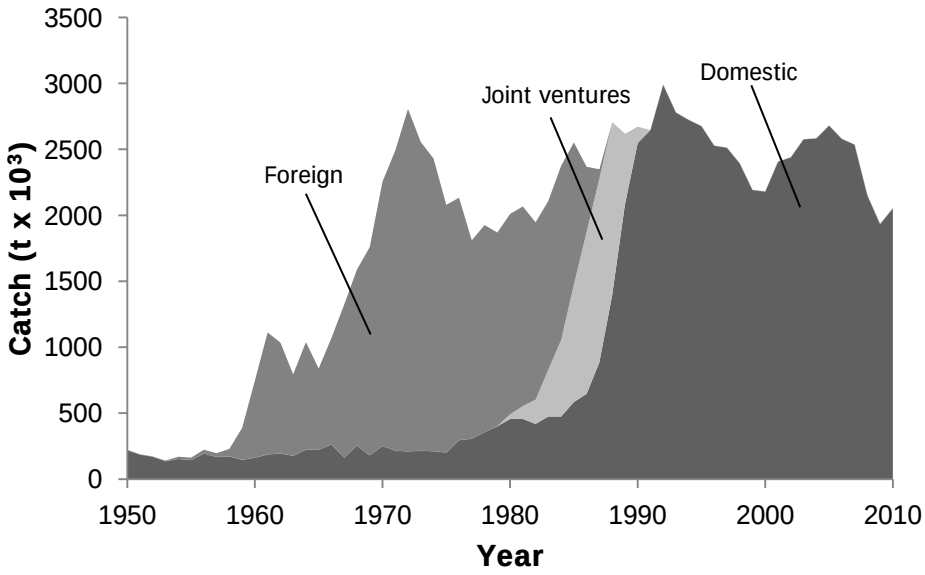

Figure 7. Total commercial catches and discards by Foreign, joint venture and domestic fisheries in Alaska's EEZ from 1960-2010, by both domestic and foreign vessels. Note: Foreign catch may not include all discards.

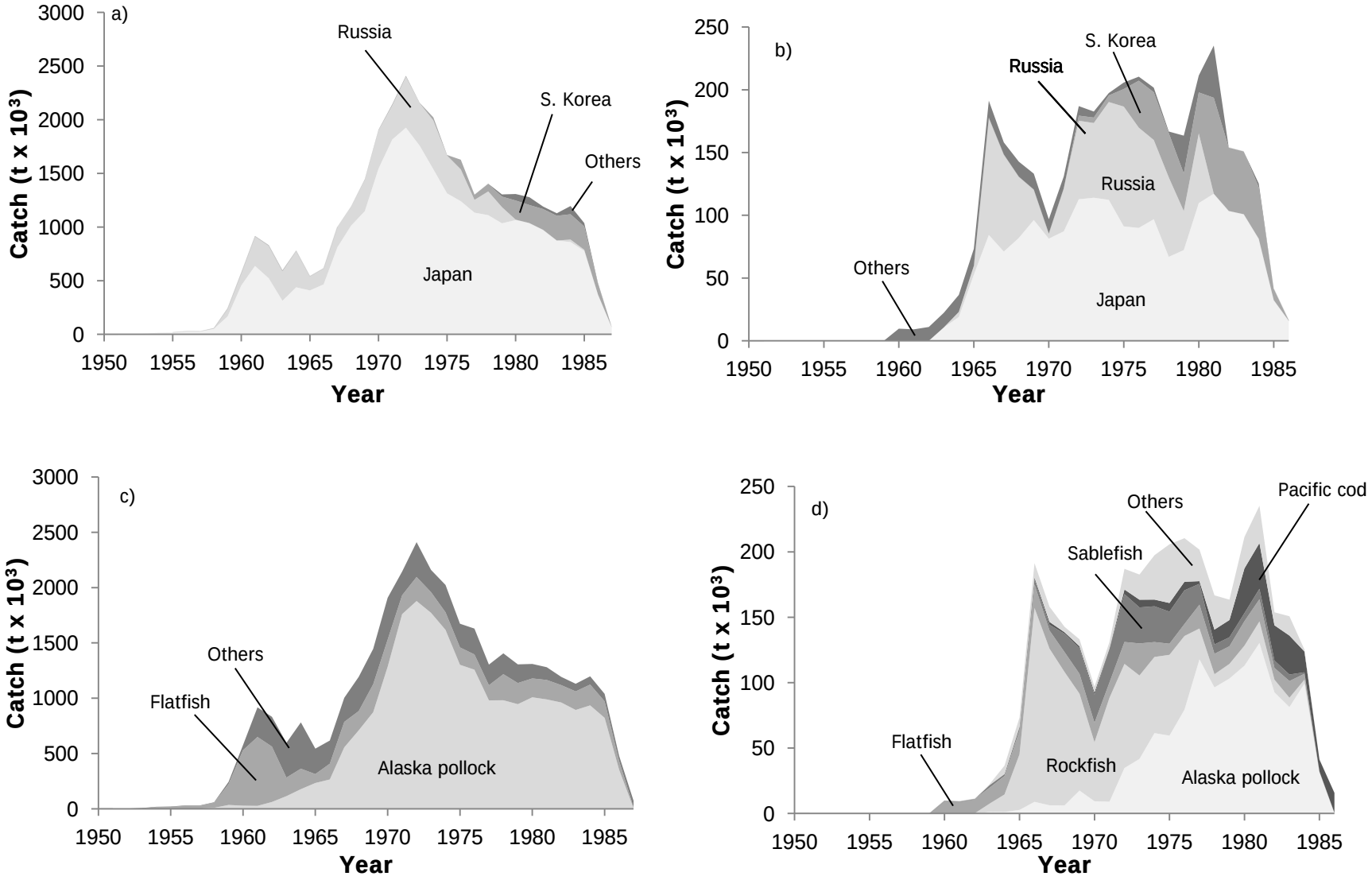

Figure 8. Total foreign catch in Alaska EEZ from 1950-1987 by country in a) Bering Sea and Aleutian Islands (BSAI), and b) Gulf of Alaska (GOA). Total foreign catch in Alaska EEZ from 1950-1987 by major taxa in b) BSAI and d) GOA. 'Others' includes Canada, China, Germany, Mexico and Poland. Note that BSAI and GOA have different scales.

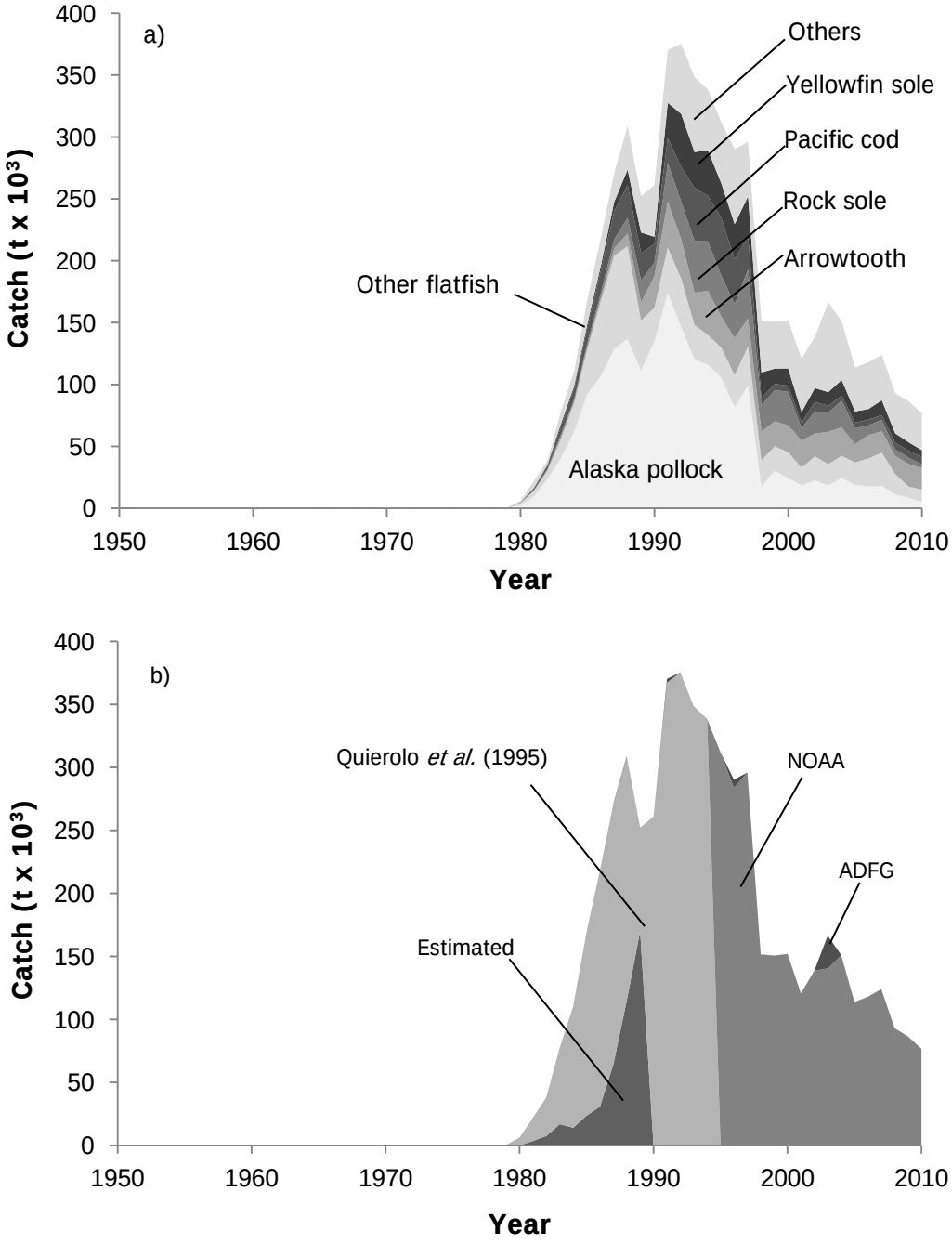

Figure 9. a) Taxonomic breakdown of total reconstructed discards in major Alaskan fisheries from 1950-2010. Note there are small amounts of discards estimated prior to 1980 but amounts (0-400 t·year^{-1}) are too small to appear in the figure. b) Reconstructed commercial discards by source

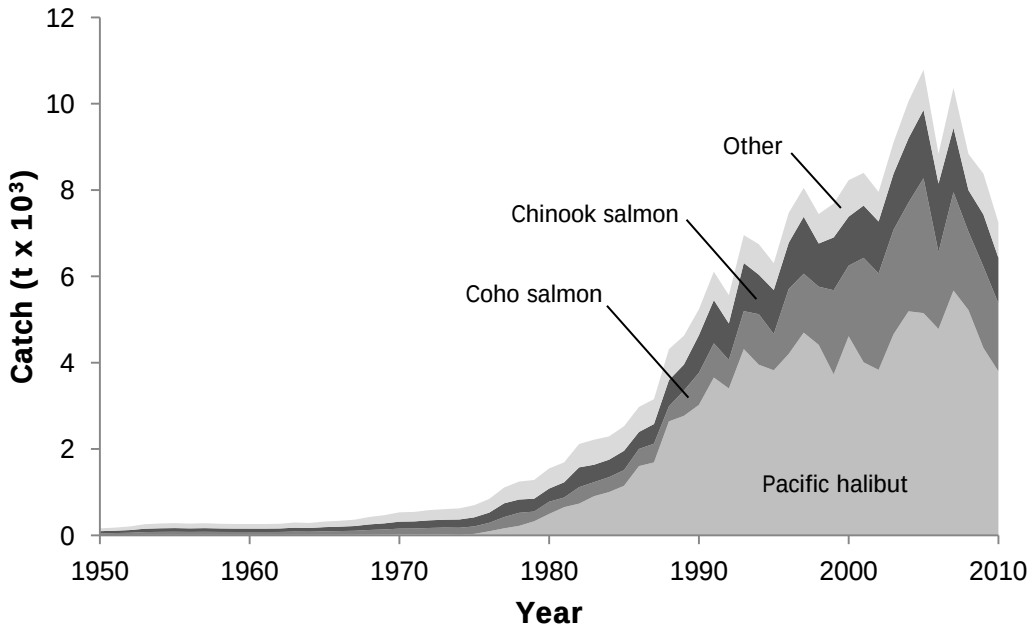

Figure 10. Total reconstructed recreational catch by taxa for Alaska from 1950-2010. Others grouping includes 14 taxonomic groups.

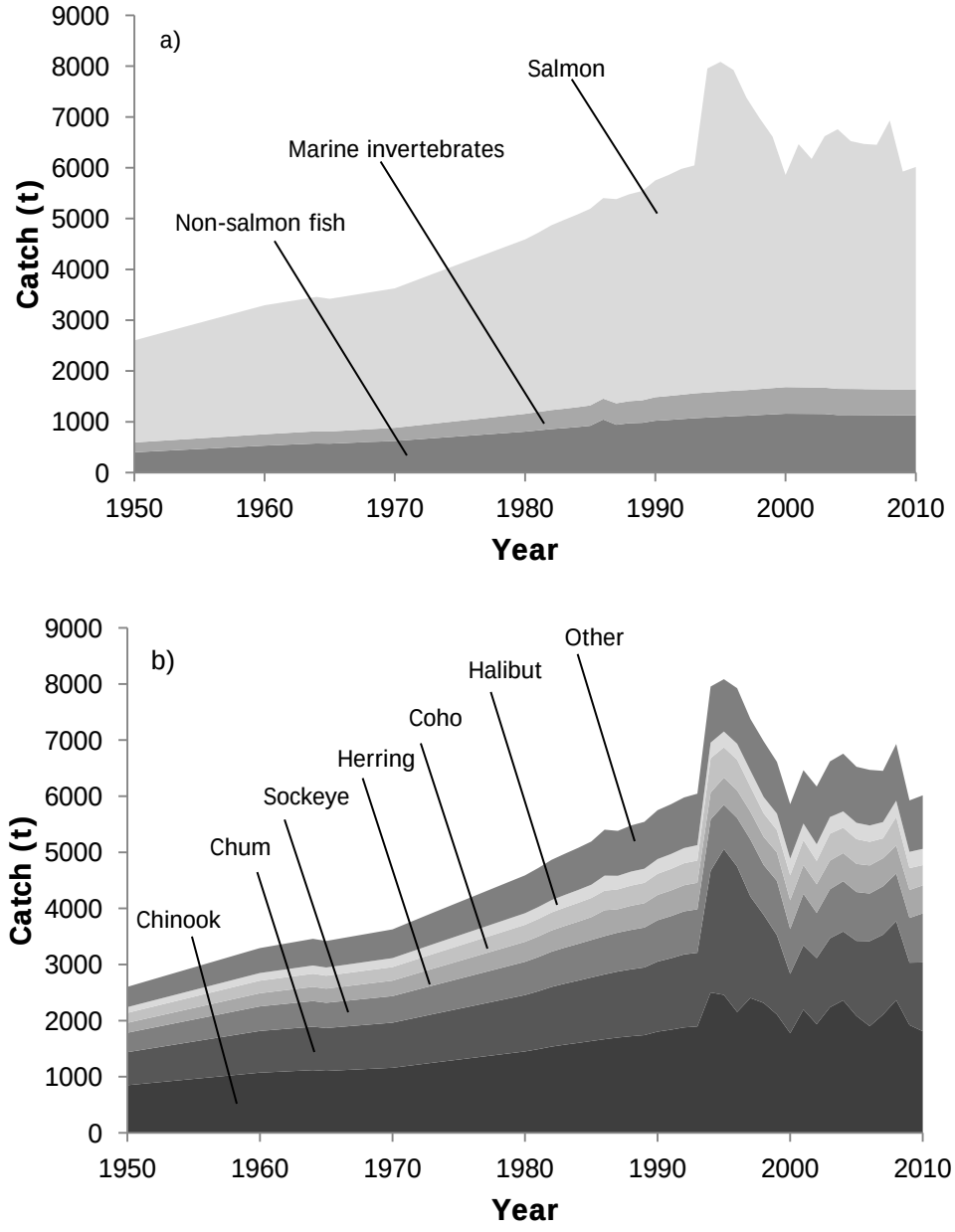

Figure 11. Taxonomic breakdown of total subsistence harvest for coastal communities in Subarctic Alaska by a) 3 major hierarchal resource categories and by b) major species. Others grouping in b includes 58 taxa.

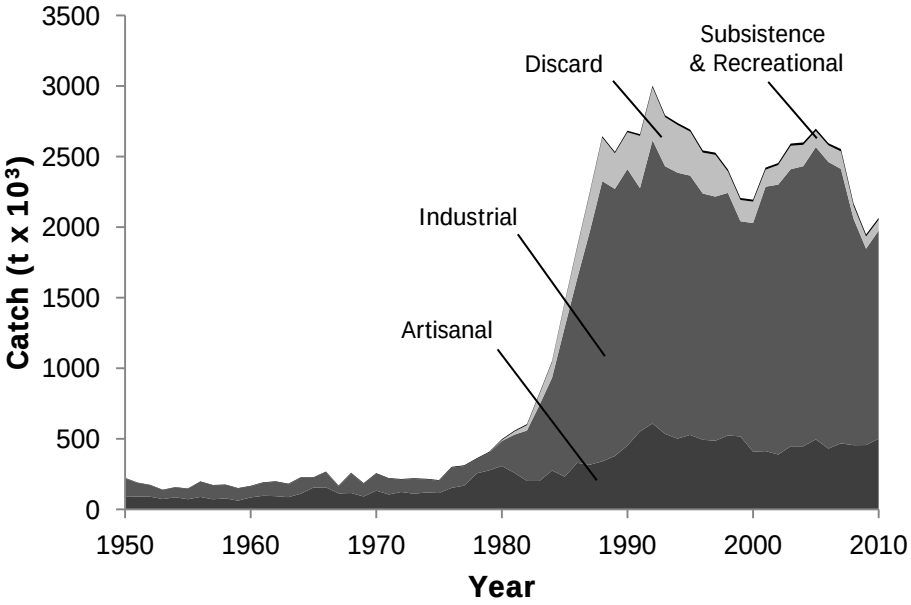

Figure 12. Sectoral breakdown of the total reconstructed catch for Alaska for SAUP

Appendices

Appendix Table A1. Per capita catch rates (in kg/person/year) for salmon, non-salmon fish, and marine invertebrate resource categories for 124 coastal communities in Subarctic Alaska

Community	1973-2011 Average per-capita catch rate			Range of per-capita catch rates observed			# of years with survey data		
	Salmon	Non-salmon	Inverts	Salmon	Non-salmon	Inverts	Salmon	Non-salmon	Inverts
Akhiok	65.6	11.8	22.9	33.1 - 125.6	1 - 21.8	4.4 - 41.1	6	6	5
Akiachak	257.2	Excl.	Excl.	257.2	-	-	1	-	-
Akiak	138.5	Excl.	Excl.	138.5	-	-	1	-	-
Akutan	8.6	9.3	2.2	6.9 - 10.3	4.5 - 14	1.6 - 2.9	2	2	2
Alakanuk	32.6	13.5	14.6*	32.6	13.5	14.6c	1	1	0
Aleknagik	40.9	Excl.	Excl.	36.4 - 45.3	-	-	2	-	-
Anchor Point	1.8	1.8	0.5	1.8	1.8	0.5	1	1	1
Angoon	18.1	10.6	7.8	13.8 - 22.5	8 - 13.3	3.3 - 12.4	2	2	2
Aniak	96.0	Excl.	Excl.	96.0	-	-	1	-	-
Atka	59.2	65.6	4.5	59.2	65.6	4.5	1	1	1
Brevig Mission	24.1	18.6	0.4	24.1	18.6	0.4	1	1	1
Chenega Bay	109.4	66.6	13.9	13.4 - 446.9	9.9 - 214.5	0.8 - 58.7	8	8	8
Chickaloon	34.0	Excl.	Excl.	34.0	-	-	1	-	-
Chignik Bay	45.5	30.0	13.7	37.8 - 59.3	6.2 - 58.6	3 - 28.1	4	4	4
Chignik Lagoon	63.2	17.8	19.3	41.9 - 83.6	14 - 22.7	13.8 - 29.1	3	3	3
Chignik Lake	58.3	13.4	8.5	43.5 - 72.8	9.1 - 19.1	2.7 - 13.7	4	4	4
Clark's Point	117.1	11.5	0.8	98.3 - 135.9	8.2 - 14.9	0.8	2	2	2
Coffman Cove	28.0	39.8	37.3	28.0	39.8	37.3	1	1	1
Cooper Landing	63.7*	Excl.	Excl.	63.7a	-	-	0	-	-
Cordova	6.8	3.8	1.1	2.8 - 10.5	1.7 - 6.6	0.3 - 3.1	5	5	5
Craig	14.7	13.9	10.5	14.7	13.9	10.5	1	1	1
Dillingham	25.7	1.7	0.3	22.6 - 28.9	1.5 - 2	0.3	2	2	2
Edna Bay	43.7	93.0	48.9	22.1 - 65.2	86.5 - 99.6	11.2 - 86.5	2	2	2
Eek	63.7*	35.5	14.6*	63.7a	35.5	14.6c	0	1	0
Egegik	35.6	5.1	8.6	35.6	5.1	8.6	1	1	1
Ekwok	351.9	Excl.	Excl.	351.9	-	-	1	-	-
Elfin Cove	42.7	39.0	17.3	42.7	39.0	17.3	1	1	1
Emmonak	46.5	11.8	0.1	20 - 73.1	7.7 - 15.9	0.1	2	2	1
False Pass	108.8	45.5	16.8	108.8	45.5	16.8	1	1	1
Fritz Creek	2.3	2.4	0.8	2.3	2.4	0.8	1	1	1
Game Creek	18.8	50.6	35.2	18.8	50.6	35.2	1	1	1
Golovin	109.8	76.3	9.0	109.8	76.3	9.0	1	1	1
Gustavus	63.7*	34.5*	14.6*	63.7a	34.5*	14.6c	0	0	0
Haines	5.3	7.8	0.7	4 - 6.6	5.8 - 9.7	0.5 - 1	2	2	2
Hollis	22.1	19.2	46.9	22.1	19.2	46.9	1	1	1
Homer	2.7	3.7	3.2	2.7	3.7	3.2	1	1	1
Hoonah	14.7	10.6	10.6	9 - 20.5	6.9 - 14.3	6.1 - 15.2	2	2	2
Hope[a]	63.7*	34.5*	14.6*	63.7a	34.5*	14.6*	0	0	0
Hydaburg	29.4	23.9	39.2	29.4	23.9	39.2	1	1	1
Igiugig	117.7	16.4	14.6*	92.8 - 154.6	1.5 - 33.8	14.6*	3	4	0
Iliamna	111.8	15.2	0.3	84.8 - 153.9	2.5 - 36.7	0.1 - 0.7	5	3	3
Ivanof Bay	87.5	27.9	25.8	81.2 - 93.8	8.7 - 47.1	14.4 - 37.2	2	2	2
Kake	12.9	10.1	6.5	8.3 - 17.4	8.1 - 12.2	6.3 - 6.6	2	2	2

Karluk	169.7	33.1	8.9	98.3 - 310.1	10 - 64.9	4.1 - 13	5	5	5
Kasaan	31.9	59.1	50.8	17.5 - 46.3	26.5 - 91.6	42.4 - 59.3	2	2	2
Kenai	0.9	0.6	0.3	0.4 - 1.3	0.2 - 0.8	0.1 - 0.4	4	4	4
Kenny Lake	8.7	Excl.	Excl.	8.7	-	-	1	-	-
King Cove	42.8	19.0	7.2	42.8	19.0	7.2	1	1	1
King Salmon	34.3	1.1	1.4	14 - 54.5	1 - 1.2	1.4	2	2	1
Kipnuk	63.7*	35.8	14.6*	63.7a	29.1 - 42.5	14.6*	0	2	0
Klawock	17.5	12.8	12.0	11.5 - 23.5	9.2 - 16.4	8.9 - 15.1	2	2	2
Klukwan	90.5	124.8	4.3	64.9 - 116.2	29.3 - 220.3	0.1 - 8.5	2	2	2
Kodiak City	1.8	2.2	0.7	1.3 - 2.6	1 - 4.3	0.4 - 1.5	4	4	4
Kodiak Coast Guard Station	1.1	2.2	0.3	1.1	2.2	0.3	1	1	1
Kokhanok	273.3	33.3	1.7	241.2 - 313.8	0.2 - 67.4	0.3 - 3.1	3	4	2
Koliganek	196.1	Excl.	Excl.	178.6 - 213.5	-	-	2	-	-
Kotlik	28.6	16.4	14.6*	28.6	16.4	14.6*	1	1	0
Kwethluk	60.6	Excl.	Excl.	60.6	-	-	1	-	-
Larsen Bay	66.2	29.2	30.2	32 - 95.8	2.4 - 62.4	5.8 - 44.7	11	11	9
Levelock	177.5	9.6	0.6	24.5 - 341.1	0.4 - 20.3	0.5 - 0.8	4	5	3
Lower Kalskag	55.0	Excl.	Excl.	55.0	-	-	1	-	-
Manokotak	57.0	17.6	2.9	43.1 - 69.2	9.7 - 28.8	2.4 - 3.8	3	4	3
Marshall	53.9	Excl.	Excl.	53.9	-	-	1	-	-
Mekoryuk	63.7*	32.7	14.6*	63.7a	32.7	14.6*	0	1	0
Metlakatla	63.7*	34.5*	14.6*	63.7a	34.5*	14.6*	0	0	0
Meyers Chuck	143.1	321.6	168.2	143.1	321.6	168.2	1	1	1
Mountain Village	32.5	Excl.	Excl.	23.1 - 41.9	-	-	2	-	-
Naknek	31.1	3.1	1.5	25.9 - 36.2	3 - 3.2	1.5	2	2	1
Nanwalek	60.6	45.8	13.7	30 - 89.6	21.3 - 79.8	6.1 - 19.2	8	8	8
Napakiak	79.9	17.0	0.0	79.9	17.0	0.0	1	1	1
Napaskiak	72.9	25.9	14.6*	72.9	25.9	14.6*	1	1	0
Naukati Bay	26.1	44.7	46.2	26.1	44.7	46.2	1	1	1
Nelson Lagoon	33.2	6.6	8.8	33.2	6.6	8.8	1	1	1
New Stuyahok	89.9	Excl.	Excl.	51.4 - 128.4	-	-	2	-	-
Newhalen	135.3	7.6	1.5	79.7 - 184.7	1.1 - 15	1.5	5	4	1
Newtok	63.7*	74.0	14.6*	63.7a	49.7 - 92.1	14.6*	0	4	0
Nightmute	63.7*	155.1	14.6*	63.7a	131.1 - 199	14.6*	0	4	0
Nikolski	95.2	148.3	3.7	95.2	148.3	3.7	1	1	1
Ninilchik	6.1	6.0	3.4	2.2 - 10	2.5 - 9.5	2.7 - 4.2	2	2	2
Nondalton	167.1	Excl.	Excl.	97.4 - 239	-	-	7	-	-
Nunapitchuk	61.5	Excl.	Excl.	61.5	-	-	1	-	-
Old Harbor	61.5	16.9	14.6	42.7 - 125.2	0.1 - 40.4	10.2 - 24.1	8	8	6
Oscarville	123.1	36.7	14.6*	123.1	36.7	14.6*	1	1	0
Ouzinkie	55.2	24.0	12.6	9.6 - 100.6	2.9 - 52.5	3.8 - 27.3	11	11	9
Pedro Bay	313.1	Excl.	Excl.	156.4 - 589.4	-	-	3	-	-
Pelican	63.7*	34.5*	14.6*	63.7a	34.5*	14.6*	0	0	0
Perryville	109.9	39.9	18.9	101.9 - 123.6	32.6 - 49	9.1 - 30.3	3	3	3
Petersburg	34.2	27.1	28.1	34.2	27.1	28.1	1	1	1
Pilot Point	58.8	10.1	6.2	58.8	10.1	6.2	1	1	1
Point Baker	45.7	49.1	53.3	35.8 - 55.6	30.6 - 67.6	49.8 - 56.9	2	2	2
Port Alexander	63.7*	34.5*	14.6*	63.7a	34.5*	14.6*	0	0	0
Port Alsworth	77.0	Excl.	Excl.	34.7 - 200.8	-	-	4	-	-

Port Graham	57.3	53.9	11.6	18.8 - 106.3	31.4 - 73	5.8 - 18.1	8	8	8
Port Heiden	44.2	10.8	14.6	44.2	10.8	14.6	1	1	1
Port Lions	46.5	21.1	16.2	17.5 - 95.7	0.6 - 53.8	5.8 - 27.2	7	7	5
Port Protection	51.3	70.2	86.4	35.3 - 67.2	63.5 - 76.8	38.6 - 134.2	2	2	2
Quinhagak	28.5	23.6	14.6*	28.5	23.6	14.6*	1	1	0
Russian Mission	108.0	19.7	0.1	51.6 - 164.4	19.7	0.1	2	1	1
Saint George	1.8	15.7	0.9	1.8	15.7	0.9	1	1	1
Saint Paul	0.7	29.1	0.6	0.7	29.1	0.6	1	1	1
Sand Point	29.2	13.7	5.0	29.2	13.7	5.0	1	1	1
Saxman	46.0	23.8	19.5	46.0	23.8	19.5	1	1	1
Seldovia	16.6	15.0	11.1	3 - 23.6	1.8 - 27.2	2.2 - 17.3	4	4	4
Sitka	2.4	3.1	1.7	2.4	3.1	1.7	1	1	1
Skagway	63.7*	34.5*	14.6*	63.7a	34.5*	14.6*	0	0	0
South Naknek	47.7	5.7	1.6	21.4 - 69.8	2.1 - 10.9	1.6	3	3	2
Stebbins	55.6	35.6	14.6*	55.6	35.6	14.6*	1	1	0
Talkeetna	10.1	Excl.	Excl.	10.1	-	-	1	-	-
Tenakee Springs	17.5	11.9	18.8	17.5	11.9	18.8	1	1	1
Thorne Bay	15.4	10.4	11.0	15.4	10.4	11.0	1	1	1
Togiak	25.3	14.8	3.7	25.3	13.4 - 16.2	3.7	1	2	1
Toksook Bay	63.7*	183.5	14.6*	63.7a	142.9 - 233.9	14.6*	0	4	0
Trapper Creek	8.7	Excl.	Excl.	8.7	-	-	1	-	-
Tuluksak	100.1	Excl.	Excl.	97.8 - 102.3	-	-	2	-	-
Tuntutuliak	63.7*	34.3	14.6*	63.7a	34.3	14.6*	0	1	0
Tununak	38.1	261.6	2.5	38.1	183.9 - 498	2.5	1	5	1
Twin Hills	52.6	28.6	2.0	52.6	28.6	2.0	1	1	1
Tyonek	112.7	7.5	3.4	75.4 - 150	5.8 - 9.1	1 - 5.8	2	2	2
Ugashik	222.1	25.6	14.6*	222.1	25.6	14.6*	1	1	0
Unalaska	63.7*	34.5*	14.6*	63.7a	34.5*	14.6*	0	0	0
Valdez	1.4	1.0	0.2	0.4 - 2	0.4 - 1.6	0.1 - 0.4	3	3	3
Whale Pass	14.0	18.1	26.8	11.5 - 16.4	16 - 20.1	20.3 - 33.2	2	2	2
Whittier	63.7*	34.5*	14.6*	63.7a	34.5*	14.6*	0	0	0
Yakutat	33.3	24.3	16.9	24.8 - 41.8	18.9 - 29.6	11.5 - 22.2	2	2	2
Average Coastal Community	**63.7**	**34.5**	**14.6**				**108[a]**	**95[b]**	**80[c]**

Source: Per-capita catch rates obtained by dividing subsistence harvest rates from (ADFG 2013) by coastal community population data (http://commerce.alaska.gov)

Notes:

- 9 coastal communities (Cooper Landing, Gustavus, Hope, Metlaka, Pelican, Port Alexander, Skagway, Unalaska, and Whittier) did not have any catch estimates but CSIS survey data indicated that a large percentage of households were involved in subsistence fishing. We applied the average per-capita catch rate from the communities with harvest estimates from 1973-2011, to generate catch estimates for these communities

* Indicates that this community did not have any harvest estimates for this resource category and the average coastal community per-capita catch rate was used

Excl. – Non-salmon fish and invertebrate subsistence catch was not estimated for the 23 communities located further than 25 km from the Alaskan coastline.

a – Salmon harvest estimates were available for at least 1 year for 108 communities. We used the average salmon per-capita catch rate from these communities to estimate salmon harvest for another 16 communities without data.

b – Non-salmon fish harvest estimates were available for at least 1 year for 95 communities. We used the average non-salmon fish per-capita catch rate from these communities to estimate non-salmon fish harvest for another 8 communities without data.

c – Marine invertebrate harvest estimates were available for at least 1 year for 80 communities. We used the average marine invertebrate per-capita catch rate from these communities to estimate marine invertebrate harvest for another 23 communities without data.

Appendix Table A2 - Taxonomic breakdown used to disaggregate salmon, non-salmon fish, and marine invertebrate subsistence catch estimates and conversion factors (CFs) used to convert edible weight to round weight

Resource Category and Taxa subgroup	CF	Taxa	Scientific Name	Catch Composition:
Salmon:				
Chinook Salmon	1.35	Chinook Salmon	*Oncorhynchus tshawytscha*	42.3%
Chum Salmon	1.39	Chum Salmon	*Oncorhynchus keta*	29.3%
Coho Salmon	1.33	Coho Salmon	*Oncorhynchus kisutch*	8.8%
Pink Salmon	1.35	Pink Salmon	*Oncorhynchus gorbuscha*	2.4%
Sockeye Salmon	1.37	Sockeye Salmon	*Oncorhynchus nerka*	17.3%
Non-Salmon fish:				
Bass		White weakfish	*Atractoscion nobilis*	0.1%
Capelin	1.28	Capelin	*Mallotus villosus*	0.2%
Char	1.45	Arctic char	*Salvelinus alpinus alpinus*	5.2%
Cisco		Sardine Cisco	*Coregonus autumnalis*	0.2%
		Bering Cisco	*Coregonus laurettae*	0.3%
Cod	1.59	Pacific Cod	*Gadus macrocephalus*	2.5%
		Pacific Tom Cod	*Microgadus proximus*	0.4%
		Saffron Cod	*Eleginus gracilis*	0.2%
		Unknown Cod	Gadidae	0.3%
Cutthroat trout	1.45	Cutthroat trout	*Oncorhynchus clarkii clarkii*	0.3%
Dolly Varden	1.45	Dolly Varden	*Salvelinus malma malma*	4.9%
Eulachon		Eulachon	*Thaleichthys pacificus*	1.4%
Flounder	1.49	Flatfishes	*Pleuronectiformes*	0.8%
		Starry Flounder	*Platichthys stellatus*	0.2%
Greenling	1.43	Unknown Greenling	*Hexagrammidae*	0.1%
		Lingcod	*Ophiodon elongatus*	0.7%
Halibut	1.39	Pacific Halibut	*Hippoglossus stenolepis*	25.7%
Herring	1.43	Pacific Herring	*Clupea pallasii pallasii*	44.2%
Lamprey	1.30	lampreys	*Petromyzontidae*	0.2%
Rockfish	1.75	Black Rockfish	*Sebastes melanops*	1.2%
		Unknown Rockfish	*Sebastes* spp.	2.6%
Sablefish	1.47	Sablefish	*Anoplopoma fimbria*	0.4%
Sculpin	2.56	Sculpins	Cottidae	0.1%
Shark	1.82	Unknown Sharks	*Selachimorpha*	0.01%
		Spiny dogfish	*Squalus suckleyi*	0.1%
Skates	2.56	Unkown skates	Rajidae	0.2%
Smelt	1.41	Smelts	Osmeridae	3.3%
Steelhead	1.45	Steelhead	*Oncorhynchus mykiss*	0.6%
Remora		Remoras	Echneidae	0.1%
Tuna/mackerels	1.47	Scombridae	Scombridae	0.0%
Whitefish		Humpback Whitefish	*Coregonus pidschian*	1.9%
		Broad Whitefish	*Coregonus nasus*	0.8%
		Round Whitefish	*Prosopium cylindraceum*	0.5%
		Unknown Whitefish	*Coregonus* spp.	0.0%
		Alaska pollock	*Theragra chalcogramma*	0.03%
Unknown marine fish		Unidentified Marine fishes	Marine fishes	0.1%
Marine Invertebrates:				
Abalone	2.38	Pinto abalone	*Haliotis kamtschatkana*	1%
Chitons		Chitons	Chitonidae	8%
Clams	2.22	Butter Clams	*Saxidomus* spp.	23.0%
		Pacific Littleneck Clams	*Leukoma staminea*	5.2%
		Razor Clams	*Siliqua patula*	4.6%
		Unknown Clams	Bivalvia	1.5%
Cockles	2.38	Cockles	*Clinocardium* spp.	5.1%
Crabs	1.67	Dungeness Crab	*Cancer magister*	10.0%

		King Crab	Lithodidae	7.8%
		Tanner Crab	*Chionoecetes* spp.	7.5%
		Hair crab	*Erimacrus isenbeckii*	0.05%
		Unknown Crabs	Decapoda	0.01%
Geoducks	3.03	Pacific Geoduck	*Panopea generosa*	0.34%
Mussels	3.85	Mussels	*Mytilus* spp.	0.8%
Octopus	1.25	Giant Pacific Octopus	*Enteroctopus dofleini*	4%
Oyster	7.14	Oyster	*Crassostrea* spp.	0.1%
Scallops	8.33	Scallops	Pectinidae	1%
Sea cucumber	4.00	California sea cucumber	*Apostichopus californicus*	5%
Sea Urchin	3.33	Sea urchins	*Strongylocentrotus* spp.	1%
Shrimp	1.89	Shrimps	Pandalidae	14%
Squid	1.41	Squid	*Loligo* spp.	0.1%
Limpets, snails and jingles	3.57[a]	Gastropods	Gastropoda	0.4%
Unidentified invertebrates		Unidentified invertebrates	Marine invertebrates	0.2%

Sources:

- Taxonomic breakdown is the catch composition of the total subsistence harvest estimates from ADFG (2013) from 1973-2011 for the coastal communities included in our estimate
- Conversion factors are from Crapo *et al.* (2004)
- We assumed a CF of 1.33 for fish species and 2.0 for marine invertebrates for taxa groups where values were not available

Notes: [a] For snails only