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Estuarine Fish Ecology of the Yukon River Delta, 2014–2015

by

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and

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April 2017

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat or long
monetary symbols (U.S.)	\$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

A survey of fish species in the Yukon River Delta, primarily focused on juvenile Chinook salmon *Oncorhynchus tshawytscha*, was conducted in 2014 and 2015. The primary objective of this project was to get basic information on the fish assemblage in the delta, the outmigration phenology of salmon smolt, and the size and distribution of species using delta habitats. Sampling occurred during summer months starting with ice breakup, and included regular collections in habitats in major distributaries of the delta as well as monthly surveys in marine waters of the delta front. Water temperatures were much warmer in 2014 and 2015 than previous surveys of the Delta in 1986. Juvenile Chinook salmon were abundant within distributary samples throughout the sample period, utilizing all major distributaries of the river delta. Outmigration phenology of juvenile Chinook salmon was earlier in 2015 (median outmigration date 10 June) than 2014 (median outmigration date 23 June) and 1986 (median outmigration date 24 June). Average size at outmigration for distributary samples was also variable and significantly different among years (mean length in 1986 was 95 mm, in 2014 was 98 mm and in 2015 was 92 mm). Non-Chinook salmon species also showed evidence of interannual differences in size, seasonal growth patterns, and interannual outmigration phenologies. For example, chum salmon *O. keta* were smallest in 1986 (mean length 43 mm) and largest in 2014 and 2015 (48 mm). Like Chinook salmon, chum salmon outmigrated earliest in 2015 (median outmigration 10 June) compared to 2014 (median outmigration 20 June) and 1986 (median outmigration 18 June). Important non-salmon species captured in the Yukon River delta included: coregonids, burbot *Lota lota*, Arctic lamprey *Lethenteron camtschaticum*, saffron cod *Eleginus gracilis*, Pacific herring *Clupea pallasii*, ninespine stickleback *Pungitius pungitius*, rainbow smelt *Osmerus mordax*, and sheefish *Stenodus leucichthys*.

Key words Chinook salmon *Oncorhynchus tshawytscha*, chum salmon *O. keta*, coho salmon *O. kisutch*, pink salmon *O. gorbuscha*, whitefish, coregonid, Arctic lamprey *Lethenteron camtschaticum*, burbot *Lota lota*, sheefish *Stenodus leucichthys*, Pacific herring *Clupea pallasii*, saffron cod *Eleginus gracilis*, ninespine stickleback *Pungitius pungitius*, rainbow smelt *Osmerus mordax*, outmigration, length, delta, Yukon River

INTRODUCTION

The Yukon River Delta, like many estuaries, is an important transition zone and rearing habitat for anadromous and resident species, such as juvenile salmon *Oncorhynchus* spp., whitefish species (Subfamily Coregoninae), Arctic lamprey (*Lethenteron camtschaticum*), burbot (*Lota lota*), and others. The Yukon River is the longest river in Alaska and its basin encompasses an area of over 855,000 square kilometers, with the headwaters reaching into British Columbia, 3,200 kilometers from the mouth of the Yukon River (Brabets et al. 2000). Despite its size and importance to Alaska fisheries resources, limited biological information exists for estuarine habitats of the Yukon River.

Several studies have identified estuarine and early marine processes as critical in structuring productivity patterns for juvenile salmon (Beamish et al. 2011; Beamish and Mahnken 2001; Burla et al. 2010; Farley et al. 2007; Scheuerell et al. 2009; Weitkamp et al. 2011). Outmigration timing and growth may be strongly interrelated, and subsequent survival from this interaction has been demonstrated in Chinook salmon *O. tshawytscha*, stocks elsewhere (Scheuerell et al. 2009). There are also substantial data to support the critical size-critical period hypothesis that juvenile salmon that fail to reach a critical size during their first summer in marine waters have higher late fall and winter mortality rates (Beamish and Mahnken 2001; Farley et al. 2007). Size selective mortality has been demonstrated for juvenile Yukon Chinook salmon, where fish have a higher probability of surviving to adulthood if they attain a minimum size threshold by the end of the fish’s first summer at sea (Howard et al. 2016). Furthermore, juvenile Chinook salmon studies from the Columbia River have demonstrated that interannual variability of adult returns was best described by juvenile marine growth rate and size of juveniles (Tomaro et al. 2012). The interplay of growth, outmigration timing, size, diet and condition of juvenile Chinook salmon throughout early marine rearing habitats is, therefore, integral to addressing the role of estuarine and early marine processes in structuring cohort strength of Yukon River stocks.

Previous estuarine research of the Yukon River is from 2 fish surveys conducted in 1986 and 1987 as part of the *Outer Continental Shelf Environmental Assessment Program* (Martin et al. 1988; Martin et al. 1989). The primary purpose of these studies was to identify the importance of aquatic habitats for juvenile salmon and other fishes, and to determine their vulnerability to potential impacts of an oil spill should oil development occur in this region. In other northern deltaic river systems, juvenile salmon use distributaries and tidal channels for rearing, growth, and protection from predators prior to movement into higher salinity marine waters (Healy 1980; Levy and Northcote 1982; Levings et al. 1991; Hering et al. 2010; Spilseth and Simenstad 2011). During 1986, the Yukon River estuary was broadly sampled and included sampling stations in the inner delta platform (tidal channels), delta front, and distributaries (Martin et al. 1988; Figure 1). Juvenile Chinook salmon were captured in all habitats except tidal channels. During 1987, sampling was limited to the mainstem of the Yukon River, 3 sites on the delta platform/front, and 1 consistently sampled tidal channel and mudflat site. A single large juvenile Chinook salmon was captured in the tidal channel and none were captured in the mudflat (Martin et al. 1989). Additionally, relatively few juvenile Chinook salmon (69 fish) were captured in surface trawls targeting the top 1.8 m of the water column on the delta platform and front (Martin et al. 1989). Martin et al. (1988) concluded that juvenile Chinook salmon move rapidly through the Yukon River Delta by strong river flow to deeper estuarine habitats, with limited use of intertidal habitats. However, the limited spatial and temporal scope of the previous study warrants further and expanded research in this area.

In 2014 and 2015, a team of scientists from Alaska Department of Fish and Game (ADF&G), National Oceanic and Atmospheric Administration’s Alaska Fisheries Science Center (AFSC) and local fishermen and technicians from Yukon Delta Fisheries Development Association (YRDFA) conducted sampling in the Yukon River Delta. The methods and locations sampled were informed by the previous study conducted in the 1980s, but expanded upon those efforts to sample the entire delta and incorporate additional analyses to understand the ecology of the region. This study was intended to provide basic information on the outmigration phenology and size of outmigrating salmon, particularly juvenile Chinook salmon, and build upon the previous study by also examining the overall fish community, and juvenile Chinook salmon diet and nutritional status.

OBJECTIVES

1) Describe environmental conditions in the Yukon River Delta in 2014 and 2015 summer seasons.
2) Summarize catches of fish species in the Yukon River Delta.
3) Describe spatial distributions and timing of juvenile salmon and other fishes across habitats.
4) Describe size distributions of juvenile salmon and other fishes during the summer season.

STUDY AREA

The Yukon River Delta is a complex environment composed of an emergent delta plain, a sub-ice depositional delta platform, a steep delta front, and a relatively shallow prodelta (Martin et al.

1989; Figure 1). The platform, which separates the delta front and pro-delta from the shoreline of the plain, extends as much as 30 km offshore of the plain with depths between 1 and 3 m. It is incised with numerous sub-ice channels between 5 m and 15 m deep that act as offshore extensions of the major river distributaries. These channels transport sediment from the platform and the river into the marine environment (Dupré 1980), and may act as outmigration corridors for juvenile fish. The platform drops off steeply along the delta front which marks the transition between fresh and estuarine waters of the Yukon River and the marine environment (Martin 1988). Fresh water from the Yukon River stretches offshore of the delta front as a buoyant surface layer that defines the estuary of the Yukon River. The offshore extent of this surface layer is determined by river discharge and winds.

The delta plain is composed of a complex of distributaries, marshes, lakes, and tidal sloughs. Three primary channels or distributaries of the river, known as South Mouth (SM), Middle Mouth (MM), and North Mouth (NM), connect directly with the open water of the delta platform. Off these primary channels, there are a number of smaller channels and sloughs.

In this study, small fish were sampled in distributary, delta platform (tidal channels and mudflats), and delta front areas (Figure 1). Together the distributary and delta front samples provided a comprehensive sampling of the estuarine/nearshore rearing habitat for a variety of fish species, and particularly salmon.

METHODS

DATA COLLECTION

Delta Front Sampling

The outer part of the Yukon River Delta (beyond major land masses) was sampled during the summers of 2014 and 2015, along 5 transects set perpendicular to the delta front. An alternate transect (Stuart) was also chosen to allow for additional sampling when weather, ocean conditions, or equipment difficulties prevented sampling 1 or more of the primary transects in a given sample cruise. Each transect had 3 sampling stations located at the 8 m, 11 m, and 14 m depth contours (Figure 2). These depths were selected to sample the range of habitats from the beginning of the marine environment to the edge of the Yukon River plume. The location of each sampling station was recorded by GPS. Two tows were attempted at each station during each sample event. Transects were sampled once in each of June, July, and August of each year. All sampling was conducted during daylight hours.

All stations were sampled in 2014 with a mid-water trawl (10 m foot and head ropes, 20 m length, 1.6 cm nylon mesh at the head rope decreasing to 0.4 cm at the cod end), towed near the surface to sample the top 3 m of the water column. At the 2 offshore (deeper) stations, the net was also towed below the surface to sample the water column from 2 m to 5 m deep. In 2015, the surface tows at all stations were made using a surface trawl (12 m foot and head ropes, 15 m length, 1.6 cm nylon mesh at the head rope decreasing to 0.4cm at the cod end), and the deeper tows at the offshore stations were made with the midwater trawl. The trawl was towed for 20 minutes at each station, in both years.

After retrieval of the trawl, all captured fishes were sorted, counted, identified to species, and each species subsampled. Up to 50 fish of each species was measured for length to the nearest mm (fork length (FL) or total length (TL) dependent upon species). Salmon were assigned a unique sample number and individually frozen for further laboratory analysis. Up to 5 fish from each salmon species were retained for stomach content analysis from each station. Individuals that could not be identified in the field were vouchered and returned to the lab for identification.

Delta Platform Sampling

Tidal channels and mud flats (delta platform) were also sampled in 2014 for salmon and other fish during high tide, using a combination of push nets and beach seines. Push nets were operated from a skiff pushing the net up-channel during high tide and was used in channels where the banks were too soft for walking. Narrow channels with stable banks were sampled using a beach seine dragged up-channel during high tide. The seine was set by round haul, where 1 end of the net is held on shore and the other end is towed into the current by the skiff and brought to shore at the upstream bank. Stations were selected on the day of sampling in an attempt to broadly sample these habitats across the delta. All sampling was conducted during daylight.

Initially each station was sampled at least twice each week, beginning shortly after ice breakup. However, tidal channel and mud flat sampling was eventually abandoned at the end of June 2014 due to low fish catches and logistical difficulties. Analyses do not include tidal channel and mud flat samples and no further discussion will be presented of these data (raw catch data and sample locations available in Appendices A1 and A2).

Distributary Sampling

Inner delta (waters within major land masses) sampling occurred in active distributaries. Sampling began each year shortly after ice breakup in the lower river and continued through the end of July. The location of each sampling station was recorded by GPS. Sampling sites were selected in 2014 based on a broad distribution of sites, observed catches of fish, and catchability of gear at the site. In 2014, all tributary stations on the SM and MM, and 1 station (HAM) on the NM were sampled at least twice each week. An additional station on NM (OPP) was sampled weekly. Sample sites were fixed in 2015 and included 1 additional sampling station in each of the NM and MM (Figure 3). In 2015 all stations were sampled 3 times each week.

Distributaries were sampled by fisherman-biologist teams using surface tow nets towed between 2 skiffs. The net was towed against the direction of the current. The net selected measures 6.8 m wide and 1.8 m depth at the mouth tapering to a 0.3 m by 0.3 m bag at the cod end; this net shares the same dimensions as the tow net used by Martin et al. (1989). Tows were standardized to 15 minutes and 3 tows were conducted at each station during each sample event. A digital flow meter (General Oceanics 2030R[1]) was placed over the side of the skiff during the period of time the net was deployed to calibrate the volume of water sampled in each tow. All sampling was conducted during daylight.

After retrieval of collection gear, all captured fishes were sorted, counted, identified to species, and each species was subsampled (up to 50 fish per station). Subsampled fish were measured for length, unidentified voucher specimens were preserved, and up to 5 fish from each species of salmon were preserved in formalin for stomach content analysis. For Chinook salmon smolt, tissue samples for genetic analyses were collected, preserved in ethanol, and individually numbered. Whole Chinook salmon smolt were also collected, weighed, and preserved for energetic analyses.

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1 Product names used in this report are included for scientific completeness but do not constitute a product endorsement.

ENVIRONMENTAL DATA

Available data sources were used for large scale environmental characteristics. River discharge data are available from a gauge site near Pilot Station, Alaska, approximately 198 km upstream of the Yukon River delta. These data are provided by the U.S. Geological Survey National Water Information System database. River ice breakup timing data are recorded at various river locations by NOAA National Weather Service's Alaska-Pacific River Forecast Center. Ice breakup at Alakanuk and neighboring Emmonak in the south mouth was used for analyses. Air temperature has consistently been recorded at the Nome airport by the National Weather Service. As the closest consistently sampled air temperature to the study location and the longest local dataset, Nome air temperature was used as a proxy for air temperatures on the Yukon Delta.

Environmental data were collected with each sample event for delta front, delta platform and distributary stations. A SeaBird SBE19 CTD collected water column profiles of salinity, temperature, depth, and turbidity at each mile along the delta front transects. On the delta front, environmental data were averaged by station and cruise for the top 10 m of the water column. Surface temperature and depth were recorded before each sample event for delta platform and distributary stations. Additionally, salinity was recorded for delta platform stations at the top and bottom of the water column, by collecting a water sample using a Fieldmaster basic water bottle and measuring salinity with either an Extech ExStik conductivity/salinity meter or a refractometer.

CATCH ANALYSES

All sampled fish were identified to the lowest taxon possible, often species, but whitefishes in particular could only be consistently and reliably differentiated to subfamily. Multiple life stage groups within each species/family were often evident, but defining those groups was challenging without age information. Adults were identified as those individuals of sizes larger than the minimum length at maturity from pertinent literature; all other fish were considered immatures and probably consisted of multiple age groups in most cases (Table 1). Arctic lamprey ammocoetes, Arctic lamprey juveniles, and juvenile salmon were identifiable based on size and gross morphological differences among adults of their species. Ninespine stickleback (*Pungitius pungitius*) is not differentiated by maturity class here because little information is available on size at maturity of this species in the Bering Sea.

Table 1.–Length range defining adult from immature life history stage for common fish species encountered.

Species	Adult Length Cutoff	Literature Source
Burbot	>203 mm	ADF&G species profile (http://www.adfg.alaska.gov/index.cfm?adfg=burbot.main, cited June 3, 2016)
Coregonids	>200 mm	Brown et al. 2012
Rainbow Smelt	>170 mm	Dion and Bromaghin 2008
Sheefish	>540 mm	Brown et al. 2012
Pacific Herring	>202 mm	Average of smallest sizes of spawning herring observed in Norton Sound commercial and test fisheries (1980–2007), and AYKDBMS (http://www.adfg.alaska.gov/CommFishR3/WebSite/AYKDBMSWebsite/Default.aspx)
Saffron Cod	>300 mm	Cohen et al. 1990

Note: Any fish above the length classification is considered an adult and excluded from analyses of immature fish.

Delta Front

Catch rate was measured as catch per minute (#/min) for all trawl caught fish, for each 20 minute tow. The study design of the front sampling employed implicit spatial and depth coverage around the western and northern boundaries of the front. Because the overall effort was spatially and temporally balanced, catch per minute was averaged across all stations and transects sampled, for each sample month. In addition, for juvenile Chinook and chum salmon, average length was calculated for each sample month.

Distributary

Temporal and spatial investigations were restricted to those distributary sites that were consistently sampled throughout the season in each study year (Table 2).

Table 2.–Stations used for temporal and spatial distribution analyses from each of the South Mouth (SM), Middle Mouth (MM), and North Mouth (NM) distributaries.

Distributary	2014	2015
SM	Flat, Martin	Flat, Martin, Aproka
MM	F&G Eddy, Seagull	F&G Eddy, Seagull, Nunatak
NM	Ham, OPP	Ham, OPP, NM Slough

Any comparisons made to the Martin et al. (1989) study used SM sites only because the earlier study only sampled SM. Furthermore, temporal data used from the earlier study were restricted to their Sites 13 and 17, which were the most consistently sampled throughout the season (Martin et al. 1989). It should be noted that the Martin and Aproka sites in the present study are geographically equivalent to Sites 13 and 17 in the Martin et al. (1989) study, though river topography has changed greatly since the 1980s.

Distributary catch per unit effort (CPUE) for each set of the tow net was calculated in 2 ways. For all comparisons to the previous Martin et al. (1989) study which used catch per minute as a measure for CPUE, CPUE in the present study was also determined as catch per minute. For all other analyses, CPUE was evaluated as catch (*C*) per unit surface area swept (*a*):

$$CPUE = \frac{C}{a}.$$

The swept area (*a*) for each tow was estimated as:

$$a = \#\ flowmeter\ revolutions\ \times \frac{0.0269\ \mathrm{m}}{\mathrm{revolution}} \times 6.8\ \mathrm{m\ net\ width}.$$

Individual tow CPUE was averaged for each statistical sample week (Table 3) and for each of 3 distributaries to investigate temporal and spatial differences in catch. For example, the CPUE value of SM distributary for a given week was the average of the CPUE for each of the replicate tows at each of the SM sites.

Unlike CPUE, size investigations included all pertinent size data from distributary sampling, including samples collected from sites that were not consistently sampled across the season. Weight data were only collected for juvenile Chinook and coho salmon (*Oncorhynchus kisutch)*. In addition to descriptive statistics, *t*-tests for comparisons among years were conducted where appropriate. Analysis of Variance (ANOVA) was used for length comparisons by year for Chinook and chum salmon (*Oncorhynchus keta*), where the Martin et al. (1989) data was included as a third year category. It was hypothesized that higher spring temperature (mean May air temperature in Nome) would be associated with larger mean length in a given year. Length-weight relationships were explored for juvenile Chinook and coho salmon using the least-squares regression on log transformation of the equation:

$$W = aL^b$$

Where *W* is weight, *L* is length, *a* is a constant and *b* is a growth coefficient.

Table 3.–Statistical weeks used in this study during the sample period in each year.

Statistical Week	2014 Dates	2015 Dates
22	5/26–6/1	5/25–5/31
23	6/2–6/8	6/1–6/7
24	6/9–6/15	6/8–6/14
25	6/16–6/22	6/15–6/21
26	6/23–6/29	6/22–6/28
27	6/30–7/6	6/29–7/5
28	7/7–7/13	7/6–7/12
29	7/14–7/20	7/13–7/19
30	7/21–7/27 [a]	7/20–7/26
31	No sample	7/27–8/2 [b]

[a] Actual sample end date July 25.

[b] Actual sample end date July 28.

RESULTS AND DISCUSSION

ENVIRONMENTAL CONDITIONS

River discharge and ice breakup timing

Consistent with the earlier ice breakup timing in 2014, peak discharge occurred May 22 in 2014 compared to June 3 in 2015. Discharge patterns were very different between the 2 years: discharge remained steady in 2014 through the sample period, but discharge had a higher peak in 2015 and dropped off dramatically afterwards (Figure 4).

River ice breakup in the lower river in 2014, as assessed at Alukanuk (SM of the delta), was the second earliest on record on May 11. Ice breakup timing in 2015 occurred on May 19 in the lower river, which is slightly earlier than the long term average at Emmonak/Alukanuk, Alaska.

Temperature

Distributary water temperatures in both years of this study were above the long-term historical average documented for the lower Yukon River (Figure 5). Water temperatures in 2015 were particularly high and exceeded the historic maxima on 9 days, and on 2 days exceeded the historic by more than 1°C. In 2014 average May temperature was 9.2°C (SD = 0.9), average June temperature was 13.4°C (SD = 1.7), and average July temperature was 16.2°C (SD = 0.8). In 2015 average May temperature was 8.8°C (SD = 1.6), average June temperature was 15.2°C (SD = 2.4), and average July temperature was 17.4°C (SD = 0.8).

Marine Conditions

Weather conditions differed between sampling years. In June and August 2014, prevailing winds were from the northwest at 5–15 mph, and sea state was high (4–6 ft) at the beginning of the cruise becoming light toward the end. Winds in July 2014 were primarily from the southwest at 10–20 mph and a moderate sea state (3–6 ft) throughout the cruise. Prevailing winds during all cruises in 2015 were easterly. June 2015 had predominantly southeast winds of 10–15 mph and seas of 3–5 ft. Winds were lighter through most of July and August 2015 cruises. Prevailing winds during this period were southeast from calm to 10 mph and seas were generally calm or with a low swell, except the end of the August cruise when southeast winds rose to 20 mph and seas of 6–8 ft halting sampling.

On the delta front, average turbidity was highest in June, average salinity was variable across months, and average monthly sea surface temperature was highest in August for both 2014 and 2015 (Table 4).

Table 4.–Delta front environmental characteristics measured in cruises conducted in June, July and August.

Year	Cruise	Mean Turbidity (NTU)	Mean Salinity (PSU)	Mean Temperature (°C)
2014	June (6/17–6/21)	18.86	19.11	9.69
	July (7/22–7/26)	15.89	20.16	10.70
	August (8/20–8/24)	7.07	19.00	13.75
2015	June (6/10–6/14)	18.98	18.08	6.60
	July (7/3–7/8)	9.85	21.04	11.87
	August (8/6–8/10)	11.08	23.06	11.97

CATCHES

As expected, catches in the delta front were primarily marine species (Table 5), and those in the distributaries were primarily anadromous and resident freshwater species (Table 6). Few species were caught in both delta front and distributary habitats; primarily Arctic lamprey and salmon species.

Use of the 2-boat tow nets in distributaries appeared most effective of all sampling attempted and yielded the highest fish catches overall. The productivity of several sampling sites was explored in 2014, and the establishment of most productive sites was necessary in the first year of study, consistent with the 2014 sampling plan (Appendices A2–A4). Groundwork laid with establishment of sites in 2014 was built upon in the 2015 sample plan and implementation (Appendices A2 and A5). Comparisons of catch results between 2014 and 2015 should consider that sampling plans were different between the 2 years.

On the Yukon Delta Front, sampling occurred later in 2014 for all cruises than in 2015. Weather conditions and logistical challenges hampered the ability to conduct 2 tows at each station, on each transect, in each month, in each year (Appendix A6). Notably, no sampling occurred in June 2014 at Kawanak transect, July 2014 at Taku transect, and July 2015 at Kwiguk transect. Stations at the alternate Stuart transect were substituted. In August sampling on the Apoon transect had to be halted for adverse weather and the inner and middle stations could not be sampled. However, the overall sampling effort remained balanced spatially and temporally to enable overall catch patterns by month and year.

Table 5.–Delta front sample species composition.

Species	2014 Catch	2014 Percent	2015 Catch	2015 Percent
Juvenile Chinook salmon	25	0.1%	42	0.4%
Juvenile chum salmon	182	0.8%	480	4.1%
Immature Herring	3,039	13.2%	3,930	33.6%
Immature Rainbow Smelt	8,141	35.4%	1,006	8.6%
Immature Saffron Cod	7,784	33.8%	1,977	16.9%
Ninespine stickleback	3,464	15.0%	3,511	30.0%
Other	386	1.7%	763	6.5%
Total	23,021	100%	11,709	100%

Note: The category "Other" includes immature and adult life stage individuals not identified, as well as other species encountered infrequently.

Table 6.–Distributary sample species composition.

Species	2014 Catch	2014 Percent	2015 Catch	2015 Percent
Juvenile Chinook salmon	406	1.5%	951	1.1%
Juvenile chum salmon	9,727	36.7%	11,834	13.5%
Juvenile coho salmon	218	0.8%	329	0.4%
Juvenile pink Salmon	430	1.6%	8,825	10.0%
Immature Burbot	756	2.9%	8,494	9.7%
Immature Coregonid	11,543	43.6%	49,309	56.2%
Juvenile Arctic Lamprey	1,052	4.0%	2,342	2.7%
Immature Sheefish	2,106	8.0%	4,928	5.6%
Other	244	0.9%	803	0.9%
Total	26,482	100%	87,815	100%

Note: The category "Other" includes immature and adult life stage individuals not identified, as well as other species encountered infrequently.

Delta Front

The number of fish captured differed substantially between sampling years; 22,697 fish were captured in 2014 versus 10,932 in 2015. In both years, the majority of fish captured were from 4 species: rainbow smelt (*Osmerus mordax*), saffron cod (*Eleginus gracilis*), Pacific herring (*Clupea pallasii*), and ninespine stickleback. The combined catch of these species accounted for 99% of the total species catch in 2014, and 91% of the total species catch in 2015 (Table 5). The composition of these dominant species differed between years. In 2014, rainbow smelt were the most numerous species and accounted for 36% of the total catch, followed closely by saffron cod with 34% of the total catch. Ninespine stickleback and Pacific herring accounted for 15% and 13% each. In 2015, ninespine stickleback and Pacific herring were the most abundant species and totaled 32% of the total catch each, whereas saffron cod and rainbow smelt accounted for 18% and 9%, respectively. Also in 2015, chum salmon accounted for 4% of the total catch, whereas in 2014 this species was less than 1% of the total catch. Chinook salmon accounted for less than 1% of the total catch in both years.

Chinook salmon (Oncorhynchus tshawytscha)

A total of 25 Chinook salmon were captured on the delta front stations in 2014 and 42 were captured in 2015. The highest catch rate occurred in June of both years (Figure 6). Juvenile Chinook salmon were more prevalent at stations on transects located in Norton Sound, and 34% of the Chinook salmon in both years captured at the Apoon station located off the mouth of the north tributary. In June of both years, fish were captured at all station depths, but approximately half of the Chinook salmon were caught at the middle station where water depths averaged 35 ft. Another 38% of the catch occurred at the inshore station in water depths of 25 ft or less, whereas the stations farthest offshore had the lowest catch. In July and August, no Chinook salmon were captured at the nearshore stations.

The length range of juvenile Chinook salmon captured on the delta front was 78–131 mm FL, and an average length of 102 mm (SD = 17). Too few samples were available to explore spatial patterns or interannual differences in size (Figure 7). In both sampling years, the average length of juvenile Chinook salmon captured on the Delta front in June was larger than the average length of juvenile Chinook salmon from distributary samples for the same time period (Table 7).

Table 7.–Mean fork length (SD) of Chinook salmon from delta front and distributary habitats during the same sample periods, for those sample periods with length sample size ≥10.

Habitat	June 2014 (6/16–6/22)	June 2015 (6/8–6/14)	July 2015 (7/6–7/12)
Delta Front	104 mm (16)	94 mm (9)	116 mm (13)
Distributary	94 mm (8)	90 mm (7)	87 (9)

Chum salmon (Oncorhynchus keta)

Juvenile chum salmon were caught on all cruises in both years. Catch in 2015 was significantly higher than in 2014, with a total of 153 chum salmon caught in 2014 and 373 chum salmon caught in 2015. Chum salmon were captured on all transects and at every station except the nearshore station on the Taku transect directly off the mouth of the south tributary. In 2014, chum salmon catch rates were highest in June of both years (Figure 8).

The length range of juvenile chum salmon captured on the delta front was 25–119 mm FL, and an average length of 66 mm (SD = 20). Small differences in lengths among years may be due to cruises occurring later in 2014 than 2015 for all months. Juvenile chum salmon length increased over the course of the sample season in both years (Figure 9). Juvenile chum salmon captured on the Delta front were typically larger than juvenile chum salmon captured in the distributaries during the same sample period (Table 8).

Table 8.–Mean fork length (SD) of chum salmon from delta front and distributary habitats during the same sample periods, for those sample periods with length sample size ≥10.

Habitat	June 2014 (6/16–6/22)	July 2014 (7/2–7/27)	June 2015 (6/8–6/14)	July 2015 (7/6–7/12)
Delta Front	53 mm (7)	89 mm (13)	46 mm (6)	71 mm (9)
Distributary	46 mm (6)	51 mm (7)	47 mm (5)	52 mm (6)

Rainbow smelt (Osmerus mordax)

Catch of immature rainbow smelt varied substantially between years comprising approximately 31% of the total catch in 2014, but only 3% of the catch in 2015 (Table 5). Immature rainbow smelt catch rate peaked in the June sample period in 2014 and in the August sample period in 2015 (Figure 10). In 2014, catch rate was high at Kwiguk transect, whereas in 2015 catch rate was high at Taku transect. These transects cover the southwestern part of the sampling area, near the south mouth of the river. Rainbow smelt ranged in size from 15 mm to 220 mm FL, and an average length of 91 mm (SD = 33).

Saffron cod (Eleginus gracilis)

Saffron cod were the second most numerous species captured on the delta front in 2014 comprising 33% of the total catch (Table 5). In 2015, saffron cod made up only 17% of the total catch, making them the third most numerous species after ninespine stickleback and Pacific herring. In 2014, saffron cod catch rate peaked in the July sample period and in 2015 saffron cod catch rate peaked in the August sample period (Figure 11). In both years the largest catch rates were found on the Kawanak transect, just offshore of the middle mouth of the river. The size range of saffron cod sampled was 19–300 mm, and an average length of 80 mm (SD = 47).

Pacific herring (Clupea pallasii)

Pacific herring made up approximately 30% of the total species catch in 2015, compared to 13% in 2014 (Table 5). Pacific herring were most abundant in August trawls in both years (Figure 12). In 2014, herring catch rate was highest at the Kawanak transect, just off the middle mouth of the Yukon River. In 2015, herring catch rate was highest at the Taku transect, just south of the south mouth of the river. Pacific herring ranged in size from 22 mm FL to 290 mm FL, and an average length of 74 mm FL (SD = 39). The majority of herring in both years were less than 80 mm FL.

Ninespine stickleback (Pungitius pungitius)

On the delta front, ninespine stickleback were captured at all depth strata and accounted for approximately 15% of the total species catch in 2014, and 30% in 2015 (Table 5). This species was caught in roughly equal numbers in both 2014 and 2015, but the composition of the catch was different in each year. In 2014 stickleback catch rate was highest in June, primarily at the Taku transect south of the south mouth. In 2015, stickleback catch rate was highest in August at stations throughout the study area (Figure 13). Ninespine stickleback ranged in size from 21 mm to 84 mm total length, and an average length of 49 mm TL (SD = 9).

Distributary

The total number of fish captured increased substantially between years with a total of 27,269 fish captured in 2014 and 90,696 fish captured in 2015. Captured fish were predominantly immature, though adult and larval stage individuals were occasionally caught for some species. In both years, immature coregonids (whitefish and cisco) were most abundant followed by juvenile chum salmon. These 2 species combined accounted for approximately 78% of the total catch in 2014 and 67% of the total catch in 2015. Immature sheefish (*Stenodus leucichthys*), juvenile lamprey, and immature burbot were the next most abundant species, accounting for a combined 14% of the catch in 2014, while juvenile pink salmon and immature burbot were common in 2015 and accounted for a combined 19% of the total catch. Juvenile Chinook salmon made up 1.5% and 1.0% of the total catch in 2014 and 2015, respectively. (Table 6).

Chinook salmon (Oncorhynchus tshawytscha)

Although more juvenile Chinook salmon were captured in 2015 compared to 2014, they represented a relatively similar contribution to the catch between years (Table 6). There were no apparent differences in CPUE among distributaries, though temporal differences are evident among years and distributaries (Figure 14). Catches of juvenile Chinook salmon spanned the sampling period. In 2014, juvenile Chinook salmon abundance peaked in MM and NM sites the second week of June, and an MM catches potentially exhibiting a second group of fish the first week of July. SM sites showed the highest juvenile Chinook abundance between the third week of June and first week of July in 2014. Catches of juvenile Chinook salmon in 2015 indicated 3 groups of fish outmigrating during the season: a peak in the second week of June at all 3 distributaries, a peak the first week of July at SM sites, and a small peak at the end of July at MM and NM sites.

Based on the temporal differences in juvenile Chinook salmon catches among distributaries in 2014 and 2015, sampling efforts of the Martin et al. (1989) study (which only sampled SM sites) should be considered cautiously in terms of interpreting overall outmigration phenology. However, it is still possible to compare SM sites with the prior study to look at gross changes in outmigration phenology that may relate to broad temperature patterns or river ice breakup timing. The first quartile, midpoint and third quartile of marine entry in the SM detected by these projects were earliest in 2015 and latest in 1986 (Figure 15 and Table 9). It appears that marine entry phenology, at least as represented by SM sampling with the few years of available data, is potentially more influenced by spring temperatures than the river ice breakup date. The first quarter of juvenile Chinook salmon passage in 2014 was approximately 29 days after ice breakup, which was the greatest lag between ice breakup and early marine entry among the years. Conversely, warmer spring temperatures among the 3 years appear to coincide with earlier marine entry timing.

Table 9.–Juvenile Chinook salmon marine entry phenology from SM sampling, mean spring air temperature and ice breakup dates for 1986, 2014, and 2015 sampling.

Year	25% marine entry date	50% marine entry date	75% marine entry date	Nome mean May air temperature	Ice breakup date at Emmonak
1986	17 Jun	24 Jun	10 Jul	0.9°C	30 May
2014	9 Jun	23 Jun	2 Jul	1.7°C	11 May
2015	3 Jun	10 Jun	26 Jun	5.1°C	19 May

Length ranges were similar among sample years between approximately 56 mm and 136 mm. Although NM fish in 2015 appeared relatively smaller than SM and MM fish, differences in length patterns among distributaries were confounded by interactions with temporal changes in size. No distributary level effect on length was observed in 2014. The average length was smaller in 2015 (92 mm, SD 12 mm) compared to 2014 (98 mm, SD 10 mm), potentially due to earlier outmigration timing. When including data from the Martin et al. (1989) study, size was significantly different among years ($F_{2,\ 1660} = 45.06$, $p < 0.001$; Figure 16). Moreover, there was evidence of seasonal growth: fish captured earlier in the season (prior to a significant number of ice-free growing days) were smaller than those outmigrating later in 2014 (Figure 17). A similar trend of increasing size appeared in June of 2015, but a group of much smaller fish outmigrated in July, which was not present in 2014 (Figures 17 and 18). This group of small individuals may represent subyearling fish, and future otolith ageing may be used to investigate this possibility. Outmigration sampling conducted near Dawson, Canada has indicated that freshwater age-0 Chinook salmon outmigrate later than their age-1 counterparts (Bradford et al. 2008), so the temporal difference in size/age classes may be warranted for Yukon Chinook stocks.

Associated weight data available for juvenile Chinook salmon allowed us to also examine length-weight relationships at marine entry. In 2014 the length-weight relationship was fit using *a* and *b* values of 7.62×10^{-6} ($\pm 1.75 \times 10^{-6}$, $p < 0.001$) and 3.07 (± 0.05, $p < 0.001$). In 2015, the length-weight relationship was fit using *a* and *b* values of 6.09×10^{-6} ($\pm 1.03 \times 10^{-6}$, $p < 0.001$) and 3.11 (± 0.04, $p < 0.001$; Figure 19).

Chum salmon (Oncorhynchus keta)

Juvenile chum salmon were proportionally more abundant in 2014 catches compared to 2015 catches, and were the second most abundant fish species in both years (Table 6). Overall abundance appeared to be higher in MM and SM sites compared to NM sites. Outmigration phenology of juvenile chum salmon in 2014 appeared to be dissimilar for SM sites compared to NM and MM sites, but more similar in 2015 among sites (Figure 20). Median marine entry timing in 2015 (10 June) was 10 days earlier than in 2014 (20 June) and 8 days earlier than in 1986 (18 June). In 2015, CPUE was high through mid-June and then dropped to low levels through the end of the July. In contrast, 2014 CPUE was also high at MM and NM sites in May through early June and then dropped, but SM CPUE remained high until the end of June.

The length range of juvenile chum salmon observed was 30 mm to 91 mm, though 99% of individuals were less than 65 mm in length. The chum salmon were significantly larger in 2015 compared to 2014, though the difference was very small ($t(7095) = -5.05$, $p < 0.001$). The average size of fish from 2014 was 47 mm (SD = 7) and the average size of fish from 2015 was 48 mm (SD = 8). When including data from the Martin et al. (1989) study, length was significantly different among the 3 sample years ($F_{2,\ 8464} = 194.6$, $p < 0.001$; Figure 21). Growth was evident among juvenile chum salmon over the course of the sample period (Figure 22). In 2014 SM sites appeared to catch fish slightly larger than in the other distributaries and in 2015 NM sites appeared to catch fish slightly smaller than the other distributaries, but temporal differences interacted with this effect (Figure 23).

Coho salmon (Oncorhynchus kisutch)

Juvenile coho salmon contributed a proportionally smaller amount in 2015 relative to 2014 total catches, though coho salmon made up less than 1% of the catch in both years. Clear differences in abundance by distributary were not evident in 2014, but in 2015 it was apparent that fewer juvenile coho salmon were migrating through NM sites compared to MM and SM sites (Figure 24). Juvenile coho salmon were present throughout the sample period, but peaked in abundance weeks 23–25 (approximately the first half of June). In 2015 the peak was very synchronous among distributaries.

The length range of juvenile coho salmon was slightly broader in 2015 (71–142 mm) compared to 2014 (83–139 mm), but mean lengths significantly greater in 2014 compared to 2015 ($t(492.5) = 4.6803$, $p < 0.001$). Interestingly, unlike other salmon species examined in this study, juvenile coho salmon did not appear to exhibit growth over the course of the season, and size appeared to somewhat decline by week in both years (Figure 25). No evidence of spatial patterns was associated with size (Figure 26), though sample sizes were too small to evaluate in most weeks outside of peak outmigration.

Associated weight data available for juvenile coho salmon allowed us to also examine length-weight relationships at marine entry (Figure 27). In 2014 the length-weight relationship was fit using a and b values of 1.34×10^{-5} ($\pm 4.34 \times 10^{-6}$, $p = 0.025$) and 2.92 (± 0.07, $p < 0.001$). In 2015 the length-weight relationship was fit using a and b values of 9.09×10^{-6} ($\pm 2.87 \times 10^{-6}$, $p = 0.002$) and 3.00 (± 0.07, $p < 0.001$).

Pink salmon (Oncorhynchus gorbuscha)

Pink salmon made up a much larger proportion of the catch in 2015 (10%) compared to 2014 (2%) (Table 6). In the Yukon River, even-year pink salmon runs tend to be stronger than odd-year runs. Consequently, because pink salmon offspring outmigrate following emergence during their first spring, we would expect odd-year offspring outmigration to be stronger than even-year offspring outmigration. Very few pink salmon were caught in 2014, but abundance peaked near the last week of June (Figure 28a). In 2015, during the dominant outmigration year, pink salmon outmigration peaked in the first weeks of sampling, and the true peak may have occurred prior to the last week of May start date (Figure 28b). Outmigration continued through the last week of June in 2015.

Length sample sizes in 2014 were small for juvenile pink salmon. There was no difference in pink salmon length across years, and average length was 41 mm (SD = 9 in 2015, SD = 6 in 2014). In 2015, average length appeared to increase by week until early July when length appeared to plateau (Figure 29). Although spatial trends in length may be possible, temporal variation is confounding.

Burbot (Lota lota)

Burbot were common in samples beginning in late June of each year. Only 14 burbot of adult size were captured and the remainder was considered immature fish. In 2014, immature burbot comprised roughly 3% of the total fish catch, but in 2015 immature burbot made up 10% of the total catch (Table 6). Immature burbot were more abundant in the NM and MM sites than in the SM sites in both sampling years (Figure 30). In all locations, immature burbot were rare in catches early in the sampling periods. In 2014, immature burbot catch increased near 25 June and remained at a relatively high level until mid-July. In 2015, large numbers of immature burbot became abundant in the catch in all distributaries around 20 June with several hundred immature burbot occurring in each tow. The high catches abruptly ended at the end of June after which immature burbot occurred in catches in the low single digits.

Burbot ranged in size from 19 mm to 460 mm in 2014 and 15 mm to 810 mm in 2015. Mean immature burbot size was 89 mm (SD = 32) in 2014 and 41 mm (SD = 23) in 2015.

Coregonids

Coregonids (whitefish and cisco) were abundant in both 2014 and 2015 with immature sized fish comprising the majority of the catch. Adult coregonids comprised less than 1% of the total coregonid catch. Immature whitefish and cisco comprised 44% of the total fish caught in 2014 and 56% of the total fish in 2015 (Table 6). Immature coregonids occurred in low numbers in catches throughout the sampling period. Abundance varied spatially in both years, with higher CPUE at SM sites compared to MM and NM sites (Figure 31). In both years, a dramatic increase in the CPUE occurred with the appearance of a large number of small fish (≤50 mm). Outmigration timing appeared to be slightly earlier in 2015 compared to 2014 (Figure 31).

Coregonids ranged in size from 19 mm to 450 mm in 2014 and 18 mm to 440 mm FL in 2015. Mean sizes of immature coregonids were 58 mm (SD = 28) in 2014 and 58 mm (SD = 29) in 2015. Only 5% and 6% of the sampled fish were greater than 100 mm in length in 2014 and 2015 respectively.

Arctic Lamprey (Lethenteron camtschaticum)

Juvenile (metamorphosed) Arctic lamprey were the most prevalent size group of this species. Juvenile Arctic lamprey were captured in all distributaries. Juvenile lamprey contributed relatively similar amounts to the overall catches in both 2014 and 2015 (Table 6). Juvenile lamprey were most abundant during June: very few lamprey were captured after July first. The cumulative average CPUE was higher at SM compared to MM and NM distributaries in 2014, but SM and MM CPUE were similar to each other and higher than NM sites in 2015 (Figure 32).

Less than 1% of the catch in both years included ammocoete (larval) Arctic lamprey. Ammocoetes were captured throughout the sampling period during both 2014 and 2015, though catches were low. Ammocoete catch did not vary significantly by distributary in either sample year (Figure 33). In 2015, the majority of ammocoetes were captured in late May and early June. In 2014 no distinct temporal patterns were apparent.

Ammocoetes and juvenile Arctic lamprey lengths were only measured during the 2015 sampling season. Ammocoete length ranged from 55 mm to 194 mm, with a mean length of 108 mm (SD = 18). Juvenile length ranged from 31 mm to 216 mm, with mean length of 133 mm (SD = 18).

Sheefish (Stenodus leucichthys)

Immature sheefish were 8% of the total fish catch in 2014, and 6% in 2015 (Table 6). Only 2 adult length sheefish were encountered. Immature sheefish CPUE was similar among distributaries in 2014, but was higher in SM in 2015. Unlike some other species where peak abundance was earlier in 2015 than in 2014, immature sheefish had similar timing patterns in both sampling years. Sheefish were absent from catches until the third week of June when catch increased to several hundred fish per tow. Sheefish were still being captured in small numbers when sampling ended at the end of July (Figure 34).

Sheefish ranged in length from 27 mm to 700 mm, but less than 1% of fish were over 100 mm in length. Mean immature sheefish length was 68 mm (SD = 19) in 2014 and 66 mm (SD = 17) in 2015.

RECOMMENDATIONS

Assessing Yukon River distributary habitats with 2-boat tow nets provided effective juvenile fish sampling, and is a recommended method for future work in this habitat. Because of the dynamic and complex nature of the Yukon River distributaries, a critical component of the success of the field component of this work is attributable to having local fishermen participate as boat captains in this study. These fishermen were most capable in navigating the river, finding appropriate fishing sites, and it is recommended that any future work benefit from using the skills and knowledge that only local residents possess.

Results of this study indicate spatial and temporal patterns in distribution, outmigration, and size. Consequently, future research should endeavor to capture the full temporal and spatial extent of fish in this habitat to avoid skewing inferences about size or timing at outmigration. This may require flexibility when working in distributary habitats to accommodate for dynamic river changes, such as the timing of ice breakup and river warming. Catches of juvenile salmon in this study did decline by the end of July, but salmon were caught even on the last day of sampling, suggesting that the total outmigration continues into August.

Sampling with the small trawl nets on the delta front was also successful. Spatial and temporal patterns in catch suggest that northern transects may be more productive sampling locations than southern transects. In this research, the delta front sampling was designed to cover a broad spatial area at the expense of intensive sampling to maximize catch. Future research should focus on either spatial evaluation of estuarine habitat use, or on the influence of the Yukon River estuary on juvenile Chinook salmon growth and condition prior to entering the marine environment within a smaller sample area. Gear and vessels used in this research are limited by the shallow environment of the delta front and intensive sampling is required to increase catch sizes in this highly variable environment.

Further work is needed now that productive test fishery sites and gear combinations have been identified. Although this study provided a valuable first step, it will take several more years of study before a clear picture of the ecology and life history patterns of fishes in the Yukon River Delta can be expected.

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FIGURES

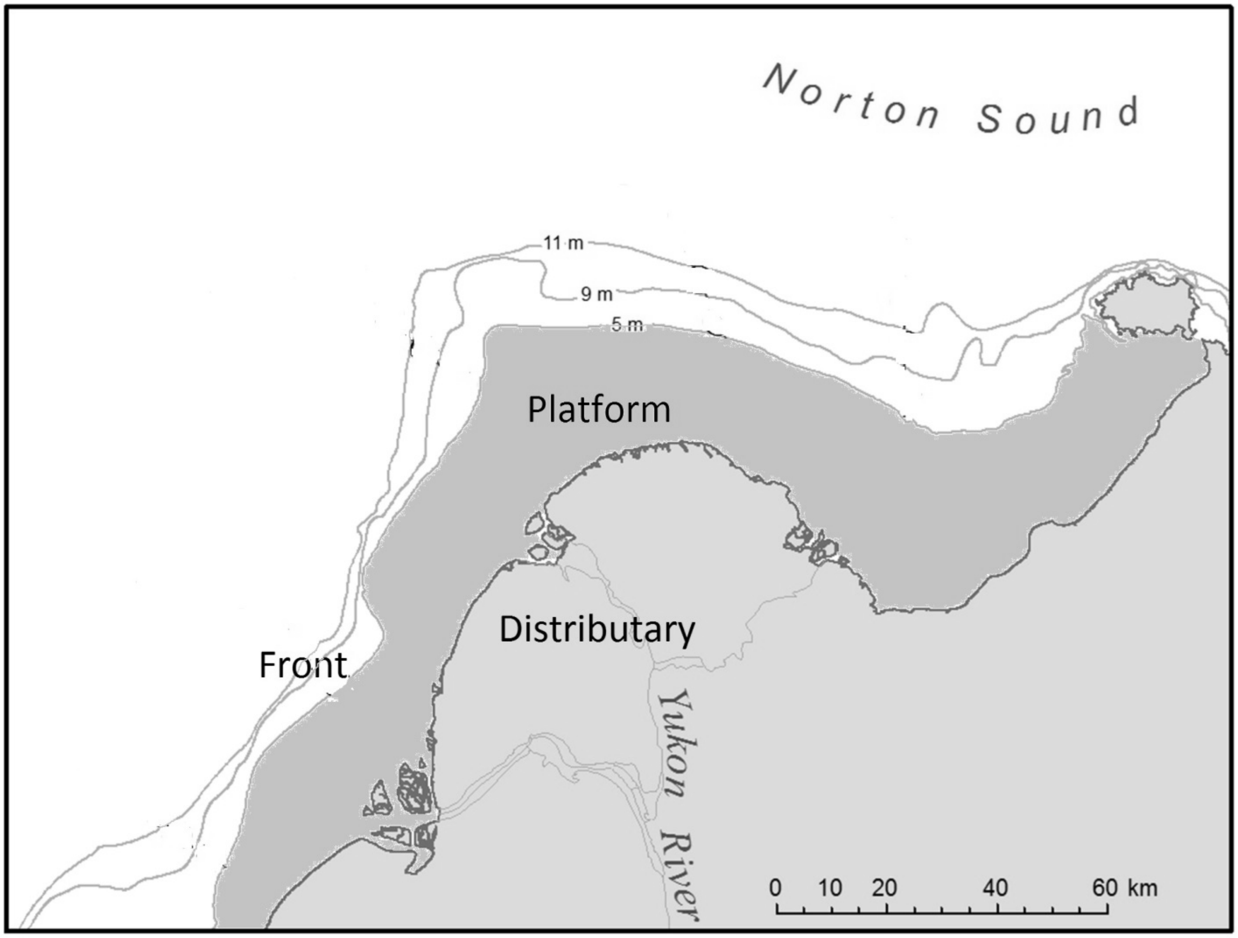

Figure 1.–Major depositional environments of the Yukon River delta, including the distributaries (notably south, middle, and north mouths of the river) in light grey, the inner delta platform in dark grey, and the more steeply sloping delta front represented by bathymetric contours.

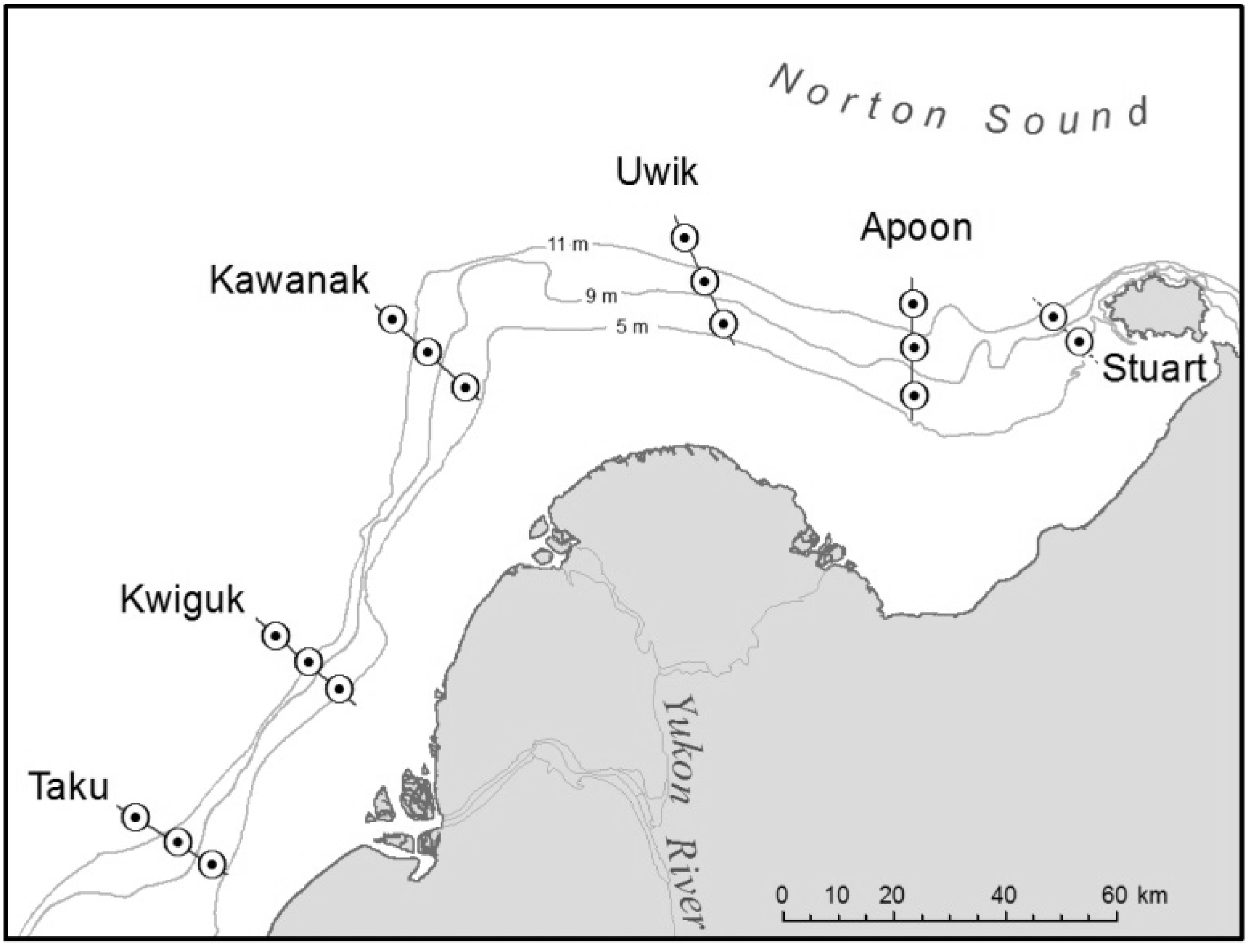

Figure 2.–Sampling locations (circles) and transect names for the 5 transects sampled on the Yukon River Delta front (Bathymetry contours are provided for reference).

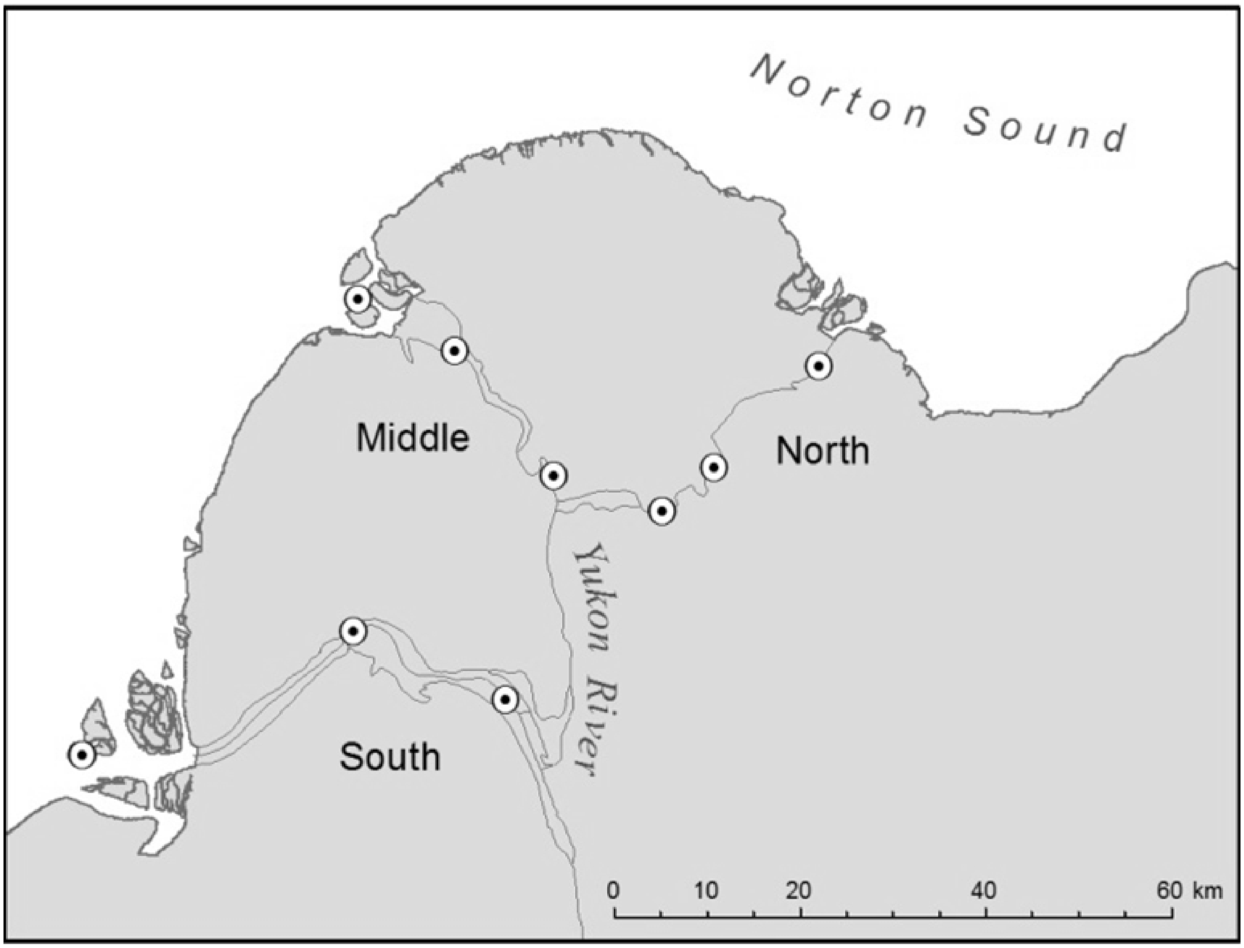

Figure 3.–Sampling locations (circles) for sampling in South Mouth, Middle Mouth, and North Mouth distributaries of the Yukon River.

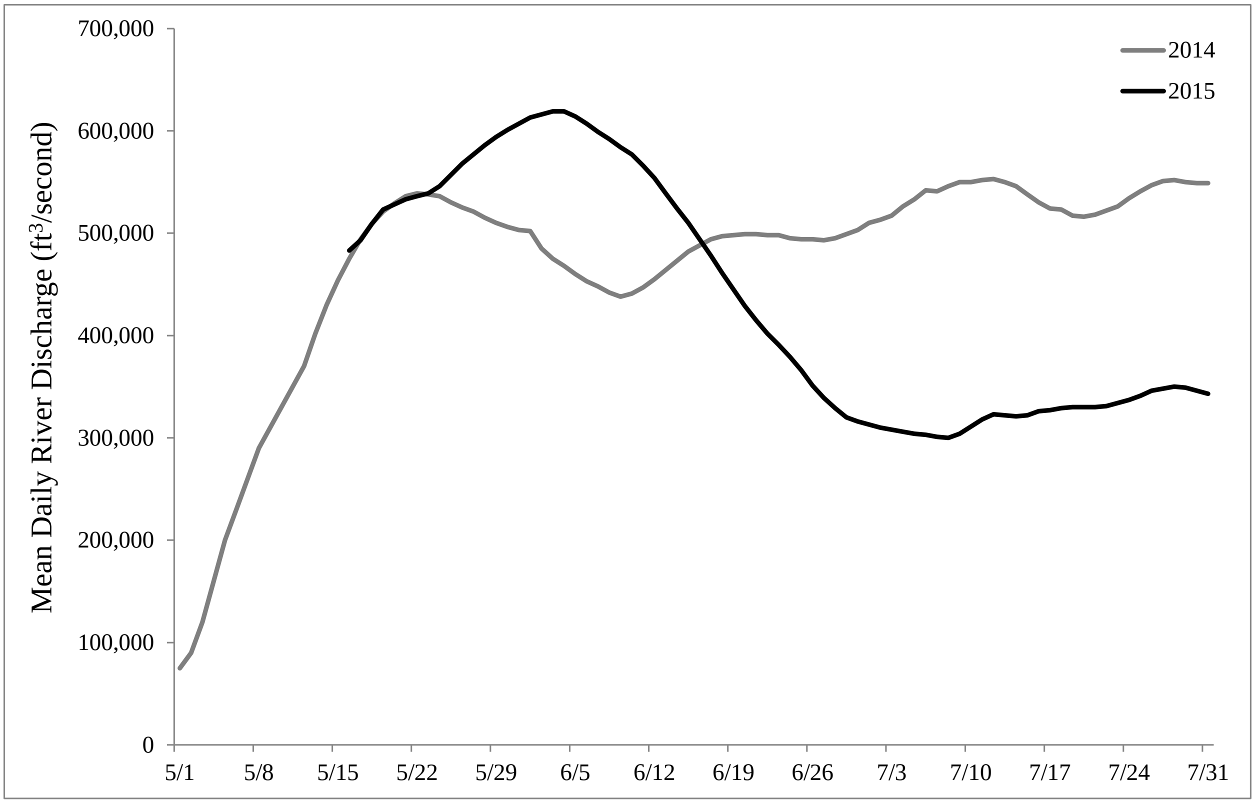

Figure 4.–Mean daily discharge measured at Pilot Station, AK in 2014 and 2015.

Source: http://waterdata.usgs.gov/ak/nwis/sw

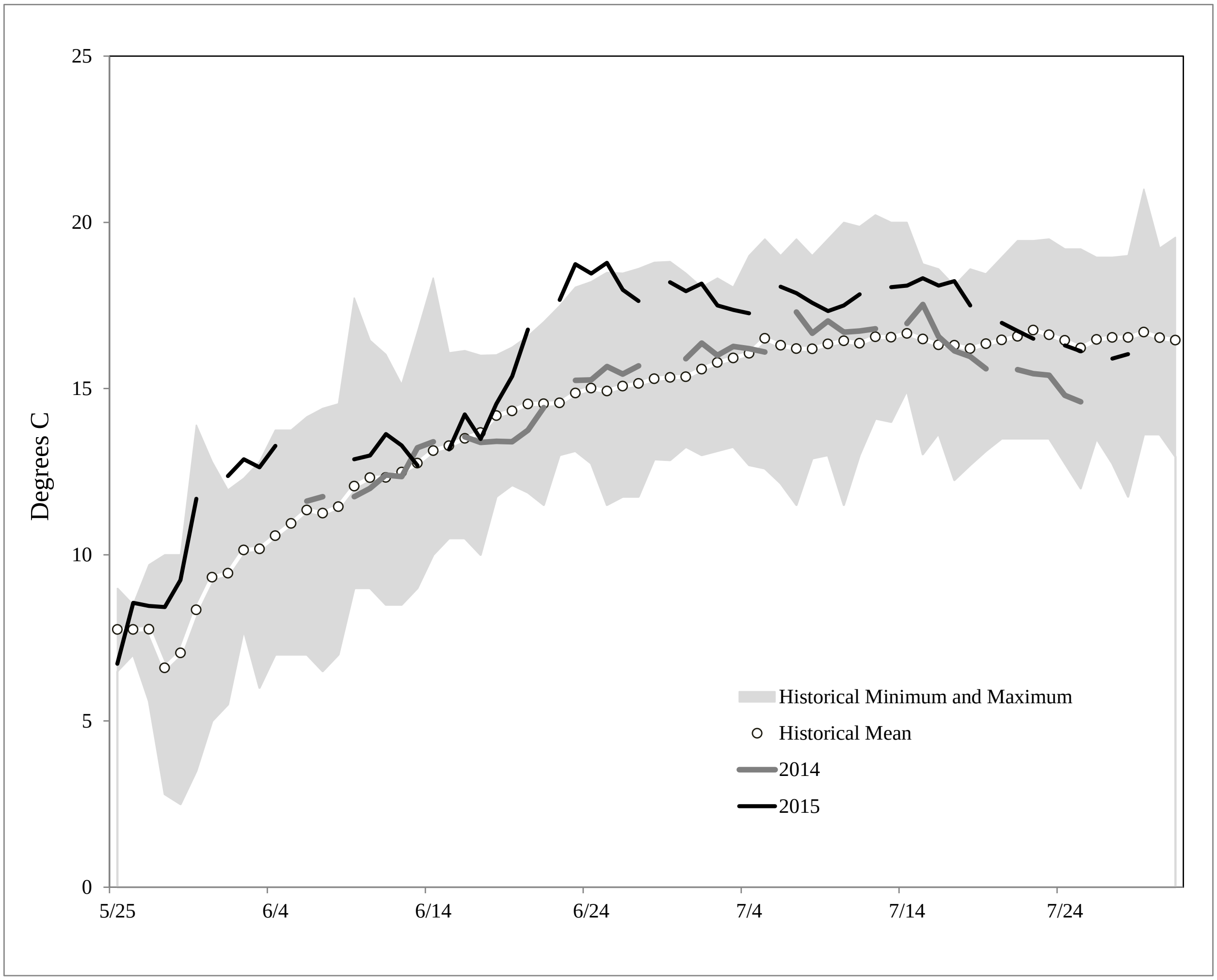

Figure 5.–Historical temperature range and mean observed in the Yukon River delta (1984–2014) (data courtesy ADF&G Lower Yukon test fishery project), compared to 2014 and 2015 temperatures assessed by this study during sampling.

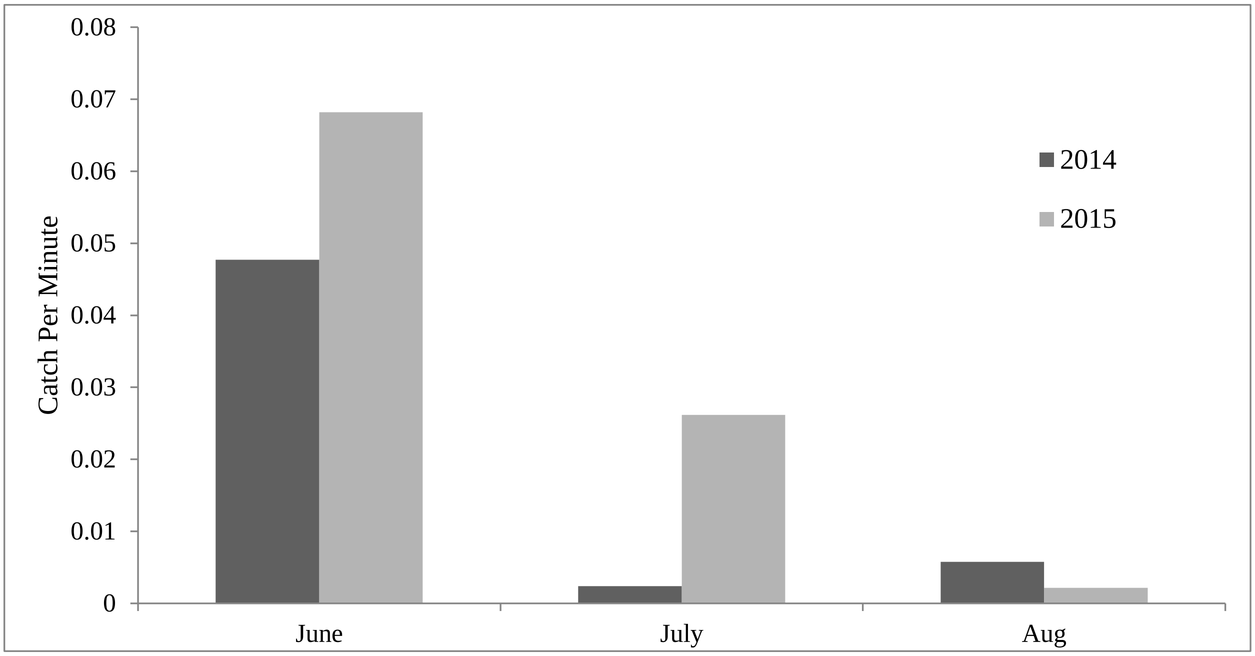

Figure 6.–Average juvenile Chinook salmon catch per minute by month in 2014 and 2015 on the Yukon Delta Front.

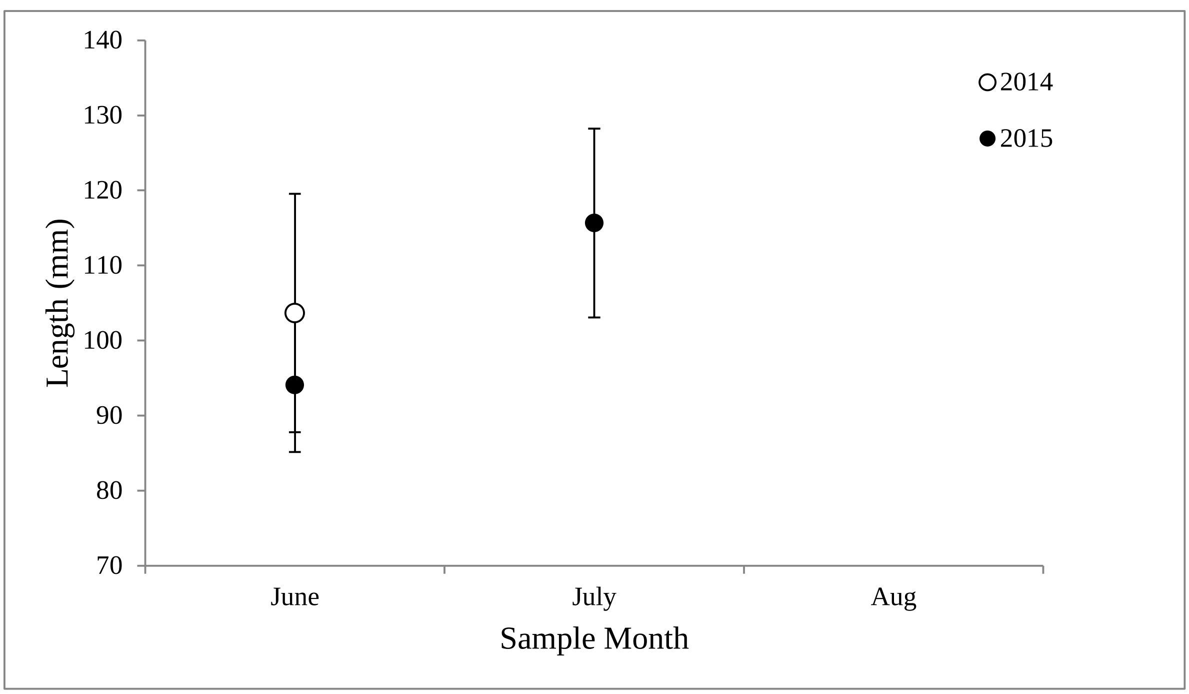

Figure 7.–Mean length of juvenile Chinook salmon by sample month and year.

Note: Error bars represent standard deviation. No mean estimate is provided if fewer than 10 individuals were captured in that sample month.

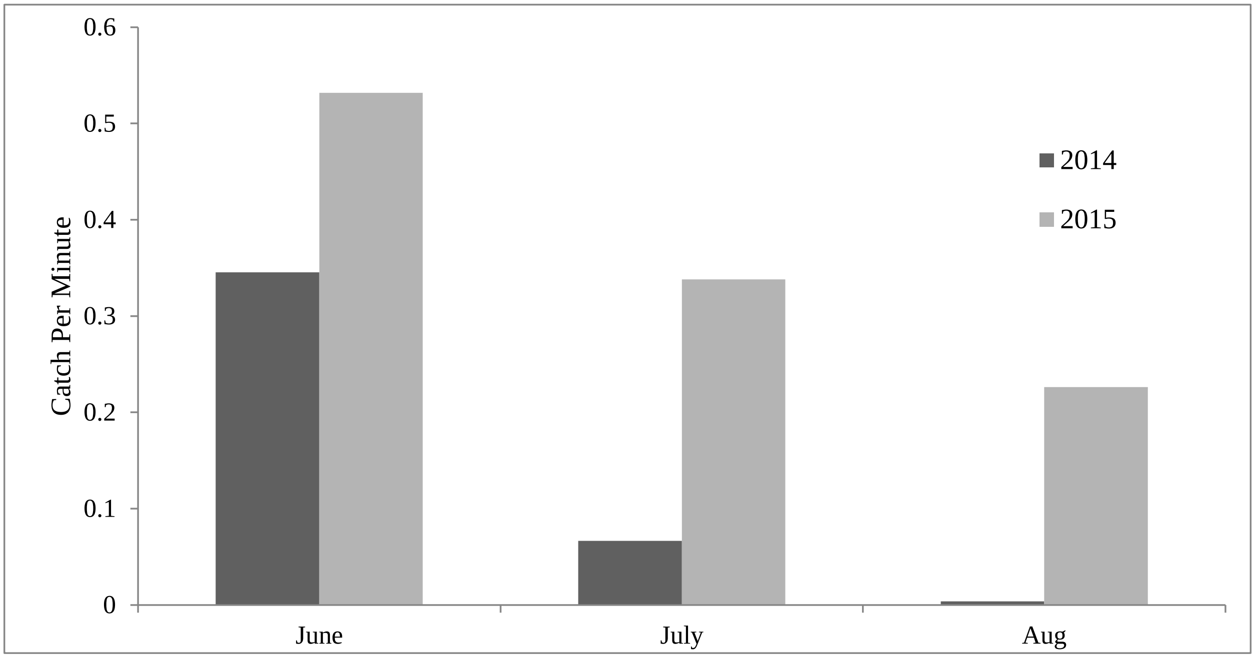

Figure 8.–Average juvenile chum salmon catch per minute by month in 2014 and 2015 on the Yukon Delta Front.

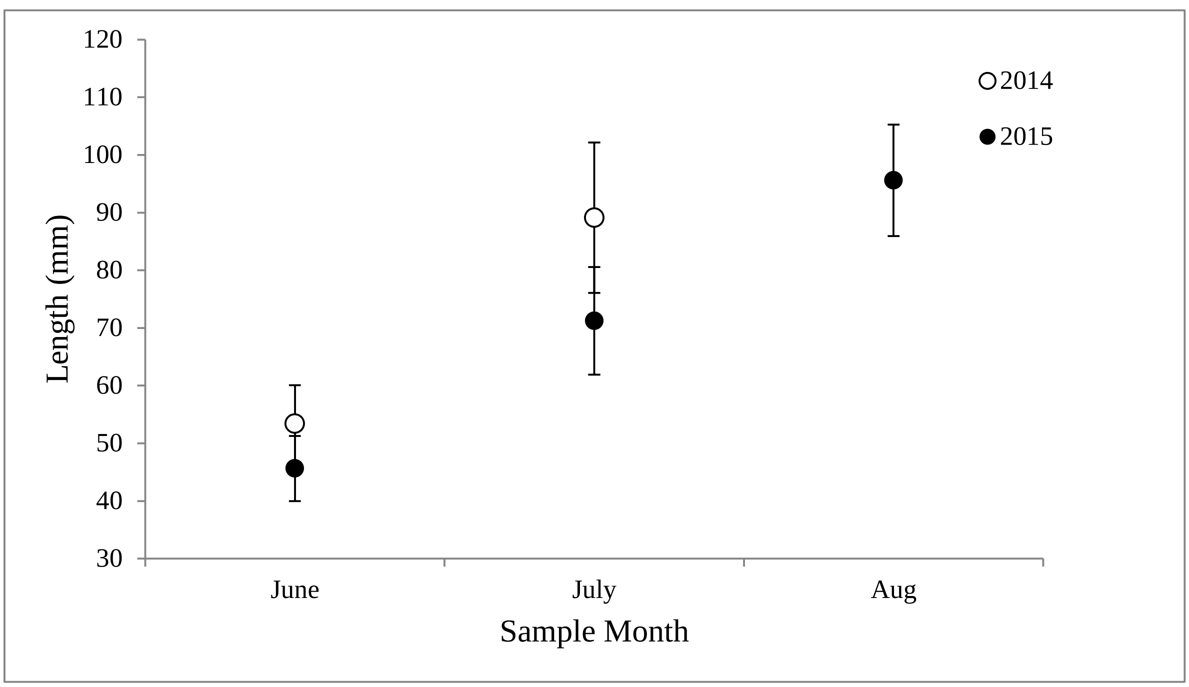

Figure 9.–Mean length of juvenile chum salmon by sample month and year. Error bars represent standard deviation. No mean estimate is provided if less than 10 individuals were captured in that sample month.

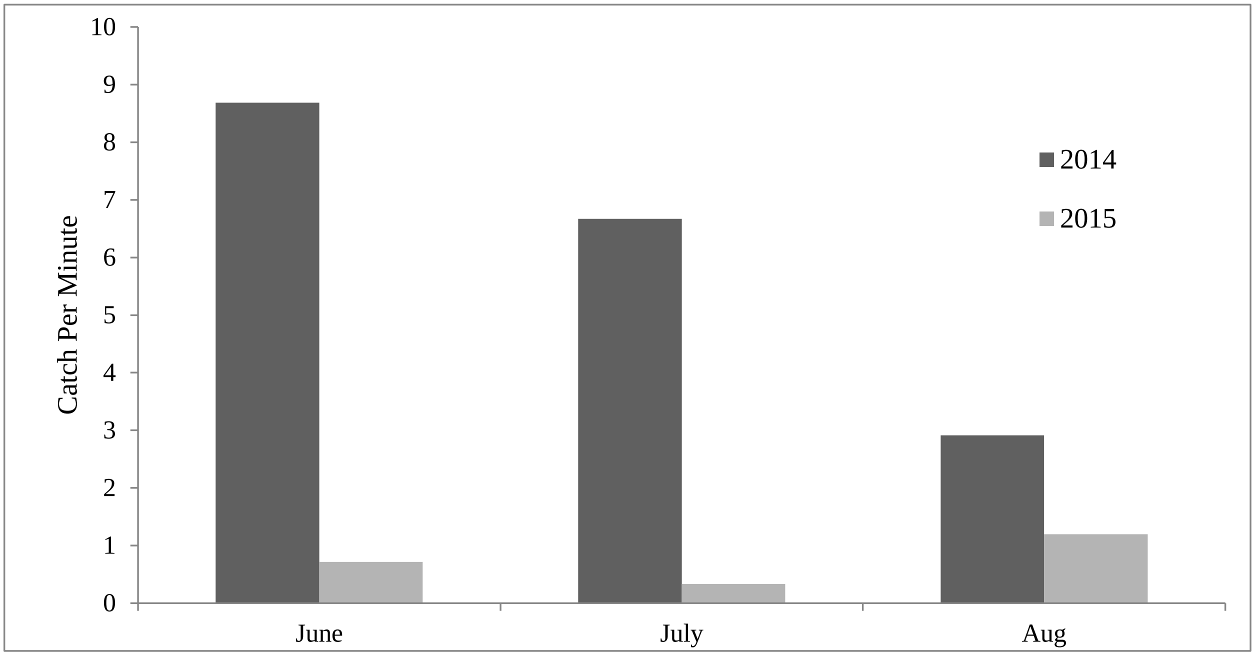

Figure 10.–Average immature rainbow smelt catch per minute by month in 2014 and 2015 on the Yukon Delta Front.

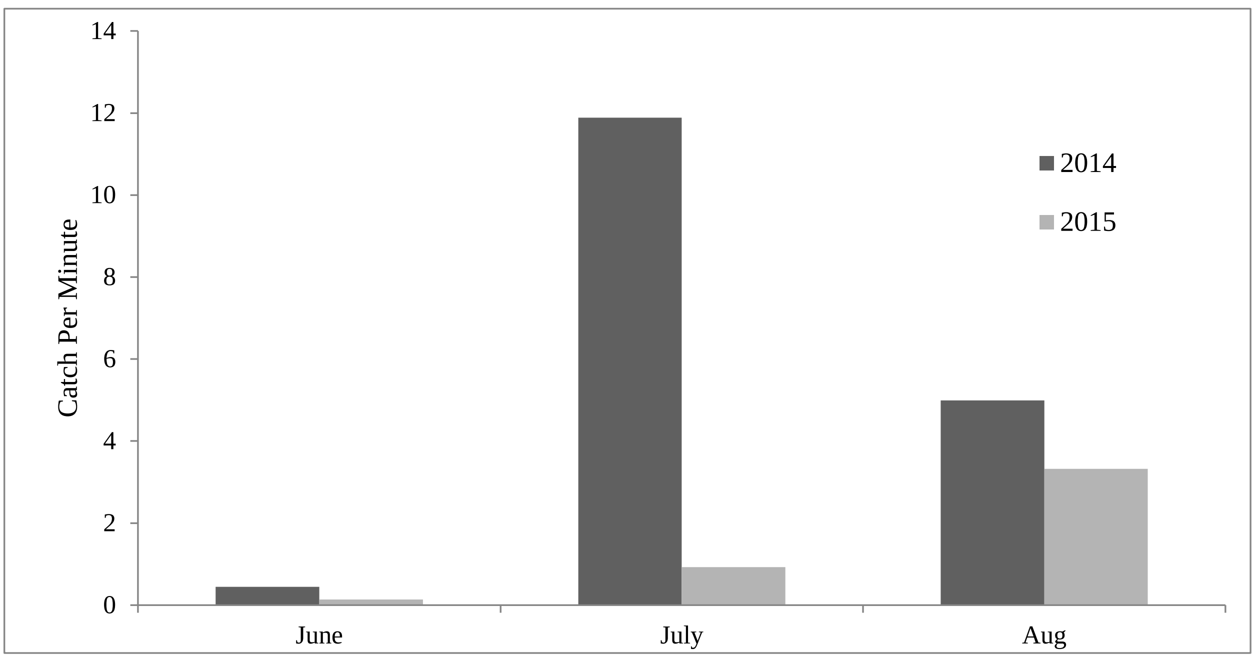

Figure 11.–Average immature saffron cod catch per minute by month in 2014 and 2015 on the Yukon Delta Front.

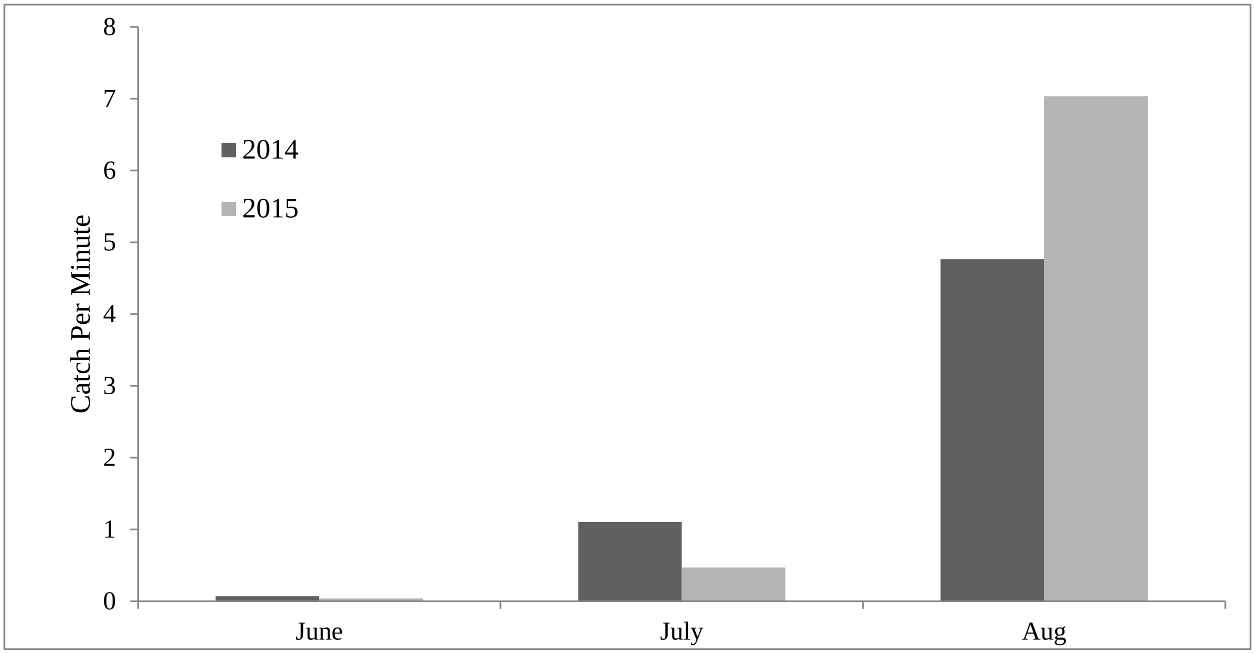

Figure 12.–Average immature pacific herring catch per minute by month in 2014 and 2015 on the Yukon Delta Front.

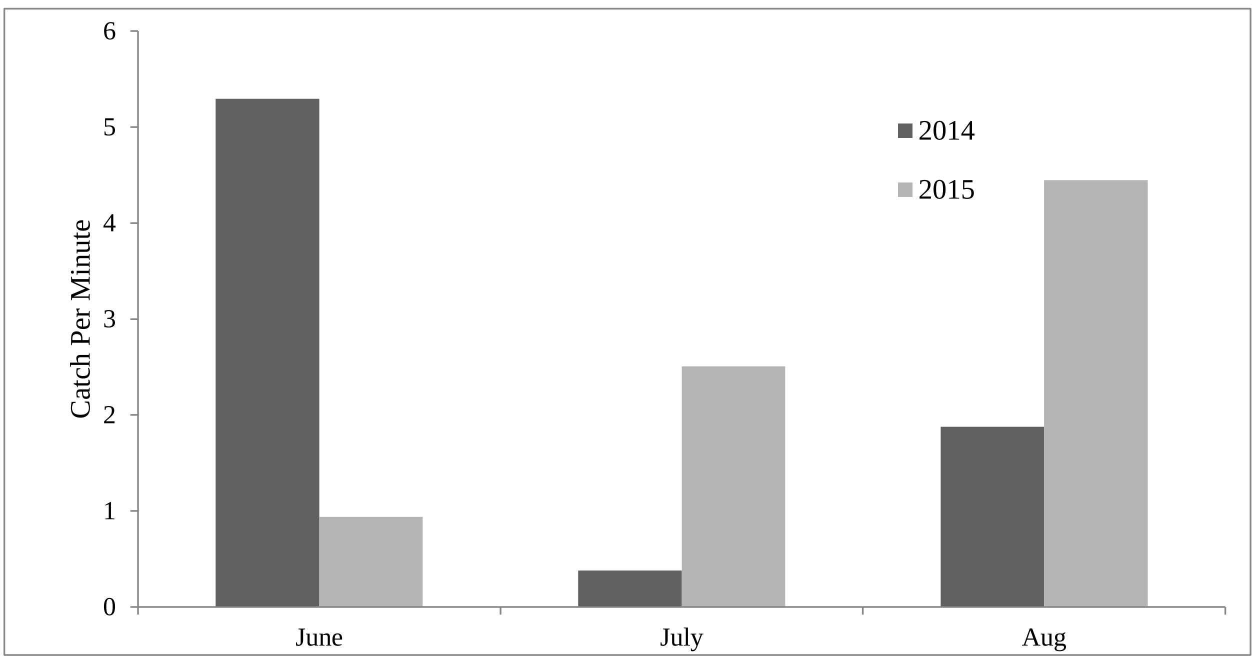

Figure 13.–Average ninespine stickleback catch per minute by month in 2014 and 2015 on the Yukon Delta Front.

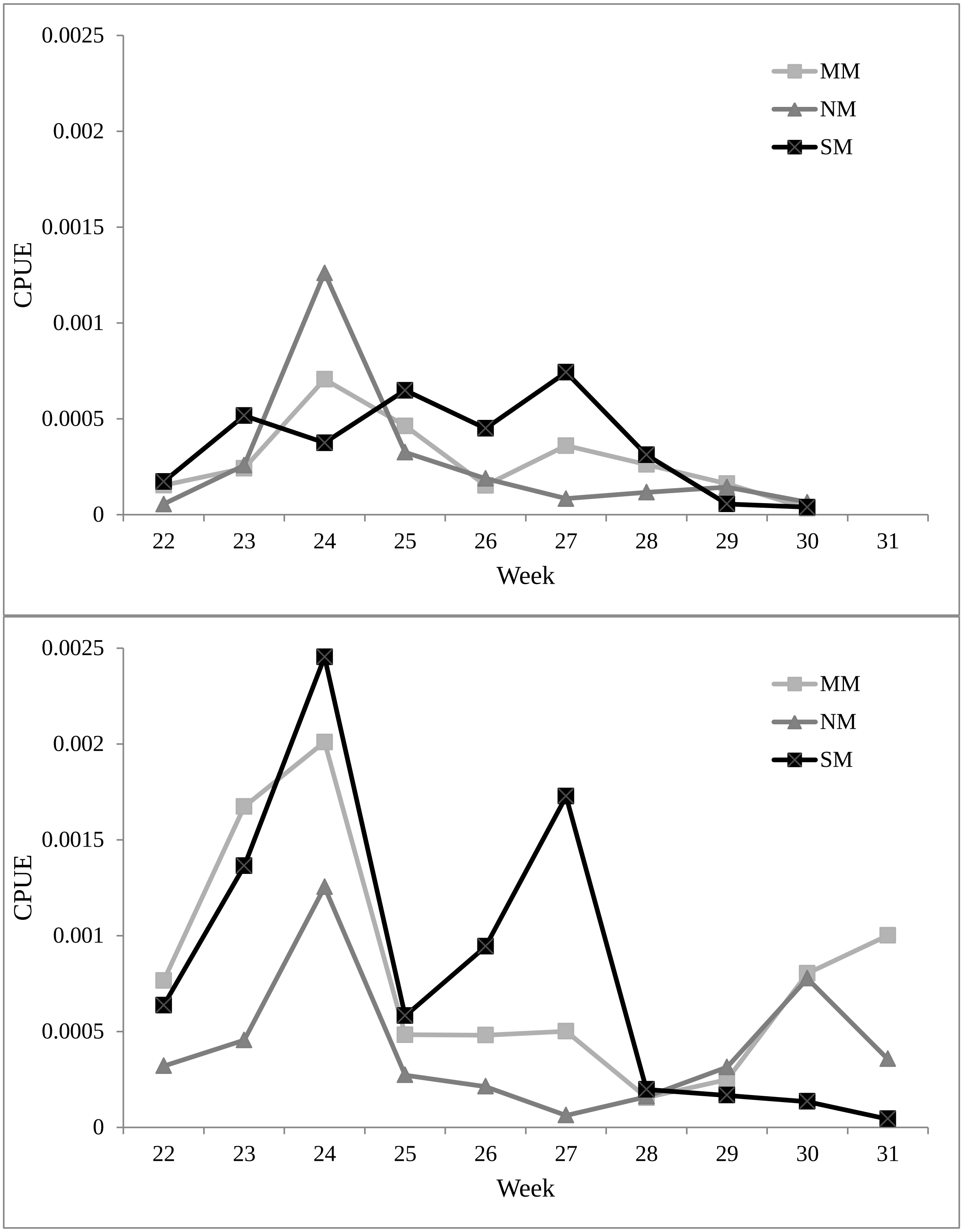

Figure 14.–Juvenile Chinook salmon CPUE (catch per unit surface area swept) by statistical week and distributary in 2014 (top) and 2015 (bottom).

Note: Statistical weeks begin the last week of May and end the last week of July in both years.

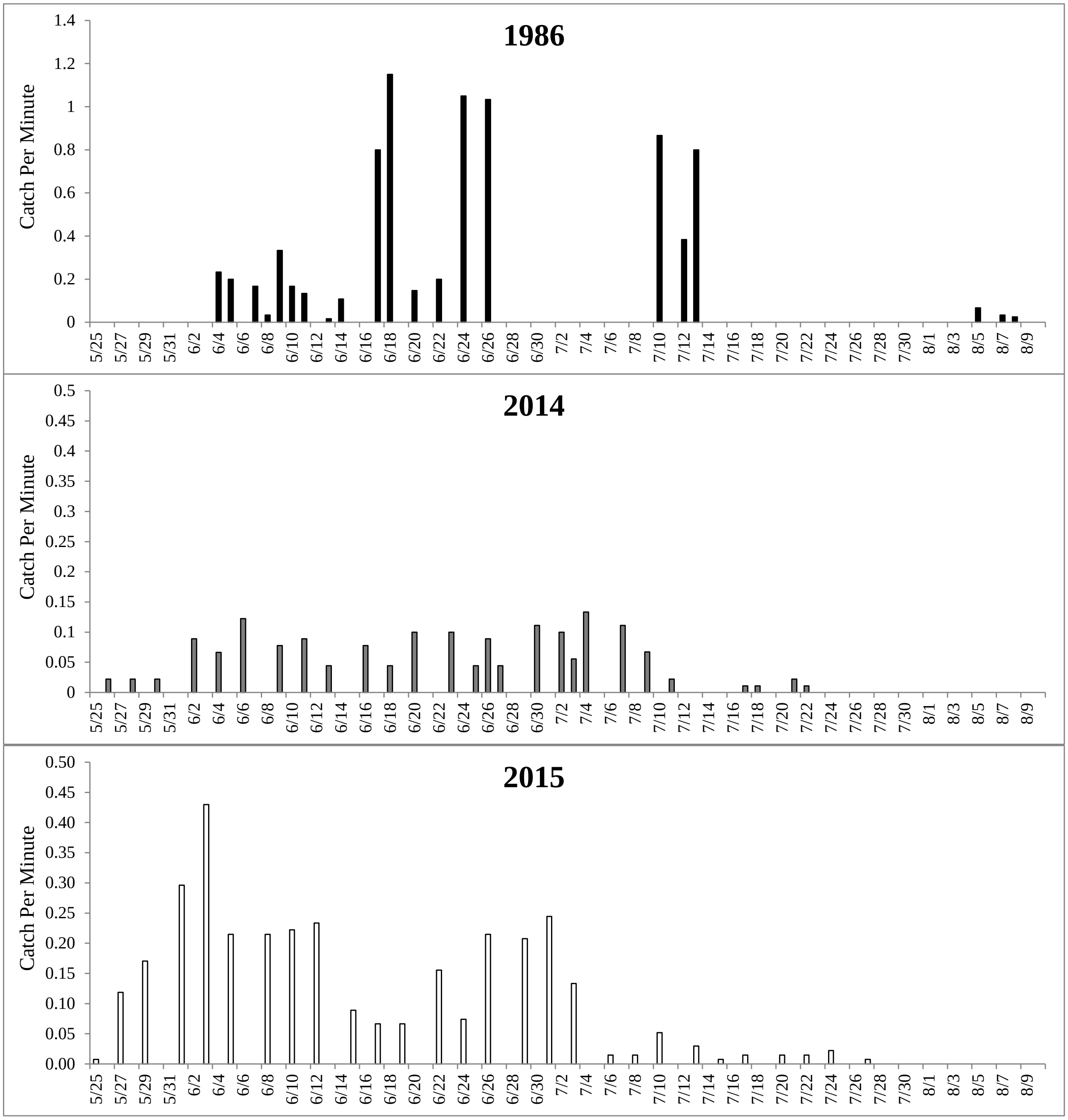

Figure 15.–Catch per minute from South Mouth sampling in 1986, 2014 and 2015.

Note: 1986 data from Stations 13 and 17 in Martin et. al (1989). Note the differences in y-axes between 1986 sampling and the present study.

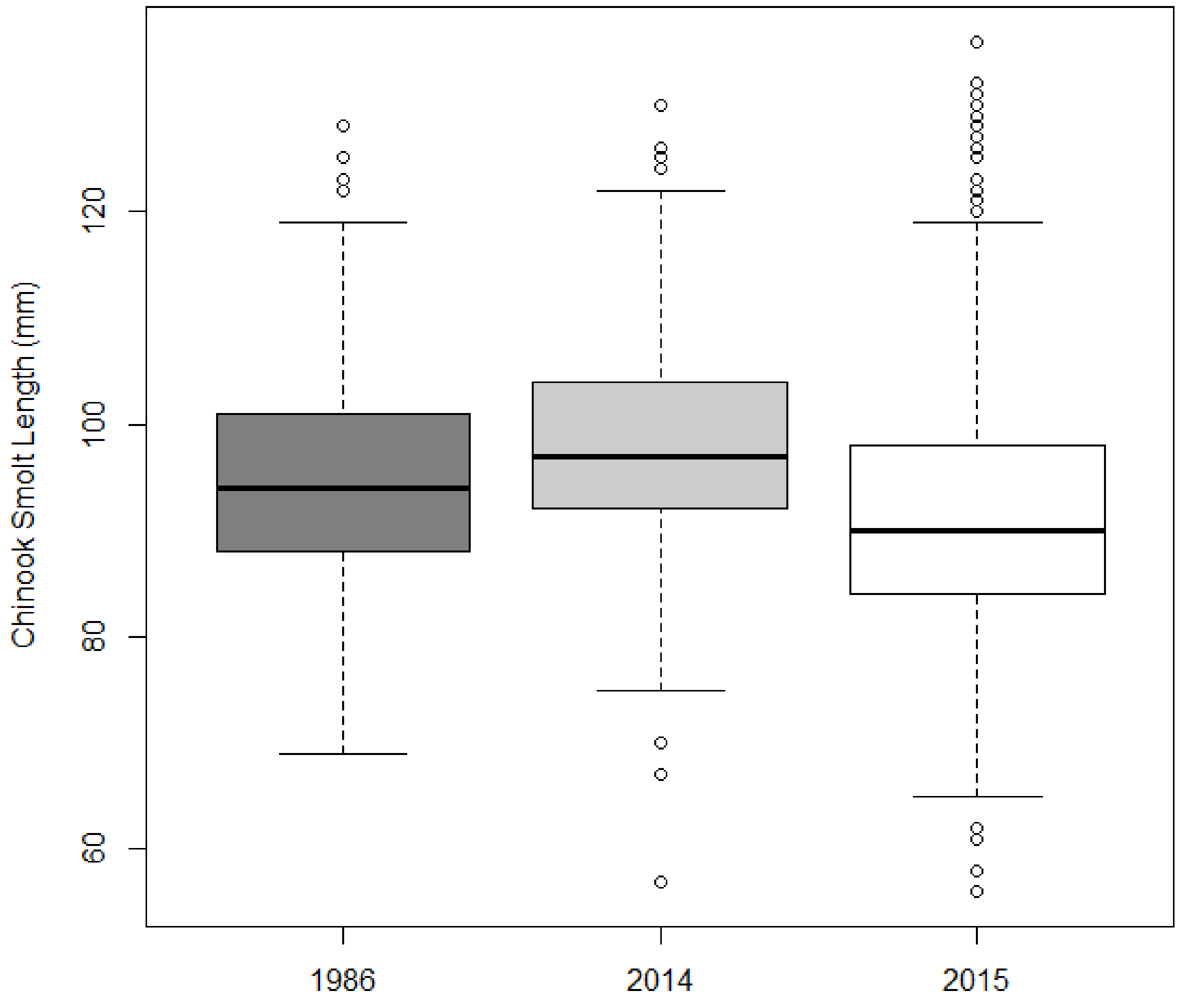

Figure 16.–Juvenile Chinook salmon length distribution sampled in 1986, 2014, and 2015.

Note: The box represents the interquartile range, with the thick black line representing the median; the whiskers represent the length distribution and open circles are considered outlier values beyond 2 standard deviations from the mean.

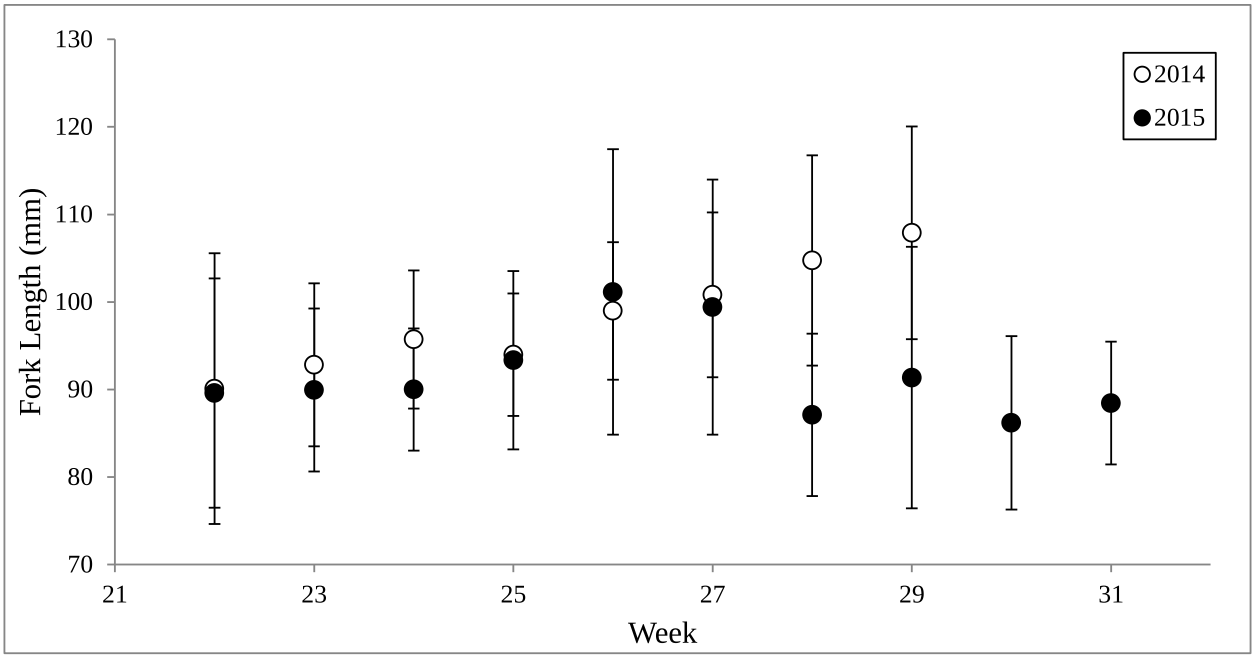

Figure 17.–Mean length of juvenile Chinook salmon by week in 2014 and 2015.

Note: Error bars represent standard deviation.

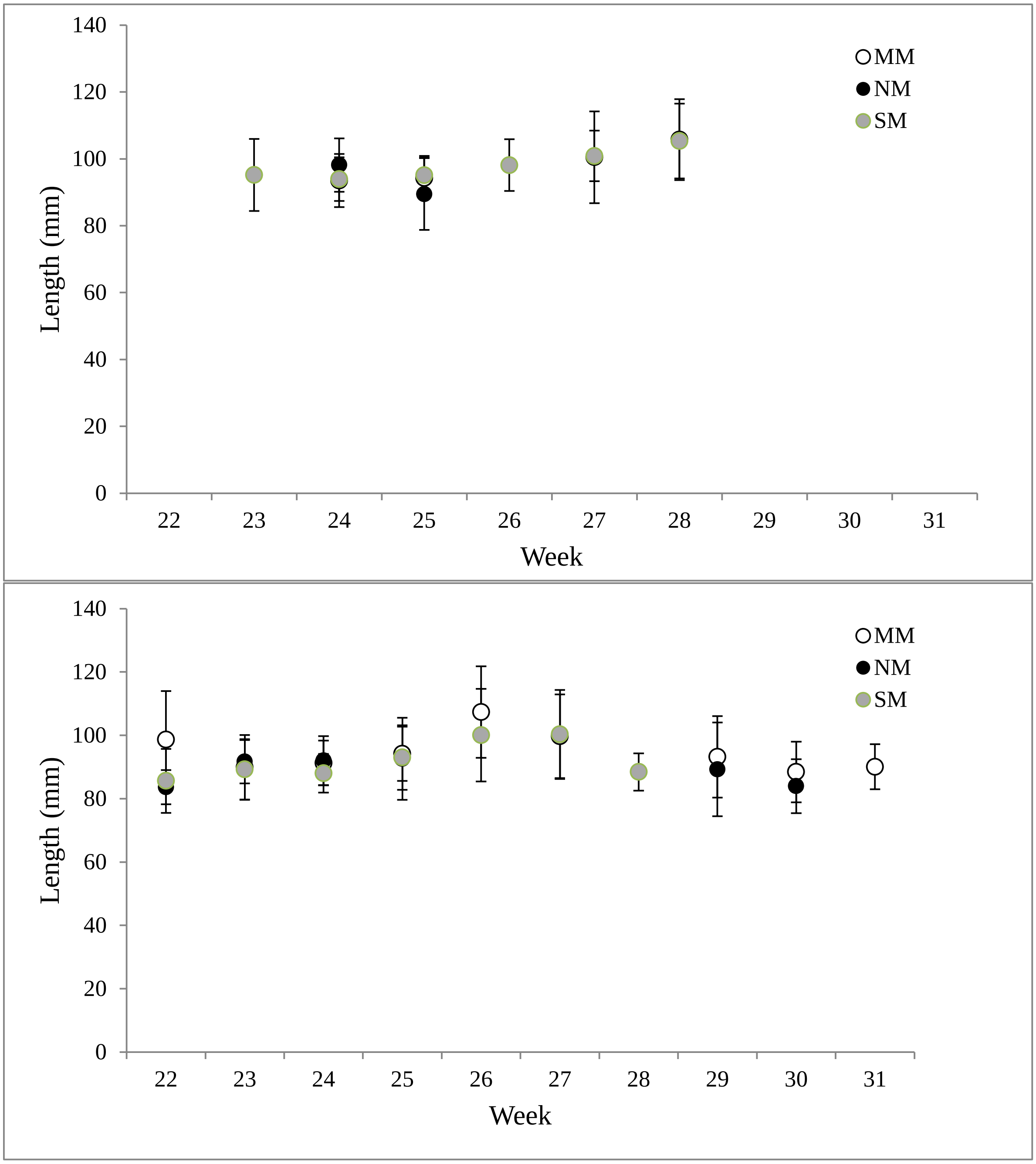

Figure 18.–Mean length of juvenile Chinook salmon by week and distributary in 2014 (top) and 2015 (bottom).

Note: Error bars represent standard deviation. No mean estimate is provided if fewer than 10 individuals were captured in that week.

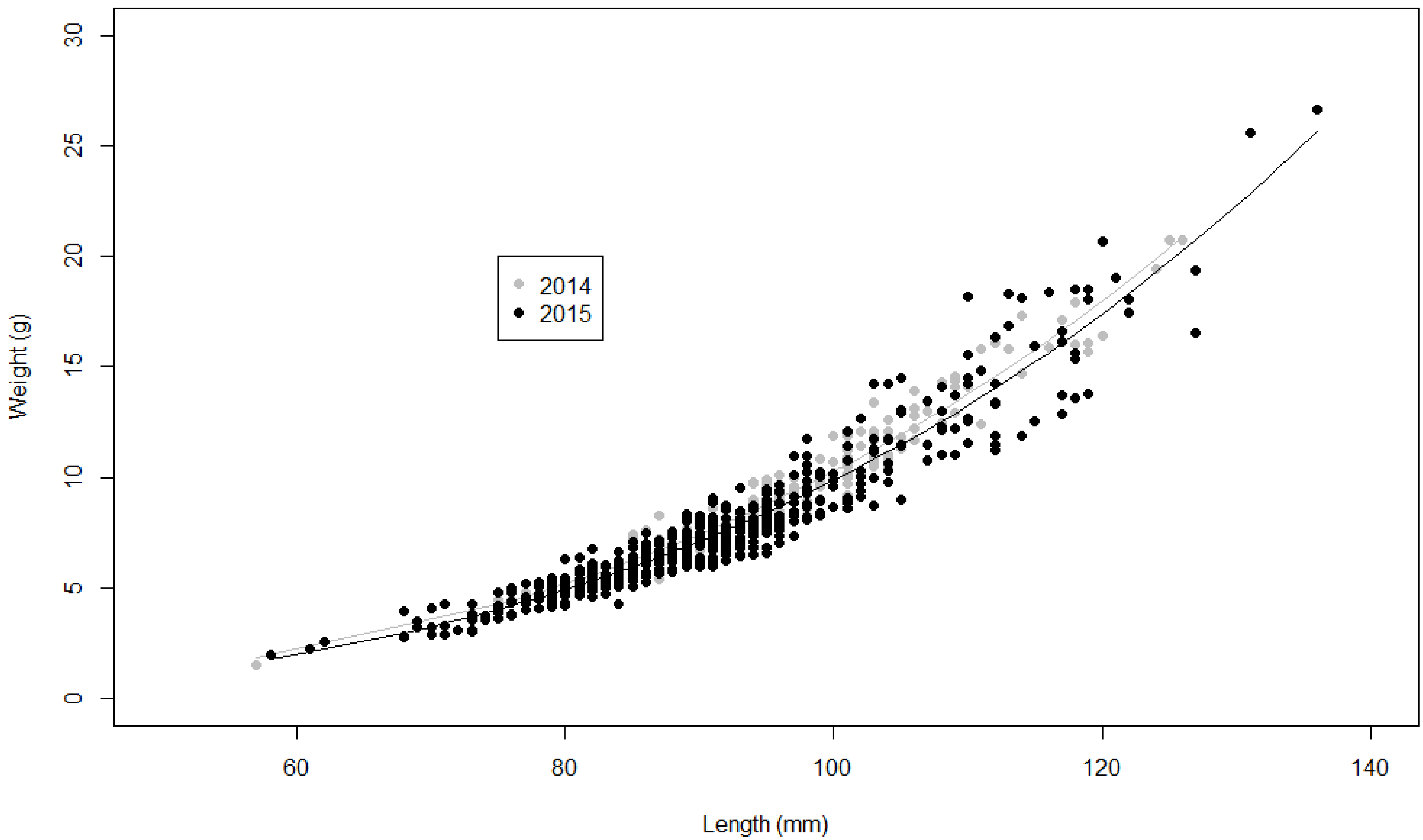

Figure 19.–Relationship between length and weight of juvenile Chinook salmon in 2014 and 2015.

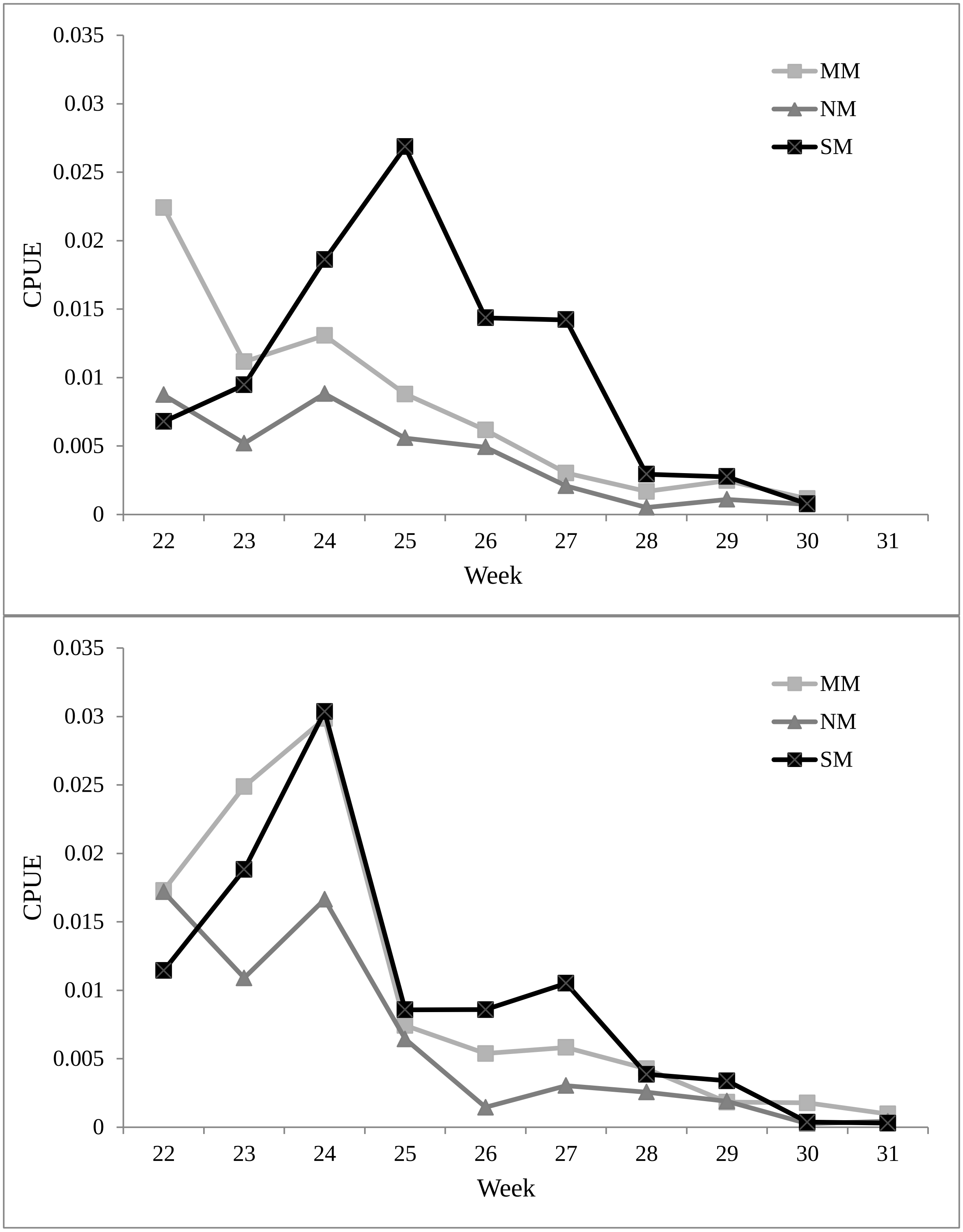

Figure 20.–Juvenile chum salmon CPUE (catch per unit surface area swept) by statistical week and distributary in 2014 (top) and 2015 (bottom).

Note: Statistical weeks begin the last week of May and end last week of July in both years.

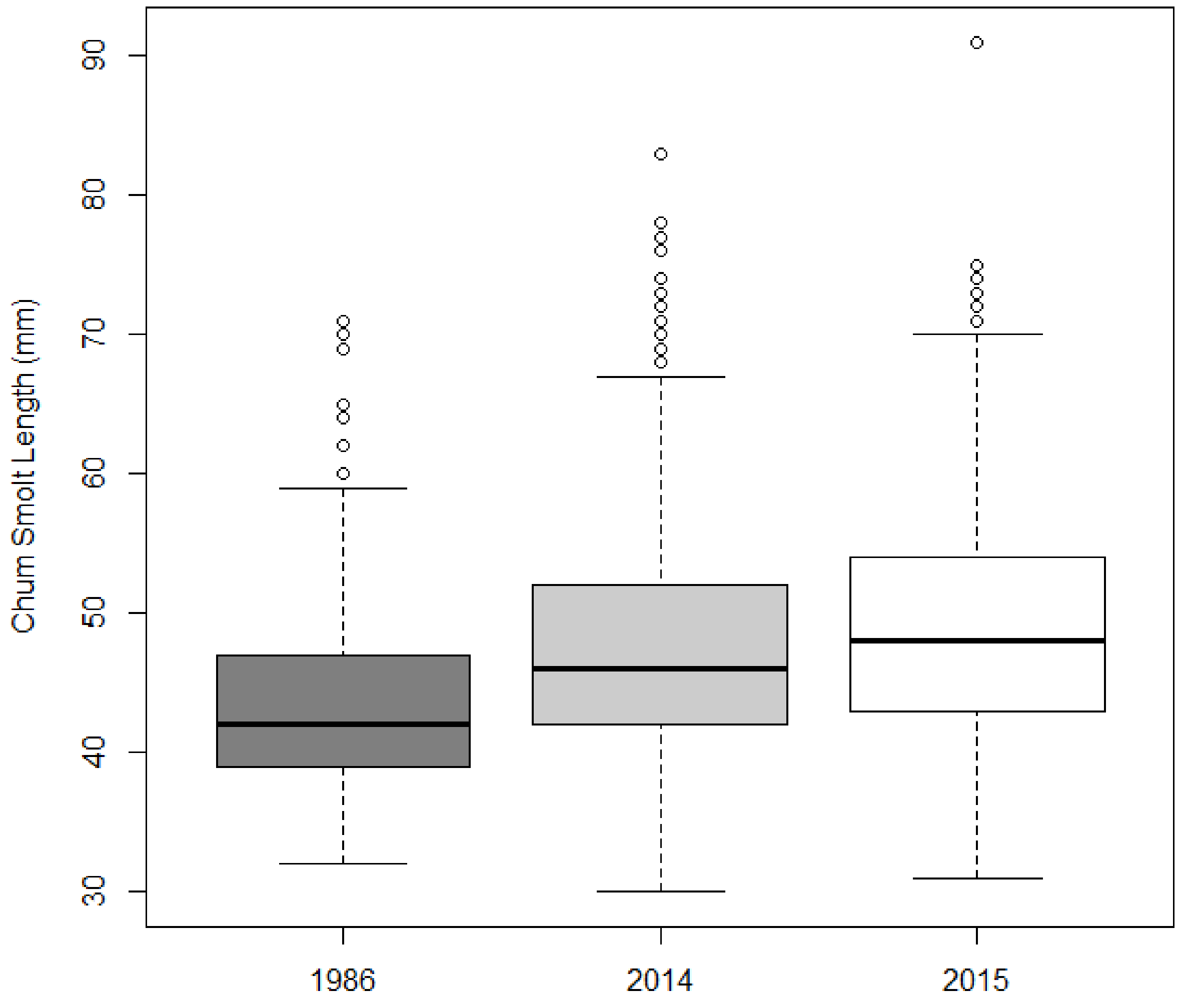

Figure 21.–Juvenile chum salmon length distribution sampled in 1986, 2014 and 2015.

Note: The box represents the interquartile range, with the thick black line representing the median, the whiskers represent the length distribution and open circles are considered outlier values beyond 2 standard deviations from the mean.

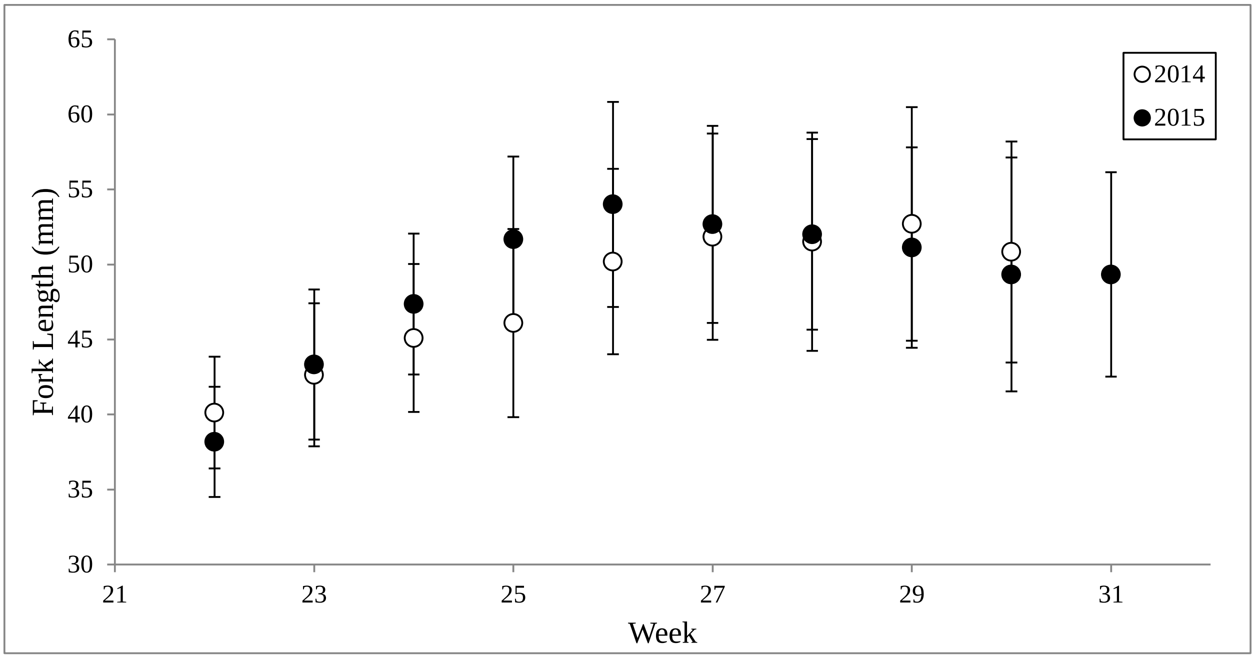

Figure 22.–Mean length of juvenile chum salmon by week in 2014 and 2015.

Note: Error bars represent standard deviation.

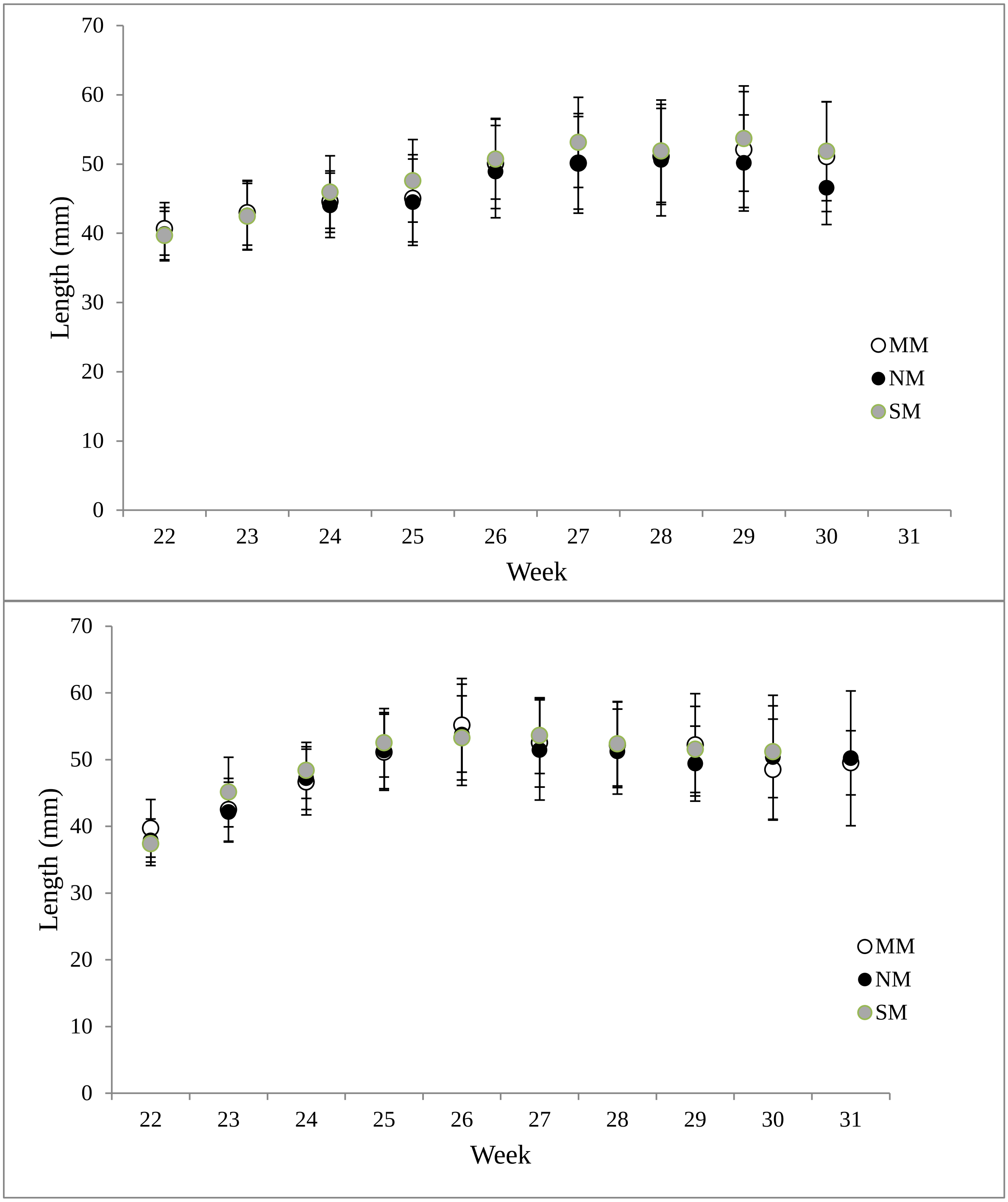

Figure 23.–Mean length of juvenile chum salmon by week and distributary in 2014 (top) and 2015 (bottom).

Note: Error bars represent standard deviation. No mean estimate is provided if fewer than 10 individuals were captured in that week.

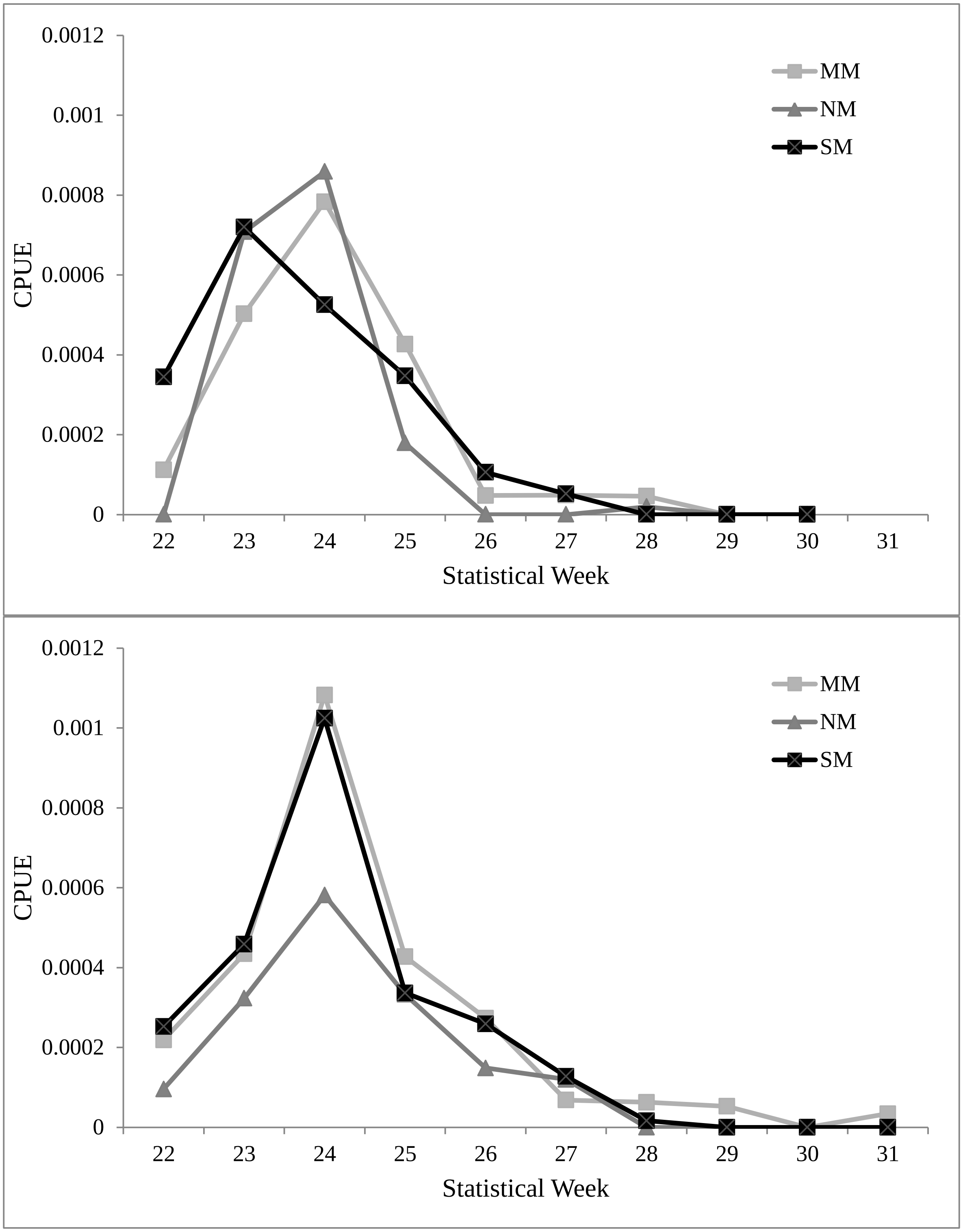

Figure 24.–Juvenile coho salmon CPUE (catch per unit surface area swept) by statistical week and distributary in 2014 (top) and 2015 (bottom).

Note: Statistical weeks begin the last week of May and end last week of July in both years.

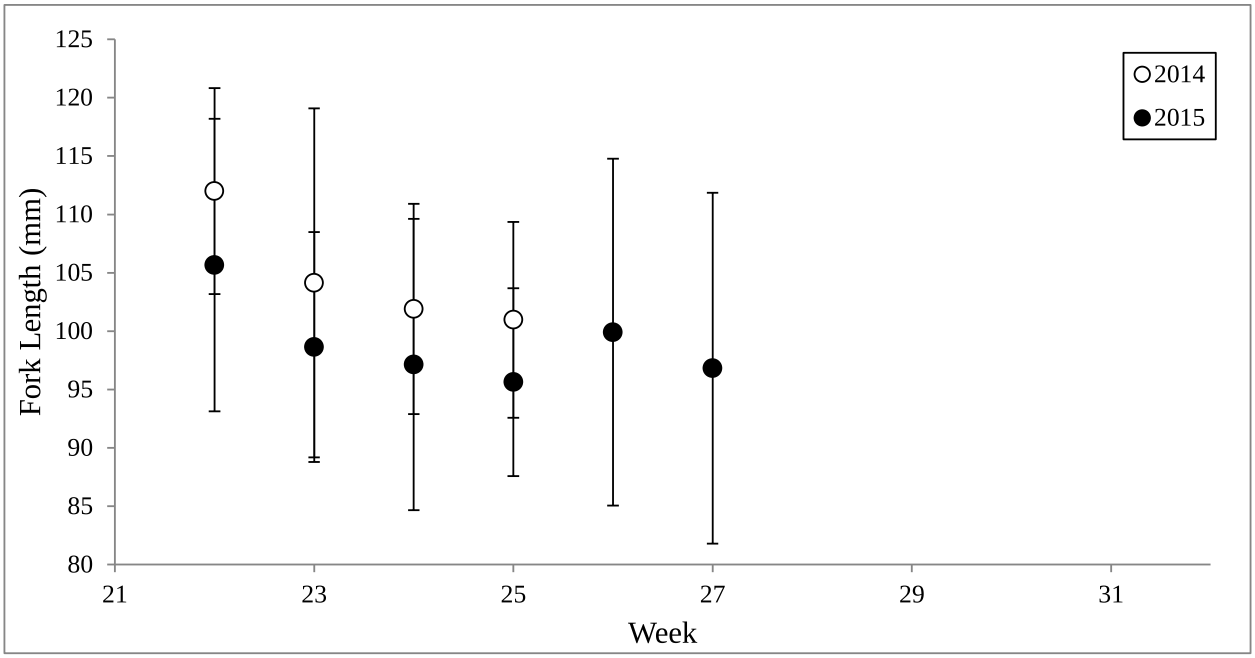

Figure 25.–Mean length of juvenile coho salmon by week in 2014 and 2015.

Note: Error bars represent standard deviation.

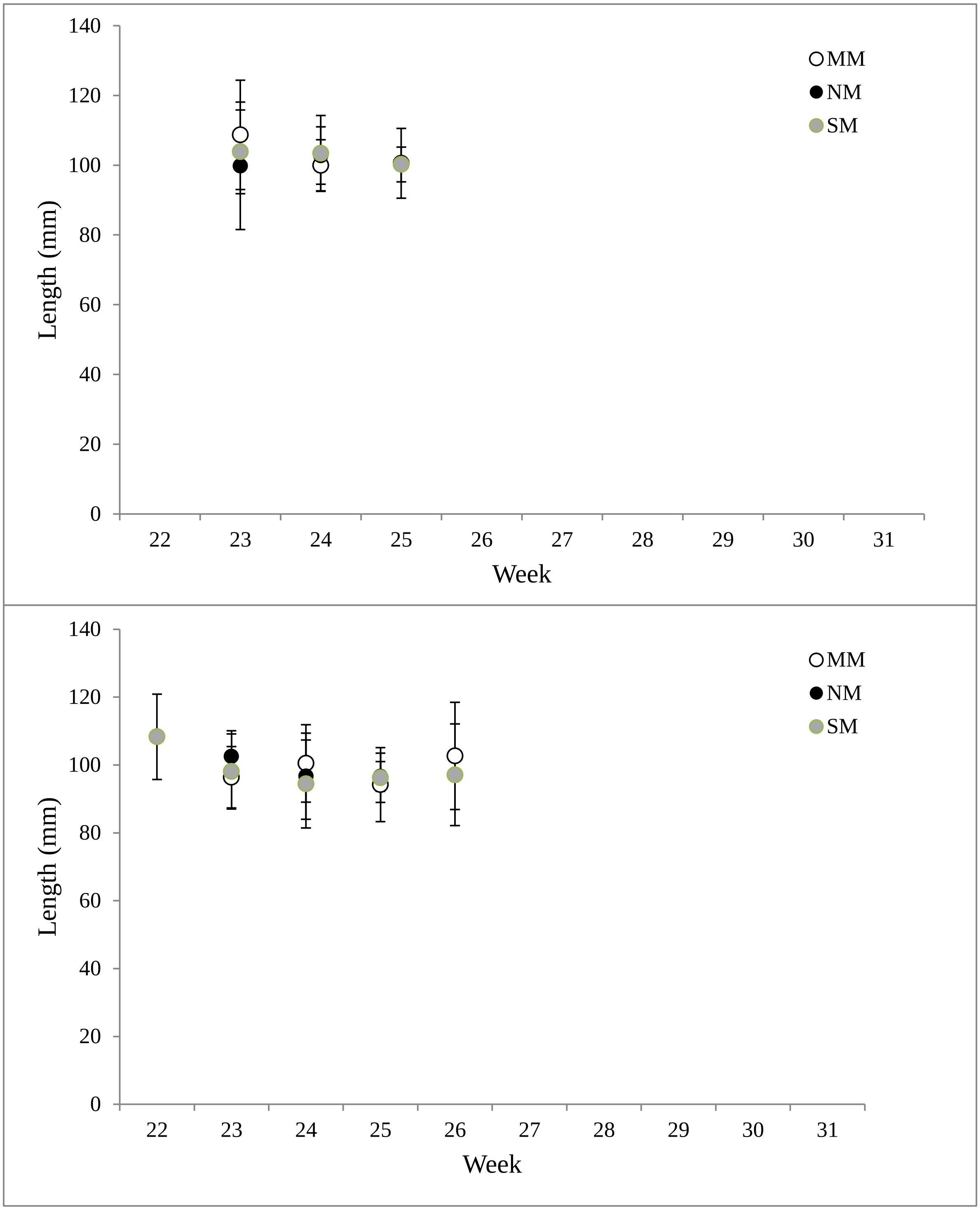

Figure 26.–Mean length of juvenile coho salmon by week and distributary in 2014 (top) and 2015 (bottom).

Note: Error bars represent standard deviation. No mean estimate is provided if less than 10 individuals were captured in that week.

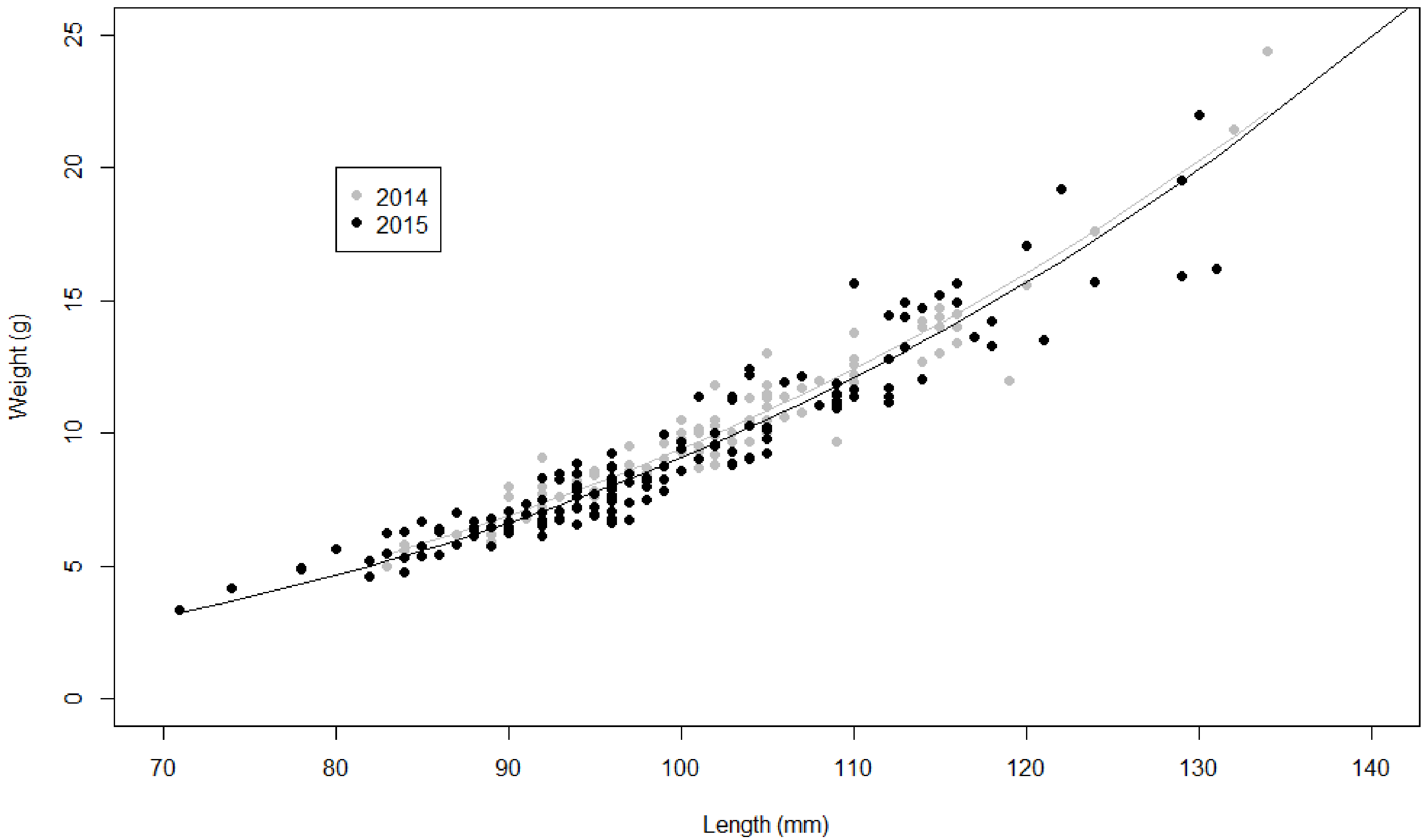

Figure 27.–Relationship between length and weight of juvenile coho salmon in 2014 and 2015.

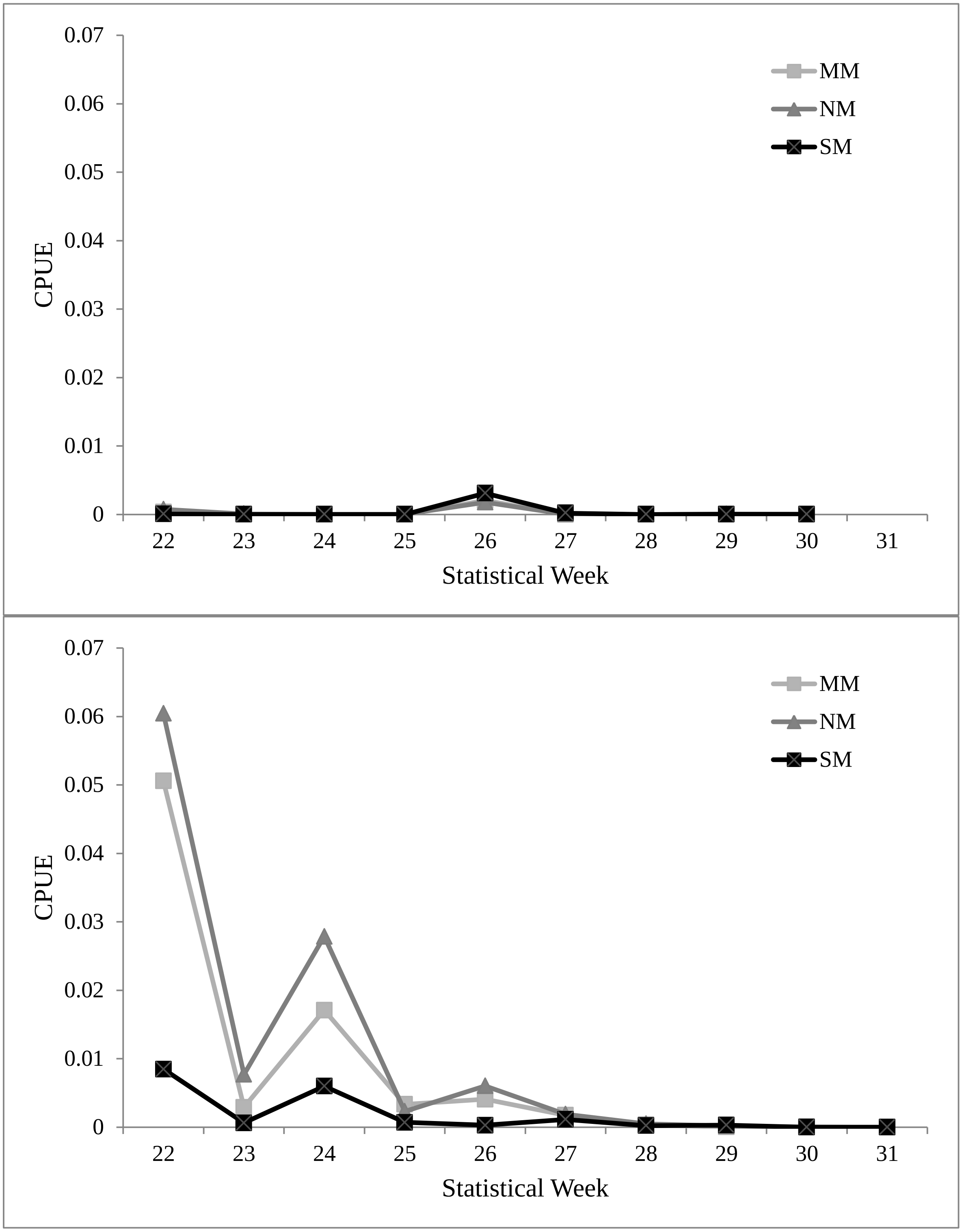

Figure 28.–Juvenile pink salmon CPUE (catch per unit surface area swept) by statistical week and distributary in 2014 (top) and 2015 (bottom).

Note: Statistical weeks begin the last week of May and end last week of July in both years.

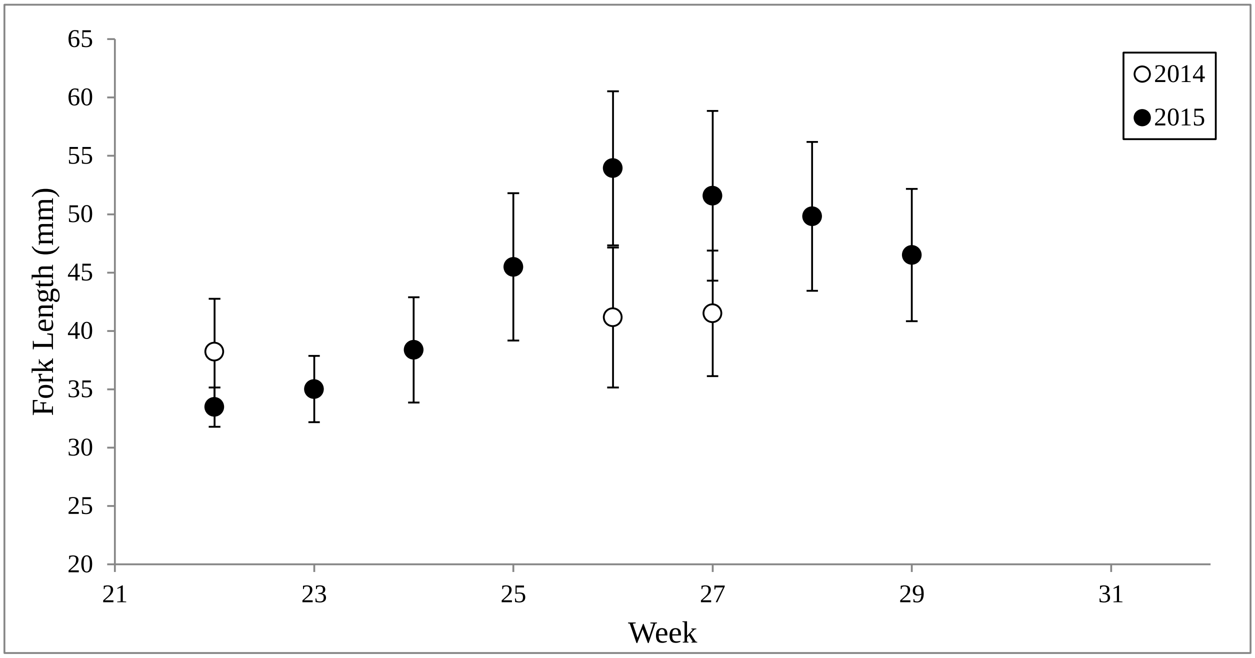

Figure 29.–Mean length of juvenile pink salmon by week in 2014 and 2015.

Note: Error bars represent the standard deviation.

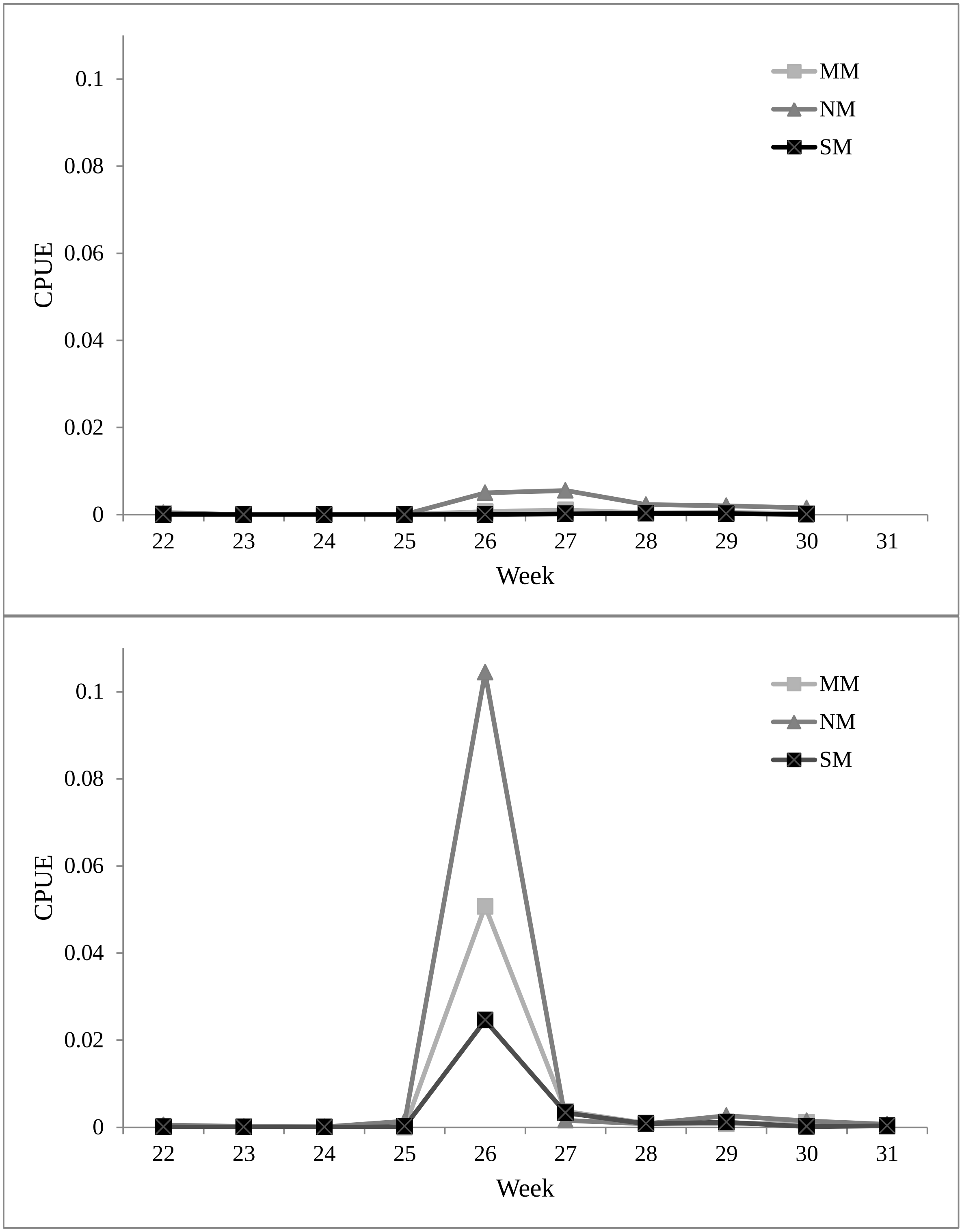

Figure 30.–Immature burbot CPUE (catch per unit surface area swept) by statistical week and distributary in 2014 (top) and 2015 (bottom).

Note: Statistical weeks begin the last week of May and end last week of July in both years.

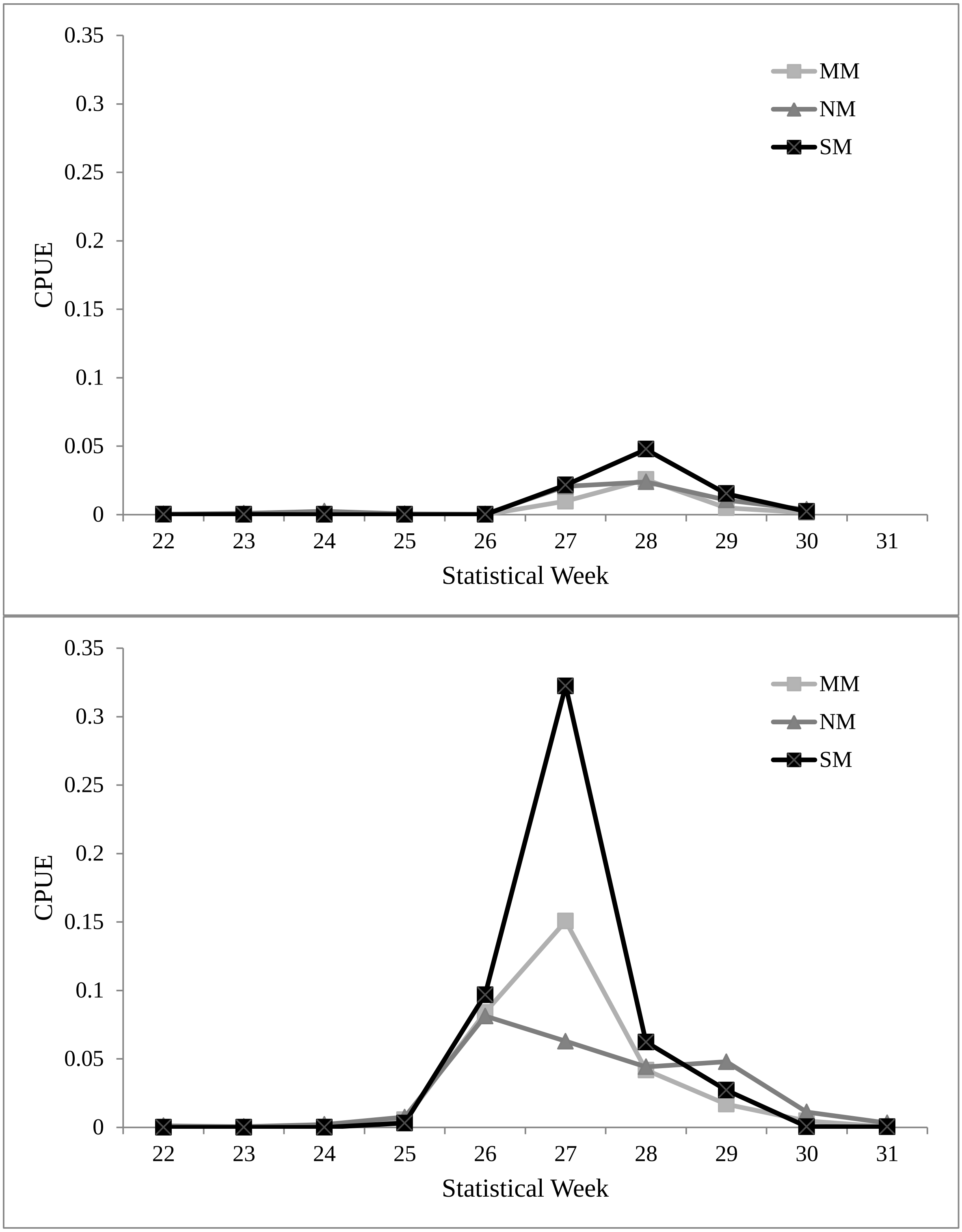

Figure 31.–Immature coregonid CPUE (catch per unit surface area swept) by statistical week and distributary in 2014 (top) and 2015 (bottom).

Note: Statistical weeks begin the last week of May and end last week of July in both years.

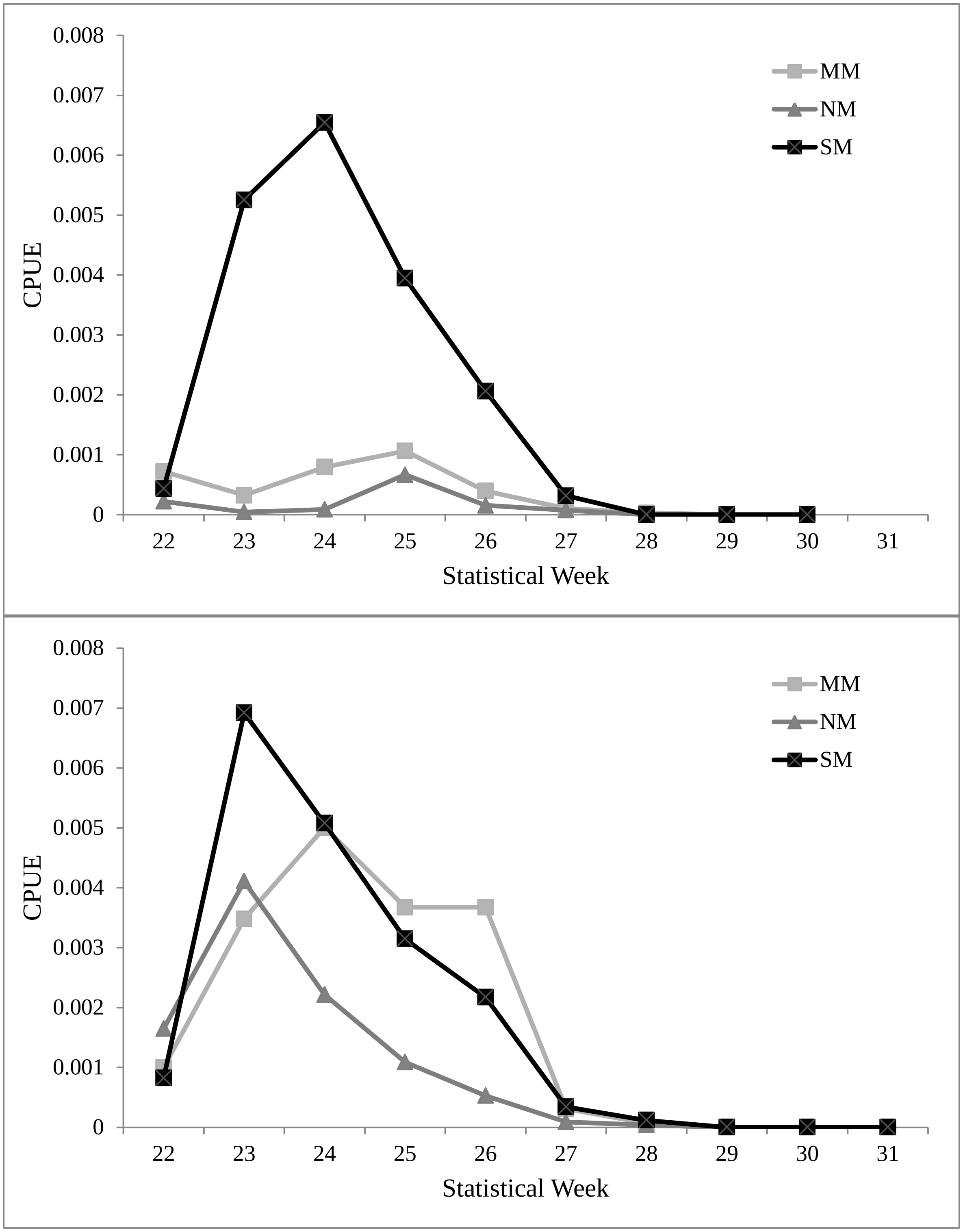

Figure 32.–Juvenile Arctic Lamprey CPUE (catch per unit surface area swept) by statistical week and distributary in 2014 (top) and 2015 (bottom).

Note: Statistical weeks begin the last week of May and end last week of July in both years.

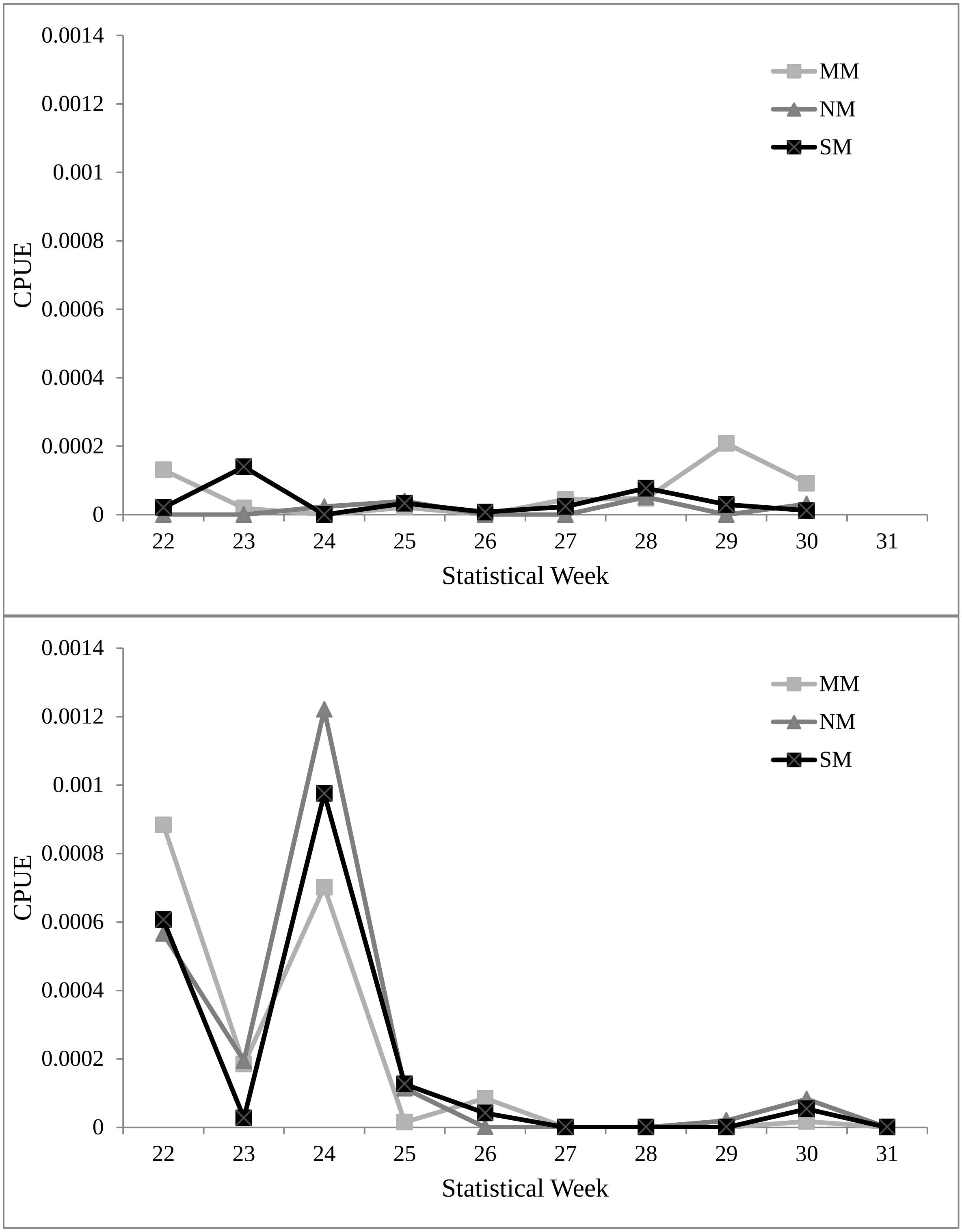

Figure 33.–Ammocoete Arctic Lamprey CPUE (catch per unit surface area swept) by statistical week and distributary in 2014 (top) and 2015 (bottom).

Note: Statistical weeks begin the last week of May and end last week of July in both years.

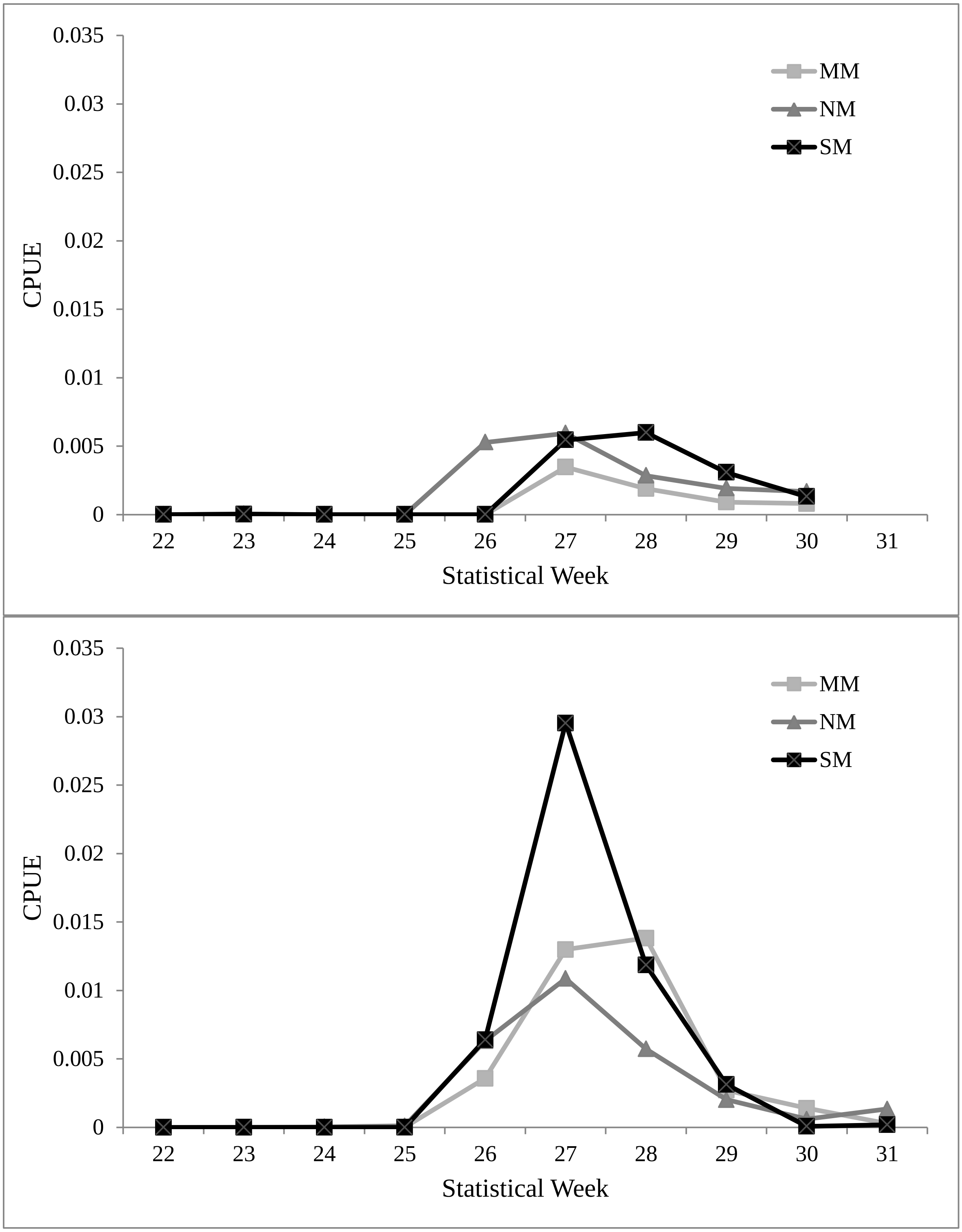

Figure 34.–Immature sheefish CPUE (catch per unit surface area swept) by statistical week and distributary in 2014 (top) and 2015 (bottom).

Note: Statistical weeks begin the last week of May and end last week of July in both years.

APPENDIX A: ADDITIONAL CATCH AND SAMPLING DATA

Appendix A1.–Catch data from delta platform sampling in 2014.

Arctic Lamprey

Gear	Station	Date	Set	Catch	N Length	Mean Length	SD Length	Minimum Length	Maximum Length
Push	Tincan	6/10/2014	2	1	0	–	–	–	–
Push	2 Fork	6/17/2014	1	1	0	–	–	–	–
Push	Kwiguk Mouth	6/17/2014	3	1	0	–	–	–	–
Push	Kwiguk Mouth	6/17/2014	4	1	0	–	–	–	–
Push	Kwiguk Mouth	6/17/2014	5	1	0	–	–	–	–
Push	Agagowik	6/21/2014	1	2	0	–	–	–	–
Push	Kwiguk Mouth	6/21/2014	3	2	0	–	–	–	–

Burbot

Gear	Station	Date	Set	Catch	N Length	Mean Length	SD Length	Minimum Length	Maximum Length
Push	2 Fork	6/10/2014	1	3	3	86	31	55	117
Push	2 Fork	6/10/2014	2	4	4	99	9	90	110
Push	2 Fork	6/10/2014	3	1	0	–	–	–	–
Seine	2 Fork	6/10/2014	1	1	1	85	–	85	85
Seine	2 Fork	6/10/2014	2	1	1	110	–	110	110
Seine	2 Fork	6/10/2014	3	1	1	83	–	83	83

Chinook salmon

Gear	Station	Date	Set	Catch	N Length	Mean Length	SD Length	Minimum Length	Maximum Length
Push	Tincan	6/10/2014	5	1	1	93	–	93	93
Push	Kwiguk Mouth	6/17/2014	1	1	1	89	–	89	89
Push	Kwiguk Mouth	6/17/2014	3	1	1	91	–	91	91
Push	Kwiguk Mouth	6/17/2014	4	2	2	90	6	85	94
Push	Kwiguk Mouth	6/17/2014	5	2	2	96	4	93	98
Push	Kwiguk Mouth	6/21/2014	3	2	2	92	4	89	95

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Gear	Station	Date	Set	Catch	N Length	Mean Length	SD Length	Minimum Length	Maximum Length
				Chum salmon					
Push	Aproka Mouth	6/7/2014	1	2	2	37	1	36	37
Push	Aproka Mouth	6/7/2014	2	2	2	40	4	37	43
Push	Aproka Mouth	6/7/2014	3	1	1	36	–	36	36
Push	Snotty2	6/7/2014	1	2	2	44	1	43	45
Push	Snotty2	6/7/2014	2	1	1	43	–	43	43
Push	2 Fork	6/10/2014	1	2	2	47	4	44	50
Push	2 Fork	6/10/2014	2	2	2	44	3	42	46
Seine	Casey	6/10/2014	1	4	4	42	1	41	43
Seine	Casey	6/10/2014	2	6	6	42	1	41	43
Push	Tincan	6/10/2014	1	8	0	–	–	–	–
Push	Tincan	6/10/2014	2	4	0	–	–	–	–
Push	Tincan	6/10/2014	3	7	0	–	–	–	–
Push	Tincan	6/10/2014	4	13	0	–	–	–	–
Push	Tincan	6/10/2014	5	10	0	–	–	–	–
Push	2 Fork	6/17/2014	1	1	1	39	–	39	39
Push	2 Fork	6/17/2014	2	2	2	274	320	48	500
Push	2 Fork	6/17/2014	3	3	3	46	6	39	51
Push	Bogamwik	6/17/2014	1	2	2	45	1	44	45
Push	Bogamwik	6/17/2014	2	2	0	–	–	–	–
Push	Casey	6/17/2014	2	2	2	46	1	45	46
Push	Channel off Kwiguk	6/17/2014	1	1	1	43	–	43	43
Push	Channel off Kwiguk	6/17/2014	2	6	6	43	3	38	46
Push	Kwiguk Mouth	6/17/2014	1	14	14	49	6	36	55
Push	Kwiguk Mouth	6/17/2014	2	14	14	48	8	36	58
Push	Kwiguk Mouth	6/17/2014	3	14	0	–	–	–	–
Push	Kwiguk Mouth	6/17/2014	4	19	0	–	–	–	–
Push	Kwiguk Mouth	6/17/2014	5	7	0	–	–	–	–
Push	Mauk	6/17/2014	4	1	0	–	–	–	–
Push	Murphy	6/17/2014	1	2	2	36	0	36	36

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Chum salmon continued									
Gear	Station	Date	Set	Catch	N Length	Mean Length	SD Length	Minimum Length	Maximum Length
Push	Agagowik	6/21/2014	1	1	1	45	–	45	45
Push	Alak Mouth	6/21/2014	1	2	2	47	1	46	47
Push	Alak Mouth	6/21/2014	2	4	4	44	4	40	50
Push	Kotlik CG	6/21/2014	1	2	2	38	3	36	40
Push	Kotlik CG	6/21/2014	2	2	2	41	3	39	43
Push	Kotlik CG	6/21/2014	3	1	0	–	–	–	–
Push	Kwiguk Mouth	6/21/2014	2	2	2	40	1	39	40
Push	Kwiguk Mouth	6/21/2014	3	5	5	47	5	40	54
Push	Kwiguk Mouth	6/21/2014	4	4	4	46	7	36	50
Push	Tincan Mouth	6/21/2014	1	4	4	43	7	35	52
Push	Tincan Mouth	6/21/2014	2	5	5	46	6	40	54
Push	Tincan Mouth	6/21/2014	3	6	6	48	4	40	53
Push	Iksovik	6/24/2014	1	8	8	48	9	38	62
Push	Iksovik	6/24/2014	2	6	6	50	6	41	59
Push	Iksovik	6/24/2014	3	14	14	49	4	41	56
Push	Iksovik2	6/24/2014	1	1	1	46	–	46	46
Push	Iksovik2	6/24/2014	2	1	1	48	–	48	48
Push	Lazy Slough	6/24/2014	1	1	1	50	–	50	50
Push	Lazy Slough	6/24/2014	2	3	3	39	5	34	44
Push	RMM	6/24/2016	1	9	9	50	9	44	69
Push	RMM	6/24/2016	2	6	6	51	5	45	60
Push	RMM	6/24/2016	3	1	1	50	–	50	50
Push	RMM	6/24/2016	4	1	1	30	–	30	30
Coho salmon									
Gear	Station	Date	Set	Catch	N Length	Mean Length	SD Length	Minimum Length	Maximum Length
Push	Kwiguk Mouth	6/17/2014	3	1	1	96	–	96	96

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Coregonid									
Gear	Station	Date	Set	Catch	N Length	Mean Length	SD Length	Minimum Length	Maximum Length
Push	Aproka Mouth	6/7/2014	2	1	1	106	–	106	106
Push	2 Fork	6/10/2014	1	4	4	93	13	80	110
Push	2 Fork	6/10/2014	2	7	7	113	58	85	244
Push	2 Fork	6/10/2014	3	4	2	88	4	85	90
Seine	2 Fork	6/10/2014	1	5	5	90	12	80	110
Seine	2 Fork	6/10/2014	2	5	5	123	71	85	249
Seine	2 Fork	6/10/2014	3	2	2	105	1	104	105
Seine	Casey	6/10/2014	1	2	2	174	73	122	225
Seine	Casey	6/10/2014	2	1	1	150	–	150	150
Push	Tincan	6/10/2014	4	1	0	–	–	–	–
Push	2 Fork	6/17/2014	1	5	5	121	36	85	181
Push	2 Fork	6/17/2014	2	2	2	96	2	94	97
Push	2 Fork	6/17/2014	3	1	1	89	–	89	89
Push	Kwiguk Mouth	6/17/2014	2	1	1	126	–	126	126
Push	Mauk	6/17/2014	4	1	1	102	–	102	102
Push	Tincan Mouth	6/21/2014	1	1	1	102	–	102	102
Push	Iksovik	6/24/2014	2	1	1	123	–	123	123
Push	RMM	6/24/2014	1	1	1	130	–	130	130
Push	RMM	6/24/2014	2	1	1	160	–	160	160

Isopod									
Gear	Station	Date	Set	Catch	N Length	Mean Length	SD Length	Minimum Length	Maximum Length
Push	2 Fork	6/10/2014	1	1	0	–	–	–	–
Push	2 Fork	6/10/2014	2	2	1	48	–	48	48
Push	2 Fork	6/17/2014	1	47	0	–	–	–	–
Push	2 Fork	6/17/2014	2	105	0	–	–	–	–
Push	2 Fork	6/17/2014	3	106	0	–	–	–	–
Push	Kwiguk Mouth	6/17/2014	3	1	0	–	–	–	–
Push	Kwiguk Mouth	6/17/2014	4	1	0	–	–	–	–
Push	Mauk	6/17/2014	1	2	0	–	–	–	–
Push	Mauk	6/17/2014	2	1	0	–	–	–	–
Push	Alak Mouth	6/21/2014	1	1	0	–	–	–	–
Push	Kotlik CG	6/21/2014	1	2	0	–	–	–	–

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Isopod continued

Gear	Station	Date	Set	Catch	N Length	Mean Length	SD Length	Minimum Length	Maximum Length
Push	Kotlik CG	6/21/2014	2	1	0	–	–	–	–
Push	Kotlik CG	6/21/2014	3	1	0	–	–	–	–
Push	Kwiguk Mouth	6/21/2014	3	1	0	–	–	–	–
Push	Tincan Mouth	6/21/2014	1	1	0	–	–	–	–
Push	Tincan Mouth	6/21/2014	2	1	0	–	–	–	–
Push	Tincan Mouth	6/21/2014	3	2	0	–	–	–	–
Push	Iksovik	6/24/2014	1	2	0	–	–	–	–
Push	Iksovik	6/24/2014	3	1	0	–	–	–	–
Push	Iksovik2	6/24/2014	1	3	0	–	–	–	–
Push	Iksovik2	6/24/2014	2	3	0	–	–	–	–
Push	RMM	6/24/2014	1	1	0	–	–	–	–
Push	RMM	6/24/2014	2	2	0	–	–	–	–

Ninespine stickleback

Gear	Station	Date	Set	Catch	N Length	Mean Length	SD Length	Minimum Length	Maximum Length
Seine	2 Fork	6/10/2014	1	3	3	49	2	46	50
Seine	Casey	6/10/2014	2	1	1	44	–	44	44
Push	2 Fork	6/10/2014	1	3	3	49	3	46	51
Push	2 Fork	6/10/2014	2	5	5	54	5	50	61
Push	2 Fork	6/10/2014	3	1	1	45	–	45	45
Push	2 Fork	6/17/2016	1	2	2	47	3	45	49
Push	2 Fork	6/17/2016	2	2	2	51	18	38	63
Push	2 Fork	6/17/2016	3	1	1	38	–	38	38

Pink salmon

Gear	Station	Date	Set	Catch	N Length	Mean Length	SD Length	Minimum Length	Maximum Length
Push	Lazy Slough	6/24/2014	2	1	1	35	–	35	35
Push	Iksovik	6/24/2014	1	5	5	41	4	35	45
Push	Iksovik	6/24/2014	3	8	8	35	9	20	46
Push	Iksovik2	6/24/2014	2	1	1	34	–	34	34
Push	RMM	6/24/2014	2	4	4	36	4	32	40
Push	RMM	6/24/2014	3	2	2	38	11	30	45

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Rainbow smelt

Gear	Station	Date	Set	Catch	N Length	Mean Length	SD Length	Minimum Length	Maximum Length
Push	Snotty2	6/7/2014	1	1	1	115	–	115	115
Push	2 Fork	6/10/2014	1	2	2	61	1	60	62
Push	2 Fork	6/10/2014	2	7	7	60	3	57	65
Push	2 Fork	6/10/2014	3	2	2	61	1	60	62
Seine	2 Fork	6/10/2014	1	2	2	61	1	60	62
Seine	2 Fork	6/10/2014	2	1	1	58	–	58	58
Push	2 Fork	6/17/2014	1	31	10	58	3	54	64
Push	2 Fork	6/17/2014	2	21	0	–	–	–	–
Push	2 Fork	6/17/2014	3	38	1	93	–	93	93
Push	Kwiguk Mouth	6/17/2014	2	1	1	192	–	192	192

Sheefish

Gear	Station	Date	Set	Catch	N Length	Mean Length	SD Length	Minimum Length	Maximum Length
Seine	2 Fork	6/10/2014	1	1	1	164	–	164	164
Seine	2 Fork	6/10/2014	2	1	1	274	–	274	274
Seine	2 Fork	6/10/2014	3	1	1	295	–	295	295
Seine	Casey	6/10/2014	2	1	1	168	–	168	168
Push	2 Fork	6/10/2014	1	1	1	164	–	164	164
Push	2 Fork	6/10/2014	2	1	1	274	–	274	274
Push	2 Fork	6/10/2014	3	1	0	–	–	–	–

Starry flounder

Gear	Station	Date	Set	Catch	N Length	Mean Length	SD Length	Minimum Length	Maximum Length
Seine	2 Fork	6/10/2014	2	1	1	152	–	152	152
Seine	2 Fork	6/10/2014	3	3	3	143	15	127	155
Push	2 Fork	6/10/2014	2	2	2	157	7	152	162
Push	2 Fork	6/10/2014	3	3	0	–	–	–	–
Push	Tincan Mouth	6/21/2014	1	1	1	166	–	166	166

Threespine stickleback

Gear	Station	Date	Set	Catch	N Length	Mean Length	SD Length	Minimum Length	Maximum Length
Push	2 Fork	6/17/2014	1	1	1	83	–	83	83

Unidentified larval fish

Gear	Station	Date	Set	Catch	N Length	Mean Length	SD Length	Minimum Length	Maximum Length
Push	Kotlik CG	6/21/2014	2	1	0	–	–	–	–
Push	Iksovik	6/24/2014	1	1	1	28	–	28	28

Note: Length provided in mm.

Appendix A2.–Geographic coordinates for exploratory and standard stations.

Habitat	Station Name	Latitude	Longitude
Front	Apoon 1	63.3904	-163.3528
	Apoon 2	63.4668	-163.3772
	Apoon 3	63.5371	-163.4042
	Kawanak 1	63.2943	-164.9507
	Kawanak 2	63.3408	-165.1071
	Kawanak 3	63.3822	-165.2487
	Kwiguk 1	62.7825	-165.2132
	Kwiguk 2	62.8171	-165.3365
	Kwiguk 3	62.8489	-165.4679
	Stuart 1	63.5127	-162.7921
	Stuart 2	63.5474	-162.8971
	Taku 1	62.4685	-165.5508
	Taku 2	62.4959	-165.6831
	Taku 3	62.5231	-165.8431
	Uwik 1	63.4612	-164.0721
	Uwik 2	63.5233	-164.1609
	Uwik 3	63.5869	-164.2553
Platform	2 Fork	62.52312	-164.96437
	Agagowik	62.77343	-164.87926
	Alak Mouth	62.74104	-164.88348
	Aproka Mouth	62.72556	-164.19125
	Below Martin	62.74642	-164.52931
	Bogamwik	62.73267	-164.26042
	Casey	62.64066	-164.84447
	Channel off Kwiguk	62.79023	-164.7265
	Iksovik	63.09143	-164.56178
	Iksovik 2	63.08229	-164.56592
	Kotlik CG	63.04581	-163.41145
	Kwiguk Mouth	62.81798	-164.86909
	Lazy Slough	62.75251	-164.5425
	Mauk	62.81099	-164.81844
	Murphy	62.57091	-164.81927
	RMM	63.03051	-164.65285
	Snotty 2	62.99577	-164.36041
	Tincan	62.64176	-164.84377
	Tincan Mouth	62.67552	-164.92017

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Habitat	Station Name	Latitude	Longitude
Distributary	Alak Bottom	62.70882	-164.79684
	Alak Top	62.68897	-164.61943
	Aluk	62.67714	-164.58287
	Aproka	62.70104	-164.15154
	Chuck	62.79599	-164.05663
	F&G Eddy	62.91883	-164.12471
	Fish Village	62.52114	-163.854
	Flat	62.58374	-165.01997
	Ham	62.8946	-163.90987
	Harpak	62.72012	-164.11482
	Kwiguk Slough 1	62.76476	-164.49516
	Kwiguk Slough 2	62.79205	-164.72047
	Martin	62.76121	-164.502
	NM Slough	63.06507	-163.60211
	Nunatak	63.03939	-164.55797
	OPP	62.95256	-163.79491
	Scour	62.56419	-163.95148
	Seagull	63.02658	-164.35808
	Sunshine	62.71185	-164.44551
	Tat	62.59722	-164.04028

Appendix A3.–Number of sets towed per station used in CPUE analysis, by mouth of river and sample date, 2014.

		SM		MM		NM	
Week	Date	Flat	Martin	F&G Eddy	Seagull	Ham	OPP
22							
	5/26/2014	6		6		6	
	5/28/2014	6		6	6	6	
	5/30/2014	6		6	6	6	
	Total	18		18	12	18	
23							
	6/2/2014	6		6	6	6	
	6/4/2014	6		6	6	6	
	6/6/2014	6	6	6		6	
	Total	18	6	18	12	18	
24							
	6/9/2014	6	6	6	6	6	
	6/11/2014	6	6	6	6	6	
	6/12/2014					6	6
	6/13/2014	6	6	6	6	6	
	6/14/2014						
	Total	18	18	18	18	24	6
25							
	6/16/2014	6	6	6	6	10	
	6/18/2014	6	6	6	6	6	
	6/19/2014					6	6
	6/20/2014	6	6	6	6	6	
	Total	18	18	18	18	28	6
26							
	6/23/2014	6	6	6	6	6	
	6/25/2014	6	6	6	6	6	
	6/26/2014	6	6				
	6/27/2014	6	6	6	6	6	
	6/28/2014					6	6
	Total	24	24	18	18	24	6
27							
	6/30/2014	6	6	6	6	6	
	7/1/2014			6	6	6	
	7/2/2014	6	6	6	6	6	
	7/3/2014	6	6				
	7/4/2014	6	6	6	6	6	
	7/5/2014					6	6
	Total	24	24	24	24	30	6

Note: Blanks represent no effort.

Appendix A4.–Number of sets towed for exploratory stations, by mouth of river and sample date, 2014. Blanks represent no effort.

		SM											MM	
Week	Date	Alak Bottom	Alak Top	Aluk	Aproka	Fish Village	Harpak	Kwiguk slough 1	Kwiguk slough 2	Scour	Sun-shine	Tat	Chuck	Nunatak
22														
	5/26/2014			6		1							6	
	5/28/2014			6								6		
	5/30/2014			6								6		
	Total			18		1						12	6	
23														
	6/2/2014			10						6				
	6/4/2014			6						6				
	6/6/2014									6				6
	Total			16						18				6
24														
	6/9/2014									6				
	6/11/2014									6				
	6/13/2014									6				
	6/14/2014						6						6	
	Total						6			18			6	
25														
	6/16/2014				6									
	6/18/2014				6									
	6/20/2014				6									
	Total				18									
26														
	6/23/2014				6									
	6/25/2014				6									
	6/26/2014				6									
	6/27/2014				6									
	Total				24									

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Week	Date	SM											MM	
		Alak Bottom	Alak Top	Aluk	Aproka Isle	Fish Vill.	Harpak	Kwiguk slough 1	Kwiguk slough 2	Scour	Sun-shine	Tat	Chuck	Nunatak
27														
	6/30/2014				6									
	7/2/2014				6									
	7/3/2014				6									
	7/4/2014				6									
	Total				24									
28														
	7/7/2014				6									
	7/8/2014				6									
	7/9/2014				6									
	7/11/2014				6									
	Total				24									
29														
	7/14/2014	6	6					6	6		6			
	7/16/2014				6									
	7/17/2014				6									
	7/18/2014				6									
	Total	6	6		18			6	6		6			
30														
	7/21/2014				6									
	7/22/2014				6									
	7/24/2014				6									
	7/25/2014				6									
	Total				24									
Grand Total		6	6	34	132	1	6	6	6	36	6	12	12	6

Appendix A5.–Number of sets towed per station used in CPUE analysis, by mouth of river and sample date, 2015.

		SM			MM			NM		
Week	Date	Flat	Martin	Aproka	F&G Eddy	Seagull	Nunatak	Ham	OPP	NM Slough
22										
	5/25/2015	3	3	3						
	5/26/2015							3	3	3
	5/27/2015	3	3	3	3	3	3			
	5/28/2015							3	3	3
	5/29/2015	3	3	3	3	3	3			
	5/30/2015							3	3	3
	Total	9	9	9	6	6	6	9	9	9
23										
	6/1/2015	3	3	3	3	3	3			
	6/2/2015							3	3	3
	6/3/2015	3	3	3	3	3	3			
	6/4/2015							3	3	3
	6/5/2015	3	3	3	3					
	6/6/2015							3	3	3
	Total	9	9	9	9	6	6	6	6	6
24										
	6/8/2015	3	3	3	3	3	3			
	6/9/2015							3	3	3
	6/10/2015	3	3	3	3	3	3			
	6/11/2015							3	3	3
	6/12/2015		3	3	4	3	3			
	6/13/2015							3	3	3
	Total	6	9	9	10	9	9	9	9	9
25										
	6/15/2015	3	3		3	3	3			
	6/16/2015							3	3	3
	6/17/2015	3	3	3	3	3	3			
	6/18/2015							3	3	3
	6/19/2015	3	3	3	3	3	3			
	6/20/2015							3	3	3
	Total	9	9	6	9	9	9	6	6	6

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		SM			MM			NM		
Week	Date	Flat	Martin	Aproka	F&G Eddy	Seagull	Nunatak	Ham	OPP	NM Slough
26										
	6/22/2015	3	3	3	3	3	3			
	6/23/2015							3	3	3
	6/24/2015	3	3	3	3	3	3			
	6/25/2015							3	3	3
	6/26/2015	3	3	3	3	3	3			
	6/27/2015							3	3	3
	Total	9	9	9	9	9	9	6	6	6
27										
	6/29/2015	3	3	3	3	3	3			
	6/30/2015							3	3	3
	7/1/2015		3	3	3	3	3			
	7/2/2015							3	3	3
	7/3/2015	3	3	3	3	3	3			
	7/4/2015							3	3	3
	Total	6	9	9	9	9	9	9	9	9
28										
	7/6/2015	3	3	3	3	3	3			
	7/7/2015							3	3	3
	7/8/2015	3	3	3	3	3	3			
	7/9/2015							3	3	3
	7/10/2015	3	3	3	3	3	3			
	7/11/2015							3	3	3
	Total	9	9	9	9	9	9	6	6	6
29										
	7/13/2015	3	3	3	3	3	3			
	7/14/2015							3	3	3
	7/15/2015	3	3	3	3	3	3			
	7/16/2015							3	3	3
	7/17/2015	3	3	3	3	3	2			
	7/18/2015							3	3	3
	Total	9	9	9	9	9	8	6	6	6

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		SM			MM			NM		
Week	Date	Flat	Martin	Aproka	F&G Eddy	Seagull	Nunatak	Ham	OPP	NM Slough
30										
	7/20/2015	3	3	3	3	3	3			
	7/21/2015							3	3	3
	7/22/2015	3	3	3	3	3	3			
	7/23/2015							3	3	3
	7/24/2015	3	3	3	3	3	3			
	7/25/2015							3	3	3
	Total	9	9	9	9	9	9	9	9	9
31										
	7/27/2015	3	3	3	3	3	3			
	7/28/2015							3	3	3
	Total	3	3	3	3	3	3	3	3	3
Grand Total		78	84	81	82	78	77	69	69	69

Note: Blank cells indicate no effort.

Appendix A6.–Number of sets towed per station used in CPUE analysis on the delta front. Blanks represent no effort.

		2014			2015		
		June	July	August	June	July	August
Transect	Station	(6/17-6/21)	(7/22-7/26)	(8/20-8/24)	(6/10-6/14)	(7/3-7/8)	(8/6-8/10)
Stuart	Inner	2				1	
	Middle	2				1	
Apoon	Inner	1	1	1	1	1	
	Middle	2	2	1	1	1	
	Outer	3	2	2	1	1	2
Uwik	Inner	2	2	1	1	1	1
	Middle	2	2	2	2	2	2
	Outer	1	1	1	1	3	2
Kawanak	Inner		1	3	1	1	1
	Middle		1	2	2	1	2
	Outer		3	2	2	1	3
Kwiguk	Inner	1	1	1	1		1
	Middle	1	1	1	2		2
	Outer	2	2	2	2		2
Taku	Inner			1	1	1	1
	Middle	1		2	2	2	2
	Outer	1		2	2	3	2
Total		21	19	24	22	20	23