FALL 2018 SUBSISTENCE FISHERY MONITORING ON THE COLVILLE RIVER

DATA REPORT

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Prepared for

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Anchorage, Alaska

Prepared by

ABR, INC.—ENVIRONMENTAL RESEARCH & SERVICES
Anchorage, Alaska

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April 2019

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ACKNOWLEDGMENTS

The 2018 Arctic Cisco study was funded by ConocoPhillips Alaska, Inc. (CPAI), and we are grateful to Robyn McGhee of CPAI for logistic support and guidance. Field support was provided by ABR personnel John Seigle, Julie Parrett, Tim Obritschkewitsch, Robert McNown, Katie Hayden, and Joe Welch, and by Nuiqsut resident Fredrick Tukle. Pam Odom (Publications Specialist) of ABR helped prepare this report. Pam also arranged travel, and Tony LaCortiglia handled gear logistics and transport. Terry Schick provided in-house report review. We thank the residents of Nuiqsut for their continued involvement in and support of this program. We thank the Kuukpik Hotel and Nanuk Corporation staff for their support throughout the season. As is always true, we are especially indebted to all the fishers who graciously continue to share information on their harvests.

INTRODUCTION

ABR, Inc.—Environmental Research & Services (ABR) works with fishery stakeholders in Nuiqsut, Alaska, to monitor the Colville River subsistence fishery, which is conducted using gillnets each fall after freeze-up in the Niġliq Channel of the Colville River (Figures 1 and 2). 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. The monitoring effort is supported by Conoco Philips Alaska, Inc. (CPAI). Over the years, the objectives of the project have evolved to include quantifying temporal 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*; a whitefish species called "Qaaktaq" in Iñupiaq), which are a staple in the diet of Nuiqsut residents and are traded widely with other northern Alaska communities. The program also attempts to quantify harvest of other subsistence species captured in the Arctic Cisco fishery. In addition to the data report, we prepared a manuscript following the 2016 season, which has been reviewed by CPAI and is being submitted for peer review to a scientific journal at the time of this writing. A second manuscript is being produced in 2019. The first manuscript is titled "Factors influencing intra-annual harvest of Arctic Cisco during the annual Colville River delta under-ice subsistence fishery," and it describes the long-term changes and trends in the fishery and monitoring efforts during the 30 plus years of monitoring from 1985–2016. The second paper will detail the harvest of other subsistence whitefish species caught during the Arctic Cisco fishery harvest season.

The objectives of the 33rd year of the harvest monitoring program were to:

- continue working with key fishery stakeholders per agreements made in 2007 (Seigle et al. 2008);
- monitor the harvest of Arctic Cisco (and other species) throughout the fall fishing season by interviewing fishery participants;
- record fishing 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 harvested fishes;
- measure water salinity, temperature, pH, and dissolved oxygen in primary fishing areas; and
- compare the 2018 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 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 2 local fishing experts, Fredrick Tukle, Jr., and Patrick Easterday. ABR fishery monitors conducted daily interviews of fishers for harvest events from 12 October to 17 November 2018 in Nuiqsut. Additional harvest updates were received via social media posts until 1 January 2019. 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

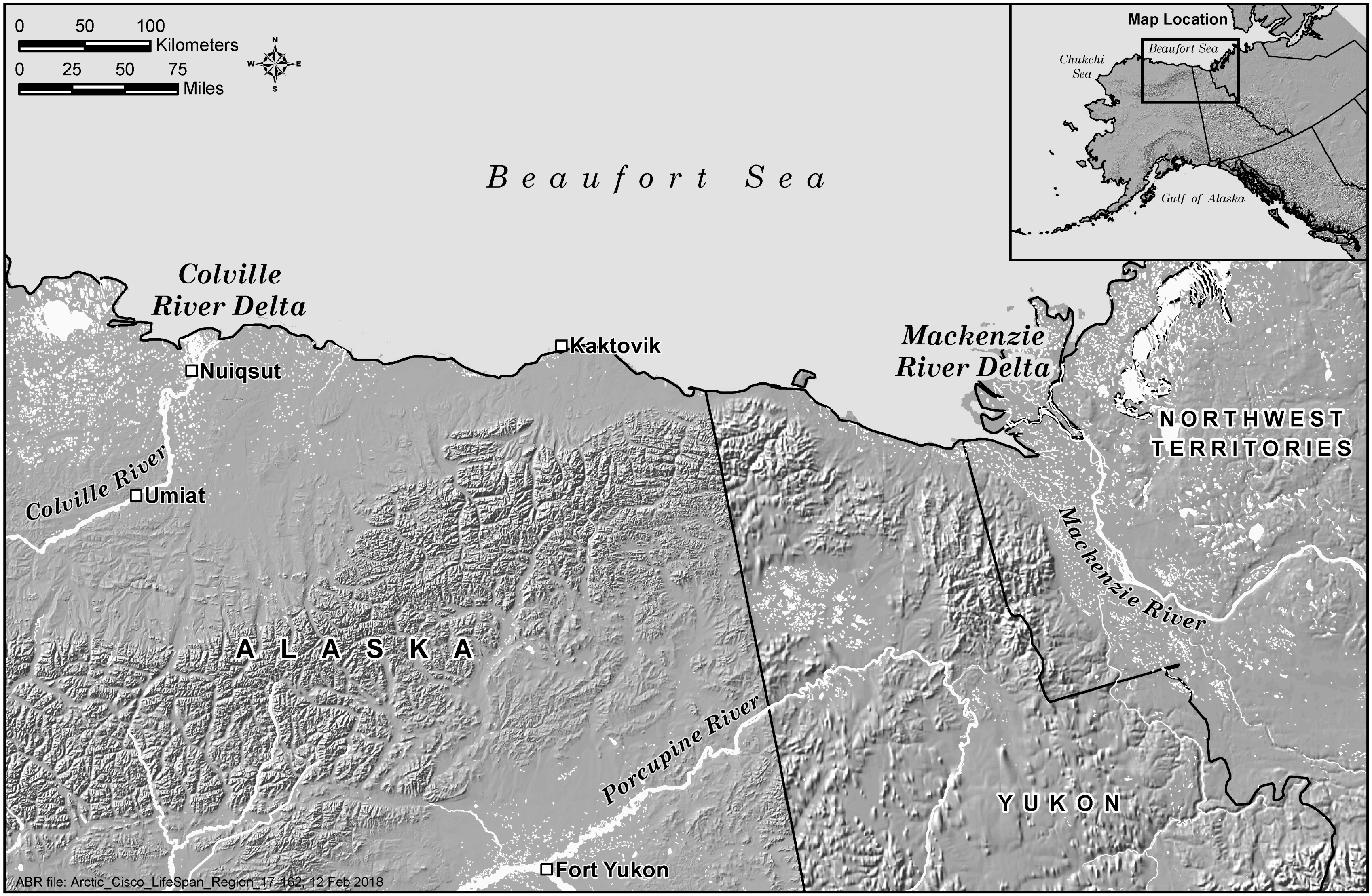

Figure 1. Waters important to the life history of Arctic Cisco in Canada and Alaska and the nearshore Beaufort Sea.

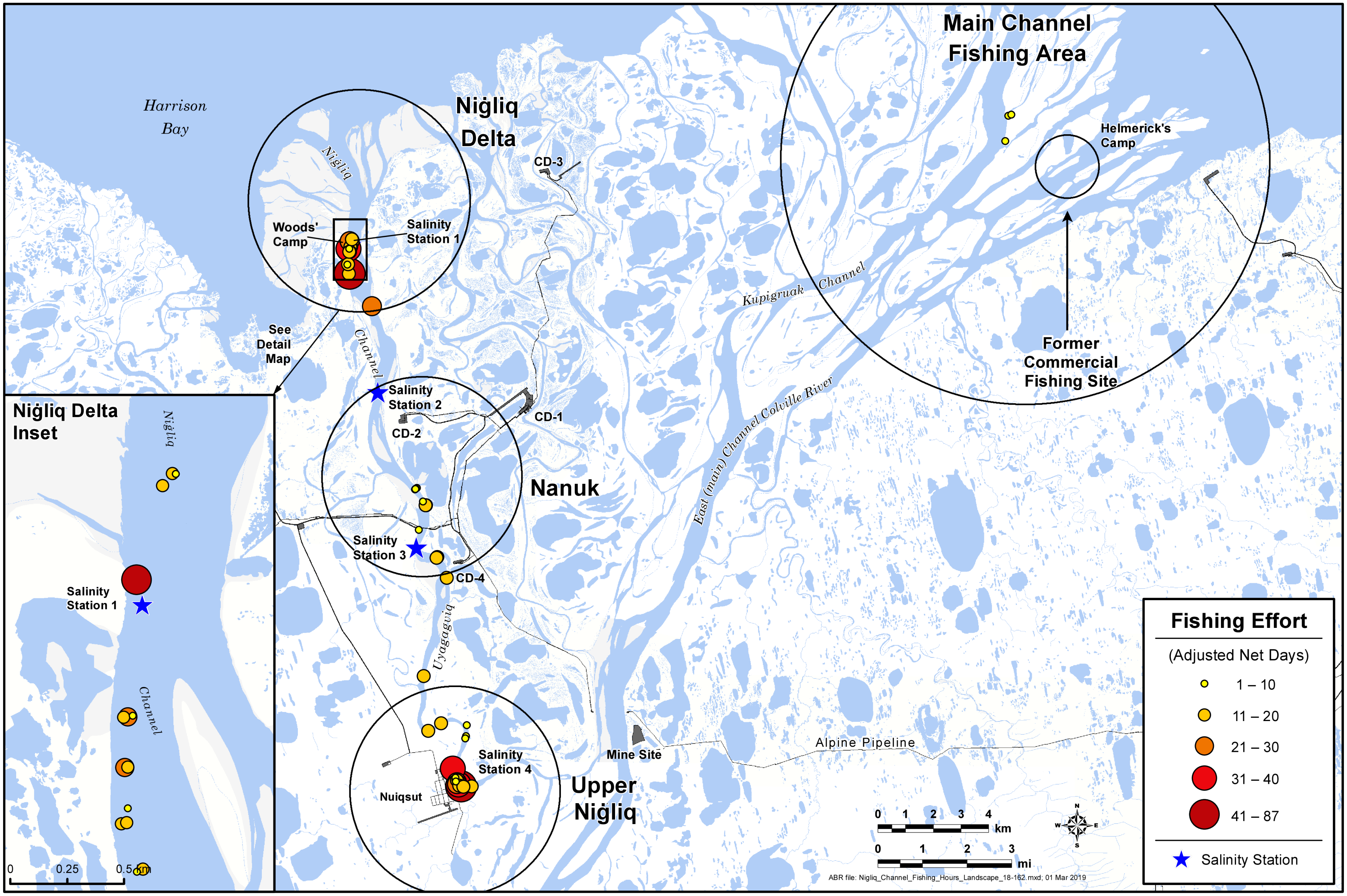

Figure 2. Water sampling stations and net sites in each of the 3 main subsistence fishing areas in the Niġliq Channel of the Colville River, Alaska, 2018.

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 and 2017). 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 information on their harvest activities as well as a sub-sample of fish from their harvest for age, length, and weight analyses (~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 ageing. 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).

WATER QUALITY

We measured water salinity and temperature approximately 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 depth increments to the river bottom. The monitoring team measured temperature (°C) at a depth of 3 m.

RESULTS AND DISCUSSION

FISHERY EFFORT AND HARVEST

In 2018, the onset of ice formation on the Colville River was reported as ~5 October, with the first net deployments on 11 October in the Upper Niġliq fishing area within the Niġliq Channel (Table 1, Figure 2). ABR scientists arrived on 12 October, the day of the first harvest in the 2018 fall fishery. ABR scientists and our local subsistence expert technicians conducted 294 interviews (down from 316 in 2017) from 13 October to 17

Table 1 Estimated onset of the fall subsistence fishery for Arctic Cisco in the Niġliq Channel of the Colville River, Alaska, 1985–2018.

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
2017	15 October	12 October
2018	11 October	12 October
Average	8 October	

November, although 6 nets remained in the river following our surveys. Five of the remaining nets were removed by 21 November, according to later conversations with our local hires. We confirmed via social media that the last remaining net (located in the Upper Niġliq adjacent to town) was pulled on 1 January 2019. Harvest data for the last net, following ABR's departure, was scant. However, the few harvest interviews conducted during this period were said to be representative of the average harvests (according to the net owner), which took place every 3 days between 17 November 2018 and 1 January 2019.

A total of 32 households deployed 47 nets set between the Niġliq Channel and the Main Channel Colville River (Table 2). A total of 55 net-sets (52 in Niġliq Channel and 3 in the Main Channel) were completed with these 47 nets (during the 2018 fall under-ice fishing season (Table 2, Figure 3, Appendix A). This effort was a reduction from 2017 in which 35 households deployed 54 nets for a total of 67 net-sets. We calculated 848.5 net-days of fishing effort in the Niġliq Channel in 2018 and estimated 16.3 net-days in the Main Channel for a total of 864.8 net-days of effort in 2018 (Appendix A); this was down from 1,057.5 net-days of total effort in 2017. Six mesh sizes were deployed in 2018, but as in previous years, the most frequently used mesh size was 7.6 cm (570.3 adjusted net-days). This was followed by 6.4-cm mesh nets (121.7 net-days), 8.9-cm mesh nets (83.8 net-days), 7.0-cm mesh nets (56.8 net-days), 8.3-cm mesh nets (28.2 net-days), and 12.7-cm mesh nets (4.0 net-days). In the Niġliq Channel, most of the fishing effort took place in the Upper Niġliq (390.7 adjusted net-days, 46.0%), followed by the Niġliq Delta (338.0 net-days, 39.8%) and the Nanuk fishing areas (119.8 net-days, 14.1%) (Table 3, Figure 4).

We recorded total harvests of 17,449 Arctic Cisco in 7.6-cm mesh nets in the Niġliq Channel in 2018, which is a substantial increase over the recorded harvest of just under 10,000 fish in 2017 (Table 3, Figure 5). An additional 336 fish were recorded in the Main Channel. A total of 25,226 Arctic Cisco were recorded as being harvested from nets of a known mesh size and known fishing duration (as opposed to harvest records where total Arctic Cisco harvests were reported as pooled data from 2 or more mesh size nets) (Table 3). These observations of overall catch were used to calculate the Arctic Cisco CPUE by mesh size. In 2018, the total average estimated CPUE for 7.6-cm nets in the Niġliq Channel was 57.3 fish per net-day, which was the highest estimate on record. Harvest rates were highest in the Niġliq Delta (96.3 fish per net-day), followed by the Nanuk area (33.0 fish per net-day), and finally, the Upper Niġliq (20.3 fish per net-day) (Tables 3 and 4). Additionally, the 5 interviews conducted for harvests from 7.6-cm mesh nets in the Main Channel resulted in an estimated CPUE of 40.3 fish per net-day (Table 3). These totals bring the long-term average estimated CPUE for 7.6-cm nets in the Niġliq Channel to 19.5 (95% CI = 14.9–24.1) (Table 4, Figure 6). Long-term average CPUE for 7.6-cm mesh nets, by Niġliq Channel section, now stands at 8.9 (95% CI = 6.6–11.2) in the Upper Niġliq, 16.4 (95% CI = 12.6–20.1) in the Nanuk, and 30.2 (95% CI = 21.7–38.7) in the Niġliq Delta (Table 4).

Overall, observed CPUE in 2018 for all mesh sizes ranged from 8.7 fish per net-day in 8.9-cm mesh nets in the Upper Niġliq area to 131.6 fish per net-day in 6.4-cm mesh nets in the Niġliq Delta (Table 3). We used these CPUE estimates to calculate a total estimated harvest of 48,056 fish (Table 5). This represents a 45% increase over the estimated harvest of 33,247 Arctic Cisco in 2017, and is the second highest harvest estimate (excluding commercial harvests) since the inception of the harvest monitoring program in 1985 (average = 33,079; 95% CI = 28,160–37,998; Appendix B). Thus, despite a reduction in fishing effort, CPUE results in 2018 indicate one of the strongest annual fishing efforts since the inception of monitoring of this fishery.

A total of 9 species (down from 12 in 2017) were recorded during the 2018 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 30,569 fish of all species were recorded during interviews in 2018, which is the greatest total of recorded fish since 1985. Of all fish recorded in harvest interviews, Arctic Cisco were the dominant harvest species caught (26,168 fish; 85.6% of harvest), which is normal for the annual fall under-ice gillnet fishery, followed by Fourhorn Sculpin (2,282 fish; 7.5% of harvest), Least Cisco (1,748 fish; 5.7%), Humpback Whitefish (155 fish; 0.5%), Rainbow

Table 2. Summary statistics for fall fishing effort in the Colville River delta, Alaska, 2018. Values in parentheses are the total number sets for those nets.

Fall Fishing Statistics	Summary of 2018 Effort
Number of recorded harvest events	294
Number of Households	32
Number of mesh nets	
5.1 cm (2.0 in)	0
6.4 cm (2.5 in)	3(4)
7.0 cm (2.75 in)	4(4)
7.6 cm (3.0 in)	29(36)
8.3 cm (3.25 in)	2(3)
8.9 cm (3.5 in)	6(6)
10.2 cm (4.0 in)	0
12.7 cm (5.0 in)	2(2)
Total Nets	47
Number of Nets in Niġliq Channel	46
Average Nets/Household	1.47
Net sets by location	
Upper Niġliq	23
Nanuk	11
Niġliq Delta	18
Main Channel	3
Total number of sets	55
Adjusted net days	
5.1 cm mesh nets	0
6.4 cm mesh nets	121.7
7.0 cm mesh nets	56.8
7.6 cm mesh nets	570.3
8.3 cm mesh nets	28.2
8.9 cm mesh nets	83.8
10.2 cm mesh nets	0
12.7 cm mesh nets	4
Adjusted net days by location	
Upper Niġliq	390.7
Nanuk	119.8
Niġliq Delta	338.0
Main Channel	16.3
Total adjusted net days	864.8

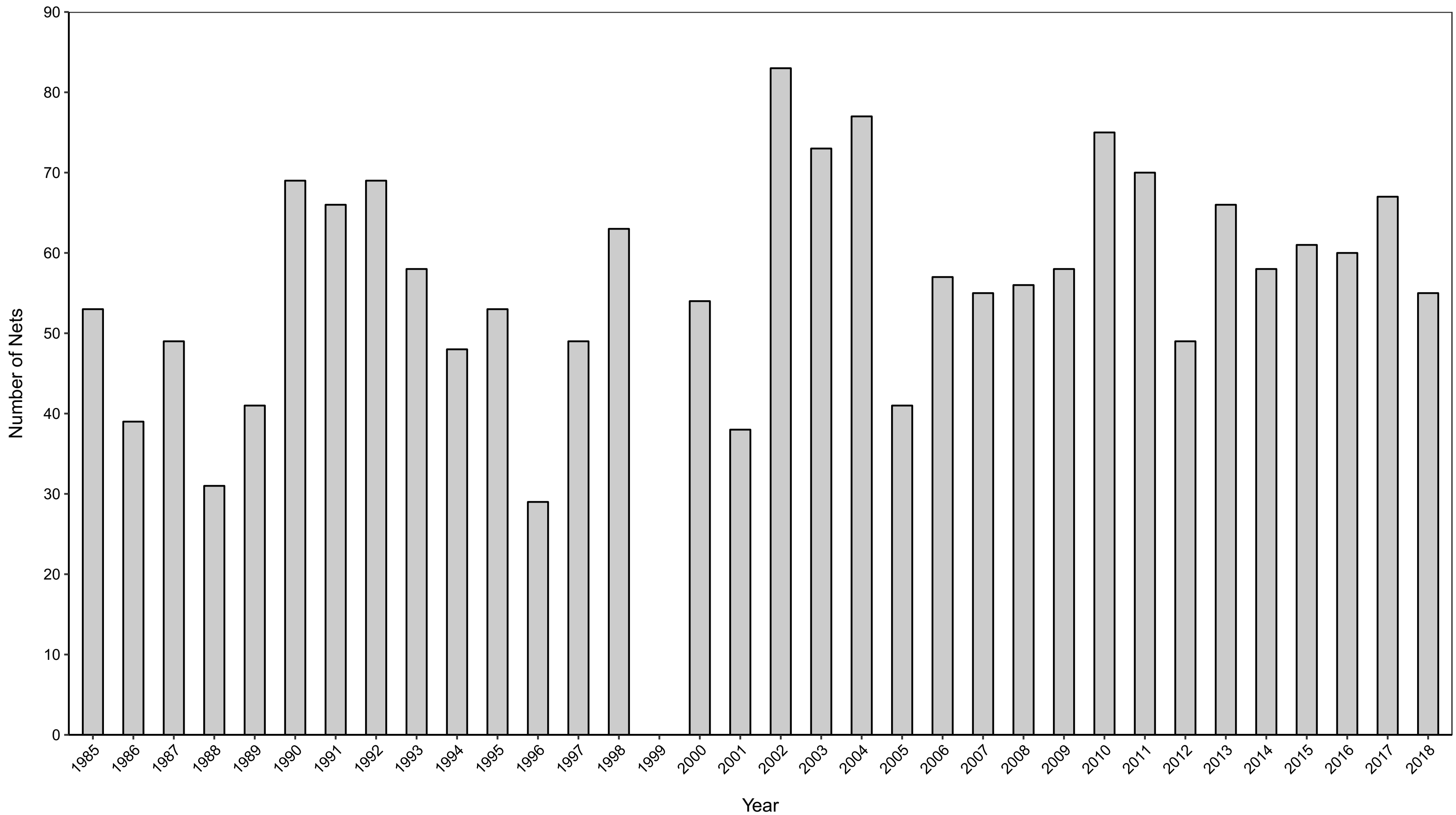

Figure 3. Number of nets deployed annually in the fall subsistence fishery for Arctic Cisco, Colville River, Alaska, 1985–2018.

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 three Niġliq Channel fishing areas and in the Main Channel fishing area by mesh size, Colville River, Alaska, 2018. Nets are standardized to 18 m length.

	Mesh size (cm)				
Location	6.4	7	7.6	8.3	8.9
Upper Niġliq Area					
Number of Interviews	5	10	90	2	5
Catch (# of fish)	417	209	2,563	31	65
Effort (net-days)	21.3	8.5	126.5	2.7	7.5
CPUE (fish/net-day)	19.5	24.6	20.1	11.6	8.7
Nanuk Area					
Number of Interviews	–	–	27	4	15
Catch (# of fish)	–	–	1,168	441	208
Effort (net-days)	–	–	35.4	4.7	17.7
CPUE (fish/net-day)	–	–	33.2	94.5	11.8
Niġliq Delta Area					
Number of Interviews	7	21	79	–	13
Catch (# of fish)	1,535	3,897	13,718	–	638
Effort (net-days)	11.7	37.7	142.5	–	15.3
CPUE (fish/net-day)	131.6	103.5	96.6	–	41.6
Total Niġliq Channel					
Number of Interviews	12	31	196	6	33
Catch (# of fish)	1,952	4,106	17,449	472	911
Effort (net-days)	33	46.2	304.4	7.4	40.5
CPUE (fish/net-day)	59.2	88.9	57.3	63.8	22.5
Main Channel Area					
Number of Interviews	–	–	5	–	–
Catch (# of fish)	–	–	336	–	–
Effort (net-days)	–	–	8.3	–	–
CPUE (fish/net-day)	–	–	40.3	–	–
Total					
Number of Interviews	12	31	201	6	33
Catch (# of fish)	1,952	4,106	17,785	472	911
Effort (net-days)	33.0	46.2	312.7	7.4	40.5
CPUE (fish/net-day)	59.2	88.9	56.9	63.8	22.5

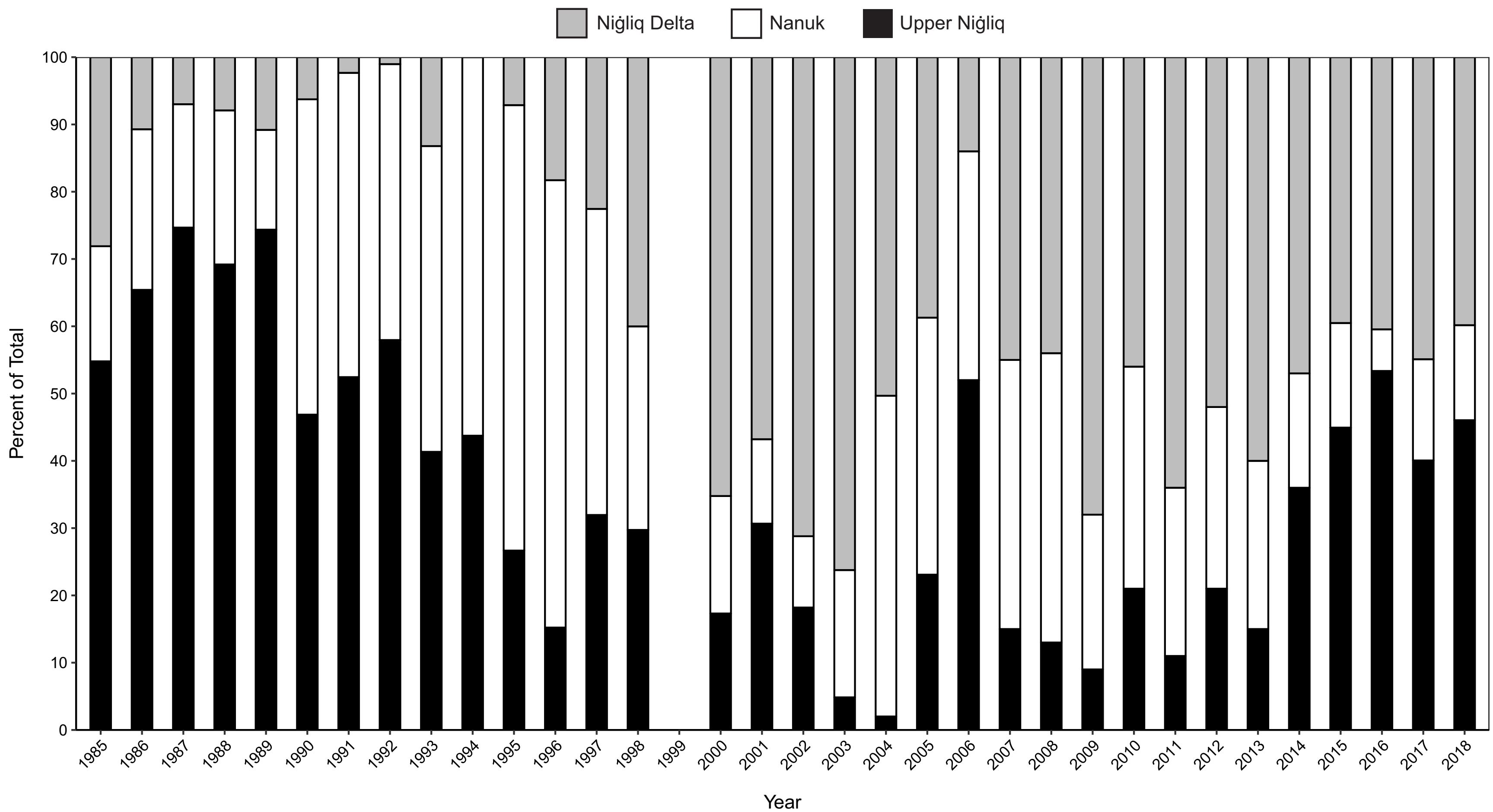

Figure 4. Percent of annual fishing effort in each of 3 Niġliq Channel fishing areas, Colville River, Alaska, 1985–2018.

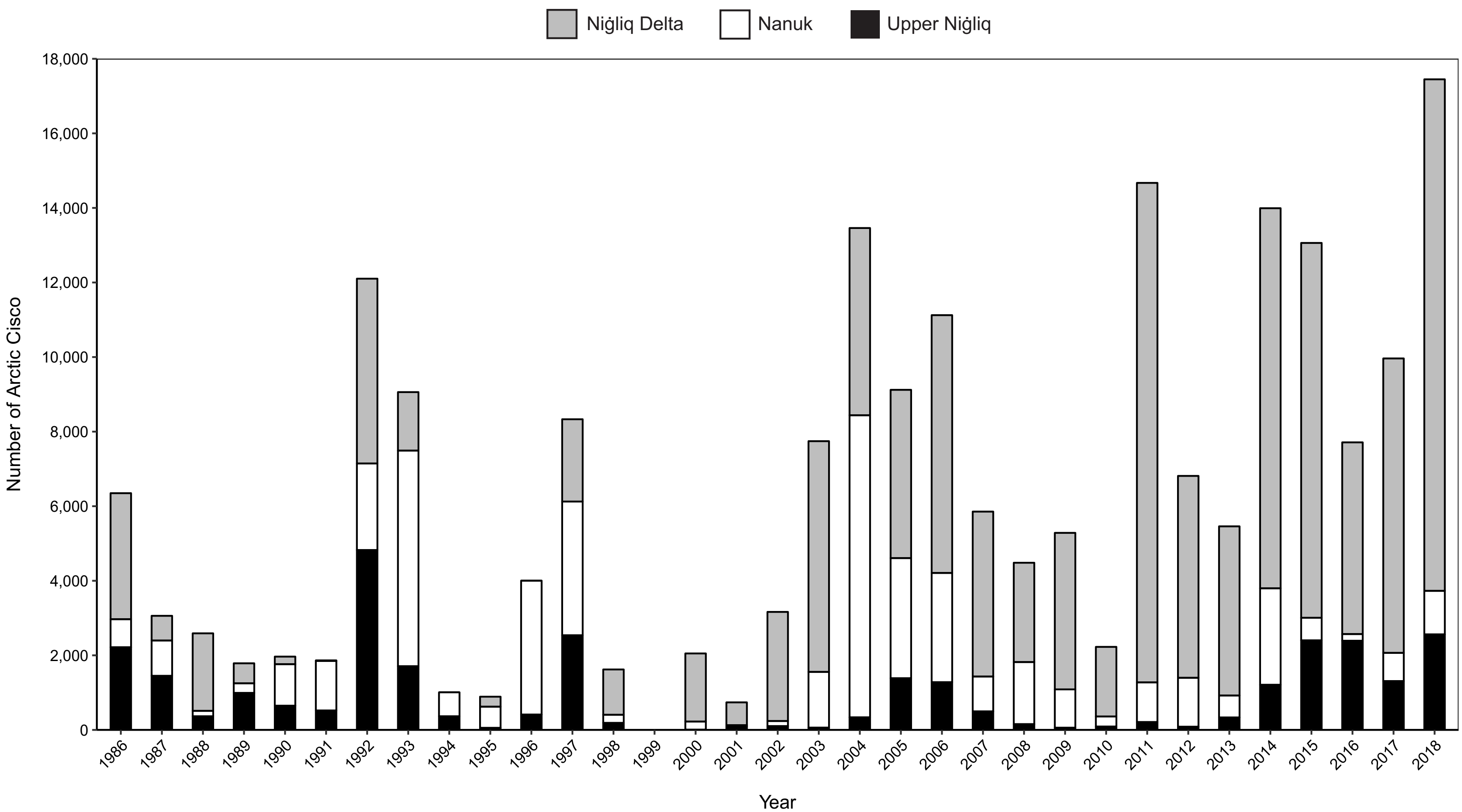

Figure 5. The observed number of Arctic Cisco harvested in 7.6-cm mesh nets in each of three Niğliq Channel fishing areas, 1986–2018.

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, 1986–2018. 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
2017[a]	1,310	119.3	11.0	757	37.8	20.0	7,896	161.3	49.0	9,963	318.4	31.3
2018[a]	2,563	126.5	20.3	1,168	35.4	33.0	13,718	142.5	96.3	17,449	304.4	57.3
Total[b]	963	89	8.9	1,549	101	16.4	4,020	155.4	30.2	6,531.6	345.2	19.5

[a] Upper Niġliq catch and effort values include fish and net data from the Uyagagviq area (Area 630).
[b] Denotes average CPUE from 1986–2018.

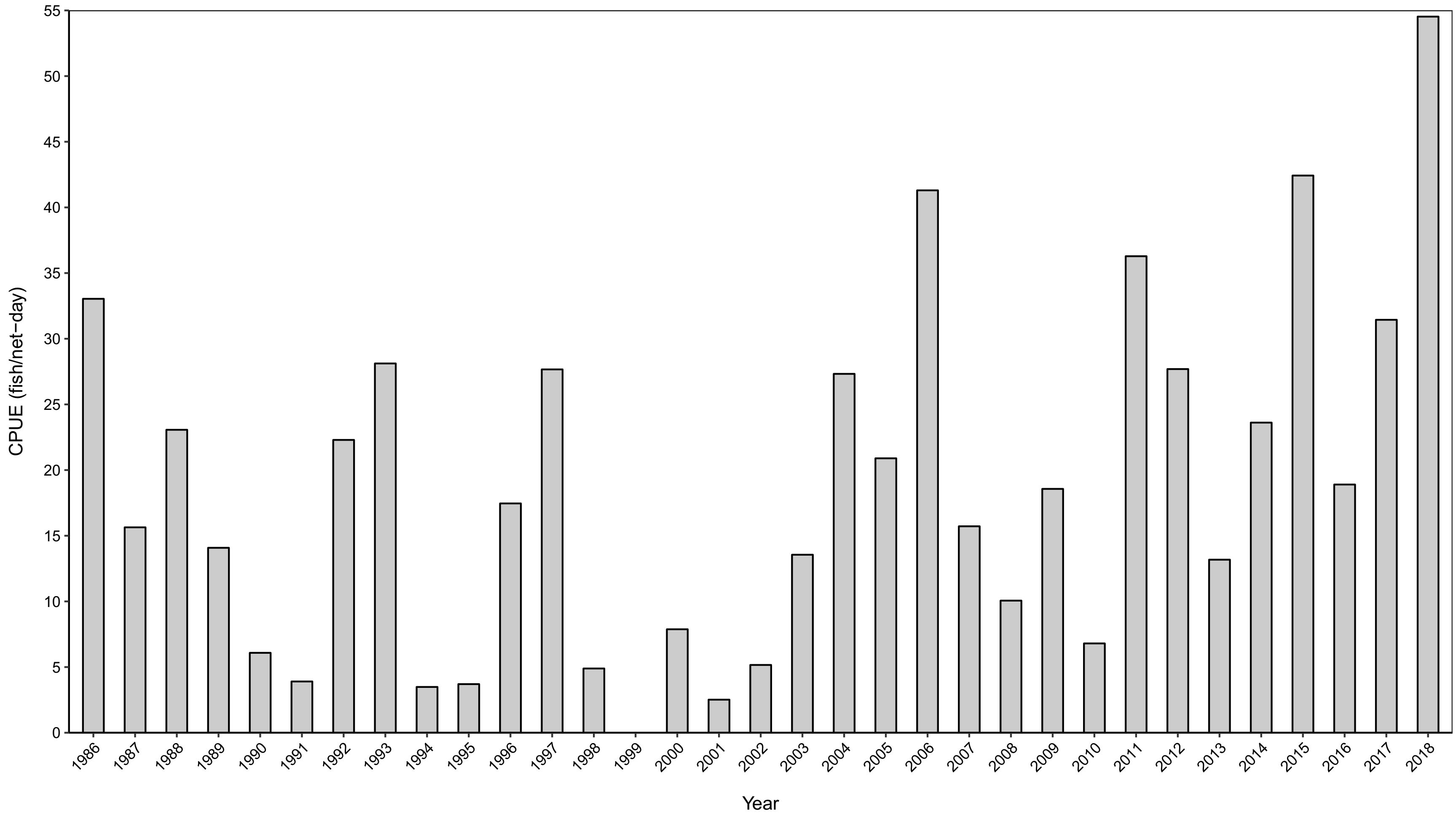

Figure 6. Catch per unit effort of Arctic Cisco in 7.6-cm mesh gill nets, Niġliq Channel, Colville River, Alaska, 1986–2018.

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, 2018.

Mesh Size (cm)	Nïġliq Channel net-days	CPUE (fish/net day)	Estimated Nïġliq Channel Harvest	Main Channel Area net-days	CPUE (fish/net day)	Estimated Main Channel Harvest	Total Estimated Harvest
5.1	–	–	–	–	–	–	–
6.4	115.0	59.2	6,808	6.7	N/A	–	6,808
7.0	56.8	88.9	5,052	–	–	–	5,052
7.6	563.7	57.2	32,242	6.7	40.3	270	32,512
8.3	28.2	63.8	1,797	–	–	–	1,797
8.9	83.8	22.5	1,886	–	–	–	1,886
12.7	1	–	–	3.0	–	–	–
		Total	47,786			270	48,056

Smelt (119 fish; 0.4%), Saffron Cod (54 fish; 0.2%), Broad Whitefish (35 fish; 0.1%), Burbot (7 fish; <0.01%), and Dolly Varden Char (1; <0.01%).

It is worth noting that in 2018, an increased effort was made to estimate the bycatch of Fourhorn Sculpin, a fish that is caught in large numbers, particularly at the Niġliq Delta. Typically, this species is discarded near the net locations, with any given day's bycatch of Fourhorn Sculpin mixing with the previous day's harvest of this species. The harvest team made a concerted effort to enumerate daily harvest rates of Fourhorn Sculpin in 2018, either by removing the fish from near nets where it was caught on a daily basis or by stacking them neatly, thereby improving our ability to discern any given day's catch of Fourhorn Sculpin, leading to improved confidence in our daily counts.

Least Cisco harvest in 2018 (1,748 fish) was greater than in 2017 (1,223 fish), but this species' overall contribution to the fishery as a percentage of harvest in 2018 remained approximately level with 2017. Least Cisco is commonly caught as bycatch in the Arctic Cisco fishery. However, the average contribution of Least Cisco to the fall fishery harvest across all years is ~18%. In the past 6 years (a period of higher than average Arctic Cisco harvests), the average Least Cisco harvest is 4.5%. One question we intend to analyze for the second manuscript, described above in the Introduction, is the relationship between Arctic Cisco harvests and bycatch results for other subsistence whitefish species including Least Cisco.

LENGTH, WEIGHT, AND AGE OF CATCH

ABR measured a sub-sample of 1,098 Arctic Cisco and 138 from all mesh sizes in 2018. Arctic Cisco ranged in length from 215 mm to 403 mm with an average of 341.2 mm (95% CI = 340.2–342.3 mm) and a median of 341 mm, which was larger than the median value as in 2017 (Figure 7). The middle 50% of fish ranged from 329 mm to 353 mm, which was much larger than in 2017 (315–336 mm), 2016 (312 mm–339 mm) and 2015 (315 mm–339 mm). Least Cisco ranged from 190 mm to 400 mm with an average of 321 mm (95% CI = 316.7–324.6) and a median of 319 mm.

During the 2018 field surveys, we received 179 Arctic Cisco, which were analyzed for age (via otoliths), length, and weight. These fish were caught in all parts of the river using 6.4-cm, 7.0-cm, 7.6-cm, 8.3-cm, and 8.9-cm mesh nets. Most (n = 131) of the otolith samples for Arctic and Least Cisco (n = 131 and 59, respectively)

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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, 1985–2018. 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	13,782
2017	89.7	0	6.0	0.3	0.5	<0.01	1.2	<0.01	<0.01	0	0.2	0.10	0	(b)	<0.01	20,224
2018	85.6	0	5.7	0.1	0.5	0	0.4	0.0	<0.01	0	0.2	<0.01	0	7.5	0.0	30,569

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

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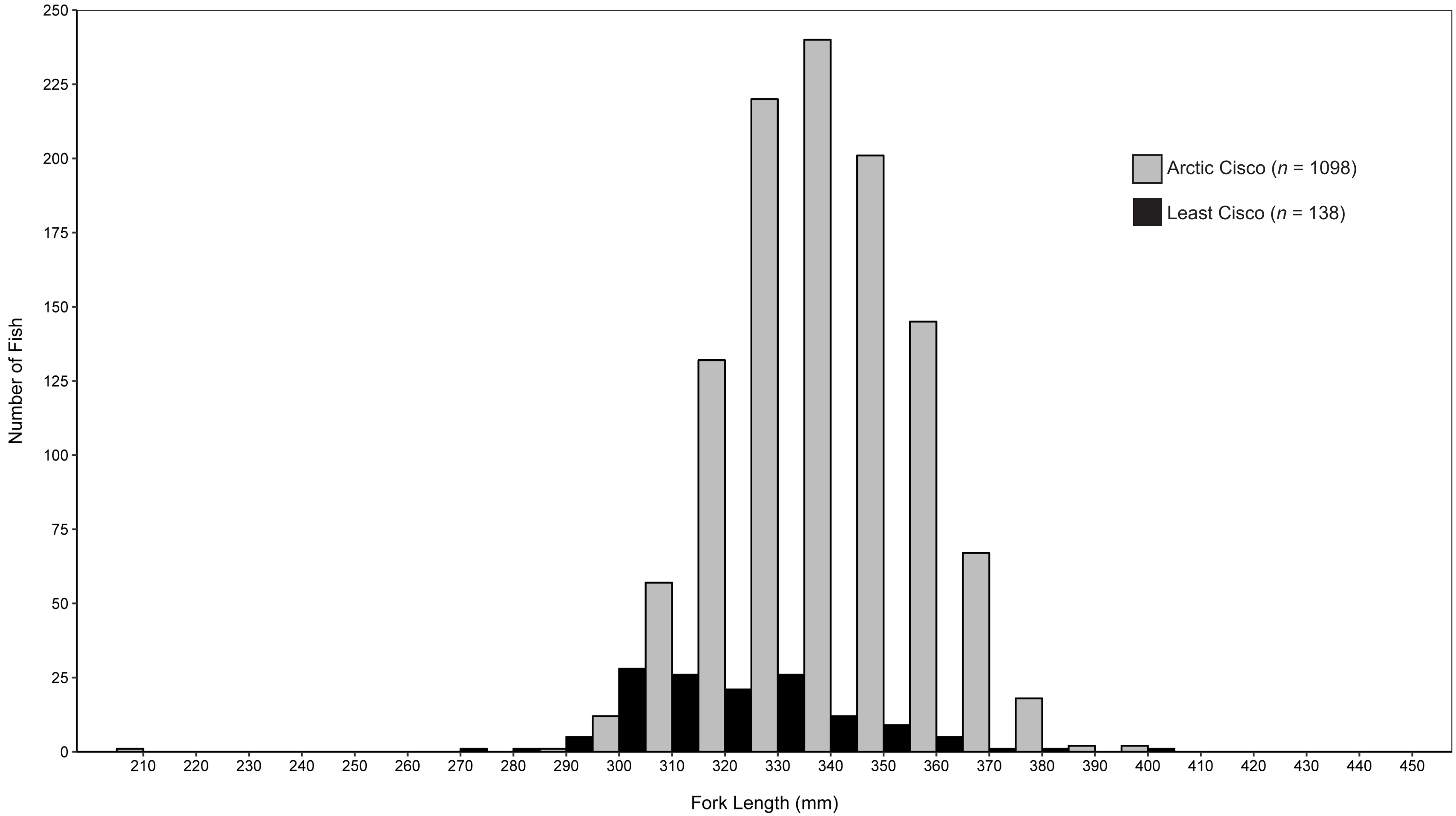

Figure 7. Length frequency of Arctic Cisco captured in all net mesh sizes in the fall subsistence fishery, Niġliq Channel, Colville River, Alaska, 2018.

came from 7.6-cm mesh nets. As of the date of submission of this draft report, Least Cisco otoliths have yet not been fully examined and results are pending. For Arctic Cisco, length and weight were strongly correlated (R^2 = 0.89, all mesh sizes) (Figure 8). For all net mesh sizes combined, fish ranged in age from 5 to 8 years, with an age composition of 1.7%, age 5; 22.3%, age 6; 58.7%, age 7; and 17.3%, age 8. For 7.6-cm-mesh caught Arctic Cisco only, fish ranged in age from 5 to 8 years with an age composition of 1.5%, age 5; 23.7%, age 6; 59.5%, age 7; and 15.3%, age 8. As might be expected for fish not yet sexually mature, fork lengths generally increased as a function of age (Figure 9).

We estimated an age-specific CPUE by applying the percentages for age-composition of Arctic Cisco to the overall CPUE of 54.5 fish per adjusted net-day and by assuming that our sub-sample in 7.6-cm mesh nets was representative of age-composition throughout the river. We obtained an estimate of 0.8 age-5 fish per net-day, 12.9 age-6 fish per net-day, 32.5 age-7 fish per net-day, and 8.3 age-8 fish per net-day (total = 54.5 fish per net-day; Table 4, Figure 10). The Arctic Cisco caught in 7.6-cm mesh nets in 2018 represent the 2010–2013 hatching year classes (i.e., fish that are 58 years of age). We are confident in closing the book on the 2009 year class and its contribution to the Colville River fishery as it is likely that most of these fish had already returned to spawn in the Mackenzie River system during summer 2018.

Based on our age readings for the 2018 survey samples, the estimated CPUE of 8.3 fish per net-day (7.6-cm mesh) has raised the overall contribution of the fish per net-day for the 2010 year class cohort to a total of ~36 fish per net-day since 2014 (representing age-4, age-6, age-7, and age-8 fish). We assume that 2018 is likely the last year that the 2010 year class will contribute meaningfully to harvests in the Colville River fall fishery because those fish will begin migrating back to spawning grounds in the Mackenzie River system during the summer and fall of 2019, never to return to Alaskan waters. The 2010 year class was interesting in that age-5 fish were absent in the age samples collected in 2015, though the class reappeared in samples over the following 3 seasons. This suggests that the 2010 year class may have been residing in mostly unfished segments of the Colville River or, perhaps more likely, that the harvest monitoring team, by random chance, did not obtain any 2010 year class samples of Arctic Cisco during the 2015 surveys (Figure 11). It is also interesting to report that age-5 (2013 year class cohort) contribution to the 2018 harvest was again minimal, raising the question as to whether we will see as much contribution from that year class (as age-6 fish) in the 2019 fishery. Recent communications with the University of Alaska Fairbanks (UAF) summer fyke net survey team, which conducts fish surveys in marine waters at Prudhoe Bay, suggests that smaller than normal 2018 young-of-the-year catch results for Arctic Cisco may indicate a partial recruitment failure for this year class. Thus, we may expect to see a considerable reduction in the near-term future harvest of Arctic Cisco within the next 4–5 years.

The estimated cumulative total CPUE for the year classes after 2010 is currently 47.6 fish per net-day for 2011 (representing age-5, age-6, and age-7 fish), 14.9 fish per net-day for 2012 (age-5 and age-6 fish), 0.8 fish per net-day for 2013 (age-5 fish) (Table 7).

WATER QUALITY

Salinity and temperature monitoring began on 15 October 2018 at station 4. The remaining 3 stations (3, 2, and 1 from upstream to downstream) were established on 20 October and all 4 stations were maintained until 15 November. Salinity at the downstream locations (Niġliq Delta) registered at 15 parts per thousand (ppt) by 20 October and by 27 October at station 3 (at 3-m depth). Salinity never surpassed 12 ppt during the survey season at the most upstream station near Nuiqsut in the Upper Niġliq (Figures 2 and 12). Salinity at 3-m depth peaked at 22.5 ppt on 27 October (Station 1), at 20.8 ppt on 4 November (Station 2), at 18.8 ppt on 11 November (Station 3), and 12.0 ppt on 13 November (Station 4).

For comparison, salinity in 2016 peaked at 25.1 ppt in the Niġliq Delta area on 9 November (Seigle et al. 2017 and 2018), while salinity never surpassed 19 ppt at the 3-m depth mark in the Niġliq Delta location in 2017. Whereas salinity in the Upper Niġliq area (Station 4) near Nuiqsut

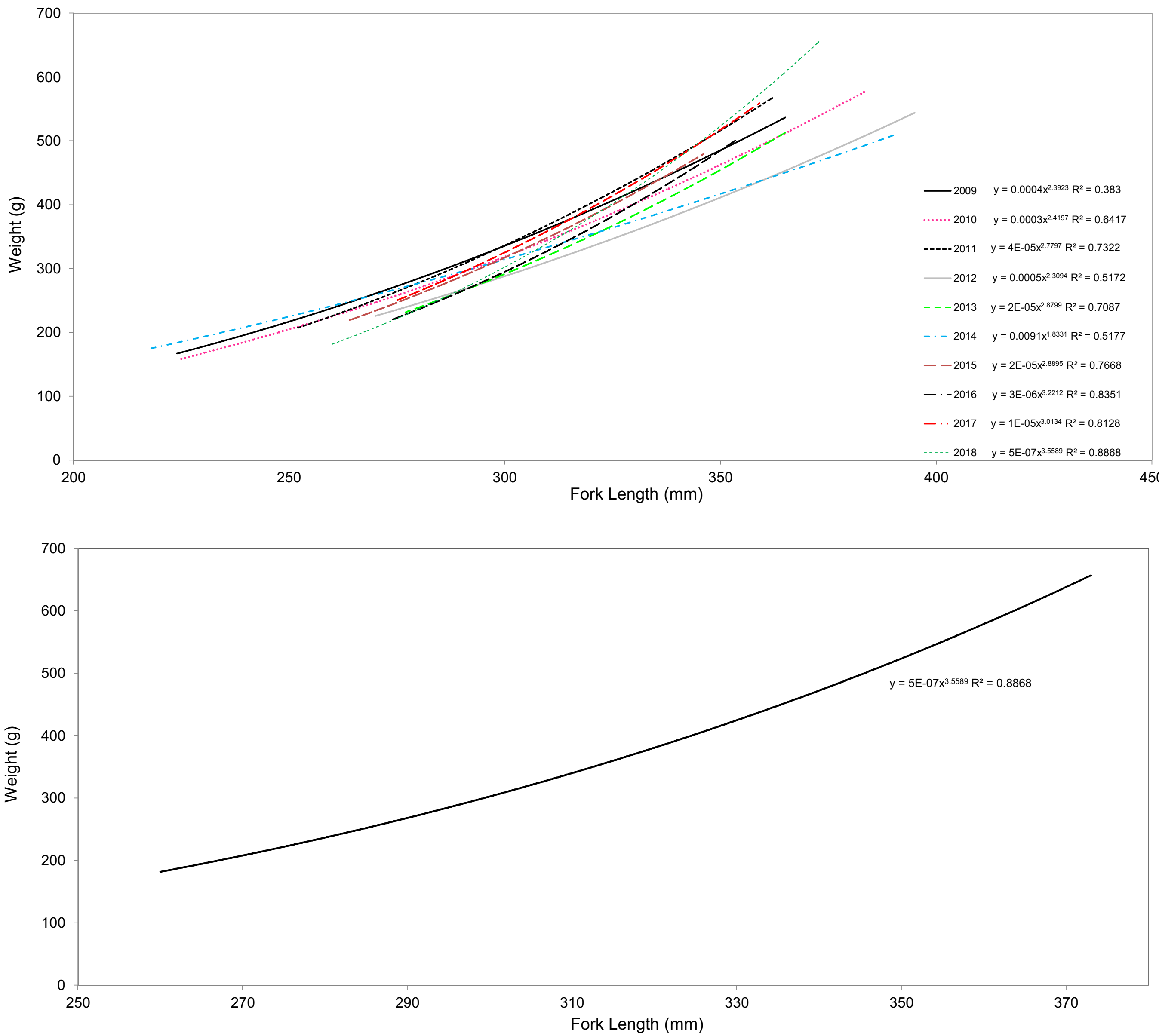

Figure 8. Length-weight regression for Arctic Cisco captured in 7.6-cm mesh nets in the fall subsistence fishery, Niġliq Channel, Colville River, Alaska, 2009–2018. Individual year regressions above and 2018 regression only, below.

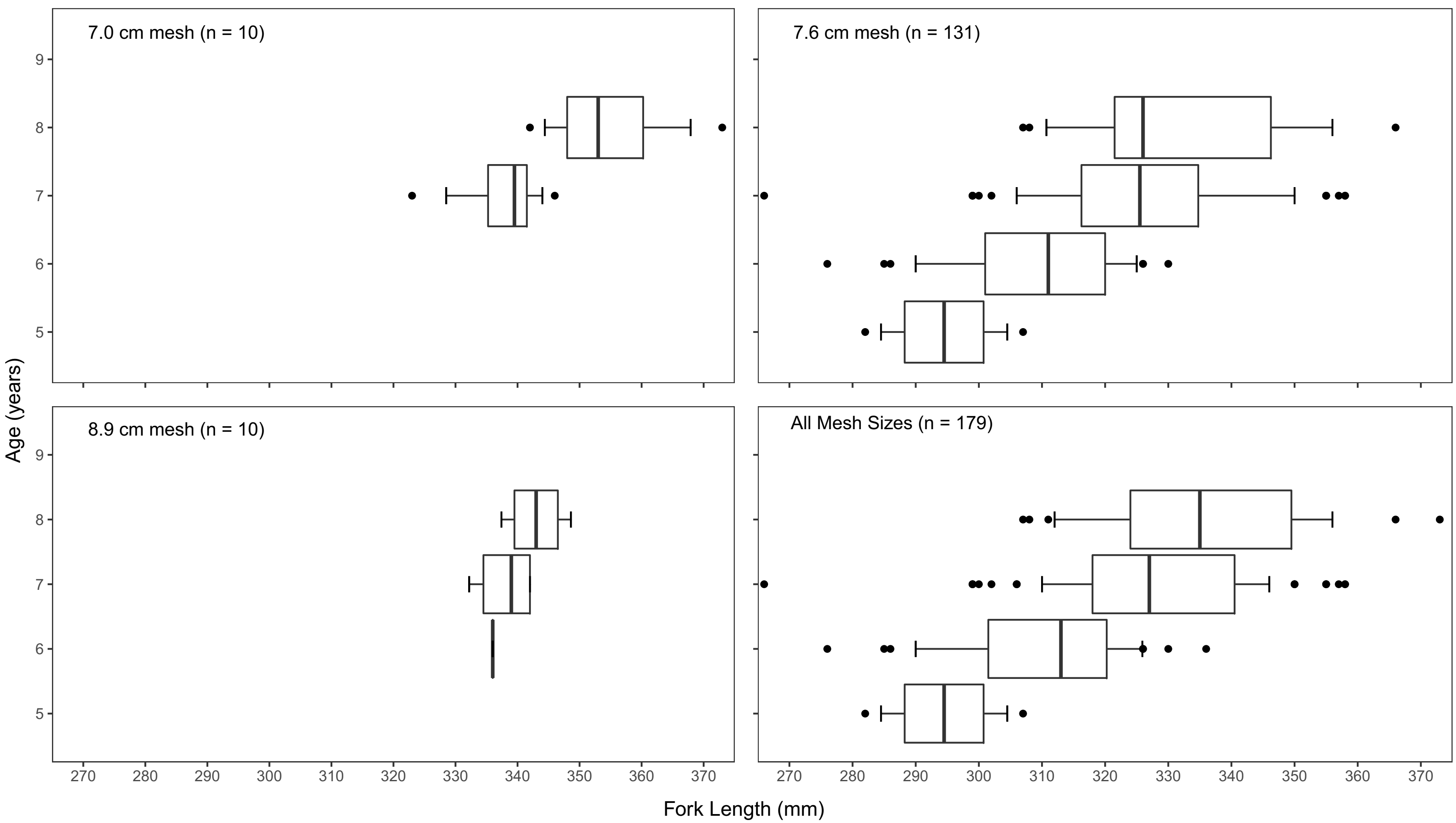

Figure 9. Age-specific length distribution by net mesh size of Arctic Cisco harvested in the fall subsistence fishery, Niġliq Channel, Colville River, Alaska, 2018.

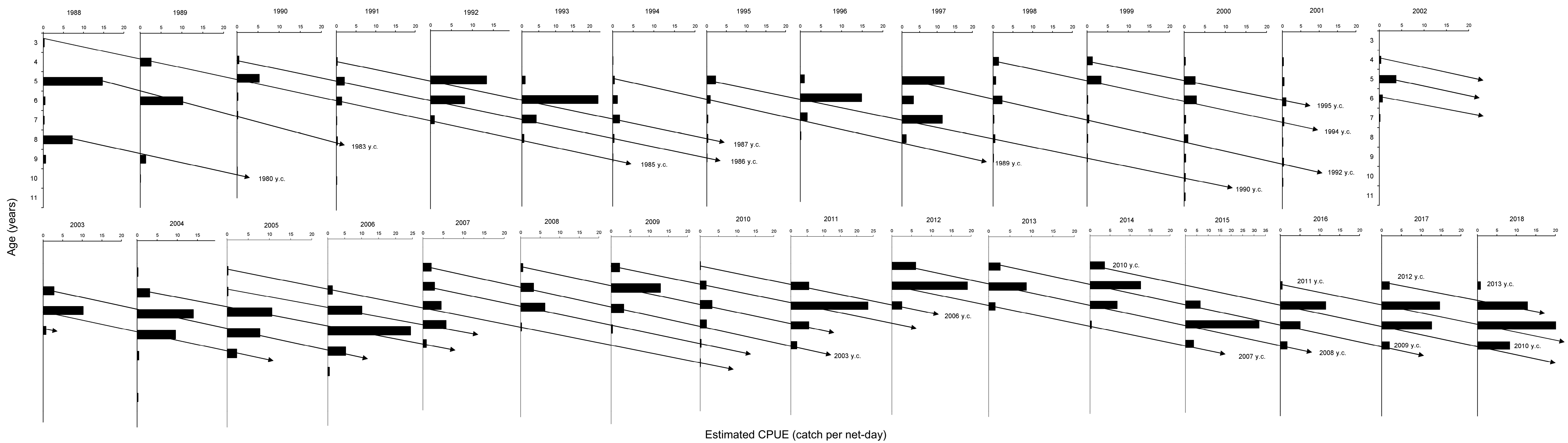

Figure 10. Catch per unit effort of Arctic Cisco by age class in the fall subsistence fishery, Niġliq Channel, Colville River, Alaska,1988–2018.

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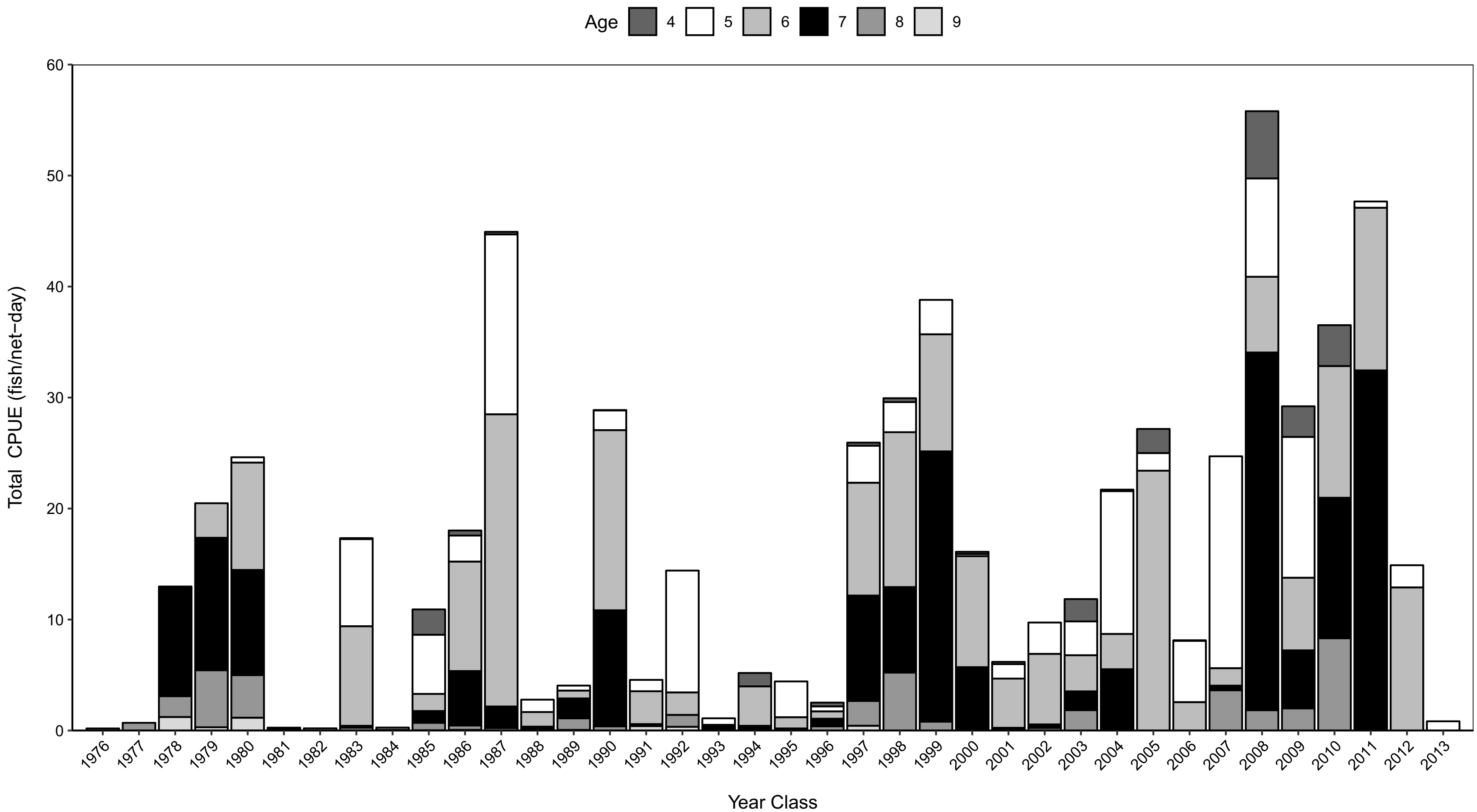

Figure 11. Cumulative catch per unit effort of Arctic Cisco by year class in the fall subsistence fishery, Niġliq Channel, Colville River, Alaska, 1976–2013.

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 (1981–2013).

Year Class	CPUE
1981	0.4
1982	0.2
1983	17.3
1984	0.3
1985	10.9
1986	18.0
1987	44.9
1988	2.8
1989	4.3
1990	29.2
1991	4.7
1992	14.4
1993	1.1
1994	5.4
1995	4.4
1996	2.5
1997	25.9
1998	29.9
1999	38.8
2000	16.1
2001	6.2
2002	9.7
2003	11.8
2004	21.7
2005	27.2
2006	8.1
2007	24.7
2008	55.7
2009	29.1
2010[a]	36.2
2011[a]	47.6
2012[a]	14.9
2013[a]	0.8

[a] Calculation assumes that the 2010–2013 year classes are still contributing to cumulative CPUE.

reached a maximum of 12.2 on 19 November in 2016, the salinity never surpassed 3.3 ppt in 2017 at the 3-m depth mark. Ideal salinity conditions for Arctic Cisco (>15 ppt) were generally present at the 3 downstream stations during most of 2018 survey season at the 3-m depth mark (Stations 2, 3, and 4; Figures 2 and 12). These salinity conditions likely are not harmful to, and may have contributed positively to, the generally high harvests in all parts of the channel in 2018.

Water temperatures were generally higher upstream near Nuiqsut and lower at downstream stations in the delta (Figure 12). However, we did observe a few instances (29 October, 2 November, and 8 November) in which downstream temperatures exceeded upstream temperatures. Otherwise, temperatures at each station increased or decreased relative to one another throughout the season, as is normal. We do not have a clear explanation for these single-day pulses in temperature, though we might speculate that ground water sources downstream or marine waters may have perhaps contributed to the ~1° C increase at those locations.

SUMMARY

Results for the 2018 under-ice fall gillnet fishery in the Nuiqsut area indicate that fishing in 2018 represented one of the most successful efforts for the target species, Arctic Cisco, since harvest monitoring began in the mid-1980s. The estimated CPUE of 57.3 Arctic Cisco per net-day in 7.6-cm mesh nets in 2018 was the highest on record in the Niġliq Channel. The overall success of the fishery was driven by a particularly high catch rate of ~97 fish per-net day in 7.6-cm mesh nets in the Niġliq Delta area of the river. Fishing results were well above the long-term average in other parts of the Niġliq Channel as well, which likely indicates why overall fishing effort was highest in areas adjacent the village, in the Upper Niġliq. Indeed, for many fishers there is little incentive to travel all the way to the delta area on a daily basis if CPUE upstream is sufficiently high for their subsistence needs. The overall "observed" harvest of more than 30,000 fish (all species and all mesh sizes) is also the highest on record and yet another indicator that 2018 was a very successful year for the fall fishery participants. Age and length structure of Arctic Cisco in 2018 indicates larger fish, associated

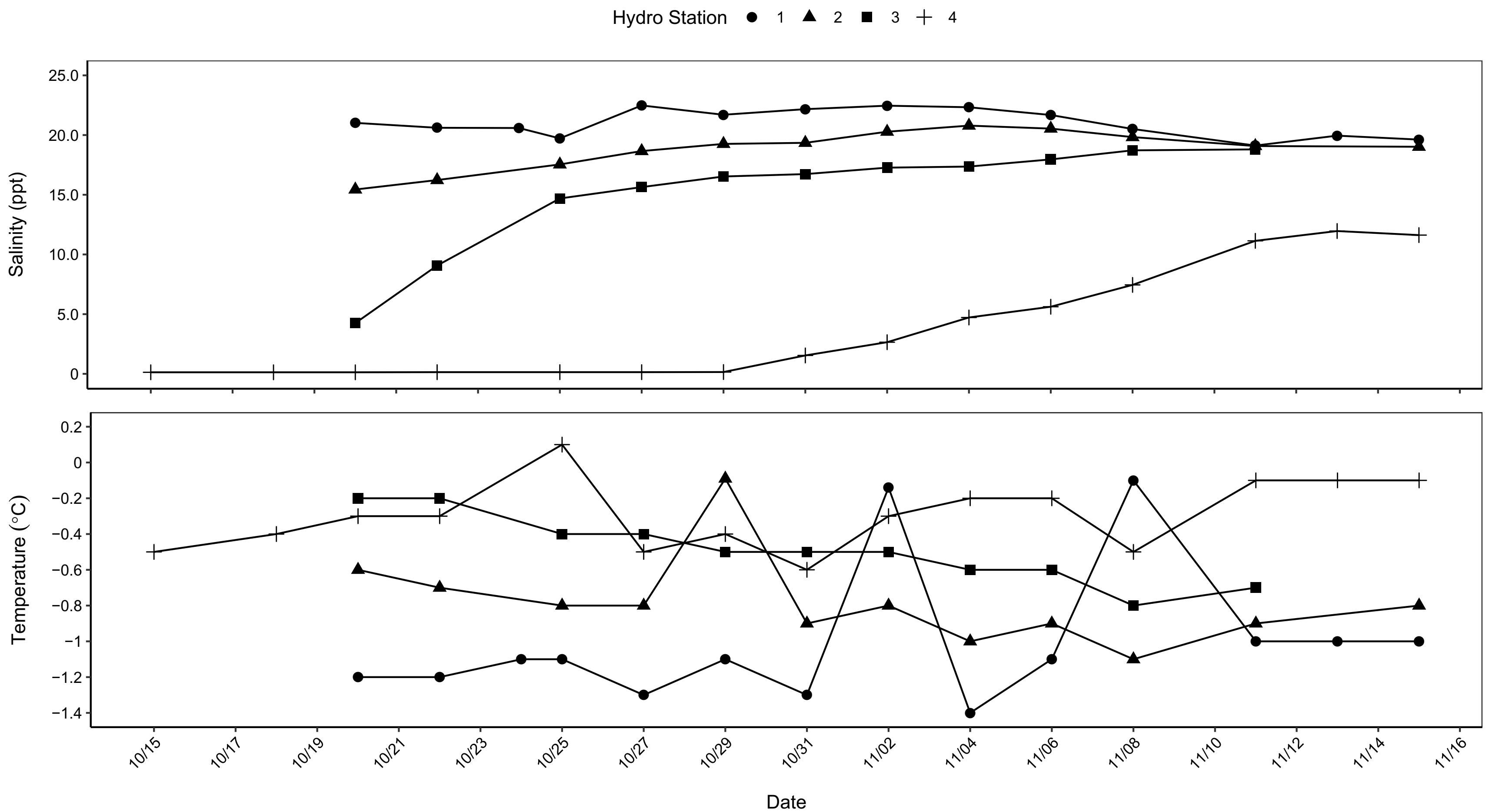

Figure 12. Salinity and temperature measured at 3.0-m depth from 4 water stations on the Niġliq Channel, Colville River, Alaska, 21 October to 20 November 2018.

with age-6 (2012 year class) age-7 (2011 year class) and age-8 (2010 year class) dominated the harvest results. Age-5 (2013 year class) fish were largely absent, raising the question as to whether they will appear in the fishery in larger percentages in 2019, just as the 2010 year class reappeared in 2016 (as age-6 fish) following a low apparent harvest rate in 2015.

We expect Arctic Cisco numbers to decline in the fishery in the near future as young-of-the-year catches in summertime fyke net surveys at Prudhoe Bay have been low in recent years. Least Cisco were caught in low numbers in the fall fishery in the Niġliq Channel again in 2018, but appeared physically healthy. We are interested to see whether Least Cisco harvests increase or decrease in the years to come as Arctic Cisco numbers likely begin to temporarily decline following record high harvests. Because of this, we will increase our focus on whitefish species and Fourhorn Sculpin population dynamics as well in future study years. Overall, it is fair to say that fishers expressed great pleasure with the large harvest rates in 2018.

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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, 2018.

Fisher Code	Fishing Area	Net	Net Code	Length (m)	Stretched Mesh (cm)	Start Date	End Date	Net-days	Adjusted Net-days
11	Upper Nigliq	A	16 11A 1	80	3.5	10/13/2018	10/25/2018	12	16.0
24	Niġliq Delta	A	16 24A 1	100	3	10/20/2018	11/4/2018	15	25.0
25	Nanuq	A	16 25A 1	60	3	10/30/2018	11/10/2018	11	11.0
25	Nanuq	B	16 25B 1	80	3.5	10/31/2018	11/10/2018	10	13.3
25	Nanuq	C	16 25C 1	60	3.5	11/1/2018	11/10/2018	9	9.0
28	Upper Niġliq	A	16 28A 1	80	3	10/17/2018	10/29/2018	12	16.0
31	Upper Niġliq	A	16 31A 1	60	5	10/17/2018	10/18/2018	1	1.0
31	Upper Niġliq	B	16 31B 1	60	3	10/18/2018	10/21/2018	3	3.0
31	Upper Niġliq	B	16 31B 2	60	3	10/21/2018	10/26/2018	5	5.0
31	Upper Niġliq	C	16 31C 1	80	3	10/20/2018	10/26/2018	6	8.0
32	Nanuq	A	16 32A 1	80	3	10/25/2018	11/8/2018	14	18.7
32	Nanuq	B	16 32B 1	80	3	10/25/2018	11/8/2018	14	18.7
42	Upper Niġliq	A	16 42A 1	60	3	10/13/2018	11/21/2018	39	39.0
55	Niġliq Delta	A	16 55A 1	100	2.75	11/4/2018	11/17/2018	13	21.7
56	Upper Niġliq	A	16 56A 1	80	3	10/13/2018	10/23/2018	10	13.3
56	Niġliq Delta	B	16 56B 1	80	3	10/22/2018	11/7/2018	16	21.3
63	Niġliq Delta	A	16 63A 1	80	2.75	10/18/2018	11/4/2018	17	22.7
66	Upper Niġliq	A	16 66A 1	80	3	10/14/2018	10/20/2018	6	8.0
66	Upper Niġliq	B	16 66B 1	60	3	10/14/2018	10/25/2018	11	11.0
70	Nanuq	A	16 70A 1	100	3	10/22/2018	10/28/2018	6	10.0
70	Niġliq Delta	A	16 70A 2	100	3	10/28/2018	11/5/2018	8	13.3
70	Niġliq Delta	B	16 70B 1	90	3	10/28/2018	11/5/2018	8	12.0
72	Upper Niġliq	A	16 72A 1	60	3	10/11/2018	10/26/2018	15	15.0
72	Nanuq	A	16 72A 2	60	3	10/26/2018	11/3/2018	8	8.0
72	Niġliq Delta	A	16 72A 3	60	3	11/3/2018	11/15/2018	12	12.0
72	Niġliq Delta	B	16 72B 1	60	3	11/3/2018	11/8/2018	5	5.0
74	Main Channel	A	16 74A 1	100	3	10/23/2018	10/27/2018	4	6.7
74	Niġliq Delta	A	16 74A 2	100	3	10/27/2018	11/17/2018	21	35.0
74	Main Channel	B	16 74B 1	60	5	10/23/2018	10/26/2018	3	3.0
74	Niġliq Delta	C	16 74C 1	100	3.5	10/28/2018	11/8/2018	11	18.3
74	Niġliq Delta	D	16 74D 1	100	2.5	10/28/2018	11/8/2018	11	18.3
77	Upper Niġliq	A	16 77A 1	80	2.5	10/28/2018	1/1/2019	65	86.7
82	Niġliq Delta	A	16 82A 1	80	3	10/22/2018	11/6/2018	15	20.0
82	Niġliq Delta	B	16 82B 1	100	3	10/23/2018	11/21/2018	29	48.3
87	Upper Niġliq	A	16 87A 1	100	3	10/23/2018	11/12/2018	20	33.3

Appendix A. Continued.

Fisher Code	Fishing Area	Net	Net Code	Length (m)	Stretched Mesh (cm)	Start Date	End Date	Net-days	Adjusted Net-days
93	Upper Niġliq	A	16 93A 1	90	3.5	10/18/2018	10/29/2018	11	16.5
93	Nanuq	B	16 93B 1	70	3.25	10/27/2018	11/3/2018	7	8.2
94	Niġliq Delta	A	16 94A 1	80	3	11/6/2018	11/10/2018	4	5.3
95	Upper Niġliq	A	16 95A 1	80	3	10/13/2018	10/30/2018	17	22.7
100	Upper Niġliq	A	16 100A 1	60	3	10/16/2018	10/31/2018	15	15.0
100	Niġliq Delta	A	16 100A 2	60	3	11/7/2018	11/21/2018	14	14.0
101	Niġliq Delta	A	16 101A 1	40	3.5	10/25/2018	11/10/2018	16	10.7
102	Upper Niġliq	A	16 102A 1	30	2.75	10/14/2018	10/21/2018	7	3.5
107	Upper Niġliq	A	16 107A 1	60	3	10/23/2018	10/31/2018	8	8.0
108	Nanuq	A	16 108A 1	60	3	10/20/2018	10/28/2018	8	8.0
108	Nanuq	A	16 108A 2	60	3	10/29/2018	11/5/2018	7	7.0
110	Main Channel	A	16 110A 1	100	2.5	10/23/2018	10/27/2018	4	6.7
110	Niġliq Delta	A	16 110A 2	100	2.5	10/27/2018	11/2/2018	6	10.0
112	Upper Niġliq	A	16 112A 1	60	3	10/17/2018	10/31/2018	14	14.0
113	Nanuq	A	16 113A 1	60	3	10/20/2018	10/28/2018	8	8.0
114	Upper Niġliq	A	16 114A 1	80	3.25	10/20/2018	10/25/2018	5	6.7
114	Upper Niġliq	A	16 114A 2	80	3.25	10/25/2018	11/4/2018	10	13.3
115	Upper Niġliq	A	16 115A 1	80	3	11/1/2018	11/21/2018	20	26.7
116	Upper Niġliq	A	16 116A 1	60	2.75	10/23/2018	11/1/2018	9	9.0
117	Niġliq Delta	A	16 117A 1	100	3	11/6/2018	11/21/2018	15	25.0
Total									864.83

Appendix B. Estimated harvest of Arctic Cisco from the Colville River delta commercial and subsistence fisheries, 1967–2018.

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
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

Appendix B. Continued.

Year	Estimated Commercial Harvest[a]	Estimated Subsistence Harvest	Estimated Total harvest
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
2017[e]	–	33,247	33,247
2018[e]	–	48,056	48,056
Average	23,383	26,199	33,079

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