FALL 2015 SUBSISTENCE FISHERY MONITORING ON THE COLVILLE RIVER

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Cover: A subsistence fisherman from Nuiqsut stands over his day's harvest of Arctic Cisco on the Niġliq Channel of the Colville River. 2015 © ConocoPhillips Alaska, Inc. All rights reserved.

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FINAL REPORT

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The 2015 Arctic Cisco study was funded by ConocoPhillips Alaska, Inc. (CPAI), and we are grateful to Robyn McGhee and Valli Peterson of CPAI for logistic support and guidance. Field support was provided by ABR personnel John Seigle, John Rose, Laura Gutierrez, and Joe Welch, and by Nuiqsut resident Jerry Pausanna. Ashley Hovis provided laboratory support for fish processing. Pam Odom (Publications Specialist) of ABR helped prepare this report. Pam also arranged travel and Tony LaCortiglia and Nancy Lampman handled gear logistics and transport. Adrian Gall provided in-house report review.

In 2016 we celebrated 30 years of industry-supported harvest monitoring. The occasion was celebrated with food, cake, and a slide-show at the Nuiqsut Community Center. Many people came out to help us celebrate this outstanding fishery monitoring program. We thank the residents of Nuiqsut for their continued involvement in and support of this program. We thank the Kuukpik Hotel staff for the comfortable accommodations and good food and the Nanuk Corporation and its employees for entertainment and insights as they prepared for the ice road season. We are especially indebted to all the fishers who continue to graciously share information on their harvests and for teaching us so much about snow-machine performance and maintenance!

INTRODUCTION

In 2015, ABR, Inc.—Environmental Research & Services (ABR) worked with fishery stakeholders in Nuiqsut, Alaska to continue long-term monitoring of the Colville River subsistence fishery, which is conducted each fall after freeze-up in the Niġliq Channel of the Colville River. The 2015 subsistence fishery monitoring program marked the 30th year of industry funded fall-fishery harvest monitoring as part of long-term studies that have taken place since 1985. Monitoring has been conducted by several contractors over that time period (MJM Research [1985–2005], LGL Alaska Research Associates [2006]), and ABR [2007–2015]) on behalf of ConocoPhillips Alaska, Inc., (CPAI) and its predecessors (see Daigneault and Reiser 2007 and Moulton et al. 2006). The 2015 fall subsistence harvest was the first complete season following the completion of CPAI construction activities related to the development of the CD5 pads, connecting roads, and the Niġliq Channel bridge crossing.

The monitoring program focuses primarily on the fall harvest of Arctic Cisco (*Coregonus autumnalis*; Qaaktaq, in Iñupiaq), which are a staple in the diet of Nuiqsut residents and traded widely with other northern Alaska communities. The program also attempts to quantify harvest of other subsistence species captured in the Qaaktaq fishery. The monitoring program began as a result of local fisherman and agency personnel expressing the need for an early warning system to be implemented to detect potential impacts to fish health from activities associated with exploration and development of oil and gas in the nearshore marine environment and on the Colville River delta (henceforth the Colville delta). The monitoring program estimates the total fishing effort and catch and works with fishers to assess the general health of the fishery.

BACKGROUND

Very little was known of the basic life history of Arctic Cisco until fish monitoring studies were initiated by the oil industry in the nearshore environments of the Prudhoe Bay region in the early 1980s (Gallaway et al. 1983). Those studies discovered that all Arctic Cisco in Alaska originate in the Mackenzie River system in Canada (Figure 1). Young-of-the-year drift down river into the Beaufort Sea in early summer, and prevailing easterly winds and ocean currents transport these young fish passively along the Beaufort Sea coast to the west. The number of young-of-the-year Arctic Cisco (i.e., recruitment strength) in Alaska and the Colville River region is correlated with the consistency and strength of easterly winds in the Beaufort Sea region during summer (Fechhelm and Fissell 1988). This wind- and ocean current-driven recruitment process largely determines the age structure of Arctic Cisco in Alaska (Gallaway and Fechhelm 2000). For example, the number of young-of-the-year Arctic Cisco at Prudhoe Bay is highly correlated with harvest rates for the Colville fishery 5–7 years later (ABR et al. 2007).

Young Arctic Cisco in Alaskan Beaufort Sea waters spend their summers feeding in deltas and nearshore brackish waters before returning to deep pools of the Colville River for overwintering (Craig 1984, Moulton et al. 1986). After achieving maturity (females at age 7–8, males at age 6–7), Arctic Cisco migrate during summer to their source rivers within the Mackenzie River system for fall spawning. These adult fish do not return to rearing streams in Alaska but rather stay in the Mackenzie system where they continue to spawn well into their teen-aged years (Craig and Halderson 1981, Gallaway et al. 1983, Bond and Erickson 1985, Bickham et al. 1989, Moulton 1989, Bond and Erickson 1997).

The subsistence fishery is conducted almost exclusively on the Niġliq Channel of the Colville River (Figure 2). A commercial Arctic Cisco fishery was also operated by the Helmericks family on the Main Channel of the Colville River for ~50 years starting in the early 1950s. In 1993, the year with the highest combined harvest from these 2 fisheries, ~78,254 fish (~31,340 kg) were taken on the Colville delta (Moulton and Seavey 2004, Moulton et al. 2010). In contrast, only 5,859 fish total (~2,799 kg) were harvested in 2001, which was the lowest harvest on record.

OBJECTIVES

The objectives of the 30th year of the harvest monitoring program were to:

- monitor the harvest of Arctic Cisco (and other species) throughout the fall fishing

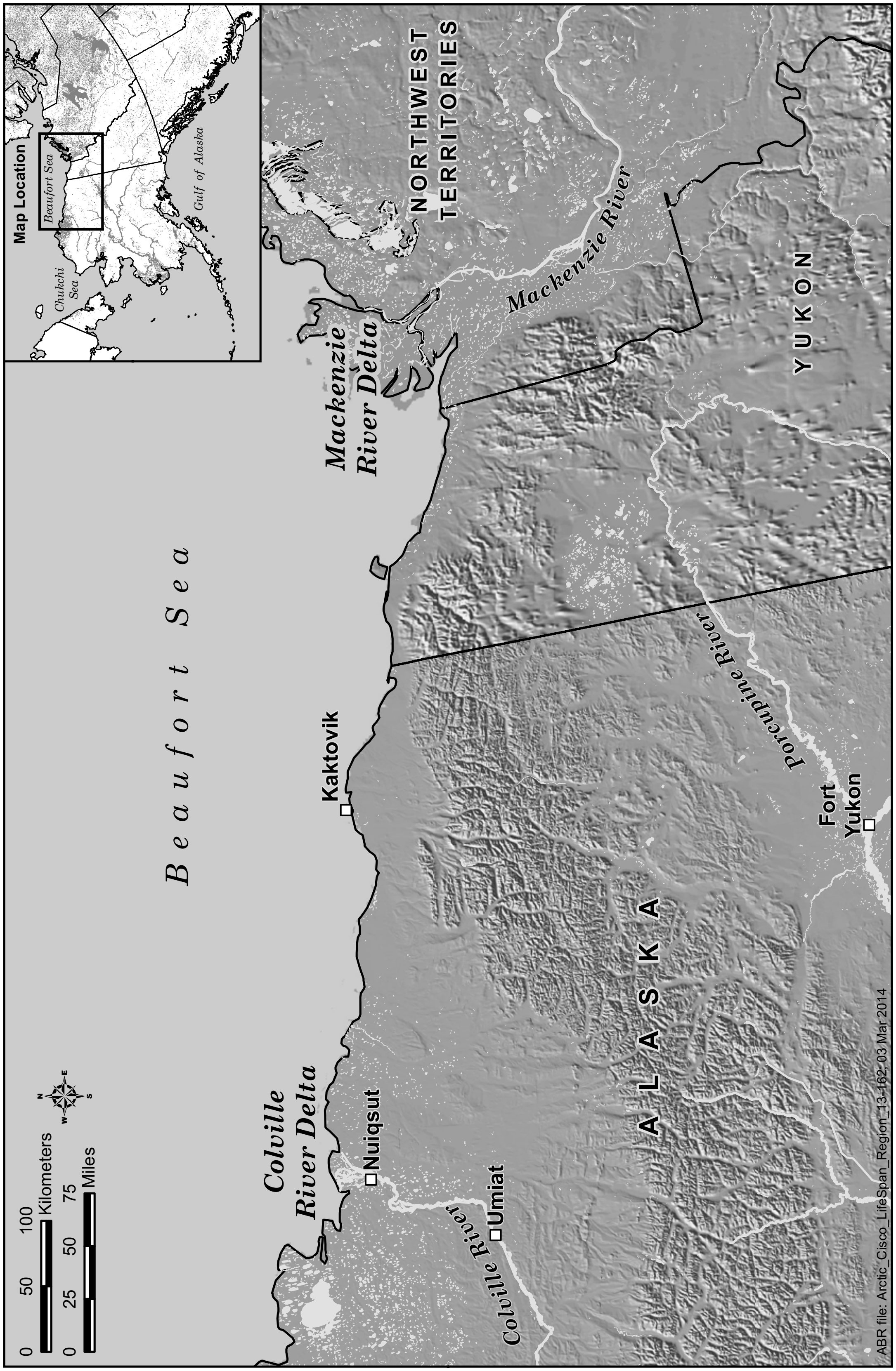

Figure 1. Waters important to the life history of Arctic Cisco in Canada (Mackenzie River drainages) and Alaska (Colville River delta) and the nearshore Beaufort Sea.

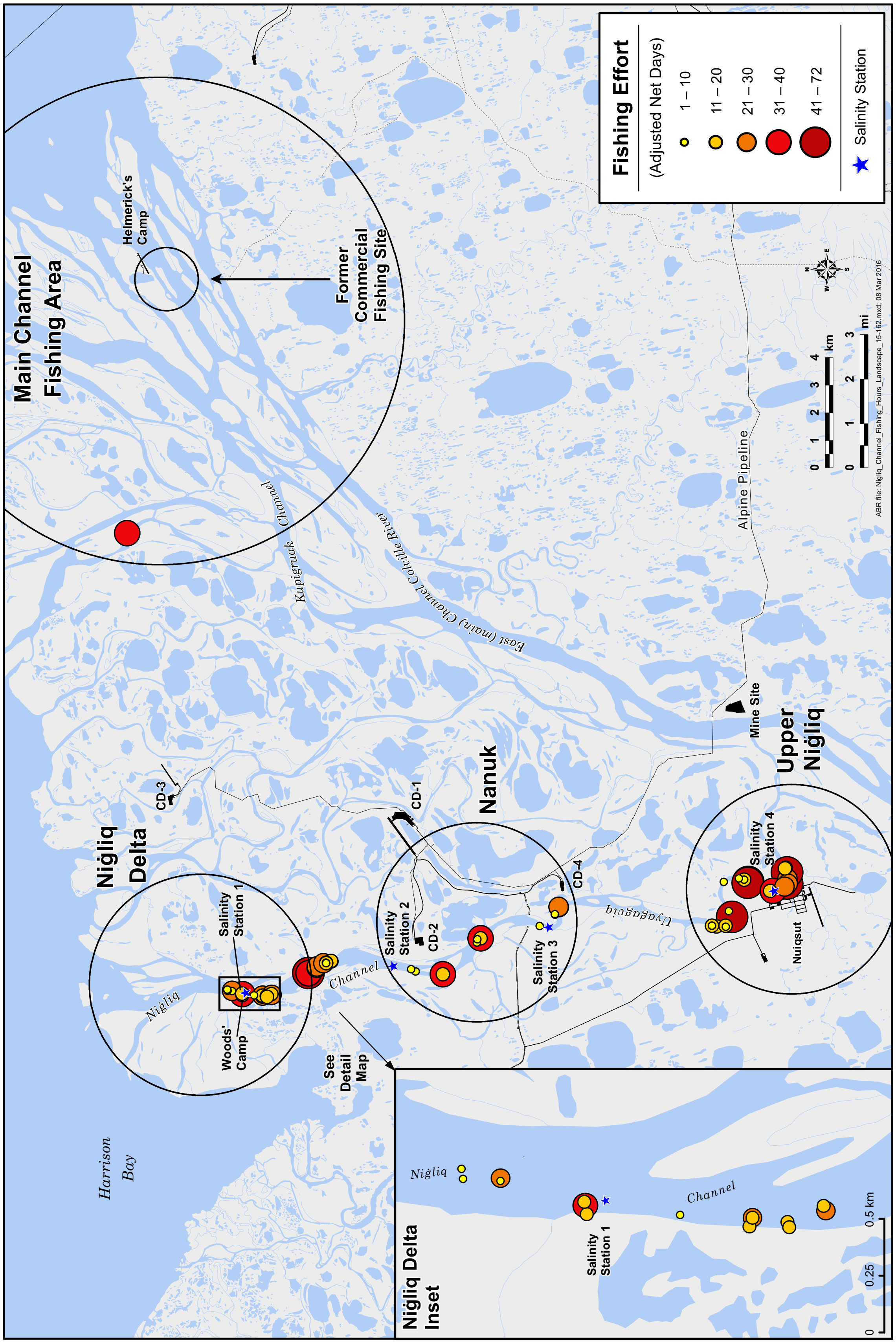

Figure 2. Water sampling stations and net sites in each of the 3 main subsistence fishing areas in the Nigliq Channel of the Colville River, Alaska, 2015. The amount of effort for each net set (adjusted net-days) is depicted by both color and the size of the net symbol.

season, using interviews of fishery participants;

- record the effort (number and type of nets fishing at any given time) throughout the fall fishing season;
- collect age, length, and weight information for a subsample of Arctic Cisco harvested;
- measure water salinity in primary fishing areas to correlate to upriver fish movement and subsequent harvest; and
- compare the 2015 results with previous years' results for this program and other historical data.

METHODS

FISHERY EFFORT AND HARVEST

Four traditional fishing areas hosted the majority of fishing in the Colville delta in 2015 (Figure 2). Three of the 4 traditionally used areas are located in the Niġliq Channel (in order of upstream to downstream): the Upper Niġliq area (adjacent to the town of Nuiqsut), the Nanuk area, and the Niġliq Delta area (includes nets between the Nanuk and Niġliq Delta areas). A fourth traditionally used area located in the Kupigruak Channel on the eastern Colville delta (henceforth, the Main Channel fishing area) also was fished in 2015 (Figure 2).

The ABR fishery monitoring team included 2 ABR biologists and local fishing expert Jerry Pausanna. Fishery monitors traveled each day by snow machine to the intensively fished areas of the Colville delta to conduct interviews for harvest assessment. When a member of the ABR monitoring team observed a fisher on their way to or from a harvest, permission was asked to either assist in the harvest, or to conduct an interview and assess the recently completed harvest event. If a fisher expressed desire to work alone or not participate in an interview, the monitoring team respected those wishes and moved on to another net.

During interviews, we asked the following questions:

- How many nets are you fishing?
- How long have your nets been actively fishing (helps define total season effort)?
- What are your net dimensions?
- How many Qaaktaq did you harvest in each net?
- How many fish of other species did you harvest?
- How often are you checking your nets (helps monitors determine when to meet fishers)?
- Do other people check your nets (helps monitors recognize when friends or relatives are assisting the net owner)?
- Where is your net and has it been moved recently (helps monitors determine location and end times for calculating effort in specific river sections)?

A harvest event occurs anytime a fisher checks his or her net. Each event may be recorded by harvest monitors on location at the time of the net check, after the fact (usually within 24–48 hours) in Nuiqsut, or at a later date via email or telephone. Catch data from post-harvest interviews were included in the overall harvest assessment even if it was unclear in which nets the fish had been captured (i.e., the fisher reported how many fish he/she caught in a day but not how many fish were caught in individual nets of varying mesh sizes and net lengths). Reported harvest numbers from these interviews were used in catch per unit effort (CPUE) analysis only if the fisher also reported the number of days each net fished and the number of fish caught in nets of each mesh size. In 2015, as in previous years, ABR distributed a "North Slope Fisheries Logbook" to interested fishers (see Appendix B in Seigle et al. 2014). These books are periodically distributed to fishers to assist them in tracking their personal harvests year round. However, unlike in years past, no fishers shared daily harvest information from logbooks in 2015.

Catch per unit effort (CPUE), expressed as fish/net-day, was calculated using estimates of effort adjusted to account for differing net lengths and mesh sizes. The net length and effort were standardized to a net length of 18 m (60 ft) and full-day (24-hour) set duration. For example, if an 80 ft net was used during a 24-hour period, fishing effort was calculated as 80 ft/60 ft × 1 day = 1.3 adjusted net-days. Because mesh size affects capture rates depending on the size of the fish, we specify whether data are summarized by all mesh sizes combined, by individual mesh sizes, or limited to the most frequently used mesh size of 7.6 cm (3 inches). CPUE was calculated for all mesh sizes but is most commonly presented in this report for nets with 7.6-cm mesh as this has historically been the most frequently used mesh size in the Arctic Cisco fall fishery. Average CPUE was calculated for each mesh size deployed in the fishery. Those numbers were then multiplied by known overall effort for each net to arrive at a total estimated harvest number for Arctic Cisco in the fishery.

LENGTH, WEIGHT, AND AGE OF CATCH

When possible, we measured fork length (to the nearest mm) of a sub-sample of fish caught in nets. Depending on the number of fish in the harvest and the amount of time available for the interview, monitors measured every fish or every second, third, or fourth fish from each net. The monitoring team endeavored to obtain a total count and a sub-sample of lengths for each fish species captured. However, Arctic Cisco were measured first. Other species, such as Least Cisco (*Coregonus sardinella*), were measured as time permitted primarily because Arctic Cisco are the target species of fall fishing and monitoring efforts.

The total number of fish measured on a given day varied depending on a fisher's availability, the total number of fish caught, and the number of fishers in the area. When several fishers were harvesting simultaneously in the same area, monitors attempted to obtain a sub-sample of measurements from every fisher. When possible, ABR paid a participation honorarium to fishers who were willing to donate a sub-sample of fish from their harvest for age and length weight analysis (~10/day at $10/fish) or who otherwise provided detailed information about their fishing efforts and harvests outside of normal daily encounters with the monitoring team. Most samples were donated from 7.6-cm mesh nets as this is the most common mesh size used in the fishery, although fish from other known mesh sizes were accepted. The fish were kept frozen and transported to Anchorage where they were measured for fork length and weight (g) using a top-loading electronic scale.

Fish weight can be an indicator of body condition when adjusted for fish length, with fish that are heavy for their length presumably indicating better fish health as a result of good foraging conditions (Richter et al. 2000). We tested for differences in fish weight as a function of fish length using an ANCOVA model with length as a covariate and year (2009–2015) as a factor. We used a natural logarithm transformation of weight to approximate a linear relationship and stabilize the variance. We also tested for overall differences in the intercept and slope due to year by using likelihood ratio tests to compare nested models. We subtracted the mean fish length (310.0 mm) from the length values in order to center fish length at the mean length. This allowed us to interpret the intercept term as the expected weight for a fish of mean length. We censored extreme values (those with standardized residuals <-3 or >3) to control for the influence of these few outliers. We used Bonferroni adjustments for all multiple comparisons.

Otoliths (i.e., sagittae) were extracted for aging, cleaned with tap water and stored in 96-well pipette trays. The break-and-burn technique was used to prepare one otolith from each fish for ageing (Chilton and Beamish 1982). Otoliths were broken in half along the transverse axis using a sharp scalpel or by pressing the otolith between a fingernail and forefinger. The broken edge of one half of the otolith was held over an open flame for several seconds until it acquired an amber color. The otolith half was then placed broken edge up in putty and the surface was brushed with mineral oil to emphasize the growth rings under magnification. The otolith preparations were examined under a dissecting microscope at 25× magnification using reflected light. Alternating bands of dark and light on the otolith (hereafter, annuli) correspond to winter and summer growth, respectively, and together represent one year's growth. The central core region of the otolith, composed of a dark and light region, was recognized as the first summer and winter growth of an age 0 fish. All annuli outside this region were then counted to determine the age of the fish.

WATER QUALITY

We measured water salinity every other day from 18 October–15 November at 4 traditional water sampling stations corresponding to areas of concentrated fishing effort (Figure 2). At these salinity stations, we removed surface ice and lowered a sampling probe connected to a YSI Professional Plus meter into the water. Salinity was measured in parts per thousand (ppt) and was recorded at the surface and at 0.5-m increments of depth until the probe reached the river bottom. While measuring salinity, the monitoring team collected additional ambient water chemistry features at 3 m depth, including temperature (°C), pH, dissolved oxygen (% and mg/L), and conductance (µS/cm). Aside from temperature, these additional water quality parameters are collected for database records and are not analyzed in the current report. At the end of each sampling event, a small piece of insulation was used to cover the hole in the ice. In this way, the sampling hole was only partially frozen upon return 48 hours later.

RESULTS

FISHERY EFFORT AND HARVEST

The ABR monitoring team arrived in Nuiqsut on 12 October 2015. Cool temperatures in late September and early October in the Colville delta resulted in the first net being deployed on 6 October (Table 1). The average start date for the fishery from over 30 years of harvest monitoring is 8 October, while the recent five-year average start date was 13 October. ABR fishery monitors observed 291 harvest events in 2015 (Table 2),down from 384 in 2014 and 376 events in 2013. A total of 34 fishers (hereafter identified by Fisher Codes) deployed 59 nets (74 sets) during the fall fishery in 2015 (Table 2, Figure 3, Appendix A). The number of nets was slightly higher than the average (56.1; 95% CI: 50.9 to 61.3) and median (56.0) numbers of nets deployed from 1985 to 2014. For the 55 nets, 65 of 74 total sets occurred in the Niġliq Channel in 2015 (Table 2). Five of those nets were either first set in the Niġliq Channel and then moved to Main Channel or vice versa.

Harvest activities in the Niġliq Channel began on 6 October with 2 nets deployed by 1 fisher (Figure 4). The number of nets deployed increased steadily through October and peaked at

Table 1. Estimated onset of the fall subsistence fishery for Arctic Cisco in the Niġliq Channel of the Colville River, Alaska, 1985–2015.

Year	Start Date	Five year average of start date
1985	2 October	–
1986	3 October	–
1987	8 October	–
1988	14 October	–
1989	22 October	9 October
1990	6 October	10 October
1991	12 October	12 October
1992	26 September	10 October
1993	3 October	7 October
1994	3 October	4 October
1995	16 October	6 October
1996	28 September	3 October
1997	13 October	6 October
1998	28 September	5 October
1999	--	6 October
2000	3 October	3 October
2001	6 October	5 October
2002	14 October	5 October
2003	16 October	9 October
2004	9 October	9 October
2005	7 October	10 October
2006	14 October	12 October
2007	4 October	10 October
2008	4 October	7 October
2009	6 October	7 October
2010	5 October	6 October
2011	13 October	6 October
2012	21 October	9 October
2013	9 October	10 October
2014	16 October	12 October
2015	6 October	13 October
Average	8 October	

Table 2. Summary statistics for fall fishing effort in the Colville River delta, Alaska, 2015. Values in parentheses are the total number sets for those nets.

	Summary of 2015 Effort
Number of recorded harvest events	291
Number of Households	30
Number of 5.1 cm mesh nets	0
Number of 6.4 cm mesh nets	5(8)
Number of 7.0 cm mesh nets	2(2)
Number of 7.6 cm mesh nets	36(44)
Number of 8.3 cm mesh nets	5(6)
Number of 8.9 cm mesh nets	8(11)
Number of 10.2 cm mesh nets	2(2)
Number of 12.7 cm mesh nets	1(1)
Number of Nets in Niġliq Channel	55
Total Number of Nets	59
Average Nets/Household	2.0
Net sets in Upper Niġliq	25
Net sets in Nanuk	14
Net sets in Niġliq Delta	26
Net sets in Main Channel	9
Total number of sets	74
Adjusted net days 5.1 cm mesh nets	0
Adjusted net days 6.4 cm mesh nets	98.7
Adjusted net days 7.0 cm mesh nets	45.0
Adjusted net days 7.6 cm mesh nets	843.0
Adjusted net days 8.3 cm mesh nets	146.7
Adjusted net days 8.9 cm mesh nets	184.0
Adjusted net days 10.2 cm mesh nets	5.7
Adjusted net days 12.7 cm mesh nets	1.0
Adjusted net days by Upper Niġliq	530.0
Adjusted net days by Nanuk	183.3
Adjusted net days by Niġliq Delta	466.0
Adjusted net days by Main Channel	144.7
Total adjusted net days	1,324.0

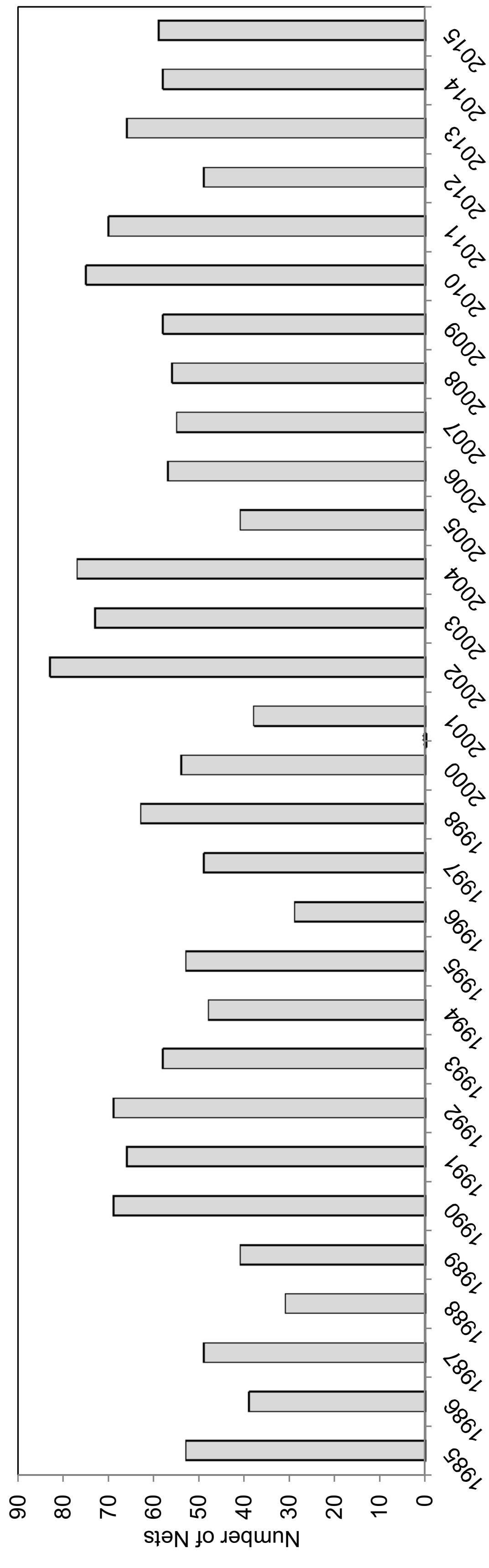

Figure 3. Number of nets deployed annually in the fall subsistence fishery for Arctic Cisco, Colville River, Alaska, 1985–2015.

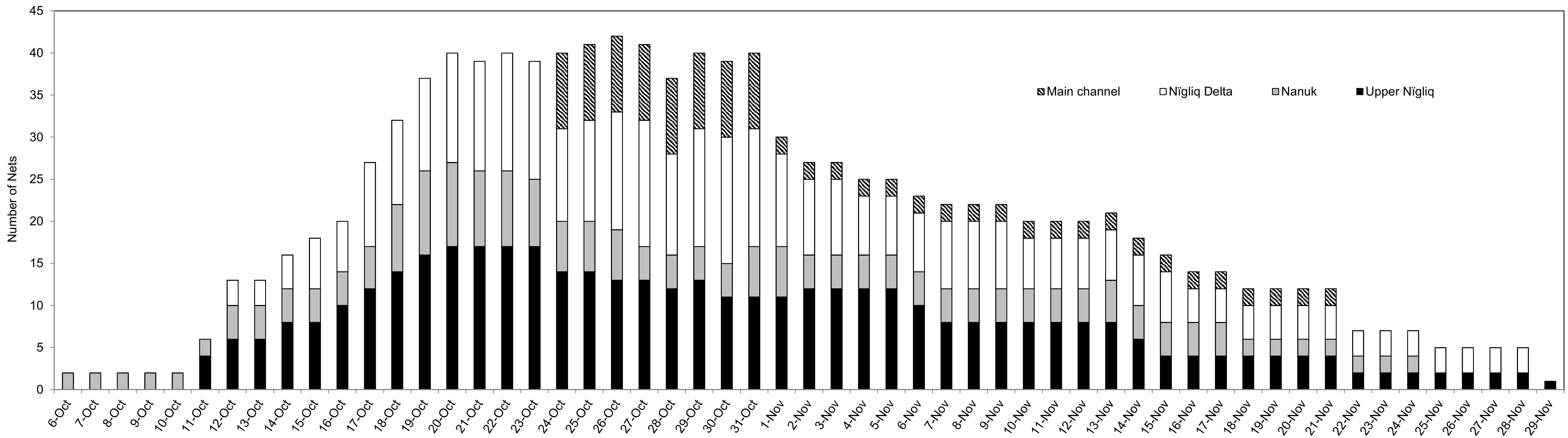

Figure 4. Number of nets fishing each day in each of the 3 Niġliq Channel fishing areas and in the Main Channel, Colville River, Alaska, 6 October to 28 November 2015.

42 active nets on 26 October (Niġliq Channel and Main Channel areas combined). Of the 34 fishers, 8 pulled at least 1 net and reset it at another location during the fishing season. At least 30 nets were active in all parts of the river from 18 October through 1 November. Harvest activities ended on 21 November in the Main Channel and 29 November on the Niġliq Channel.

After standardizing for net length, there were 1,324 net-days of fishing effort during the 2015 fall fishery (Table 2, Appendix A). This represents a 13.3% decrease in total effort compared to the 2014 fishery (1,499.8 adjusted net-days) and the decrease occurred in both the Niġliq Channel (129 fewer adjusted net-days than 2014) and the Main Channel (47 fewer adjusted net-days than 2014; Table 2). In the Niġliq Channel, fishing effort was highest in the Upper Niġliq (44.9% of total effort), followed by the Niġliq Delta (39.5%), and the Nanuk area (15.5%; Figure 5).

Gill nets of 7 different mesh sizes were used in the fall fishery in 2015, although most nets (36 of the 59 total nets, 61%) were 7.6-cm mesh nets (Table 2). In the Niġliq Channel, a total of 13,061 Arctic Cisco were documented during harvest monitoring in 7.6-cm mesh nets, the fourth highest harvest in the recorded history of the fishery (Figure 6). This is more than double the historical average (5,744; 95% CI: 4,077 to 7,411) of documented harvest for Arctic Cisco in 7.6 cm mesh nets over the previous 29 seasons. Increased harvest occurred in the Upper Niġliq, where the total harvest of Arctic Cisco in 7.6-cm mesh nets was 98% higher in 2015 (2,403) than in 2014 (1,211) (Table 3). In contrast, harvests were 77% lower in the Nanuk (605 versus 2,588), 1% lower in the Niġliq Delta (10,193 versus 10,053).

The observed harvest and effort are used to calculate CPUE. The CPUE can be compared among years for different net types and sections of river and used to calculate total harvest estimates. The total observed CPUE of Arctic Cisco in 7.6-cm mesh nets in the Niġliq Channel (42.4 fish/net-day) was the highest CPUE recorded in the history of the monitoring project (Table 3, Figure 7). The 2015 CPUE in 7.6-cm mesh nets for Arctic Cisco in the Upper Niġliq (22.8 fish/net-day) area was the highest recorded since monitoring began in 1985, and more than double the CPUE recorded in the same area in 2014 (Table 3). The CPUE in the Niġliq Delta area (59.2 fish/net-day) was more than double the 2014 CPUE (27.5 fish per adjusted net-day) and the third highest CPUE in the past 30 years. In contrast, the CPUE in the Nanuk area was lower in 2015 (18.5 fish/net-day) than in 2014 (26.2 fish/net-day). In the Main Channel area, the CPUE in 7.6-cm mesh nets was 67 fish/net-day (Table 4a) versus 18.7 fish/net day in 2014. However, it must be noted that the Main Channel 2015 CPUE is estimated from only 2 days of harvest information. The Niġliq Channel daily average CPUE in 2015 for 7.6-cm mesh nets exceeded 30 fish per adjusted net-day on 27 days, peaking at 87 Arctic Cisco per adjusted net-day on 5 November (Figure 8). There were 4 additional days with average daily CPUE values above 20 fish per adjusted net-day.

The 2015 harvest is the largest estimated harvest since commercial fishing ceased in 2002 and also the largest harvest overall (commercial plus subsistence fishing) since 1996 (Appendix B). We recorded a total of 20,977 Arctic Cisco in nets of all mesh sizes combined for the Niġliq Channel in 2015, which is 4,404 more fish than in 2014. In the Main Channel, we recorded 782 fish in 2015, a decrease of 984 fish compared to 2014 (1,766 fish). These totals include fish caught in nets of unknown size that are excluded from CPUE-based estimates. CPUE estimates varied widely among mesh sizes, ranging from 5.1 fish/net-day in 8.9-cm mesh nets to 190.8 fish/net-day in 6.4-cm mesh nets (Table 4a). CPUE multiplied by fishing effort (net-days) for each mesh size yields harvest estimates of 46,323 Arctic Cisco from the Niġliq Channel and 5,784 from the Main Channel fishing area of the Colville River for an estimated total harvest of 52,107 Arctic Cisco in 2015 (Table 4b), which is 18,867 fish higher than harvest estimates for 2014.

A total of 9 species of fish were documented in the Colville River fall fishery harvest in 2014, including Fourhorn Sculpin (*Myoxocephalus quadricornis*) which were recorded but not counted for this monitoring project (Table 5). A total of 22,586 fish (all species and mesh sizes) were counted during interviews, the second highest number recorded during the history of the monitoring project. Arctic Cisco made up the majority (95.6%) of recorded harvests followed by Least Cisco (2.2%), Rainbow Smelt (*Osmerus mordax*, 0.7%), Humpback Whitefish (*C.*

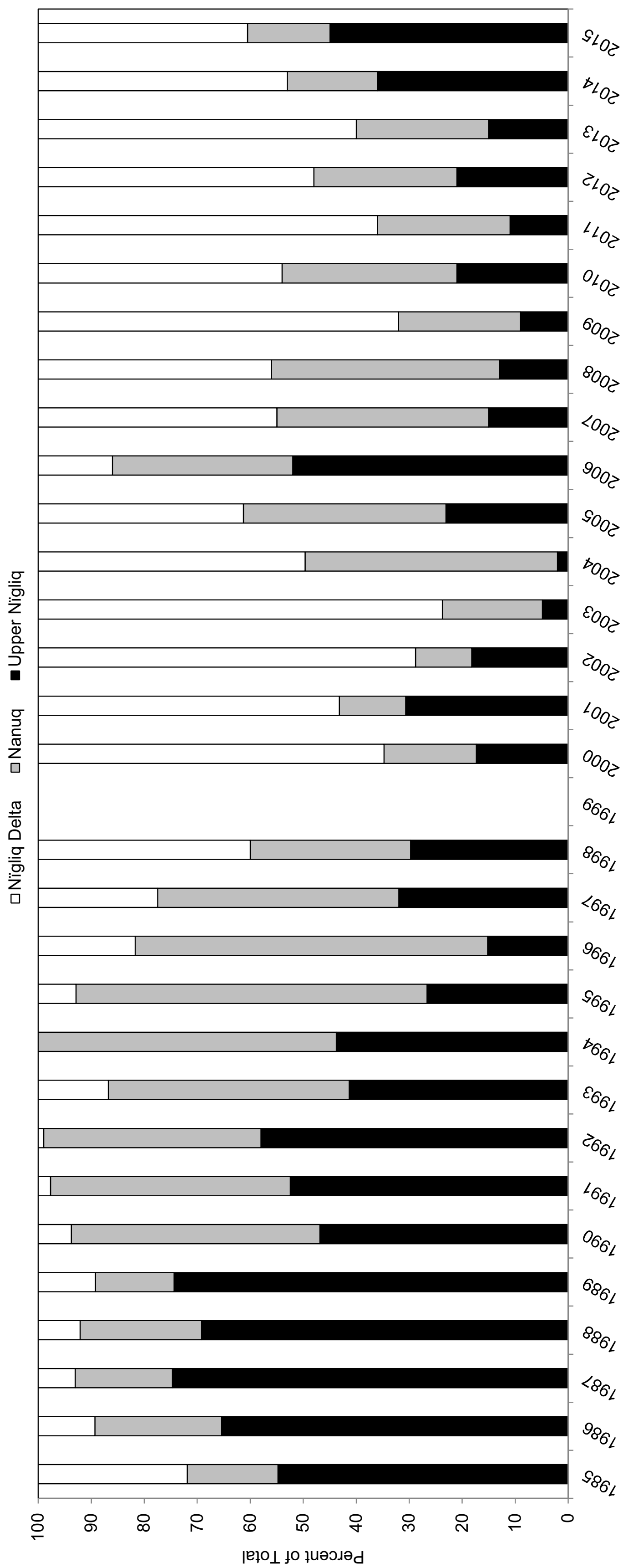

Figure 5. Percent of annual fishing effort in each of 3 Niġliq Channel fishing areas, Colville River, Alaska, 1985–2015. All nets are included regardless of length and mesh size.

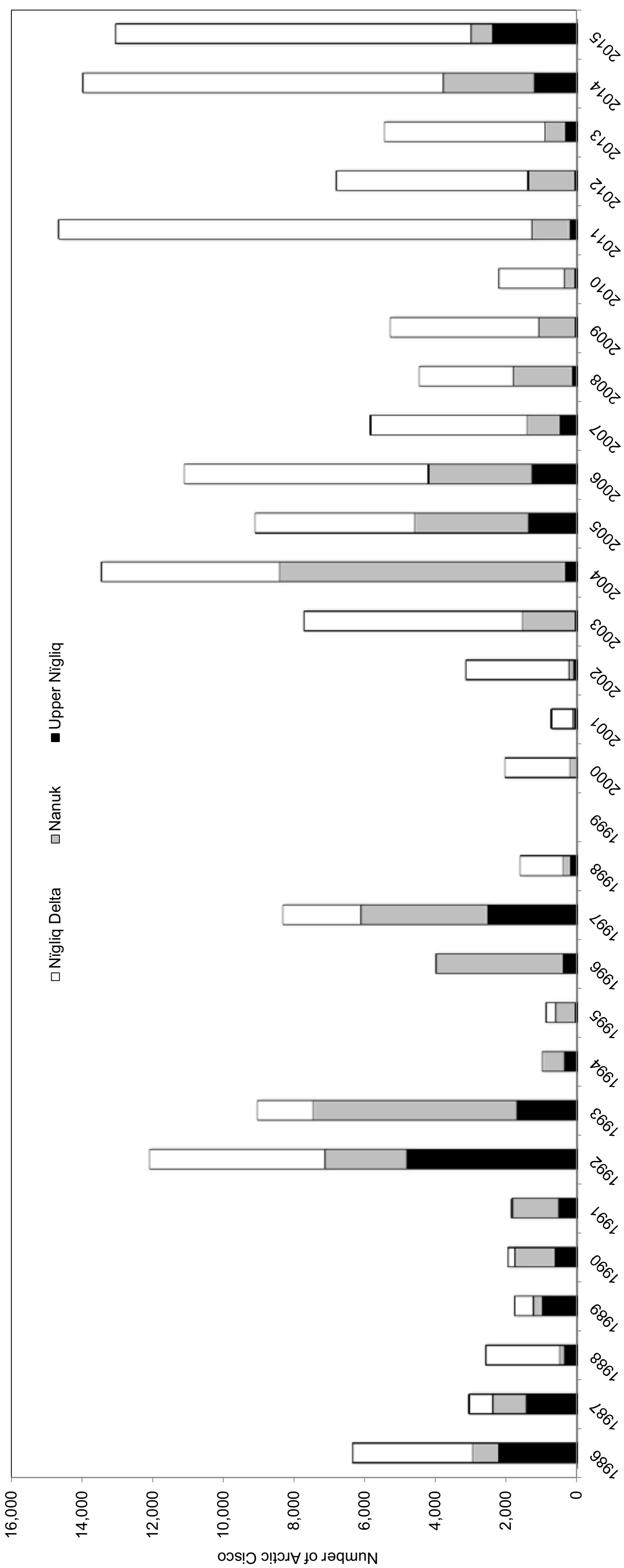

Figure 6. The observed number of Arctic Cisco harvested in 7.6-cm mesh nets in each of 3 Nigliq Channel fishing areas, 1986–2015. Data from 2005–2015 are not directly comparable to older data because the fishery was not monitored for the entire season during prior years.

Table 3. Observed catch of Arctic Cisco (number of fish), effort (adjusted net-days), and catch per unit effort (CPUE; fish/net-day) for each fishing area in the Niġliq Channel, Colville River, Alaska, 1986–2015. Catch and effort data are for 7.6 cm mesh gillnets standardized to 18 m length.

	Upper Niġliq			Nanuk			Niġliq Delta			Total Niġliq Channel		
Year	Observed Catch	Effort	CPUE	Observed Catch	Effort	CPUE	Observed Catch	Effort	CPUE	Observed Catch	Effort	CPUE
1986	2,218	115.7	19.2	752	25.1	29.9	3,379	51.3	65.8	6,349	192.2	33.0
1987	1,451	131.7	11.0	948	32.6	29.1	661	31.3	21.1	3,060	195.7	15.6
1988	366	56.9	6.4	146	18.0	8.1	2,078	37.3	55.7	2,590	112.3	23.1
1989	993	90.8	10.9	258	14.3	18.0	535	21.7	24.7	1,786	126.8	14.1
1990	650	147.1	4.4	1,114	148.5	7.5	202	27.6	7.3	1,966	323.1	6.1
1991	522	143.0	3.7	1,327	326.9	4.1	16	8.0	2.0	1,865	477.9	3.9
1992[a]	4,825	316.2	15.3	2,322	130.4	17.8	4,956	96.2	51.5	12,103	542.8	22.3
1993[a]	1,709	106.2	16.1	5,783	158.3	36.5	1,568	57.7	27.2	9,060	322.2	28.1
1994	366	99.0	3.7	642	190.2	3.4	0	0.0	–	1,008	289.2	3.5
1995[a]	56	50.3	1.1	568	178.3	3.2	267	12.0	22.3	891	240.7	3.7
1996	413	36.0	11.5	3,591	193.3	18.6	0	0.0	–	4,004	229.3	17.5
1997	2,539	119.0	21.3	3,586	128.8	27.8	2,207	53.3	41.4	8,332	301.2	27.7
1998	189	92.3	2.0	218	83.7	2.6	1,214	155.3	7.8	1,621	331.3	4.9
1999						No Data						
2000	8	8.0	1.0	217	62.0	3.5	1,826	190.4	9.6	2,051	260.4	7.9
2001	92	62.0	1.5	36	22.7	1.6	611	208.8	2.9	739	293.4	2.5
2002	103	115.7	0.9	137	36.7	3.7	2,925	460.9	6.3	3,165	613.2	5.2
2003	62	11.7	5.3	1,495	104.0	14.4	6,187	455.7	13.6	7,744	571.3	13.6
2004	338	22.0	15.4	8,102	270.9	29.9	5,021	199.7	25.1	13,461	492.6	27.3
2005	1,387	90.0	15.4	3,222	169.5	19.0	4,512	177.0	25.5	9,121	436.5	20.9
2006[a]	1,281	105.0	12.0	2,930	83.3	35.0	6,913	81.3	85.0	11,124	269.7	41.3
2007[a]	498	63.0	7.9	935	109.2	8.6	4,422	200.2	22.1	5,855	372.5	15.7

Table 3. Continued.

Year	Upper Niġliq			Nanuk			Niġliq Delta			Total Niġliq Channel		
	Observed Catch	Effort	CPUE	Observed Catch	Effort	CPUE	Observed Catch	Effort	CPUE	Observed Catch	Effort	CPUE
2008[a]	156	44.0	3.5	1,665	203.3	8.2	2,662	198.3	13.4	4,483	445.6	10.1
2009[a]	0	0.0	0.0	1,027	88.3	11.6	4,258	196.3	21.7	5,285	284.6	18.6
2010[a]	91	34.7	2.6	270	98.0	2.8	1,866	193.0	9.7	2,227	326.0	6.8
2011[a]	212	27.3	7.8	1,064	56.3	18.9	13,395	320.7	41.8	14,671	404.3	36.3
2012[a]	86	24	3.6	1,313	48.3	27.2	5,413	173.7	31.2	6,812	246.0	27.7
2013[a]	335	48.0	7.0	589	39.3	15.0	4,536	327.0	13.9	5,460	414.3	13.2
2014[a]	1,211	123.7	9.8	2,588	98.8	26.2	10,193	370.0	27.5	13,992	592.5	23.6
2015[a]	2,403	105.3	22.8	605	32.7	18.5	10,053	169.8	59.2	13,061	307.8	42.4
Total[b]	847	82	8.4	1,636	109	16	3,513	154.3	27.2	5,996.1	345.4	17.8

[a]Upper Niġliq catch and effort values include fish and net data from the Uyagagviq area (Area 630).
[b]Denotes average CPUE from 1986–2015.

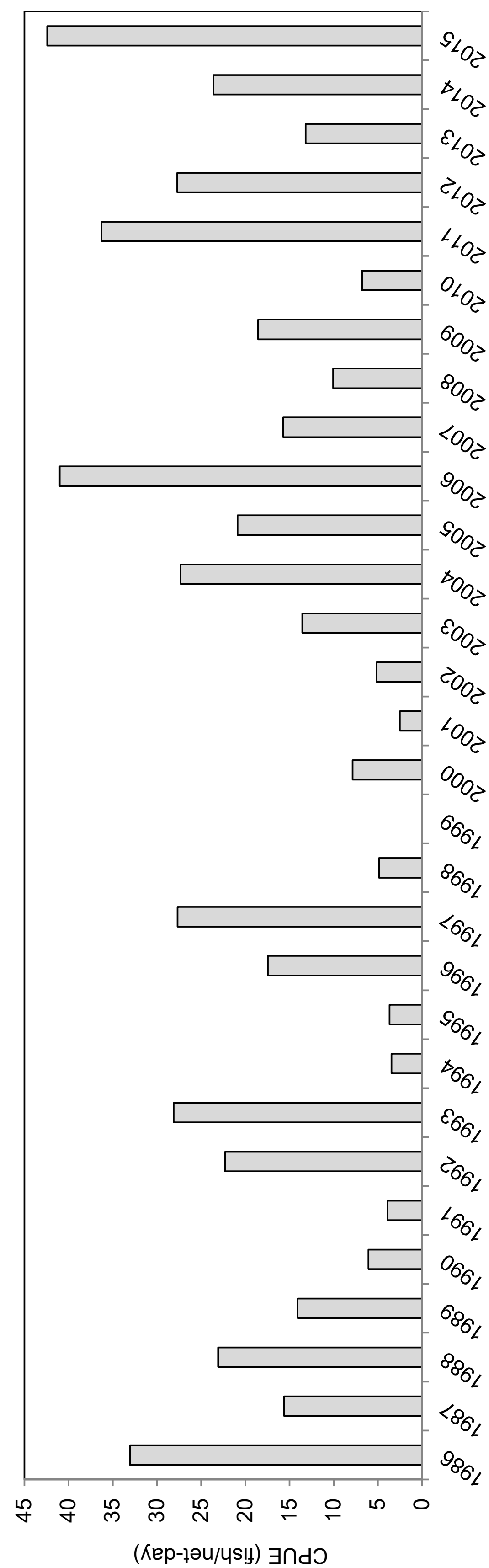

Figure 7. Catch per unit effort (CPUE; fish/net-day) of Arctic Cisco in 7.6-cm mesh gill nets, Nigliq Channel, Colville River, Alaska, 1986–2015. Effort is standardized to an 18 m net length.

Table 4a. Observed catch of Arctic Cisco (number of fish), effort (adjusted net-days), and catch per unit effort (CPUE; fish/net-day) for each fishing area in three Niġliq Channel fishing area and in the Main Channel fishing area by mesh size, Colville River, Alaska, 2014. Nets are standardized to 18 m length.

	Mesh Size (cm)				
Location	5.1	6.4	7.6	8.3	8.9
Upper Niġliq Area					
Observed Catch (# of fish)	247	–	1,211	32	48
Effort (net-days)	21.7	–	123.7	5.3	31.3
CPUE (fish/net-day)	11.4	–	9.8	6	1.5
Nanuk Area					
Catch (# of fish)	–	–	2,588	–	72
Effort (net-days)	–	–	98.8	–	15.3
CPUE (fish/net-day)	–	–	26.2	–	4.7
Niġliq Delta Area					
Catch (# of fish)	–	450	10,193	–	228
Effort (net-days)	–	5	370	–	20
CPUE (fish/net-day)	–	90	27.5	–	11.4
Total Niġliq Channel					
Catch (# of fish)	247	450	13,992	32	348
Effort (net-days)	21.7	5	592.5	5.3	66.7
CPUE (fish/net-day)	11.4	90	23.6	6	5.2
Main Channel Area					
Catch (# of fish)	–	–	579	–	–
Effort (net-days)	–	–	31	–	–
CPUE (fish/net-day)	–	–	18.7	–	–
Total					
Catch (# of fish)	247	450	14,571	32	348
Effort (net-days)	21.7	5	623.5	5.3	66.7
CPUE (fish/net-day)	11.4	90	23.4	6	5.2

Table 4b. The estimates of total harvest of Arctic Cisco in the Niġliq Channel and Main Channel fishing areas. Estimates are based on calculated effort and estimated CPUE for each river section by mesh size, Colville River, Alaska, 2015.

Mesh Size (cm)	Nïgliq Channel net-days	CPUE (fish/net day)	Estimated Nïgliq Channel Harvest	Main Channel Area net-days	CPUE (fish/net day)	Estimated Main Channel Harvest	Total Estimated Harvest
5.1	35	11.4	399	--	--	--	
6.4	50.7	90	4563	13.3	--	--	
7.6	1008.6	23.61519	23818.281	178.6	18.7	3,336	
8.3	10.7	6	64.2	--	--	--	
8.9	203	5.22	1059.66	--	--	--	
		Total	29,904			3,336	33,240

pidschian, 0.4%), Saffron Cod (*Eleginus gracilis*, 0.2%), and Broad Whitefish (*C. nasus*, 0.1%). Burbot (*Lota lota*) and Sheefish (*Stenodus nelma*) were recorded but made up a negligible proportion (~0.01%) of the harvest.

The CPUE for Least Cisco in 7.6-cm mesh nets was tied for third lowest on record in the Niġliq Channel (1.0 fish/net-day; Table 6). CPUE was highest in the Niġliq Delta (1.4 fish/net-day), followed by the Nanuk area (0.7 fish/net-day) and the Upper Niġliq area (0.4 fish/net-day). The long-term average CPUE for Least Cisco harvest in the Niġliq Channel is 3.1 fish/net-day (95% CI: 2.2 to 3.9 fish/net-day).

LENGTH, WEIGHT AND AGE OF CATCH

A sub-sample of fish was measured daily at net sites to determine the length distribution present in the fishery. ABR measured fork lengths of 1,175 Arctic Cisco in 2015. Arctic Cisco ranged in length from 227 mm to 403 mm (Figure 9) with a median of 326 mm. The middle 50% of fish ranged between 315 mm and 339 mm. Arctic Cisco were measured from 5 of 7 net mesh sizes deployed in 2015. Median fork lengths were 298 mm in 6.4-cm mesh nets, 320 mm in 7.0-cm mesh nets, 323 cm in 7.6-cm mesh nets, 327 mm in 8.3-cm mesh nets, and 346 mm in 8.9-cm mesh nets (Figure 10). Least Cisco fork lengths ranged from 271 mm to 359 mm with a median of 324 mm. The middle 50% of measured Least Cisco (all mesh sizes) ranged between 315 and 336 mm.

In 2015, we received 195 donated Artic Cisco from several fishers to be used for additional laboratory analysis of age, length, and weight. Length and weight were strongly correlated (R^2 = 0.72) in all mesh sizes (Figure 11). In 7.6-cm mesh nets, the length-weight correlation for 2015 was greater than in the combined sample (R^2 = 0.77), and had the strongest correlation of the past 7 years (Figure 12).

Body condition of fish (weight adjusted for differences in length) differed among years (F [13, 1047]= 4.52, P < 0.001). Fish harvested in 2011 were heaviest at mean length (368 g), indicating that fish had the best body condition compared to the other 6 years (Table 7). In contrast, fish harvested in 2012 were lighter at mean length (315 g) than fish harvested in other years (Figure 12). In 2009, longer fish were heavier at mean length and shorter fish were lighter at mean length than in other years, suggesting that in that year, older fish had better body condition than younger fish.

Through otolith analysis of sub-sampled fish, we determined that Arctic Cisco in all mesh sizes combined (7.0 cm, 7.6 cm, and 8.3 cm) ranged in age from 6 to 8 years of age in 2015 (Figure 13). Most fish (76.6%) were age 7, followed by 14.5% age 6, and 8.8% age 8. Mesh-size of nets affects the size (and therefore age class) of fish captured, with

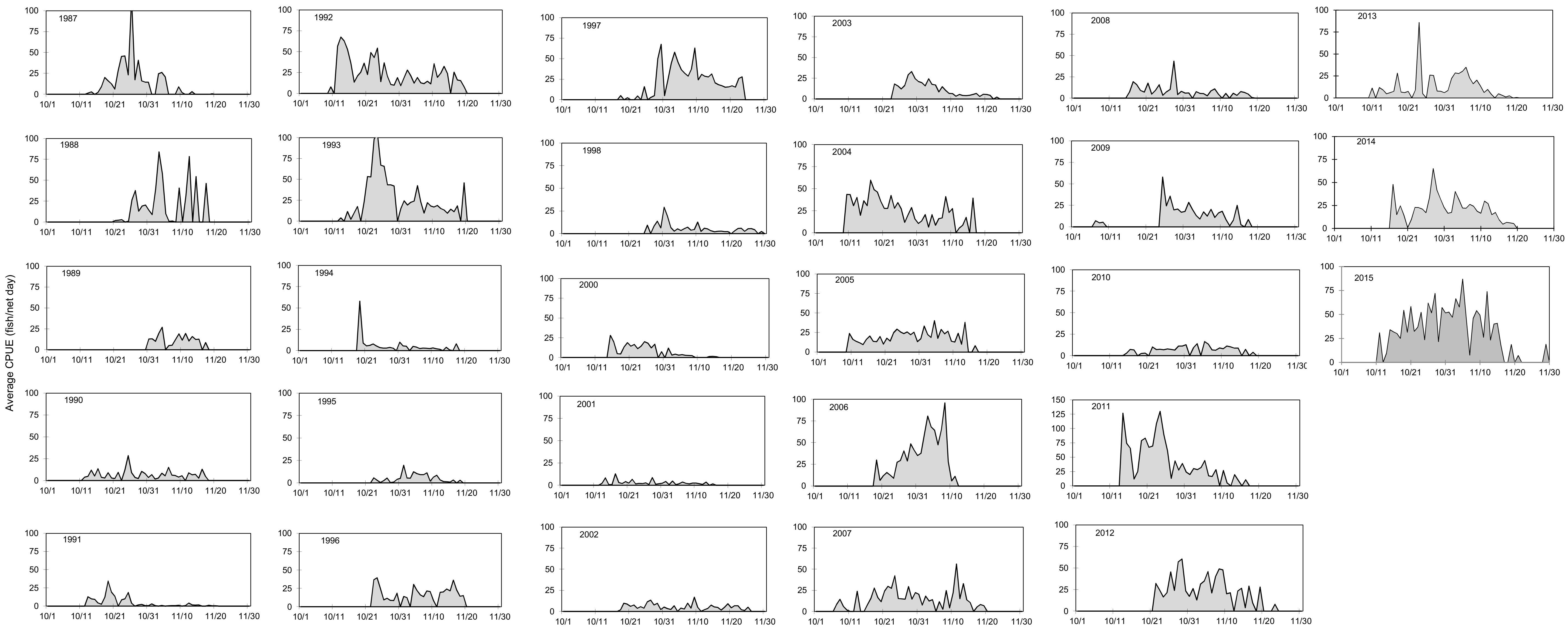

Figure 8. Average daily catch per unit effort (CPUE; fish/net-day) of Arctic Cisco in 7.6-cm gill nets, Niġliq Channel, 1987–2015. Effort is standardized to an 18 m net length.

Table 5. Species composition of the observed harvest from the fall subsistence fishery for Arctic Cisco expressed as a percent of the sampled catch, Colville River, Alaska, 1985–2015. Table includes all fish caught in every net, regardless of mesh size and location.

Year	Arctic Cisco	Bering Cisco	Least Cisco	Broad Whitefish	Humpback Whitefish	Arctic Grayling	Rainbow Smelt	Round Whitefish	Dolly Varden Char	Northern Pike	Saffron Cod	Burbot	Arctic Flounder	Fourhorn Sculpin	Sheefish	Total Observed
1985	69.5	(a)	14.8	15.1	0.5	0	0.2	0	0	0	0	0	0	(b)	0	2,705
1986	95.9	(a)	3.8	0.3	0.0	0	0.03	0.01	0	0	0	0	0	(b)	0	8,952
1987	71.8	(a)	18.7	5.5	3.8	0	0.01	0	0.03	0	0.03	0.06	0	(b)	0	6,826
1988	90.6	(a)	8.3	0.6	0.5	0	0	0	0	0	0	0.1	0	(b)	0	2,948
1989	66.2	(a)	23.7	7.0	3.1	0	0.03	0	0	0	0.03	0.03	0	(b)	0	2,946
1990	39.6	21.8	30.2	5.3	2.9	0	0.2	0	0.1	0	0.03	0.01	0	(b)	0	7,911
1991	62.8	1.2	30.0	1.0	3.8	0	1	0.03	0	0	0.04	0.09	0	(b)	0	7,576
1992	89.2	0.1	6.0	0.2	0.1	0	0	0	0	0	0	0	0	4.4	0	24,305
1993	85.4	0.02	11.1	0.3	0.4	0	0.04	0	0	0	0.01	0	0	2.7	0	17,155
1994	39.6	0.1	44.6	2.2	13.2	0	0.3	0	0	0	0	0	0	(b)	0	3,792
1995	34.7	0.2	35.0	7.6	22.3	0	0.2	0	0	0	0	0.1	0	(b)	0	7,155
1996	81.9	0	4.8	0.1	0.4	0	0.1	0	0	0	0.02	0.02	0.02	12.5	0	5,730
1997	74.8	0	22.9	1.3	0.9	0	0	0	0	0	0	0	0	(b)	0	19,758
1998	39.6	0	50.8	0.4	8.9	0	0	0.2	0	0	0	0	0	(b)	0	6,481
2000	79.4	0.1	14.0	0.2	6.0	0	0.3	0	0	0	0.03	0	0	(b)	0	3,871
2001	35.6	0.1	29.6	5.5	27.8	0	0.1	0	0	0	0	1.3	0	(b)	0	3,515
2002	49.8	0.1	30.6	1.6	17.5	0	0.2	0	0	0	0.1	0.2	0	(b)	0	8,445
2003	66.3	0.2	22.3	0.2	9.4	0	0.9	0	0	0	0.6	0.1	0	(b)	0	16,654
2004	74.7	0.06	24.2	0.0	0.9	0	0.08	0	0	0	0.04	0.03	0	(b)	0	20,705
2005	81.3	0	14.8	0.2	3.5	0	0.15	0	0	0	0.01	0	0	(b)	0	13,957
2006	86.6	0	12.0	0.4	0.9	0	0	0	0	0.1	0	0	0	(b)	0	17,344
2007	71.7	0	22.3	0.4	5.5	0	0	0	0	0	0.1	0	0	(b)	0	14,686
2008	84.1	0.2	14.7	0.0	0.1	0	0.7	0	0	0	0.1	0.01	0	(b)	0	9,199
2009	85.4	0.2	9.2	0.2	0.5	0	4.3	0	0	0	0.1	0.03	0	(b)	0	11,700
2010	60.7	0	34.4	0.4	3.0	0	1.3	0	0	0	0.2	0	0	(b)	0	18,505
2011	94.8	0	4.0	0.1	0.6	0	0.4	0	0	0	0.09	0	0	(b)	0	28,211
2012	77.8	0	19.8	0.6	0.9	0	0.4	0	0	1	0.5	0	0	(b)	0	17,172
2013	82.5	0	7.7	0.1	2.3	0	5.5	0	0	0	1.8	0	0	(b)	0	13,872
2014	95.4	0	2.1	0.4	0.6	<0.01	1.3	0	0	0	0.2	<0.01	0	(b)	0	19,217
2015	95.6	0	2.2	0.1	0.4	0	0.7	0	0	0	0.2	<0.01	0	(b)	<0.01	22,586

a) = included with Arctic Cisco prior to 1990
b) = always present but not counted

Table 6. Observed catch of Least Cisco (number of fish), effort (net-days), and catch per unit effort (CPUE; fish/net-day) for each fishing area in the Niġliq Channel, Colville River, Alaska, 1986–2015. Catch and effort data are for 7.6-cm mesh gillnets standardized to 18 m length.

	Upper Niġliq			Nanuk			Niġliq Delta			Total Niġliq Channel		
Year	Catch	Effort	CPUE	Catch	Effort	CPUE	Catch	Effort	CPUE	Catch	Effort	CPUE
1986	146	115.7	1.0	16	25.1	1.0	24	51.3	0.0	186	192.2	1.0
1987	730	131.7	6.0	63	32.6	2.0	12	31.3	0.0	805	195.7	4.0
1988	93	56.9	2.0	12	18.0	1.0	105	37.3	3.0	210	112.3	2.0
1989	332	90.8	4.0	16	14.3	1.0	10	21.7	0.0	358	126.8	3.0
1990	711	147.1	5.0	416	148.5	3.0	179	27.6	6.0	1,306	323.1	4.0
1991	50	143.0	0.0	272	326.9	1.0	0	8.0	0.0	322	477.9	1.0
1992	261	316.2	1.0	88	130.4	1.0	151	96.2	2.0	500	542.8	1.0
1993	181	106.2	2.0	498	158.3	3.0	96	57.7	2.0	775	322.2	2.0
1994	330	99.0	3.0	711	190.2	4.0	0	0	–	1,041	289.2	4.0
1995	238	50.3	5.0	494	178.3	3.0	94	12.0	8.0	826	240.7	3.0
1996	14	36.0	0.0	195	193.3	1.0	0	0	–	209	229.3	1.0
1997	1,370	119.0	12.0	1,575	128.8	12.0	203	53.3	4.0	3,148	301.2	10.0
1998	544	92.3	6.0	577	83.7	7.0	935	155.3	6.0	2,056	331.3	6.0
1999						No Data						
2000	11	8.0	1.0	97	62.0	2.0	330	190.4	2.0	438	260.4	2.0
2001	129	62.0	2.0	222	22.7	10.0	491	208.8	2.0	842	293.4	3.0
2002	176	115.7	2.0	165	36.7	5.0	1,033	460.9	2.0	1,374	613.2	2.0
2003	25	11.7	2.0	459	104.0	4.0	1,038	455.7	2.0	1,522	571.3	3.0
2004	167	22.0	8.0	2,493	270.9	9.0	1,483	199.7	7.0	4,143	492.6	8.0
2005	405	90.0	5.0	710	140.3	5.0	700	177.0	4.0	1,815	407.3	4.0
2006	274	92.7	3.0	261	67.3	4.0	414	65.0	6.0	949	225.0	4.0
2007	939	63.0	15.0	559	109.4	5.0	1,085	188.7	6.0	2,583	361.2	7.0
2008	78	44.0	1.8	529	188.0	2.8	460	233.2	2.0	1,067	465.2	2.3
2009	6	1.7	3.6	321	88.3	3.6	265	181.3	1.5	592	271.3	2.2

Table 6. Continued.

Year	Upper Niġliq			Nanuk			Niġliq Delta			Total Niġliq Channel		
	Catch	Effort	CPUE	Catch	Effort	CPUE	Catch	Effort	CPUE	Catch	Effort	CPUE
2010	139	34.7	4.0	235	92.0	2.6	225	193.3	1.2	599	320	1.9
2011	8	27.3	0.3	90	56.3	1.6	550	292.0	1.9	648	375.7	1.7
2012	92	24.0	3.8	585	48.3	12.1	319	173.7	1.8	996	246.0	4.0
2013	74	48.0	1.5	21	23.3	0.9	93	322.0	0.3	188	393.3	0.5
2014	61	123.7	0.5	76	82.8	0.9	93	322.0	0.3	230	528.5	0.4
2015	43	119.7	0.4	23	32.7	0.7	242	169.8	1.4	308	322.2	1.0
Total	7,627	2,392	3.2	11,779	3,054	3.9	10,630	4,385	2.4	30,036	9,831	3.1

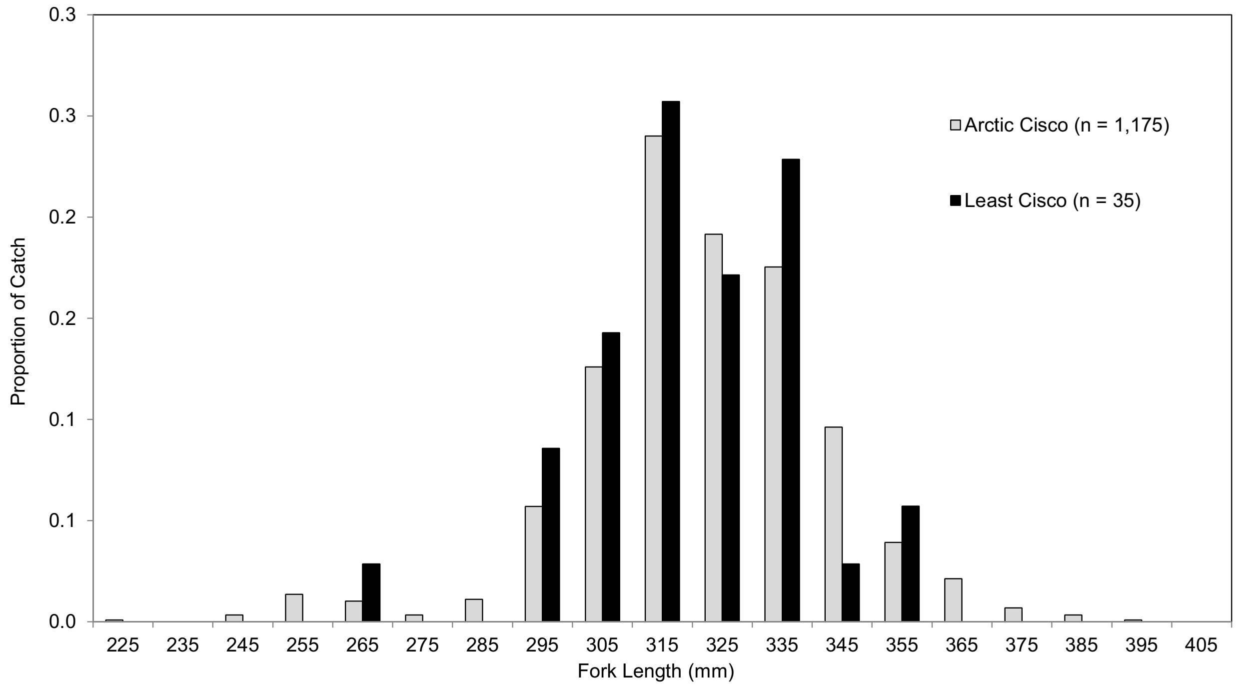

Figure 9. Length frequency (10 mm increments) of Arctic Cisco and Least Cisco captured in all mesh sizes in the fall subsistence fishery, Niġliq Channel, Colville River, Alaska, 2015.

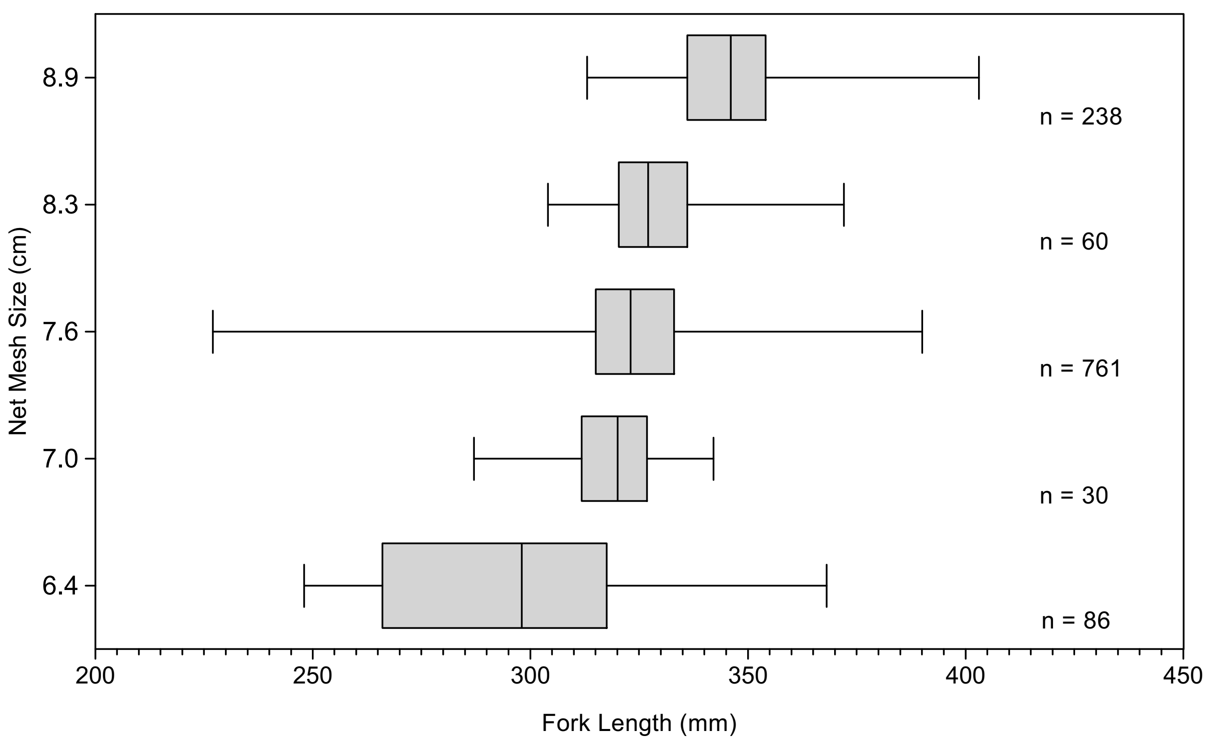

Figure 10. Length frequencies of Arctic Cisco in the fall subsistence fishery by gillnet mesh size, Niġliq and Main channels, Colville River, Alaska, 2015. Boxes represent the middle 50% of data while horizontal lines within the boxes represent median values. Whiskers represent the minimum and maximum fish length.

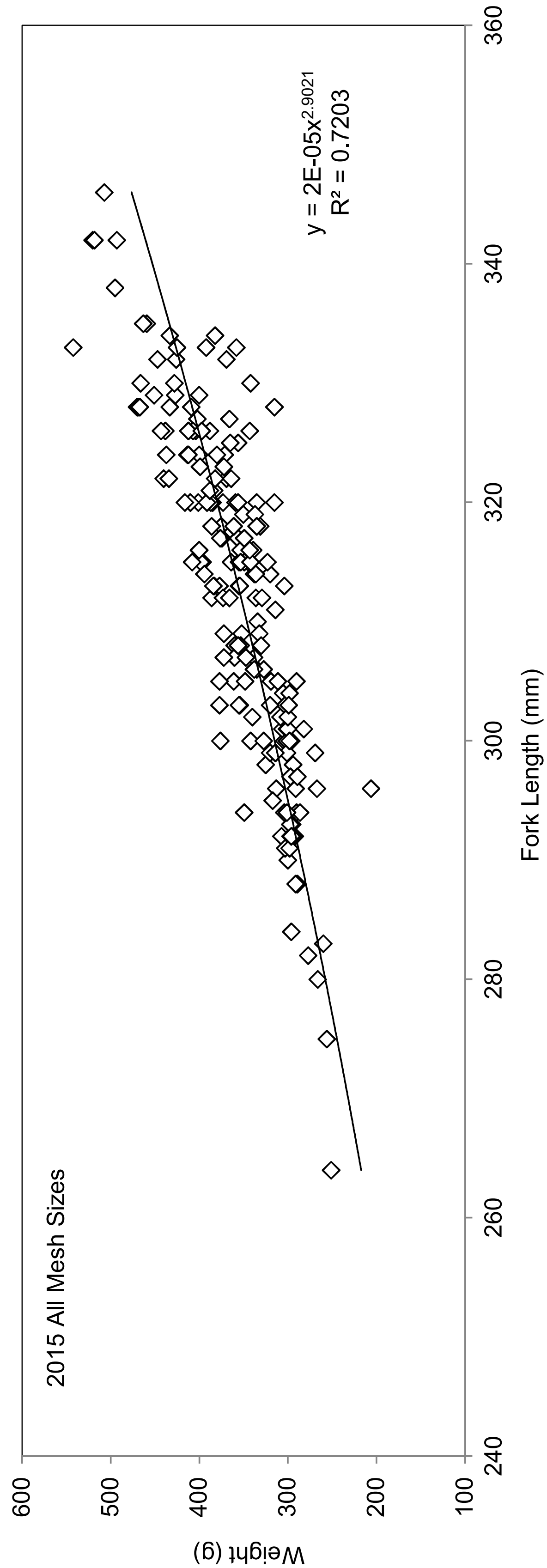

Figure 11. Length-weight relationship of Arctic Cisco captured in the fall subsistence fishery, Nigliq Channel, Colville River, Alaska, 2015. Includes fish captured in all mesh sizes and all nets (n = 195).

Table 7. Results of tests for differences among years in weight and length measurements. Values in columns with the same letters were not significantly different ($P > 0.05$).

Year	n	Mean Weight (g)	Mean Length (mm)	Weight Adjusted to the Mean Length (g)	Slope (g/mm at the Mean Length)
2009	138	383.8 A	313.8 A	356.9 AB	1.012 A
2010	146	358.9 AB	312.7 A	338.9 C	1.009 B
2011	120	343.9 B	300.9 C	368.2 A	1.009 B
2012	206	307.6 C	306.2 BC	315.0 E	1.010 AB
2013	158	334.9 B	313.7 A	320.2 DE	1.009 B
2014	141	344.9 B	313.6 A	330.0 CD	1.008 B
2015	152	357.9 AB	311.7 AB	348.5 B	1.009 B

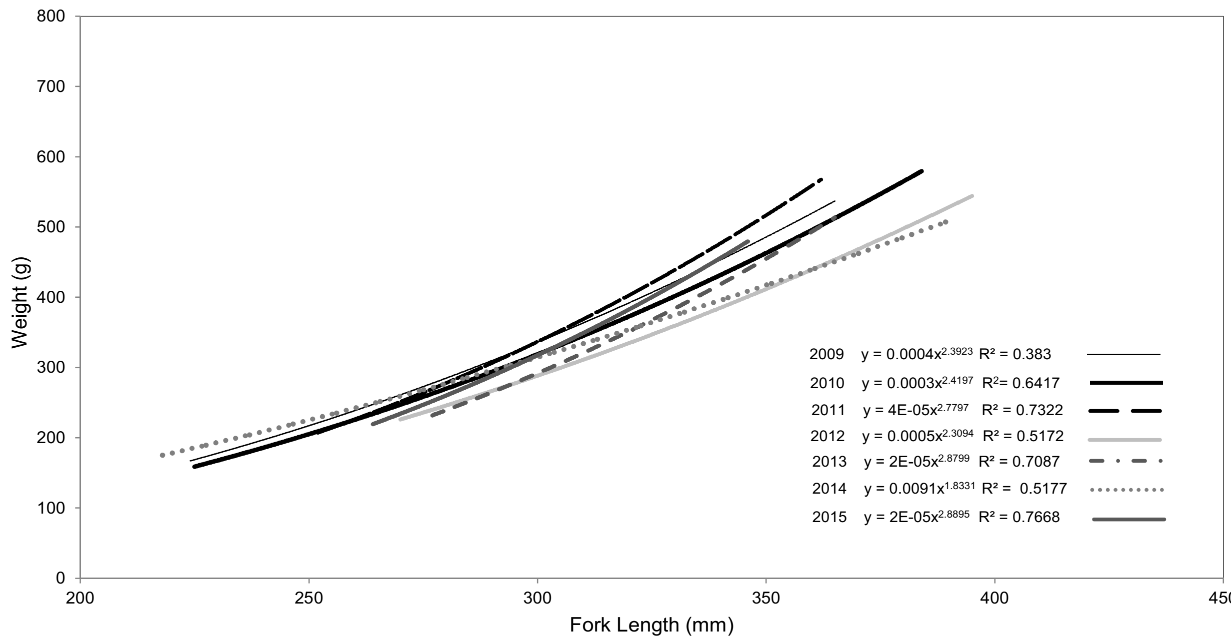

Figure 12. A 7-year (2009–2015) comparison of length-weight regression lines for Arctic Cisco captured in 7.6-cm mesh nets in the fall subsistence fishery, Niġliq Channel, Colville River, Alaska.

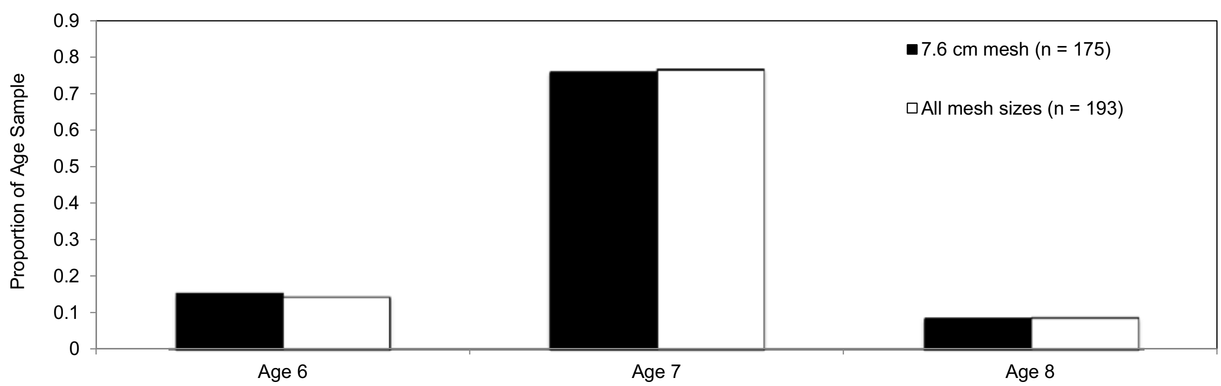

Figure 13. Age composition of Arctic Cisco harvested in 7.6 cm mesh nets (n = 175) and all mesh sizes combined (n = 193), Niġliq Channel, Colville River, Alaska, 2015.

smaller mesh capturing smaller fish. Because most of the donated fish (175; 91%) came from 7.6-cm mesh nets, age composition in 7.6-cm mesh nets was similar to the full sample of all mesh sizes combined (Figure 14).

The age composition of Arctic Cisco in 2015 harvests (as a percentage of catch) combined with the overall CPUE of 42.4 fish per adjusted net-day in 7.6-cm mesh nets (Table 3, Figure 13), allowed for estimation of age-specific CPUE. Assuming that the age composition of sub-sampled fish is representative of all harvested fish, the CPUE of Arctic Cisco in 7.6-cm mesh nets was 6.6 per adjusted net-day for age 6 fish, 32.2 for age 7 fish, and 3.6 for age 8 fish (Figure 15). The Arctic Cisco caught in 2015 represent the 2007 (age 9), 2008 (age 8), and 2009 (age 7) year classes. The estimated cumulative total CPUE by year class is 24.7 fish/net-day for 2007 (age 8, age 7, age 6, and age 5 fish), 54.0 for 2008 (age 7, age 6, age 5, and age 4 fish), 22.0 for 2009 (age 6, age 5, and age 4 fish), and 3.7 for 2010 (age 4 fish) (Table 8). The 2010 year class was not represented (as age 5 fish) in sub-sampled otoliths in 2015 (Figure 16).

SALINITY AND TEMPERATURE

We began sampling salinity at pre-established stations on 18 October and continued sampling every other day until 15 November (Figure 17). Salinity measurements (3 m depth) at the 3 downstream salinity stations (Stations 1, 2, and 3; Figure 2) were >15 ppt, the preferred minimum salinity for Arctic Cisco, at the beginning of sampling as well as during the traditional peak period of fishing effort in early November (Figure 18). This optimal salinity range was maintained above the 15 ppt threshold until the end of the monitoring season, peaking at 24.8 ppt in the Niġliq Delta area on 11 November. Salinity in the Upper Niġliq area (Station 4) adjacent to Nuiqsut started at 1.27 ppt and increased steadily to 13.97 ppt on the last day of monitoring. Temperature trends were opposite of the salinity trends at all 4 stations for most of the sampling season (Figure 17). Temperatures were coldest at Station 1, located farthest downstream (-1.2 to -0.4 °C) and warmest at Station 4, located farthest upstream (0.4 to 0.6 °C; Appendix C).

DISCUSSION

Since the late 1990's, a higher percentage of fishing effort on the Niġliq Channel has typically occurred in the Niġliq Delta fishing area, followed by the Nanuk area, and then the farthest upstream Upper Niġliq area. Our experience with the fishery has indicated that the typical increase in fishing effort from upstream to downstream locations in the Niġliq Channel has resulted from the perception among fishers that fish harvests returns, relative to effort, are greater with distance downstream from Nuiqsut. This perception is supported by the fact that CPUE for 7.6 cm mesh nets has been higher in the Niġliq Delta than in the Nanuk and Upper Niġliq fishing areas in 21 of the 30 years of monitoring. Since 2013, there has been a steady increase in effort in the Upper Niġliq near Nuiqust. In 2015, the Upper Niġliq area received a higher proportion of fishing effort (45% compared to the Niġliq Delta (40%) and Nanuk (15%) areas for the first time since 2006 and only the second time since 1992.

One indicator of the success of the fishing season is the number of Arctic Cisco recorded directly or indirectly by the harvest monitoring team. We recorded more than 13,000 Arctic Cisco in 2015 harvests, the fourth most on record. CPUE is another important indicator of fishery success. Average CPUE has typically increased from upstream to the farthest downstream area in this fishery. However, in 2015, CPUE in 7.6-cm mesh nets in the Upper Niġliq area was greater than the Nanuk fishing area for the first time since 1994, though still lower than the Niġliq Delta. CPUE in the Upper Niġliq area was the highest recorded since the inception of monitoring and was nearly triple the long-term average. The CPUE for in the Nanuk area also was greater than the long-term average. The overall Niġliq Channel CPUE was the third most in the history of the monitoring program and day to day average CPUE was high throughout much of the season, indicating that 2015 was one of the most successful fishing seasons in the Niġliq Channel since harvest monitoring began.

Results of Arctic Cisco harvests from the Main Channel fishing area were limited in 2015, in part due to a reduction in effort compared to 2014, but also related to our fishery monitoring methods. We generally focus monitoring efforts on the

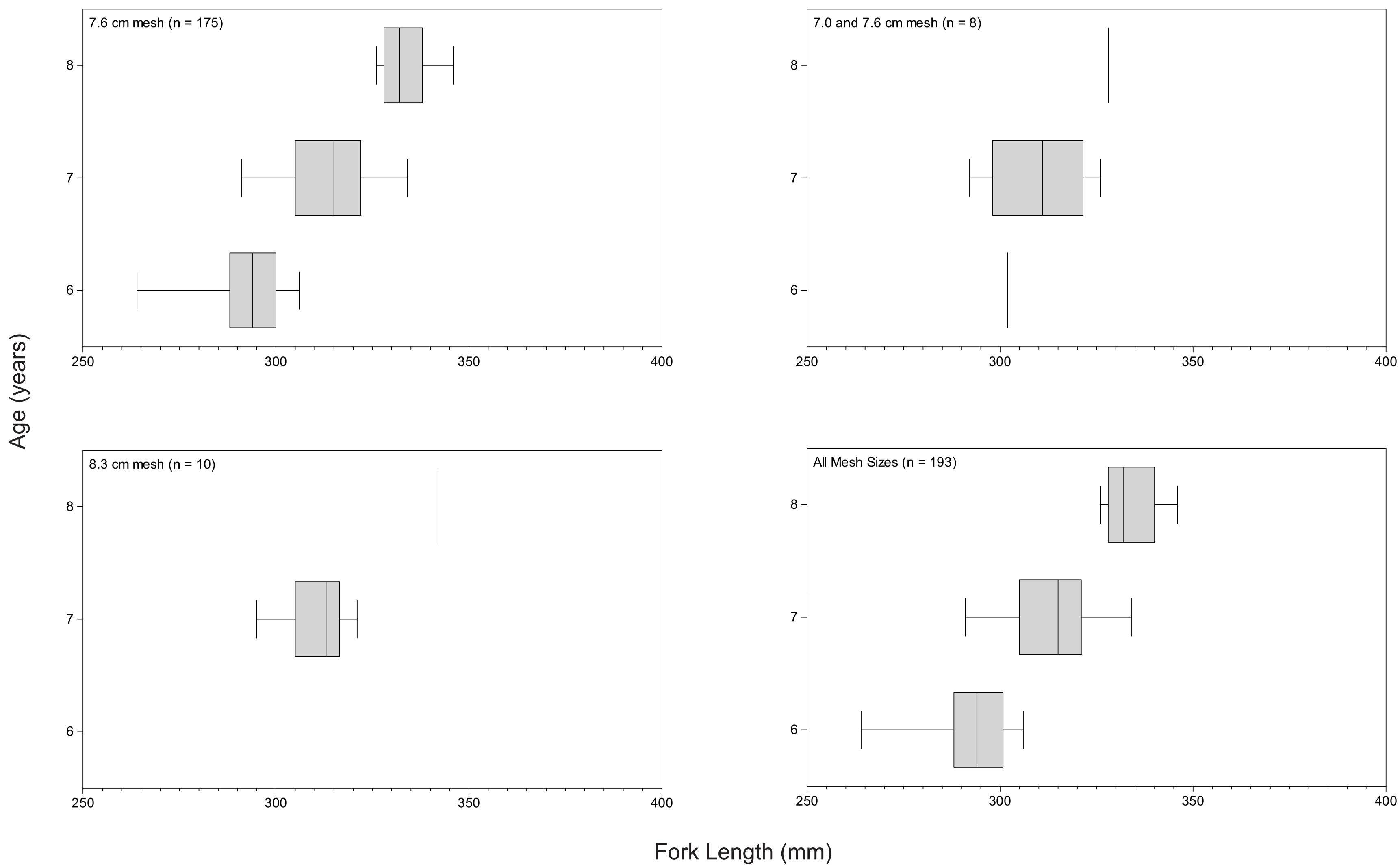

Figure 14. Age-specific length distribution of Arctic Cisco harvested in the fall subsistence fishery (n = 193), Niġliq Channel, Colville River, Alaska, 2015.

Niġliq Channel because of: 1) the greater number of fishers in that area; 2) the greater likelihood of encountering fishers on a daily basis at predictable hours compared to the more distant Main Channel; and 3) our reliance on local hires to provide information about harvests in the Main Channel fishing area. Furthermore, the fishing effort (all mesh sizes) in the Niġliq Channel far exceeded that of the Main Channel. Although communication between Main Channel fishers and the monitoring team was extremely limited, one piece of anecdotal information from a fisher indicated that fishing effort was reduced in this area due to the large number of Least Cisco caught as bycatch in 2015. Despite large bycatch, fishing efforts for Arctic Cisco were rewarded with very high CPUE in 7.6-cm mesh nets. However, this estimate (67 fish per net day) results from only 2 days of fishing and therefore it is possible that we significantly over- or underestimated the harvest from the Main Channel area.

Despite the overall reduction in fishing effort in 2015, the estimated harvest of 46,323 Arctic Cisco in the Niġliq Channel is well above the 5-year average estimated annual harvest of 26,000. This large harvest suggests that previous reports of large numbers of young-of-the-year Arctic Cisco captured in summertime fyke net surveys near Prudhoe Bay (Craig Reiser, LGL, 2009 and 2010, personal communications; Seigle and Parrett 2008) were strong indicators of large subsistence harvests in the years that followed. The increase in harvests in 2014 and 2015 illustrate the positive effects of year class recruitment and strength on subsequent fishing success. Another contributing factor to high CPUE for Arctic Cisco in 2015 was that salinity in the Niġliq Channel was optimal (>15 ppt; Moulton and Field 1988, Moulton 1994) throughout much of the fishing season.

Least Cisco typically represent a large proportion of the overall fall fishery harvest and remain an important subsistence harvest species. However, in 3 of the last 5 years, Arctic Cisco have made up ~95% of the recorded harvest. The CPUE for Least Cisco was low in 2015, but those measured by the monitoring team mirrored the length distribution of Arctic Cisco, indicating that Least Cisco offered similar subsistence value in terms of fish size, though Arctic Cisco is still the preferred harvest species because of their higher fat content and overall superior flavor (Appavoo et al. 1991). The anecdotal accounts of large numbers of Least Cisco in the Main Channel may explain their low numbers in the Niġliq Channel.

Fishers indicated that they were happy with the size (weight relative to length) of Arctic Cisco in 2015. Fish length increased with the net mesh size used and there was positive correlation between length and weight, indicating that these fish were relatively healthy. In any given year, fishers may indicate that "fish look smaller". An analysis of Arctic Cisco lengths and weights over the past 7 years suggest that, with the exception of 2009 when fish were lighter than expected for their length, year-to-year changes in weight are consistent with changes in length. This implies that fish body-condition is good (i.e., they are gaining appropriate weight as they grow longer). Assuming the sampled fish were representative of all fish caught in 7.6-cm mesh, sub-sampled fish did tend to be shorter in some years (e.g., 2011), though still at an expected weight for their length. However, the perceived differences in fish size in any given year may reflect a different age distribution among years, rather than differences in body condition.

The age structure of the fishery is an important factor influencing the size of Arctic Cisco harvested from year to year. The sub-sampled age structure of Arctic Cisco in 2015 indicates that the bulk of the harvested fish were from the 2007 (age 8), 2008 (age 7), and 2009 (age 6) year classes. The 2010 (age 5) year class was conspicuously absent from Arctic Cisco sub-samples despite being present in the Niġliq Channel harvests in 2014. This could be due to several factors such as fish behavior (e.g., schooling behavior by year class in a different part of the river) or environmental factors that influenced the 2010 year class strength as a whole at some point over the previous 5 years. It will be interesting to see if the 2010 year class reemerges in higher numbers in 2016, perhaps as a result of fishing activities occurring in closer proximity to locations where 2010 year class fish are overwintering (Fechhelm et al 2007). If the 2010 year class does not appear in nets in 2016, we could see reduced harvests beginning in 2016 as the 2007 and 2008 year classes leave the fishery to spawn in the Mackenzie River system. As an example of the type of impact this could have on

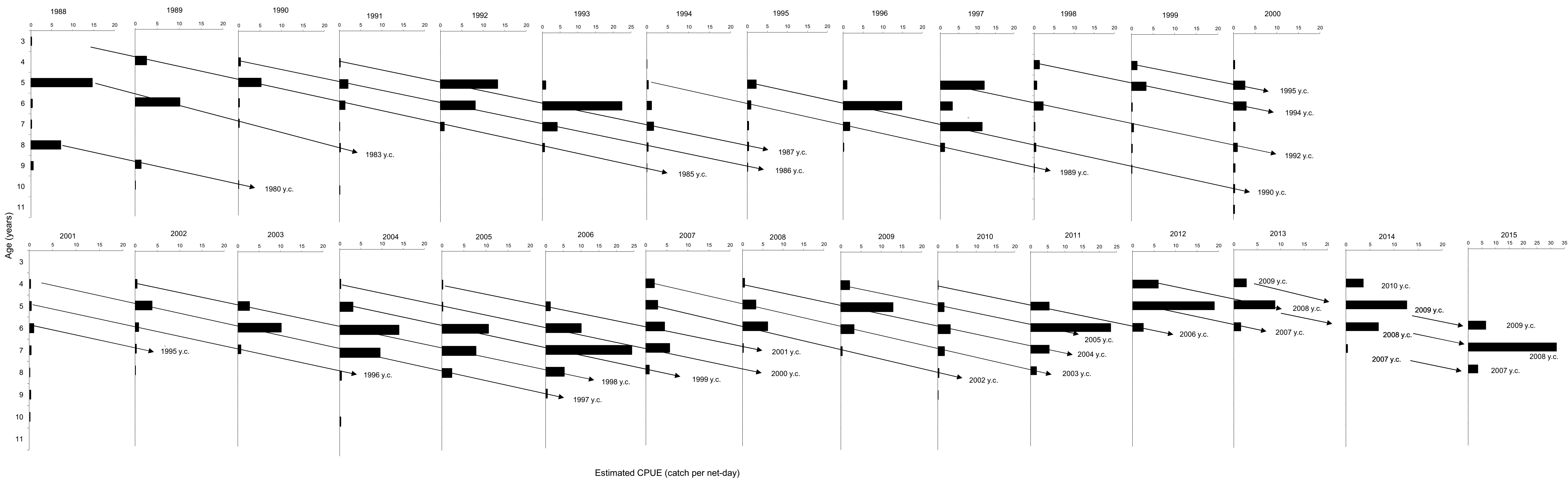

Figure 15. Catch per unit effort (CPUE) of Arctic Cisco by age class in the fall subsistence fishery, Niġliq Channel, 1988–2015. Arrows demonstrate the progression of select year classes through the fishery. Only fish harvested in 7.6-cm mesh gill nets are included and counts are standardized to 18 m net length, as described in text.

Table 8. Cumulative catch per unit effort (CPUE) of Arctic Cisco in 7.6-cm mesh gill nets by year class in the fall subsistence fishery, Niġliq Channel, Colville River (1981–2010).

Year Class	CPUE
1981	0.4
1982	0.4
1983	25.2
1984	0.3
1985	10.8
1986	15.1
1987	37.8
1988	2.4
1989	4.3
1990	29.1
1991	4.8
1992	15.4
1993	1.1
1994	4.8
1995	3.8
1996	2.5
1997	26.4
1998	30.0
1999	38.8
2000	16.0
2001	6.2
2002	9.5
2003	12.0
2004	22.1
2005	27.2
2006	8.1
2007[a]	24.7
2008[a]	54.0
2009[a]	22.0
2010[a]	3.7

[a] Calculation assumes that the 2007–2010 year classes are still contributing to cumulative CPUE.

the fishery, the 2008 year class appears to be the largest contributor to the fishery in the history of monitoring, with a cumulative CPUE of over 50 since entering the fishery in 2012. However, year class strength from year to year has been quite variable from year to year (Figure 16), and thus the ultimate contribution by the 2010 year class to the fall fishery is incomplete for the time being.

SUMMARY

The 2015 fishery was one of the most successful harvest years on record with the highest CPUE recorded for Arctic Cisco, and follows the successful completion of construction activities for the CD5 bridge, road and pad facilities. Importantly, local fishers also perceived the 2015 season to be one of the best in recent memory. The 2007 year class will likely exit the fishery for spawning grounds in the summer of 2016. The 2008 year class, one of the largest year classes recorded, should appear in smaller numbers in fishers' nets as well. It will be interesting to observe what impact, if any, the 2010 Arctic Cisco year class has on the fishery as well as the 2011 year class as it makes its first appearance in the fishery in 2016 fall harvests.

Our monitoring in 2015 marked 30 years of industry-supported harvest monitoring and assessment of the fall Arctic Cisco fishery near Nuiqsut, Alaska. During this time, the community of Nuiqsut has worked closely with fishery monitors to ensure that the fishery is observed in detailed manner consistent with local values. The program is unique in that it provides a rare long-term dataset for a subsistence fishery in the Arctic.

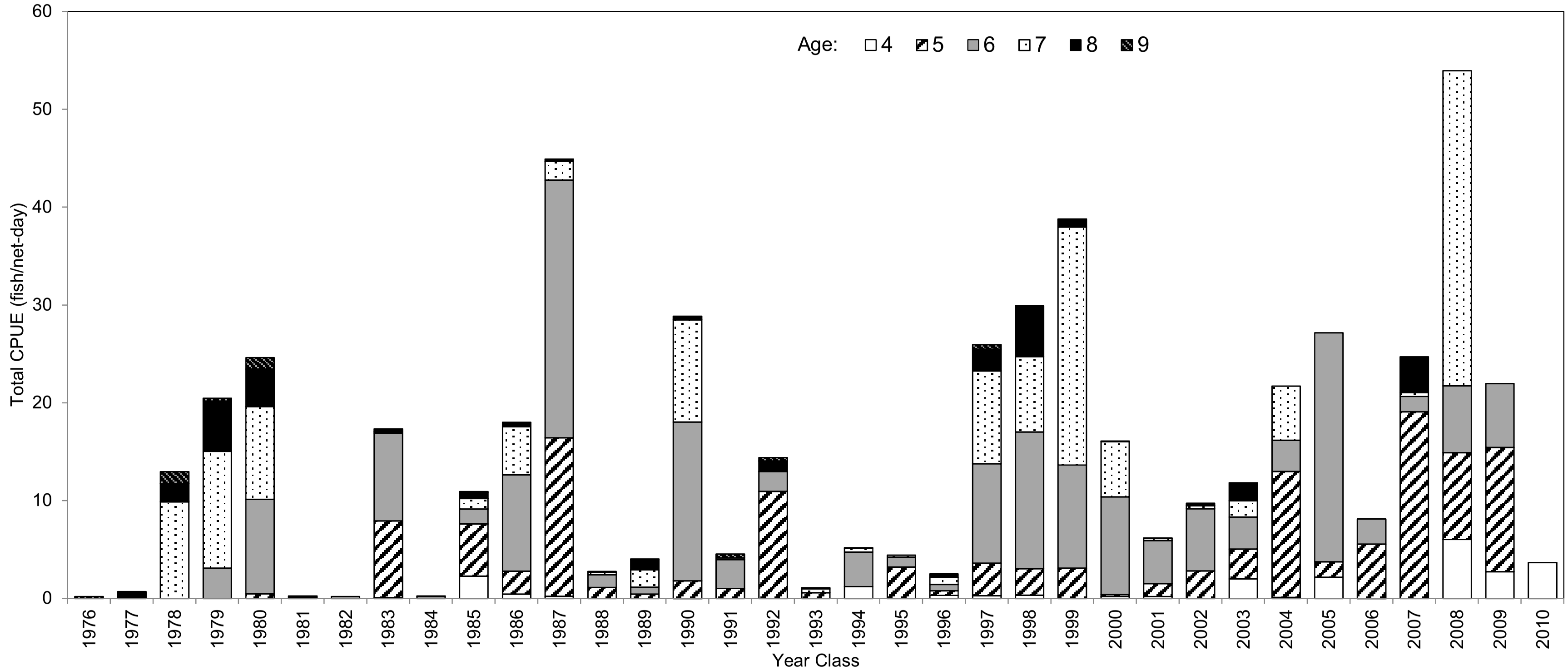

Figure 16. Cumulative catch per unit effort (catch per net-day) of Arctic Cisco by year class (year of hatch) in the fall subsistence fishery, Niġliq Channel, Colville River, 1976–2010 (capture dates 1985–2015). Catch per unit effort was estimated only for fish captured in 7.6-cm mesh nets.

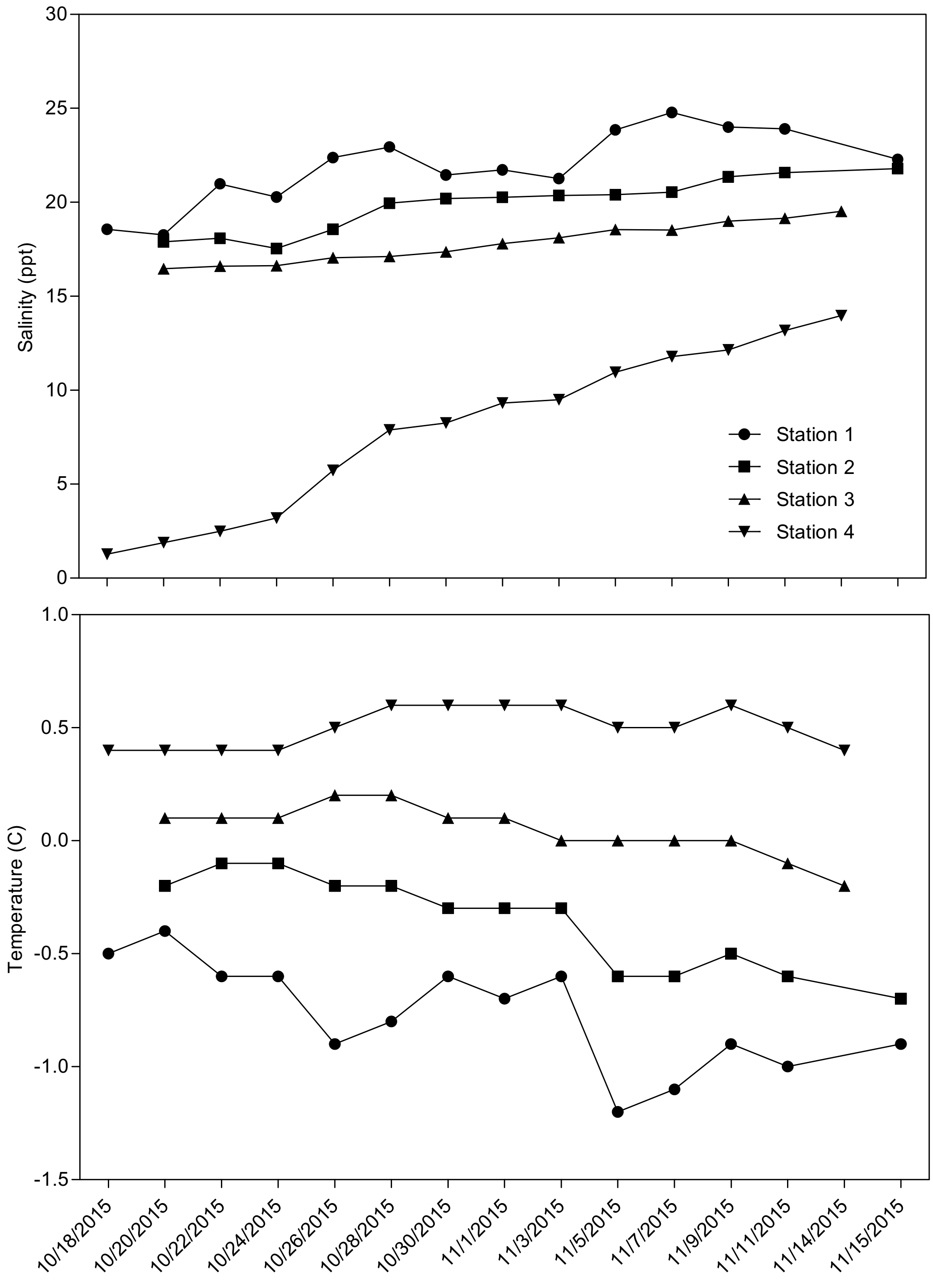

Figure 17. Salinity (parts per thousand) and temperature (°C) measured at 3.0 m depth from 4 water stations on the Niġliq Channel, Colville River, Alaska, 18 October to 15 November 2015.

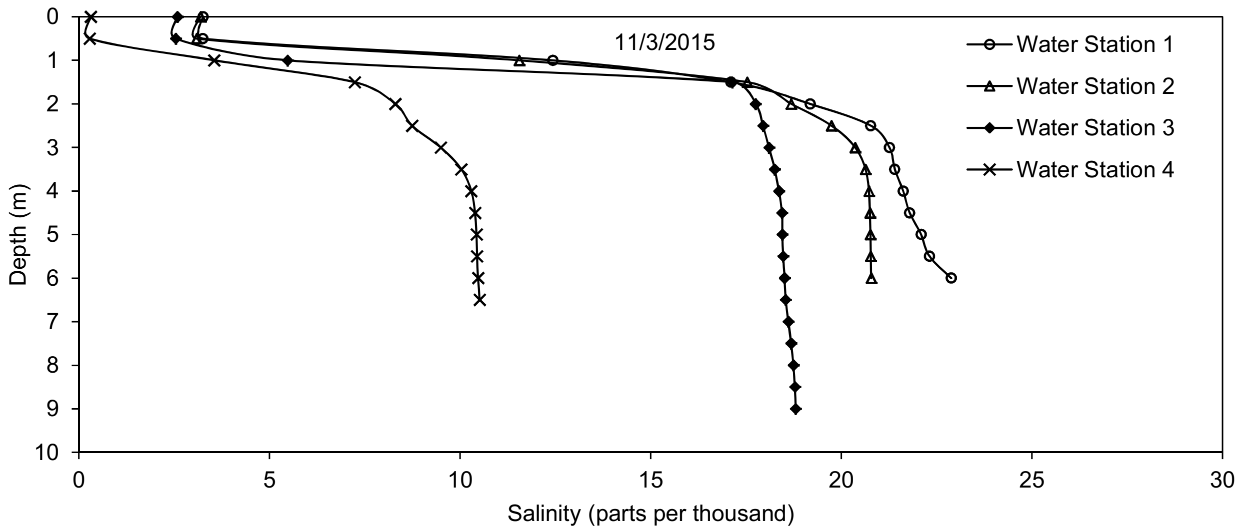

Figure 18. Water salinity depth profiles in Niġliq Channel fishing areas, Colville River, Alaska, early November 2015.

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Appendix A. Total fishing effort (adjusted net-days) recorded for the fall subsistence fishery for Arctic Cisco in 3 Niġliq Channel fishing areas and in the Main Channel fishing area, Colville River, Alaska, 2015.

Fisher Code	Fishing Area	Net	Net Code	Length (m)	Stretched Mesh (cm)	Start Date	End Date	Net-days	Adjusted Net-days
7	Upper Niġliq	A	157A1	30.48	7.62	10/16/2015	11/28/2015	43.00	71.67
7	Nanuk	B	157B1	24.38	7.62	10/19/2015	11/13/2015	25.00	33.33
7	Nanuk	C	157C1	24.38	6.99	10/19/2015	11/13/2015	25.00	33.33
10	Upper Niġliq	A	1510A1	18.29	8.89	10/19/2015	11/9/2015	21.00	21.00
24	Nanuk	A	1524A1	24.38	7.62	10/31/2015	11/1/2015	1.00	1.33
25	Niġliq	B	1525B1	24.38	8.89	10/22/2015	11/7/2015	16.00	21.33
25	Niġliq	A	1525A1	30.48	7.62	10/17/2015	10/22/2015	5.00	8.33
27	Main channel	A	1527A1	30.48	6.99	10/24/2015	10/31/2015	7.00	11.67
28	Niġliq	A	1528A1	24.38	7.62	10/17/2015	10/27/2015	10.00	13.33
31	Upper Niġliq	A	1531A1	24.38	7.62	11/2/2015	11/5/2015	3.00	4.00
31	Upper Niġliq	B	1531B1	18.29	7.62	11/3/2015	11/5/2015	2.00	2.00
31	Upper Niġliq	A	1531A2	24.38	7.62	11/10/2015	11/21/2015	11.00	14.67
32	Nanuk	A	1532A1	24.38	8.26	10/6/2015	10/26/2015	20.00	26.67
32	Nanuk	B	1532B1	24.38	8.26	10/6/2015	10/26/2015	20.00	26.67
33	Upper Niġliq	A	1533A1	18.29	12.70	10/28/2015	10/29/2015	1.00	1.00
33	Upper Niġliq	B	1533B1	30.48	6.35	10/29/2015	11/3/2015	5.00	8.33
33	Upper Niġliq	C	1533C1	24.38	7.62	11/4/2015	11/13/2015	9.00	12.00
33	Nanuk	C	1533C2	24.38	7.62	11/13/2015	11/24/2015	11.00	14.67
33	Nanuk	B	1533B2	30.48	6.35	11/14/2015	11/24/2015	10.00	16.67
41	Niġliq	A	1541A1	24.38	7.62	10/19/2015	11/3/2015	15.00	20.00
41	Niġliq	B	1541B1	30.48	7.62	11/7/2015	11/28/2015	21.00	35.00
41	Niġliq	C	1541C1	18.29	7.62	11/8/2015	11/28/2015	20.00	20.00
42	Upper Niġliq	A	1542A1	30.48	7.62	10/11/2015	11/6/2015	26.00	43.33
42	Upper Niġliq	B	1542B1	18.29	7.62	10/11/2015	11/6/2015	26.00	26.00
48	Nanuk	A	1548A1	24.38	8.89	10/18/2015	10/23/2015	5.00	6.67
48	Nanuk	B	1548B1	18.29	10.16	10/18/2015	10/23/2015	5.00	5.00
48	Main channel	A	1548A2	24.38	8.89	10/24/2015	10/31/2015	7.00	9.33
49	Main channel	A	1549A1	30.48	7.62	10/24/2015	10/31/2015	7.00	11.67
51	Upper Niġliq	A	1551A1	24.38	7.62	10/16/2015	11/28/2015	43.00	57.33
55	Niġliq	A	1555A1	30.48	7.62	10/20/2015	10/30/2015	10.00	16.67
56	Niġliq	A	1556A1	24.38	8.26	10/14/2015	11/3/2015	20.00	26.67
56	Niġliq	B	1556B1	24.38	7.62	10/15/2015	11/1/2015	17.00	22.67
65	Upper Niġliq	A	1565A1	18.29	7.62	10/17/2015	10/24/2015	7.00	7.00

Appendix A. Continued.

Fisher Code	Fishing Area	Net	Net Code	Length (m)	Stretched Mesh (cm)	Start Date	End Date	Net-days	Adjusted Net-days
70	Nanuk	A	1570A1	30.48	7.62	10/12/2015	10/17/2015	5.00	8.33
70	Nanuk	B	1570B1	24.38	6.35	10/12/2015	10/17/2015	5.00	6.67
70	Niġliq	A	1570A2	30.48	7.62	10/17/2015	11/1/2015	15.00	25.00
70	Niġliq	B	1570B2	24.38	6.35	10/17/2015	10/27/2015	10.00	13.33
72	Upper Niġliq	A	1572A1	24.38	8.26	10/12/2015	10/23/2015	11.00	14.67
72	Upper Niġliq	B	1572B1	18.29	7.62	10/19/2015	10/23/2015	4.00	4.00
72	Main channel	A	1572A2	24.38	8.26	10/24/2015	11/21/2015	28.00	37.33
72	Main channel	B	1572B2	18.29	7.62	10/24/2015	11/21/2015	28.00	28.00
74	Main channel	A	1574A1	30.48	7.62	10/24/2015	10/31/2015	7.00	11.67
77	Upper Niġliq	A	1577A1	18.29	7.62	10/11/2015	11/29/2015	49.00	49.00
77	Upper Niġliq	B	1577B1	15.24	6.35	10/18/2015	11/13/2015	26.00	21.67
79	Main channel	A	1579A1	30.48	7.62	10/24/2015	10/31/2015	7.00	11.67
82	Niġliq	A	1582A1	30.48	7.62	10/30/2015	11/15/2015	16.00	26.67
82	Niġliq	B	1582B1	24.38	7.62	11/1/2015	11/15/2015	14.00	18.67
82	Main channel	A	1582A2	30.48	7.62	10/24/2015	10/31/2015	7.00	11.67
82	Main channel	B	1582B2	30.48	7.62	10/24/2015	10/31/2015	7.00	11.67
84	Nanuk	A	1584A1	24.38	7.62	10/18/2015	10/20/2015	2.00	2.67
87	Upper Niġliq	A	1587A1	18.29	7.62	10/14/2015	11/21/2015	38.00	38.00
87	Upper Niġliq	B	1587B1	30.48	7.62	10/14/2015	10/25/2015	11.00	18.33
87	Niġliq	B	1587B2	30.48	7.62	10/25/2015	11/21/2015	27.00	45.00
87	Upper Niġliq	C	1587C1	18.29	8.89	10/20/2015	10/23/2015	3.00	3.00
87	Niġliq	C	1587C2	18.29	8.89	10/26/2015	11/28/2015	33.00	33.00
88	Niġliq	A	1588A1	18.29	8.89	10/29/2015	11/9/2015	11.00	11.00
88	Niġliq	B	1588B1	24.38	8.26	10/29/2015	11/9/2015	11.00	14.67
89	Niġliq	A	1589A1	24.38	7.62	10/12/2015	10/23/2015	11.00	14.67
89	Niġliq	B	1589B1	24.38	6.35	10/12/2015	10/23/2015	11.00	14.67
89	Niġliq	C	1589C1	24.38	8.89	10/12/2015	10/23/2015	11.00	14.67
89	Niġliq	D	1589D1	24.38	7.62	10/15/2015	10/31/2015	16.00	21.33
89	Niġliq	B	1589B2	24.38	6.35	10/23/2015	10/27/2015	4.00	5.33
89	Niġliq	A	1589A2	24.38	7.62	10/25/2015	10/31/2015	6.00	8.00
89	Niġliq	C	1589C2	24.38	8.89	10/26/2015	10/31/2015	5.00	6.67
89	Niġliq	E	1589E1	24.38	7.62	10/27/2015	10/31/2015	4.00	5.33
11	Upper Niġliq	A	1589A1	24.38	6.35	10/11/2015	10/20/2015	9.00	12.00
93	Upper Niġliq	A	1593A1	24.38	8.89	10/12/2015	11/14/2015	33.00	44.00
94	Niġliq	A	1594A1	18.29	7.62	10/20/2015	10/24/2015	4.00	4.00
95	Upper Niġliq	A	1595A1	18.29	7.62	10/18/2015	11/14/2015	27.00	27.00
95	Nanuk	B	1595B1	24.384	7.62	10/31/2015	11/1/2015	1.00	1.33

Appendix A. Continued.

Fisher Code	Fishing Area	Net	Net Code	Length (m)	Stretched Mesh (cm)	Start Date	End Date	Net-days	Adjusted Net-days
96	Upper Niġliq	A	1596A1	6.10	10.16	10/25/2015	10/27/2015	2.00	0.67
102	Nanuk	A	15102A1	0.00	7.62	10/17/2015	10/22/2015	5.00	0.00
103	Upper Niġliq	A	15103A1	24.38	8.89	10/17/2015	10/27/2015	10.00	13.33
104	Upper Niġliq	A	15104A1	24.38	7.62	10/21/2015	11/2/2015	12.00	16.00
Total									1,324.0

Appendix B. Estimated harvest of Arctic Cisco from the Colville River delta commercial and subsistence fisheries, 1967–2015.

Year	Estimated Commercial Harvest[a]	Estimated Subsistence Harvest	Estimated Total harvest
1967	21,904		21,904
1968	41,948		41,948
1969	19,593		19,593
1970	22,685		22,685
1971	41,312		41,312
1972	37,101		37,101
1973	71,575		71,575
1974	44,937		44,937
1975	30,953		30,953
1976	31,659		31,659
1977	31,796		31,796
1978	18,058		18,058
1979	9,268		9,268
1980	14,753		14,753
1981	38,176		38,176
1982	15,975		15,975
1983	18,162		18,162
1984	27,686		27,686
1985[b]	23,678	46,681	70,359
1986[b]	29,595	33,253	62,848
1987[b]	27,948	20,847	48,795
1988[b]	10,470	6,098	16,568
1989[b]	24,802	12,892	37,694
1990[b]	21,772	11,224	32,996
1991[b]	23,731	8,269	32,000
1992[b]	22,754	45,401	68,155
1993[b]	31,310	46,994	78,304
1994[b]	8,958	10,956	19,914
1995[b]	14,311	8,573	22,884
1996[b]	21,817	41,205	63,022
1997[b]	16,990	33,274	50,264

Appendix B. Continued.

Year	Estimated Commercial Harvest[a]	Estimated Subsistence Harvest	Estimated Total harvest
1998[b]	8,752	13,559	22,311
1999[b]	8,872	–	8,872
2000[b]	2,619	9,956	12,575
2001[b]	1,924	3,935	5,859
2002[b]	3,935	7,533	11,468
2003[b]	–	23,369	23,369
2004[b]	–	40,605	40,605
2005[b, c]	–	–	–
2006[c, d]	–	–	–
2007[e]	–	42,226	42,226
2008[e]	–	17,222	17,222
2009[e]	–	22,792	22,792
2010[e]	–	23,837	23,837
2011[e]	–	43,276	43,276
2012[e]	–	22,728	22,728
2013[e]	–	22,240	22,240
2014[e]	–	33,240	33,240
2015[e]	–	52,107	52,107

[a] Commercial harvest numbers provided by J. Helmericks, 1967–2002. No commercial harvest after 2002
[b] MJM monitoring
[c] No harvest estimates calculated
[d] LGL monitoring
[e] ABR monitoring

Appendix C. Ambient water chemistry at 3 meters depth for 4 water stations on the Niġliq Channel, 18 October to 15 November 2015, Colville River, Alaska.

Date	Salinity Station	Depth	Salinity (ppt)	Water Temperature (°C)	Percent Oxygen	Oxygen Concentration (mg/L)	Specific Conductance (mS/cm)	pH
18-Oct	1	3	18.6	-0.5	100.1	13.0	3.3	7.17
18-Oct	4	3	1.3	0.4	102.8	14.7	2.9	6.13
20-Oct	1	3	18.3	-0.4	98.2	12.8	30.8	7.82
20-Oct	2	3	17.9	-0.2	90.5	11.7	30.2	7.77
20-Oct	3	3	16.5	0.1	94.7	12.2	27.8	7.69
20-Oct	4	3	1.9	0.4	98.5	14.0	3.5	7.64
22-Oct	1	3	21.0	-0.6	99.9	12.6	35.1	7.69
22-Oct	2	3	18.1	-0.1	93.2	12.0	30.4	7.71
22-Oct	3	3	16.6	0.1	91.0	11.7	28.0	7.79
22-Oct	4	3	2.5	0.4	103.0	14.7	4.9	7.63
24-Oct	1	3	20.3	-0.6	97.2	12.5	33.9	7.70
24-Oct	2	3	17.5	-0.1	95.4	12.3	29.6	7.68
24-Oct	3	3	16.6	0.1	92.7	11.9	28.1	7.71
24-Oct	4	3	3.2	0.4	99.1	14.0	6.2	7.45
26-Oct	1	3	22.4	-0.9	98.6	12.6	37.1	7.74
26-Oct	2	3	18.6	-0.2	92.5	11.9	31.3	7.70
26-Oct	3	3	17.0	0.2	96.3	12.4	28.7	7.64
26-Oct	4	3	5.7	0.5	101.0	14.0	10.6	7.63
28-Oct	1	3	22.9	-0.8	92.3	11.7	38.1	7.64
28-Oct	2	3	20.0	-0.2	86.6	11.0	33.3	7.62
28-Oct	3	3	17.1	0.2	92.3	11.9	28.9	7.59
28-Oct	4	3	7.9	0.6	99.4	13.5	14.1	7.51
30-Oct	1	3	21.5	-0.6	95.6	12.2	35.7	7.63
30-Oct	2	3	20.2	-0.3	92.3	11.7	33.7	7.58
30-Oct	3	3	17.4	0.1	93.1	12.0	29.2	7.65
30-Oct	4	3	8.3	0.6	100.1	13.5	19.7	7.52
1-Nov	1	3	21.7	-0.7	92.0	11.8	36.1	7.60
1-Nov	2	3	20.3	-0.3	94.8	12.0	33.9	7.58
1-Nov	3	3	17.8	0.1	92.6	11.9	29.9	7.43
1-Nov	4	3	9.3	0.6	98.3	13.2	16.5	7.68
3-Nov	1	3	21.3	-0.6	92.0	11.8	35.4	7.61
3-Nov	2	3	20.4	-0.3	94.6	12.0	34.0	7.60
3-Nov	3	3	18.1	0.0	92.7	11.9	30.4	7.57
3-Nov	4	3	9.5	0.6	104.6	13.9	16.8	7.56

Appendix C. Continued.

Date	Salinity Station	Depth	Salinity (ppt)	Water Temperature (°C)	Percent Oxygen	Oxygen Concentration (mg/L)	Specific Conductance (mS/cm)	pH
5-Nov	1	3	23.9	-1.2	99.9	12.8	39.8	7.68
5-Nov	2	3	20.4	-0.6	93.5	12.0	34.2	7.61
5-Nov	3	3	18.5	0.0	92.0	11.8	31.1	7.46
5-Nov	4	3	11.0	0.5	100.5	13.4	19.1	7.35
7-Nov	1	3	24.8	-1.1	93.7	11.8	41.3	7.63
7-Nov	2	3	20.5	-0.6	91.5	11.7	34.3	7.56
7-Nov	3	3	18.5	0.0	92.1	11.7	31.1	7.48
7-Nov	4	3	11.8	0.5	98.4	13.1	20.5	7.41
9-Nov	1	3	24.0	-0.9	90.2	11.4	39.7	7.61
9-Nov	2	3	21.4	-0.5	88.8	11.3	35.7	7.57
9-Nov	3	3	19.0	0.0	89.4	11.5	31.8	7.54
9-Nov	4	3	12.2	0.6	89.6	11.8	21.0	7.49
11-Nov	1	3	23.9	-1.0	97.4	12.3	39.6	7.50
11-Nov	2	3	21.6	-0.6	92.8	11.8	39.5	7.48
11-Nov	3	3	19.1	-0.1	88.5	11.3	32.1	7.48
11-Nov	4	3	13.2	0.5	95.3	12.5	22.7	7.36
14-Nov	3	3	19.5	-0.2	91.0	11.7	32.9	7.43
14-Nov	4	3	14.0	0.4	93.4	12.2	23.9	7.27
15-Nov	1	3	22.3	-0.9	96.8	12.4	37.3	7.37
15-Nov	2	3	21.8	-0.7	94.0	12.0	36.3	7.48