FALL 2016 SUBSISTENCE FISHERY MONITORING ON THE COLVILLE RIVER

DATA REPORT

Prepared for

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INTRODUCTION

ABR, Inc.—Environmental Research & Services (ABR) works with fishery stakeholders in Nuiqsut, Alaska to monitor the Colville River subsistence fishery, which is conducted each fall after freeze-up in the Niġliq Channel of the Colville River (Figures 1 and 2) and is supported by ConocoPhilips Alaska, Inc. (CPAI). The monitoring program began in 1985 when the North Slope Borough, in consultation with local fisherman and industry, requested information on the potential impacts to fish health from activities associated with exploration and development of oil and gas near Prudhoe Bay and in the Colville River delta (Moulton et al. 2010). Initial surveys in the Colville River delta sought only to obtain estimates of the total subsistence and commercial fishing effort and harvest during the fall under-ice fishery. Over the years, the objectives of the project have evolved to include quantifying time trends in fishing effort and harvest results and assessments of the general health of the fishery. We also include input from fishers about their perception of the health of the fishery and to determine monitoring goals.

The monitoring program has traditionally focused on the fall harvest of Arctic Cisco (*Coregonus autumnalis*; Qaaktaq, in Iñupiaq), which are a staple in the diet of Nuiqsut residents and are commonly traded with other northern Alaska communities. The program also attempts to quantify harvest of other subsistence species captured in the Arctic Cisco fishery. While the monitoring protocol developed over the previous 30 years was repeated in 2016, ABR is implementing a new reporting method at the request of CPAI to summarize the results of 2016 fishery. In lieu of a detailed monitoring report, we are providing CPAI with a condensed data report.

The objectives of the 31st year of the harvest monitoring program were to:

- continue working with subsistence fishers and other key stakeholders in the community (Seigle et al. 2008);
- monitor the harvest of Arctic Cisco and other subsistence species throughout the fall fishing season with 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, temperature, pH, and dissolved oxygen in primary fishing areas; and
- compare the 2016 results with previous year's results for this program and other historical data.

METHODS

FISHERY EFFORT AND HARVEST

Four traditional fishing areas host the majority of fall subsistence fishing in the Colville River delta (upstream to downstream): the Upper Niġliq area (adjacent to the town of Nuiqsut), the mid-channel Nanuk area, the Niġliq Delta area , and the Main Channel area (Figure 2). The ABR fishery monitoring team included 2 scientists and a local fishing expert, Jerry Pausanna. ABR fishery monitors conducted daily interviews of fishers for harvest events from 15 October to 20 November 2016. A harvest event occurred anytime a fisher checked his or her net. The event may have been recorded by harvest monitors on location at the time of a harvest; after the event in Nuiqsut; or at a later date via email, social media, or telephone. During interviews, we recorded net length, net mesh size, and start and end times for each harvest event.

To calculate fishing effort (i.e., net-days), we adjusted the recorded net length and effort to a standardized net length of 18 m (60 ft) and a 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. Catch per unit effort (CPUE), expressed as catch per net-day, was calculated using these adjusted estimates of effort. In this report, we specify when data presentations are all mesh sizes combined and when they are limited to the most frequently used mesh of 7.6-cm (3 in).

During harvest interviews, we asked:

- 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 Arctic Cisco and other fish species did you harvest in each net?
- How frequently do you check your nets?
- Where is your net and has it been moved recently (i.e., within the past week)?

Reported harvest numbers from these interviews were used in CPUE analysis only if the fisher also knew the number of days that each net fished and the number of fish caught in nets of each mesh size.

LENGTH, WEIGHT, AND AGE OF CATCH

During harvest events, fish were removed from nets, tallied by species, and a sub-sample was measured for fork length (to the nearest mm; Seigle et al. 2016). The total number of fish measured during a harvest event depended on several factors including a fisher's availability, the total number of fish caught in the net, and the number of other active fishers in the area. When several fishers were harvesting simultaneously in the same area, we attempted to obtain a sub-sample of measurements from every fisher.

When possible, we paid a participation honorarium to fishers who were willing to donate a subsample of fish from their harvest for age, length, and weight analysis (~10 fish/day at $10/fish). Honoraria were also offered to fishers who otherwise provided detailed information about their fishing efforts (and the efforts of other fishers) 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 we measured them for fork length (mm) and weight (g) using a top-loading electronic scale, and extracted otoliths for ageing.

Otoliths (sagittae) were extracted and cleaned with tap water and stored in 96-well pipette trays for aging. We prepared 1 otolith from each fish using the break-and-burn technique (Chilton and Beamish 1982). The otolith preparations were examined under a dissecting microscope at 25× magnification using reflected light. Alternating bands of dark and light on the otolith 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 (Seigle et al. 2016).

SALINITY AND TEMPERATURE

We measured water salinity and temperature every other day after the start of on-ice activities at water quality stations corresponding to areas of concentrated fishing effort (Figure 2). We removed surface ice and lowered the probe-end of 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 to the river bottom. The monitoring team measured temperature (°C) at 3-m depth.

RESULTS

FISHERY EFFORT AND HARVEST

Ice started forming on the Colville River by the second week of October. Net deployment was delayed, however, because many fishers had concerns about travelling by snow machine without sufficient snow accumulation over the ice to operate their snow-machines safely and efficiently. The first Arctic Cisco nets were deployed near Nuiqsut on 15 October (Table 1, Figure 2). ABR monitors conducted 329 interviews from 15 October–20 November, although fishing continued until at least 1 December (Table 2). A total of 29 households deployed 60 nets (56 in Niġliq Channel and 4 in the Main Channel) during this period (Figure 3, Appendix A). We calculated 1,228.7 net-days of fishing effort in the Niġliq Channel and an 90 net-days in the Main Channel for a total of 1,318.7 net-days of effort in 2016 (Table 2). Five mesh sizes were deployed in 2016, but as in previous years, the most frequently used mesh size was 7.6-cm (1,035.8 adjusted net days). For the first time since 2006, most of the fishing effort (~53%) was concentrated in the Upper Niġliq area of the Niġliq Channel (Figure 4).

We recorded harvests totaling 7,712 Arctic Cisco in 7.6-cm mesh nets in the Niġliq Channel in 2016 (Table 3, Figure 5). An additional 187 fish were recorded in the Main Channel. A total of 9,147 Arctic Cisco were captured in nets of a known mesh size (all mesh) and fishing duration (Table 3). We used these observations to calculate the overall Arctic Cisco CPUE by mesh size. In 2016, the total average CPUE for 7.6-cm nets in the Niġliq Channel (18.9 fish/net-day) was

lower than in 2015 (42.4 fish per net-day) but higher than the long-term mean CPUE (17.8; 95% CI 13.5–22.2; Table 4, Figure 6). Estimated CPUE was highest in the Niġliq Delta (26.3 fish per net-day; 95% CI = 19.2–35.2), followed by the Nanuk area (20.0 fish per net-day; 95% CI = 11.7–19.7), and lowest in the Upper Niġliq area (11.8 fish per net-day; 95% CI = 6.1–10.9). The few harvest interviews from the Main Channel indicate a CPUE of 70.1 fish per net-day in 7.6-cm mesh nets (Table 3).

Overall, observed CPUE in 2016 ranged from 3.0 fish per net-day in 8.9-cm mesh nets in the Upper Niġliq area to 70.1 fish per net-day in 7.6-cm mesh nets calculated for the Main Channel area (Table 5). We used these CPUE estimates to calculate a total estimated harvest of 26,577 fish. This represents a 49% decrease from the highest estimated harvest of ~52,107 Arctic Cisco captured in 2015, and is lower than the long-term subsistence harvest average of 25,202 fish (95% CI = 19,591–30,814; Appendix B).

A total of 7 species were recorded during the 2016 fall fishery (Table 6). If we include fish reported to us but that could not be associated with a specific mesh size or known fishing effort, a total of 13,872 fish of all species were recorded in 2016, down from 22,586 fish in 2015. Arctic Cisco were the numerically dominant species harvested (12,651 fish; 91.8% of harvest), followed by Least Cisco (*Coregonus sardinella*) (463 fish; 3.4%), Rainbow Smelt (*Osmerus mordax*) (332 fish; 2.4%), Saffron Cod (*Eleginus gracilis)* (258 fish; 1.9%), Humpback Whitefish (*C. pidschian*) (58 fish; 0.4%), Broad Whitefish (*C. nasus*) (17 fish; 0.1%), and Burbot (*Lota lota*) (2 fish; 0.02%).

LENGTH, WEIGHT, AND AGE OF CATCH

ABR measured a sub-sample of 874 Arctic Cisco from all mesh sizes in 2016, fewer than the 1,175 fish measured in 2015. Arctic Cisco ranged in length from 212 mm to 455 mm with an average of 325.9 mm (95% CI: 324.6–327.2 mm) and a median of 324 mm (Figure 7). The middle 50% of fish ranged from 312 mm to 339 m, which was similar to the range in 2015 (315 mm to 339 mm). Additionally, ABR measured 64 Least Cisco that ranged in length from 209 mm to 358 mm with an average of 314.5 mm (95% CI: 309.5–319.5 mm) and a median of 319.5 mm.

In 2016, we received 188 Arctic Cisco from several fishers to be used for additional laboratory analysis of age, length, and weight. These fish were caught in all parts of the river using 7.0-cm, 7.6-cm, and 8.9-cm mesh nets, though most (139) of the otolith samples came from 7.6-cm mesh nets in the Niġliq Channel. Length and weight were strongly correlated (R^2 = 0.84) when calculated from fish caught in all mesh sizes (Figure 8). For all mesh sizes, fish ranged in age from 5 to 9 years, with an age composition of 2.8% age-5, 61% age-6, 27% age-7, and 9% age-8 (Figure 10). Fish lengths increased with age and by the mesh size in which they were caught, with the exception of 8.9-cm mesh nets in which 5 age-7 fish were smaller than the 6 age-6 fish.

We estimated an age-specific CPUE by applying the percent age-composition of Arctic Cisco to the overall CPUE of 18.9 fish per adjusted net-day and assuming that our sub-sample in 7.6-cm mesh nets was representative of age-composition throughout the river. We obtained an estimate of 0.55 age-5 fish per net-day, 1.8 age-8 fish per net-day, 5.1 age-7 fish per net-day, and 11.5 age-6 fish per net-day (total = 18.9 fish per net-day; Figure 9). The Arctic Cisco caught in 7.6-cm mesh nets in 2016 represent the 2008–2011 year classes (fish that are 5−8 years of age).

The estimated CPUE of 24.7 fish per net-day for the 2007 year class has not increased since 2015. This suggests that no fish from the 2007 year class were caught in the Colville River system in fall 2016 and that these fish had already returned to spawn in the Mackenzie River system during summer 2016. The estimated cumulative total CPUE for subsequent years is 55.8 fish per net-day for 2008 (age-8, age-7, age-6, age-5, and age-4 fish), 27.2 fish per net-day for 2009 (age-7, age-6, age-5, and age-4 fish), 15.6 fish per net-day for 2010 (age-6 and age-4), and 0.6 fish/net-day for 2011 (age-5 fish) (Table 7). The 2010 year class did not have age-composition representation as age-5 fish in 2015, but the year class has reappeared in 2016 as age-6 fish, indicating that this year class may simply have been residing in mostly unfished segments of the Colville River or that the harvest monitoring team was unable to obtain representative year class donations of Arctic Cisco in 2015 (Figure 11).

WATER QUALITY

Due to a lack of snow on the river following freeze-up, salinity and temperature monitoring did not begin until 22 October 2016. Salinity was higher at the 3 downstream stations than at the

station nearest Nuiqsut. Ideal salinity conditions for Arctic Cisco (>15 ppt) were present at the 3 downstream stations (Stations 1, 2, and 3; Figure 2) by 28 October (Figure 12). Salinity peaked at 25.1 ppt in the Niġliq Delta area on 9 November. Salinity in the Upper Niġliq area (Station 4) near Nuiqsut was below 5 ppt until 5 November before a gradual climb to a maximum of 12.24 on 19 November. In contrast to salinity, water termperature was higher upstream near Nuiqsut and lower downstream in the delta (Figure 12). Temperatures were coldest at the downstream location (-1.3 to -0.9 °C) and warmest at the upstream station (-0.2 to 0.1 °C).

SUMMARY

The results of 31st year of fall fishery harvest monitoring on the Colville River revealed a better than long-term average harvest result in 2016, although there was a nearly 50% decline in the average CPUE for Arctic Cisco captured in 7.6-cm mesh nets from the record harvests of 2015. In 2016, there was a continuing shift in harvest effort toward the Upper Niġliq area following several years of the fishing effort taking place primarily in the Niġliq Delta area. Nonetheless, the greatest return on fishing effort was achieved in Niġliq Delta and in general, harvests of Arctic Cisco increased with distance downstream from Nuiqsut. We obtained few reports of fishing effort in the Main Channel area and this probably resulted in an incomplete picture of fishing results in that area, although it is clear that the vast majority of fishing effort still takes place in the Niġliq Channel. Age structure of Arctic Cisco in 2016 indicated a return to normal age distribution in which age-5 and -6 fish are the dominate age classes harvested with fewer age-4, -7, and -8 fish present. Following some concerns about the lack of the 2010 year class caught in 2015, that year class appeared in reasonably strong numbers in 2016.

Anecdotally, fishers raised few concerns to the harvest monitoring team relating to the size of their 2016 harvests of Arctic Cisco. In general, fishers appeared pleased with harvests relative to effort, even considering the larger harvests in 2015.

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PLATES

Plate 1. Fishers en route to a harvest event in the Niġliq Channel during the under-ice fishery in November 2016.

Plate 2. A fisher retrieves his Qaaktaq net during a harvest event in the Niġliq Delta area in November 2016.

Plate 3. An ABR fishery harvest monitor discusses a harvest event with a fisher in the Niġliq Delta area during November 2016.

Plate 4. An ABR fishery harvest monitor collects salinity and temperature data at a water quality station during November 2016.

Table 1. Estimated onset of the fall subsistence fishery for Arctic Cisco in the Niġliq Channel of the Colville River, Alaska, 1985–2016.

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
2016	15 October	13 October
Average	8 October	

Table 2. Summary statistics for fall fishing effort in the Colville River delta, Alaska, 2016. Values in parentheses are the total number sets for those nets.

Summary of 2016 Effort	
Number of recorded harvest events	329
Number of Households	29
Number of 5.1 cm mesh nets	0
Number of 6.4 cm mesh nets	2 (2)
Number of 7.0 cm mesh nets	5 (7)
Number of 7.6 cm mesh nets	42 (46)
Number of 8.3 cm mesh nets	1 (1)
Number of 8.9 cm mesh nets	10 (12)
Number of 10.2 cm mesh nets	0
Number of 12.7 cm mesh nets	0
Number of Nets in Niġliq Channel	56
Total Number of Nets	60
Average Nets/Household	2.07
Net sets in Upper Niġliq	35 net sets; 31 nets
Net sets in Nanuk	5 net sets; 5 nets
Net sets in Niġliq Delta	24 net sets; 20 nets
Net sets in Main Channel	4 net sets; 4 nets
Total number of sets	68 net sets; 60 nets
Adjusted net days 5.1 cm mesh nets	0
Adjusted net days 6.4 cm mesh nets	25.0
Adjusted net days 7.0 cm mesh nets	101.5
Adjusted net days 7.6 cm mesh nets	1035.8
Adjusted net days 8.3 cm mesh nets	7.0
Adjusted net days 8.9 cm mesh nets	149.3
Adjusted net days 10.2 cm mesh nets	0
Adjusted net days 12.7 cm mesh nets	0
Adjusted net days by Upper Niġliq	655.6
Adjusted net days by Nanuk	76.0
Adjusted net days by Niġliq Delta	497.1
Adjusted net days by Main Channel	90.0
Total adjusted net days	1,318.7

Table 3. Observed catch of Arctic Cisco (number of fish), effort (adjusted net-days), and catch per unit effort (CPUE; fish/net-day) in three Niġliq Channel fishing areas and in the Main Channel fishing area by mesh size, Colville River, Alaska, 2016. Nets are standardized to 18 m length.

	Mesh size (cm)			
Location	7	7.6	8.3	8.9
Upper Niġliq Area				
Number of Interviews	24	104	6	30
Catch (# of fish)	507	2,392	16	145
Effort (net-days)	27.0	203.3	2.0	48.7
CPUE (fish/net-day)	18.8	11.8	8.0	3.0
Nanuk Area				
Number of Interviews	–	7	–	–
Catch (# of fish)	–	180	–	–
Effort (net-days)	–	9	–	–
CPUE (fish/net-day)	–	20	–	–
Niġliq Delta Area				
Number of Interviews	8	103	–	5
Catch (# of fish)	530	5,140	–	50
Effort (net-days)	16.3	195.2	–	9.0
CPUE (fish/net-day)	32.4	26.3	–	5.6
Total Niġliq Channel				
Number of Interviews	32	214	6	35
Catch (# of fish)	1,037	7,712	16	195
Effort (net-days)	43.3	407.6	2.0	57.7
CPUE (fish/net-day)	23.9	18.9	8.0	3.4
Main Channel Area				
Number of Interviews	–	2	–	–
Catch (# of fish)	–	187	–	–
Effort (net-days)	–	2.7	–	–
CPUE (fish/net-day)	–	70.1	–	–
Total				
Number of Interviews	32	216	6	35
Catch (# of fish)	1,037	7,899	16	195
Effort (net-days)	43.3	410.2	2.0	57.7
CPUE (fish/net-day)	23.9	19.3	8.0	3.4

Table 4. 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, 1986–2016. 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

Table 4. 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
2007[a]	498	63.0	7.9	935	109.2	8.6	4,422	200.2	22.1	5,855	372.5	15.7
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
2016[a]	2,392	203.3	11.8	180	9.0	20.0	5,140	195.2	26.3	7,712	407.5	18.9
Total[b]	898	86	8.5	1,588	105	16	3,567	155.7	27.2	6,053.3	347.4	17.8

[a] Upper Niġliq catch and effort values include fish and net data from the Uyagagviq area (Area 630).
[b] Average CPUE from 1986–2016.

Table 5. 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, 2016.

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	–	–	–	–	–	–	–
6.4	13.3	N/A	–	11.7	N/A	–	–
7.0	101.5	23.9	2,426	–	–	–	313
7.6	957.5	18.9	18,097	78.3	70.1	5,491	23,588
8.3	7.0	8.0	56	–	–	–	2,922
8.9	149.3	3.4	508	–	–	–	2,660.8
Total			21,086			5,491	26,577

Table 6. 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, 1985–2016. 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
2016	91.8	0	3.4	0.1	0.4	0	2.4	0	0	0	1.9	0.01	0	(b)	0.0	13,782

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

Table 7. 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–present).

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	24.7
2008[a]	55.8
2009[a]	27.2
2010[a]	15.6
2011[a]	0.6

[a] Calculation assumes that the 2008–2011 year classes are still contributing to cumulative CPUE.

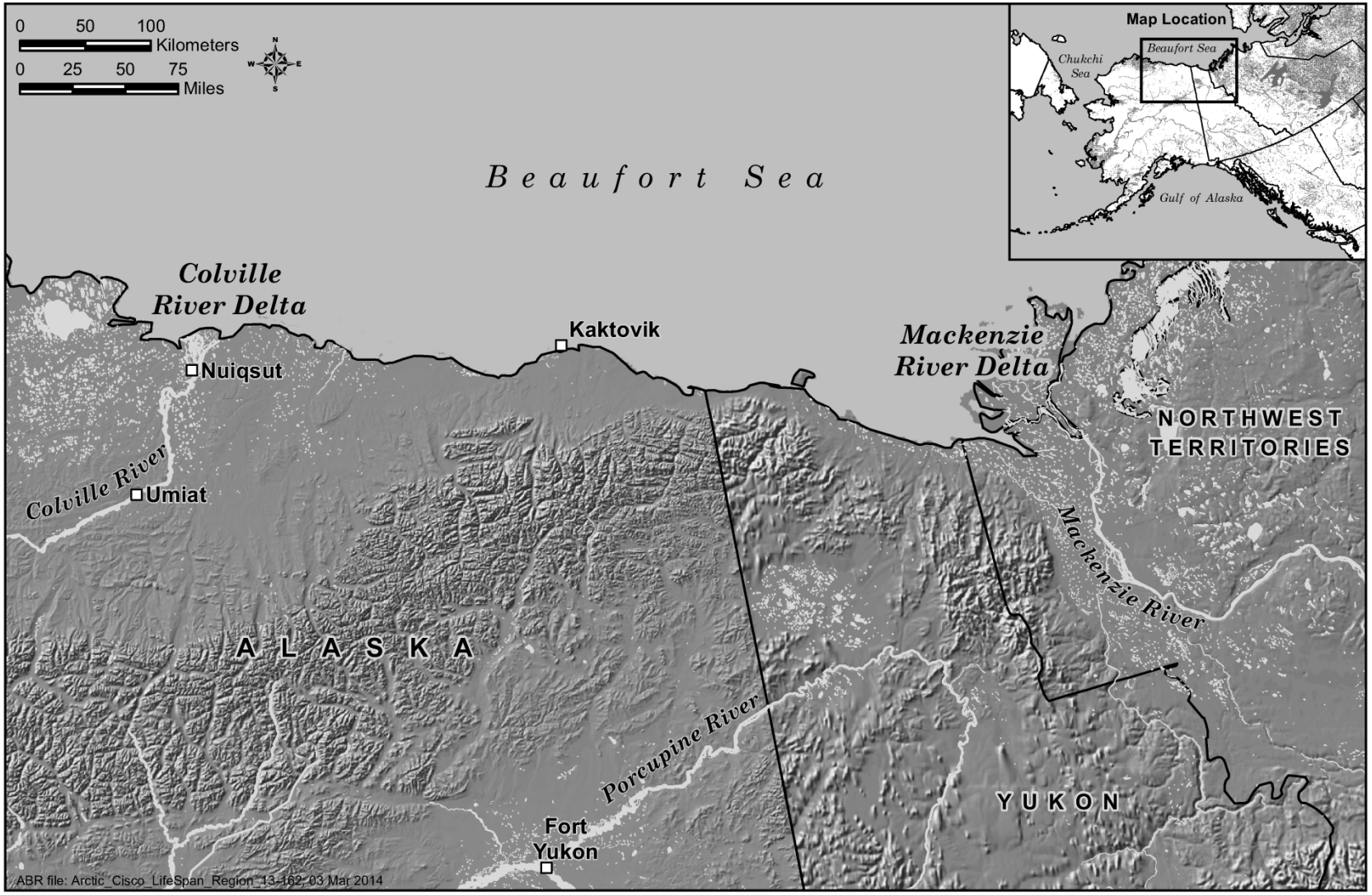

Figure 1. Waters important to the life history of Arctic Cisco in Canada (Mackenzie River drainages) and Alaska (Colville River delta) and the nearshore Beaufort Sea.

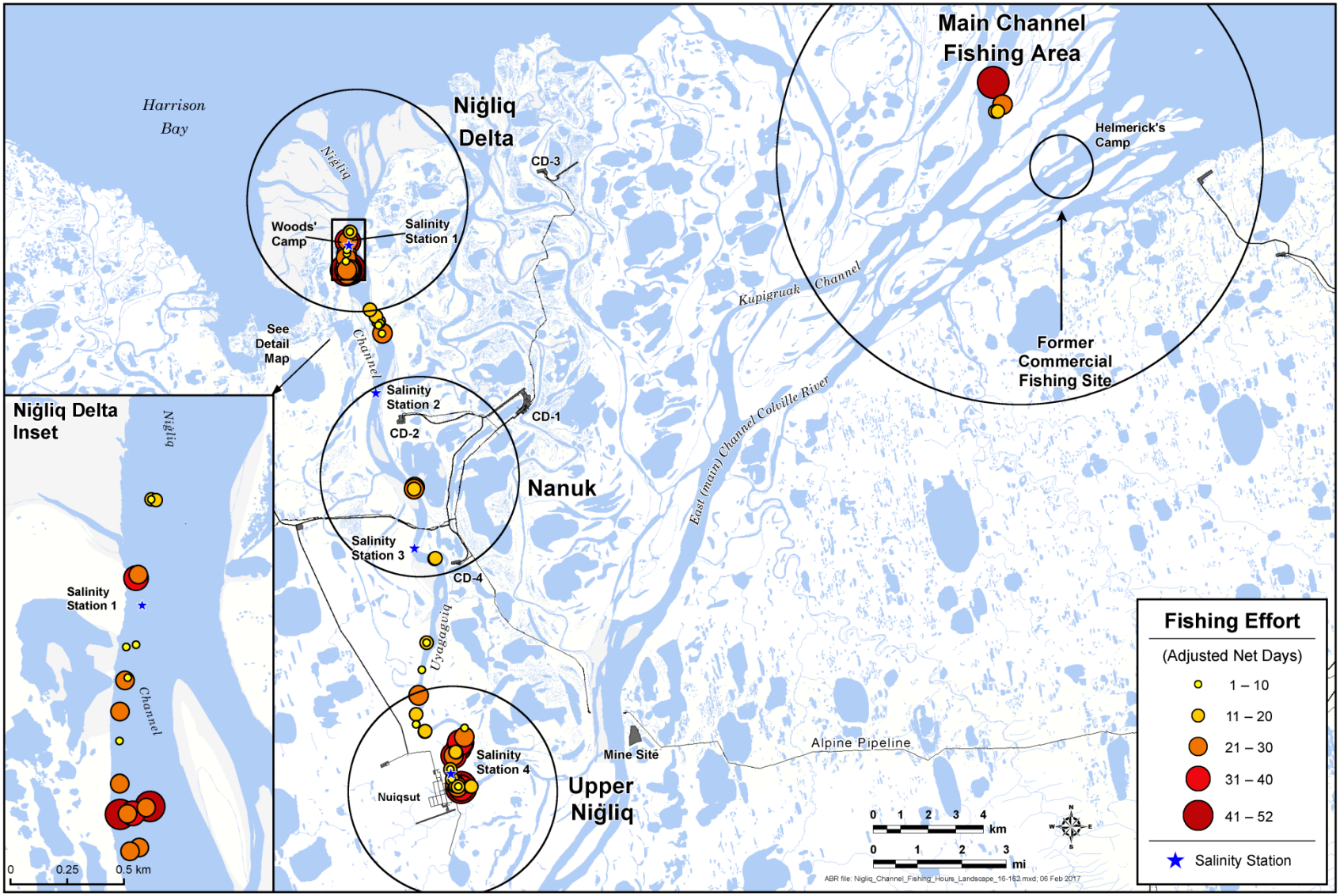

Figure 2. Water sampling stations and net sites in each of the 3 main subsistence fishing areas in the Niġliq Channel of the Colville River, Alaska, 2015. The amount of effort for each net set (adjusted net-days) is depicted by both color and the size of the net symbol.

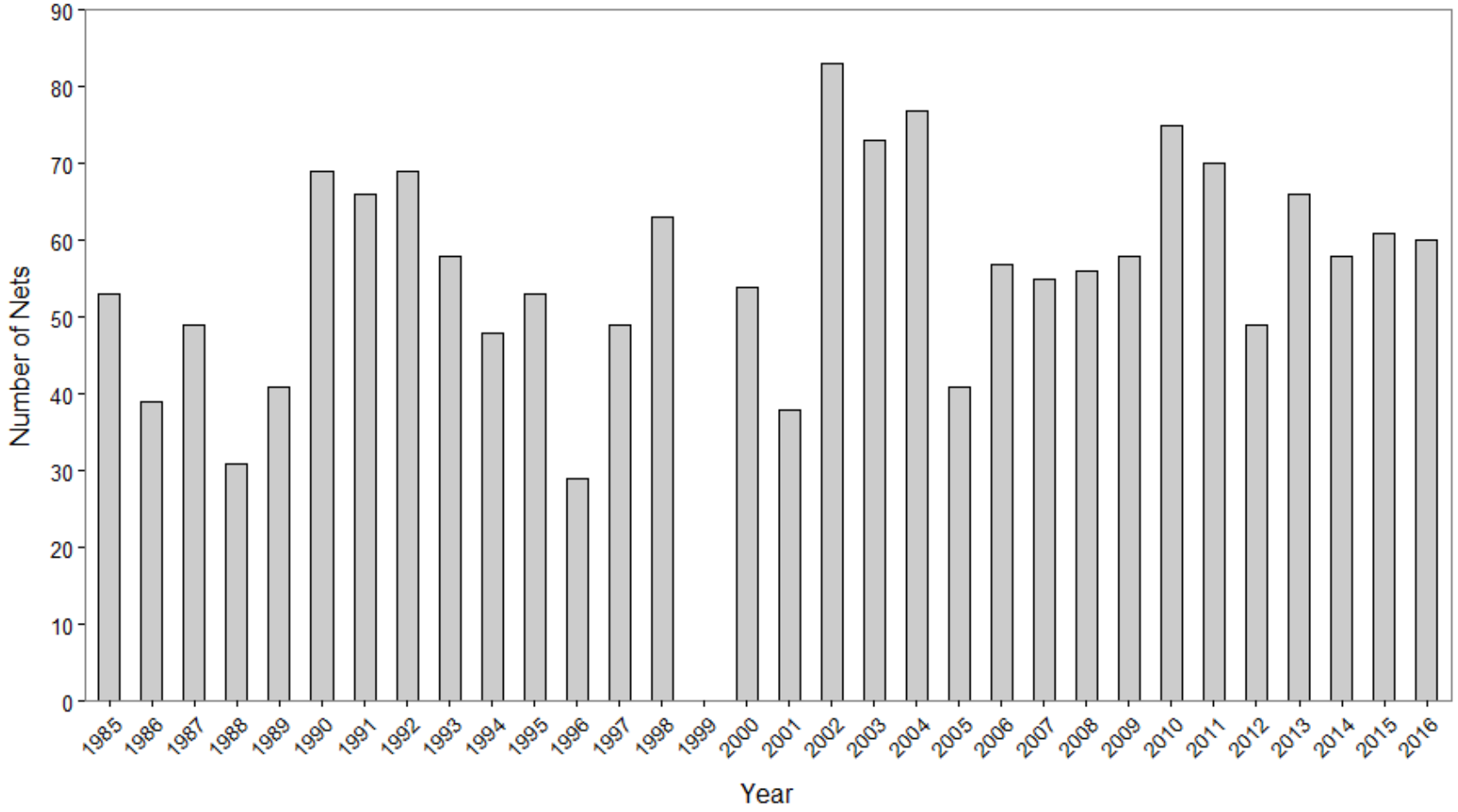

Figure 3. Number of nets deployed annually in the fall subsistence fishery for Arctic Cisco, Colville River, Alaska, 1985–2016.

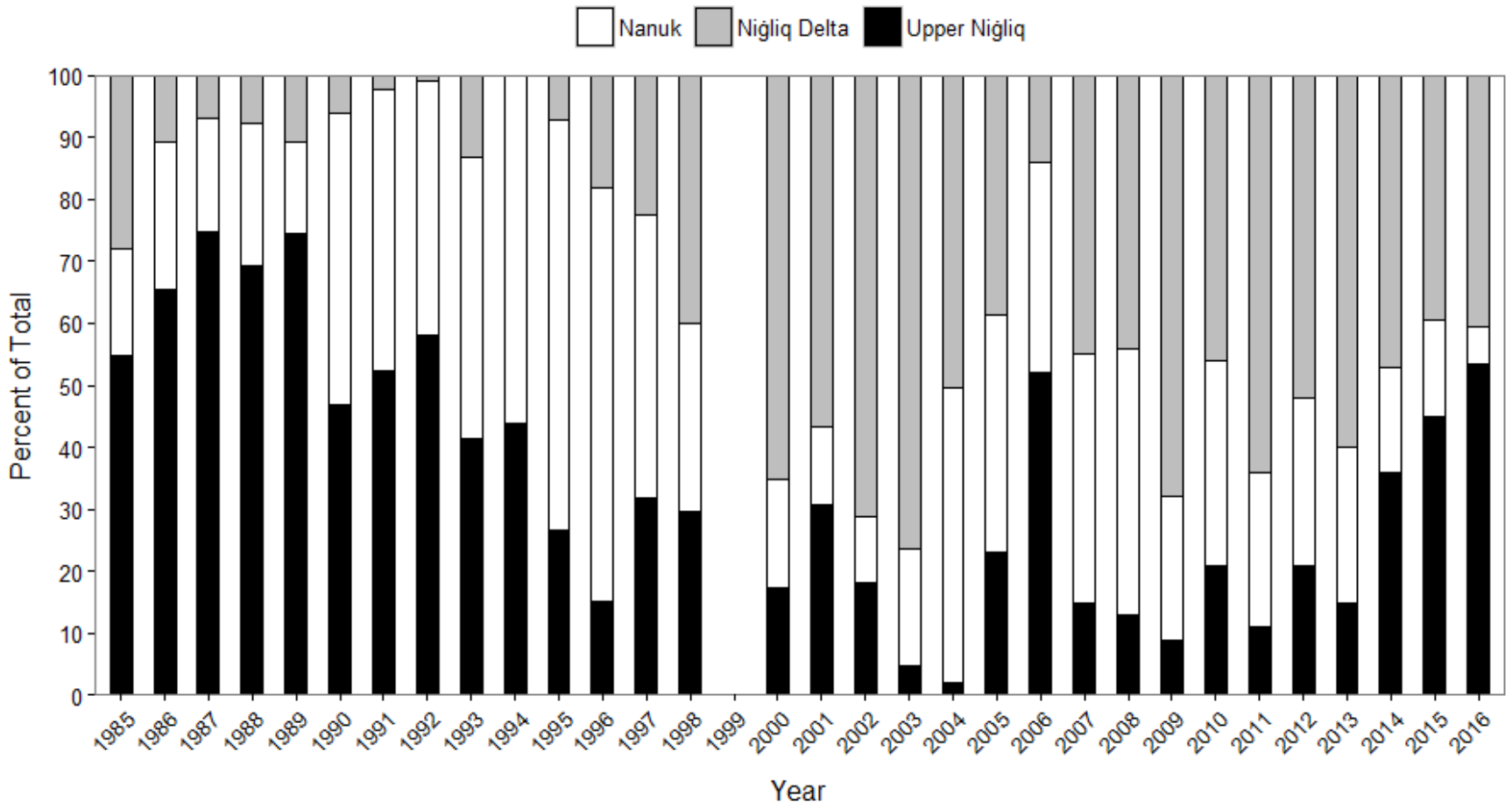

Figure 4. Percent of annual fishing effort in each of 3 Niġliq Channel fishing areas, Colville River, Alaska, 1985–2016. All nets are included regardless of length and mesh size.

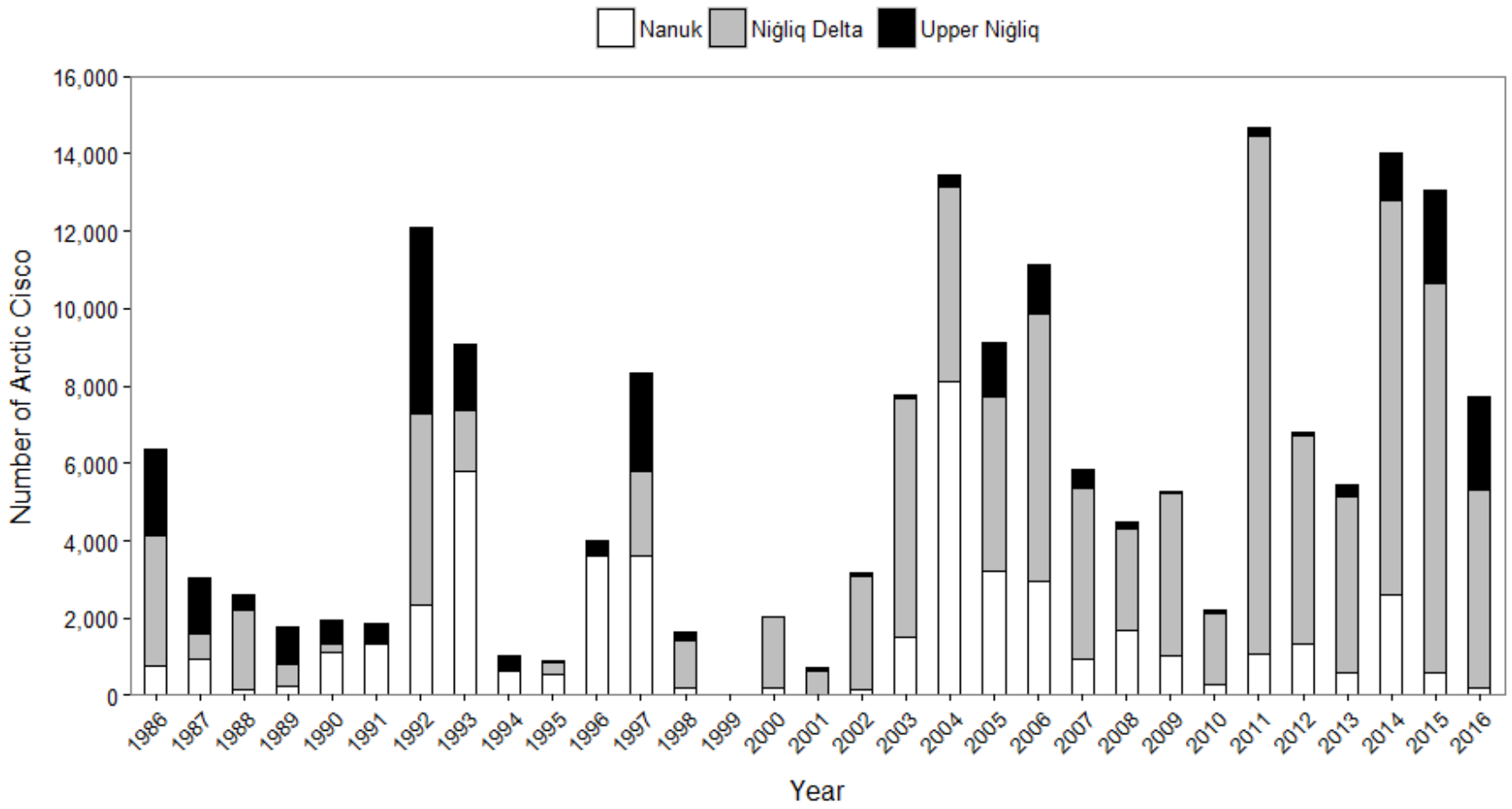

Figure 5. The observed number of Arctic Cisco harvested in 7.6-cm mesh nets in each of 3 Niġliq Channel fishing areas, 1986–2016. Data from 2005–2016 are not directly comparable to older data because the fishery was not monitored for the entire season during prior years.

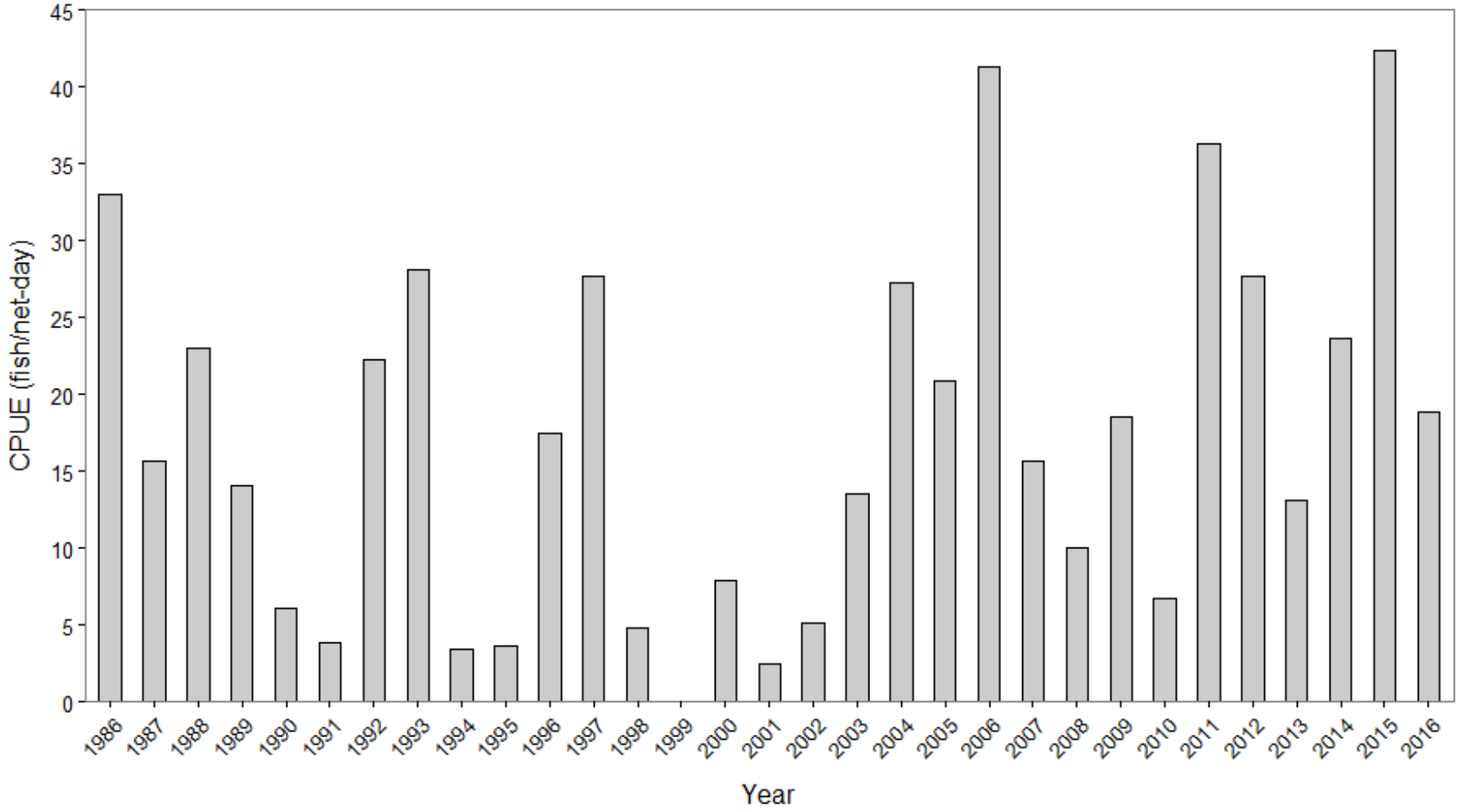

Figure 6. Catch per unit effort (CPUE; fish/net-day) of Arctic Cisco in 7.6-cm mesh gill nets, Niġliq Channel, Colville River, Alaska, 1986–2016. Effort is standardized to an 18 m net length.

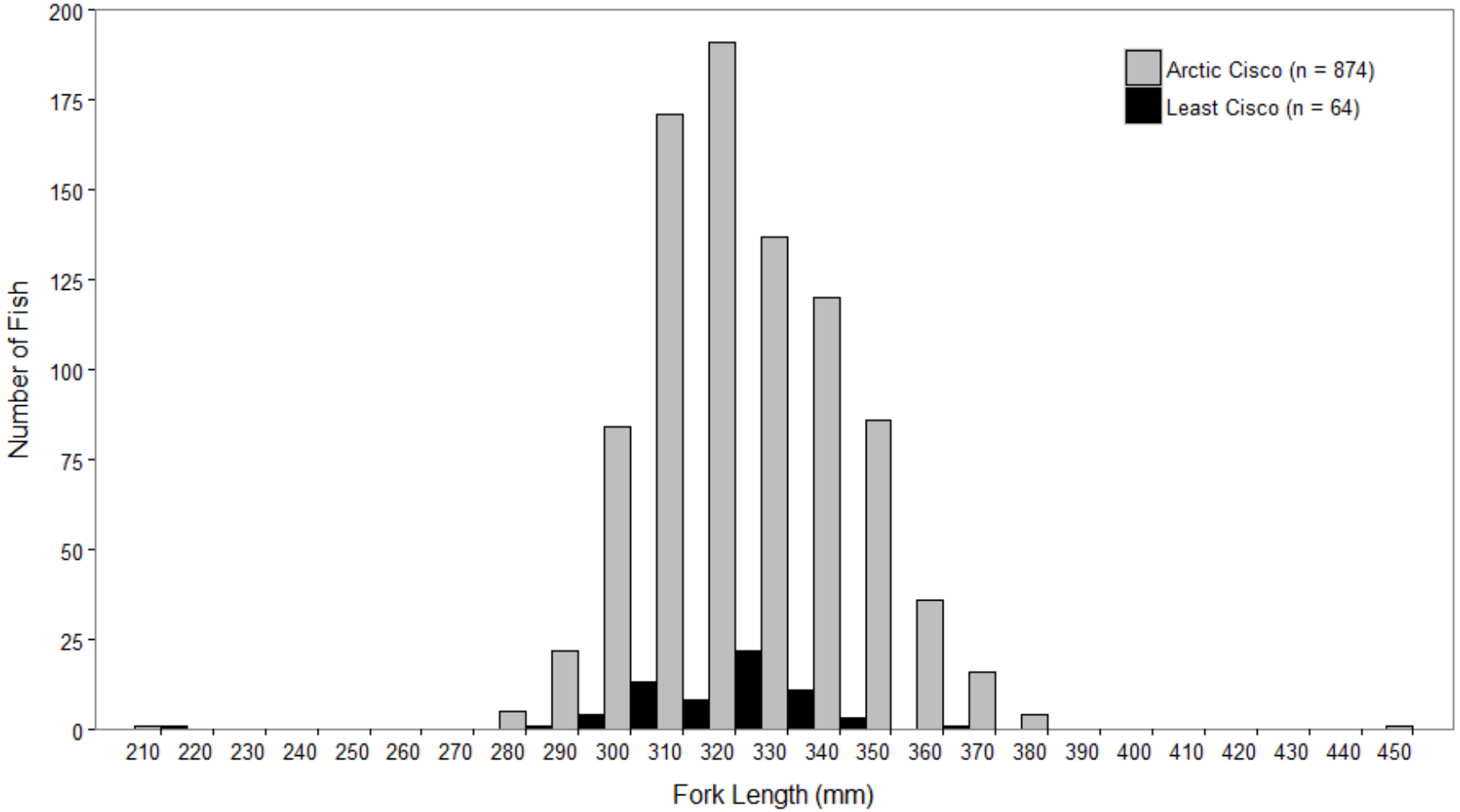

Figure 7. Length frequency (10 mm increments) of Arctic Cisco and Least Cisco captured in all mesh sizes in the fall subsistence fishery, Niġliq Channel, Colville River, Alaska, 2016.

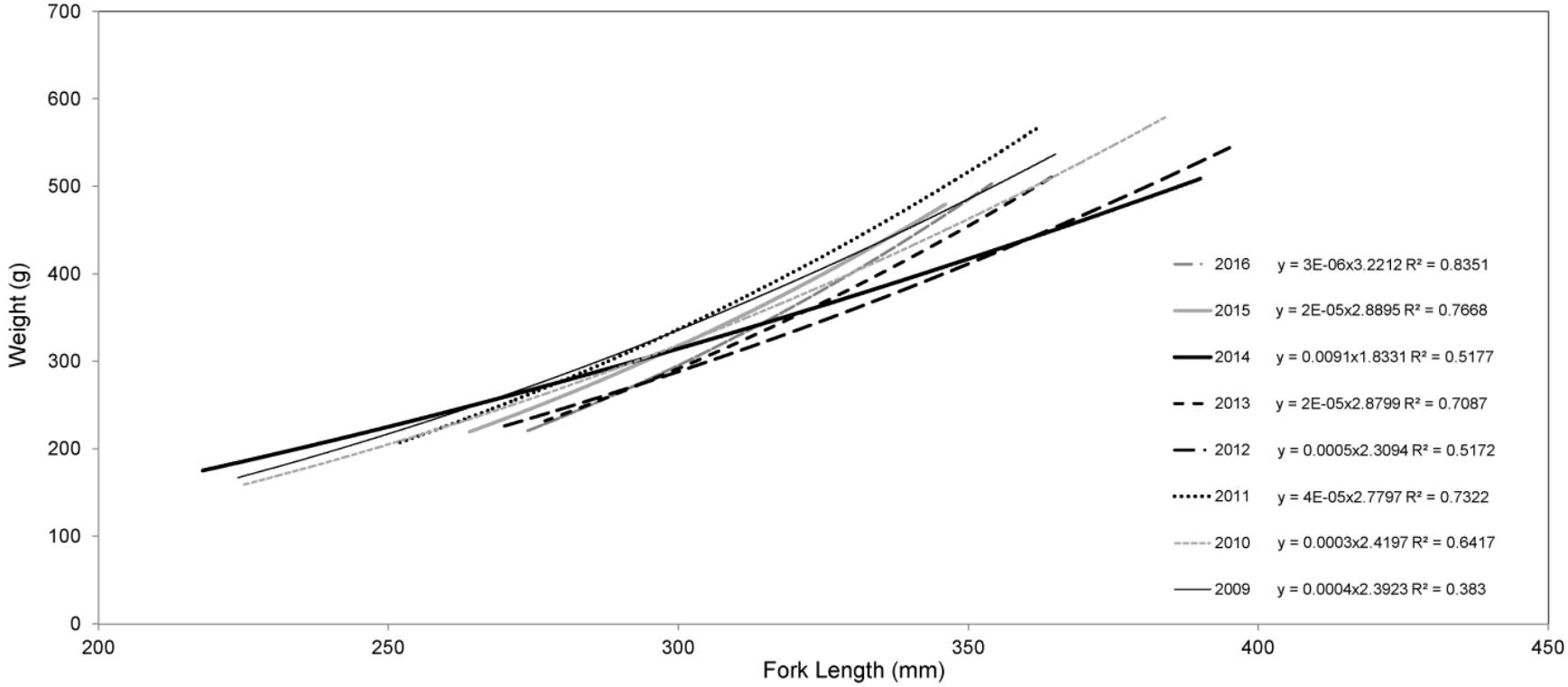

Figure 8. Length-weight regression for Arctic Cisco captured in 7.6-cm mesh nets in the fall subsistence fishery, Niġliq Channel, Colville River, Alaska, 2009–2016.

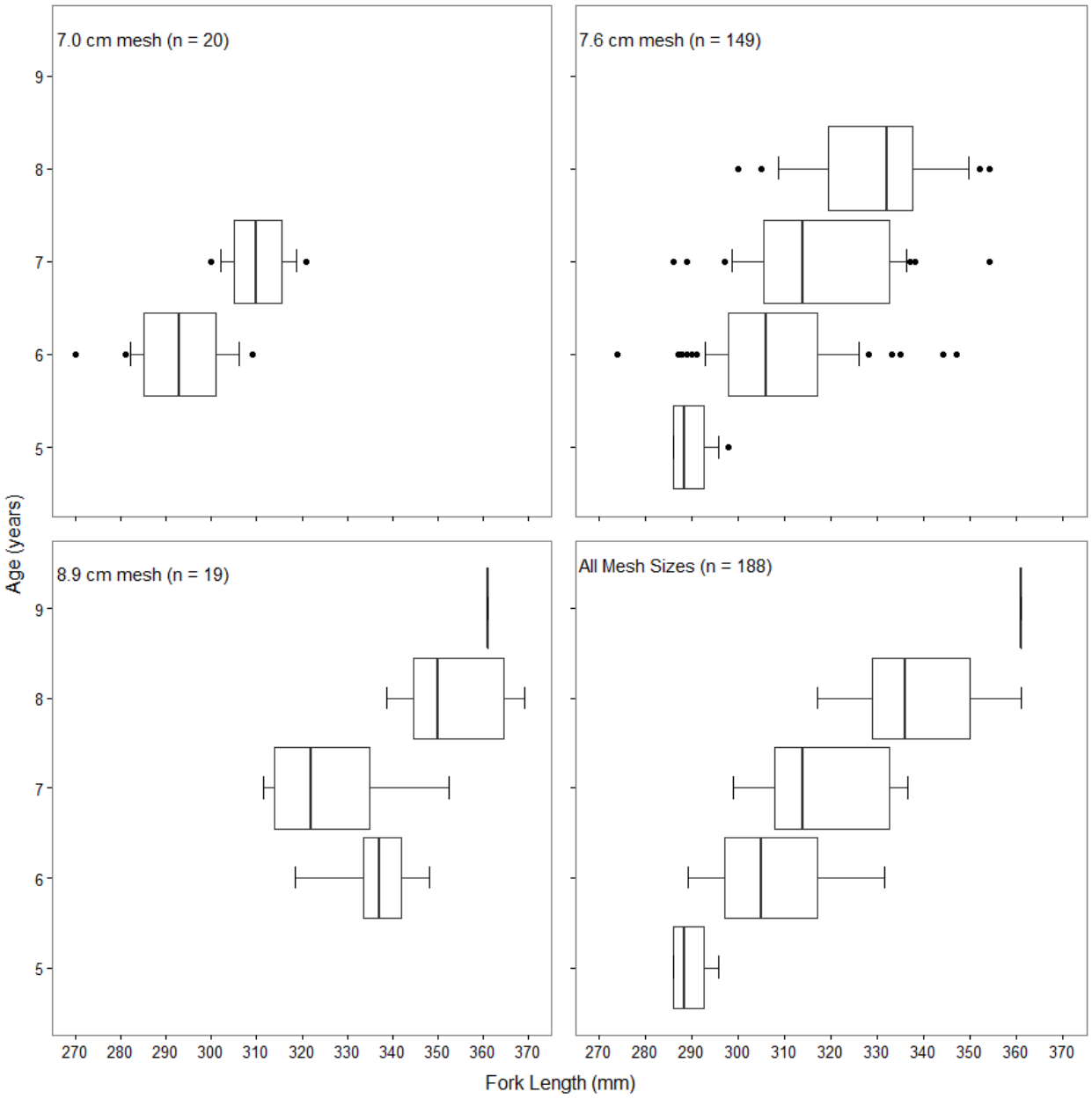

Figure 9. Age-specific length distribution of Arctic Cisco harvested in the fall subsistence fishery, Niġliq Channel, Colville River, Alaska, 2016, by mesh size. Boxes represent the middle 50% of data while horizontal lines within the boxes represent median values. Whiskers represent the 10th and 90th percentiles and black dots represent the lowest and highest 10% of values.

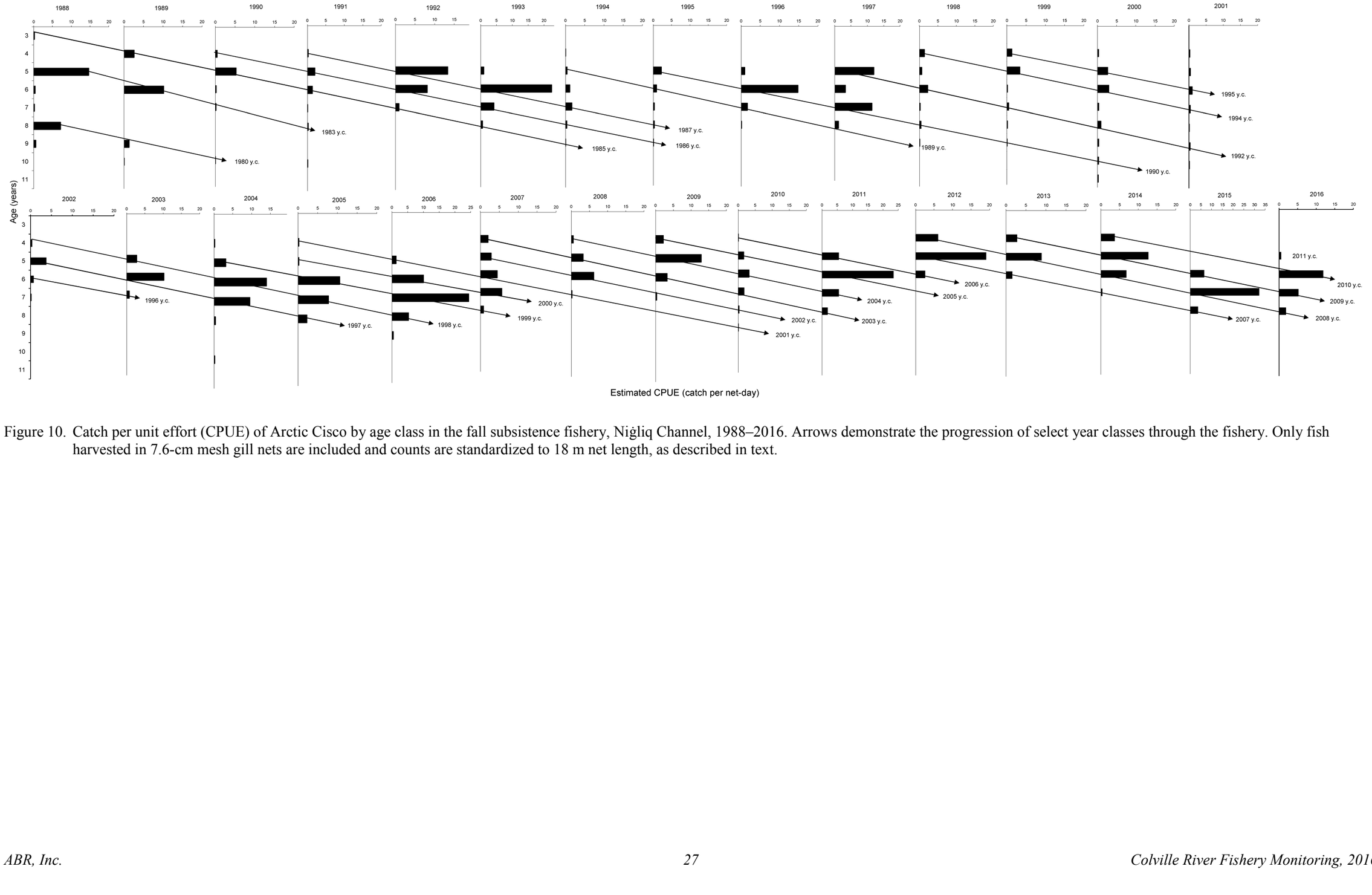

Figure 10. Catch per unit effort (CPUE) of Arctic Cisco by age class in the fall subsistence fishery, Niġliq Channel, 1988–2016. Arrows demonstrate the progression of select year classes through the fishery. Only fish harvested in 7.6-cm mesh gill nets are included and counts are standardized to 18 m net length, as described in text.

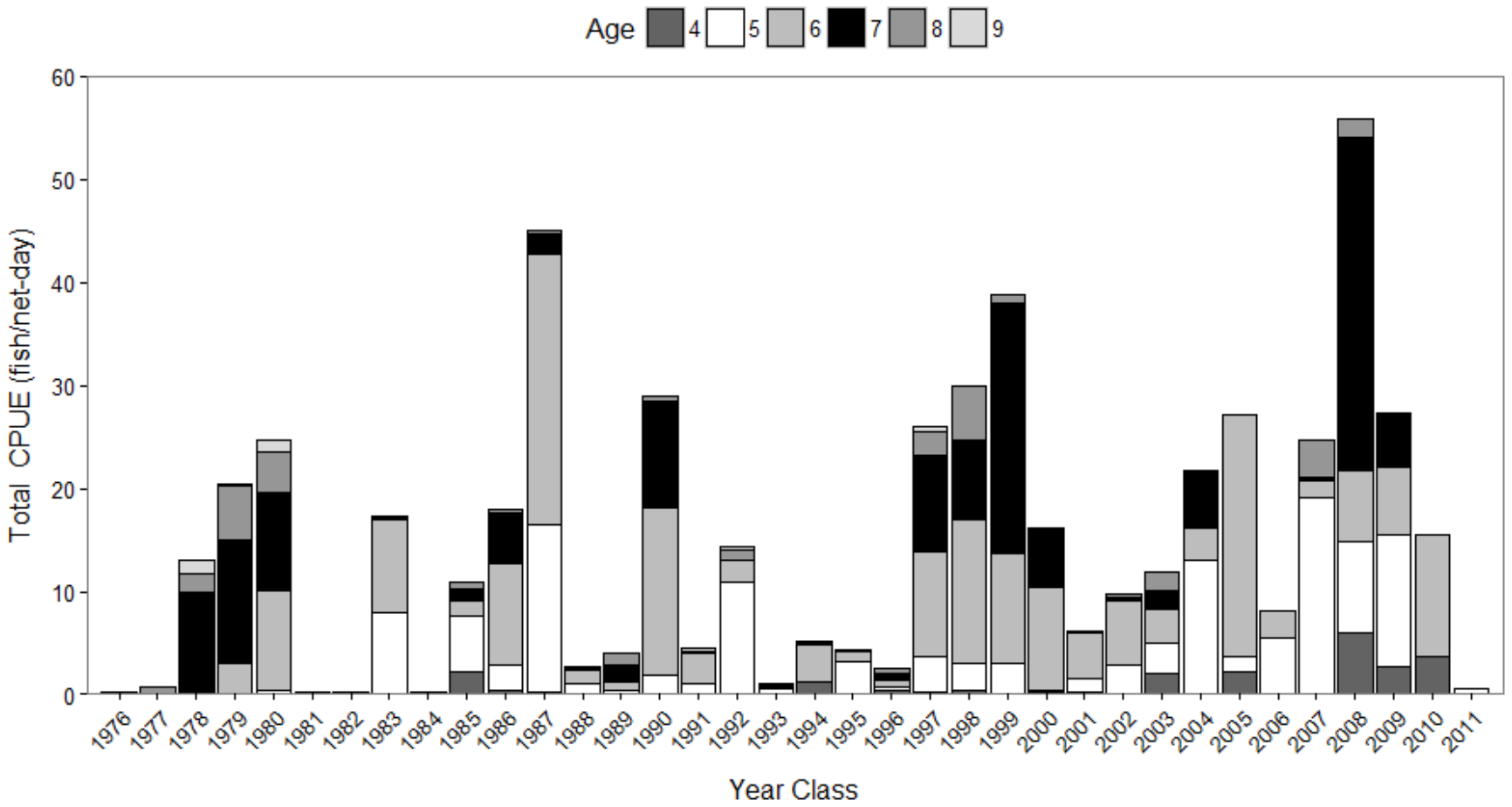

Figure 11. Cumulative catch per unit effort (catch per net-day) of Arctic Cisco by year class (year of hatch) in the fall subsistence fishery, Niġliq Channel, Colville River, 1976–2011 (capture dates 1985–2016). Catch per unit effort was estimated only for fish captured in 7.6-cm mesh nets.

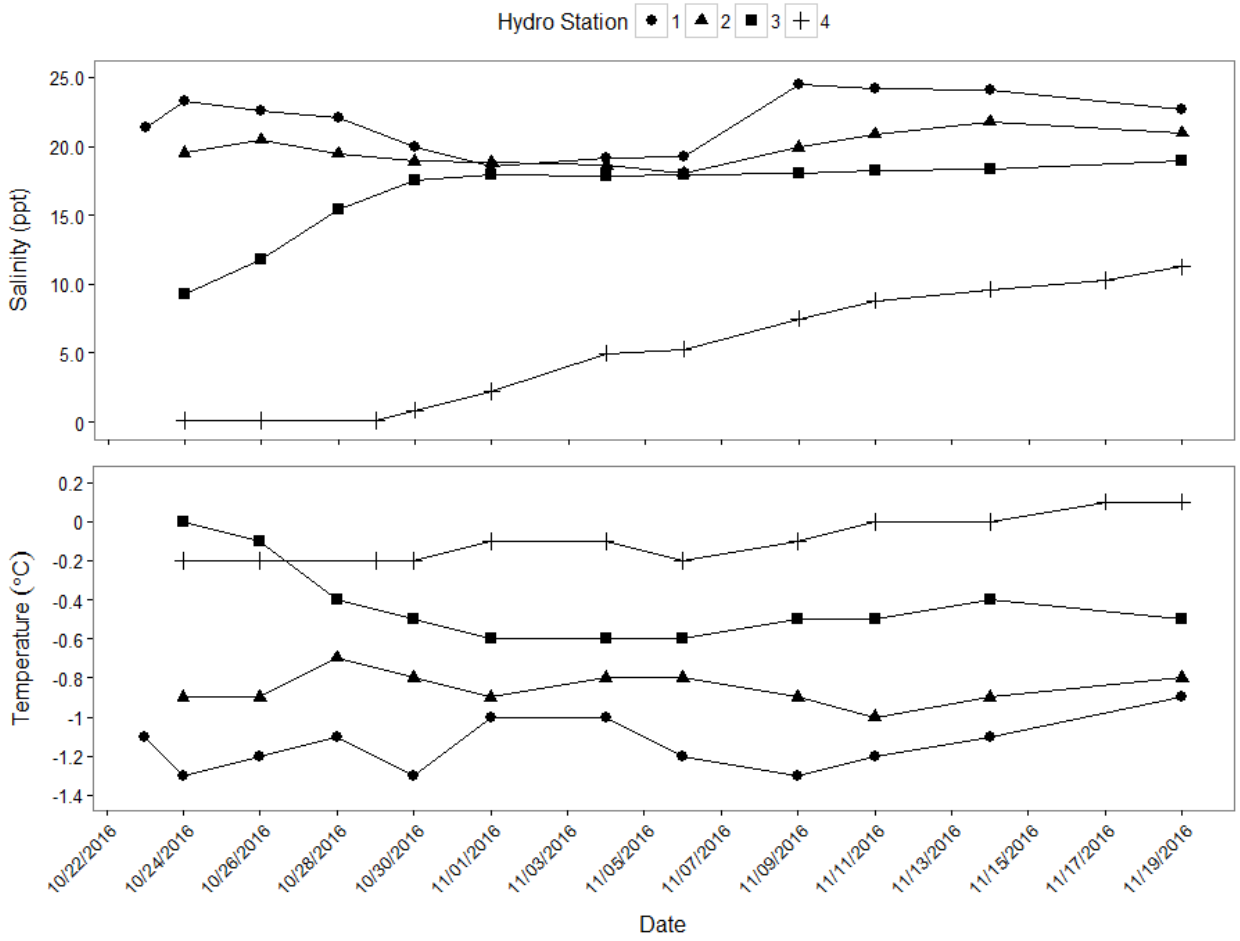

Figure 12. Salinity (parts per thousand) and temperature (°C) measured at 3.0 m depth from 4 water stations on the Niġliq Channel, Colville River, Alaska, 23 October to 19 November 2016.

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, 2016.

Fisher Code	Fishing Area	Net	Net Code	Length (m)	Stretched Mesh (cm)	Start Date	End Date	Net-days	Adjusted Net-days
6	Niġliq Delta	A	166A1	24.38	7.0	10/31/2016	11/12/2016	12	16.00
6	Niġliq Delta	B	166B1	24.38	8.9	11/12/2016	11/16/2016	4	5.33
7	Upper Niġliq	A	167A1	24.38	7.6	10/27/2016	11/23/2016	27	36.00
7	Upper Niġliq	B	167B1	24.38	7.6	10/28/2016	11/23/2016	26	34.67
16	Upper Niġliq	A	1616A1	24.38	8.9	10/26/2016	11/9/2016	14	18.67
16	Upper Niġliq	A	1616A2	24.38	8.9	11/9/2016	11/19/2016	10	13.33
16	Upper Niġliq	B	1616B1	24.38	8.9	10/29/2016	11/9/2016	11	14.67
16	Upper Niġliq	C	1616C1	24.38	7.6	10/29/2016	11/25/2016	27	36.00
16	Upper Niġliq	D	1616D1	18.29	7.6	11/2/2016	11/25/2016	23	23.00
25	Niġliq Delta	A	1625A1	18.29	7.6	10/31/2016	11/16/2016	16	16.00
27	Upper Niġliq	A	1627A1	18.29	8.9	10/30/2016	11/1/2016	2	2.00
27	Upper Niġliq	B	1627B1	15.24	8.9	11/2/2016	11/23/2016	21	17.50
28	Upper Niġliq	A	1628A1	18.29	8.9	10/24/2016	11/13/2016	20	20.00
28	Niġliq Delta	B	1628B1	24.38	7.6	10/28/2016	11/18/2016	21	28.00
31	Upper Niġliq	A	1631A1	18.29	7.6	10/24/2016	10/30/2016	6	6.00
31	Upper Niġliq	B	1631B1	24.38	7.6	10/25/2016	11/13/2016	19	25.33
31	Upper Niġliq	C	1631C1	18.29	7.6	10/29/2016	11/6/2016	8	8.00
32	Nanuk	A	1632A1	24.38	7.6	10/23/2016	11/7/2016	15	20.00
32	Nanuk	B	1632B1	24.38	7.6	10/23/2016	11/2/2016	10	13.33
33	Upper Niġliq	A	1633A1	24.38	7.6	10/24/2016	10/30/2016	6	8.00
33	Upper Niġliq	A	1633A2	24.38	7.6	10/30/2016	11/18/2016	19	25.33
33	Upper Niġliq	B	1633B1	18.29	7.6	10/30/2016	11/18/2016	19	19.00
42	Upper Niġliq	A	1642A1	18.29	7.6	10/20/2016	11/16/2016	27	27.00
51	Upper Niġliq	A	1651A1	24.38	7.6	10/31/2016	11/23/2016	23	30.67
51	Niġliq Delta	B	1651B1	30.48	7.6	11/1/2016	11/23/2016	22	36.67
51	Niġliq Delta	C	1651C1	18.29	7.6	11/1/2016	11/23/2016	22	22.00
55	Upper Niġliq	A	1655A1	30.48	7.6	10/20/2016	10/27/2016	7	11.67
55	Niġliq Delta	A	1655A2	30.48	7.6	10/28/2016	11/1/2016	4	6.67
55	Upper Niġliq	B	1655B1	18.29	8.9	10/21/2016	10/27/2016	6	6.00
56	Niġliq Delta	A	1656A1	24.38	7.6	10/24/2016	11/6/2016	13	17.33
56	Niġliq Delta	B	1656B1	24.38	7.6	10/25/2016	11/8/2016	14	18.67
63	Niġliq Delta	A	1663A1	24.38	7.6	10/24/2016	11/23/2016	30	40.00
64	Nanuk	A	1664A1	18.29	7.6	10/28/2016	11/23/2016	26	26.00
65	Upper Niġliq	A	1665A1	18.29	7.0	10/21/2016	10/27/2016	6	6.00
65	Upper Niġliq	A	1665A2	18.29	7.0	11/3/2016	11/23/2016	20	20.00

Appendix A. Continued.

Fisher Code	Fishing Area	Net	Net Code	Length (m)	Stretched Mesh (cm)	Start Date	End Date	Net-days	Adjusted Net-days
65	Upper Niglıq	B	1665B1	6.10	8.3	11/2/2016	11/23/2016	21	7.00
70	Niglıq Delta	A	1670A1	30.48	7.6	10/22/2016	11/9/2016	18	30.00
70	Niglıq Delta	B	1670B1	30.48	7.0	10/26/2016	11/9/2016	14	23.33
70	Niglıq Delta	C	1670C1	18.29	7.6	10/26/2016	11/9/2016	14	14.00
70	Nanuk	D	1670D1	30.48	7.6	10/28/2016	11/1/2016	4	6.67
70	Nanuk	E	1670E1	30.48	7.6	11/1/2016	11/7/2016	6	10.00
70	Niglıq Delta	E	1670E2	30.48	7.6	11/7/2016	11/10/2016	3	5.00
71	Upper Niglıq	A	1671A1	24.38	6.4	10/21/2016	10/31/2016	10	13.33
72	Upper Niglıq	A	1672A1	18.29	7.6	10/24/2016	11/11/2016	18	18.00
72	Main Channel	B	1672B1	18.29	7.6	10/29/2016	11/23/2016	25	25.00
72	Main Channel	C	1672C1	30.48	7.6	10/29/2016	11/23/2016	25	41.67
74	Main Channel	A	1674A1	30.48	7.6	10/27/2016	11/3/2016	7	11.67
74	Main Channel	B	1674B1	30.48	6.4	10/27/2016	11/3/2016	7	11.67
77	Upper Niglıq	A	1677A1	24.38	7.6	10/25/2016	12/1/2016	37	49.33
77	Upper Niglıq	B	1677B1	18.29	7.6	10/29/2016	12/1/2016	33	33.00
79	Niglıq Delta	A	1679A1	24.38	7.6	10/26/2016	11/12/2016	17	22.67
79	Niglıq Delta	B	1679B1	30.48	7.6	10/26/2016	11/12/2016	17	28.33
82	Niglıq Delta	A	1682A1	24.38	7.6	10/22/2016	11/23/2016	32	42.67
82	Niglıq Delta	B	1682B1	30.48	7.6	10/23/2016	11/23/2016	31	51.67
82	Niglıq Delta	C	1682C1	18.29	8.9	10/26/2016	11/18/2016	23	23.00
82	Niglıq Delta	D	1682D1	18.29	7.6	10/26/2016	11/17/2016	22	22.00
93	Upper Niglıq	A	1693A1	27.43	8.9	10/29/2016	11/11/2016	13	19.50
95	Upper Niglıq	A	1695A1	18.29	7.6	10/19/2016	11/11/2016	23	23.00
95	Niglıq Delta	B	1695B1	24.38	7.6	10/28/2016	11/7/2016	10	13.33
100	Niglıq Delta	A	16100A1	24.38	8.9	10/28/2016	11/2/2016	5	6.67
100	Niglıq Delta	A	16100A2	24.38	8.9	11/2/2016	11/4/2016	2	2.67
100	Niglıq Delta	B	16100B1	18.29	7.6	10/30/2016	11/18/2016	19	19.00
102	Upper Niglıq	A	16102A1	9.14	7.0	10/15/2016	10/19/2016	4	2.00
102	Upper Niglıq	A	16102A2	9.14	7.0	10/29/2016	11/23/2016	25	12.50
102	Upper Niglıq	B	16102B1	30.48	7.0	10/21/2016	11/3/2016	13	21.67
105	Niglıq Delta	A	16105A1	24.38	7.6	10/22/2016	11/7/2016	16	21.33
106	Niglıq Delta	A	16106A1	22.25	7.6	10/26/2016	10/28/2016	2	2.43
106	Niglıq Delta	A	16106A2	22.25	7.6	10/29/2016	11/6/2016	8	9.73
Total									1,318.69

Appendix B. Estimated harvest of Arctic Cisco from the Colville River delta commercial and subsistence fisheries, 1967–2016.

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
1998[b]	8,752	13,559	22,311

Appendix B. Continued.

Year	Estimated commercial harvest[a]	Estimated subsistence harvest	Estimated total harvest
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
2016[e]	–	26,577	26,577
Average	23,383	25,202	32,763

[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