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**Demographic Change, Economic Conditions, and Subsistence Salmon Harvests in Alaska's
Arctic-Yukon-Kuskokwim Region**

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Abstract.—This paper addresses broad demographic and economic characteristics of the Arctic-Yukon-Kuskokwim region (AYK) of Alaska. AYK human population growth has generally been moderate over time. Because out-migration regularly exceeds in-migration, especially in the villages, population growth is mainly a product of natality. We anticipate future population growth patterns will be similar. In terms of regional characteristics, the linguistically and geographically distinct populations of the AYK region are similar in terms of active traditional cultures, a strong reliance on subsistence, and relatively high measures of income poverty. While commercial fishing income is not a large contributor to total regional income, it is an important component of income for households in proximity to commercial fish processors. Many commercial fishermen are also subsistence harvesters, and for many, commercial fishing income provides the means to purchase equipment and other inputs to subsistence activities. The relationship between subsistence harvests, population growth, and commercial fishing is examined using a simple least squares regression model. Earnings from commercial salmon fishing was positively correlated with subsistence harvests while earnings from other commercial fishing reduces subsistence harvests for a set of lower Kuskokwim River communities. Separately, population growth was not positively correlated with subsistence salmon harvests in the same communities.

Introduction

This paper addresses broad demographic and economic characteristics of the Arctic-Yukon--Kuskokwim region (AYK) of Alaska. The AYK region includes vast lands, complex ecosystems, and rich cultures (Krueger et al. 2009). This paper first provides a general overview of the regional characteristics of the people, the economy, and subsistence salmon harvests. Second, Kuskokwim River communities are examined to identify specific variables affecting subsistence harvests. In particular, we test relationships between commercial fishing income, population growth, and subsistence salmon harvests using a simple econometric model. As such we identify general relationships and patterns that can be further explored in more detailed future research. Our study uses data from the U.S. Census Bureau, Alaska Department of Labor, Alaska Department of Fish and Game, U.S. Bureau of Economic Analysis, and Alaska Commercial Fisheries Entry Commission.

The Region

Four census areas account for the majority of communities impacted by Arctic-Yukon-Kuskokwim sustainable salmon initiative research (Figure 1). The Bethel census area includes most Kuskokwim river communities (up to Stony River). The Wade Hampton census area includes Alaska fishery management areas one and two of the lower Yukon River and all of the coastal district of the Yukon River.ⁱⁱ To the north is the Nome census area, which includes all communities in the Norton Sound region.ⁱⁱⁱ To the northeast is the Yukon-Koyukuk census area, stretching from the Canadian Yukon territories to the lower Yukon. The Yukon-Koyukuk census area includes the upper management area of the Yukon River. As we will discuss later in the

paper, rules governing subsistence and commercial fishing vary across management districts of the river systems.

Throughout this paper, the AYK region is defined as the region made up of the Bethel, Wade Hampton, Nome, and Yukon-Koyukuk census areas. This AYK region is a huge geographic area covering 235,000 square miles, nearly as large as the state of Texas. Not unexpectedly, this region is incredibly diverse in terms of language, culture, geography, and ecology. Alaska Natives make up more than 80% of the roughly 40,000 people who live in this region (US Census 2000). Alaska Natives living in this region include Iñupiat and Yupiit Eskimos, and Athabascan peoples.

[insert color Figure 1 about here]

Alaska Native people are the largest private landowners of this region. As a product of the Alaska Native Claims Settlement Act, Native Village and Native Regional Corporations possess fee simple title to surface and subsurface lands throughout the state. In the interior region of Alaska, the Doyon Alaska Native Regional Corporation owns and manages roughly 12.5 million acres (Doyon Corporation 2008).^{iv} In the area encompassed by the Bethel and Wade Hampton census areas the Calista Native Regional Corporation owns and manages around 6.5 million acres (Calista Corporation 2008). In the Nome census area, the Bering Straits Native Regional Corporation owns and manages around 2.1 million acres (Bering Straits Corporation, 2008). A majority of lands were selected in light of traditional subsistence activities and the vast majority of lands owned and managed by Native Corporations in the AYK region are adjacent to Yukon and Kuskokwim area watersheds (Figure 1).

The People

In 2000, the AYK region was the residence for about 6% of Alaska's total population and more than 27% of the statewide Alaska Native population (Figure 2). In addition to the two regional centers of Bethel and Nome, people in the AYK region live in about 100 small communities ranging in size from 27 people to just over 1,000. Roughly one-third of the AYK communities have populations below 200, another one-third between 200 and 500, and a final third have between 500 and 1,000 people (Figure 2). These data exclude the regional centers of Bethel and Nome with total populations of 5,471 and 3,505, respectively.

[insert Figure 2 about here]

The regional centers of Bethel and Nome make up about 23% of the AYK area population (Figure 3). Compared to the villages, a large share of population in the regional centers is non-Native. In 2000, of the roughly 6,300 non-Natives lived in the AYK, 50% were from the cities of Bethel or Nome.

With the exception of the Yukon-Koyukuk census area, the AYK population has increased during 1980-2000 (FIGURE 3). However, compared to the rest of Alaska, population growth in the AYK region has been relatively slow over time. Average AYK annual growth rates between 1980 and 1990 were about 2% and less than 1% between 1990 and 2000. Statewide annual growth rates of the Alaska Native population were about 3.0% from 1980 to 1990 and 2.3% between 1990 and 2000.^v

At the same time, patterns of growth differed across places. For example, many villages have nearly doubled in size since 1980. Large population growth also occurred in regional centers during this period. Population growth in the regional centers of Bethel and Nome (2,856 people) accounted for about 27% of the regional AYK population change.^{vi} A slightly greater share of

this growth has occurred in the regional center of Bethel as compared to the regional center of Nome (Figure 3).

[insert FIGURE 3. about here]

Generally, population growth in the AYK region has been driven by natural increase (natality), rather than in-migration (Figure 4). Except for in the Bethel census area, between 1990 and 2000 out-migration has exceeded in-migration. In many communities, young adults, and particularly young women, made up a disproportionate share of out-migrants.^{vii} Overall, births have exceeded deaths and out-migration accounting for the population increase observed in villages. Consequently, in the Bethel, Wade Hampton and Nome census areas children and young adults make up a large share of the population.

[insert FIGURE 4. about here]

Demographic changes in terms of household composition have most likely affected subsistence harvests of salmon. These changes suggest that more people do not necessarily mean increasing harvests. A high birthrate, for example, means there was a high percentage of families with young children. Magdanz et al. (2009) has shown that families with young children were often less productive subsistence producers. Also, the loss of relatively more women than men may lead to a decrease in subsistence fishing activity since women have traditionally been the processors of fish in their community. Processing is time and labor intensive and with fewer people to process fish, less incentive exists to catch fish. Consistent with this feature of the subsistence economy, Magdanz et al. (2009) has also found that single young male head of households were the lowest subsistence producers.

The Alaska Department of Labor and Workforce Development projects populations in most of the AYK region to grow by about 1% per year through 2020. The exception was the Yukon-

Koyukuk census area where the total population is expected to decrease by 0.5% per year. If the Native population grows at the same rate as total population, it will increase by about 5,000 by 2020 (AKDOL 2007).

Finally, the AYK region is rich in terms of traditional culture. A related measure is the share of people who actively speak an indigenous language. Indigenous language retention in all AYK regions is greater than averages in other parts of Alaska (Figure 5). In addition, a greater share of the Bethel census area population speaks a language other than English compared to any other AYK region. In particular, a much greater share of children in the Bethel census area speak a traditional language relative to children in other AYK regions.

[insert Figure 5. about here]

The Economy

This section provides an overview of the AYK regional economy. Subsistence activities in the AYK region interact with the cash economy. Indeed, the local economies in many parts of the AYK region are mixed subsistence and cash economies. We begin this section by presenting standard economic data and conclude by discussing the interaction between cash and subsistence in the mixed economy.

In terms of standard economic benchmarks of income and employment, households in the AYK region fall below state averages. In 1999, median household income of \$34,155 in the combined Bethel and Wade Hampton census area was about 65% of statewide income (\$51,571).^{viii} Median household income in villages outside of the city of Bethel was even lower.^{ix} In the Nome census area median household income was about \$41,250 and median household income in the Yukon-Koyukuk census area was the lowest at \$28,666.

The mean income level for the AYK region was below the federal poverty line for a large share of households. In 1999 just under 10% of the Alaska population lived in households with income less than the poverty line while in the entire AYK 21.4% of the population lived in households with income less than the poverty line (Figure 6).^x In Wade Hampton, about 26% of people live in households falling below the poverty line, slightly greater than in the Bethel census area (20%). Residents of the Bethel and Wade Hampton census areas made up just under 4% of the Alaska population yet they accounted for about 9% of the poor. In Nome and Yukon-Koyukuk census areas respectively 17% and 24% of the population lived in households with income below the poverty line.

[insert FIGURE 6 about here]

Of those living in poverty in the AYK region, 32% live in households with income that was less than 50% of the federal poverty line. In the Yukon-Koyukuk census area, of the households with income below the federal poverty line, about 40% of the poor had incomes that were less than half of the federal poverty line. This fact highlights the acuteness of income poverty in the AYK region.

Incomes in the AYK region have improved over time. In the Bethel and Wade Hampton combined census areas, real median household income grew about 8% between 1989 and 1999 and the share of the population living in poverty declined from about 30% in 1989 to 22% in 1999. In 1989 median household income in the Bethel and Wade Hampton census areas was about 58% of median income of all Alaska households improving to 66% in 1999. In the Yukon-Koyukuk census area, the share of persons living in poverty declined slightly or remained constant between 1989 and 1999.

An important component of income and income growth in the AYK region was federal and state transfer income. In 2004, 61% of total personal income was made up by net-earnings, 32% by transfer payments, and 7% by personal dividend, interest, or rental income (Bureau of Economic Analysis 2007). Transfers are payments by state or federal government to individuals for which no service is performed. Transfers include retirement and disability insurance benefits, Medicare and Medicaid, income maintenance benefits, unemployment insurance benefits, veterans' benefits, and Federal grants and loans to students. Transfers also include Alaska Permanent Fund dividend payments (PFD) which were first distributed in 1982. The 2004 PFD was about \$919 per eligible Alaska resident.

The growth in total personal income in the AYK region has been driven in part by increases in federal and state transfers. Transfer receipts made up about 21% of total personal income in 1980 while in 2004 transfer receipts had increased to 32% (Figure 7). In 2004, transfer receipts made up about 14% of total personal income in Alaska and in the rest of the US.

[insert Figure 7 about here]

Earnings are categorized into two sources, private earnings and government earnings. Government earnings accounted for roughly 46% of total earnings. Major sources of private earnings included retail trade and transportation and warehousing. Total fisheries earnings for the AYK region accounted for less than 1% of total private earnings in 2004. However, participation in the commercial fisheries was concentrated in lower Kuskokwim River and lower Yukon River communities. Commercial fishing provides an important source of cash income for hundreds of permit holders who participate in those fisheries. In the Wade Hampton, Bethel, and Yukon-Koyukuk census areas, commercial salmon harvests accounted for the vast majority of all

commercial fish harvests. In the Nome census area, the economic value of the commercial crab fishery is greater than the commercial salmon fishery.

The regional total employment picture reflects income patterns.^{viii} Unemployment rates in the AYK region are among the highest in the state. In 2000, roughly 18% of the labor force was unemployed and an additional 39% of the working age population was not in the labor force. In the Wade Hampton and Yukon-Koyukuk census areas the share of the working age population unemployed or not in the labor force was closer to 60%.

[insert FIGURE 8 about here]

Few labor markets exist in rural western Alaska and particularly in villages. The population unemployed or out of the labor force is sizeable in regional centers and villages (Figure 8). Unemployment rates in regional centers of Bethel and Nome were about 10% and the working age population not in the labor force was about 30% in 2000. In the remaining AYK area, unemployment rates averaged 21%. About 42% of the working age population was not in the labor force. The population “not in the labor force” is particularly high because most people living in villages have good information on available jobs. There are few cash jobs in most villages and many individuals do not actively “search” or look for employment the same way that someone living in a larger urban area would. Consequently, a large share of the population classified as “out of the labor force” by the U.S. Census Bureau were really unemployed.

Employment patterns also differed by race and gender. In terms of race, the non-Native population has higher employment and labor force participation rates compared to the Native population (see Appendix Table 1).^{xi} This difference is largely explained by the fact that many non-Natives with specialized training move to rural Alaska for employment opportunities. In villages of the Bethel and Nome census areas about 66% of the non-Native population work in

the educational services industry. In the regional centers of Nome and Bethel about 35% of non-Natives work in educational or the health services industries.^{xii} In terms of gender, unemployment rates for females were relatively lower than for men. In 2000, unemployment rates for females were around 12% for the region as a whole. In regional centers female unemployment rates were less than 8%.

Much of the AYK region is characterized by a mixed subsistence and cash economy. Subsistence harvests of fish, plants, and marine and land mammals play an important role in supporting human food consumption. Frequently cash earnings from jobs are used as “inputs” to support activities associated with subsistence harvests. Cash is used to pay bills and to buy supplies and fuel for subsistence fishing and hunting (Kruse 1982). Few cash jobs and high unemployment rates lead to households relying more on subsistence harvests for food but also limits their ability to pay for expenses with subsistence activities.

Over time equipment requiring cash inputs has become a more important part of subsistence harvest activities. Fishing is done in boats with motors, set and drift nets are made of nylon based materials, four wheelers and snow machines have replaced dog teams, and modern firearms are essential. As a result, cash income has become increasingly important as an input to subsistence harvests in the AYK region.

Subsistence Salmon Harvests

In light of high unemployment, low household incomes, and acute income poverty, subsistence salmon harvests play a critical role as a food source for residents in the AYK region. At the same time, subsistence opportunities are also an important part of the culture.

The link between culture and subsistence was described by Senator Moris Udall (AZ) in debating the development of the Alaska National Interest Lands Conservation Act (ANILCA). He noted "... the intent of this legislation to protect the Alaska Native subsistence way of life, and the Alaska Native culture of which it is a primary and essential element, for generation upon generation, for as long as the Alaska Native people themselves choose to participate in that way of life"^{xiii} Similarly, Rosita Worl, an accomplished Alaska Native anthropologist, noted the multifaceted linkages between culture and subsistence in her 2002 testimony before a U.S. Senate Committee discussing ANILCA and subsistence hunting and fishing in Alaska. Worl notes that "the cultural component includes the values and ideologies that govern and direct subsistence behavior or activities. For example, the value of sharing is key to subsistence and the survival of Native societies" (Worl 2002).

Most communities in this region are located on the Yukon and Kuskokwim Rivers, which provide easy access to the subsistence fishery (Figure 1). Salmon harvests occur in the river system as well as in near-shore marine waters for coastal communities. Even the tundra villages (west of Bethel and north of the Kuskokwim River) participate in subsistence salmon harvests. For instance, the majority of families in the village of Nunapitchuk travel up and down the Johnson River to the Kuskokwim River to participate in subsistence salmon harvests.

Subsistence salmon harvests continue to make up a large share of total household consumption in the AYK region. The Alaska Division of Subsistence estimated that most households participated in subsistence fish harvests (greater than 90%) and that these participation rates were greater than other Alaska regions (Wolfe 2000). Similarly, a controlled study exploring traditional food use in seven AYK area villages found that on average people derived 22% of their diet from traditional subsistence foods (Bersamin et. al. 2007). Elders over

60 years of age derived the most (43%) and youth ages 14-19 derived the least (7%) (Bersamin et. al. 2007).

While subsistence harvests remain high, per household subsistence harvests have decreased over time (Figure 9).^{xiv} Prior to 1990, harvests were highest in the Yukon-Koyukuk census area, averaging over 100 fish per household.^{xv} Since 1990, harvests have declined and less variation occurred among regions. From 1990 through 2004, harvests in the entire AYK region decreased from about 80 fish per household to about 40 per household. From 2000 to 2002, harvests in the Yukon-Koyukuk census area dropped to around 20 fish per household. The Yukon-Koyukuk census area includes most of the upper Yukon River management area (the Yukon River above its confluence with the Koyukuk River, near Galena in Figure 1). These declines in household harvests over time are consistent with the changes in household composition described earlier in the paper. A similar declining pattern was also described by Magdanz et al. (2009) for ten communities in the Norton Sound region (1994-2003).

[insert Figure 9. about here]

Subsistence harvests vary significantly across households within a community. Wolfe and Walker (1987) found that about 30% of household's harvest 70% of traditional foods within a community. This relationship has also been validated in other Western Alaskan contexts (Magdanz et. al. 2009). Over time, the ratio seems to be consistent across communities but the mix of wages and subsistence change within households as households mature (Wolfe and Walker 1987). Households with young parents are not very productive either as hunters or wage earners. As they mature, household adults earn more money, some use their earnings to buy better equipment and harvest more food. Wolfe and Walker (1987) characterizes 'super-households' as those which have high incomes and high subsistence productivity. Over time,

households age and become less productive. Children move out and start their own households and the process begins again.

In terms of formal rules for subsistence harvests, regulations vary among drainages. On the Kuskokwim River few formal restrictions exist for subsistence salmon harvests (of any species). Subsistence permits or licenses have never been required on the river. No harvest limits for salmon occur, and restrictions on gear and timing are minor (ADF&G 2005).^{xvi} On the Yukon River, generally more regulations govern subsistence salmon harvests (ADF&G 2005). For instance, on the Yukon, permits and bag limits are enforced in some areas and gear and timing limitations are more restrictive relative to the Kuskokwim River.^{xvii} In both areas, all local residents (both Native and non-Native) are eligible to participate in subsistence harvests.

Chinook subsistence salmon harvests are important to the Bethel, Yukon-Koyukuk, and Wade Hampton census areas (Figures 10-12). Chinook salmon are a main subsistence fish for human consumption (Andrews and Coffing 1986). Although moderate population growth has occurred in the Bethel census area, the relationship between population growth and subsistence Chinook harvests is unclear (Figure 10). From 1970 to about 1985 there appears to be no correlation. In certain periods, such as the period after 1996, population growth was actually negatively related to subsistence salmon harvests. Of course, many other factors influence subsistence harvests such as the varying abundance of Chinook salmon runs each year (Linderman and Bergstrom 2009) but these general data suggests caution in inferring that population growth is always correlated with increased subsistence harvests.

[insert Figure 10. about here]

The human population of the Yukon-Koyokuk census area has grown very little between 1978 and 2004 (Figure 11). Since population changes have been so insignificant, changes in the Chinook salmon harvest are unlikely to be due to human population growth.

[insert Figure 11. about here]

Similar to the Yukon-Koyokuk census area, chinook salmon subsistence harvests remain relatively constant over time in the Wade Hampton census area (Figure 12). Chinook salmon harvests moderately increased over time along with population. Harvests per household averaged four fish in 1978 and 3 fish in 2004.

[insert Figure 12 about here]

Increased cash income may have mixed effects on subsistence harvests. At the community level, some researchers have hypothesized that higher income is negatively related to higher subsistence productivity (Wolfe and Walker 1987). Wealthier communities could have relatively lower subsistence harvests; people with higher incomes substitute purchased foods in place of subsistence harvested food. At the same time, cash is an important input to support subsistence activities and higher incomes may increase subsistence harvests (Kerkvliet and Nebesky 1997).

Kuskokwim Commercial Fishery

AYK regional commercial fishery context

The estimated value of the total gross commercial catch for permit holders residing in the AYK region was \$7,894,484 in 2004 (CFEC, 2005).^{xviii} Commercial salmon harvests accounted for about 80% of this total. In 2004, chum salmon made up about 10% of total AYK commercial harvests, coho salmon 71%, sockeye salmon 8%, and Chinook salmon 10% (ADF&G 2004). In terms of value Chinook salmon harvests made up about 70% of value followed by coho salmon

at 26% (ADF&G 2004). In more recent years, sockeye and chum salmon harvests have increased (see Linderman and Bergstrom 2009).^{xix}

While direct regional earnings from commercial fisheries are not as large as the Bristol Bay commercial fishery, earnings are an important contributor to income in lower Kuskokwim River and lower Yukon River communities.^{xx} The vast majority of commercial salmon comes from the lower Yukon River, the lower Kuskokwim River, and nearby coastal marine waters. Hundreds of residents from the AYK region participate in the fishery (Knapp 2009). Knapp (2009) reports that the average earnings per permit fished was around \$4,000. Given median household income of about \$30,000 and high rates of income poverty (discussed earlier), earnings from commercial fishing provided an important source of income for AYK area residents participating in the fishery. Permit holders residing in the Bethel census area accounted for about 50% of total estimated AYK commercial salmon earnings in 2004 and permit holders in the Wade Hampton census area accounted for about 45% of the estimated commercial salmon earnings (CFEC 2005).

The Community Development Quota (CDQ) program plays an important role in the regional commercial fishing industry. In 1992 the North Pacific Fishery Management Council (NPFMC) established the CDQ program “with the goal of creating fisheries related economic development in Western Alaska” (CDQ 2008). A total of six CDQ organizations exist and three are in the AYK region. AYK area CDQ’s include Norton Sound Economic Development Corporation, Yukon Delta Development Fisheries Association, and Coastal Villages Region Fund; these three organizations represent approximately forty one coastal communities. Currently, CDQ groups are given roughly 7.5% of the Bering Seas/Aleutian Islands quota for pollock, halibut, sable-fish, and Bering Sea opilio, bairdi, and king crab (Northern Economics 2002). In addition to

managing quota shares through direct harvests or through the lease of quota, CDQ's participate in the development of near-shore commercial fisheries for salmon and herring. For instance, Coastal Villages Region Fund currently operates a salmon processing plant in Quinhagak and will be opening another facility in the Kuskokwim Bay near the city of Platinum.^{xxi} CDQ revenues are invested back into CDQ operations and community development operations intended to benefit member coastal communities. Because of data limitations it is difficult to identify revenues and employment generated by CDQs in the AYK region.

Commercial fishing income and the Kuskokwim fishery

To explore the linkages between commercial fishing, total income, and subsistence salmon harvests more carefully, we focused our analyses on the Bethel census area. As indicated in Figure 1, the Bethel census area includes the vast majority of people and places in the Kuskokwim River watershed. The area also includes the lower section of the Kuskokwim River (downstream from the village of Tuluksak), the section of the Kuskokwim where most commercial fishing occurs. Because of the way that economic data have been structured and reported, Bureau of Economic Analysis data for the Bethel census area can be compared to Alaska Commercial Fisheries Entry Commission data. We also focus on this area because corresponding Alaska Department of Fish and Game (ADF&G) subsistence harvest survey data exist for the same lower Kuskokwim communities allowing us to explore linkages between commercial and subsistence salmon harvests.

In terms of its size compared to other Alaska commercial fisheries, the lower river Kuskokwim commercial fishery is relatively small. Yet, as we will describe, the commercial

fishery plays an important role in this portion of the region and is an important source of income for households using commercial salmon fishing permits.

The commercial fishery directly and indirectly contributes to personal income. In terms of direct effects, households earn income as sole proprietors or as employees of a commercial fishing establishment. In terms of indirect effects, various support industries provide employment, and fishing income spent in the region generates additional income – i.e., multiplier effects. Available data, limit our focus to only the direct effects of commercial fishing income on total personal income. We look at this overall for the region and then in terms of contribution to individual permit holders.

Direct earnings from commercial fisheries make up a small share of total personal income for the entire Bethel census area (Figure 13).^{xxii} From 1986 to 2004, the earnings from commercial fisheries was in the range of 16% to less than 1% of total private earnings. The contribution of fishing income to private earnings has declined somewhat steadily since 1995, when fisheries earnings accounted for 3.2% of private earnings. In 2004 fishing income was about 0.5% of private earnings. To provide some context, income from commercial fishing made up about 10% of private earnings in the Dillingham census area and 3% in the Bristol Bay region in 2004 (Bureau of Economic Analysis 2007). At the same time, if we could exclude the city of Bethel and report data only for lower Kuskokwim communities the contribution of commercial fisheries to total earnings would be much greater in the lower Kuskokwim region compared to the regional total.

[insert Figure 13 about here]

In the Kuskokwim River region, the majority of commercial permit holders reside in the Bethel census area. About 98% of permits fished were owned by people residing in the Bethel census area. The majority of these permit holders who fished, live in lower Kuskokwim river because the biggest commercial buyer of salmon is in Quinhagak in Kuskokwim Bay (Figure 1); permit holders living in up-river places do not have access to a major buyer. In 1988 just over 800 permits were fished. The number of permits fished began to decline in 1996 reaching a low of about 400 by 2002 increasing to about 500 by 2005.

In terms of the value of commercial permits, prior to 1996, average revenue per permit fished was between \$5,000 and \$7,000 (see Figure 15.) – with an average of about 780 permits fished. In 2004, the average revenue per permit fished was about \$3,300 (with 466 permits fished). Considering that median household income in 2000 was around \$29,000 for the two census tracts outside of the city of Bethel, commercial fishing income is an important component of total income for households using commercial fishing permits in the lower Kuskokwim River communities.

“Economic disaster” and the Kuskokwim commercial and subsistence fisheries

Total commercial and subsistence salmon harvests for the Kuskokwim River are shown in Figure 14 below. As indicated, chum and coho salmon have historically made up the largest share of total harvests in the Kuskokwim River (Figure 14; see also Linderman and Bergstrom 2009). The 1997 harvest decline corresponds with the precipitous decline in chum and coho salmon runs.

[insert Figure 14. about here]

The reduction in total harvests beginning in 1997 was due primarily to a decline in commercial fishing. Commercial fishing harvests began to decline around 1997 as declining run sizes led to limitations or closures of the commercial fishery (Figure 15). During this period, targeted species changed from predominantly chum salmon prior to 1996 to coho salmon in later years (see Figure 14). Corresponding to this decline in commercial harvests was a price decline - due in part to competition from farmed salmon - which can be seen as early as 1995 (see Knapp 2009). The average value of each permit fished declined rapidly during this period, dropping from a high of nearly \$7,000 in 1994 to about \$1,500 in 1997. Because of declining runs and the closure of the commercial fishery the area was declared a disaster area by the Alaska governor for five of six years.

[insert Figure 15. about here]

A major change in the commercial salmon market occurred during this period and contributed declines in commercial fishing income. Also, closure of the chum salmon fishery facilitated the closure of major fish processors / buyers in the city of Bethel. To date, a large buyer of commercial salmon does not exist in the Bethel area. Commercial fisherman in up-river communities were the hardest hit by this change because fisherman in some lower Kuskokwim River communities (e.g., Tuntutuliak and down-river) continued to have access to a major buyer in Quinhagak. In spite of the importance of commercial fishing income for households with commercial permits, the closure of the commercial fishery does not appear to be associated with large out-migration from Bethel or Wade Hampton localities. Between 1995 and 2000, the population only declined about 5% due to out-migration, a smaller population decline relative to almost all other Alaska regions during the same period (US Census 2000).

The subsistence fishery was also impacted by the commercial closure but changes were not as dramatic. In general, subsistence harvests have been relatively constant over time in “bad” years and in “good” years as compared to the regional commercial fishery (Figure 16). Over the entire period, subsistence harvests averaged around 216,000 fish with a standard deviation of 40,103 fish – the standard deviation of commercial harvests was roughly 10 times greater (473,742 fish). Even with the closing of commercial fisheries from 1999 to 2001, subsistence harvests did not increase. Similarly, in 1988, when runs were abundant, subsistence harvests were generally constant.

[insert Figure 16. about here]

The stability of subsistence harvests in the Kuskokwim River area is notable in that it is not a product of external rules. While the regional commercial fishery is tightly controlled and monitored by the state, the subsistence fishery is largely unregulated, in terms of formal state rules, relative to other Alaska regions. For Kuskokwim River communities no subsistence bag limits for salmon exist nor are subsistence permits required. Starting in 2001, some limits to the season and start dates were imposed on the Kuskokwim River but relative to the lower and upper Yukon River management areas, subsistence salmon harvests were largely unregulated on the Kuskokwim River.^{xxiii}

Mean subsistence harvests have been relatively constant over time compared to commercial harvests; however, an important change in subsistence harvests occurred after the 1997 decline in run sizes. Mean subsistence harvests from 1980-1996 were 230,637 fish while mean harvests after 1997 were 196,913 fish.

The harvest change was observable for lower Kuskokwim communities (down-river of Tuluksak; Figure 17).^{xxv} Average subsistence harvests in lower Kuskokwim communities

(excluding Bethel) were 130,143 fish from 1990-1996, from 1997-2004 from average subsistence harvests were 101,429 fish. Similarly, the average catch per household prior to 1997 (124 fish) was significantly greater than average catch per household after 1997 (80.5 fish) in lower Kuskokwim communities. The difference between mean harvests is still significant even when including subsistence harvests from the city of Bethel.

[insert Figure 17 about here]

Why did subsistence harvests decline during this period? Although salmon escapements declined, it is not clear that these declines were the single factor in reducing subsistence salmon harvests. Competition from commercial fishing actually declined during this period and subsistence harvests have stayed below their historic average even as run sizes for some species show signs of recovery (Linderman and Bergstrom 2009).

Anecdotal evidence also indicates that subsistence fisherman did not view the period as an absolute disaster. A 2000 ADF&G Kuskokwim fisheries harvest survey asked respondents to rate the “quality” of fishing that year. Sixty-one percent of households indicated chum salmon fishing was good or average and seventy-two percent reported that coho salmon fishing was good or average (Boyd and Coffing 2001). Thus, while a sizeable share of households reported abnormally poor fishing, a majority of households reported average to good fishing.

If reduced salmon escapements were not the single variable behind the decline in harvests on the Kuskokwim River, at least two other factors should be considered. First, self-regulating local institutions may have contributed to the decline in subsistence harvests as local people cut-back on average harvests. As described earlier, the Yup’ik people of the Kuskokwim River region maintain a strong traditional culture. As a people who have been dependent on fluctuating resources for generations their informal rules and customs undoubtedly account for such

uncertainty (Fienup-Riordan 1986). The extent to which certain informal rules may have affected subsistence harvests after the “economic crisis” period is an important area for future study.

Similarly important future research should describe how these informally based local community rules develop in light of resource uncertainty and how these institutions change in light of major disruptions to the normal harvest cycle, such as the late 1990’s economic crisis.

A second explanation involves the relation between subsistence and commercial fishing. Commercial fishing could be an important input to subsistence for households with commercial fishing income. Commercial fishing income, an average of \$5,000 to \$6,000 per permit holder in the early 1990’s, and closer to \$3,000 in 2004, could provide important resources to support subsistence activities for households in the Kuskokwim area. As commercial fishing income declined during this period, households may have reduced the use of certain equipment or could have cut-back on the number and distance of fishing trips.

Kuskokwim River commercial fishing income, population growth, and subsistence salmon harvests

A simple econometric model was used to explore relationships among commercial fishing income, population growth, and subsistence salmon harvests for lower Kuskokwim River communities. We form a panel of subsistence and commercial salmon harvests over time and by place by combining two data sources described below. The use of panel data allow us to provide a consistent estimate of certain coefficients in spite of omitted variables (Wooldridge 2001). That is, while important explanatory variables may be missing from our data, the use of panel data allow us to obtain reasonably reliable estimates of the effect of commercial fishing income and population growth on subsistence salmon harvests.

The standard equation we estimate can be written as

$$y_{it} = x_{it}\beta + c_i + u_{it}$$

where i represents the sixteen lower Kuskokwim places and t corresponds to the period 1990 to 2005. The coefficient c represents a constant term that is group specific (i.e., communities) but does not vary over time and u is the error term.

The dependent variable in our equation (y) is average household subsistence salmon harvests. This variable was regressed on a small set of independent variables (x) by community (i) over time. Independent variables include three-year average population growth rates, average household income from Kuskokwim River commercial salmon harvests, and average household “other” commercial fishing income. A dummy variable equal to one after 1996 (and zero before) is used to capture the period of the declining chum runs and the associated restrictions on the commercial fishery (i.e. a “shock”). A second dummy variable is used to identify the city of Bethel. Including this dummy variable allows us to control for the fact that household subsistence harvests in Bethel are likely to differ from other communities.

Data used in this model were from ADF&G subsistence salmon harvest surveys for lower Kuskokwim River communities and Alaska commercial fisheries data.^{xxiv} Since about 1990, ADF&G subsistence salmon surveys have been conducted annually in several Kuskokwim River communities. These data contain annual subsistence salmon harvests and an annual estimate of the total number of households for each lower Kuskokwim River place. Based on personal correspondence with ADF&G personnel, to our knowledge consistent survey methods and instruments have been used since about 1990. We used data from lower river communities (down-river from Tuluksak) including the Tundra Villages.^{xxv}

We combined ADF&G data with data from the Alaska Commercial Fisheries Entry Commission (CFEC). CFEC data are also available at a community level for all types of commercial fishing. We separated commercial salmon fishing income in the Kuskokwim region from other types of commercial fishing income. For residents in the Kuskokwim region, most other types of commercial fishing happen outside of the Kuskokwim River - e.g., earnings from the Bristol Bay salmon fishery. In estimating this equation, we used both a fixed-effects model and a random-effects model that controls for the fact that the error term (u) does not have constant variance.^{xxvi} In both cases, similar results occurred.

Results

The analysis offered here should only be considered a small step in a multifaceted approach needed to better understand subsistence harvests in the AYK region. Many complexities of AYK area fisheries exist (e.g., timing, equipment, distribution of permits, fuel costs) that have not been addressed in our analysis. Note also that the results were based on data from the sixteen lower Kuskokwim communities and include the city of Bethel. Further analysis that yields a better understanding of the linkages between population growth, the commercial fishery, and the subsistence salmon fishery is warranted.

In terms of results, earnings from commercial salmon fishery was positively correlated with subsistence salmon harvests. At the community level, income earned from the Kuskokwim River commercial salmon fishery was a significant variable and positively related to subsistence salmon harvests (Appendix Table 2). A similar outcome was observed in both fixed and random effects models, although the relationship was stronger under the random effects model. The relationship was not as large at the community level. The model estimates that a \$1,000 increase

in average household Kuskokwim commercial salmon fishing income would only increase subsistence salmon harvests by about 5-12 fish per household. Given that the average catch per household in this region was about 80 fish, as noted earlier, a \$1,000 decrease in income could reduce harvests up to about 10%. The primary finding was that earnings from the commercial salmon fishery were positively related to subsistence salmon harvests.

In contrast to earnings from commercial salmon fishing, the regression results indicated that commercial fishing income from other commercial fisheries was negatively related to subsistence salmon harvests in the Kuskokwim. The negative coefficient on this variable was as strong as the positive effect of earnings from the commercial salmon fishery. One interpretation of this finding was that households holding other commercial fishing permits leave the region more frequently to fish in commercial fisheries outside of the Bethel census area and as a result Kuskokwim River subsistence salmon harvests declined.

Regression results indicated that population growth was negatively related to subsistence salmon harvests. Moderate population growth was associated with declining subsistence harvests. This result was based on data from all sixteen communities in our sample, including the city of Bethel. Data used were average annual three year growth rates; however, similar results occurred for annual growth rates and five-year average annual growth rates. Average annual five-year growth rates were a significant variable and negative for both fixed and random effects models. As discussed earlier, population growth for the region has been moderate over time.

Regression analyses indicated that subsistence salmon harvests declined after 1997. The statistically significant coefficient on the “shock” variable tells us that from 1997 on, households in the sixteen communities harvested fewer fish compared to previous years (i.e., before 1997).

As discussed earlier, the harvest decline could be a function of reduced run sizes and/ or local informal customs that limited harvests.

Household subsistence salmon harvests were on average lower for the community of Bethel than in other communities. Bethel households harvested fewer fish when compared to the households in lower Kuskokwim villages included in our sample - again this result was statistically significant. The result could be due in part to different household composition and a relatively greater share of the population engaged in the formal cash economy in Bethel than elsewhere (Appendix Table 1).

Discussion of results

The econometric results provided insight into the linkages among commercial fishing income, population numbers, and subsistence salmon harvests. Similar to existing studies looking at the general relationship between income and subsistence harvests (e.g., Wolfe and Walker 1987; Kerkvliet and Nebesky 1987) mixed results occurred our analyses. We find that income from different sources has different effects on subsistence salmon harvests. Income from commercial salmon fishing was associated with increased subsistence harvests and therefore the hypothesis that commercial salmon fishing income and subsistence harvests were negatively correlated can be rejected. This evidence was consistent with the notion that households in lower-Kuskokwim River communities use earnings from commercial salmon fishing as an input to support subsistence activities. When income from commercial salmon fishing declined so did subsistence salmon harvests. In contrast, income from other commercial fishing reduced subsistence salmon harvests. A likely explanation was that households who earned income in commercial fisheries elsewhere spent less time subsistence fishing on the Kuskokwim.

Population growth was not associated with greater subsistence salmon harvests. In fact, the econometric results showed a statistically significant and negative relationship between population growth and household subsistence harvests for the sixteen communities (including Bethel) in our sample. While this result may not intuitively be plausible, the negative relationship observed between population and subsistence harvest was consistent with the economic and demographic changes in the AYK region described earlier. For instance, more households were involved in the cash economy, there were fewer women relative to men living in villages, and families were younger. While households may have greater income for subsistence, the opportunity cost of subsistence harvest also increased. Taking time for subsistence activities may trade off with time available for earning cash income. Also, the number of women living in villages has declined. Because subsistence is a team effort, men may have harvested fewer fish when women were not able to assist in processing. Our earlier observation of an increased number of young families, known to harvest fewer fish, was also consistent with our findings. Finally, informal rules and customs may have been important, such as the goal of avoiding waste or other cultural constraints, could have mitigated the effects of population increase on subsistence salmon harvests.

These results allowed us to reject the hypothesis that subsistence harvests were unchanged after widespread closures of the commercial fishery. Subsistence harvests after 1997 have been consistently below a historical average. Lower escapement of salmon undoubtedly accounts for some of this decline but the role of other factors should also be considered in future research.

Finally, the results provided evidence that Bethel households do not harvest the same amount of salmon as households in other communities. Bethel area households harvested less when compared to households in the fifteen other villages included in our sample. This result may be

explained in part due to differences in household composition. Also, these findings were consistent with the hypothesis that greater cash income trades off with subsistence because incomes were higher in Bethel and households participate at greater rates in the cash economy than elsewhere.

These econometric results help to identify general relationships affecting subsistence salmon harvests and point to variables that can be impacted through public policy. Our findings, however, were by no means exhaustive nor conclusive. Further investigation that controls for other variables important in the decision to conduct subsistence harvest activities could validate these initial findings and provide more relevant information to policymakers considering regulatory changes of commercial fisheries in different river systems. Many factors influence subsistence salmon harvests, including variability in run sizes, local institutions, and changes in household composition over time. Accounting for these other variables will help refine the relationships identified here. Also, our findings should be considered in light of our relatively small sample of sixteen communities; expanding the analysis to communities in other regions could validate these preliminary findings. Better data at the household level over time, for instance, would allow for better estimates. Also, the analysis could be improved by data that captures more of the complexity of the fishery such as timing, fuel costs, and distance to market. Data allowing exploration of similar relationships on the Yukon River would also provide valuable insight.

Further empirical and analytical modeling of these relationships would also be valuable. For instance, policymakers need to understand how management of the commercial fishery affects subsistence harvests in a region where fishermen often participate in both subsistence and commercial fisheries. Further policy analysis might allow one to better predict changes in

subsistence catch given specific levels of commercial catch and income. Such research could also help to explain why some households are high subsistence producers in a community and how this changes from year to year.

Conclusion

This paper addressed broad demographic and economic characteristics of the AYK region. We noted that regional population growth has been moderate over time but growth rates have been relatively great in the regional center of Bethel and in a small number of villages. Out-migration of the human population regularly exceeds in-migration, especially in the villages, and consequently growth is largely a product of natural increase. We anticipate future population growth patterns will be similar.

In terms of regional characteristics, the linguistically and geographically distinct populations of the AYK region were similar in terms of active traditional cultures and a strong reliance on subsistence. We also noted that formal rules governing subsistence and commercial salmon harvests vary across regions and the impact of these rules on subsistence salmon harvests is an important area for future research.

The AYK region was characterized by high unemployment, low household incomes, and high levels of income poverty. While commercial fishing income was not a large contributor to total regional income, it was an important component of income for communities in proximity to a commercial fish processor and for households using commercial fishing permits. We also noted that many commercial fishermen were also subsistence harvesters and that commercial fishing income can provide equipment and other inputs important in supporting subsistence activities.

To explore the relationship between commercial fishing income, population growth, and subsistence salmon harvests we focused on the Kuskokwim River region. A simple econometric regression model provided evidence that subsistence salmon harvests were positively correlated with income from commercial salmon fishing on the Kuskokwim River but negatively related to commercial fishing income from other regions. Subsistence harvests also appeared not to have increased with population growth.

Links between subsistence salmon harvests and population growth are complex. Many factors including local institutions, variability in escapement, and changes in regulations are variables that should receive future attention. Also, the recent sharp rise in fuel prices has made groceries more expensive causing some households to increase their reliance on subsistence salmon while at the same time increasing the costs of fishing. Some anecdotal evidence that high fuel prices are causing people to leave rural Alaska (Martin et al. 2008). The long term impact of fuel prices and their direct and indirect effects on salmon harvests remain to be seen.

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Appendix Tables

APPENDIX TABLE 1.—Employment in the AYK region, 2000. Source: US Census 2000, summary file 3 and 4. Unemployment rate refers to the share of civilians in the labor force who are unemployed. Those who are employed or who are actively seeking employment are in the labor force. Working age population is the population 16 and older.

Source	Unemployment Rate*	Working age population**	Share of the working age population not in the labor force
AYK region: Native	22.0%	19,932	43.7%
AYK region: non-Native	5.5%	5,138	17.8%
Regional Center: Native	16.3%	3,584	39.1%
Regional Center: non-Native	3.4%	2,660	15.5%
Villages: Native	23.3%	16,348	44.8%
Villages: non-Native	7.9%	2,478	20.3%
AYK region: Female	12.0%	11,669	39.5%
Regional Center: Female	7.8%	2,937	31.3%
Villages: Females	13.6%	8,732	42.3%

APPENDIX TABLE 2.— Table 1. Fixed effects (within) and feasible generalized least squares regressions statistics examining associations with the dependent variable (y) of average household subsistence salmon harvests vs. population growth, and earnings. Absolute value of t statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Source	Fixed effects	FGLS (random effects)
three_year_growth	-.451	-1.52
<i>[This variable is the three-year average population growth rate by community.]</i>	(1.12)	(3.97)***
salmon_earnings	0.005	0.008
<i>[This variable is the average household income from the Kuskokwim commercial salmon fishery by community.]</i>	(2.02)**	(3.30)***
other_fisheries_earnings	-0.005	-0.012
<i>[This variable is the average household income from other commercial salmon fisheries (e.g. Bristol Bay) by community.]</i>	(3.37)***	(13.86)***
shock	-21.773	-17.722
<i>[This is a dummy variable equal to one after 1996 and zero otherwise.]</i>	(2.87)***	(2.82)***
Bethel		-56.235
<i>[This is a dummy variable equal to</i>		(11.55)***

*one for the city of Bethel and zero
otherwise.]*

constant	106.164	115.585
	(11.64)***	(14.89)***
Observations	183	183
Number of places	16	16
R-squared within	0.34	
R-squared between	0.69	
R-squared overall	0.36	
Wald chi ²		475.94***

Figure Captions

FIGURE 1. Population and population change in Alaska's Arctic-Yukon-Kuskokwim Region

FIGURE 2. Total population of communities in the AYK region, 2000*

FIGURE 3. Total population and Native share of the total population in the AYK region, 1980-2000

FIGURE 4. Population change in the AYK region, 1990-2000

FIGURE 5. Share of Alaska Native population speaking a language other than English, 2000

FIGURE 6. Alaska population living in households with income less than the poverty line, 1999

FIGURE 7. Real Total Personal Income over Time (in 1000's), AYK Region, 1980-2004

FIGURE 8. AYK regional employment, 2000

FIGURE 9. Subsistence salmon harvest per household AYK region, 1978-2004

FIGURE 10. Kuskokwim River subsistence Chinook salmon harvest and population of the Bethel census area 1960 – 2004

FIGURE 11. Upper Yukon subsistence Chinook salmon harvest and population of the Yukon-Koyukuk census area 1978 – 2005

FIGURE 12. Lower Yukon subsistence Chinook salmon harvest and population of the Wade Hampton census area 1978 – 2005

FIGURE 13. Real earnings by place of work, Bethel Census Area

FIGURE 14. Total salmon harvests in the Kuskokwim River, by species, 1980-2004

FIGURE 15. Commercial salmon harvests (gill net) and average value per permit fished, Kuskokwim River region, 1990-2005

FIGURE 16. Subsistence as a share of total salmon harvests in the Kuskokwim River, 1980-2003

FIGURE 17. Subsistence salmon catch, lower Kuskokwim communities (excluding Bethel), 1990-2004

FIGURE 18. Median household income for select regions, 1999

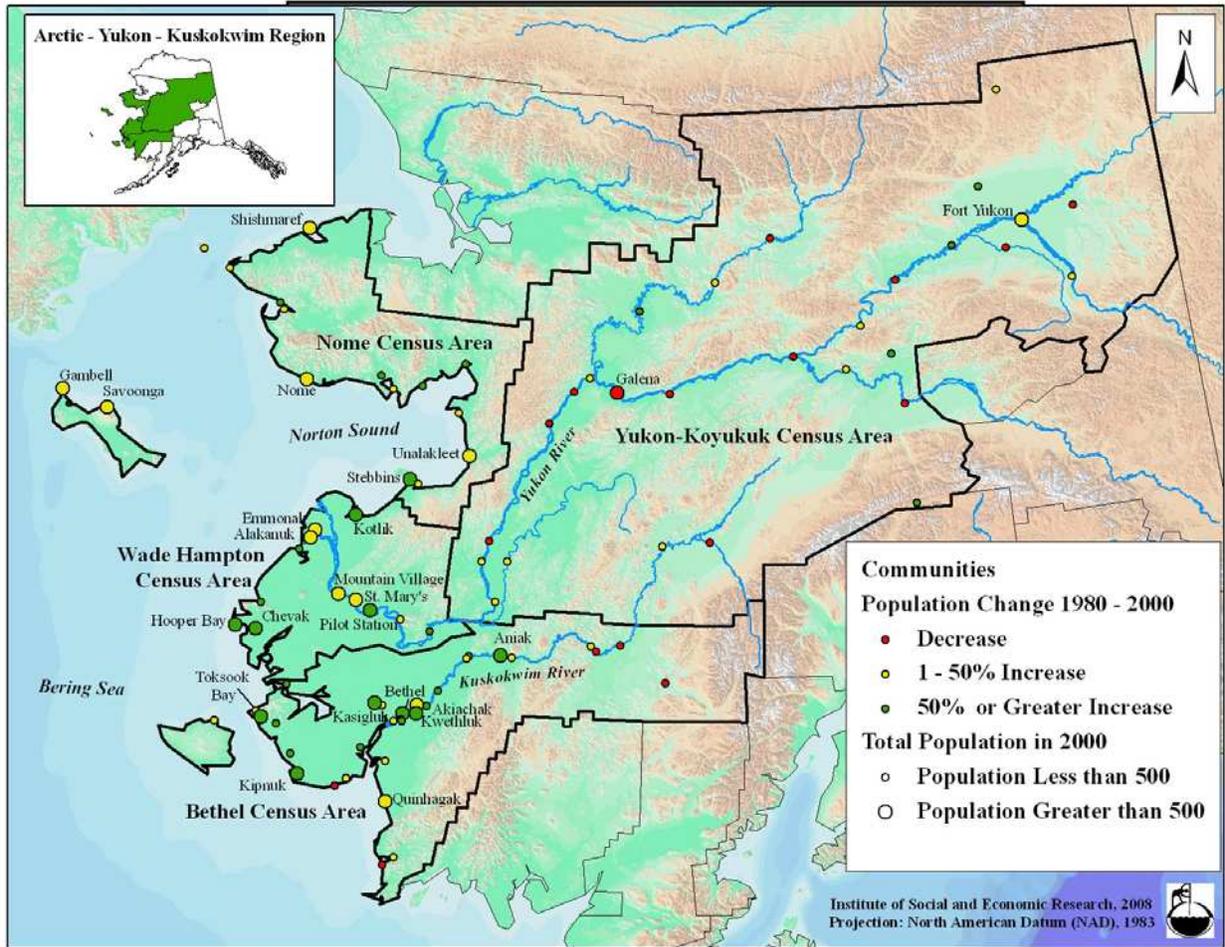
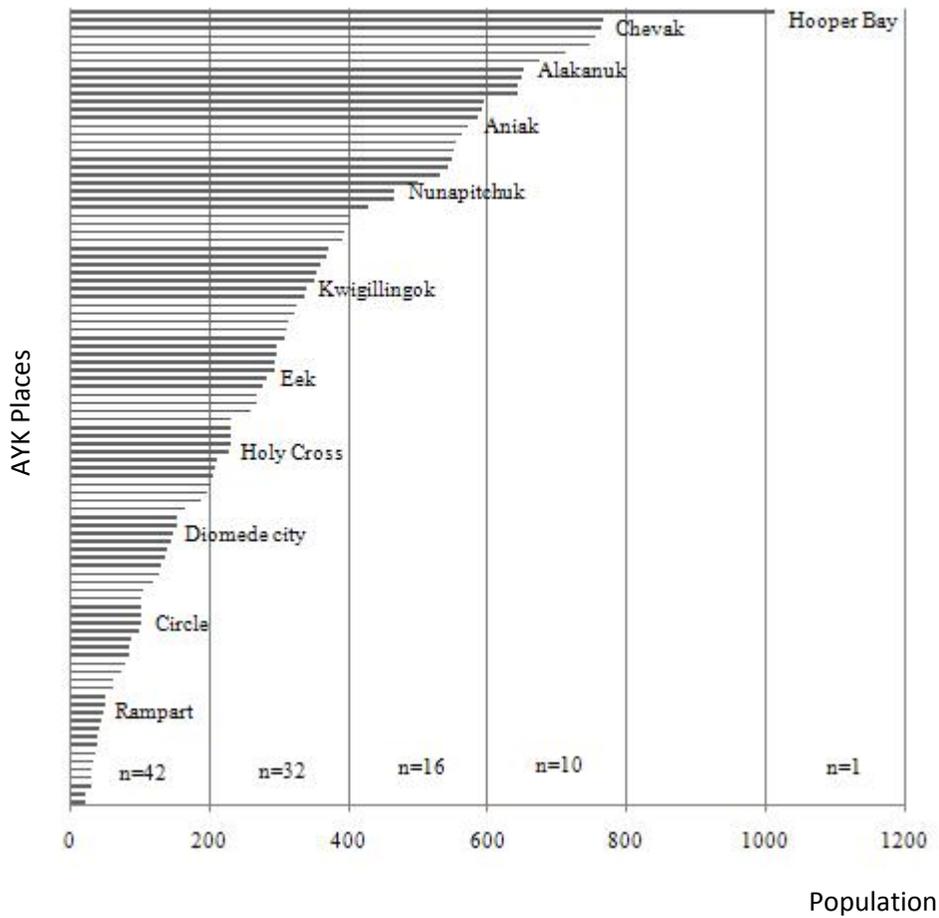


FIGURE 1. Population and population change in Alaska’s Arctic-Yukon-Kuskokwim Region.

Source: US Decennial Census 1980, 1990, and 2000.

FIGURE 2. Total population of communities in the AYK region, 2000*. Data for the regional centers of Bethel and Nome with total populations of 5,471 and 3,505, respectively was not included in the figure.



Source: US Census 2000, summary file 1.

*Census designated places excluding regional centers of Nome and Bethel.

**n=number of places

FIGURE 3. Total population and Native share of the total population in the AYK region, 1980-2000.

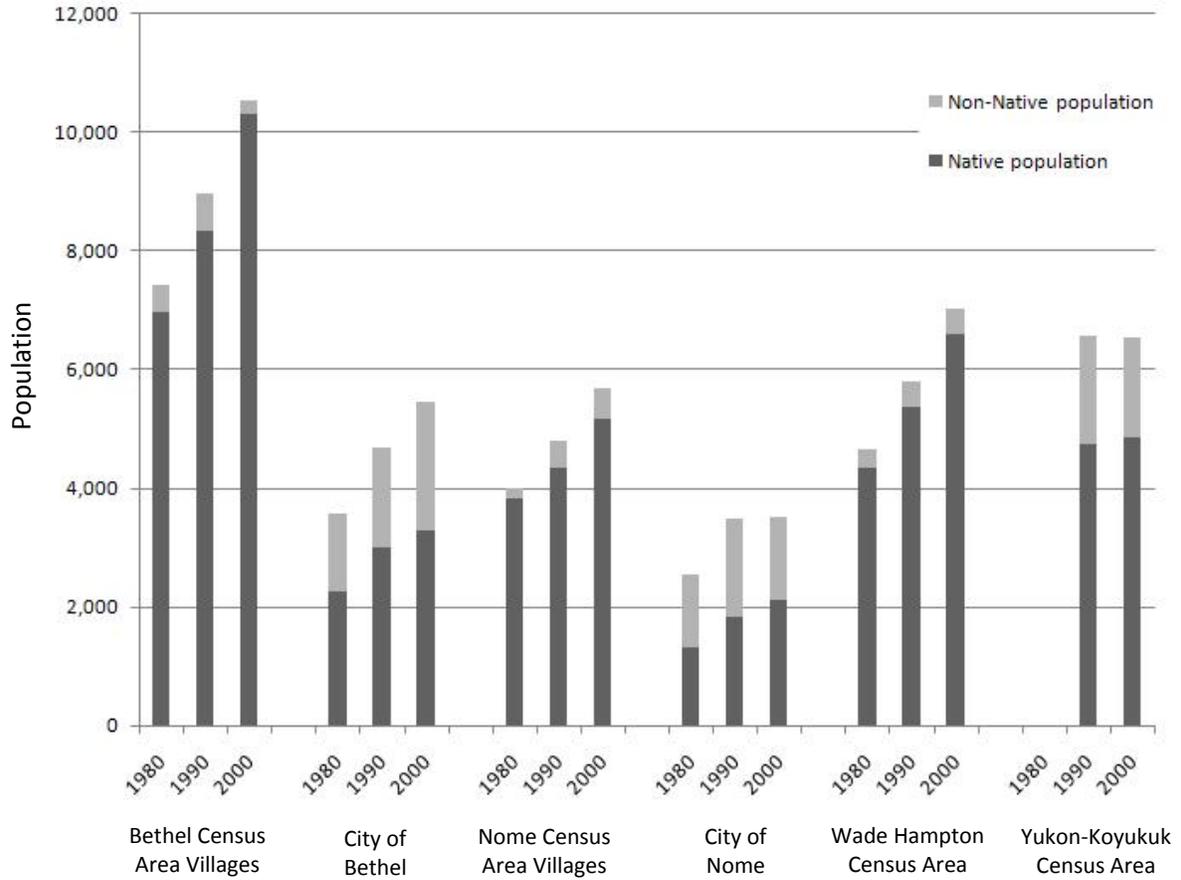
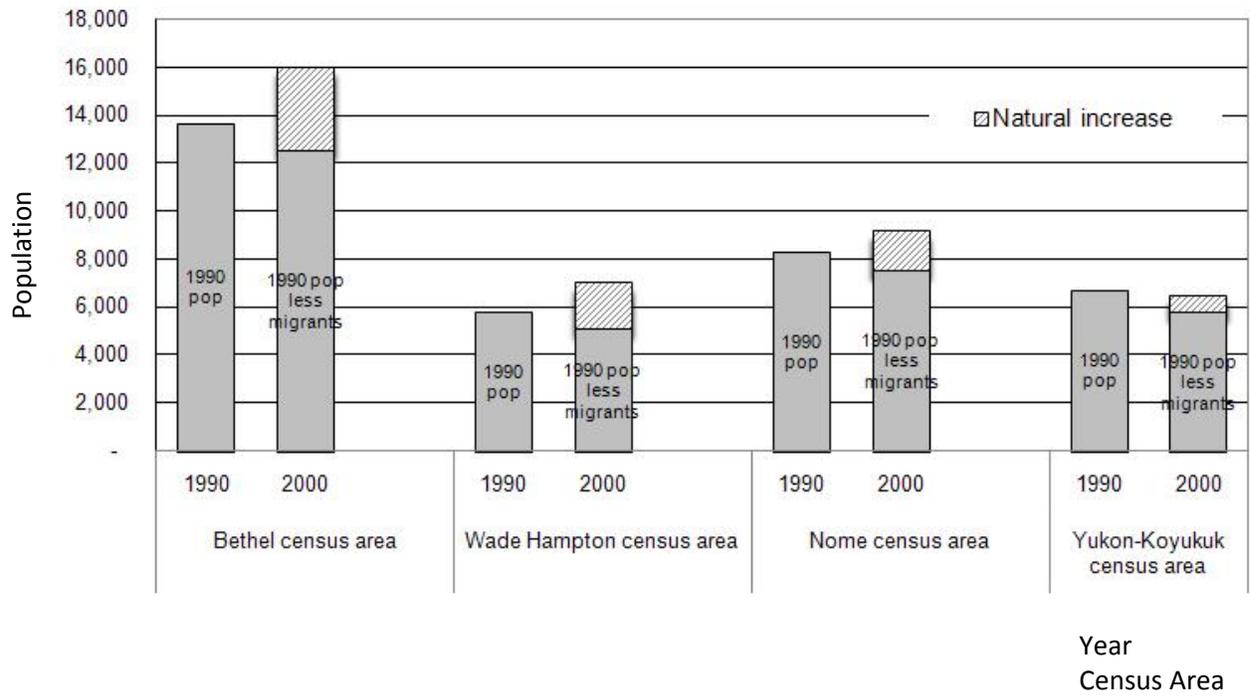
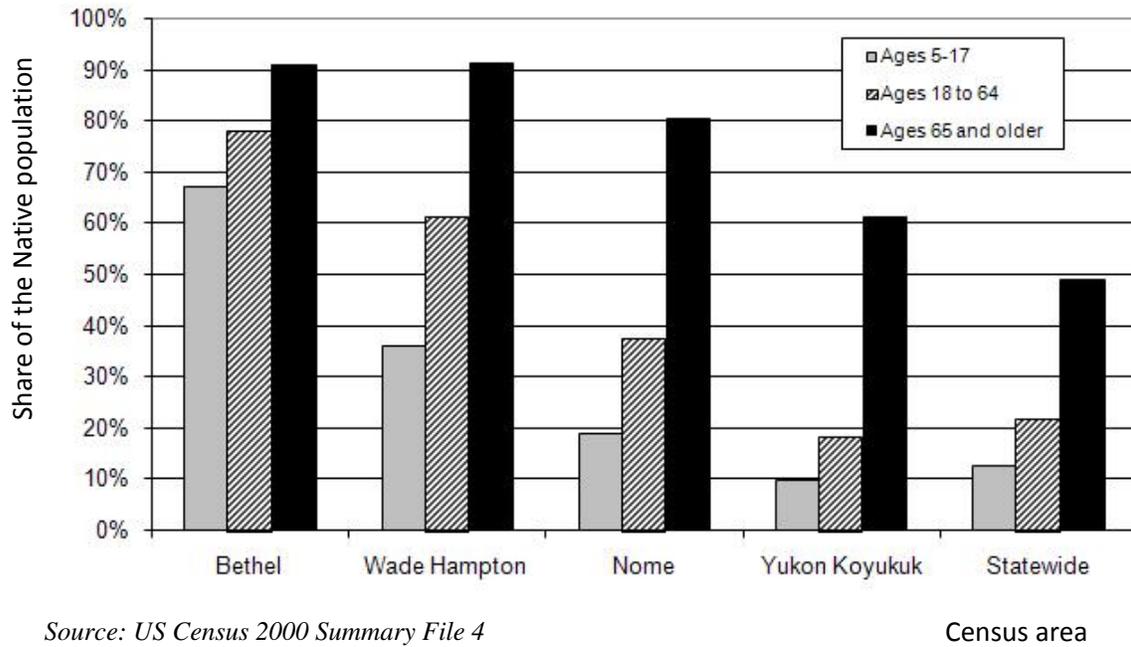


FIGURE 4. Population change in the AYK region, 1990-2000.



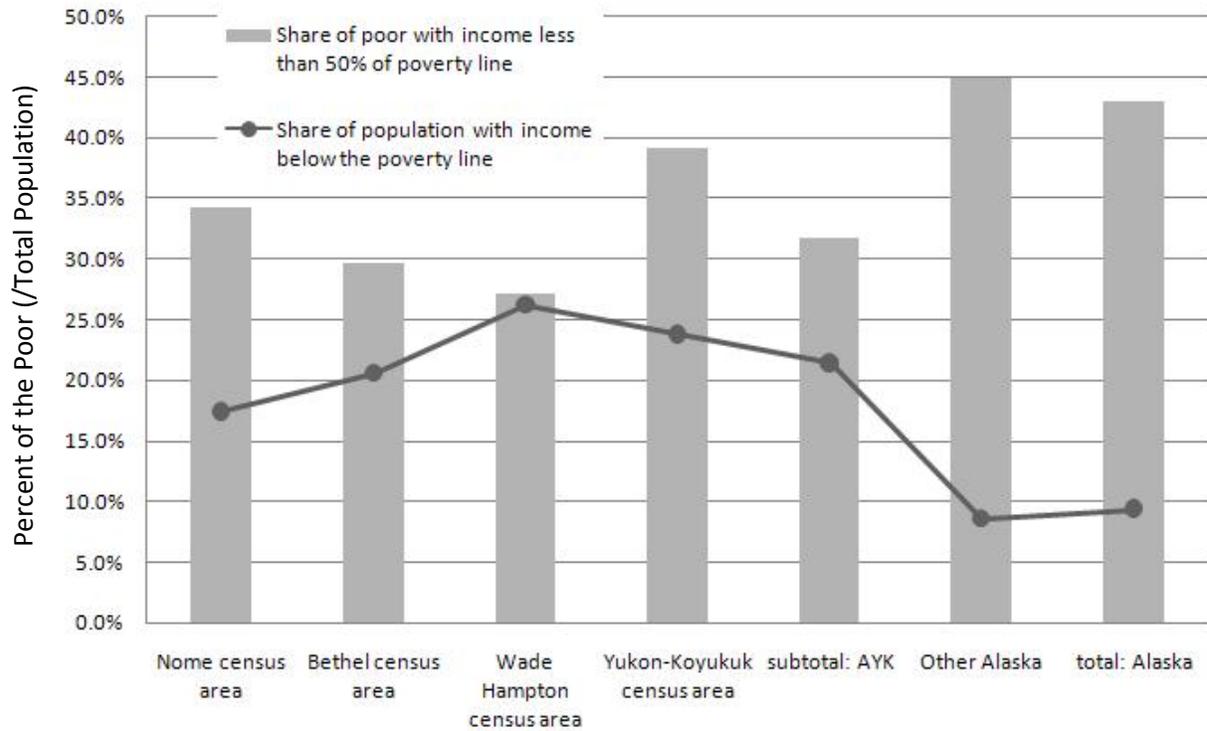
Source: Alaska Department of Labor, Administrative Services Division, Research and Analysis, Demographics Unit.

FIGURE 5. Share of Alaska Native population speaking a language other than English, 2000.



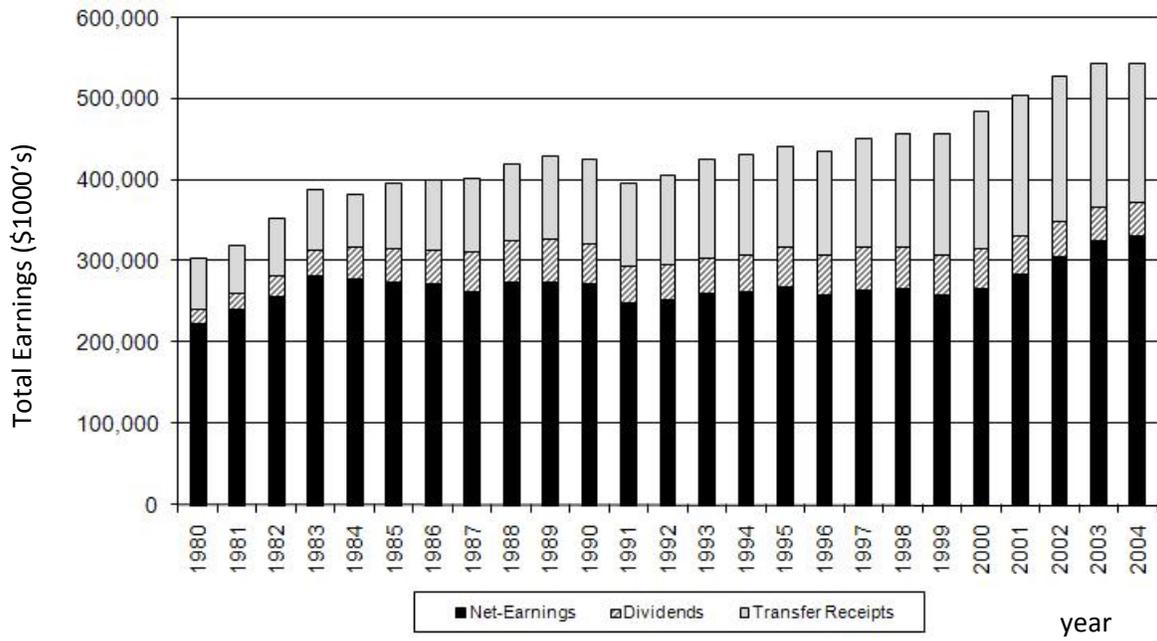
Source: US Census 2000 Summary File 4

FIGURE 6. Alaska population living in households with income less than the poverty line, 1999



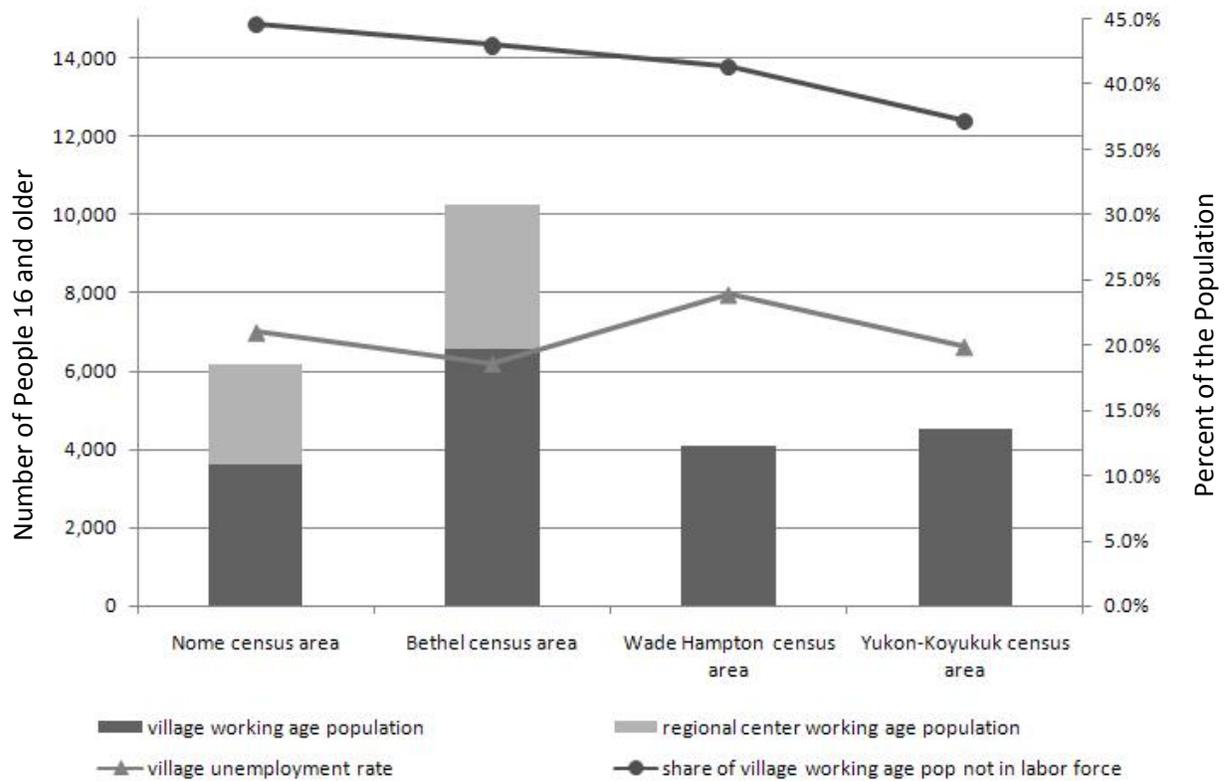
Source: US Census 2000, summary file 3.

FIGURE 7. Real Total Personal Income over Time (in 1000's), AYK Region, 1980-2004



Source: US Regional Economic Information System, Bureau of Economic Analysis, U.S. Department of Commerce

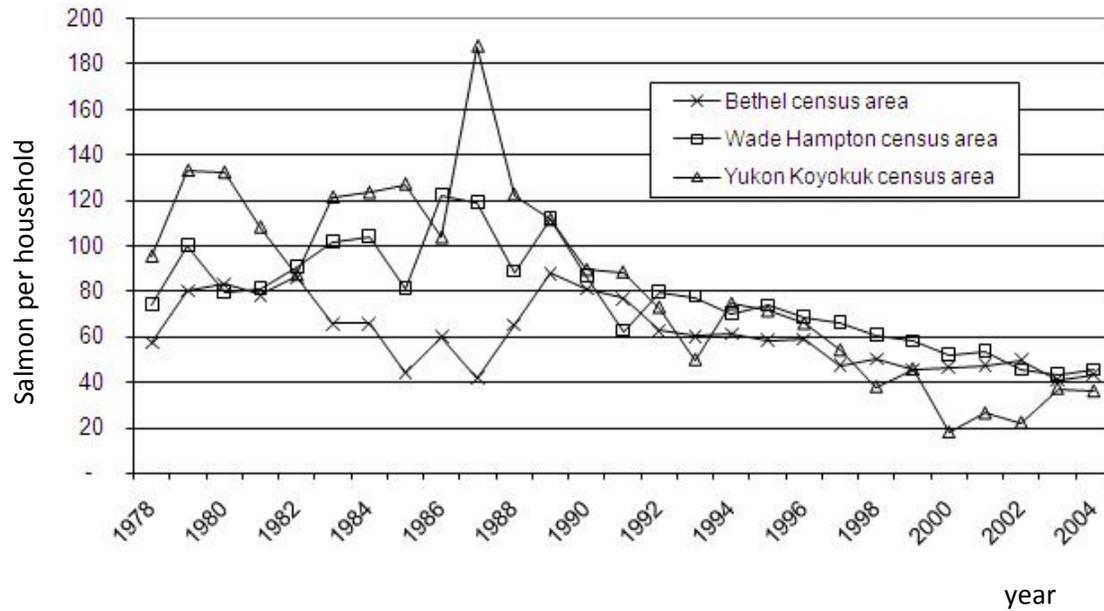
FIGURE 8. AYK regional employment, 2000*



* The working age population includes everyone sixteen years of age and older. By definition, those in the labor force include employed and unemployed persons. The unemployed are persons not employed and actively looking for work. The unemployment rate is the share of civilians in the labor force who are not employed. The share of the population not in the labor force is the number of people not in the labor force divided by the working age population.

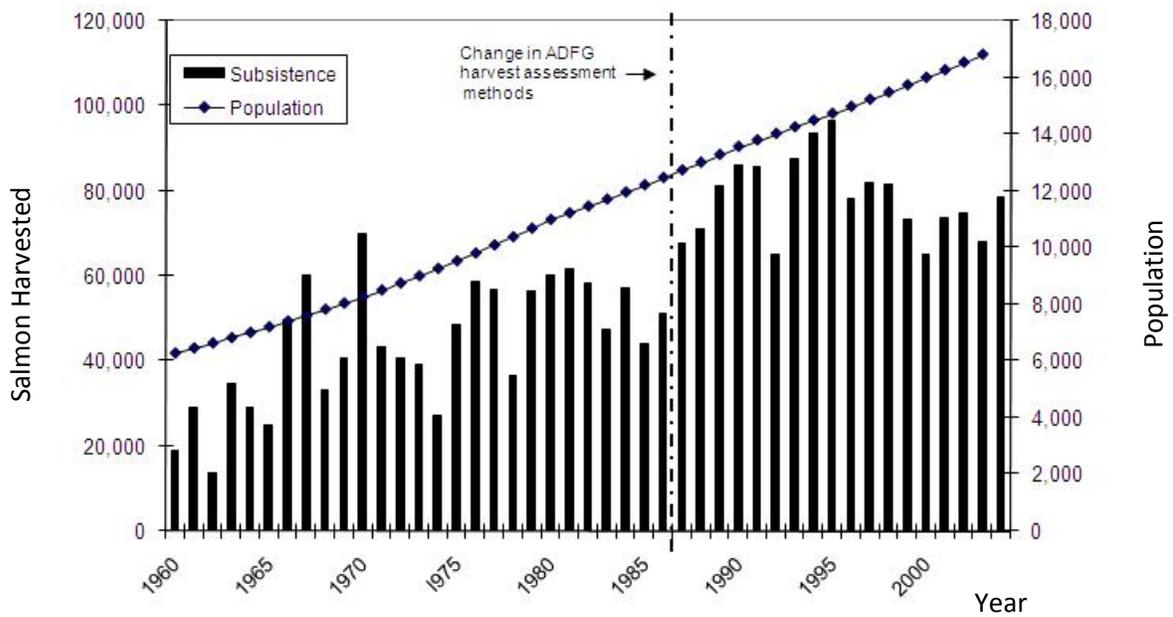
Source: US Census 2000, summary file 3.

FIGURE 9. Subsistence salmon harvest per household AYK region, 1978-2004



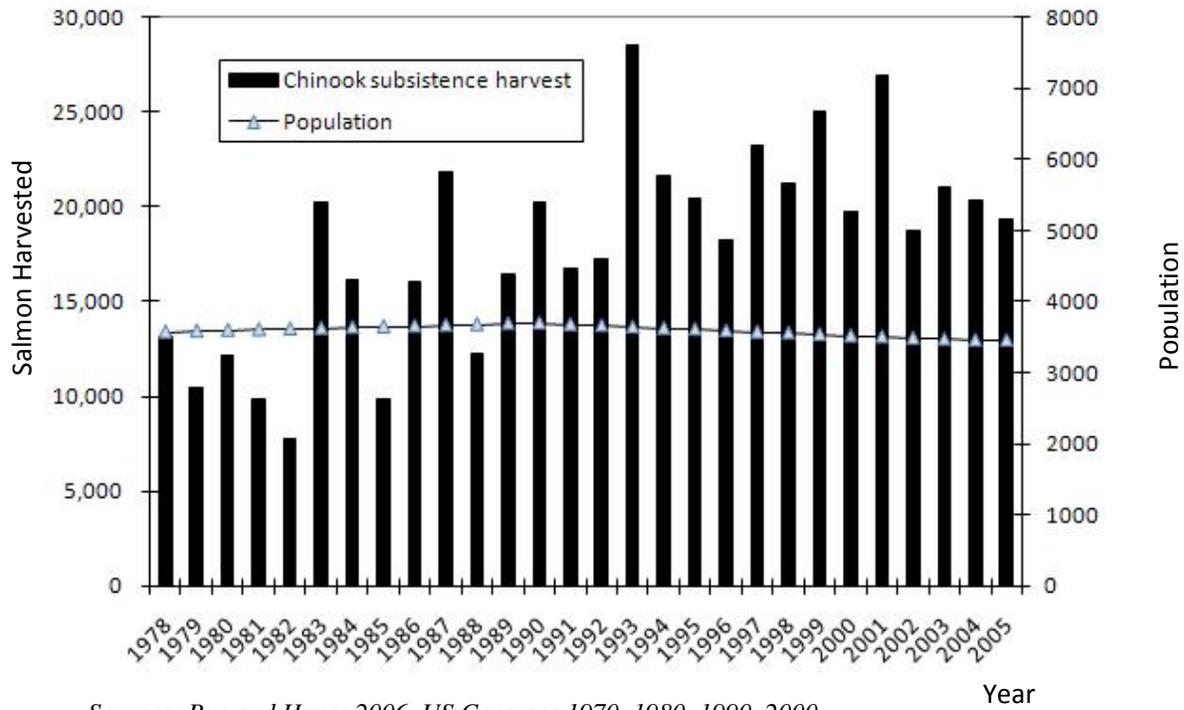
Source: Hayes et al. 2008; Bue and Hayes 2006; Whitmore, et al. 2005; US Censuses 1970, 1980, 1990, 2000; Calista Corporation 1991

FIGURE 10. Kuskokwim River subsistence Chinook salmon harvest and population of the Bethel census area 1960 – 2004.



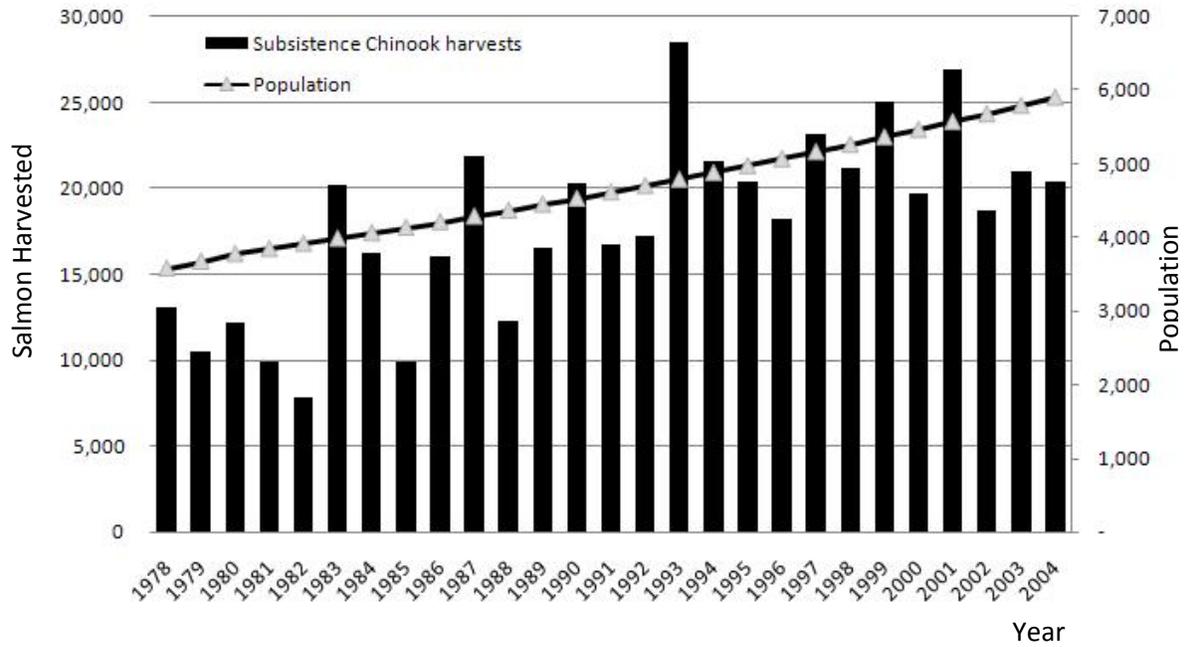
Source: Whitmore et al. 2005; US Censuses 1970, 1980, 1990, 2000; Calista Corporation 1991

FIGURE 11. Upper Yukon subsistence Chinook salmon harvest and population of the Yukon-Koyukuk census area 1978 – 2005



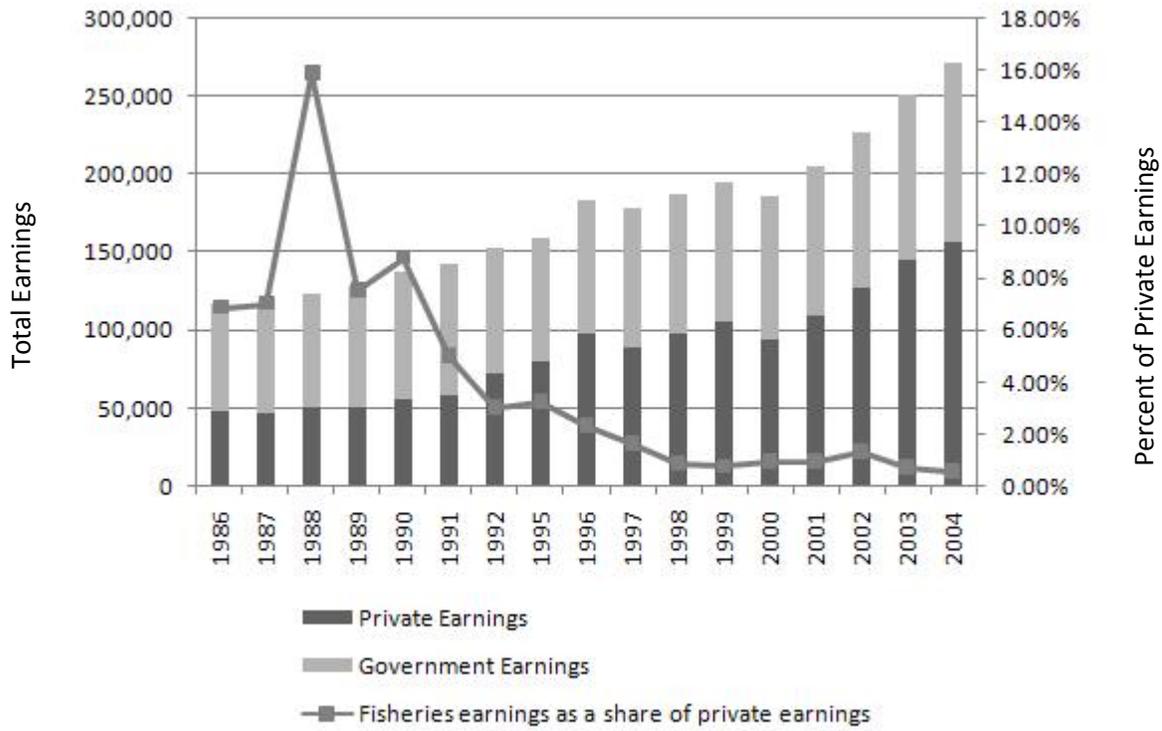
Sources: Bue and Hayes 2006, US Censuses 1970, 1980, 1990, 2000.

FIGURE 12. Lower Yukon subsistence Chinook salmon harvest and population of the Wade Hampton census area 1978 – 2005



Sources: Bue and Hayes 2006, US Censuses 1970, 1980, 1990, 2000.

FIGURE 13. Real earnings by place of work, Bethel Census Area*



*Data for 1993 and 1994 not available.

Source: Regional Economic Information System, Bureau of Economic Analysis, U.S. Department of Commerce

Figure 14. Total salmon harvests in the Kuskokwim River, by species, 1980-2004

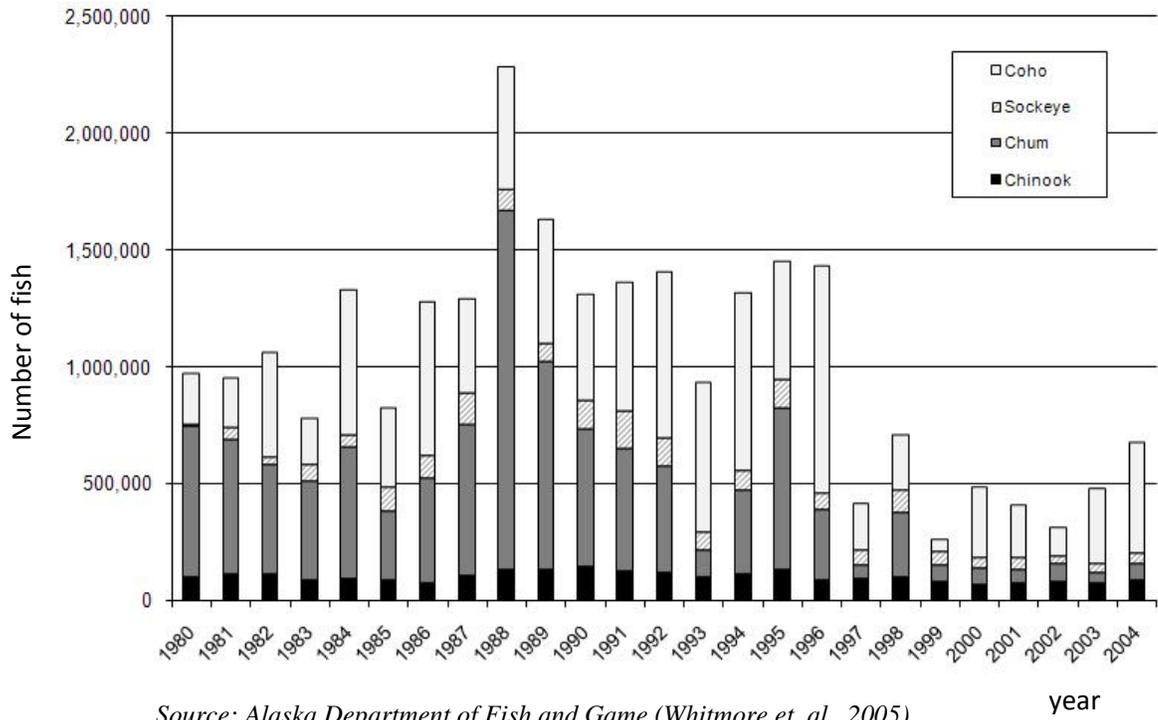
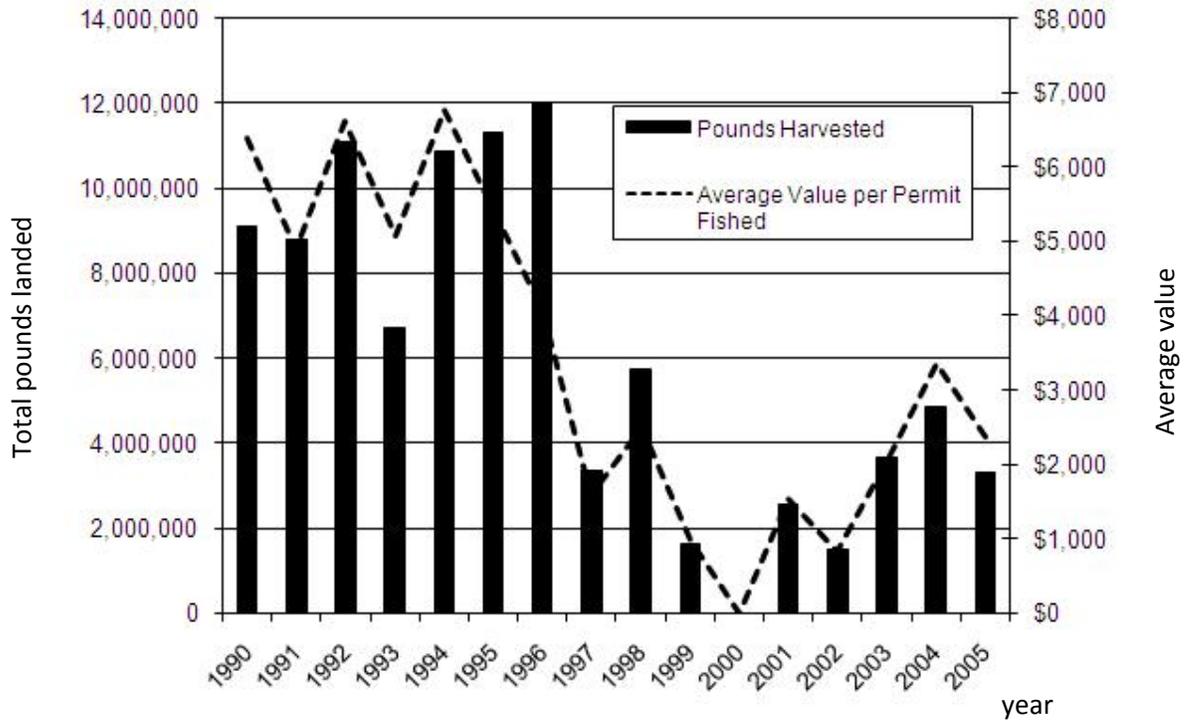
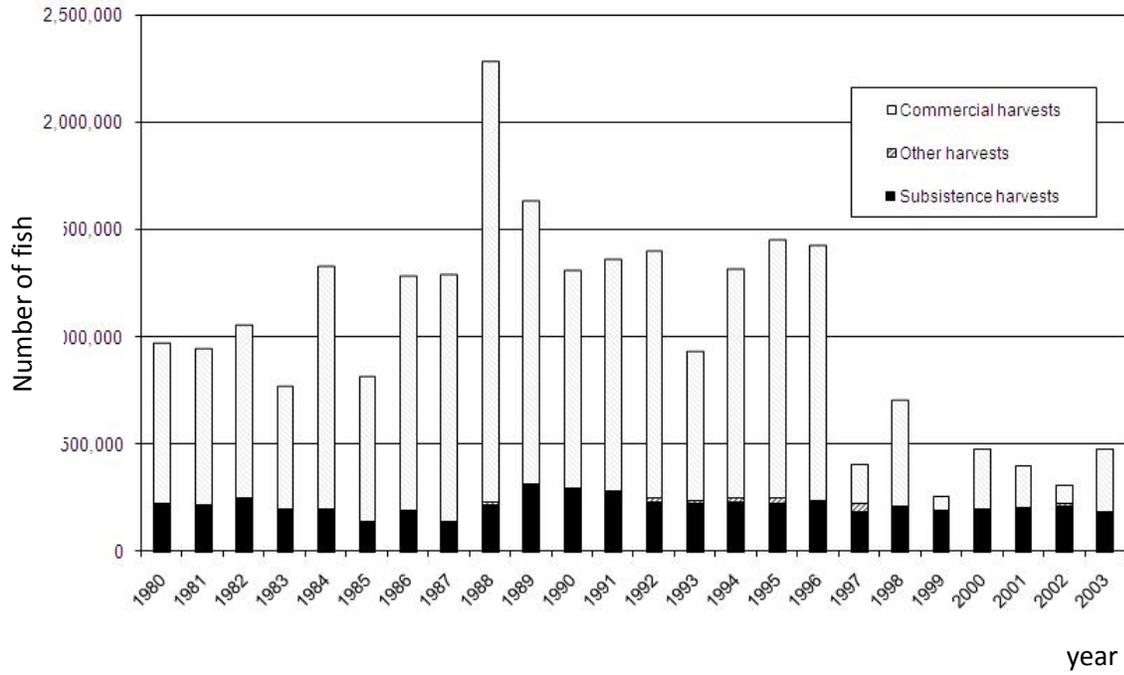


FIGURE 15. Commercial salmon harvests (gill net) and average value per permit fished, Kuskokwim River region, 1990-2005.



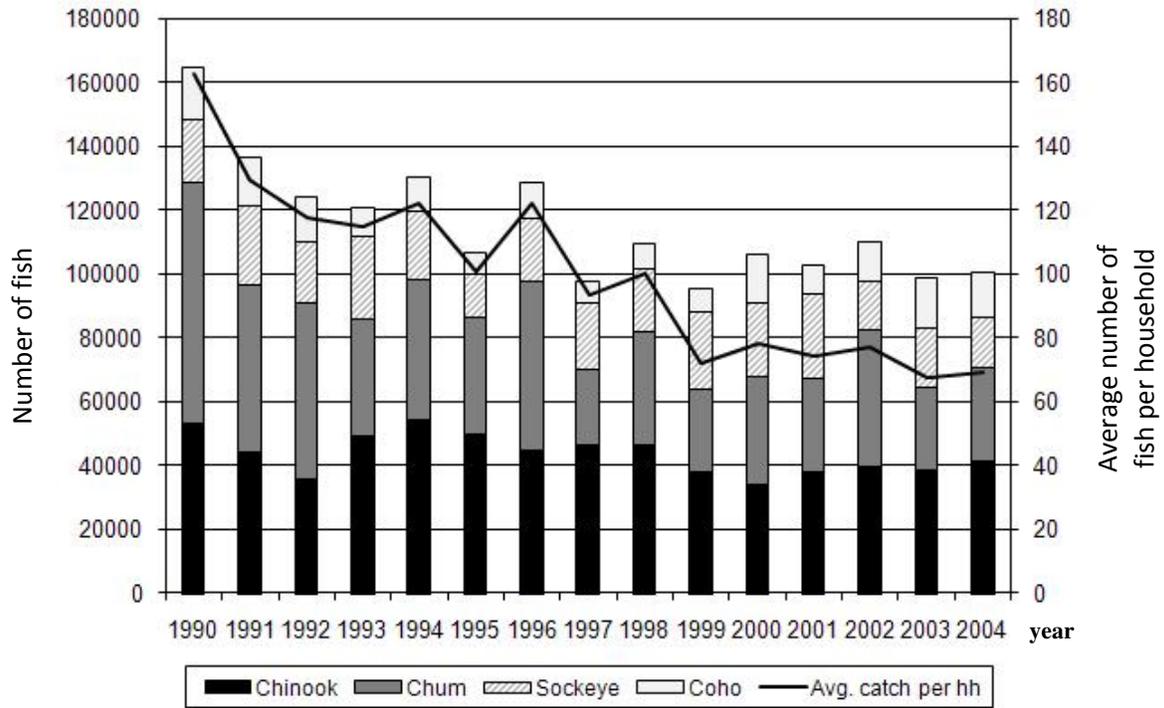
Source: AK Commercial Fisheries Entry Commission Database (CFEC)

FIGURE 16. Subsistence as a share of total salmon harvests in the Kuskokwim River, 1980-2003



Source: Alaska Department of Fish and Game (Whitmore et. al. 2005)

FIGURE 17. Subsistence salmon catch, lower Kuskokwim communities (excluding Bethel), 1990-2004



Source: Alaska Department of Fish and Game Kuskokwim Subsistence Survey

Endnotes

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- ⁱⁱ Together the Bethel and Wade Hampton Census areas are equivalent to the Calista Native regional corporation boundary.
- ⁱⁱⁱ The Nome Census area boundaries are equivalent to the boundaries of the Bering Straits Native Regional Corporation.
- ^{iv} The vast majority of Doyon Regional Corporation lands are within the Yukon-Koyukuk census area.
- ^v A small share of this increase can be accounted for by the way that the US Census asked the race question. Prior to 2000 respondents were asked to indicate a “single-race choice” while in 2000 respondents could indicate one or more races. The number we report for 2000 is based on the “Alaska Native race alone or in combination” category. Statewide annual growth rates for the non-Native population were 3.2% from 1980-1990 and 1.1% from 1990 to 2000.
- ^{vi} The total change in population between 1980 and 2000 for the entire AYK region was about 10,500.
- ^{vii} Hamilton and Seyfrit (1994) note a “gender gap” with a disproportionate share of women leaving rural villages relative to men statewide and specifically in the Bethel census area. Census data from 2000 confirm a similar pattern.
- ^{viii} Unless otherwise noted economic data on income, poverty, and employment is from 2000 US Decennial Census Summary Files Three and Four
- ^{ix} Median household income in the city of Bethel was \$57,321 in 1999. Median household income in the entire Bethel census area (including the city of Bethel) was \$35,701.
- ^x Federal poverty guidelines are based on family size. Although separate guidelines are issued by Congress for Alaska, Hawaii, and the other 48 states the US Census applies the same guidelines when reporting poverty. For a family of four, the poverty line used for the 2000 census was around \$17,000.
- ^{xi} Non-Natives make up about 30% of the employed population the AYK region. In villages they make up less than 20% of employed workers while in regional centers they make up about 50% of employed workers.
- ^{xii} US Census 2000, Summary File Four data
- ^{xiii} As quoted on <http://www.alaskool.org/projects/subsistence/timeline/ANILCA.htm>
- ^{xiv} For our estimates, we combined household counts from the US Census with harvest totals by ADF&G district, considering Bethel census area to be equivalent to the ADF&G Kuskokwim districts, Wade-Hampton contiguous with the lower Yukon districts, and Yukon-Koyukuk contiguous with the upper Yukon districts.
- ^{xv} The spike in 1987 for Yukon-Koyukuk is due to a high fall chum salmon harvest.
- ^{xvi} Some general rules include the gear restrictions that drift nets cannot exceed a total length of fifty fathoms and gill nets can be of any mesh size except nets with six inch or smaller mesh can only be thirty-five meshes deep (ADF&G, 2005). See endnote xxiii for an exception related to a temporary windows closure. In terms of permits, regulation 5 AAC 01.280 notes that for the entire region “fish may be taken for subsistence purposes without a subsistence fishing permit.” In terms of timing, salmon may be taken at any time in districts 1 and 2. In districts 4 and 5

salmon may be taken at any time except from June to Sept. 8, twelve hours before, during, and six hours after the opening of the commercial fishery (5 AAC 01.260).

^{xvii} Permits are required in some sub-districts of the Yukon management area and there are bag limits associated with the permits. In contrast to the Bethel census area, permits are also required in several rivers in the Yukon census area (see regulation 5 AAC 01.230). In terms of timing, a schedule determines when salmon can be harvested on the river and there are varying rules by sub-district on the closure period following commercial fishing (which are generally more restrictive relative to the Kuskokwim) (see regulation 5 AAC 01.210).

^{xviii} The \$7,894,484 number (or \$6,155,077 for salmon) describes earnings by place of residence. Gross earnings for salmon landed in the AYK area fisheries was approximately \$4,741,273 in 2004. The lower Yukon fishery makes up about 61.6% of the total value for salmon and the Kuskokwim /Goodnews Bay fishery about 33% of the value. See regional CFEC fisheries statistics for 2004 at <http://www.cfec.state.ak.us/gpbycen/2004/mnu.htm> for earnings by place of residence and <http://www.cfec.state.ak.us/bit/mnusalm.htm> for earnings by regional fishery.

^{xix} In 2006, Sockeye salmon made up about 15% of total AYK commercial harvests, Coho salmon 41%, Chum salmon 37%, and Chinook salmon 7% (ADF&G 2006). In terms of value Chinook salmon harvests made up about 82% of value followed by Coho at 18% and Sockeye and Chum at 9% each (ADF&G 2004).

^{xx} The Wade Hampton census area includes most districts in the State of Alaska's "lower Yukon salmon management area" and the Bethel census area includes all but one of the districts in Alaska's "Kuskokwim salmon management area." Regional maps are located at http://www.cf.adfg.state.ak.us/region3/finfish/salmon/maps/ayk_all.php

^{xxi} This information is taken from the Coastal Villages Region Fund webpage <http://www.coastalvillages.org/projects.html>

^{xxii} The data in this table are from the US Bureau of Economic Analysis (BEA) Regional Economic Accounts. BEA data provides earnings by place of work. "Earnings" is the sum of wage and salary income disbursed in a year, supplements to wage and salary income, and proprietors' income. Reported "fisheries earnings" includes earnings from all establishments engaged in commercial fishing. As such, BEA data on commercial fishing earnings is a proxy for the income that is generated from commercial fishing. It is not an estimate of total revenue from commercial fishing. Data from the Alaska Commercial Fisheries Entry Commission database (CFEC) provide estimates of total revenue from commercial fishing based on the total catch times the average market price.

^{xxiii} Starting in 2001, there was a Sunday, Monday, Tuesday closure of the subsistence fishery until the state fisheries managers determined escapement goals were met. The idea was to create windows for fish passage to allow the earliest part of the runs to escape catch. The schedule has generally been lifted by the end of June. This constraint does not appear to have achieved the State goal of allowing for greater levels of early escapement (Toshihide "Hamachan" Hamazaki, ADF&G, presentation at 2008 Kuskokwim Interagency Meeting). Similarly, it seems unlikely that subsistence harvest amounts declined due to the imposition of the windows closure (personal correspondence, Tracie Krauthoefer, ADF&G Bethel).

^{xxiv} Survey methods are outlined in Simon et al. (2007). ADF&G provided these data to us by community over time. We were also given a sample survey instrument and Tracie Krauthoefer (ADF&G Bethel) provided very helpful background information.

^{xxv} Places include Akiachak, Akiak, Atmautluak, Bethel, Eek, Kasigluk, Kipnuk, Kongiganak, Kwethluk, Kwigillingok, Napakiak, Napaskiak, Nunapitchuk, Oscarville, Tuluksak, and Tuntutuliak.

^{xxvi} A Hausman test indicates that c_i and x_{it} are correlated and so we run a fixed effects equation. However, the Hausman test is marginally significant and we also find evidence for heteroskedasticity consequently we run a random effects model controlling for heteroskedasticity.