FALL 2017 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, AK

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

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The 2017 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, 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. Adrian Gall 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 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 ConocoPhillips Alaska, Inc. (CPAI). Over the years, the objectives of the project have evolved to include quantifying time trends in fishing effort and harvest results and assessments of the general health of the fishery. We also include input from fishers about their perception of the health of the fishery and to determine monitoring goals.

The monitoring program has traditionally focused on the fall harvest of Arctic Cisco (*Coregonus autumnalis*; 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. While the monitoring protocol developed over the previous 31 years was repeated in 2017, ABR began implementing a new reporting method in 2016, at the request of CPAI, to summarize the results of the fishery annually (Seigle et al. 2017). In lieu of a detailed monitoring report, we are providing CPAI with a condensed data report. In addition to this data report, we prepared a manuscript following the 2016 season which is currently under review by CPAI and which will be submitted for peer review to a scientific journal as soon as the internal review process is completed. The paper 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 objectives of the 32nd year of the harvest monitoring program were to:

- continue working with key stakeholders as per agreements made in 2007 (Seigle et al. 2008);
- monitor the harvest of Arctic Cisco (and other species) throughout the fall fishing season with interviews of 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 Arctic Cisco harvested;
- measure water salinity, temperature, pH, and dissolved oxygen in primary fishing areas; and
- compare the 2017 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 a local fishing expert, Fredrick Tukle, Jr. ABR fishery monitors conducted daily interviews of fishers for harvest events from 15 October to 20 November. Our local-hire fishery expert continued informal surveys with the few remaining fishers through 25 November 2017. 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.

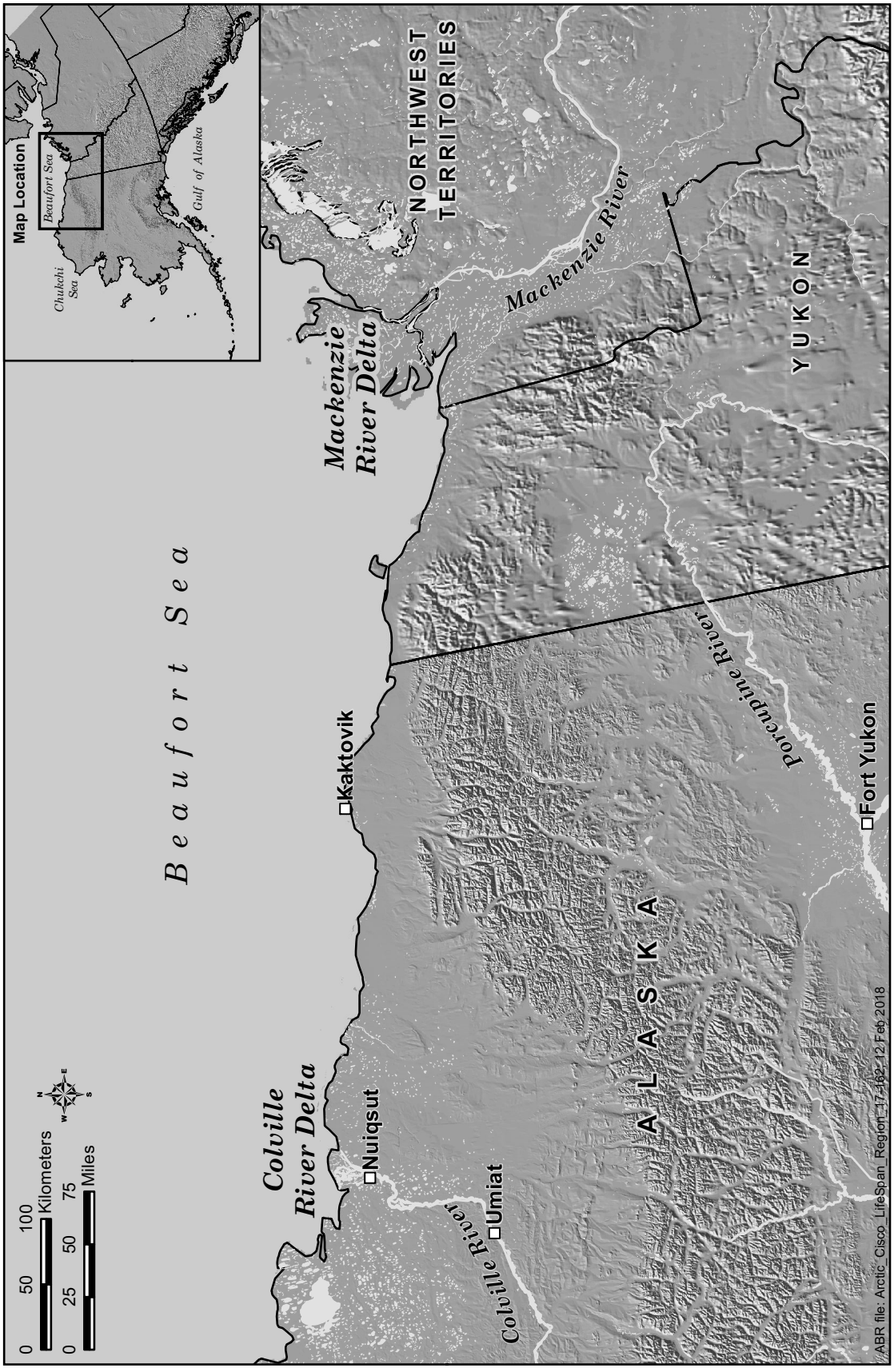

Figure 1. Waters important to the life history of Arctic Cisco in Canada (Mackenzie River drainages) and Alaska (Colville River delta) and the nearshore Beaufort Sea.

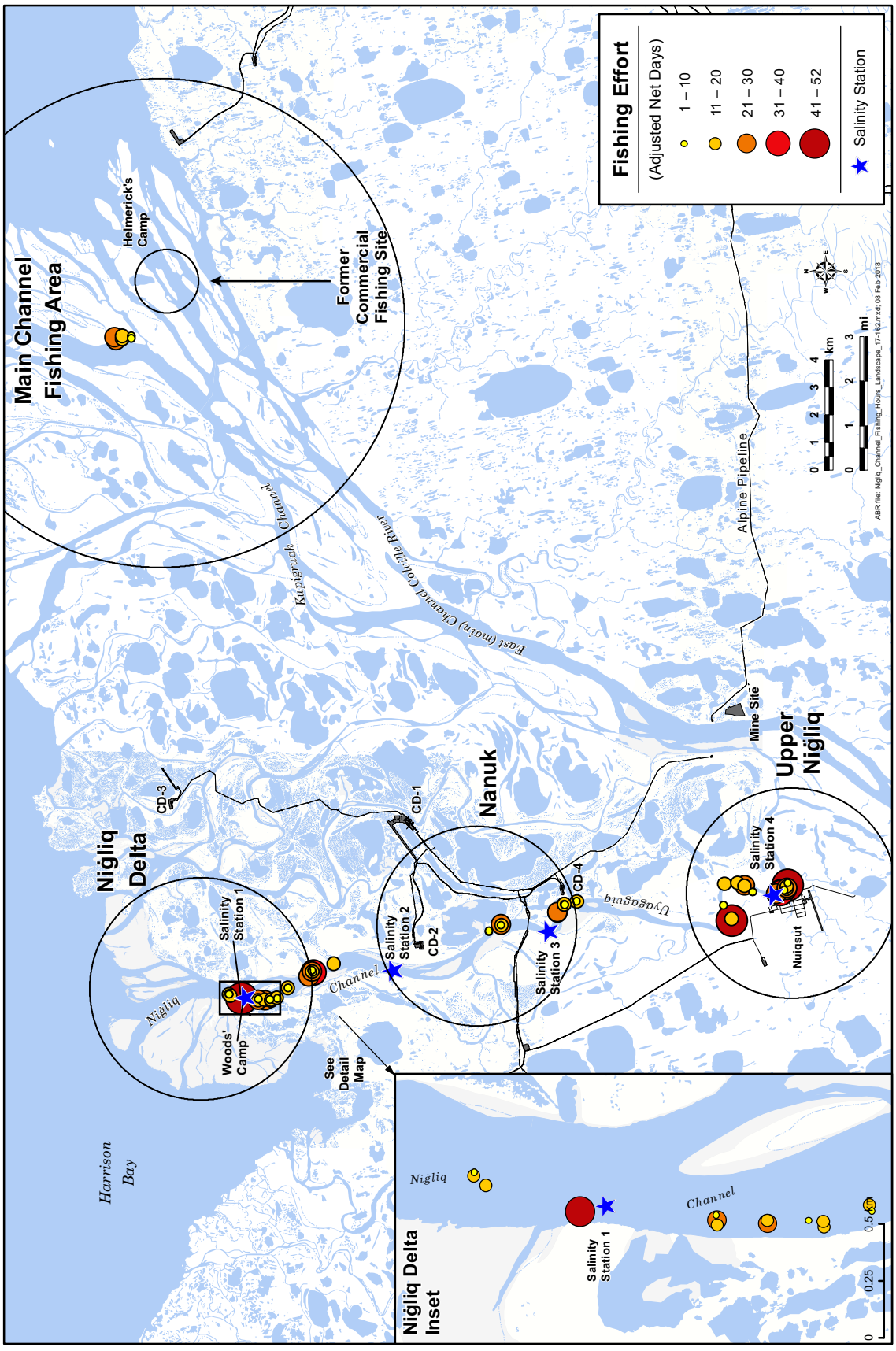

Figure 2. Water sampling stations and net sites in each of the 3 main subsistence fishing areas in the Nigliq Channel of the Colville River, Alaska, 2017. The amount of effort for each net set (adjusted net-days) is depicted by both color and the size of the net symbol.

To calculate fishing effort (i.e., net-days), we adjusted the recorded net length and effort to a standardized net length of 18 m (60 ft) and a full-day (24-hour) set duration. For example, if an 80 ft net was used during a 24-hour period, fishing effort was calculated as 80 ft/60 ft × 1 day = 1.3 adjusted net-days. Catch per unit effort (CPUE), expressed as catch per net-day, was calculated using these adjusted estimates of effort. In this report, we specify when data presentations are all mesh sizes combined and when they are limited to the most frequently used mesh of 7.6 cm (3 in).

During harvest interviews, we asked:

- How many nets are you fishing?
- How long have your nets been actively fishing (helps define total season effort)?
- What are your net dimensions?
- How many Arctic Cisco and other fish species did you harvest in each net?
- How frequently do you check your nets?
- Where is your net and has it been moved recently (i.e., within the past week)?

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

LENGTH, WEIGHT, AND AGE OF CATCH

During harvest events, fish were removed from nets, tallied by species, and a sub-sample was measured for fork length (to the nearest mm; Seigle et al. 2016 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 increments to the river bottom. The monitoring team measured temperature (°C) at a depth of 3 meters.

RESULTS

FISHERY EFFORT AND HARVEST

The onset of ice formation on the Colville River was reported to ABR personnel on 13 October. Net deployment began shortly thereafter on 15 October in the Upper Niġliq fishing area within the Niġliq Channel (Table 1, Figure 2). Coincidentally, this was the same start date for

Table 1. Estimated onset of the fall subsistence fishery for Arctic Cisco in the Niġliq Channel of the Colville River, Alaska, 1985–2017.

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
Average	8 October	

fishing in the Niġliq Channel in 2016. ABR scientists and our local subsistence expert technician conducted 316 interviews from 15 October to 23 November, although 4 nets remained in the river following our surveys. Three of the remaining 4 nets were pulled between 24 November and 1 December, while we estimate that the fourth net was pulled sometime before 9 December. We do not believe that many harvest events occurred between the time of ABR's departure and final net removals in early December based on conversations with our local hire.

A total of 35 households deployed 54 nets set between the Niġliq Channel and the Main Channel Colville River (Table 2). A total of 67 net-sets were completed with these 54 nets (58 in Niġliq Channel and 9 in the Main Channel) during the fall fishing season (Table 2, Figure 3, Appendix A). We calculated 946.13 net-days of fishing effort in the Niġliq Channel and an 111.3 net-days in the Main Channel for a total of 1,057.47 net-days of effort in 2017 (Appendix A). Six mesh sizes were deployed in 2017, but as in previous years, the most frequently used mesh size was 7.6 cm (661.7 adjusted net-days). This was followed by 8.9-cm mesh nets (234.8 net-days), 7.0-cm mesh nets (67.3 net-days), 8.3-cm mesh nets (40.5 net-days), and 6.4-cm mesh nets (37.2 net-days). In the Niġliq Channel, most of the fishing effort took place in the Niġliq Delta (424.8 adjusted net-days, 44.9%), followed by the Upper Niġliq (379 net-days, 40.1%) and the Nanuk fishing areas (142.3 net-days, 15%) (Table 3, Figure 4).

We recorded total harvests of 9,963 Arctic Cisco in 7.6-cm mesh nets in the Niġliq Channel in 2017 (Table 3, Figure 5). An additional 2,088 fish were recorded in the Main Channel. A total of 15,059 Arctic Cisco were recorded as being harvested from nets of a known mesh size (all mesh) and fishing duration (Table 3). These observations of overall catch were used to calculate the Arctic Cisco CPUE by mesh size. In 2017, the total average estimated CPUE for 7.6-cm nets in the Niġliq Channel was 31.3 fish per net-day, which was the fifth highest since 1986. Harvest rates were highest in the Niġliq Delta (49.0 fish per net-day), followed by the Nanuk area (20.0 fish per net-day), and finally, the Upper Niġliq (11.0 fish

Table 2. Summary statistics for fall fishing effort in the Colville River delta, Alaska, 2017. Values in parentheses are the total number sets for those nets.

Summary of 2017 Effort	Total
Recorded harvest events	316
Households	35
Net mesh size	
5.1 cm (2.0 in)	0
6.4 cm (2.5 in)	3(3)
7.0 cm (2.75 in)	3(3)
7.6 cm (3.0 in)	32(38)
8.3 cm (3.25 in)	1(1)
8.9 cm (3.5 in)	13(20)
10.2 cm (4.0 in)	0
12.7 cm (5.0 in)	2(2)
Nets in Niġliq Channel	48
Total Nets	54
Average Nets/Household	1.54
Net sets	
in Upper Niġliq	21
in Nanuk	11
in Niġliq Delta	26
in Main Channel	9
Total number of sets	67
Adjusted net days	
5.1-cm mesh nets	0
6.4-cm mesh nets	37.2
7.0-cm mesh nets	67.3
7.6-cm mesh nets	661.7
8.3-cm mesh nets	40.5
8.9-cm mesh nets	234.8
10.2-cm mesh nets	0
12.7-cm mesh nets	16
Adjusted net-days by Upper Niġliq	379.0
Adjusted net-days by Nanuk	142.3
Adjusted net-days by Niġliq Delta	424.8
Adjusted net-days by Main Channel	111.3
Total adjusted net-days	1,057.5

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 120.5 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 18.3 (95% CI = 14.0–22.5) (Table 4, Figure 6). Long-term average CPUE for 7.6-cm mesh nets, by river section, now stands at 8.9 (95% CI = 6.5–11.2) in the Upper Niġliq, 15.8 (95% CI = 11.9–19.7) in the Nanuk, and 27.9 (95% CI = 20.1–35.8) in the Niġliq Delta (Table 4).

Overall, observed CPUE in 2017 for all mesh sizes ranged from 3.3 fish per net-day in 8.9-cm mesh nets in the Upper Niġliq area to 120.5 fish per net-day in 7.6-cm mesh nets in the Main Channel area (Table 3). We used these CPUE estimates to calculate a total estimated harvest of 33,247 fish (Table 5). This represents a 20% increase over the estimated harvest of 26,577 Arctic Cisco in 2016, and is higher than the long-term subsistence harvest average of 25,471 fish (95% CI = 20,030–30,911; Appendix B).

A total of 12 species were recorded during the 2017 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 20,224 fish of all species were recorded in 2017, which is an increase from 2016 (13,872), and only ~9% fewer than 2015 (22,586), one of the strongest fishing seasons on record. Arctic Cisco were the dominant harvest species (18,135 fish; 89.7.8% of harvest), which is normal for the annual fall under-ice gillnet fishery, followed once again by Least Cisco (1,223 fish; 6.0%), Rainbow Smelt (244 fish; 1.2%), Humpback Whitefish (95 fish; 0.5%), Broad Whitefish (51 fish; 0.3%), Saffron Cod (45 fish; 0.2%), Burbot (12 fish; 0.01%), Sheefish (2; <0.01%), Round Whitefish (1; <0.01%), Arctic Grayling (1; <0.01%), and Dolly Varden Char (1; <0.01%). As in all years since monitoring began, large numbers of Fourhorn Sculpin also were observed, particularly in the Niġliq Delta. However, these fish are typically discarded near the net locations, with this bycatch adding up daily. Thus, it is difficult for monitors to discern one day's catch from another, and Fourhorn Sculpin are therefore excluded from the analyses.

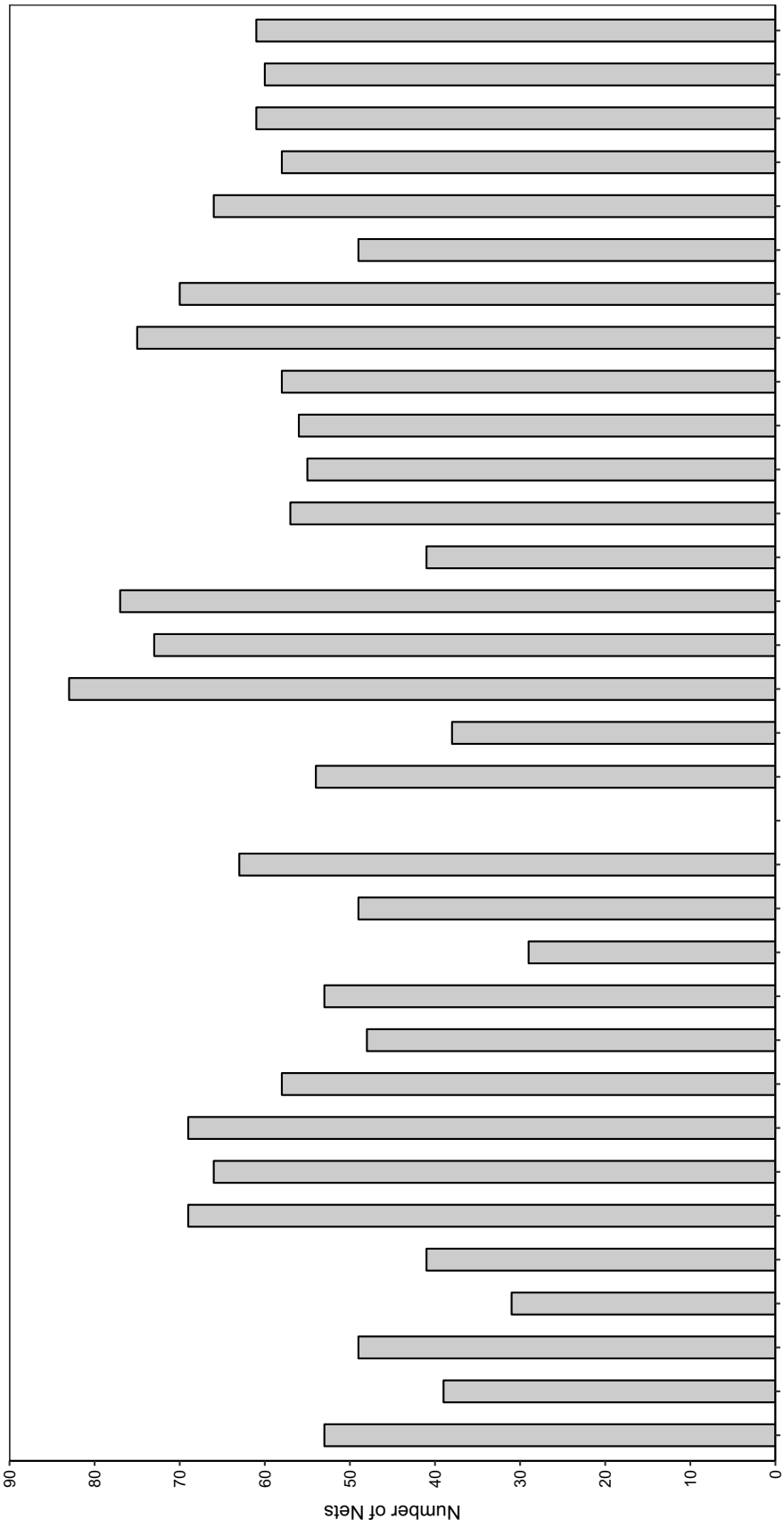

Figure 3. Number of nets deployed annually in the fall subsistence fishery for Arctic Cisco, Colville River, Alaska, 1985–2017.

Table 3. Observed catch of Arctic Cisco (number of fish), effort (adjusted net-days), and catch per unit effort (CPUE; fish/net-day) by mesh size in three Niġliq Channel fishing areas and in the Main Channel fishing area, Colville River, Alaska, 2017. 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	–	14	73	8	6
Catch (# of fish)	–	339	1,310	54	34
Effort (net-days)	–	28.0	119.3	15.0	10.3
CPUE (fish/net-day)	–	12.1	11.0	3.6	3.3
Nanuk Area					
Number of Interviews	12	–	18	–	11
Catch (# of fish)	212	–	757	–	98
Effort (net-days)	6	–	37.8	–	14.3
CPUE (fish/net-day)	35.3	–	20.0	–	6.8
Niġliq Delta Area					
Number of Interviews	3	9	89	–	51
Catch (# of fish)	46	634	7,896	–	1471
Effort (net-days)	8	14.7	161.3	–	112.8
CPUE (fish/net-day)	5.8	43.2	49.0	–	13.0
Total Niġliq Channel					
Number of Interviews	15	23	180	8	68
Catch (# of fish)	258	973	9,963	54	1603
Effort (net-days)	14	42.7	318.4	15.0	137.4
CPUE (fish/net-day)	18.429	22.8	31.4	3.6	11.7
Main Channel Area					
Number of Interviews	–	–	5	–	1
Catch (# of fish)	–	–	2088	–	120
Effort (net-days)	–	–	17.3	–	1.3
CPUE (fish/net-day)	–	–	120.5	–	90
Total					
Number of Interviews	15	23	185	8	69
Catch (# of fish)	258	973	12,051	54	1723
Effort (net-days)	14.0	42.7	335.7	15.0	138.7
CPUE (fish/net-day)	18.4	22.8	35.9	3.6	12.4

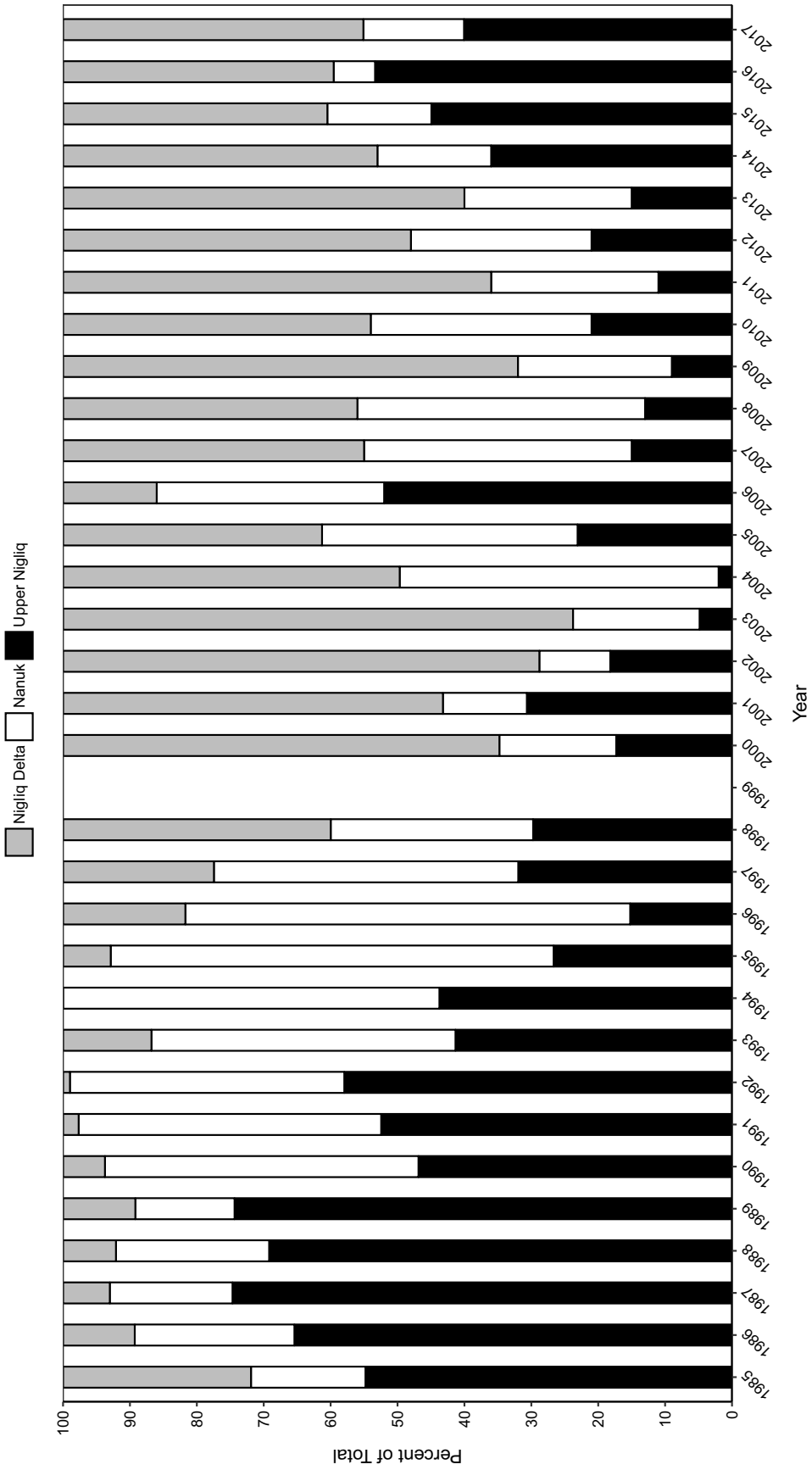

Figure 4. Percent of annual fishing effort in each of 3 Nigliq Channel fishing areas, Colville River, Alaska, 1985–2017. All nets are included regardless of length and mesh size.

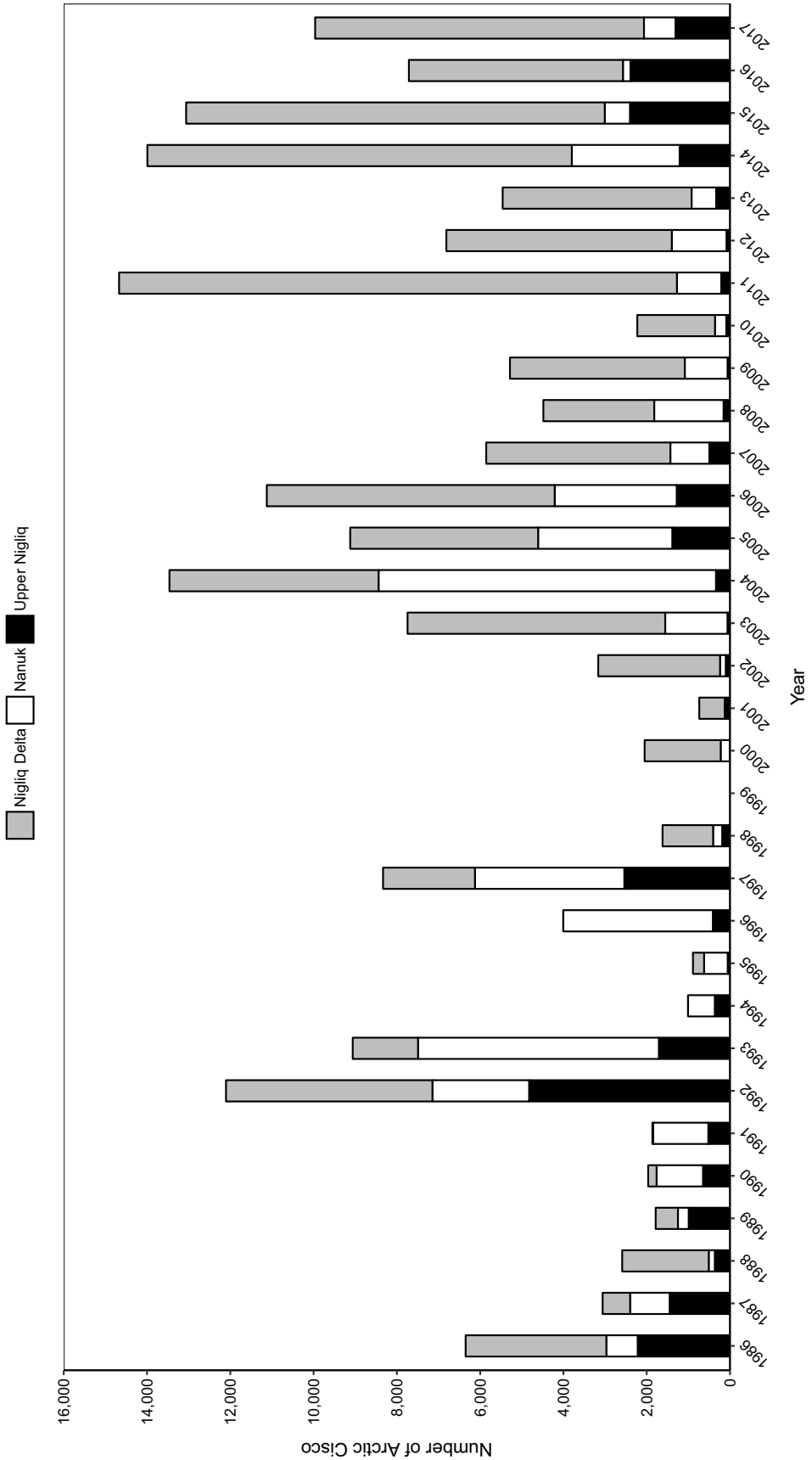

Figure 5. The observed number of Arctic Cisco harvested in 7.6-cm mesh nets in each of three Nigliq Channel fishing areas, 1986–2017. Data from 2005–2017 are not directly comparable to older data because the fishery was not monitored for the entire season during prior years.

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, 1986–2017. 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
Average[b]	912	87	8.6	1,561	103	16	3,707	155.8	27.9	6,179.4	346.5	18.3

[a] Upper Niġliq catch and effort values include fish and net data from the Uyagagviq area (Area 630).
[b] Denotes average CPUE from 1986–2017, excluding 1999 for all river sections, and 2009 for the Upper Niġliq.

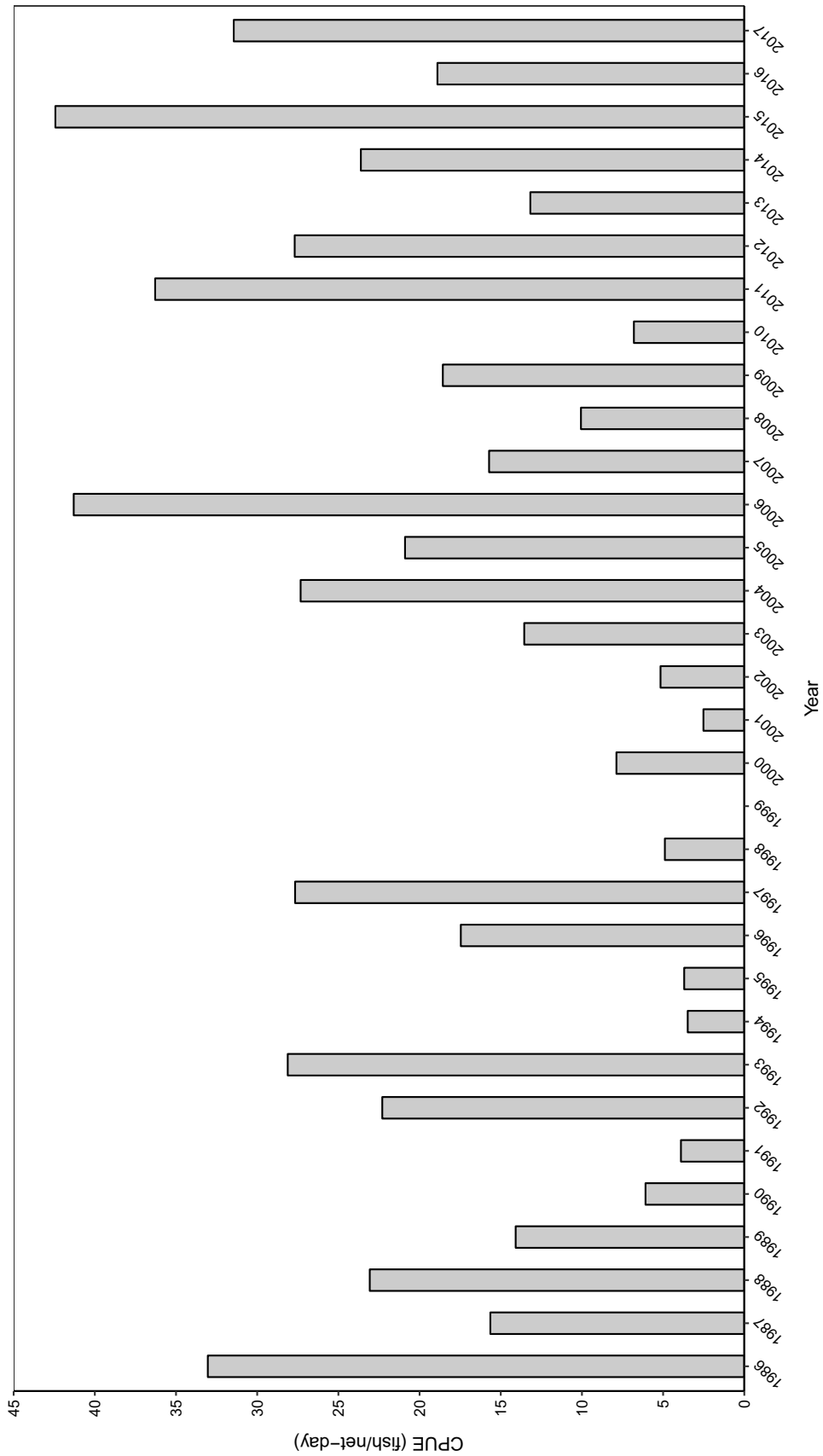

Figure 6. Catch per unit effort (CPUE; fish/net-day) of Arctic Cisco in 7.6-cm mesh gill nets, Niğliq Channel, Colville River, Alaska, 1986–2017. Effort is standardized to an 18-m net length.

Table 5. Estimates of total harvest of Arctic Cisco by mesh size in the Niġliq Channel and Main Channel fishing areas, Colville River, Alaska, 2017. Estimates are based on calculated effort and estimated CPUE for each river section.

Mesh Size (cm)	Niġliq Channel net-days	CPUE (fish/net day)	Estimated Niġliq Channel Harvest	Main Channel Area net-days	CPUE (fish/net day)	Estimated Main Channel Harvest	Total Estimated Harvest
5.1	–	–	–	–	–	–	–
6.4	15.5	18.4	285	21.7	N/A	–	285
7.0	67.3	22.8	1,535	–	–	–	1,535
7.6	587.3	31.4	18,382	74.3	120.5	8,953	27,336
8.3	40.5	3.6	146	–	–	–	146
8.9	219.5	11.7	2,568	15.3	90.0	1,377	3,945
12.7	16	–					
Total			22,917			10,330	33,247

LENGTH, WEIGHT, AND AGE OF CATCH

ABR measured a sub-sample of 713 Arctic Cisco from all mesh sizes in 2017. Arctic Cisco ranged in length from 240 mm to 515 mm with an average of 326.9 mm (95% CI = 325.4–328.4 mm) and a median of 324 mm which was the same median value as in 2016 (Figure 7). The middle 50% of fish ranged from 315 mm to 336 mm which was similar to 2016 (312 mm–339 mm) and 2015 (315 mm–339 mm).

During 2017 field surveys, we received 192 Arctic Cisco from fishers throughout the river delta to be used for additional laboratory analysis of age (via otoliths), length, and weight. These fish were caught in all parts of the river using 7.0-cm, 7.6-cm, and 8.9-cm mesh nets as in 2016. Most (n = 141) of the otolith samples came from 7.6-cm mesh nets. Length and weight were strongly correlated (R^2 = 0.81, all mesh sizes) (Figure 8). For all mesh sizes combined, fish ranged in age from 5 to 8 years, with an age composition of 6.3% age 5, 42% age 6, 45% age 7, and 6.7% age 8. Fish lengths generally increased with age and by the mesh size in which they were caught (Figure 9).

We estimated an age-specific CPUE by applying the percentages for age-composition of Arctic Cisco to the overall CPUE of 31.3 fish per adjusted net-day and assuming that our sub-sample in 7.6-cm mesh nets was representative of age-composition throughout the river. We obtained an estimate of 2.0 age-5 fish per net-day, 14.7 age-6 fish per net-day, 12.7 age-8 fish per net-day, and 2.0 age-8 fish per net-day (total = 31.3. fish per net-day; Table 4, Figure 10). The Arctic Cisco caught in 7.6-cm mesh nets in 2017 represent the 2009–2012 year classes (i.e., fish that are 58 years of age).

Based on our age readings for 2017 survey samples, the estimated CPUE of 55.8 fish per net-day for the 2008 year class has not increased since 2016. This is because we observed no representation of fish from the 2008 year class for the Colville River system in fall 2017 donated samples. It is likely that most of these fish had already returned to spawn in the Mackenzie River system during summer 2017. The estimated cumulative total CPUE for subsequent years is currently 29.1 fish per net-day for 2009 (age-8, age-7, age-6, age-5, and age-4 fish), 27.8 fish per net-day for 2010 (age-7, age-6, and age-4 fish), 15.2 fish per net-day for 2011 (age-6 and age-5 fish), and 2.0 fish per net-day for 2012 (age-5 fish) (Table 7). The 2010 year class did not have age-composition representation as age-5 fish in 2015, but the year class has reappeared in 2016 and 2017 as age-6 and age-7 fish. This suggests that the 2010 year class may simply have been residing in mostly unfished segments of the Colville River or that the

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, 1985–2017. Table includes all fish caught in every net, regardless of mesh size and location.

Year	Arctic Cisco	Bering Cisco	Least Cisco	Broad Whitefish	Humpback Whitefish	Arctic Grayling	Rainbow Smelt	Round Whitefish	Dolly Varden Char	Northern Pike	Saffron Cod	Burbot	Arctic Flounder	Fourhorn Sculpin	Sheefish	Total Observed
1985	69.5	(a)	14.8	15.1	0.5	0	0.2	0	0	0	0	0	0	(b)	0	2,705
1986	95.9	(a)	3.8	0.3	0.0	0	0.03	0.01	0	0	0	0	0	(b)	0	8,952
1987	71.8	(a)	18.7	5.5	3.8	0	0.01	0	0.03	0	0.03	0.06	0	(b)	0	6,826
1988	90.6	(a)	8.3	0.6	0.5	0	0	0	0	0	0	0.1	0	(b)	0	2,948
1989	66.2	(a)	23.7	7.0	3.1	0	0.03	0	0	0	0.03	0.03	0	(b)	0	2,946
1990	39.6	21.8	30.2	5.3	2.9	0	0.2	0	0.1	0	0.03	0.01	0	(b)	0	7,911
1991	62.8	1.2	30.0	1.0	3.8	0	1	0.03	0	0	0.04	0.09	0	(b)	0	7,576
1992	89.2	0.1	6.0	0.2	0.1	0	0	0	0	0	0	0	0	4.4	0	24,305
1993	85.4	0.02	11.1	0.3	0.4	0	0.04	0	0	0	0.01	0	0	2.7	0	17,155
1994	39.6	0.1	44.6	2.2	13.2	0	0.3	0	0	0	0	0	0	(b)	0	3,792
1995	34.7	0.2	35.0	7.6	22.3	0	0.2	0	0	0	0	0.1	0	(b)	0	7,155
1996	81.9	0	4.8	0.1	0.4	0	0.1	0	0	0	0.02	0.02	0.02	12.5	0	5,730
1997	74.8	0	22.9	1.3	0.9	0	0	0	0	0	0	0	0	(b)	0	19,758
1998	39.6	0	50.8	0.4	8.9	0	0	0.2	0	0	0	0	0	(b)	0	6,481
2000	79.4	0.1	14.0	0.2	6.0	0	0.3	0	0	0	0.03	0	0	(b)	0	3,871
2001	35.6	0.1	29.6	5.5	27.8	0	0.1	0	0	0	0	1.3	0	(b)	0	3,515
2002	49.8	0.1	30.6	1.6	17.5	0	0.2	0	0	0	0.1	0.2	0	(b)	0	8,445
2003	66.3	0.2	22.3	0.2	9.4	0	0.9	0	0	0	0.6	0.1	0	(b)	0	16,654
2004	74.7	0.06	24.2	0.0	0.9	0	0.08	0	0	0	0.04	0.03	0	(b)	0	20,705
2005	81.3	0	14.8	0.2	3.5	0	0.15	0	0	0	0.01	0	0	(b)	0	13,957
2006	86.6	0	12.0	0.4	0.9	0	0	0	0	0.1	0	0	0	(b)	0	17,344
2007	71.7	0	22.3	0.4	5.5	0	0	0	0	0	0.1	0	0	(b)	0	14,686
2008	84.1	0.2	14.7	0.0	0.1	0	0.7	0	0	0	0.1	0.01	0	(b)	0	9,199
2009	85.4	0.2	9.2	0.2	0.5	0	4.3	0	0	0	0.1	0.03	0	(b)	0	11,700
2010	60.7	0	34.4	0.4	3.0	0	1.3	0	0	0	0.2	0	0	(b)	0	18,505
2011	94.8	0	4.0	0.1	0.6	0	0.4	0	0	0	0.09	0	0	(b)	0	28,211
2012	77.8	0	19.8	0.6	0.9	0	0.4	0	0	1	0.5	0	0	(b)	0	17,172
2013	82.5	0	7.7	0.1	2.3	0	5.5	0	0	0	1.8	0	0	(b)	0	13,872
2014	95.4	0	2.1	0.4	0.6	<0.01	1.3	0	0	0	0.2	<0.01	0	(b)	0	19,217
2015	95.6	0	2.2	0.1	0.4	0	0.7	0	0	0	0.2	<0.01	0	(b)	<0.01	22,586
2016	91.8	0	3.4	0.1	0.4	0	2.4	0	0	0	1.9	0.01	0	(b)	0.0	13,782
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

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

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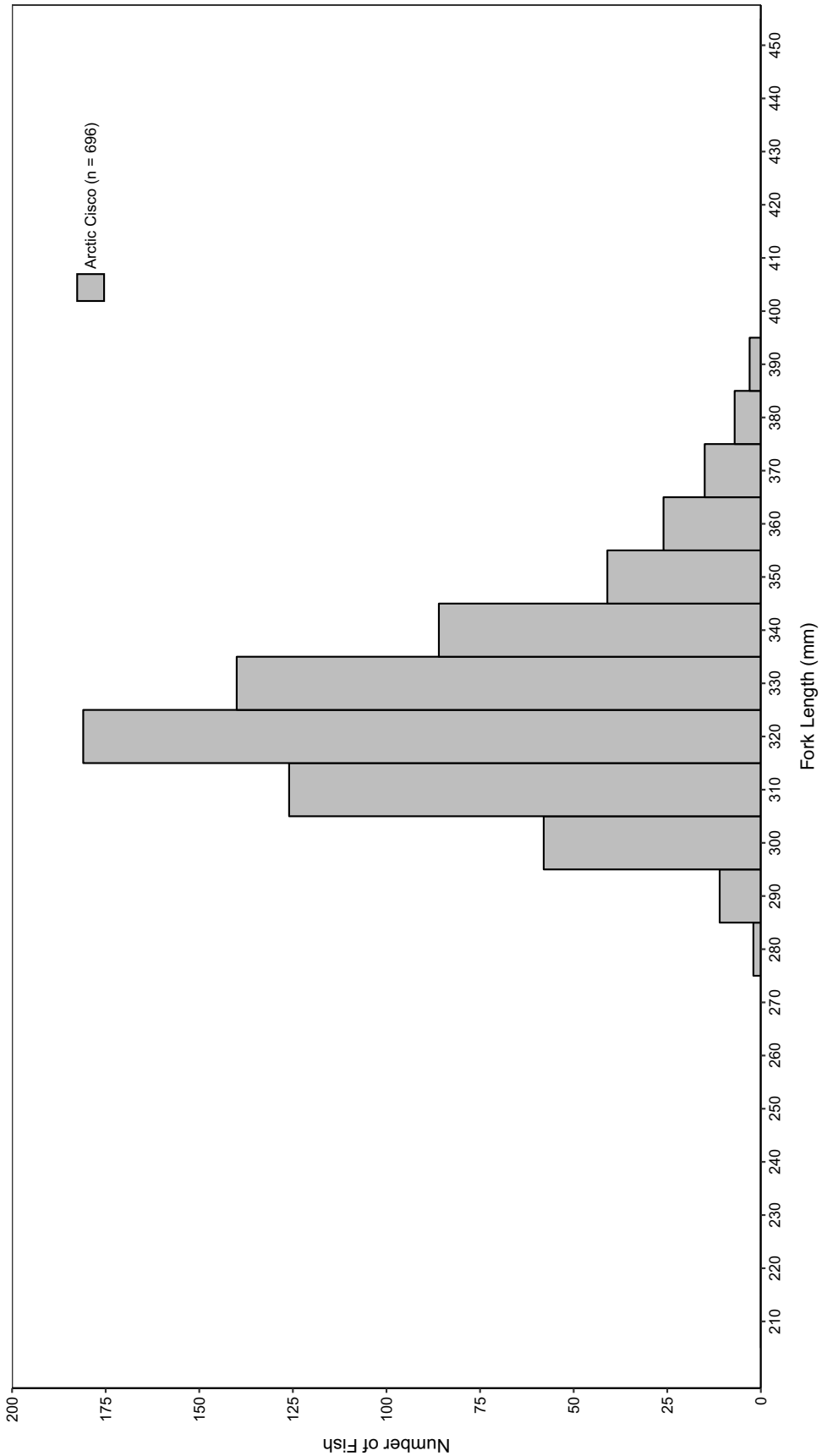

Figure 7. Length frequency (10-mm increments) of Arctic Cisco captured in all mesh sizes in the fall subsistence fishery, Nigliq Channel, Colville River, Alaska, 2017.

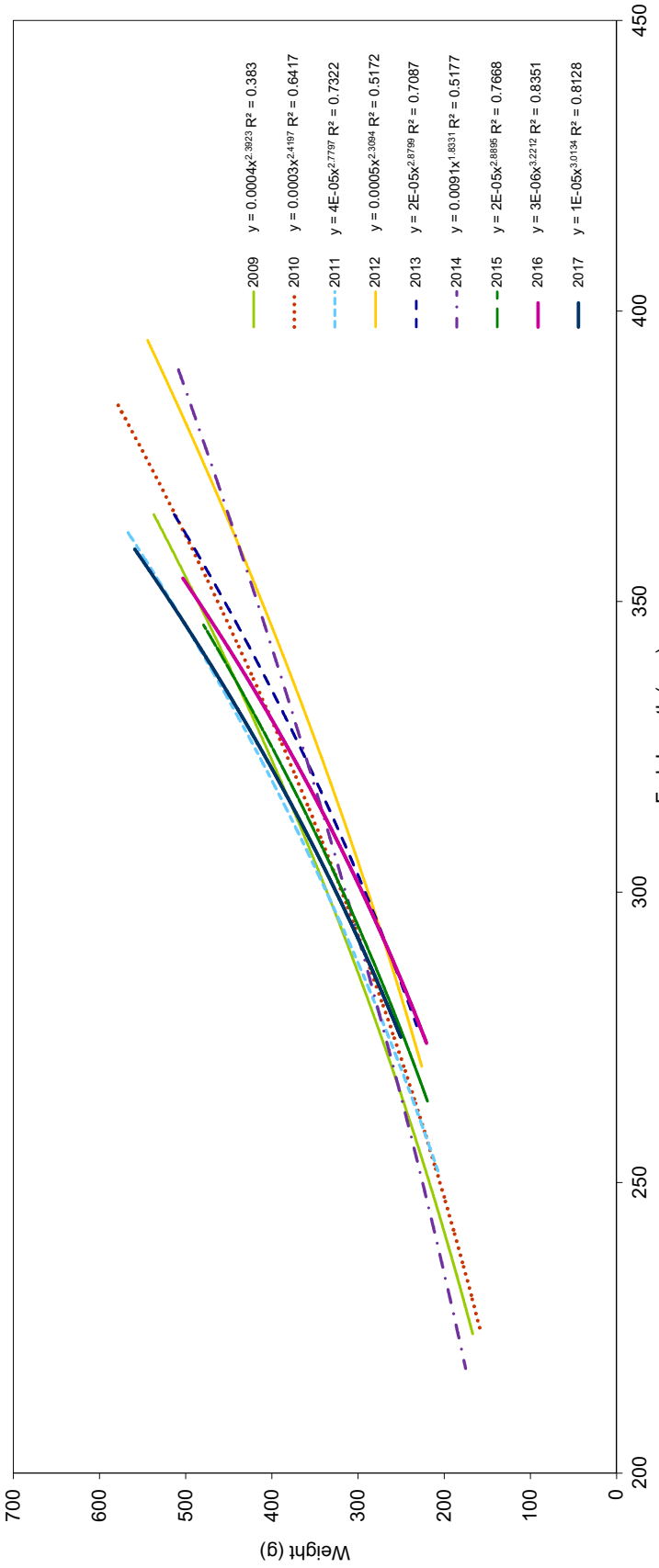

Figure 8. Length-weight regression for Arctic Cisco captured in 7.6-cm mesh nets in the fall subsistence fishery, Niglíq Channel, Colville River, Alaska, 2009–2017.

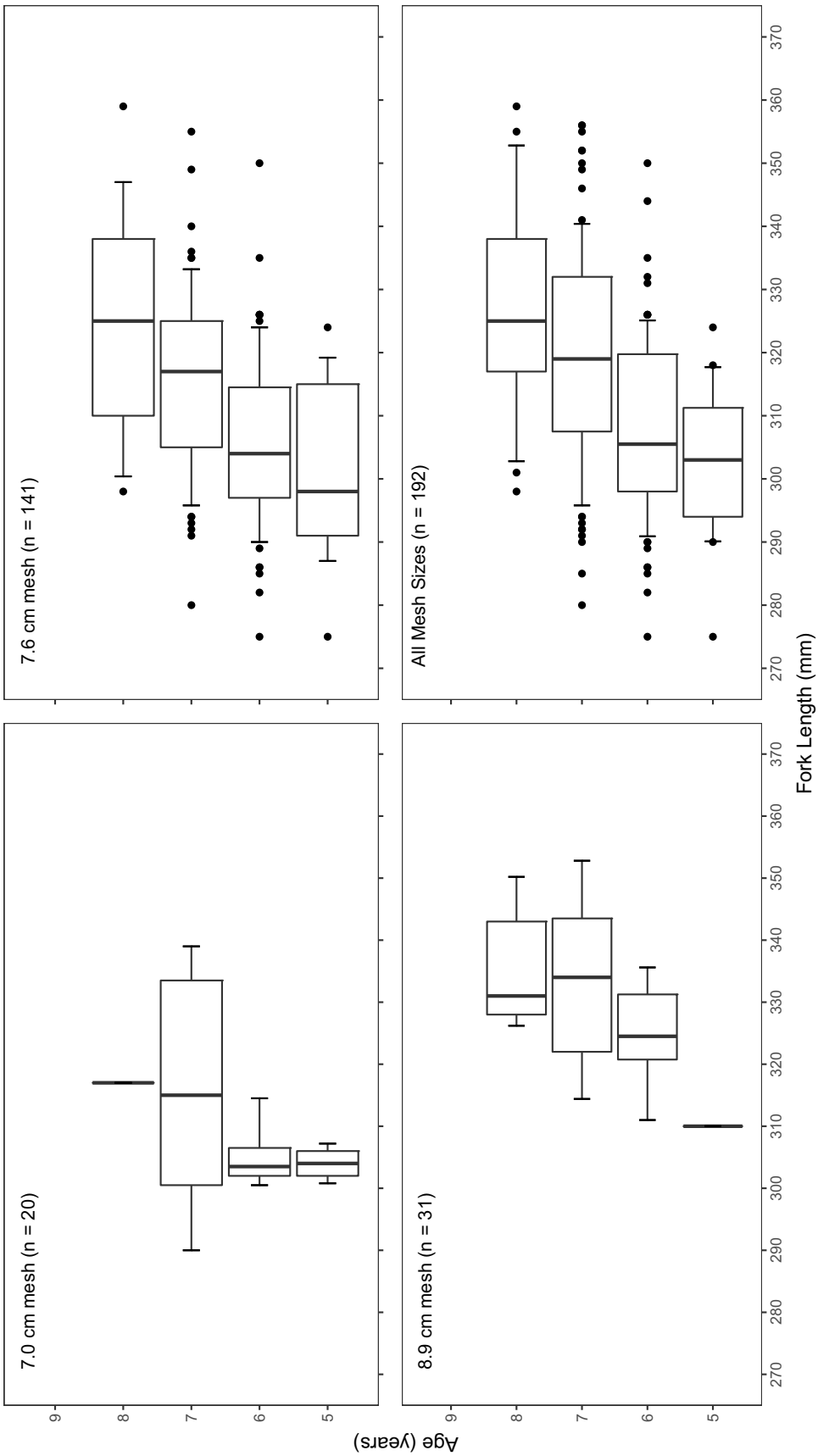

Figure 9. Age-specific length distribution by mesh size of Arctic Cisco harvested in the fall subsistence fishery, Nigliq Channel, Colville River, Alaska, 2017. Boxes represent the middle 50% of data while vertical lines within the boxes represent median values. Whiskers represent the 10th and 90th percentiles and black dots represent the lowest and highest 10% of values.

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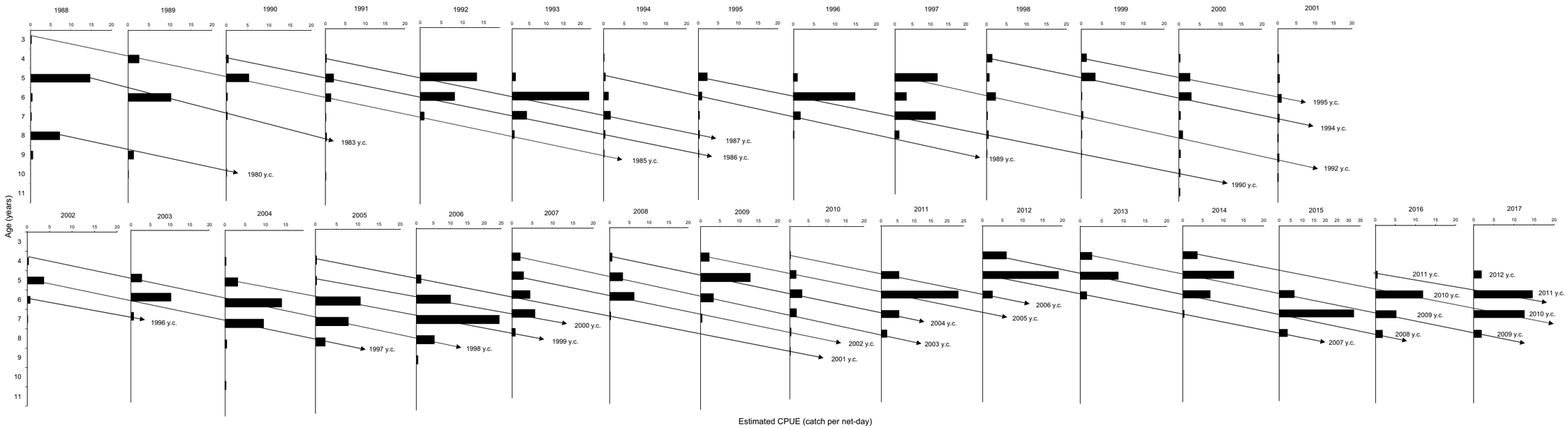

Figure 10. Catch per unit effort (CPUE) of Arctic Cisco by age class in the fall subsistence fishery, Niġliq Channel, 1988–2017. Arrows demonstrate the progression of select year classes through the fishery. Only fish harvested in 7.6-cm mesh gill nets are included and counts are standardized to 18 m net length, as described in text.

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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	0.4
1983	25.2
1984	0.3
1985	10.8
1986	15.1
1987	37.8
1988	2.4
1989	4.3
1990	29.1
1991	4.8
1992	15.4
1993	1.1
1994	4.8
1995	3.8
1996	2.5
1997	26.4
1998	30.0
1999	38.8
2000	16.0
2001	6.2
2002	9.5
2003	12.0
2004	22.1
2005	27.2
2006	8.1
2007	24.7
2008[a]	55.8
2009[a]	27.2
2010[a]	15.6
2011[a]	0.6

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

harvest monitoring team, by random chance, did not obtain 2010 year class samples of Arctic Cisco during 2015 surveys (Figure 11).

WATER QUALITY

Salinity and temperature monitoring began on 21 October 2017. Salinity was noticeably lower throughout the survey season than in years past, even at the downstream sampling stations (Stations 1 and 2, Figures 2 and 12). For example, during 2016 salinity peaked at 25.1 ppt in the Niġliq Delta area on 9 November (Seigle et al. 2017). By comparison, during 2017 the salinity never surpassed 19 ppt at the 3-m depth mark in the Niġliq Delta location. Whereas salinity in the Upper Niġliq area (Station 4) near Nuiqsut reached a maximum of 12.24 on 19 November in 2016, the salinity never surpassed 3.33 ppt in 2017 at the 3-m depth mark. Although overall salinity values in the Niġliq Channel were lower in 2017 than in previous years, it should be noted that salinity was considerably higher at the 3 downstream stations than at the station nearest Nuiqsut during the fishing season. Interestingly, ideal salinity conditions for Arctic Cisco (>15 ppt) were not present at the 2 upstream stations during the entire survey season at the 3-m depth mark (Stations 3 and 4; Figures 2 and 12). The lack of higher salinity waters in the Niġliq Channel during fall fishing in 2017could indicate greater downstream flow of under-ice fresh water (via ground water input) or decreased west winds in Harrison Bay which typically force more saline waters upstream. As is frequently the case, water temperature was higher upstream near Nuiqsut and lower downstream in the delta (Figure 12). However, there did appear to be some alternation between higher and lower temperatures in the uppermost sampling locations at various times during the season (Stations 3 and 4). This result may offer additional evidence that under-ice, downstream flowing waters (typically warmer water) were outcompeting the upstream movement of saline waters (typically colder water) at our sampling locations.

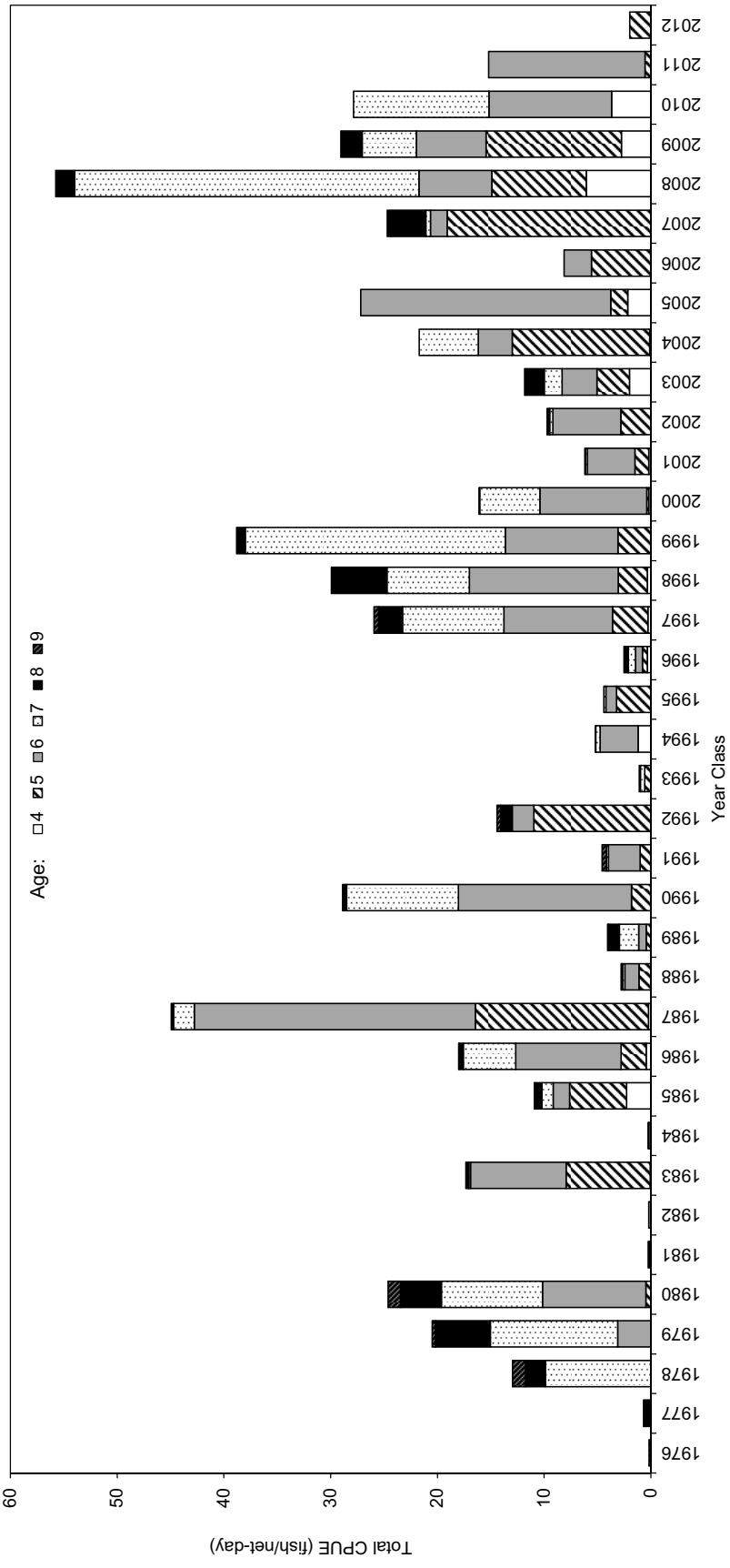

Figure 11. Cumulative catch per unit effort (catch per net-day) of Arctic Cisco by year class (year of hatch) in the fall subsistence fishery, Niglíq Channel, Colville River, 1976–2012 (capture dates 1985–2017). Catch per unit effort was estimated only for fish captured in 7.6-cm mesh nets.

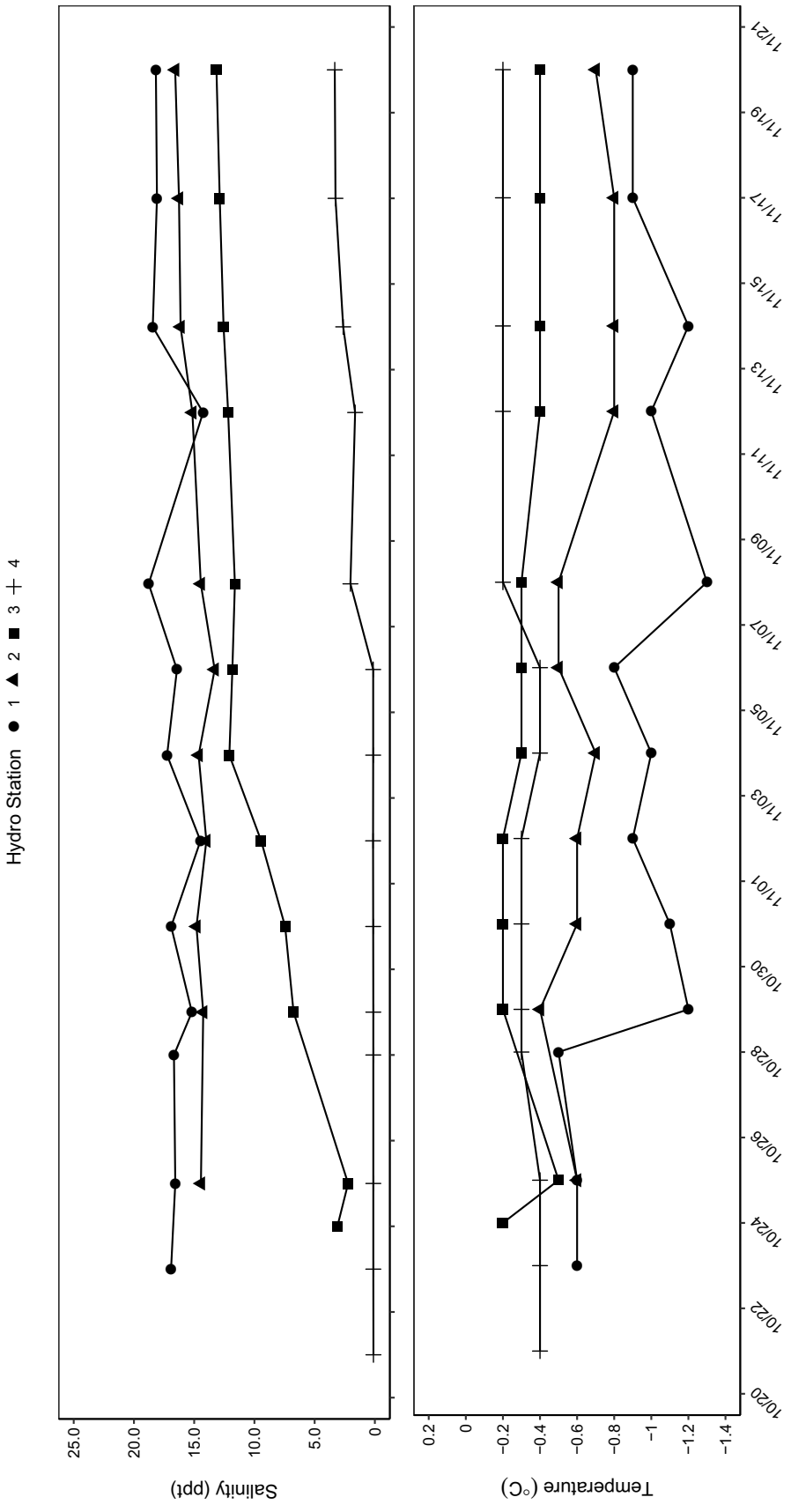

Figure 12. Salinity (parts per thousand) and temperature (°C) measured at 3.0-m depth from 4 water stations on the Nigliq Channel, Colville River, Alaska, 21 October to 20 November 2017.

SUMMARY

The results of 32nd year of fall fishery harvest monitoring on the Colville River indicate a very good year for Arctic Cisco catch rates. The 2017 CPUE of Arctic Cisco in the Niġliq Channel was the 5th best on record and a large increase over 2016 CPUE results. Effort in the fishery was focused mainly in the Upper Niġliq and Niġliq Delta fishing areas in 2017. However, catch rates were above average in all river sections of the Niġliq Channel. Once again, we did not receive a large number of fishing reports from the Main Channel, but the interviews we did receive suggest excellent results in that section of the Colville River as well. Age structure of Arctic Cisco in 2017 indicates age-6 and -7 fish (2011 and 2010 year classes, respectively) were the dominant age classes harvested, in keeping with results in 2016. Age-5 and -8 fish were represented in much smaller numbers overall, as would be expected for year-classes beginning to recruit to the fishery (Age 5, 2012 year class) and for those on the cusp of leaving the fishery (Age 8, 2009 year class).

Fishers generally expressed pleasure with harvest rates in 2017. The only concerns raised in the fishery were related to the appearance of a handful of Broad Whitefish which were infected with the *Saprolegnia* mold, with 2017 marking the 5th consecutive year of such reports. As in previous years, the harvest monitoring team worked with representatives of the North Slope Borough Department of Wildlife Management (NSB-DWM) to document instances of affected fish and, where possible, to facilitate the hand-off of these fish to NSB-DWM personnel for additional analysis. One of the more interesting developments in 2017 was the decreased salinity levels in the Niġliq Channel throughout the harvest season. However, although salinity was generally lower in all river sections in 2017, Arctic Cisco harvests remained strong and the fishery appears to be healthy.

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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, 2017.

Fisher Code	Fishing Area	Net	Net Code	Length (m)	Stretched Mesh (cm)	Start Date	End Date	Net-days	Adjusted Net-days
31	Upper Niġliq	A	16 31A 1	60	2.75	11/7/2017	11/21/2017	14	14.00
31	Upper Niġliq	B	16 31B 1	80	2.75	11/7/2017	11/21/2017	14	18.67
79	Niġliq Delta	A	16 79A 1	80	3	10/24/2017	10/31/2017	7	9.33
79	Niġliq Delta	A	16 79A 2	80	3	10/31/2017	11/12/2017	12	16.00
79	Niġliq Delta	B	16 79B 1	100	3	10/24/2017	11/2/2017	9	15.00
7	Upper Niġliq	A	16 7A 1	80	3	10/28/2017	11/7/2017	10	13.33
109	Upper Niġliq	A	16 109A 1	80	3	10/20/2017	11/6/2017	17	22.67
109	Upper Niġliq	B	16 109B 1	60	3	10/20/2017	10/28/2017	8	8.00
87	Niġliq Delta	A	16 87A 1	80	2.75	10/22/2017	11/17/2017	26	34.67
87	Niġliq Delta	B	16 87B 1	80	5	10/24/2017	11/2/2017	9	12.00
102	Nanuq	A	16 102A 1	30	2.5	10/21/2017	11/5/2017	15	7.50
102	Nanuq	B	16 102B 1	100	3	10/23/2017	10/24/2017	1	1.67
111	Main Channel	A	16 111A 1	80	3	11/7/2017	11/17/2017	10	13.33
48	Niġliq Delta	A	16 48A 1	73	3.5	10/28/2017	11/10/2017	13	15.82
25	Niġliq Delta	A	16 25A 1	60	3	10/28/2017	11/4/2017	7	7.00
25	Niġliq Delta	B	16 25B 1	60	3.5	10/29/2017	11/10/2017	12	12.00
25	Niġliq Delta	C	16 25C 1	80	3.5	11/4/2017	11/10/2017	6	8.00
108	Nanuq	A	16 108A 1	80	3.5	10/22/2017	11/6/2017	15	20.00
63	Niġliq Delta	A	16 63A 1	80	3	10/23/2017	10/28/2017	5	6.67
28	Niġliq Delta	A	16 28A 1	80	3.5	10/26/2017	11/5/2017	10	13.33
72	Main Channel	A	16 72A 1	60	3	10/30/2017	11/14/2017	15	15.00
72	Main Channel	B	16 72B 1	60	3	10/30/2017	11/14/2017	15	15.00
100	Upper Niġliq	A	16 100A 1	60	3	10/15/2017	10/29/2017	14	14.00
100	Upper Niġliq	A	16 100A 2	60	3	10/29/2017	12/1/2017	33	33.00
100	Upper Niġliq	B	16 100B 1	60	3	10/28/2017	11/28/2017	31	31.00
55	Upper Niġliq	A	16 55A 1	60	3.5	10/15/2017	10/28/2017	13	13.00
55	Niġliq Delta	A	16 55A 2	60	3.5	10/28/2017	11/17/2017	20	20.00
55	Upper Niġliq	B	16 55B 1	100	3	10/15/2017	10/28/2017	13	21.67
55	Niġliq Delta	B	16 55B 2	100	3	10/28/2017	11/12/2017	15	25.00
66	Upper Niġliq	A	16 66A 1	80	3.5	10/25/2017	10/28/2017	3	4.00
66	Upper Niġliq	A	16 66A 2	80	3.5	10/30/2017	11/6/2017	7	9.33
70	Nanuq	A	16 70A 1	80	3.5	10/28/2017	11/3/2017	6	8.00
70	Main Channel	A	16 70A 2	80	3.5	11/11/2017	11/17/2017	6	8.00
70	Nanuq	B	16 70B 1	60	3.5	10/29/2017	11/3/2017	5	5.00
70	Main Channel	B	16 70B 2	60	3.5	11/11/2017	11/17/2017	6	6.00

Appendix A. Continued.

Fisher Code	Fishing Area	Net	Net Code	Length (m)	Stretched Mesh (cm)	Start Date	End Date	Net-days	Adjusted Net-days
42	Upper Niġliq	A	16 42A 1	50	3	10/19/2017	10/26/2017	7	5.83
93	Upper Niġliq	A	16 93A 1	90	3.25	10/20/2017	11/16/2017	27	40.50
56	Niġliq Delta	A	16 56A 1	80	3	10/23/2017	11/12/2017	20	26.67
56	Upper NNiġliq	T	16 56T 1	60	5	10/18/2017	10/22/2017	4	4.00
110	Main Channel	A	16 110A 1	80	3	11/7/2017	11/14/2017	7	9.33
51	Upper Niġliq	A	16 51A 1	80	3	10/25/2017	11/14/2017	20	26.67
51	Niġliq Delta	A	16 51A 2	80	3	11/14/2017	11/17/2017	3	4.00
51	Niġliq Delta	A	16 51A 3	80	3	11/17/2017	11/22/2017	5	6.67
88	Niġliq Delta	A	16 88A 1	80	3.5	10/26/2017	11/14/2017	19	25.33
88	Niġliq Delta	A	16 88A 2	80	3.5	11/15/2017	11/22/2017	7	9.33
88	Niġliq Delta	B	16 88B 1	60	3.5	10/26/2017	11/14/2017	19	19.00
107	Upper Niġliq	A	16 107A 1	60	3	10/20/2017	11/3/2017	14	14.00
95	Upper Niġliq	A	16 95A 1	60	3	10/19/2017	11/16/2017	28	28.00
84	Upper Niġliq	A	16 84A 1	80	3.5	10/23/2017	10/28/2017	5	6.67
84	Main Channel	A	16 84A 2	80	3.5	10/28/2017	10/29/2017	1	1.33
84	Niġliq Delta	A	16 84A 3	80	3.5	10/31/2017	11/15/2017	15	20.00
84	Niġliq Delta	B	16 84B 1	100	3	11/2/2017	11/15/2017	13	21.67
49	Nanuq	A	16 49A 1	40	3.5	10/21/2017	11/6/2017	16	10.67
82	Niġliq Delta	A	16 82A 1	80	3	10/29/2017	11/12/2017	14	18.67
65	Niġliq Delta	A	16 65A 1	20	3	10/23/2017	11/7/2017	15	5.00
65	Niġliq Delta	B	16 65B 1	60	3	10/23/2017	11/6/2017	14	14.00
32	Nanuq	A	16 32A 1	80	3	10/22/2017	11/11/2017	20	26.67
32	Nanuq	B	16 32B 1	80	3	10/22/2017	11/11/2017	20	26.67
24	Niġliq Delta	A	16 24A 1	100	3	10/24/2017	11/24/2017	31	51.67
74	Main Channel	A	16 74A 1	100	2.5	10/30/2017	11/12/2017	13	21.67
74	Main Channel	B	16 74B 1	100	3	10/30/2017	11/12/2017	13	21.67
77	Upper Niġliq	A	16 77A 1	80	3	11/5/2017	12/9/2017	34	45.33
33	Nanuq	A	16 33A 1	80	3	11/5/2017	11/6/2017	1	1.33
33	Nanuq	A	16 33A 2	80	3	11/7/2017	11/18/2017	11	14.67
33	Nanuq	B	16 33B 1	93	3	11/5/2017	11/18/2017	13	20.15
33	Niġliq Delta	C	16 33C 1	80	2.5	11/12/2017	11/18/2017	6	8.00
999	Upper Niġliq	A	16 999A 1	80	3	10/29/2017	11/2/2017	4	5.33
Total									1,057.47

Appendix B. Estimated harvest of Arctic Cisco from the Colville River delta commercial and subsistence fisheries, 1967–2017.

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

Appendix B. Continued.

Year	Estimated Commercial Harvest[a]	Estimated Subsistence Harvest	Estimated Total Harvest
1999[b]	8,872	–	8,872
2000[b]	2,619	9,956	12,575
2001[b]	1,924	3,935	5,859
2002[b]	3,935	7,533	11,468
2003[b]	–	23,369	23,369
2004[b]	–	40,605	40,605
2005[b, c]	–	–	–
2006[c, d]	–	–	–
2007[e]	–	42,226	42,226
2008[e]	–	17,222	17,222
2009[e]	–	22,792	22,792
2010[e]	–	23,837	23,837
2011[e]	–	43,276	43,276
2012[e]	–	22,728	22,728
2013[e]	–	22,240	22,240
2014[e]	–	33,240	33,240
2015[e]	–	52,107	52,107
2016[e]	–	26,577	26,577
2017[e]	–	33,247	33,247
Average	23,383	25,471	32,773

[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.