FALL 2020 SUBSISTENCE FISHERY MONITORING ON THE COLVILLE RIVER

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Prepared for

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and

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EXECUTIVE SUMMARY

- The fall harvest of Arctic Cisco (*Coregonus autumnalis*), or qaaktaq in Iñupiaq, on the Colville River has been monitored since the mid-1980s in response to concerns that increasing oil and gas development would affect the migrations and feeding behavior of arctic Cisco. This is the 35th year of industry-sponsored harvest monitoring effort of the Colville River fall fishery harvest.
- The 2020 fishery began on 15 October, soon after ice conditions became safe for travel. Total fishing effort in 2020 was 1,130.9 adjusted net-days and was evenly distributed among the three primary fishing areas (Upper Niġliq fishing area, Nanuk fishing area, and Niġliq Delta fishing area). Fishing effort was greater than the previous year, which had been impacted by a warming event that temporarily halted fishing efforts.
- Harvest in the Niġliq Channel was good (11th best on record), with an average of 23.9 fish per net per day. Many fishers remarked on the large size of Arctic Cisco in 2020 harvest efforts, consistent with field and lab measurements of fish size.
- Due largely to good harvest rates and increased fish size compared to recent years in the Niġliq Channel, there was no harvest effort on the Main Channel in 2020.
- We recorded a harvest of 20,517 fish (13 species, all mesh sizes); of those, Arctic Cisco comprised 75.9% and Least Cisco comprised 9.3% of all harvest efforts. Other species included Fourhorn Sculpin, Pink Salmon, Northern Pike, Longnose Sucker, and Dolly Varden.
- As in 2019, the age-7 age class was the most common (41%), although these fish represent a smaller proportion than the previous year (2019, age-7 = 66%). A greater proportion of fish were from the youngest and oldest age classes (age-5 and age-9). Age-9 fish are less common in the fishery than other age classes as Arctic Cisco tend to migrate out of the Colville River by age-9. In general, fishers appeared pleased with the overall size and harvest rate of Arctic Cisco in the 2020 fall harvest efforts.

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INTRODUCTION

ABR, Inc.—Environmental Research & Services (ABR) works with fishery stakeholders in Nuiqsut, Alaska, to monitor the subsistence gillnet fishery in the Niġliq Channel of the Colville River which is conducted each fall after freeze-up (Figures 1 and 2). The monitoring program began in 1985 when the North Slope Borough, in consultation with local fishers 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 temporal trends in fishing effort, 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 to determine monitoring goals. The monitoring effort is supported by Conoco Philips Alaska, Inc. (CPAI) and, as of 2020, Oil Search Alaska (OSA).

The monitoring program has traditionally focused on the fall harvest of Arctic Cisco (Qaaktaq in Iñupiaq; *Coregonus autumnalis*), a whitefish species that is a staple in the diet of Nuiqsut residents and is traded widely with other northern Alaska communities. The program also attempts to quantify harvest of other subsistence and bycatch species captured in the Arctic Cisco fishery. The monitoring program has traditionally fulfilled various agency monitoring stipulations while also providing a long-term dataset that has tracked trends in the fishery over time.

The objectives of the 35th year of the harvest monitoring program were to:

- continue working with fishery participants per agreements made in 2007 (Seigle et al. 2008) to monitor the harvest of Arctic Cisco and other species throughout the fall fishing season;
- record specific fishing effort data (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;
- compare the 2020 results with data from previous years for this program and other historical data, and
- expand monitoring efforts in 2020 to include greater detail on the main channel area of the river.

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 a local fishing expert, Sam Kunaknana. ABR fishery monitors conducted daily interviews of fishers for harvest events from 16 October to 19 November 2020 in Nuiqsut. Additional harvest updates were received via text from S. Kunaknana through 30 November 2020. One fisher continued to harvest in the Upper Niġliq into January 2021, however those additional harvests are not included in this report, but we anticipate publishing the results of his winter fishing in a separate, brief report. For the purposes of this analysis, a harvest event occurred anytime a fisher checked their 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.

Niġliq Channel under-ice fishing nets can vary by length from 18.3–30.5 m (~60–100 ft) and by mesh size 7.6–12.7 cm (3.0–5.0 in). To calculate fishing effort (i.e., net-days), we adjusted the recorded net length and effort to a standardized net length of 18 m and a full-day (24-hour) set duration. For example, if a 24.4 m (80 ft) net was used during a 24-hour period, fishing effort was

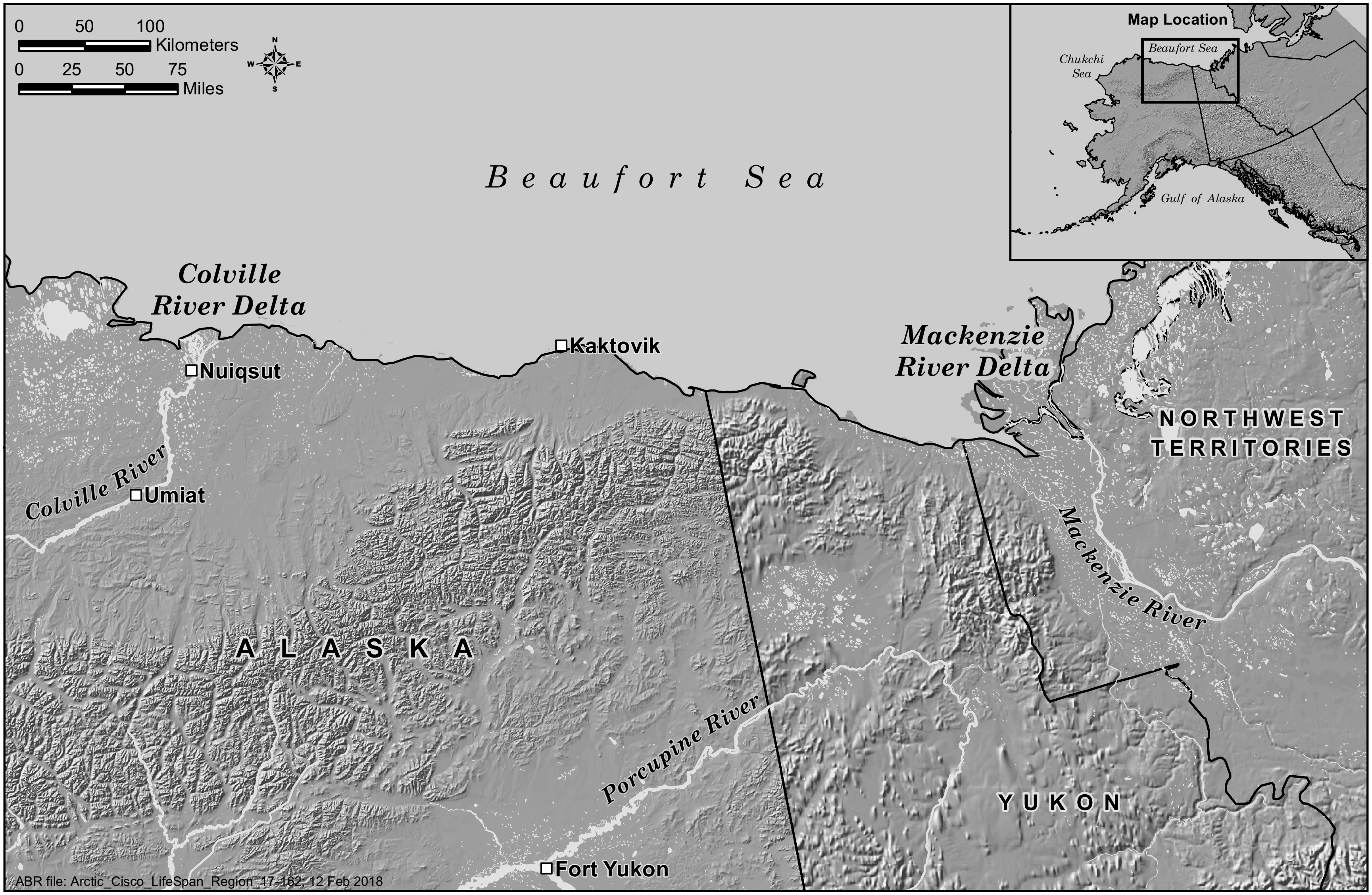

Figure 1. Waters important to the life history of Arctic Cisco in Canada and Alaska and the nearshore Beaufort Sea.

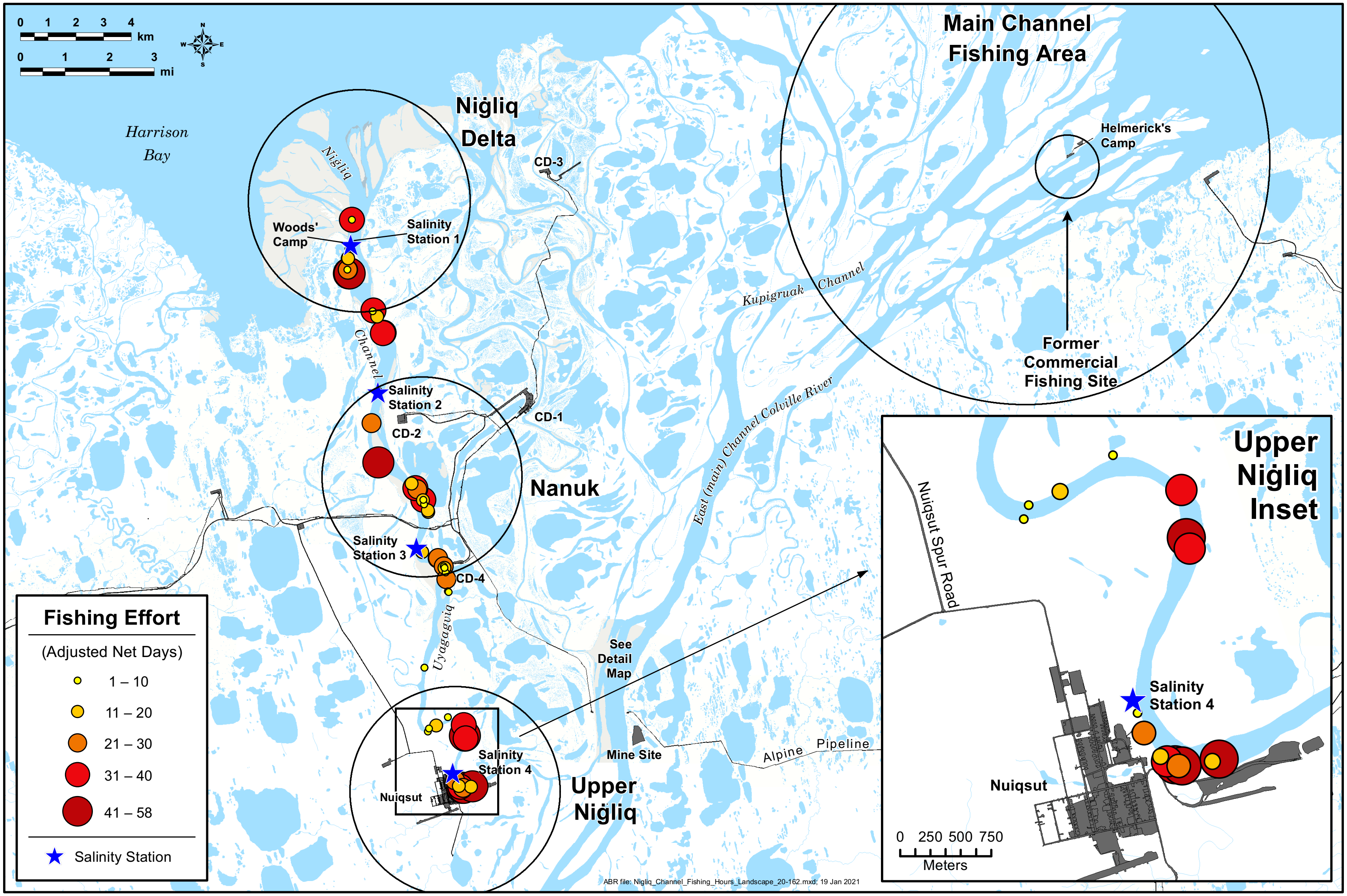

Figure 2. Water sampling stations and net sites in each of the 3 main subsistence fishing areas in the Niġliq Channel of the Colville River, Alaska, 2020.

calculated as 24.4 m/18.3 m × 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 summaries include all mesh sizes combined and when they are limited to the most frequently used mesh size of 7.6 cm.

This monitoring project is similar in many ways to a creel survey (Pollock et al. 1994), in that we are interviewing fishers on their harvests. The main difference in how this survey is conducted versus a traditional creel survey is that we assist fishers directly in many of the harvests, if given permission. During harvest interviews, we asked at least some of the following questions:

- How many nets are you fishing?
- Who else checks your nets?
- 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)?

In practice, the interviews are typically casual. We have come to know fishers well over the years as they have shared their preferred fishing locations, harvest efforts, and general interest in having us assist in harvests. Fishers were typically forthcoming in reporting harvest numbers, even if we did not run into them on the ice during a given harvest event. 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 to interview. 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 share information on their harvest activities and to donate 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 outdoors in secure coolers until they could be 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.

Sagittae otoliths (i.e., hearing stones exhibiting annular growth rings) were extracted and cleaned with tap water and stored in 96-well pipette trays until 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 approximately every other day after the start of on-ice activities at water quality stations over deep water corresponding to areas of concentrated fishing effort (Figure 2). These station locations have been revisited on an annual basis for decades by various harvest monitoring teams. 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 (1.6 ft) depth increments to the river bottom. The monitoring team also measured temperature (°C), dissolved oxygen (mg/L and % saturation), conductivity (µS/cm), pH, and turbidity at a depth of 3 m (9.8 ft) because this is the general depth at which Arctic Cisco are caught.

RESULTS AND DISCUSSION

FISHERY EFFORT AND HARVEST

In 2020, the onset of first ice formation on the Colville River was reported as appearing 8–10 October, with the first net deployment within the Niġliq Channel occurring on 15 October in the Upper Niġliq fishing area (Table 1, Figure 2). ABR scientists arrived on 16 October, the day of the first harvest in the 2020 fall fishery. The monitoring team conducted 328 interviews from 16 October to 18 November, or 115 more interviews than the 213 interviews conducted in 2019 (Table 2). At the time of the non-resident monitoring team's departure from Nuiqsut, 15 nets (11 fishers) were still active. However, the resident monitor collected effort and harvest information to characterize the fishery through 30 November. The last fisher continued to harvest in the Upper Niġliq fishing area of the Niġliq Channel into January 2021, checking his net approximately every 4–5 days during December and January. We excluded those data from analysis due to the inconsistent harvest reports and the relatively small harvests which were reported.

A total of 30 households deployed 47 nets on the Niġliq Channel of the Colville River (Table 2), and 56 net-sets were completed with those 47 nets (Table 2, Figure 3, Appendix A). One of the pre-harvest season goals was to monitor the Main Channel area of the Colville River Delta more consistently. Over the past 14 years, 3–5 fishers typically engaged in subsistence fishing effort in this area of the river each fall and net-sets were shorter in duration (usually no more than 7–10 days) compared to net-sets on the Niġliq Channel. We typically receive some harvest reports from Main Channel fishers, providing a general sense of the results of fishing in that area. We have refrained from sending monitors to the area because that

Table 1. Estimated onset of the fall subsistence fishery for Arctic Cisco in the Niġliq Channel of the Colville River, Alaska, 1985–2020.

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
2019	19 October	13 October
2020	15 October	13 October
Average	9 October	

Table 2. Summary statistics for fall fishing effort in the Colville River delta, Alaska, 2019 and 2020. Values in parentheses are the total number sets for those nets.

	Summary of 2019 Effort	Summary of 2020 Effort
Number of recorded harvest events	213	328
Number of Households	25	30
Number of 5.1 cm (2.0 in) mesh	0	0
Number of 6.4 cm (2.5 in) mesh	1(2)	0
Number of 7.0 cm (2.75 in) mesh	0	0
Number of 7.6 cm (3.0 in) mesh	34 (49)	40 (47)
Number of 8.3 cm (3.25 in) mesh	3 (6)	0
Number of 8.9 (3.5 in) cm mesh	3 (4)	6 (8)
Number of 10.2 (4.0 in) cm mesh	0	0
Number of 11.4 (4.5 in) cm mesh	1(1)	0
Number of 12.7 (5.0 in) cm mesh	0	1 (1)
Number of Nets in Nigliq Channel	41	47
Total Number of Nets	42	47
Average Nets/Household	1.68	1.57
Net sets in Upper Nigliq	24	17
Net sets in Nanuk	11	23
Net sets in Nigliq Delta	26	16
Net sets in Main Channel	1	0
Total number of sets	62	56
Adjusted net days 5.1 cm mesh nets	–	–
Adjusted net days 6.4 cm mesh nets	28.3	–
Adjusted net days 7.0 cm mesh nets	–	–
Adjusted net days 7.6 cm mesh nets	762.0	992.0
Adjusted net days 8.3 cm mesh nets	53.3	–
Adjusted net days 8.9 cm mesh nets	68.3	137.3
Adjusted net days 10.2 cm mesh	–	–
Adjusted net days 11.4 cm mesh	6.7	–
Adjusted net days 12.7 cm mesh	–	1.6
Adjusted net days by Upper Nigliq	452.7	412.6
Adjusted net days by Nanuk	85.3	375.3
Adjusted net days by Nigliq Delta	379.3	343.0
Adjusted net days by Main Channel	1.3	0.0
Total adjusted net days	918.6	1130.9

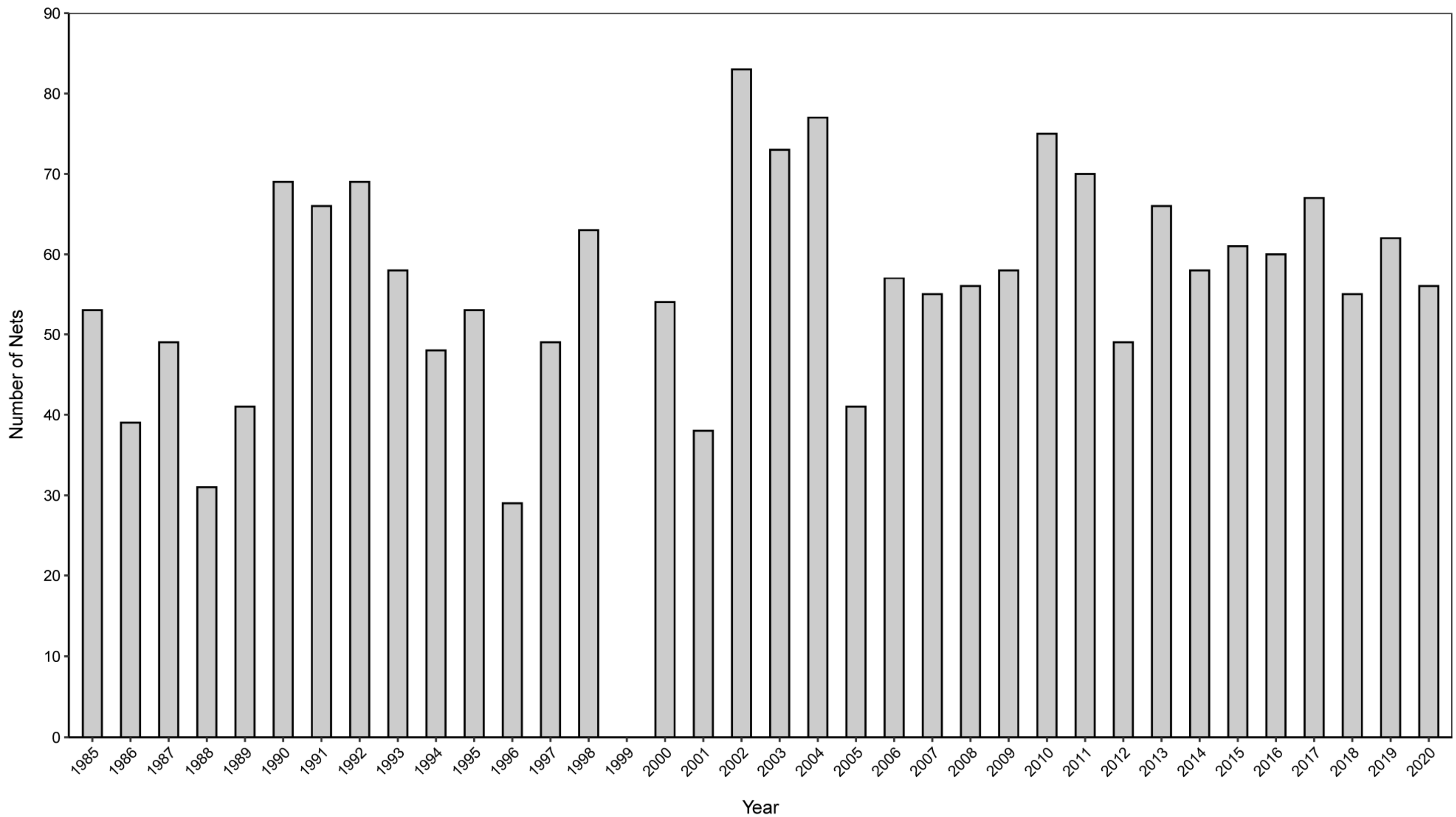

Figure 3. Number of nets deployed annually in the fall subsistence fishery for Arctic Cisco, Colville River, Alaska, 1985–2020.

would take away from resources in the Niġliq Channel which is much more heavily fished, but also because it is difficult to predict when fishers will travel to their nets in the Main Channel area. Working with OSA, we devised a plan to travel with specific fishers to the Main Channel in 2020. However, for the first time since 2009, there was no fall subsistence fishing activity in the Main Channel area of the Colville River Delta, largely due to successful fishing in the Niġliq Channel.

Overall, the 2020 fall fishing effort was greater than in 2019, both in terms of household participation (30 versus 25 households) and net deployments (47 versus 41 deployments), although there was a reduction in total net-sets (i.e., setting nets and then resetting in different locations) of these individual nets in 2020 (56 nets) compared to 2019 (62 nets). In 2019, a warming event caused melting and unsafe ice conditions, which led many fishers to pull nets for a few days before resetting them after ice conditions improved. No such significant warming event occurred in 2020, resulting in fewer net-sets.

We estimated 1,130.9 net-days of fishing effort in the Niġliq Channel in 2020 (Table 2, Appendix A). Total Niġliq Channel fishing effort in 2020 was 213.6 net-days more than in 2019 (917.3 net-days in the Niġliq Channel). Three net-mesh sizes were deployed by fishers in 2020, but as is common in the fishery over the years, the most frequently used mesh size was 7.6 cm (992.0 adjusted net-days), followed by 8.9-cm mesh nets (137.3 net-days), and a single 12.7-cm mesh net (1.6 net-days) (Table 2). The 12.7-cm mesh net is normally deployed by fishers in summer months when targeting much larger Broad Whitefish (Aanaakłiq; *Coregonus nasus*) and Pacific salmon (*Salmonidae* spp.). This single net was set by accident by a new fisher and removed the following day after no fish were harvested. In the Niġliq Channel, most of the fishing effort took place in the Upper Niġliq fishing area (412.6 net-days, 36.5%), followed by the Nanuk fishing area (375.3 net-days, 33.2%) and the Niġliq Delta (343.0 net-days, 30.3%). Fishing effort was more evenly distributed between fishing areas in 2020 than in most previous years. Fishing effort in the Nanuk area was 3.4 times higher than in 2019 (Table 2, Figure 4).

A total of 15,406 Arctic Cisco were recorded from nets of a known mesh size and known fish duration during the 2020 fall fishery (Table 3). These harvest records informed calculation of Arctic Cisco CPUE by each mesh size. The total estimated average CPUE for 7.6-cm nets in the Niġliq Channel (all fishing areas combined) was 23.9 fish per net-day, which was higher than the 2019 average CPUE of 19.5 fish per net-day and higher than the long-term average CPUE (19.6 fish per net-day; 95% CI = 15.3–24.0 fish per net-day) (Table 4, Figures 5 and 6). For individual fishing areas, harvest rates (CPUE) were highest in the Niġliq Delta fishing area (41.1 fish per net-day), followed by the Nanuk area (18.4 fish per net-day), and then the Upper Niġliq fishing area (10.1 fish per net-day) (Tables 3 and 4). The long-term average CPUE for 7.6-cm mesh nets in these fishing areas is 9.1 fish per net-day (95% CI = 6.9–11.2 fish per net-day) in the Upper Niġliq, 17.0 fish per net-day (95% CI = 13.3–20.7 fish per net-day) in the Nanuk area, and 30.5 fish per net-day (95% CI = 22.5–38.5 fish per net-day) in the Niġliq Delta.

We calculated CPUE estimates from all other mesh sizes for each main fishing area, multiplied those estimates by the number of net-days total and added them to similar estimates for 7.6 cm mesh nets to calculate a total estimated harvest for the season. Average CPUE calculated from recorded harvests in 8.9-cm (3.5-in) mesh was 16.7 fish per net-day in the Upper Niġliq area, 24.9 fish per net-day in the Nanuk area, and 25.5 fish per net-day in the Niġliq Delta area (Table 3). Using these CPUE calculations from both mesh sizes, we estimated a total harvest of 27,128 Arctic Cisco in 2020 (Table 5). This number represents an increase in harvest of almost 10,000 fish compared to 2019 (estimated harvest = 17,544), but is a 15% decrease in harvest over the long-term average of 32,666 Arctic Cisco (95% CI = 27,795–37,537; Appendix B) since the inception of harvest monitoring in 1985.

A total of 13 species were recorded during the 2020 fall fishery, 4 more species than were recorded in 2019 (Table 6). However, among these species Pink Salmon (Amaqtuuq; *Oncorhynchus gorbuscha*; *n* = 1), Northern Pike (Siulik; *Esox lucius*; *n* = 1), Longnose Sucker (Milugiaq; *Catostomus catostomus*; *n* = 1), and Dolly Varden

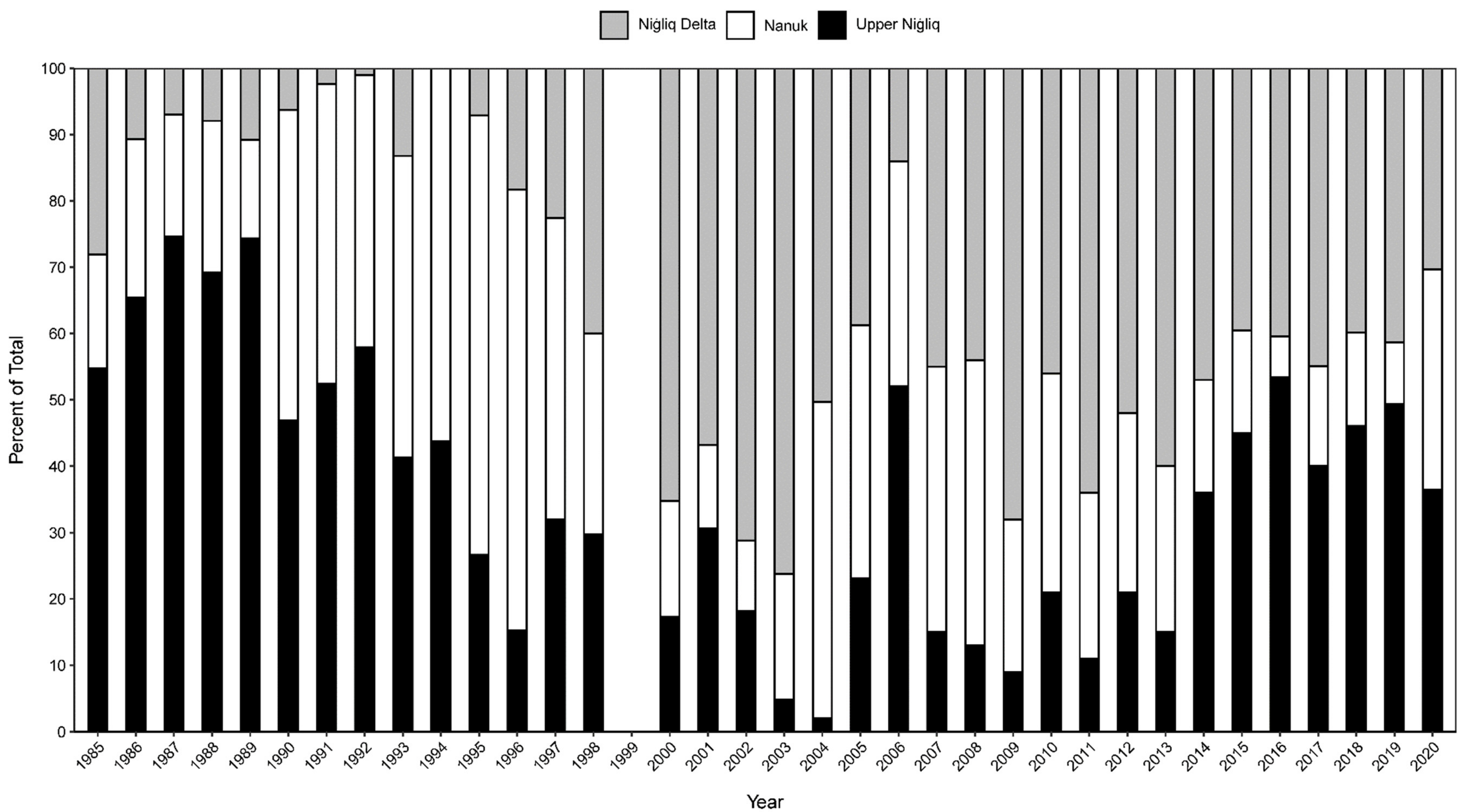

Figure 4. Percent of annual fishing effort in each of 3 Niġliq Channel fishing areas, Colville River, Alaska, 1985–2020.

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 area and in the Main Channel fishing area by mesh size, Colville River, Alaska, 2020.

	Summary of 2019 Effort	Summary of 2020 Effort
Number of recorded harvest events	213	328
Number of Households	25	30
Number of 5.1 cm (2.0 in) mesh	0	0
Number of 6.4 cm (2.5 in) mesh	1(2)	0
Number of 7.0 cm (2.75 in) mesh	0	0
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Adjusted net days by Nanuk	85.3	375.3
Adjusted net days by Nigliq Delta	379.3	343.0
Adjusted net days by Main Channel	1.3	0.0
Total adjusted net days	918.6	1130.9

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, 1986–2020. Catch and effort data are for 7.6 cm mesh gillnets standardized to 18 m length.

	Upper Nigliq			Nanuk			Nigliq Delta			Total Nigliq 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 4. Continued.

Year	Upper Nigliq			Nanuk			Nigliq Delta			Total Nigliq 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
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
2019[a]	2,225	182.3	12.2	1,059	30.6	34.6	2,970	108.0	27.5	6,254	320.9	19.5
2020[a]	2,011	198.3	10.1	2,864	155.3	18.4	8,530	207.3	41.1	13,405	560.9	23.9
Total[b]	1,031	92	9.0	1,573	99	16.9	4,121	154.0	30.1	6,725.6	344.4	19.5

[a] Upper Nigliq catch and effort values include fish and net data from the Uyagagviq area (Area 630).
[b] Denotes average CPUE from 1986–2020.

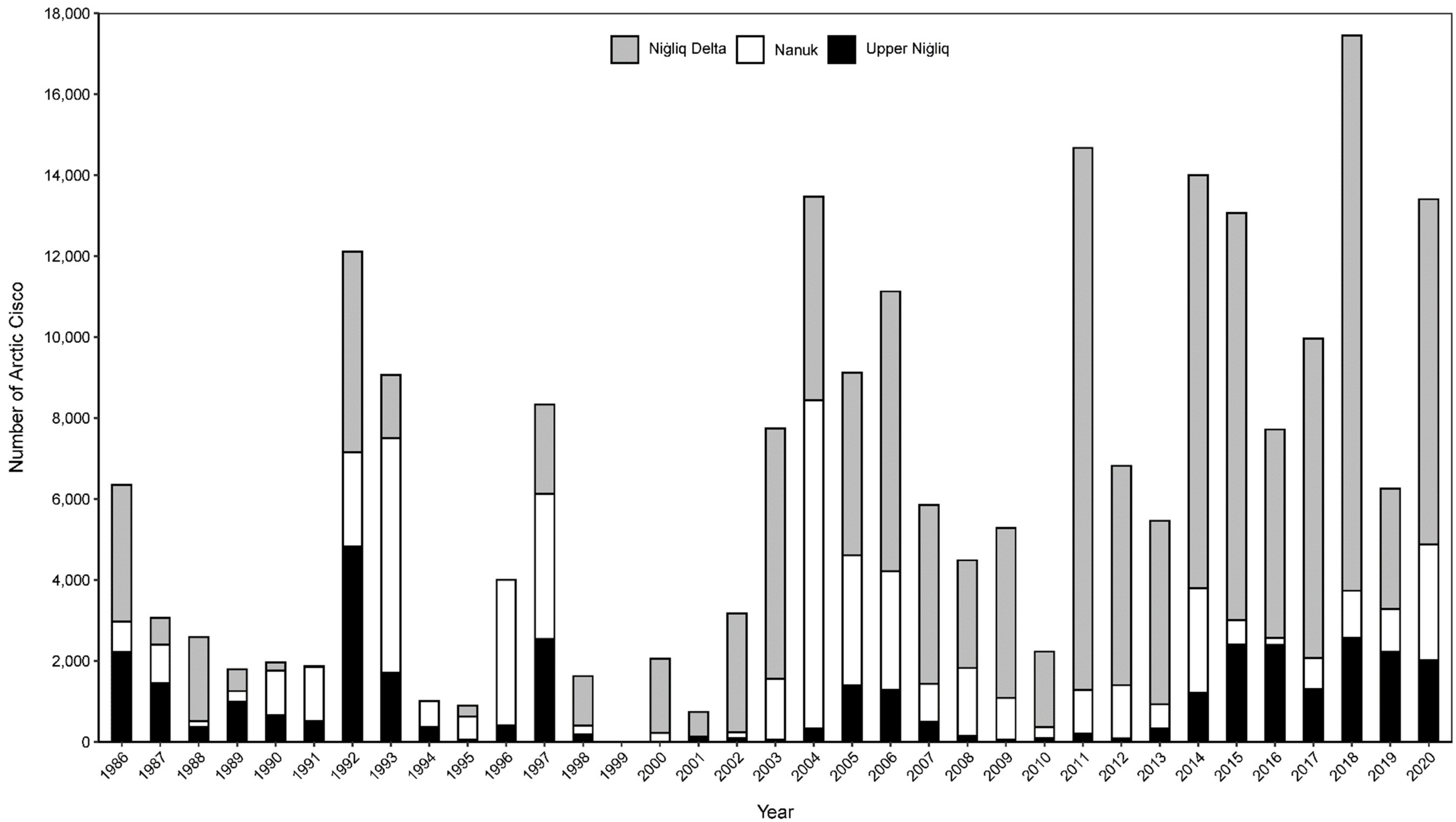

Figure 5. The observed number of Arctic Cisco harvested in 7.6-cm mesh nets in each of 3 Niġliq Channel fishing areas, 1986–2020.

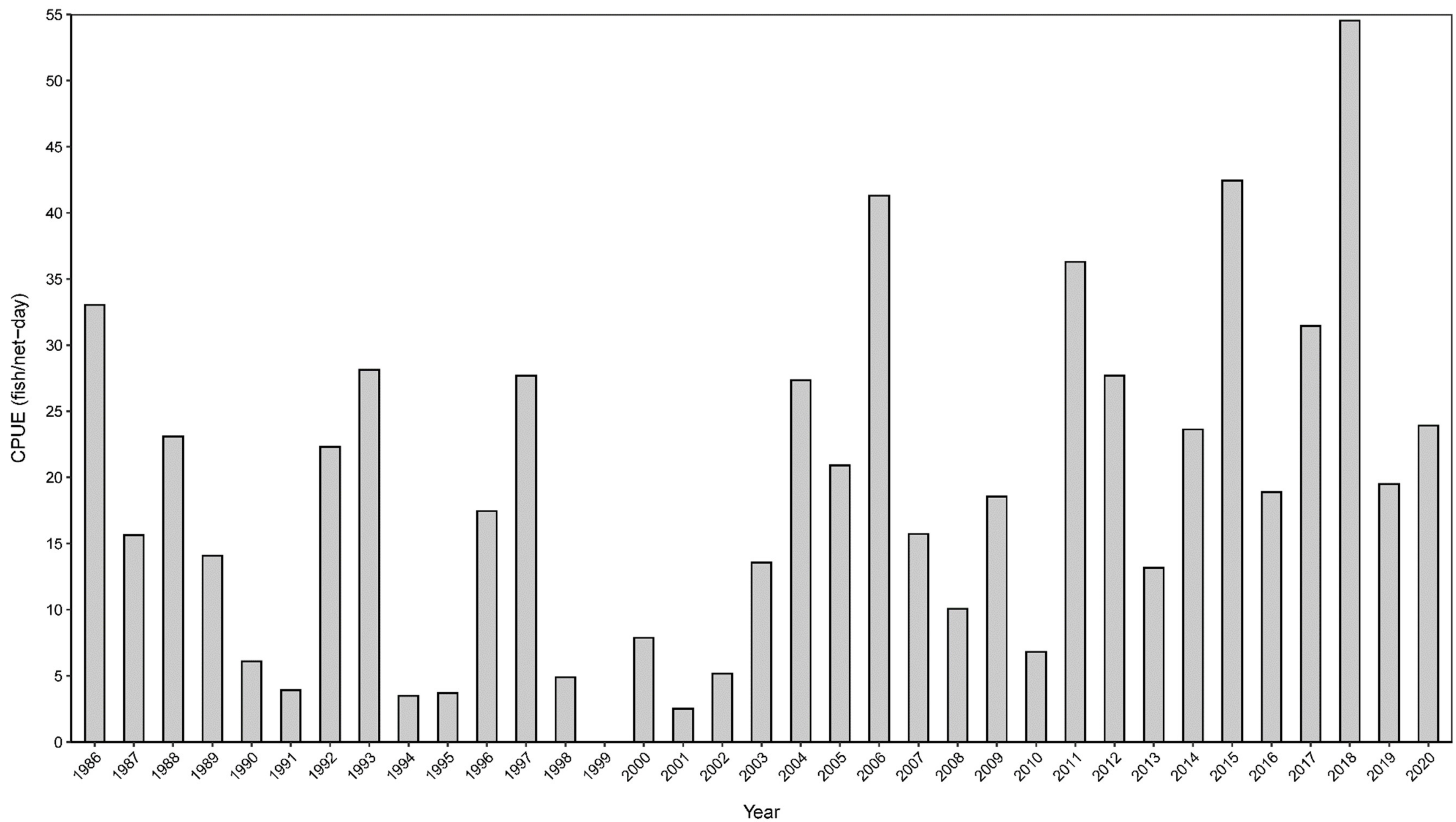

Figure 6. Catch per unit effort of Arctic Cisco in 7.6-cm mesh gill nets, Niġliq Channel, Colville River, Alaska, 1986–2020.

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, 2020.

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	–	–	–	–	–	–	–
7.0	–	–	–	–	–	–	–
7.6	992.0	23.9	23,709	0.0	0.0	0.0	23,709
8.3	–	–	–	–	–	–	–
8.9	137.3	24.9	3,419	0.0	0.0	0.0	3,419
10.2	–	–	–	–	–	–	–
11.4	–	–	–	–	–	–	–
12.7	–	–	–	–	–	–	–
		Total	27,128			0.0	27,128

(Iqalukpik; *Salvelinus malma*; *n* = 1) are rarely caught during the fall fishery, probably in part due to the smaller mesh sized used to target Arctic Cisco. If we include all fish reported to us but that could not be associated with a specific mesh size or known fishing effort, a total of 20,517 fish were recorded by harvest monitors during interviews in 2020. Arctic Cisco was the dominant harvest species (15,575 fish, 75.9% of harvest), followed by Fourhorn Sculpin (Kanayuq; *Myoxocephalus quadricornis*) (2,138 fish, 10.4% of harvest), Least Cisco (Iqalusaaq; *Coregonus sardinella*) (1,913 fish, 9.3% of harvest), Humpback Whitefish (Pikiktuuq; *Coregonus pidschian*) (757 fish, 3.7% of harvest), Broad Whitefish (62 fish, 0.3% of harvest), Rainbow Smelt (Iłhuaġniq; *Osmerus mordax*) (33 fish, 0.2% of harvest), Saffron Cod (Uugaq; *Eleginus gracilis*) (27 fish, 0.1% of harvest), Burbot (Tittaaliq; *Lota lota*) (6 fish, <0.1% of harvest), and (as stated above) 1 fish each of Pink Salmon, Northern Pike, Longnose Sucker, and Dolly Varden (<0.1% of harvest).

LENGTH, WEIGHT, AND AGE OF CATCH

ABR measured a sub-sample of 674 Arctic Cisco and 156 Least Cisco at nets during 2020. Arctic Cisco ranged in length from 286 mm to 397 mm with a mean of 351 mm; 95% CI 349–352 mm) and a median of 352 mm (Figure 7). The middle 50% of fish ranged from 340 mm to 363 mm, which was larger than fish measured in recent years; 2019 (334–356 mm), 2018 (329–353 mm), 2017 (315–336 mm), 2016 (312–339 mm), and 2015 (315–339 mm). In 2020, the harvest of fish that were larger than typical was noticeable to all and a frequent topic of conversation among fishers and monitors on the ice. Fish were also heavier at a given length when compared to previous years (Figure 8). The relationship between fish length and weight can be calculated using the allometric growth equation, $W = a*L^b$, where W = fish weight (g), *a* is the y-intercept, L = total fish length (mm), and *b* is the allometric growth coefficient (Froese 2006; Figure 8). The allometric growth coefficient (*b*) characterizes the relationship between fish length and weight, with a larger value indicating heavier fish at a given length. In 2020, the allometric growth coefficient (*b*) was the second largest since 2009 ($b = 3.355$), indicating fish in good condition. Arctic Cisco length and weight were strongly correlated ($R^2 = 0.8468$; 7.6-cm mesh).

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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, 1985–2020. 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	<0.01	0	0.2	<0.01	0	7.5	0	30,569
2019	73.9	0	13.1	1.0	2.1	0	0.4	0	0	0	0.3	0.2	0	9	0	10,399
2020	75.9	0	9.3	0.3	3.7	0	0.2	0	<0.01	<0.01	0.1	<0.01	0	10.4	<0.01	20,517

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

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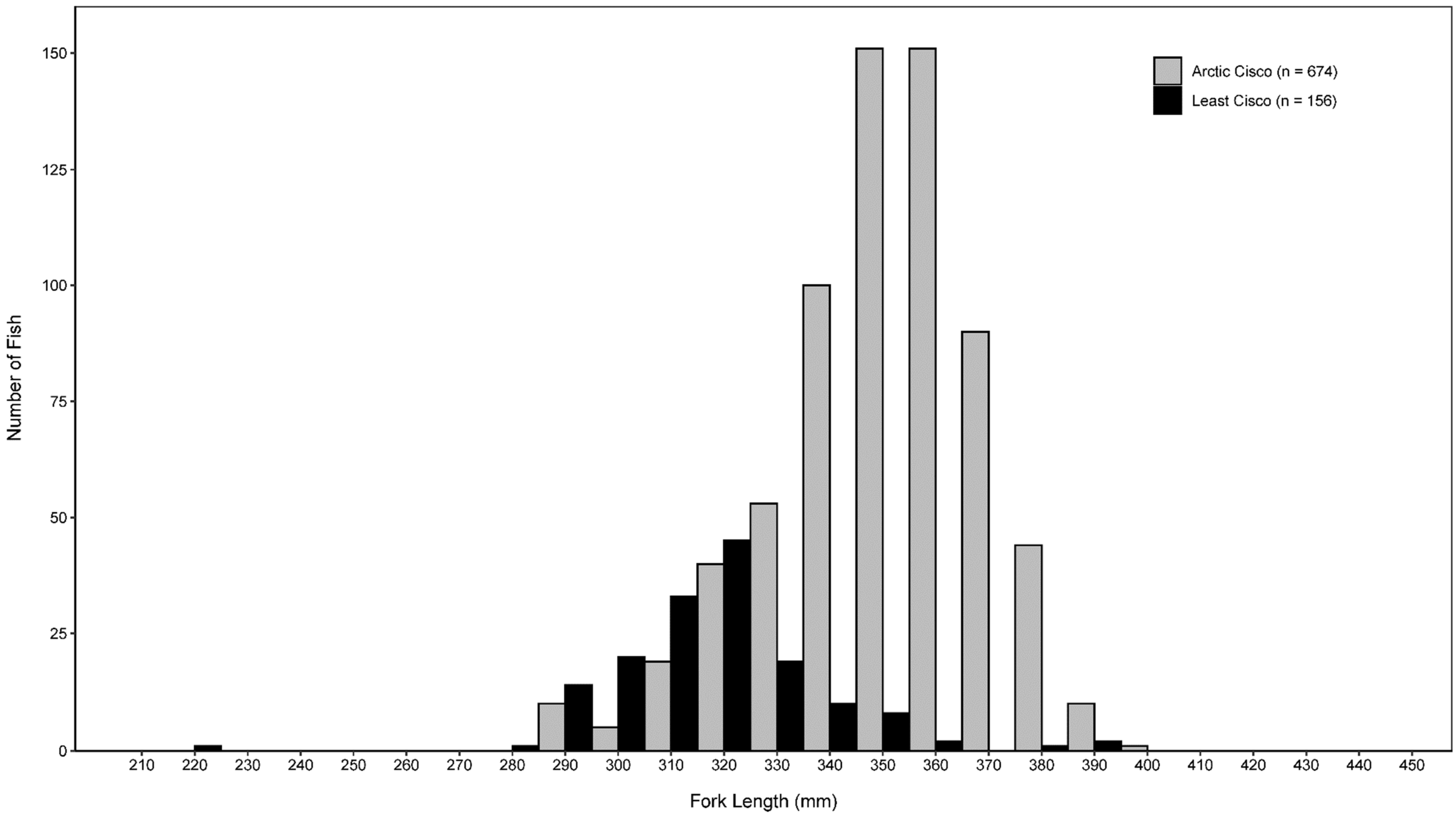

Figure 7. Length frequency of Arctic Cisco captured in all mesh sizes in the fall subsistence fishery, Niġliq Channel, Colville River, Alaska, 2020.

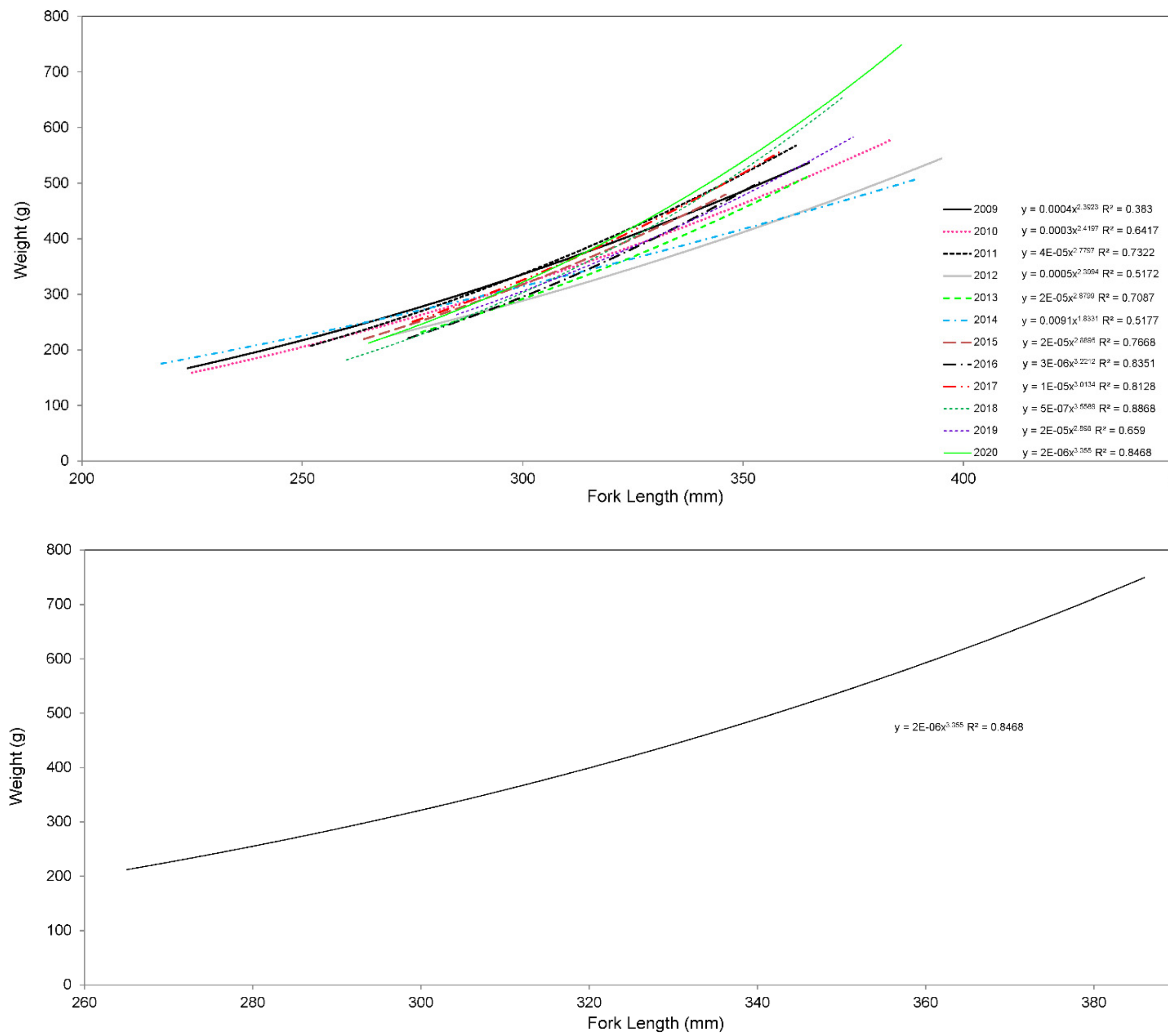

Figure 8. Length-weight regression for Arctic Cisco captured in 7.6-cm mesh nets in the fall subsistence fishery, Niġliq Channel, Colville River, Alaska, by year (upper panel) and for all years pooled (lower panel), 2009–2020.

In most years, a small group of fishers will make initial attempts at achieving their harvest goals by deploying nets in the Niġliq Channel early in the fall fishing season. If those same fishers are not satisfied with their harvest results (i.e., number or size of fish) in a given year, they may move their nets to the Main Channel area where there is very little fishing pressure. A risk of fishing in the Main Channel area is that it is considerably farther from Nuiqsut than the Niġliq Channel, with no guarantee of desired results. However, by setting their nets in the Main Channel area, fishers hope to catch more and larger Arctic Cisco, thereby justifying the longer traverse and expenditure of fuel resources. During 2020, we were told by at least two fishers that the large size and sufficient harvest numbers caught in the Niġliq Channel rendered fishing in the Main Channel unnecessary.

Least Cisco ranged from 216 mm to 387 mm with an average of 318 mm (95% CI = 314–321 mm) and a median of 318 mm. This is smaller than Least Cisco caught in 2019, which ranged from

265 mm to 408 mm with an average of 326 mm (95% CI = 320.9–330.1 mm) and a median of 323 mm, but similar in length to Least Cisco caught in 2018, which ranged 190 mm to 400 mm with an average of 321 mm (95% CI = 316.7–324.6) and a median of 319 mm. The middle 50% of Least Cisco measured in 2020 ranged from 307–327 mm, 307–341 in 2019, and 305–332 mm in 2018. During the 2020 field surveys, we received 203 Arctic Cisco and 44 Least Cisco. In addition to providing length and weight data for analysis of fish condition (above), the otoliths from these fish allowed us to compare provide a snapshot of the age structure for the fishery and to compare age with fish size. These fish were caught in all parts of the river using 7.6-cm and 8.9-cm mesh nets. Most (n = 173) of the otoliths sampled for Arctic Cisco came from fish caught in 7.6-cm mesh nets.

For all net mesh sizes used in the fishery, fish ranged in age from 5 to 9 years, with an age composition of 3.9%, age-5; 26.1%, age-6; 43.8%, age-7; 23.2%, age-8; and 3.0%, age 9. In 7.6 cm-mesh alone, Arctic Cisco fish age composition was similar to aggregate net composition, ranging in age from 5 to 9 years with 4.6%, age-5; 27.8%, age-6; 41.0%, age-7; 23.7%, age-8; and 2.9%, age-9. As might be expected for fish not yet sexually mature, fork lengths generally increased as a function of age (Figure 9). All the Least Cisco that were analyzed for age were caught in 7.6-cm

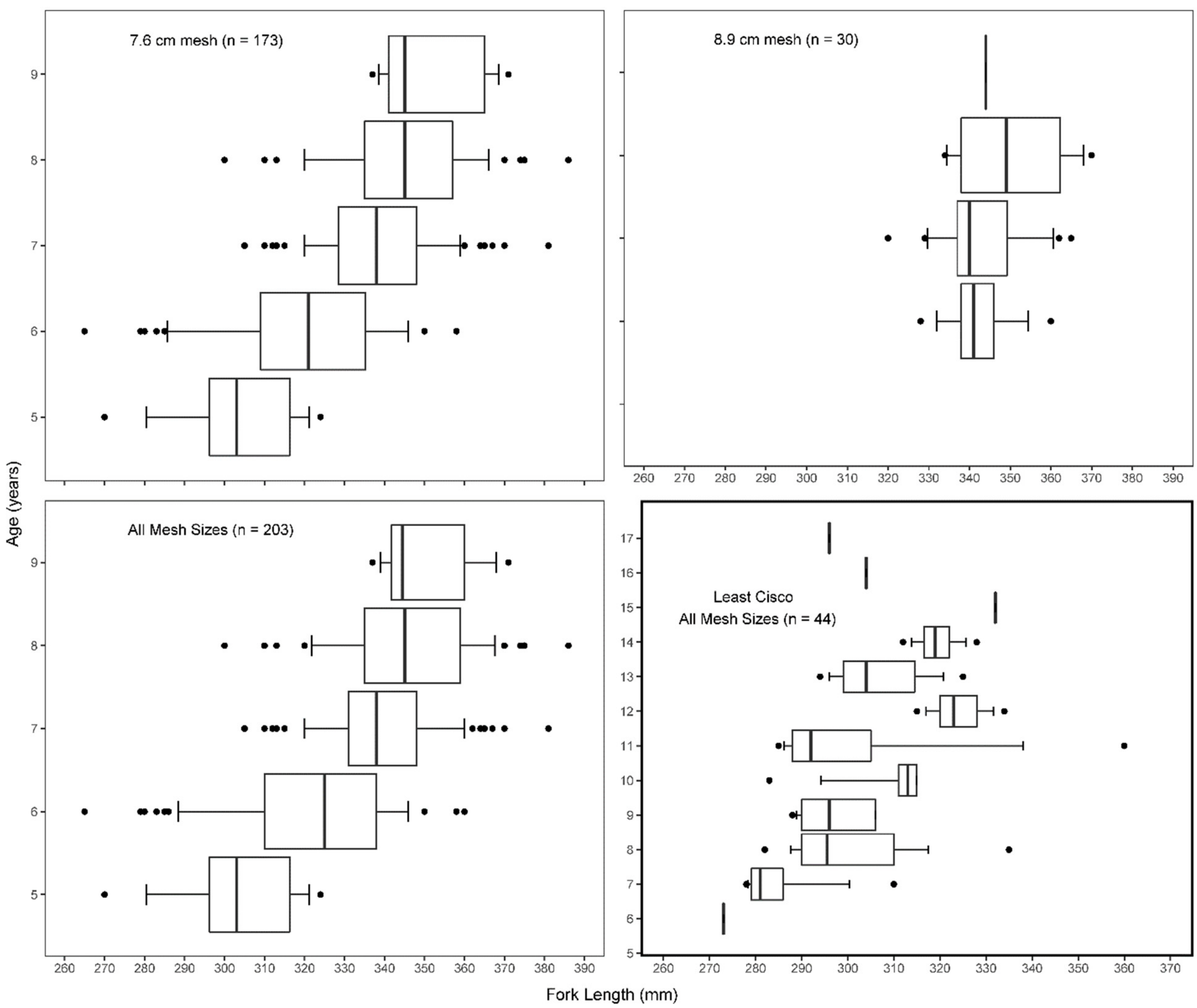

Figure 9. Age-specific length distribution by mesh size of Arctic Cisco and Least Cisco (bottom right) harvested in the fall subsistence fishery, Niġliq Channel, Colville River, Alaska, 2020.

mesh nets and ranged from 6 to 17 years of age (Figure 9). Unlike Arctic Cisco that out-migrate from the Colville River prior to maturation, some Least Cisco harvested in the Colville River fall fishery were mature, as this species reaches maturity between 3 to 8 years of age (Mecklenburg et al. 2002, Brown et al. 2012).

We estimated an age-specific CPUE by applying the percentages for age-composition of Arctic Cisco to the overall CPUE of 23.9 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 calculated an estimate of 1.1 age-5 fish per net-day, 6.7 age-6 fish per net-day, 9.7 age-7 fish per net-day, 5.7 age-8 fish per net day, and 0.7 age-9 fish per net day (total = 23.9 fish per net-day; Table 4, Figure 10). The majority of Arctic Cisco caught in 7.6-cm mesh nets in 2020 represented the 2012–2015 hatching year class (i.e., fish that were 5–8 years of age). Interestingly, we detected a small contribution from the 2011 year class (age-9 individuals) to the Colville River Fall fishery. In 2019, all age-9 individuals (2010 year class) had apparently out-migrated from the Colville River system to return and spawn to the Mackenzie River system. Occasionally, we detect age-9 fish remaining in the Colville River. It is likely that they are present in small numbers annually, but we do not detect them every year. Our estimates indicate that more than a quarter of Arctic Cisco were age-8 or age-9. As age correlates well with size in the fishery, it is reasonable to assume that the larger fish that harvesters were seeing in 2020 were often older fish.

Based on our age readings for the 2020 survey samples, the estimated CPUE of 5.7 age-8 fish per net-day (7.6 cm-mesh), has increased the overall contribution of the fish per net-day for the 2012 cohort to a total of 34.2 fish per net-day since 2016 (representing age-5, age-6, age-7, and age-8 fish). We assume that 2020 is the likely the last year that fish from the 2012 cohort will contribute meaningfully to harvests in the Colville River Fall fishery. It is possible that a small number of age-9 individuals will remain in the system, as we saw in 2020, but the majority of those fish will begin migrating back to spawning grounds in the Mackenzie River system during the summer and fall of 2021, never to return to Alaskan waters.

The 2014 cohort was nearly absent in 2019 as age-5 fish (Forster and Seigle, 2020) but recruited to the fishery in 2020 as age-6 fish. An absence of age-5 fish in fishery harvest that appear in subsequent years is not uncommon (Seigle et. al, 2019), and suggests that age-5 fish in 2019 may not have been available to the fishery because they were not present in the fished areas of the Niġliq Channel, or because they were smaller fish, which passed through the standard 7.6 cm gillnet mesh. The estimated cumulative total CPUE for the year classes after 2012 is currently 13.5 fish per net-day for 2013 (representing age-5, age-6, and age-7 fish), 6.8 fish per net-day for 2014 (age-5 and age-6 fish), and 1.1 fish per net-day for 2015 (age-5 fish) (Table 7, Figure 11).

A relevant question for Nuiqsut fishers is why harvested fish were larger in 2020 than in previous years? First, larger fish suggests better individual fish condition for some, or all age classes in the fishery, where average individuals are heavier at a given length when compared to previous years. Indeed, the 2020 Arctic Cisco fishery comprised the heaviest fish at length recorded since 2009 (Figure 8). Additionally, larger fish observed in the 2020 fishery may indicate that a greater proportion of older fish, which tend to be larger, are being harvested (Figure 9). The proportion of older fish (age-8 and age-9) was greater in 2020 (26.6%) compared to 2019 (18.1%; Forster and Seigle, 2020). However, the 2020 harvest also had a greater proportion of young fish when compared to 2019 (32.3% of age-5 and age-6 fish in 2020, compared to 15.2% age-5 and age-6 fish in 2019 (Forster and Seigle, 2020). Finally, overall greater fish size in 2020 may have occurred because fish are longer at a given age. In the 2020 fall fishery, age-6 and age-7 age average length-at-age was larger in 2020 than in 2019, although the difference was only statistically significant for age-7 (Student's t-test, $p>0.01$). Age-8 fish showed no difference in average length-at-age between 2019 and 2020 (age-5 and age-9 not tested due to low sample size). All of the factors above, combined with emergence of the 2014 year class (age-5 in 2019, age-6 in 2020) in the 2020 fishery may explain why Arctic Cisco size range seemed notably larger to fishers and observers compared to recent years.

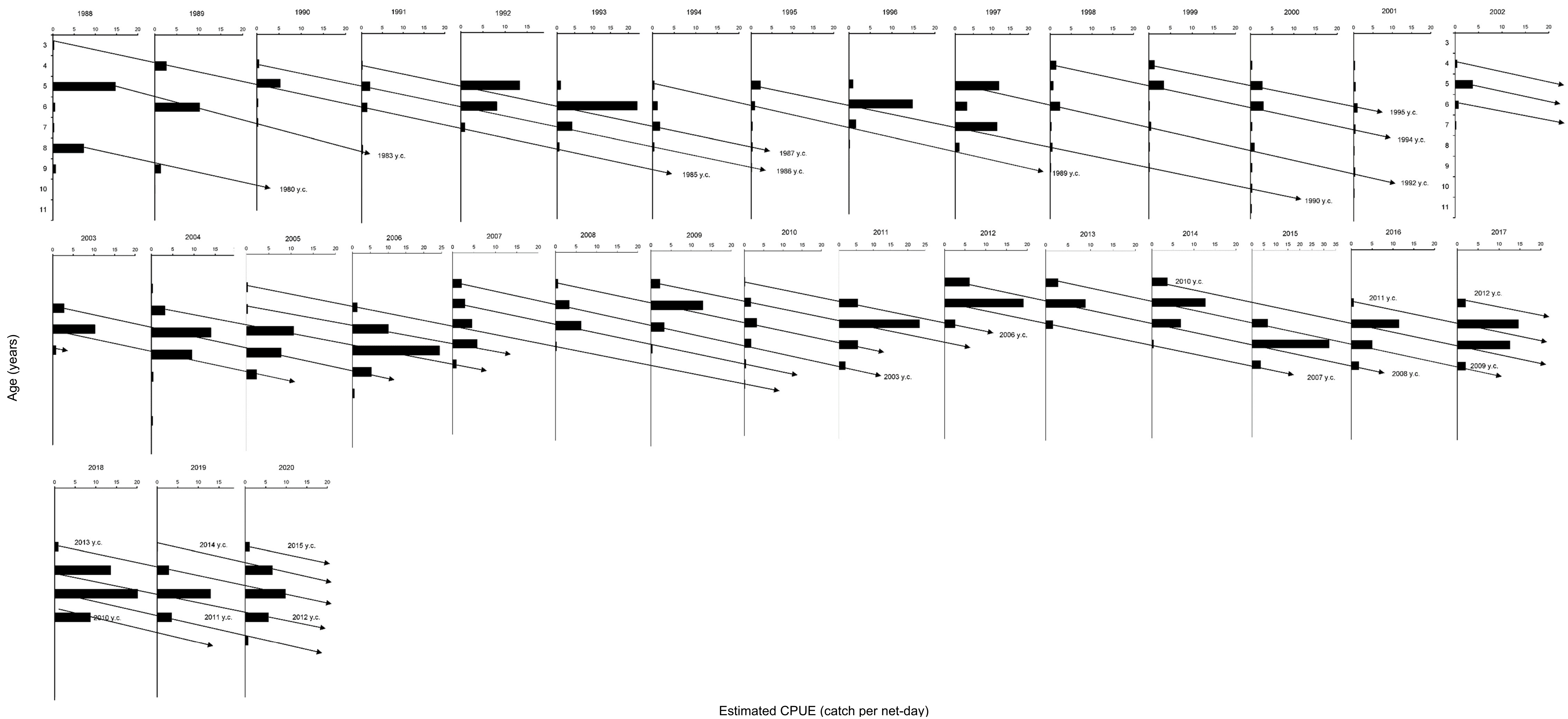

Figure 10. Catch per unit effort of Arctic Cisco by age class in the fall subsistence fishery, Niġliq Channel, 1988–2020.

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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	0.2
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	36.6
2011	53.5
2012[a]	34.2
2013[a]	13.5
2014[a]	6.8
2015[a]	1.1

[a] Calculation assumes that the 2012–2015 year classes are still contributing to cumulative CPUE.

WATER QUALITY

Salinity and temperature monitoring began on 18 October 2020 at the most upstream location adjacent to Nuiqsut (station 4). Station 3 was established 19 October, and the furthest downstream stations (stations 1 and 2) were established the following day, 20 October. All 4 stations were visited approximately every other day until 18 November, when the non-resident monitoring team crew departed Nuiqsut. Salinity at the station farthest downstream (station 1) registered above 15 ppt on 25 October (at 3-m depth) and remained above 15 ppt on all sampled days but one (14.5 ppt on 27 October). Salinity at 3-m depth peaked 20.4 ppt on 17 November at station 3, 24.6 ppt on 14 November at station 2, and 28.7 ppt on 9 November at Station 1. In contrast, the most upstream station (station 4), never exceeded salinity of 15 ppt, and reached maximum salinity of 12.6 ppt on 18 November, the last day of sampling (Figures 2 and 12).

For comparison, salinity at 3-m depth in the Niġliq Delta (station 1) area peaked at 24.7 ppt in 2019, 22.5 ppt in 2018, and 19 ppt in 2017. (Forster and Seigle 2020, Seigle et al. 2019, 2018, 2017). The Upper Niġliq area (station 4) near Nuiqsut reached a maximum of 10.8 ppt in 2019, 11.9 ppt in 2018, and 3.3 ppt in 2017. Ideal salinity conditions for Arctic Cisco (>15 ppt) were generally present at the 3 downstream stations during most of the 2020 survey season at 3-m depth (stations 1, 2, and 3; Figures 2 and 12). An influx of saltwater into the Niġliq Channel from the marine ecosystem likely contributed positively to the generally high early season CPUE in the Niġliq Delta and Nanuk fishing areas (Table 3).

Water temperatures were generally higher upstream near Nuiqsut and lower at downstream stations in the delta (Figure 12). As winter continues and freshwater inputs decrease in the river, we would expect temperatures to decrease at upstream stations. Generally, early and consistent freezing temperatures in the region led to sustained ice conditions appropriate for under-ice fishing, at least for most of the season. There was one brief period of increased air temperatures during the third week of October, with some overflow conditions which led a handful of fishers to pull their nets for a day or two for fear of the nets freezing into the ice at a later date.

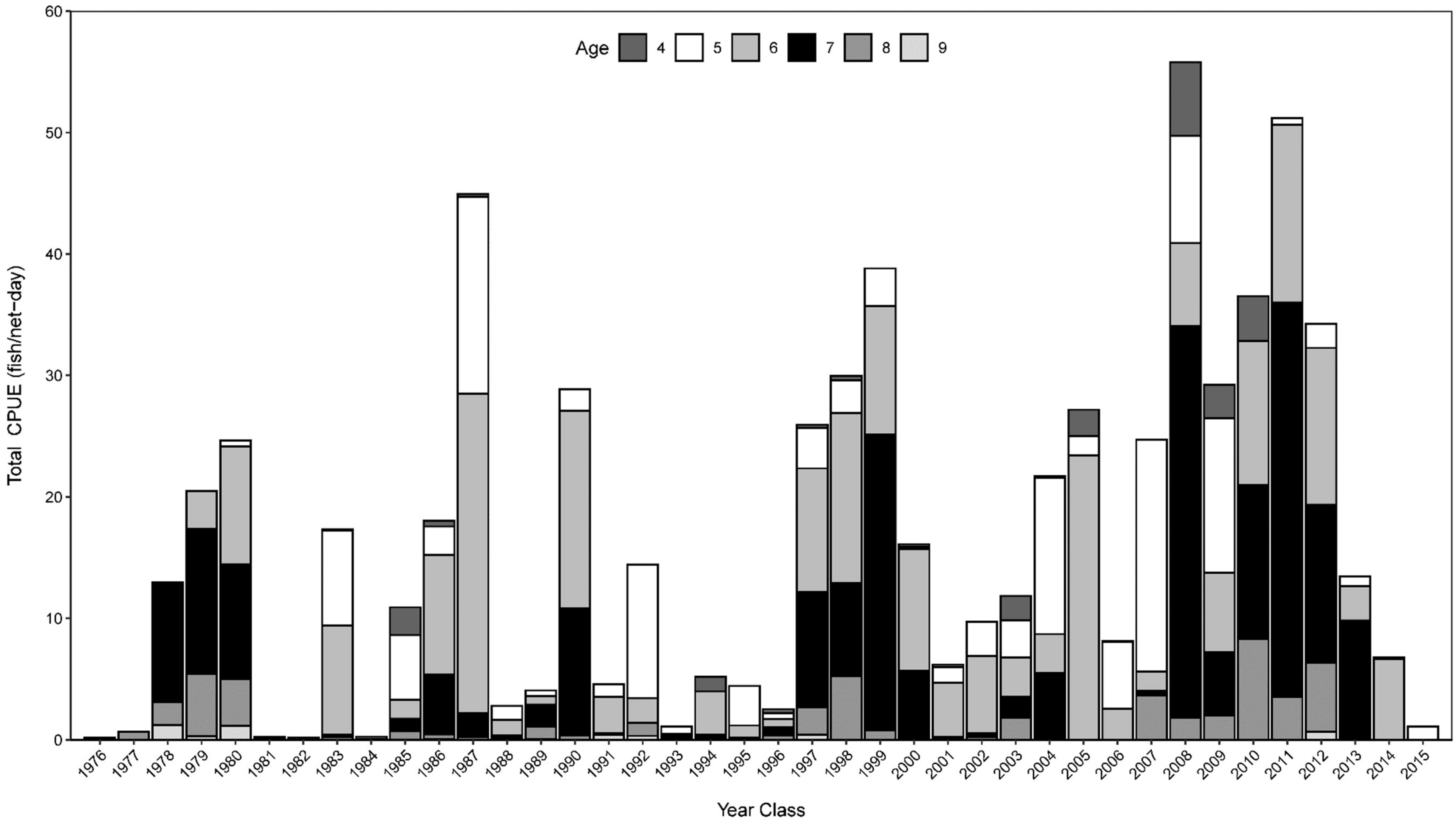

Figure 11. Cumulative catch per unit effort of Arctic Cisco by year class in the fall subsistence fishery, Niġliq Channel, Colville River, 1976–2015.

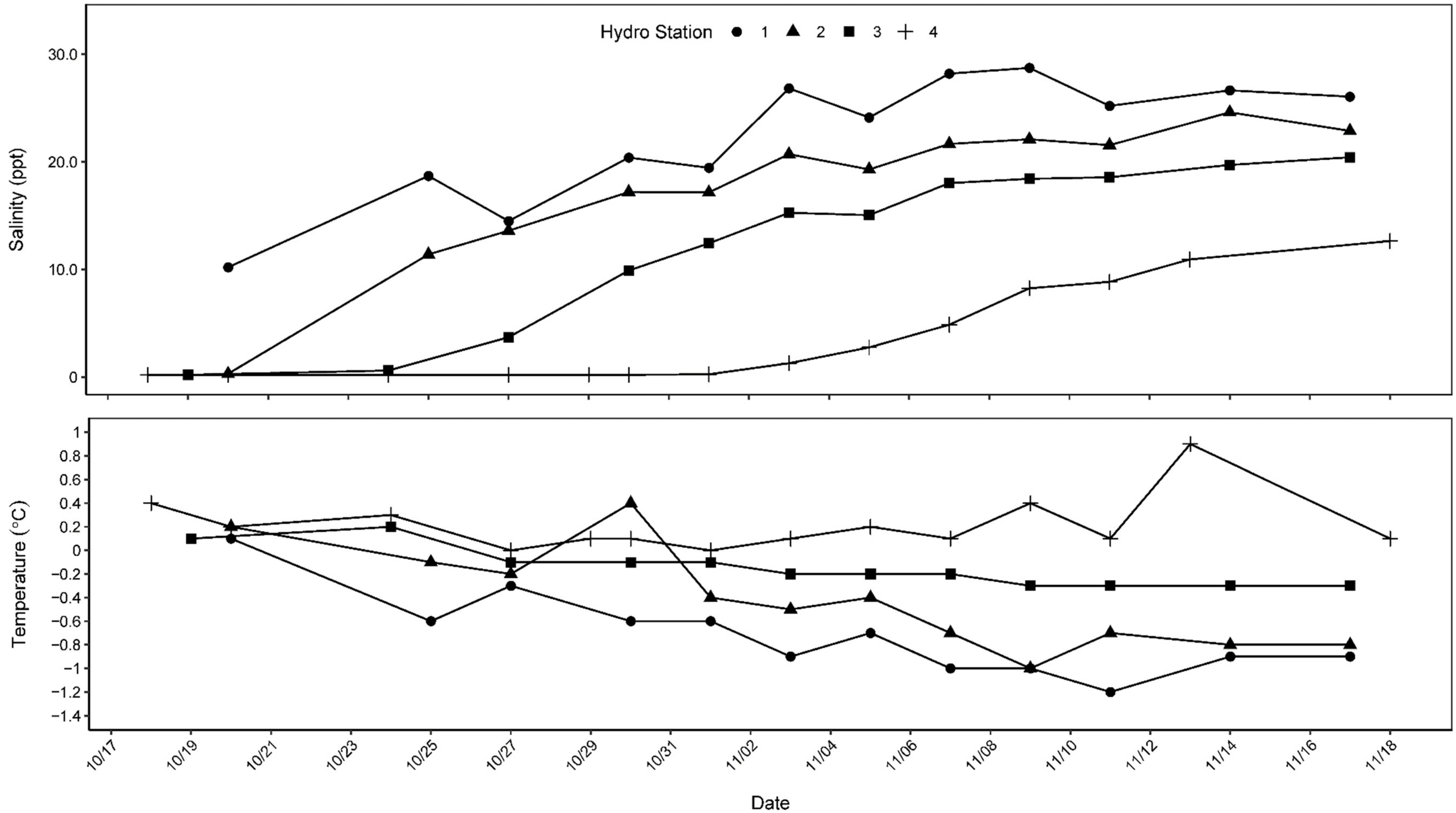

Figure 12. Salinity and temperature measured at 3.0 m depth from 4 water stations on the Niġliq Channel, Colville River, Alaska, 18 October to 18 November 2020.

SUMMARY

Harvest results for the 2020 under-ice gillnet fishery in the Niġliq Channel of the Colville River Delta were better than the 2019 season by almost all metrics, including fisher participation, CPUE, and total estimated annual harvest of Arctic Cisco. In contrast to recent years, fishing effort in 2020 was divided evenly among the three fishing areas on the Niġliq Channel fishing areas. Overall CPUE in the Niġliq Channel improved by 23% in 2020 compared to the previous year.

The total estimated harvest of Arctic Cisco in 2020 was 11th highest estimated since 1986 and a 55% increase over the 2019 harvest estimate (Table 4). The likely major factor differentiating the 2020 season from the 2019 season was related to environmental conditions. Harvest activities in 2019 were both delayed at the onset and interrupted mid-season for several days due to unsafe ice conditions related to warm weather. This resulted in a greatly reduced fishing effort compared to the 2020 season where ice conditions were suitable for safe fishing from mid-October through the end of November, with only a single day of interrupted fishing for a handful of fishers.

Fish condition (size and weight) in 2020 was also notably improved over recent years. Fishers were delighted by what they described as "big fish" in their harvests. These observations were supported the weight and length analyses indicating that fish were heavier at length than in previous years (Figures 7 and 8). Changes in the proportion of age classes, and greater length-at-age for age-6 and age-7 fish also contributed to greater fish size in 2020 harvests. The age-composition of Arctic Cisco in 2020 included a slightly higher percentage of both younger (age-5) and older (age-9) fish than are usually observed in the fall fishery. It will be interesting to see if the presence of age-9 (2012 year class) individuals persists in 2021, or if these results are indicative of something specific to the 2011 year class. The smaller mesh nets of the 2020 fall fishery caught several fish species more commonly associated with larger summer nets, including Pink Salmon, Northern Pike, Longnose Sucker, and Dolly Varden, adding additional variety and interest to the 2020 fall fishery season. Least Cisco caught as bycatch in the 2020 fall fishery were slightly smaller than in 2019 but were represented by a 12-year age range.

Finally, as a result of improved CPUE and larger Arctic Cisco being caught in 2020, no fishers set nets under ice in the Main Channel area. Although fishing effort in the Main Channel area is typically a fraction of Niġliq Channel effort, we would expect that a handful of fishers would set nets in both channels in 2021 as they target areas of less fishing pressure with larger fish.

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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, 2020.

Fisher Code	Fishing Area	Net	Net Code	Length (m)	Stretched Mesh (cm)	Start Date	End Date	Net-days	Adjusted Net-days
21	Nanuk	A	16 21A 1	100	3	10/20/2020	10/27/2020	7	11.7
24	Niqliq Delta	A	16 24A 1	100	3	10/18/2020	10/24/2020	6	10.0
24	Niqliq Delta	A	16 24A 2	100	3	10/26/2020	11/17/2020	22	36.7
24	Nanuk	A	16 24A 3	100	3	11/17/2020	11/30/2020	13	21.7
25	Nanuk	A	16 25A 1	60	3	10/31/2020	11/13/2020	13	13.0
25	Nanuk	B	16 25B 1	60	3.5	10/31/2020	11/13/2020	13	13.0
31	Upper Nigliq	A	16 31A 1	80	3	11/2/2020	11/26/2020	24	32.0
31	Upper Nigliq	B	16 31B 1	100	3	11/15/2020	11/19/2020	4	6.7
42	Upper Nigliq	A	16 42A 1	60	3	10/15/2020	11/22/2020	38	38.0
42	Upper Nigliq	B	16 42B 1	80	3	10/29/2020	10/31/2020	2	2.7
56	Nanuk	A	16 56A 1	80	3	10/18/2020	10/21/2020	3	4.0
56	Niqliq Delta	A	16 56A 2	80	3	10/23/2020	11/6/2020	14	18.7
63	Nanuk	A	16 63A 1	80	3	11/6/2020	11/24/2020	18	24.0
65	Upper Nigliq	A	16 65A 1	60	3	10/21/2020	11/12/2020	22	22.0
65	Nanuk	B	16 65B 1	80	3.5	10/27/2020	11/1/2020	5	6.7
65	Niqliq Delta	C	16 65C 1	80	3.5	11/6/2020	11/9/2020	3	4.0
70	Niqliq Delta	A	16 70A 1	100	3	10/19/2020	11/7/2020	19	31.7
77	Upper Nigliq	A	16 77A 1	80	3	10/17/2020	11/30/2020	44	58.7
77	Upper Nigliq	B	16 77B 1	80	3	10/24/2020	11/30/2020	37	49.3
77	Upper Nigliq	C	16 77C 1	80	3	11/14/2020	11/30/2020	16	21.3
79	Niqliq Delta	A	16 79A 1	60	3	10/19/2020	11/12/2020	24	24.0
79	Niqliq Delta	B	16 79B 1	80	3	10/19/2020	10/20/2020	1	1.3
79	Niqliq Delta	B	16 79B 2	80	3	10/20/2020	11/8/2020	19	25.3
87	Niqliq Delta	A	16 87A 1	100	3	10/21/2020	11/9/2020	19	31.7
87	Niqliq Delta	B	16 87B 1	100	3	10/21/2020	10/24/2020	3	5.0
88	Niqliq Delta	A	16 88A 1	100	3	10/27/2020	11/22/2020	26	43.3
88	Niqliq Delta	B	16 88B 1	100	3.5	10/28/2020	11/22/2020	25	41.7
93	Upper Nigliq	A	16 93A 1	70	3.5	10/15/2020	10/17/2020	2	2.3
93	Nanuk	A	16 93A 2	70	3.5	10/17/2020	10/20/2020	3	3.5
93	Nanuk	A	16 93A 3	70	3.5	10/23/2020	11/11/2020	19	22.2
95	Upper Nigliq	A	16 95A 1	60	3	10/21/2020	11/6/2020	16	16.0
101	Upper Nigliq	A	16 101A 1	90	3	10/19/2020	10/27/2020	8	12.0

Appendix A. Continued.

Fisher Code	Fishing Area	Net	Net Code	Length (m)	Stretched Mesh (cm)	Start Date	End Date	Net-days	Adjusted Net-days
107	Upper Nigliq	A	16 107A 1	60	3	10/15/2020	10/17/2020	2	2.0
107	Nanuk	A	16 107A 2	60	3	10/17/2020	10/20/2020	3	3.0
107	Nanuk	A	16 107A 3	60	3	10/23/2020	11/11/2020	19	19.0
108	Nanuk	A	16 108A 1	60	3	10/21/2020	11/8/2020	18	18.0
108	Nanuk	B	16 108B 1	80	3	10/21/2020	10/23/2020	2	2.7
115	Upper Nigliq	A	16 115A 1	80	3	10/20/2020	11/22/2020	33	44.0
117	Nanuk	A	16 117A 1	80	3	10/28/2020	11/5/2020	8	10.7
117	Nanuk	B	16 117B 1	80	3	11/6/2020	11/30/2020	24	32.0
118	Upper Nigliq	A	16 118A 1	100	3	10/19/2020	11/9/2020	21	35.0
118	Upper Nigliq	B	16 118B 1	100	3	10/27/2020	11/2/2020	6	10.0
118	Nanuk	C	16 118C 1	80	3	10/26/2020	11/2/2020	7	9.3
119	Niqliq Delta	A	16 119A 1	80	3	10/19/2020	11/18/2020	30	40.0
120	Upper Nigliq	A	16 120A 1	80	3	10/25/2020	11/26/2020	32	42.7
213	Nanuk	A	16 213A 1	100	3	10/19/2020	10/23/2020	4	6.7
213	Nanuk	A	16 213A 2	100	3	10/26/2020	11/10/2020	15	25.0
213	Nanuk	B	16 213B 1	100	3	10/27/2020	11/10/2020	14	23.3
214	Nanuk	A	16 214A 1	80	3	10/18/2020	11/3/2020	16	21.3
1001	Nanuk	A	16 1001A 1	60	3	10/20/2020	10/24/2020	4	4.0
1001	Niqliq Delta	B	16 1001B 1	80	3	10/24/2020	11/4/2020	11	14.7
1001	Niqliq Delta	C	16 1001C 1	80	3	10/25/2020	11/4/2020	10	13.3
1002	Upper Nigliq	A	16 1002A 1	60	3	10/22/2020	11/9/2020	18	18.0
1003	Nanuk	A	16 1003A 1	100	3	10/26/2020	11/17/2020	22	36.7
1004	Niqliq Delta	A	16 1004A 1	100	5	10/26/2020	10/27/2020	1	1.7
1005	Nanuk	A	16 1005A 1	80	3.5	10/25/2020	11/27/2020	33	44.0
Total									1,131

Appendix B. Estimated harvest of Arctic Cisco from the Colville River delta commercial and subsistence fisheries, 1967–2020.

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
2003[b]	–	23,369	23,369
2004[b]	–	40,605	40,605
2005[b, c]	–	–	–
2006[c, d]	–	–	–

Appendix B. Continued.

Year	Estimated Commercial Harvest[a]	Estimated Subsistence Harvest	Estimated Total Harvest
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
2019[e]	–	17,544	17,544
2020[e]	–	27,128	27,128
Average	23,425	25,965	32,666

[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