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

BASELINE STUDY OF MARINE FISHERIES CATCHES FROM ARCTIC ALASKA: 1950–2006

By

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NOVEMBER 2008

A report supported by the

LENFEST OCEAN PROGRAM

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PREFACE

Sustainable fisheries management relies on sufficient baseline data and an understanding of the full range of different kinds of fishing activities. Yet a number of areas of the world lack this information, particularly for small-scale fisheries.

The huge area that makes up the Amerasian Arctic, from Novaya Zemlya Island and the Kara Sea off north-western Siberia in the west to the Canadian Arctic Archipelago and Hudson Bay in the east, is fully encompassed in the United Nations Food and Agriculture Organization (FAO) Statistical Area 18. This is one of the 19 large geographic statistical areas through which the FAO documents the marine fisheries catches of the world, based on reports filed since 1950 by FAO's member countries.

So far, however, the member countries of FAO Area 18 have reported limited or no catches. The USSR and later Russia have not reported catches to the FAO for the north of Siberia (perhaps because Russia did not join the FAO until 2006). Canada has reported only limited catches from its arctic waters. The United States has not reported any catches to FAO.

As this report shows, these data gaps may occur because the reporting systems at the national and international level in these countries do not document small-scale fisheries catches. This is a critical gap because these fisheries may actually constitute much of the fish caught in these areas. The present report provides an estimate of commercial and small-scale fisheries in the U.S. part of FAO Area 18 (i.e., arctic Alaska), and is based on a technical source document available as a University of British Columbia Fisheries Centre Research Report (available at www.fisheries.ubc.ca/publications/reports/fcrr.php). This technical document highlights potential underreporting in the United States - fisheries data collected and reported by the State of Alaska from their three nautical mile jurisdiction are not incorporated into national or international catch reports.

Not only will the data presented in this report and the underlying technical document help provide improved estimates of subsistence fishing, but they could also become important baselines for understanding ecosystem changes due to warming in the Arctic. For this reason, the bottom-up process (i.e., estimation method for small-scale fisheries) used to arrive at the catch data presented here is documented in great detail in the technical source document.

SUMMARY

The Food and Agriculture Organization of the United Nations (FAO) provides global data on fisheries catches based on reports by member countries. For FAO Statistical Area 18 (Arctic), however, the United States reports no fish catches to the global community. In Alaska, communities found north of Cape Prince of Wales fall within FAO Area 18. However, the State of Alaska's Department of Fish and Game has collected time-series of commercial data, and undertakes intermittent community fisheries subsistence studies. At the regional level in Alaska, the National Oceanic and Atmospheric Administration (NOAA) does not report on either of these fisheries, as they take place within state waters. The *Sea Around Us* Project (www.seaaroundus.org), at the University of British Columbia's Fisheries Centre, undertakes catch reconstructions to account for discrepancies between globally reported and likely total catches. Our catch reconstruction includes both subsistence and commercial fisheries of marine and anadromous (migrate between fresh and saltwater) species (excluding marine mammals) from 1950-2006 for 15 coastal and near-coastal communities in arctic Alaska. Total catches over this time period were estimated to be 89,000 tonnes (196.2 million lbs), with subsistence catches contributing 54% (48,200 tonnes or 106.4 million lbs), and commercial catches estimated at over 40,700 tonnes (89.8 million lbs). Subsistence catches averaged 847 tonnes·year^{-1} (1.8 million lbs·year^{-1}, range: 589-1,139 tonnes·year^{-1}). It is only since the late-1980s that subsistence catches have exceeded those from the 1950s, when there was a higher reliance on fisheries resources. While subsistence catches showed only a small increase, the human population has increased from approximately 3,550 to approximately 12,650, which resulted in *per capita* catch rates falling from 237 kg·person^{-1}·year^{-1} (523 lbs·person^{-1}·year^{-1}) in 1950 to 78 kg·person^{-1}·year^{-1} (171 lbs·person^{-1}·year^{-1}) in 2006. One of the main drivers for this was the decrease in the amount of fish used for dog feed, when the snowmobile replaced the dogsled as the main form of transportation. The holistic historical perspective of total reconstructed fisheries catches presented here suggest that subsistence fisheries continue to be important to food security in this area, and merit careful protection, especially in the face of climate change.

INTRODUCTION

Alaskan marine fisheries in the arctic area are those that operate north of Cape Prince of Wales on the Seward Peninsula (Figure 1). This area falls within the United Nations Food and Agriculture Organization's (FAO) Statistical Area 18. These statistical areas have been defined by FAO on a statistical, rather than ecosystem basis, to allow comparison of fisheries data among different regions of the world. The National Marine Fisheries Service's Alaska branch (NMFS-Alaska) does not report on fisheries in this area, because they take place within state waters. At the federal level, the National Marine Fisheries Service (NMFS-National) reports on Alaska's fisheries, but they do not include catches taken in the arctic. As a consequence, the United States currently reports zero catches to FAO for the arctic area. The state agency, the Alaska Department of Fish and Game (ADF&G), has collected time-series of commercial data and has also undertaken community subsistence studies that are intermittent in space and time. However, no complete time series of total marine catch estimates exist for the arctic coast of Alaska.

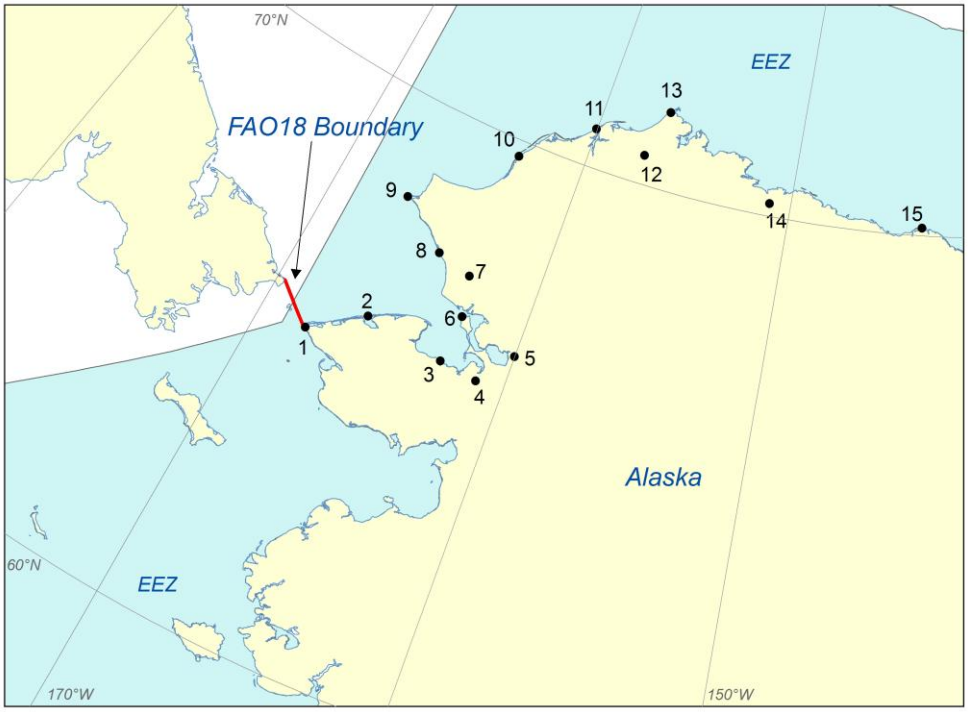

Figure 1. The U.S. state of Alaska, showing the 200 nm Exclusive Economic Zone (EEZ) and southern boundary of FAO Statistical Area 18 (Arctic). Indicated also are the arctic communities of 1) Wales, 2) Shishmaref, 3) Deering, 4) Buckland, 5) Selawik, 6) Kotzebue, 7) Noatak, 8) Kivalina, 9) Point Hope, 10) Point Lay, 11) Wainwright, 12) Barrow, 13) Atqasuk, 14) Nuiqsut and 15) Kaktovik.

Here, we present reconstructed estimates of total commercial and subsistence catches taken by the 15 coastal and near-coastal communities in Alaska's arctic waters that form part of FAO Statistical Area 18 for the years 1950 to 2006.

Fisheries in 1950 were under the mandate of the U.S. federal government. However, driven in part by the desire of Alaskans to have control over their salmon resources, statehood was achieved in 1959. At this point, the state of Alaska took control of its own fisheries management. With the implementation of the Magnuson-Stevens Act in 1976, the federal government gained responsibility of fisheries taking place from 3-200 nautical miles (nm) from shore and the state retained responsibility of the fisheries occurring within 3 nm of the coast. After Alaska gained statehood, its subsistence use of fish and wildlife was given priority over all other uses. However, in subsequent years the Alaska Board of Fisheries and Game created a rural subsistence priority, which was later ruled to be in violation of the state's constitution, and thus subsistence use and personal use fisheries are currently given priority. In 1999, the federal government also extended its jurisdiction to include fisheries on all public lands and waters under the Federal Subsistence Management Program (Woodby *et al.,* 2005).

The people of arctic communities have always relied on the Arctic Ocean for a large part of their sustenance. The area is sparsely populated, and the 15 communities represented in this study (Wales, Shishmaref, Deering, Buckland, Selawik, Kotzebue, Noatak, Kivalina, Point Hope, Point Lay, Wainwright, Barrow, Atqasuk, Nuiqsut, and Kaktovik; Figure 1) have an estimated total population of over 12,000 that

grew at an average annual rate of 5.2% per year from 1950 to 2000. The total population has since slightly decreased (Figure 2). Two communities, Atqasuk and Nuiqsut, were founded in the 1970s by people moving from existing communities to traditional lands. These 15 communities form part of three Alaska Native Regional Corporations-the Bering Straits Native Corporation (Wales and Shishmaref), NANA Regional Corporation (Deering, Buckland, Selawik, Kotzebue, Noatak, and Kivalina) and the Arctic Slope Regional Corporation (Point Hope, Point Lay, Wainwright, Barrow, Atqasuk, Nuiqsut, and Kaktovik). Marine commercial fisheries are important in Kotzebue Sound with chum salmon (*Oncorhynchus keta*) the most important component of the catch, while marine subsistence fisheries are an important component throughout the area, and target a variety of species including chum salmon, whitefish (Coregonidae) and Dolly varden (*Salvelinus malma*).

The coastal communities in arctic Alaska have relied on a mixed economy since the late 19th century, when American government and business expanded into the territory and developed commercial industries (Wolfe, 2004). Whaling, reindeer herding, and fur-trapping were important early contributors. After World War Two, the building of military stations (e.g., DEW line) also provided the opportunity for people to earn wages. More recently, the discovery of oil on the North Slope in 1968 has enabled people to participate in a mixed economy with the cash income supplementing a subsistence lifestyle.

MATERIALS AND METHODS

Time series estimates of commercial catches were taken mainly from the 2004 and 2005 Annual Management Reports from the State of Alaska (Kohler *et al.,* 2005; Banducci *et al.,* 2007), and additional unreported catches were estimated using time series analysis (see 'Commercial fisheries data' below). The Annual Management Reports detail the catch in numbers of individuals taken and average weights that were used to convert numbers of fish to round (or live) weight. A time series average for weight was used to estimate the weight of the catch in years when the report did not detail average weights. Arctic cisco taken in the Colville River fishery were assigned an average weight of 1 pound (0.45 kg; Daigneault and Reiser, 2007). Estimates of subsistence catches were taken from a variety of sources (see 'Subsistence fisheries data' below) and were expanded using a range of approaches to incorporate communities and years when no data were available. Subsistence catches in Alaska are often reported in terms of edible weight. If the edible weight to round weight conversion factors were not given, a standard conversion factor of 1.3 was used (Anonymous, 2001)

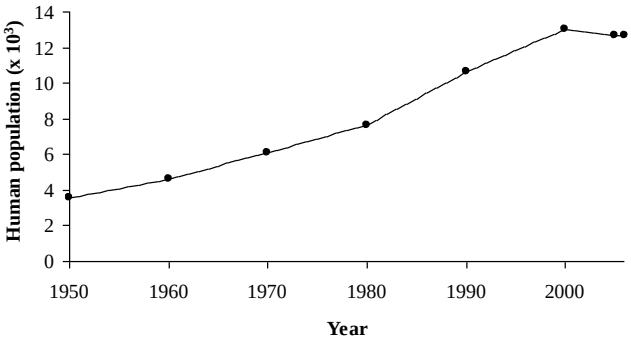

Figure 2. Human population for the fifteen communities of arctic Alaska 1950-2006. Solid circles indicate census data taken from the Division of Commerce, Community and Economic Development's website (www.dced.state.ak.us/). Intervening years are linearly interpolated. For individual community information, see Booth and Zeller (2008).

Human population data

The Alaska community database (Alaska Department of Commerce, Community and Economic Development) provides population data for the first year of every decade (www.dced.state.ak.us), and estimates for 2005 and 2006. We used linear interpolations between years of reported data. For Point Lay (no population data were reported between 1940 and 1980), we used Point Lay Biographies (Impact Assessment Inc., 1989) to estimate the population between 1950 and 1980. Total population for the 15 arctic communities grew from approximately 3,550 in 1950 to 13,000 in 2000 at an average rate of 5.2% per year, before declining to about 12,650 in 2006 (Figure 2).

Commercial fisheries data

Administratively, commercial fisheries for this area take place in the Arctic-Yukon-Kuskokwim region. This region encompasses the drainages of the Kuskokwim, the Yukon and Colville Rivers, and includes both Norton Sound and Kotzebue Sound. However, the areas of the region that coincide with FAO

Statistical Area 18 are Kotzebue Sound and the northern district of the Yukon-Northern area. Within these two areas, there are few commercial fishing opportunities, although a fishery that mainly targets chum salmon takes place in Kotzebue Sound, while another fishery in the Colville Delta targets whitefish. The commercial fishery for chum salmon in Kotzebue Sound is stated to have officially started in 1962 and the Colville River fishery officially commenced in 1967. Commercial catches were taken from the 2005 Annual Management Report and the 2007 Kotzebue Sound salmon season summary (Banducci *et al.,* 2007; Menard and Kent, 2007).

The commercial fishery in Kotzebue Sound for chum salmon, along with incidental takes of Dolly varden (*Salvelinus malma*), other species of salmon, and the fishery for sheefish (*Stenodus leucichthys*) is reported by the commercial fisheries department within ADF&G. Recent and historical data for these species were taken from the 2004 Annual Management Report (Kohler *et al.,* 2005) and the 2005 Annual Management Report (Banducci *et al.,* 2007). However, data for the commercial fishery that targets Arctic cisco largely in estuarine waters near the Colville River were taken from data supplied by Stephen Murphy (pers. comm.[1]). For the period 1974-1976 and 1981, unreported catches of Dolly varden were estimated using the respective average decadal catches.

However, although official documents report that the commercial fishery in Kotzebue Sound started in 1962, there were local commercial fisheries prior to this time. This earlier commercial fishery was informal: local people sold their catch for dog feed to people who ran dog-sled teams, the transportation link prior to the introduction of the snowmobile (C. Lean, pers. comm.[2]). Similarly, Stefanich (1973) reported that commercial fisheries in the Colville River prior to 1967 were taking approximately 64,000 whitefish and ciscos each year; Wilimovsky (1956) estimated that 10,000 pounds of whitefish were taken in one instance in 1952. Thus, these two commercial fisheries had unreported catches estimated for the period prior to their official reporting by ADF&G.

There was also a Japanese fishery in the Chuckchi Sea beginning in 1966, with most fishing effort taking place between 66-67^{O} N and 166-169^{O} W, an area largely within the current boundaries of the US Exclusive Economic Zone. This fishery's peak catches were similar to those for Kotzebue Sound, and thus, it may have been intercepting large numbers of Kotzebue area chum salmon. Commercial data for the Japanese fishery are reported for 1966 and 1967 (Anonymous, 1967, 1968).

Subsistence fisheries data

For the purposes of this study, the scope of subsistence fishing included those fisheries targeting species that rely on marine waters as part of their life history. Thus, subsistence fisheries include both anadromous and marine fish species that are taken in marine, estuarine or freshwater environments, but exclude fish species that are solely reliant on freshwater for their life-cycle. Anadromous species including chum salmon, sheefish, whitefish and Dolly varden, and marine species, including herring (*Clupea pallasii*) and cod (*Boreogadus saida* and *Eleginus gracilis*), are the main species of importance.

Catch data for subsistence fisheries come from a variety of reports that are spatially and temporally intermittent (for details of the sources used, see Booth and Zeller [2008], available at www.fisheries.ubc.ca/publications/reports/fcrr.php) and form the basis for data 'anchor' points (see Zeller *et al.,* 2007). Early studies such as those by Patterson (1974) quantify fisheries catches for several communities representing an average annual catch of important species. The state of Alaska, through its Community Profiles Database (www.subsistence.adfg.state.ak.us), maintains a database on subsistence fish catch and wildlife harvests that includes fisheries data for eleven of the fifteen communities, with most information derived from household surveys. Other studies mostly focus on a given community in a given year, although Burch (1985) presents data for Kivalina for two distinct time periods (1964-1965 and 1982-1983). The data sources used to derive estimates of non-commercial, subsistence catches also indicated that the reported catch totals incorporated catches used for dog-feed.

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[1] Stephen R. Murphy, ABR, Inc. P.O. Box 80410, Fairbanks, Alaska 99708-0410, (907)-455-6777 [information received on October 19, 2007].

[2] Charlie Lean, Norton Sound Fisheries Research and Development Director, P.O. Box 358, Nome, Alaska, 99762, 1-888-650-2477 [information received on January 24, 2008].

In order to account for catches that were not reported during these studies, yearly catches were estimated using several methods. The most common method involved interpolating between data anchor points via *per capita* catch rates. This method involves dividing reported catches of a year by the human population of the same year and then interpolating linearly between the *per capita* catch rates. Another method involved using average catches, whereby a community's catch for reported years was divided by the number of years of reported data to derive an average catch, which was applied to other years when no other data were reported. This method was used in those cases where there was known to be large variations, including zero catches, due to ice in lagoon areas (Burch, 1985). The third method was to use the same reported catch for other years that lacked reported data. This was mostly done in carrying catches forward in time from the last reported catch amount, but was also used in some cases to carry catches backwards in time from the earliest reported catches.

The two final methods involved scaling a community's catch to either another community's reported catch or to another species catch in the same community. Point Hope, Point Lay and Wainwright had only one reported anchor point for most species, and thus other anchor points in time were derived using reported changes for the same species in Kivalina. In Kotzebue, Dolly varden catches were estimated as a percentage of chum salmon catches, since there is some indication that higher catches of Dolly varden are associated with higher catches of chum. Chum salmon catches in Shishmaref were estimated by linearly interpolating the exploitation rate between two data anchor points (average 1971-1975 and 1989); for later years with missing data, the average exploitation rate was used. In Wales, chum catches were derived for 1971-1975 and 1989 using the reported change in catches for Shishmaref. For the intervening time periods, catches were estimated by linear interpolation of the exploitation rate. Eggers and Clark (2006) provide estimated total run sizes for Kotzebue District chum for 1962-2004. Catch data were converted into exploitation rates by dividing the number of chum salmon caught in reported years by the estimated total run size of that year. Average reported weights from the commercial fishery for chum in Kotzebue Sound were used to convert the number of salmon to live weights. Detailed, community-level data and all sources used are presented in the technical report of Booth and Zeller (2008) available at www.fisheries.ubc.ca/publications/reports/fcrr.php.

Human vs. dog feed component of subsistence catches

Prior to the introduction of the snowmobile in the early 1960s, dog-teams provided the main mode of transportation. The first snowmobiles were sold in Kotzebue in the early 1960s and by the winter of 1965-66 the first snowmobiles were brought into Noatak (Hall, 1971). Therefore, we assumed that for communities other than Kotzebue, the snowmobile was introduced in 1965 and for Kotzebue in 1963. Fish were one of the main sources of feed for the dog-teams in some communities. Abrahamson (1968) reported that a dog would need at least 2 pounds of dried fish per day over the winter. C. Lean (pers. comm.) indicated that in the past a dog would be fed half a chum salmon (approximately 4 lbs, given an average weight of 8 lbs per chum) during the winter, and during the rest of the year, they would be fed with other protein sources (e.g., caribou). Thus, we considered that, prior to the introduction of the snowmobile, each dog would be fed 4 pounds of fish each day over a 6 month period.

Raleigh (1957, in Mattson 1962), gave estimates for the number of dogs in the 1950s in each community excluding Wainwright, Barrow, Kaktovik, Selawik and Point Lay. Estimates of the number of dogs for communities lacking data were based on the average dogs-to-people ratio for those communities that had reported data. Patterson (1974) also provided an estimate for the total number of dogs in 1972 for the NANA region, which includes communities outside the scope of this work. However, Raleigh (1957 in Mattson 1962) also provided estimates for these communities and thus, the number of dogs in 1972 for each of the communities was based on the percentage decline of total dogs between 1957 and 1972. For 1957, we assumed that each dog was fed 4 pounds of fish per day over a 6 month period. For 1972, Patterson (1974) estimated that each dog was fed 327 pounds (round weight) of fish per year. Georgette and Loon (1993) estimated the amount of fish fed to dogs for the community of Kotzebue in 1986 and estimates are also provided for Noatak in 1999 (Georgette and Utermohle, 2000) and 2000 (Georgette *et al.* 2001). These data were transformed into anchor points based on the amount of fish used for dog-feed (as a percentage) in relation to the total estimated fish catch. The 1957 estimate of the amount of fish used for dog-feed (as a percentage of the total estimated fish catch) was held constant until the year the

snowmobile was introduced (Kotzebue 1963, all others 1965) and then scaled linearly to the 1972 estimate. For the communities that did not have any data available past the 1972 estimate, we scaled the amount of fish used for dog feed on the percentage change for Noatak because Kotzebue, as a regional centre, has a much larger population. Thus, it was possible to estimate, for each community, what percentage of catch through time was fed to dogs by linearly interpolating between anchor points.

However, for some communities the estimates of fish used for dog-feed exceeded the reported catch for the anchor years of 1957 and 1972. On further investigation, it was found that these communities relied far less on fish as a protein source and relied more heavily upon land or marine mammals. Estimates of total protein availability for each community were based on the report of Patterson (1974), who provided estimates on the weight of caribou, deer/reindeer, moose, seals, walrus, beluga, bowhead whales and birds taken in each community. The estimated amount of fish caught was added to these amounts and a percentage contribution to the available protein by fish was determined. The communities of Wales, Shishmaref, Point Hope and Kaktovik were found to have a negative balance, and they also had fish contributing less than 15% to their protein availability; thus we assumed that they did not rely heavily on fish for dog-feed. Therefore, we were also able to determine that the communities of Wainwright and Barrow, which were missing information on the number of dogs, were not heavily dependent on fish as dog-feed because they had fish contributing 3% and 5%, respectively to their total protein availability. No data were available for Point Lay, quantifying the number of dogs or contributions to protein availability, although the community is known for its beluga harvest (B. White, pers. comm.[3]); therefore it was assumed that fish were not relied upon for dog-feed for the following communities: Barrow, Kaktovik, Point Hope, Point Lay, Shishmaref, Wainwright, and Wales.

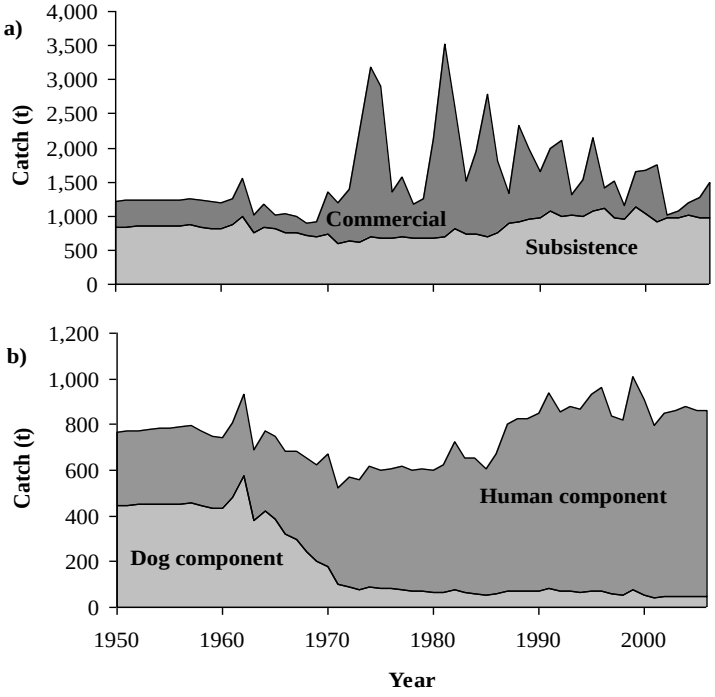

Figure 3. a) Estimated total marine and anadromous fisheries catches (excluding marine mammals) by fishing sector for fifteen coastal and near-coastal communities of Arctic Alaska, and b) breakdown of subsistence catch into estimated amounts destined for human consumption and for dog-feed.

Thus, for each community that was reliant upon fish for dog-feed (Deering, Buckland, Kotzebue, Noatak, Kivalina and Selawik) we were able to determine through time what percent of the estimated catch was used for dog-feed. For the communities of Atqasuk and Nuiqsut, which were established on traditional lands in the 1970s, the average percentage (excluding Kotzebue) was used to determine what proportion of fish was used for dog-feed in the first year that people re-settled traditional lands and the decline was based on changes represented by the community of Noatak. Although Deering in 1957 had a positive protein availability balance, the protein availability balance was negative in 1972, and therefore the change in the amount of fish fed to dogs was based on the average percent decline for the other communities, excluding Kotzebue.

[3] Bruce Wright, Senior scientist, Aleutian Pribilof Islands Association, 1131 East International Airport Rd., Anchorage Alaska 99518, (907)-276-2700 [information received on January 24, 2008].

RESULTS

Total catch time series

Prior to 1962, when commercial fisheries were part of the informal economy, total estimated catches averaged approximately 1,230 t·year^{-1} (2.7 million lbs·year^{-1}; 1950-1961), with the informal commercial sector accounting for on average 31% of the yearly catch (Figure 3). For the first years, when the commercial fishery was considered part of the formal economy (1962-1969), total catches were estimated to average approximately 1,080 t·year^{-1} (2.4 million lbs·year^{-1}). From 1970-1989, there were two peak periods of catches, 1974-1975 with catches of 3,178 and 2,909 tonnes (7.0 and 6.4 million lbs) respectively, and then in 1981-1982, with catches of 3,529 and 2,609 tonnes (7.8 and 5.8 million lbs), respectively. Catches for 1970-1989 averaged approximately 1,981 t·year^{-1} (4.4 million lbs·year^{-1}). During the 1990s, catches averaged approximately 1,651 t·year^{-1} (3.6 million lbs·year^{-1}) and in the early 2000s estimated total catches had declined to 1,355 t·year^{-1} (3.0 million lbs·year^{-1}; Figure 3).

Total commercial and subsistence catches over the time period considered here amount to approximately 89,000 tonnes (196 million lbs). The most important species is chum salmon, which accounts on average for 55% of the total yearly catch. The whitefish complex (whitefish + ciscos) is the next most important group, accounting for on average 21%, while sheefish and Dolly varden account for 12% and 8% of the total yearly catch, respectively (Figure 4).

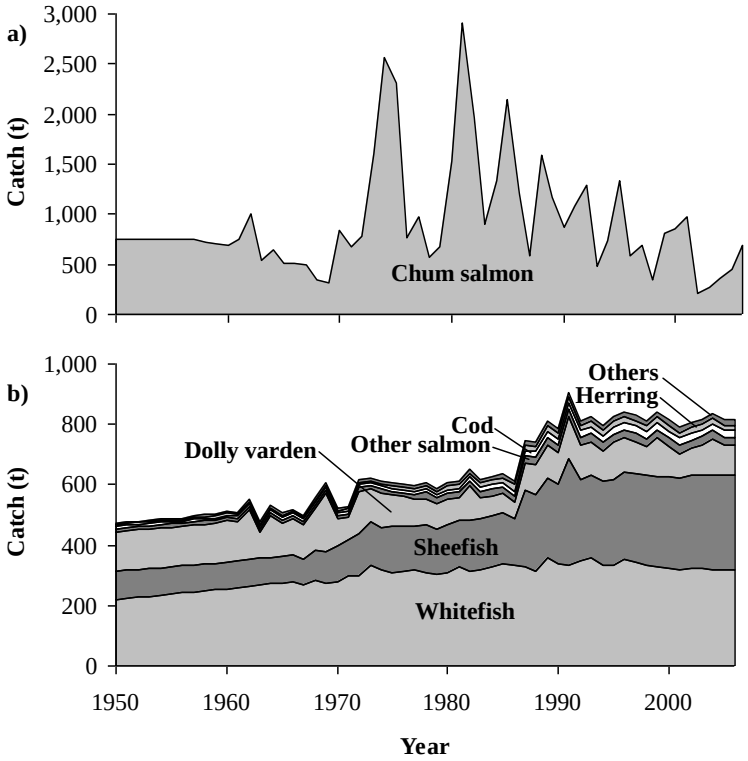

Figure 4. Taxonomic distribution of fisheries catches for the fifteen coastal communities of Arctic Alaska (by common names, marine mammals excluded) for 1950-2006 for a) chum salmon; and b) all other species. Note the difference in scale between the two panels. Whitefish includes both ciscos and whitefish; pink, coho, chinook, and sockeye salmon comprise the group 'Other salmon'; Cod includes both Arctic cod and saffron cod; while capelin, king crab, flounder and other Pleuronectidae (flatfishes), rainbow smelt, smelt and sculpin comprise the group 'Others'. See Booth and Zeller (2008) for all common, local and scientific names.

Subsistence catches

Subsistence catches account for approximately 54% of the estimated total catches (Figure 3a). From 1950-1965, prior to the Japanese high seas fleet fishing in the Chuckchi Sea, subsistence catches averaged 850 t·year^{-1} (1.9 million lbs·year^{-1}), but declined to around 685 t·year^{-1} (1.5 million lbs·year^{-1}) from 1966-1979. Catches increased to average 791 t·year^{-1} (1.7 million lbs·year^{-1}) during the 1980s and it was only since the late 1980s that subsistence catches have consistently surpassed catches from the 1950-1966 time period. Since 1990, subsistence catches have averaged 1,000 t·year^{-1}. Despite increases in subsistence catches, subsistence *per capita* catch rates have declined from 237.0 kg·person^{-1} (522.6 lbs·person^{-1}) in 1950 to 77.8 kg·person^{-1} (171.5 lbs·person^{-1}) in 2006. The sharpest drop in subsistence *per capita* catch rates came from 1950-1971, with an estimated decline of approximately 60%. Between the 1950s and 1990s, there has been a 2.4-fold drop in subsistence *per capita* catch rates (Figure 5).

<u>Use of fish for dog-feed</u>

For the eight communities that we determined were reliant on fish for

dog-feed, the percentage of fish for dog-feed accounted for 58% of the catch total in 1950 declining to 6% in 2006. Prior to the introduction of the snowmobile (1950-1962), it was estimated that the amount of fish fed to dogs averaged 459 t·year^{-1} (1 million lbs·year^{-1}). From 1963 to 1975, the amount of fish required for feed dropped from an estimated 387 t·year^{-1} (843,000 lbs·year^{-1}) to 82 t·year^{-1} (181,000 lbs·year^{-1}) or from 56 to 14 % of the estimated total subsistence catches for the eight communities. Since 1976, catches for dog-feed have averaged 65 t·year^{-1} (143,000 lbs·year^{-1}) and have declined from 13% to 6% of total catches (Figure 4).

Commercial catches

Commercial fisheries that were part of the informal economy from1950-1961 were estimated at 382 t·year^{-1} (842,000 lbs·year^{-1}). Commercial fisheries catches in 1962 were estimated at 553 tonnes (1.2 million lbs), but did not reach that level again until 1970. From 1963-1969 commercial catches averaged 249 t·year^{-1} (548,000 lbs·year^{-1}), during the 1970s reported catches averaged 1,097 t·year^{-1} (2.4 million lbs·year^{-1}), rising to around 1,408 t·year^{-1} (3.1 million lbs·year^{-1}) in the 1980s, before declining in the 1990s to average 621 t·year^{-1} (1.4 million lbs·year^{-1}). In 2000-2001, catches averaged 732 t·year^{-1} (1.6 million lbs·year^{-1}), but due to market conditions, recent commercial catches have been low, averaging 226 t·year^{-1} (497,000 lbs·year^{-1}) from 2002-2006. Chum salmon are the main contributors to the commercial catch totals accounting for an average of 93 % of total commercial catches. Peak years for chum occur every 3 to 4 years (Figure 4).

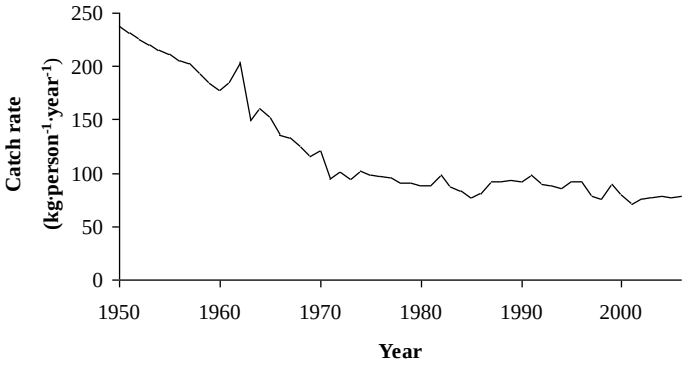

Figure5. Estimated subsistence *per capita* catch rates (total catches/total human population) for Arctic Alaska, 1950-2006 for fifteen communities.

DISCUSSION

The data presented in this report are estimates of commercial and small-scale fisheries catches for species that spend at least a portion of their life-cycle in marine waters (excluding marine mammals) taken from 1950-2006 by fifteen coastal and near-coastal communities in arctic Alaska. These data more likely represent total catches than those previously presented by reporting agencies, because they include both commercial and small-scale fisheries. Thus, they serve as useful baseline data for this area.

Furthermore, the catch reconstruction showed that more than half of the catches from 1950-2006 were from small-scale fisheries. These results underline the importance of subsistence fishing in this area and hence precautionary management to protect their livelihoods and culture. For example, it may be wise to heed the call for a ban on commercial fishing in this area to prevent fishing fleets from expanding into this area as the ice recedes (Biello, 2008) and allow the local people to maintain food security in the face of climate change and the associated ecosystem changes.

Currently, data collected at the state level on commercial and small-scale fisheries by the Alaska Department of Fish and Game are not reported to the National Marine Fisheries Service or to FAO. A more transparent catch reporting system, including data transfer information between state, regional, national, and international agencies, is needed so stakeholders can more easily access and understand available data and their limitations for policy and decision making processes. Having a baseline of information available on total fisheries catches is also important in light of global warming and impacts from ongoing developments, such as in the energy sector.

Although it appears that the commercial fisheries are well monitored by the state of Alaska, a more regular, systematic and comprehensive survey method would lead to a more complete picture of subsistence fisheries, and better track the potential impacts of global warming in this area. A subsistence

survey design incorporating each community in a specified time interval, with abundance indices for species in non-survey years could assist in clarifying actual subsistence catches. Specific attention to all salmon species would benefit the efforts to track global warming effects because species' distributions will be affected (Cheung *et al.*, in press). Coho salmon in Norton Sound have been increasing in abundance over the last two decades, but tracking similar changes in northern areas is currently difficult because salmon species, besides chum, are often described as 'other' salmon in reports. That said, chinook salmon appear to have extended their historical distributions northwards because they have been appearing in Barrow since the mid-1990s and there is no local Inupiaq name for them (C. George, pers. comm.[4]). Previously, the furthest reported extent of this species was Wainwright.

This analysis may be underestimating catch data because of the necessary use of different data sources for different time periods. For example, early reported catches were observed amounts only and excluded any adjustments for non-reporting households, whereas later reports were mostly based on a household survey method, which included estimates for non-reporting households. However, these anchor points do allow an assessment of more likely catches for the years when no data have been collected at all. Regardless, the estimates of catches presented here are likely conservative, since no marine catches have been estimated for inland communities that may still have summer camps for fishing near marine waters or that fish for anadromous species further inland.

ACKNOWLEDGEMENTS

We would like to thank Jim Menard, Jim Magdanz and Jim Simon of ADG&G, Stephen Murphy of ABR, Inc. and Bill Wilson, North Pacific Fishery Management Council for providing us with additional data and insights. We would also like to thank Oceana, and especially Susan Murray and Jonathan Warrenchuk for local and logistic support, assistance and active contributions to this work and the associated data workshop conducted in Anchorage, Alaska on 24th of January, 2008. This project has been funded by The Lenfest Ocean Program and forms part of the *Sea Around Us* Project, funded by the Pew Charitable Trusts, Philadelphia, and located at the Fisheries Centre, University of British Columbia.

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