Fishery Data Series No. 18-15

Use of Acoustic Tags to Examine Movement of Chum Salmon in Nearshore Marine Waters of Northern Norton Sound, 2015-2016

by

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May 2018

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

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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

FISHERY DATA SERIES NO. 18-15

USE OF ACOUSTIC TAGS TO EXAMINE MOVEMENT OF CHUM SALMON IN NEARSHORE MARINE WATERS OF NORTHERN NORTON SOUND, 2015-2016

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ABSTRACT

Commercial and subsistence salmon harvests occurring in marine waters of Subdistrict 1 cannot be allocated to river of origin, therefore the level of harvest on individual stocks is unknown. Acoustic tags were placed on chum salmon *Oncorhynchus keta* captured in the marine waters of Subdistrict 1 and their movements were monitored using acoustic receivers in the ocean and each Subdistrict 1 river. A total of 259 and 194 chum salmon were tagged in 2015 and 2016. In both years, only 5% of tags were undetected by either an ocean or river receiver. In 2015, 120 (46%) tagged chum salmon were considered of Subdistrict 1 origin. In 2016 129 (66%) chum salmon were of known Subdistrict 1 origin. Bonanza River had the largest number of tagged fish (30) in 2015 and Sinuk River had the most (34) in 2016. The fewest chum salmon (2) were detected in Solomon River in 2015 and Penny River in 2016. In both years, chum salmon tagged near Sinuk and Bonanza rivers were predominantly detected in those rivers but chum salmon tagged in Sections 2 and 6 had fish predominantly return to rivers in adjacent sections. Chum salmon that were last detected in rivers west of Cape Nome had a greater eastern dispersal in 2016 than in 2015. Conversely, chum salmon that were last detected in rivers east of Cape Nome had similar western dispersal patterns between years. Acoustic telemetry proved to be a robust tool for examining movements of chum salmon in marine and fresh water and its practicality makes it a viable option in other areas of Norton Sound to address similar questions about mixed stock fisheries.

Key words: chum salmon, *Oncorhynchus keta*, acoustic telemetry, acoustic tag, acoustic receiver, marine migration, Norton Sound

INTRODUCTION

Mixed stock salmon fisheries in the marine environment pose a problem for fishery managers throughout Alaska. Successful management of mixed stock fisheries relies on knowledge about stock composition of the harvest and understanding temporal and spatial movement patterns in the nearshore marine environment where fishing effort occurs. In Norton Sound (Figure 1), mixed stock fisheries occur in Subdistrict 1 where chum salmon *Oncorhynchus keta* returning to 7 major rivers are captured in marine subsistence and commercial fisheries. Chum salmon returns to rivers within this subdistrict have been highly variable, making the dual objectives of drainage-specific and subdistrict-wide escapement goals challenging to achieve on a consistent basis (Table 1). Currently, managers make decisions under the assumption that Subdistrict 1 chum salmon enter the subdistrict at Cape Nome and migrate to the west if they are Sinuk, Cripple, Penny, Snake or Nome river stocks, or migrate to the east if they are Flambeau, Eldorado, Bonanza, or Solomon river stocks (Figure 2). Within the last decade the subdistrict-wide escapement goal has been met or exceeded in most years, in large part due to strong chum salmon runs in the eastern rivers of the subdistrict (i.e., Flambeau and Eldorado rivers); however, weak runs to western rivers have resulted in unmet individual river escapement goals (i.e., Nome and Snake rivers) in some years. Variability in chum salmon returns to this area, importance to subsistence fisheries, failure to meet some escapement goals while exceeding others in the subdistrict, and divergent productivity patterns within the subdistrict underscore the importance for managers to have stock-specific marine harvest information.

Fishery managers need to predict stock-specific harvests to develop scientifically defensible management strategies that can address escapement objectives and subsistence needs and allow economic opportunities on harvestable surpluses. Fisheries in Norton Sound are challenging because most harvest occurs in marine waters and most marine harvests cannot be allocated to stock of origin, thus the level of harvest on individual stocks is unknown. Genetic stock identification cannot offer the resolution needed to differentiate between Subdistrict 1 rivers (DeCovich et al. 2012); therefore, mark–recapture studies are necessary to fill this information need.

A tagging study conducted in the Norton Sound area in 1978–1979 used Peterson-type disk tags and captured chum salmon at 4–5 locations in Norton Sound (2–3 sites in Subdistrict 1 and 2 sites in Subdistrict 5); it revealed adult chum salmon tagged in Subdistrict 1, near Cape Nome, were primarily recaptured in marine harvests in Subdistrict 1 (Gaudet and Schaefer 1982). However, it is difficult to draw conclusions from this study about how vulnerable specific chum salmon stocks are to harvest because salmon were only tagged in a small area of the subdistrict and most recaptures were from marine harvests with very few freshwater recoveries to determine river of origin.

Understanding the composition of marine harvest and movement patterns of fish in nearshore marine waters of Subdistrict 1 is needed to provide fishery managers with information to target harvest on abundant stocks, minimize subsistence restrictions, and meet escapement objectives to ensure long-term fishery sustainability. The development of low-cost acoustic tagging technology has provided opportunities to track anadromous fish in freshwater, brackish, and marine waters (Comeau et al. 2002).

This study aimed to re-examine conclusions from the previous tagging study using acoustic tagging technology: 1) to test harvest assumptions used to estimate total runs and assess the subdistrict-wide escapement goal; and 2) to provide information about migration patterns, which may inform management decisions affecting the achievement of both escapement goals and subsistence harvest opportunity.

OBJECTIVES

1. Test the assumption that chum salmon vulnerable to harvest within the marine waters of Subdistrict 1, Norton Sound District, are of Subdistrict 1 origin; and
2. Test the assumption that chum salmon of Subdistrict 1 origin migrate into the subdistrict at Cape Nome and follow the coast west if it is of western subdistrict stock origin or east if it is of eastern subdistrict stock origin.

METHODS

STUDY LOCATION

This project was conducted in the marine waters and rivers of Subdistrict 1 in Norton Sound (Figure 1). Subdistrict 1, which extends east and west along the coast for approximately 127 km, was divided into 6 sections spaced equidistant across the subdistrict. The sections were used to define tagging locations and each section included 1–3 rivers, except Section 4 which did not have any rivers. Each major river within the subdistrict was included in this study: the Sinuk, Snake, Nome, Eldorado, Flambeau, Bonanza, and Solomon rivers. Additionally, 2 smaller rivers (Penny and Cripple rivers) with small chum salmon runs (≤300 fish per year) were included to ensure all potential spawning streams for chum salmon were monitored for tagged fish (Figure 2).

FISH CAPTURE AND TAGGING

Chum salmon were captured in areas utilized by subsistence and commercial fishermen within Subdistrict 1 for 1 month from mid-June to mid-July using 25 fathom set gillnets hung with 14.94 cm (5-7/8 inch) stretched mesh. Set gillnets were deployed perpendicular to and within 250 m of shore in 6 sections of the subdistrict (Figures 3 and 4). Fishing locations were unfixed to maximize fishing efficiency and each set soaked for at least 30 minutes or until a fish was caught. Depending on the success of a set in a location, that approximate location was visited multiple times throughout the season. Nets were actively monitored; once a fish was entangled in the net, the section of net with the fish was pulled into the skiff and placed in a tote filled with seawater. The fish was removed from the net as quickly as possible, cutting the net as needed, to reduce handling time and stress on the fish. Chum salmon were retained for sampling and all other species were released immediately. Location of each set was recorded on a Garmin® GPSmap76Cx global positioning system (GPS) unit.[1]

Prior to tagging, each chum salmon was visually evaluated for condition; only apparent healthy salmon (eye and opercula movements, no bleeding) were fitted with acoustic tags. Chum salmon were placed in a 6 inch diameter modified polyvinyl chloride (PVC) tube filled with seawater (Figure 5). Acoustic tags were attached to the chum salmon by inserting 2 stainless steel darts through the dorsal musculature and pterygiophores approximately 1.5 cm medially from the fish's dorsal fin. Stainless steel wire (SS 302/304 ST0.020 gauge), which was wrapped around the tag, was threaded through the darts. The darts were then removed, leaving the stainless-steel wire exposed through the musculature (Figure 6). A 'back' was placed on the wires and fitted snuggly to the fish by twisting the wire. In general, tagging of each chum salmon took less than 3 minutes. The acoustic tag used for this study was a Lotek Wireless, Inc. MM-MS-11-28 tag with a transmitting frequency of 76 KHz, dimensions of 12 x 60 mm, a weight of 11 g, and a life expectancy of 104 days at a transmission interval of 5 sec. Each tag was uniquely numbered and tag return information was printed on the outside to increase chances of recovering the tag in the event the fish was harvested (Figure 7). All acoustic tags were activated the morning before tagging commenced to ensure they were transmitting correctly. Once the chum salmon was tagged it was placed in a tote filled with circulating seawater to recover. The acoustic tag was checked prior to release using a Lotek WHS 3250 receiver. The receiver was downloaded at the end of the day to verify the tag was working prior to release.

All tagged chum salmon were sampled for age and length. Length was measured to the nearest millimeter from mid eye to fork of tail (METF). Scales used for age determination were removed from the preferred area of the fish (INPFC 1963). One scale was collected from each fish and mounted on a gum card. Gum cards were impressed in cellulose acetate using methods described by Clutter and Whitesel (1956). Scale impressions were magnified using a microfiche reader and the age of the fish determined through visual identification of annuli. The sex of each chum salmon was determined using external characteristics such as body symmetry, kype development, and presence of an ovipositor.

To address Objective 1, the goal was to tag 10 salmon each week for 4 weeks in Sections 1, 2, 3, 5, and 6 each project year for a total of 200 chum salmon each project year. To address Objective 2, the goal was to tag 20 salmon each week for 4 weeks in Section 4 for a total of 80 chum salmon each project year. Therefore, the total tagging goal to address both objectives was 280 chum salmon per year of the project.

ACOUSTIC RECEIVERS

All receiving stations were assembled 1–2 days before deployment in marine and river locations. Assembly included installing 2 D-cell lithium batteries, initializing the receiver time stamp,

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

setting the internal beacon ping rate (every 1 minute in 2015, every 1 hour in 2016), and starting the recording function. All receivers were checked for proper operation in the office prior to going into the field and checked again right before deployment. If a receiver needed to be reset in the field, time of reset was recorded. The factory reset was 0001, January 1, 2012, and the receiver starts detecting 1 hour later. This information along with the reset time was used to adjust time and date data at the end of the season for those receivers that were reset in the field. All receivers had a life expectancy of 84 days. Receiver life expectancy was assumed to be adequate because most chum salmon pass through the weirs in Subdistrict 1 rivers by mid-August.

A total of 42 acoustic receivers in 7 arrays were deployed in nearshore marine waters and 2 receivers were placed in each of the 9 subdistrict rivers (Figure 2). Marine acoustic receivers were placed in linear arrays of 6 receivers extending perpendicular from shore with overlapping detection ranges. Arrays were approximately 25.5 km apart. In 2015, the first receiver of an array was 250 m from shore with 300 m between remaining receivers resulting in an estimated linear coverage of 2.1 km from shore. In 2016, the first receiver was placed 300 m from shore to help minimize loss of receivers due to wave action. Marine acoustic receivers were anchored using 50–75 kg pier blocks with holes drilled through the middle to accommodate ⅜-inch wire rope. All receivers were suspended 1.5 m above the seafloor on wire rope and vertical position was maintained with a sub-surface buoy approximately 1.5 m above the receiver as well as a surface buoy (Figure 8). In 2016, connections between the wire rope and nylon rope were strengthened using rope thimbles to help minimize the loss of ocean receivers because of fraying lines. All receivers were deployed with the hydrophone pointing down to help minimize acoustic noise from surface conditions in the shallow waters of Subdistrict 1. All ocean receivers were deployed in water between 2.9 m and 17.8 m in depth; for receivers in shallow water (generally <4 m), the sub-surface buoy was removed and only the surface buoy was used. In 2015, ocean receivers were placed using a skiff and helicopter. In 2016, only the helicopter was used to deploy ocean receivers. Ocean receivers were removed using a skiff outfitted with a pulley and winch system.

In the rivers, the downstream receiver was positioned above tidal influence to minimize the number of times a salmon would be detected while exploring non-natal rivers. The second receiver was positioned upstream of the first receiver at a distance that removed line of sight. River receivers were mounted on rebar driven into the riverbed in an area that provided the greatest chance of detecting tagged fish while minimizing the chance of disturbing the receiver (Figure 9). All river receivers were marked with buoys. In rivers accessible from the Nome road system, receivers were deployed using a skiff and helicopters were used to access the remote rivers. At the end of the season, receivers were removed from the water, cleaned, and returned to the office. Data were downloaded and stored as comma separated values (CSV) files before being converted to Microsoft Excel files.

Range Testing

Range testing was conducted in August in both 2015 and 2016. To complete range testing in 2015, 1 acoustic tag was attached to the paddle section of a boat oar. The oar was lowered into the water as deep as possible (~2 m) and maintained at that depth as the skiff drifted away from the target receiver. In 2016, 3 tags were attached to a weighted rope. The deepest tag was approximately 3.7 m from the bottom, the second tag was attached approximately 8.3 m from the bottom, and the final tag was attached 12.9 m off the bottom. The weighted rope was lowered over the side of the skiff until the weight touched bottom, then was lifted enough to allow the skiff to drift freely. The amount of rope and therefore the number of tags was adjusted depending on water depth. In both years, time was recorded when the skiff was 100 m, 200 m, 400 m, 600 m, 800 m, and 1,000 m from each target receiver. Distance between the target receiver and skiff was estimated using a handheld GPS. Once receivers were pulled at the end of the season and downloaded, the data were sorted for range testing acoustic tags. Field recorded time and receiver time were compared to determine if a tag was detected.

DATA ANALYSIS

Tagging and Detection Assessment

To determine if tagging goals were met in each year, the number of tagged chum salmon was summarized by subdistrict section and week and the proportion of tags deployed by week was calculated. Additionally, the age, sex, and length (ASL) distribution of tagged chum salmon was compared to the ASL distribution at the Subdistrict 1 enumeration projects to determine if tagged chum salmon were representative of the runs returning to Subdistrict 1 enumeration projects. To assess the number of detections on receivers, receiver data files were filtered for tags only and grouped by river and ocean array; the number of tag detections was summarized for all rivers combined and all arrays were combined by year.

To determine the range detection of the tags, the proportion of receivers detecting tags at distances of 100 m, 200 m, 400 m, 600 m, 800 m, and 1000 m were calculated for each project year.

Objective 1: Stock Characteristics of Subdistrict 1 Marine Catches

Receiver files were searched by tag number to determine movement of each tagged fish. Based on the last location each chum salmon was detected, one of the following fates was assigned:

> *Fate 1*: a chum salmon last detected by a Subdistrict 1 inriver receiver (*Subdistrict 1 origin*).
>
> *Fate 2*: a chum salmon last detected by a receiver at the subdistrict border arrays (1 and 7) and/or those chum salmon caught in fisheries outside Subdistrict 1 (*not of Subdistrict 1 origin*).
>
> *Fate 3*: a chum salmon last detected on Arrays 2–6 and those chum salmon captured and reported in Subdistrict 1 fisheries (*stock of origin unknown*).
>
> *Fate 4*: a chum salmon never detected after being tagged (tag loss). Tag loss includes but is not limited to salmon migrating to very small unmonitored river systems, salmon harvested in local fisheries that were not reported, and tag shedding (*stock of origin unknown*).

Fates of tagged chum salmon were summarized by subdistrict section and by week. To address Objective 1, fates were summarized for each project year and the proportion of Fate 1 salmon were calculated from the total number of tagged chum salmon. The objective was supported if the proportion of Fate 1 salmon exceeded 0.50. To examine temporal differences in tagging, fates were summarized by tagging week and a chi-square test for independence (Zar 1999) was completed. Additionally, comparisons of age and sex composition were made between Fate 1 chum salmon and ASL samples collected from chum salmon at inriver enumeration projects in the subdistrict.

To further identify patterns of Subdistrict 1 stocks in marine catches, all tagged chum salmon assigned Fate 1 were summarized by section of last detection and the proportion of tagged chum salmon last detected in each section was calculated. All tagged chum salmon assigned Fate 1 were also summarized by river of last detection (river of origin). To examine temporal differences that could affect stock of origin of harvest, tagged chum salmon assigned Fate 1 were summarized by week for each river.

Objective 2: Inferring Marine Migration Patterns

The marine movement of chum salmon tagged in Section 4 was used to evaluate Objective 2. Because there are no rivers in this section, salmon captured and tagged in Section 4 were presumed to be moving through this section to a subdistrict river or beyond. Chum salmon tagged in Section 4 and assigned Fate 1 were summarized by river of last detection.

Marine movement, within the subdistrict between arrays, of Fate 1 chum salmon was examined by summarizing the detections of chum salmon from each river at each array. To determine days in marine waters, the date of tagging was subtracted from the date of first detection in the river of origin for all Fate 1 tagged fish. The average number of days at large was calculated for each project year and a Student's *t*-test (Zar 1999) was used to compare the average days at large between years. In addition to Subdistrict 1 origin fish movement, patterns of marine migration were also explored for those fish presumed to be of origin outside Subdistrict 1. Dispersal, age, and size of chum salmon assigned Fate 2 were summarized by project year. A Student's *t*-test (Zar 1999) was used to test for differences in age and size composition between years and between Fate 1 and Fate 2 chum salmon in each year.

RESULTS

TAGGING AND DETECTION ASSESSMENT

In 2015, 259 chum salmon were tagged in Subdistrict 1 nearshore waters from June 24 to July 21 (Appendix A1). In 2016, 194 chum salmon were tagged, which was well below the goal because the skiff became inoperable in Week 2, which resulted in tagging only occurring in sections 5 and 6 (Appendix A2). It was easier and more efficient to capture chum salmon in Sections 5 and 6 in both 2015 and 2016. In most weeks, only one trip was required to achieve the tagging goal in those sections. In both years, fewer fish were tagged in the first 2 weeks than in the last 2 weeks (Table 2).

Tagged chum salmon were predominantly male in both years and salmon tagged in 2015 had a higher percentage of older (≥ age-0.4) fish than those tagged in 2016 (Table 3). In 2015, tagged chum salmon ranged in length from 516 mm to 684 mm METF (Appendix A1) and in 2016, tagged chum salmon were smaller and ranged between 484 mm and 668 mm METF (Appendix A2).

In 2015, the first receiver was deployed on June 11 and the last receiver was pulled on September 14. All river receivers and 33 ocean receivers were recovered. Two ocean receivers lost in 2015 were recovered in summer 2016. In 2016, the first receiver was deployed on June 9 and the final receiver was pulled August 30. All river receivers and 40 ocean receivers were recovered. In each year of the project, one of the recovered receivers failed to function correctly.

In 2015, there were a total of 264,855 tag detections from 232 fish using the ocean receivers and 859,456 tag detections from 123 fish using the river receivers. The last detections were August 15 for ocean arrays, and August 21 for river receivers. The dates of last detection were well before receivers were removed from the water and the internal beacon on each receiver indicated the receivers were operational until the end of August. In 2016, there were a total of 174,528 tag detections from 174 fish using the ocean receivers and 1,056,076 tag detections from 130 fish using the river receivers. The last detection on a river receiver in 2016 was August 29 and the last detection on an ocean receiver was August 22, approximately 1 week later than 2015. Most receivers still had power when removed from the water in 2016. In 2015, less than 3% of tag detections on ocean and river receivers came after July 31 and less than 5% of tag detections in 2016 came after July 31.

In 2015, a total of 15 ocean receivers were range tested and in 2016, 28 ocean receivers were range tested. Despite differences in the methods used to range test in each study year, the results were very similar between years. Receivers had the best detection ability at tag distances between 400 m and 600 m from the receiver. At distances less than 400 m and greater than 600 m, the proportion of receivers detecting tags started to decline to a minimum of 0.2 in 2015 and 0.3 in 2016 (Figure 10).

Objective 1: Stock Characteristics of Subdistrict 1 Marine Catches

All tagged chum salmon were assigned a fate based on the location of their last detection on ocean or river receivers, or if the fish was never detected after release. The largest proportion of tagged chum salmon in each year was of Subdistrict 1 origin (Fate 1). Fairly equal proportions were either assumed to leave the subdistrict (Fate 2) or were of unknown origin (Fate 3). Only 5% of the fish in both years were undetected after tagging (Fate 4; Table 4). In evaluating project Objective 1, a clear majority of chum salmon tagged in 2016 were definitively of Subdistrict 1 origin (Fate 1). In 2015, assessment of the assumption was less clear. It is possible that some of the 14 fish undetected after tagging (Fate 4) were Subdistrict 1 origin and some of the 4 fish caught in the Subdistrict 1 subsistence and commercial fisheries (part of Fate 3) were Subdistrict 1 origin in 2015. Ten of the 18 fish in these categories would need to be Subdistrict 1 origin to indicate that most of the fish were Subdistrict 1 origin in 2015. Data suggest a minimum of 24% (2015) and 14% (2016) of fish are probably available for harvest in Subdistrict 1 but originate outside the subdistrict (Table 4).

There were no obvious patterns in the distribution of fates between tagging sections within years and between years. Chum salmon tagged in Section 3 in 2015 and 2016 had similar fate proportions between years but there were few other similarities. For example, Section 1 had the second lowest proportion of Fate 1 chum salmon in 2015 (0.39) and the highest proportion of Fate 1 chum salmon in 2016 (0.86; Table 4).

There were temporal differences in fates by week in both 2015 and 2016. In 2015, the relative frequencies of fates were not the same across weeks (chi-square test: $\chi^2 = 17.71$, $df = 9$, $p = 0.039$; Table 5). For example, Fate 1 chum salmon made up a smaller proportion of Week 3 fish than in other weeks, whereas Fate 3 chum salmon were more prevalent in Week 3 than in other weeks. Fate 2 chum salmon accounted for more than a quarter of the tagged fished in Weeks 3 and 4, but only accounted for approximately 15% in Weeks 1 and 2. In 2016, the relative frequencies of fates between weeks were different as well (chi-square test: $\chi^2 = 40.96$, $df = 9$; $p < 0.001$; Table 5). Fate 1 chum salmon made up a larger proportion of the tagged salmon in Weeks 3 and 4; Fate 2 salmon were more prevalent in Week 1; and Fate 3 chum salmon made up a larger portion of Week 2 than any other week.

Of the chum salmon assigned Fate 1, age-0.4 chum salmon were more prevalent in 2015 whereas age-0.3 chum salmon were more abundant in 2016 (Table 3). By contrast, age-0.3 chum salmon were predominant in both years for those rivers with escapement enumeration projects (Table 6).

Of the 120 tagged chum salmon assigned Fate 1 in 2015, the largest number of tagged chum salmon (30) were detected in Bonanza River and the fewest (2) were detected in Solomon River (Table 7; Figure 11). In 2016, of the 129 tagged chum salmon assigned Fate 1, the largest number (34) were detected in Sinuk River and Penny River had the fewest tag detections (2; Table 8; Figure 12). In both years, chum salmon tagged near Sinuk and Bonanza rivers were predominantly detected in those rivers but chum salmon tagged in Sections 2 and 6 had fish predominantly return to rivers in adjacent sections (Tables 7 and 8). There were few other patterns consistent between years.

There was evidence of a temporal difference to the river of last detection for 2 of the rivers in the study area. In both 2015 and 2016, a greater proportion of chum salmon detected in Eldorado River were from the first 2 weeks of tagging. Conversely, Bonanza River had a greater proportion of tagged chum salmon from Weeks 3 and 4 in both 2015 and 2016 (Figures 13 and 14). Temporal trends were inconsistent between years in the other rivers where tagged chum salmon were last detected.

Objective 2: Inferring Marine Migration Patterns

Chum salmon tagged in Section 4 and last detected in rivers west of Cape Nome (Sinuk, Cripple Penny, Snake, and Nome) had different movement patterns between years. In 2015, only 10% of chum salmon, all from Nome River, were detected on Array 5 on the east side of Cape Nome (Table 9; Figure 15). In 2016, 36% of tagged chum salmon from 3 rivers (Sinuk, Cripple, and Nome) to the west of Cape Nome were detected by Arrays 5, 6, and 7 on the east side of Cape Nome before entering their final rivers (Table 9; Figure 16).

The movement patterns for chum salmon tagged in Section 4 and last detected in rivers east of Cape Nome (Flambeau, Eldorado, Bonanza, and Solomon) were similar in 2015 and 2016. A total of 27% of chum salmon in 2015 and 21% of chum salmon in 2016 destined for Flambeau, Eldorado, and Bonanza rivers were detected on Arrays 3 and 4 before being detected in their rivers of origin (Table 9; Figures 17 and 18). These results do not support the idea of a definitive entry point with no mixing of western stocks east of that point and no mixing of eastern stocks west of that point.

Movement patterns of chum salmon tagged in Sections 1–3 and 5–6 were similar to the chum salmon tagged in Section 4. Chum salmon that entered rivers to the west of Cape Nome (Sinuk, Cripple, Penny, Snake, and Nome rivers) had a greater eastern dispersal of detections on ocean receivers in 2016 than 2015 (Table 10; Figures 19 and 20). For chum salmon bound for eastern rivers (Flambeau, Eldorado, Bonanza, and Solomon) the dispersal pattern was similar between years (Table 10; Figures 21 and 22).

The average number of days a tagged fish remained in marine waters before finding its river of origin was different between years. In 2015, tagged chum salmon remained in marine waters 6.8 days (SD = 4.3) on average whereas fish were only roaming for an average of 4.7 days (SD = 2.3) in 2016 (Student’s *t*-test: $t = 4.8$, $df = 179.6$, $p < 0.001$). This is probably attributable to the large number of days chum salmon tagged in Week 1 spent in marine waters in 2015 (Table 11).

Examining the dispersal of all tagged chum salmon, there was a greater proportion of chum salmon assigned Fate 2 in 2015 (0.24) than in 2016 (0.14; Table 4). In 2015, Fate 2 chum salmon were captured in commercial fisheries in Subdistrict 2, Subdistrict 3, and Subdistrict 4 (Figure 1) and in subsistence fisheries near Shaktoolik, Teller, and Wales (Figure 23). Additionally, chum salmon were captured in the Pilgrim River sockeye salmon subsistence fishery and at the Pilgrim River weir. Finally, tagged chum salmon were also captured in the commercial fishery in the Kotzebue District and the subsistence fishery in the Noatak River (Figure 23). In addition to wider dispersal in 2015, chum salmon assigned Fate 2 were larger (593 mm METF) than those assigned Fate 1 (579 mm METF; *t*-test: $t = 2.6$, $df = 114.6$, $p = 0.009$). There was no difference in age between Fate 1 and Fate 2 chum salmon in 2015. Unlike 2015, there were no tagged chum salmon captured outside the subdistrict in 2016. Also, there were no differences in sizes (*t*-test: $t = 1.2$, $df = 35.6$, $p = 0.226$) or ages between fates in 2016.

DISCUSSION

During the original development of run reconstructions and the subdistrict-wide escapement goal for chum salmon in Subdistrict 1, Clark (2001), recommended that the 1978–1979 tagging study by Gaudet and Schaefer (1982) be repeated and improved upon to verify harvest assumptions used in run reconstruction and escapement goal analysis. From the previous tagging study, Gaudet and Schaefer (1982) suggested Subdistrict 1 was a non-interception fishery (i.e., chum salmon caught in marine waters of Subdistrict 1 were primarily bound for rivers inside Subdistrict 1) because most of the tag recoveries came from the commercial fishery within the subdistrict. This conclusion, based on 17% tag recovery, may be misleading because harvesting a tagged chum salmon in the marine waters of Subdistrict 1 is not definitive proof the salmon was destined for a Subdistrict 1 river to spawn. With the use of acoustic telemetry in this project, it was possible to determine the fate of tagged chum salmon without relying on visual identification or capture in a fishery. Acoustic tagging increased the probability of recovery (detection; 95% in both years) and allowed for increased resolution in identifying probable stocks of origin. Ultimately, the use of acoustic telemetry provided greater confidence in describing the composition of chum salmon tagged in Subdistrict 1 than the earlier study.

In this project, the proportion of tagged chum salmon assigned Fate 1, of Subdistrict 1 origin, was 46% and 66% in 2015 and 2016 (Table 4) and indicated there was variability in the composition of chum salmon in marine waters of Subdistrict 1 between years. The capture of tagged chum salmon in the Kotzebue District and Subdistricts 2–5 (Golovin Bay, Elim, Norton Bay, and Shaktoolik; Figure 23) in 2015, and absence of tagged fish captured outside Subdistrict 1 in 2016 provides additional evidence that variability exists in the composition of chum salmon in the marine waters of Subdistrict 1 in any given year. It is important to note the composition of chum salmon known to be of Subdistrict 1 origin is based solely on chum salmon assigned Fate 1. It is possible chum salmon assigned other fates were bound for Subdistrict 1 rivers but were not counted as Subdistrict 1-origin salmon because of missed detections, tag loss, or death before reaching their final destinations. Similar to our findings, Gaudet and Schaefer (1982) recovered chum salmon tagged in Subdistrict 1 in Kotzebue District and Subdistrict 2 (Golovin Bay) in the first year of their study and in Subdistrict 2 in the second year, suggesting there has always been some proportion of chum salmon in the marine waters of Subdistrict 1 bound for streams outside the subdistrict. This pattern of stock mixing prior to river entry has been observed in other salmon tagging studies as well. Chum salmon tagged in coastal waters of British Columbia were recovered in Washington and Oregon fisheries indicating a mixing with Canadian stocks during their coastal migration (Anderson and Beacham 1983). Similarly, tagged Chinook salmon were recovered in nearshore fisheries hundreds of kilometers from their natal streams (Weitkamp 2010) adding support to the idea that coastal waters can contain salmon from different areas.

There are 2 tools ADF&G management biologists can use to target the harvest of salmon: location and time. By tagging throughout the subdistrict over several weeks, stock-specific movement patterns were examined to evaluate the possibility of using location or timing to focus harvest on particular stocks. Most chum salmon assigned Fate 1 that were tagged in Sections 1, 2, and 3 (western sections) were detected in western rivers. A similar pattern was apparent for those chum salmon assigned Fate 1 tagged in Sections 5 and 6: the majority were detected in eastern rivers (Tables 7 and 8) indicating that fishermen fishing east and west of Cape Nome are probably harvesting salmon bound for streams on the same side of Cape Nome. Finally, tag detections on ocean arrays demonstrate that some chum salmon do move throughout the marine waters of the subdistrict (Tables 9 and 10; Figures 19–22), but the majority remain near their streams of origin. Currently, management decisions for subsistence and commercial fisheries are made under the assumption that chum salmon harvests in marine waters east and west of Cape Nome are targeting salmon bound for rivers east and west of Cape Nome with minimal mixing between east and west stocks. Project results suggest that using Cape Nome as an east/west demarcation for targeting abundant eastern stocks is reasonable.

The second tool fishery managers can use to target specific harvests is timing. We evaluated river of origin by week tagged to assess river-specific patterns. One pattern was consistent between years: of the chum salmon detected in Eldorado River, a larger proportion were tagged in Week 1 whereas Bonanza River chum salmon were mostly tagged in Weeks 3 and 4 (Figures 13 and 14). This result suggests there may be some ability to target the harvest of Eldorado River chum salmon in early July. This is important because the chum salmon runs to Eldorado River are often large, determine the success of meeting the subdistrict-wide escapement goal, and could probably withstand increased fishing pressure.

Objective 2, assessing chum salmon migration after entering the subdistrict at Cape Nome was more difficult to evaluate. The first obstacle in addressing this assumption was that chum salmon were being tagged and tracked in nearshore waters, once they were already present in Subdistrict 1. To be able to determine point of entry into the subdistrict would require capturing and tagging chum salmon as they enter Norton Sound and track them as they get closer to the subdistrict. The second obstacle in addressing Objective 2 was suitable fishing locations. The east side of Cape Nome (Figure 2) was challenging to access, therefore to increase fishing and tagging efficiency most of the tagging in Section 4 took place on the west side of Cape Nome just east of Array 4 (Figures 3 and 4). Chum salmon detections demonstrate that a portion of fish tagged in Section 4 were bound for eastern rivers, indicating Cape Nome may not be the point of entry into the subdistrict.

An unexpected result from this project was the consistently large number of tags detected in Bonanza River. The large number of tagged chum salmon detected in Bonanza River (Tables 7 and 8) compared to nearby Eldorado River and the disproportionate number of tags from Weeks 3 and 4 (Figures 13 and 14) in both years suggests Bonanza River may have a larger chum salmon run than previously thought and/or have a different run timing than Eldorado River. This is noteworthy because the baseline for many of the assumptions about Bonanza River chum salmon used in estimating its' contribution to the subdistrict-wide escapement goal (Clark 2001) come from assuming Eldorado and Bonanza rivers are similar. Obtaining a clearer understanding of chum salmon run strength and timing to Bonanza River may provide insight into differences between it and Eldorado River, and may present an additional opportunity for increased harvests.

Patterns in age and sex composition of tagged chum salmon were hard to discern. Fate 2 chum salmon were larger than Fate 1 fish in 2015 and there was no evidence those fish were older. This suggests that chum salmon from the larger river systems to the north and south of Subdistrict 1 may produce larger fish at age. This pattern was not detected in 2016. The disparity in sex between tagged chum salmon and the chum salmon sampled at enumeration projects may be explained by the difficulty in identifying female salmon in the ocean. Using external characteristics such as body symmetry, kype development, and presence of an ovipositor are commonly accepted to identify salmon in freshwater but can be challenging in saltwater when many of the salmon are silver and have not become sexually dimorphic. It should be noted that in general by the end of the second week of tagging, many of the captured chum salmon were starting to show typical freshwater colorization and developing kypes. Another explanation may be differences in migration timing of male and female chum salmon. In many instances male salmon will precede female salmon along migratory routes (Quinn 2005) such that during our tagging, males were more prevalent. Efforts were made to report tagged chum salmon that passed through enumeration projects; however, there were no attempts to re-evaluate sex at the weirs. Future projects should include validation of biological information at enumeration projects to help resolve the gender issue.

Range testing on the ocean receivers indicated a 'doughnut of detection' rather than a complete circle. Tagged chum salmon within 200 m of and greater than 800 m from a receiver had a lower probability of detection than chum salmon located between 300 m and 700 m from receiver (Figure 10). These results are reasonably consistent with results from other acoustic telemetry research (Hobday and Pincock 2012; Kessel et al. 2015; Huveneers et al. 2016). A likely explanation for this is close proximity detection interference (CPDI; Kessel et al. 2015). CPDI occurs when there are strong transmission echoes from a tag making it difficult to decode that tag in close proximity to a receiver. For this project, receivers were deployed in shallow water (<18 m); therefore, the straight-line distance traveled by a transmission would be similar to distances traveled by reflected (echo) signals. In this scenario, the original transmission and subsequent echoes probably arrived at the receiver at the same time which made it difficult to decode any one signal. As distance from the ocean receiver increased, detection probability increased (Figure 10), probably because straight line distance and reflection distance started to differ. We do not feel the detection doughnut affected our results because movement of tagged chum salmon was assessed by receiver arrays not by individual receiver. Therefore, a tagged salmon needed only to be within detection distance of any one receiver in a particular array to be assigned to that array. The decrease in detections at distances greater than 800 m was most likely due to the limits of acoustic technology in this environment. Detection ranges can be affected by wave action (Voegeli and Pincock 1996; Finstad et al. 2005), salinity (Finstad et al. 2005), and turbidity (Voegeli and Pincock 1996) all of which were present in our study. Additionally, soft substrate may reduce the detection range by absorbing the sound wave and limiting the distance traveled by the signal (Heupal et al. 2006). There is no evidence to suggest these factors affected any individual receiver to a greater extent than any other such that the results were biased. The large number of detections on ocean receivers (264,855 in 2015 and 174,528 in 2016) supports the belief that receivers functioned well enough to address the questions posed in this study. No attempts were made to complete range detection on river receivers. On-site evaluations conducted by ADF&G and Lotek Wireless, Inc. prior to the start of this project found range detections up to 200 m in Subdistrict 1 rivers; this detection distance was attributed to loss of line of sight between tag and receiver and was not unexpected for these relatively small rivers that wind greatly over short aerial distances. Given the high number of tag detections in each river, the detection doughnut evident on the ocean receivers is probably not a concern with the river receivers.

The goal of this project was to evaluate chum salmon movement in the Subdistrict 1 mixed stock fishery and search for patterns that may help fishery managers direct harvest on more abundant stocks within the subdistrict. The use of acoustic telemetry proved to be a viable option for completing the project objectives. There were few patterns apparent between the 2 years of the project, suggesting chum salmon stock composition in Subdistrict 1 is more variable than originally assumed, probably caused by a combination of factors including relative abundances in neighboring subdistricts, migration patterns, harvest patterns, and environmental variability. This project's results did support existing management practices that utilize Cape Nome as a dividing point to harvest more abundant eastern stocks; however, there was variability across project years. The successful use of acoustic telemetry in this project and continued advancements of the technology support its use as a practical tool for addressing mixed stock fishery questions. Future research should include replicating this project on a longer time scale of 4–5 years to gain a greater understanding of the variability of chum salmon composition in Subdistrict 1 marine waters. Additionally, receivers should be placed beyond Subdistrict 1 rivers including the Yukon River, to further evaluate the stocks that move through the subdistrict. Finally, there are other locations within Norton Sound where marine harvest cannot be differentiated between several rivers. This technology could be utilized in those situations to study chum salmon as well as other species of salmon.

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TABLES AND FIGURES

Table 1.–Chum salmon escapement goal ranges and escapements in Subdistrict 1, Norton Sound, 1997–2016.

Escapement goal range	23,000–35,000	2,900–4,300	1,600–2,500	6,000–9,200[a]	
Year	Subdistrict-wide	Nome River	Snake River	Eldorado River	Eldorado River weir
1997	50,551	5,131	6,184	14,554	14,302
1998	48,131	*1,930*	11,067	9,263	13,808
1999	*15,697*	*1,048*	484	6,478	4,218
2000	34,898	4,056	1,911	10,024	11,617
2001	44,553	*2,859*	2,182	12,002	11,635
2002	33,225	*1,720*	2,776	*1,230*	10,215
2003	17,081	*1,957*	2,201	*5,230*	3,591
2004	23,787	3,903	2,146	*1,004*	3,277
2005	38,808	5,584	2,967	13,704	10,369
2006	87,222	5,677	4,160	NS	42,105
2007	76,940	7,034	8,147	15,106	21,312
2008	32,177	*2,607*	*1,244*	NS	6,746
2009	*21,368*	*1,565*	891	*4,702*	4,943
2010	97,798	5,906	6,973	42,612	42,612
2011	66,122	3,582	4,343	14,567	16,227
2012	51,459	*1,982*	*651*	NS	13,393
2013	107,119	4,178	2,550	22,347	26,035
2014	97,234	5,589	3,983	NS	27,054
2015	92,030	6,216	4,260	NS	25,560
2016	60,749	7,093	3,666	NS	18,938

Note: Italics indicate years when escapement goals were not met. NS means no survey.

[a] Escapement goal is an expanded aerial survey goal.

[b] Escapement of chum salmon that passed the weir.

Table 2.–Number of chum salmon tagged in each section by week, 2015 and 2016.

		Subdistrict section							
		1	2	3	4	5	6	Total	Proportion
2015	Week 1	7	10	2	1	10	10	40	0.15
	Week 2	9	5	9	21	10	1	55	0.21
	Week 3	10	10	12	29	10	15	86	0.33
	Week 4	10	10	4	30	10	14	78	0.30
	Total	36	35	27	81	40	40	259	
	Proportion	0.14	0.14	0.10	0.31	0.15	0.15		
		Subdistrict section							
		1	2	3	4	5	6	Total	Proportion
2016	Week 1	2	9	9	19	10	11	60	0.31
	Week 2 [a]	0	0	0	0	10	9	19	0.10
	Week 3	11	16	12	19	4	10	72	0.37
	Week 4	1	7	3	7	15	10	43	0.22
	Total	14	32	24	45	39	40	194	
	Proportion	0.07	0.16	0.12	0.23	0.20	0.21		

[a] Tagging was only completed in Sections 5 and 6 because the skiff was inoperable.

Table 3.–Percentage of age class and sex of tagged chum salmon, 2015 and 2016.

All fish	2015						2016					
	0.2	0.3	0.4	0.5	No age	Total	0.2	0.3	0.4	0.5	No age	Total
Male	0.77	16.60	26.25	0.77	7.34	51.74	1.03	30.41	22.68	2.58	5.67	62.37
Female	0.77	14.67	16.99	1.54	6.18	40.15	1.03	14.95	15.46	2.06	4.12	37.63
No Gender	0.00	1.54	4.63	0.39	1.54	8.11	0.00	0.00	0.00	0.00	0.00	0.00
Total	1.54	32.82	47.88	2.70	15.06	100.00	2.06	45.36	38.14	4.64	9.79	100.00

Fate 1 fish	2015						2016					
	0.2	0.3	0.4	0.5	No age	Total	0.2	0.3	0.4	0.5	No age	Total
Male	0.80	19.20	30.00	1.70	5.80	57.50	1.55	34.11	19.38	0.78	7.75	63.57
Female	1.70	12.50	13.30	0.00	4.20	31.70	1.55	14.73	14.73	0.77	4.65	36.43
No Gender	0.00	1.70	5.80	0.00	3.30	10.80	0.00	0.00	0.00	0.00	0.00	0.00
Total	2.50	33.40	49.10	1.70	13.30	100.00	3.10	48.84	34.11	1.55	12.40	100.00

Table 4.–Number and proportion of tagged chum salmon assigned each fate by tagging section (1–6), 2015 and 2016.

Year		Number of salmon tagged in section:						
		1	2	3	4	5	6	Total
2015	Fate 1	14	19	19	34	20	14	120
	Fate 2	6	9	3	23	8	12	61
	Fate 3	13	5	4	24	10	8	64
	Fate 4	3	2	1	0	2	6	14
	Total	36	35	27	81	40	40	259
		Proportion of salmon tagged in section:						
		1	2	3	4	5	6	Total
	Fate 1	0.39	0.54	0.70	0.42	0.50	0.35	0.46
	Fate 2	0.17	0.26	0.11	0.28	0.20	0.30	0.24
	Fate 3	0.36	0.14	0.15	0.30	0.25	0.20	0.25
	Fate 4	0.08	0.06	0.04	0.00	0.05	0.15	0.05

Year		Number of salmon tagged in section:						
		1	2	3	4	5	6	Total
2016	Fate 1	12	17	18	29	27	26	129
	Fate 2	1	5	2	9	5	5	27
	Fate 3	1	4	3	6	5	9	28
	Fate 4	0	6	1	1	2	0	10
	Total	14	32	24	45	39	40	194
		Proportion of salmon tagged in section:						
		1	2	3	4	5	6	Total
	Fate 1	0.86	0.53	0.75	0.64	0.69	0.65	0.66
	Fate 2	0.07	0.16	0.08	0.20	0.13	0.13	0.14
	Fate 3	0.07	0.13	0.13	0.13	0.13	0.23	0.14
	Fate 4	0.00	0.19	0.04	0.02	0.05	0.00	0.05

Table 5.–Proportion of tagged chum salmon assigned each fate by week of tagging, 2015 and 2016.

2015	Proportion of salmon				
	Week 1	Week 2	Week 3	Week 4	Total
Fate 1	0.53	0.56	0.34	0.50	0.46
Fate 2	0.18	0.15	0.28	0.28	0.24
Fate 3	0.23	0.27	0.34	0.14	0.25
Fate 4	0.08	0.02	0.05	0.08	0.05
2016	Proportion of salmon				
	Week 1	Week 2	Week 3	Week 4	Total
Fate 1	0.48	0.53	0.82	0.72	0.66
Fate 2	0.32	0.05	0.06	0.07	0.14
Fate 3	0.13	0.42	0.10	0.12	0.14
Fate 4	0.07	0.00	0.03	0.09	0.05

Table 6.–Percentage of age and sex of escapement to Subdistrict 1 enumeration projects by river, 2015 and 2016.

River	Year	Sampling dates	Number of samples	Percent by sex		Percent by age class				
				Male	Female	0.1	0.2	0.3	0.4	0.5
Snake River	2015	7/15–7/27	170	45.3	54.7	0.0	6.3	60.7	33.0	0.0
	2016	7/08–8/06	149	40.3	59.7	0.0	2.7	69.1	28.2	0.0
Nome River	2015	7/10–8/13	181	45.3	54.7	0.0	7.1	60.5	31.9	0.5
	2016	7/06–8/09	186	38.7	61.3	0.0	9.1	64.0	26.4	0.5
Eldorado River	2015	7/03–7/30	203	46.8	53.2	0.0	2.2	49.1	47.8	0.9
	2016	6/26–7/24	182	52.7	47.3	0.0	4.4	54.9	38.5	2.2

Table 7.–River of last detection by tagging section in Subdistrict 1, 2015.

Tagging section	Number assigned Fate 1	Number of tagged chum salmon last detected in:								
		Section 1	Section 2		Section 3		Section 5			Section 6
		Sinuk River	Cripple River	Penny River	Snake River	Nome River	Flambeau River	Eldorado River	Bonanza River	Solomon River
1	14	**10**	2	0	1	1	0	0	0	0
2	19	6	0	3	6	2	0	0	2	0
3	19	1	0	4	**8**	**5**	1	0	0	0
4	34	2	2	1	3	6	3	7	10	0
5	20	0	1	0	3	2	**2**	**2**	**10**	0
6	14	0	0	0	1	0	2	1	8	2

Tagging section	Number assigned Fate 1	Proportion of tagged chum salmon last detected in:								
		Section 1	Section 2		Section 3		Section 5			Section 6
		Sinuk River	Cripple River	Penny River	Snake River	Nome River	Flambeau River	Eldorado River	Bonanza River	Solomon River
1	14	**0.71**	0.14	0.00	0.07	0.07	0.00	0.00	0.00	0.00
2	19	0.32	0.00	0.16	0.32	0.11	0.00	0.00	0.11	0.00
3	19	0.05	0.00	0.21	**0.42**	**0.26**	0.05	0.00	0.00	0.00
4	34	0.06	0.06	0.03	0.09	0.18	0.09	0.21	0.29	0.00
5	20	0.00	0.05	0.00	0.15	0.10	**0.10**	**0.10**	**0.50**	0.00
6	14	0.00	0.00	0.00	0.07	0.00	0.14	0.07	0.57	0.14

Note: Bold values indicate the majority of tagged chum salmon were last detected in rivers in the tagging section.

Table 8.–River of last detection by tagging section in Subdistrict 1, 2016.

		Number of tagged chum salmon last detected in:								
	Number	Section 1	Section 2		Section 3		Section 5			Section 6
Tagging section	assigned Fate 1	Sinuk River	Cripple River	Penny River	Snake River	Nome River	Flambeau River	Eldorado River	Bonanza River	Solomon River
1	12	**12**	0	0	0	0	0	0	0	0
2	17	8	2	1	2	1	0	2	0	1
3	18	5	0	1	3	2	0	5	2	0
4	29	6	2	0	3	5	0	4	8	1
5	27	2	0	0	1	4	**3**	**8**	**6**	3
6	26	1	2	0	1	4	2	6	10	0

		Proportion of tagged chum salmon last detected in:								
	Number	Section 1	Section 2		Section 3		Section 5			Section 6
Tagging section	assigned Fate 1	Sinuk River	Cripple River	Penny River	Snake River	Nome River	Flambeau River	Eldorado River	Bonanza River	Solomon River
1	12	**1.00**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	17	0.47	0.12	0.06	0.12	0.06	0.00	0.12	0.00	0.06
3	18	0.28	0.00	0.06	0.17	0.11	0.00	0.28	0.11	0.00
4	29	0.21	0.07	0.00	0.10	0.17	0.00	0.14	0.28	0.03
5	27	0.07	0.00	0.00	0.04	0.15	**0.11**	**0.30**	**0.22**	0.11
6	26	0.04	0.08	0.00	0.04	0.15	0.08	0.23	0.38	0.00

Note: Bold values indicate the majority of tagged chum salmon were last detected in rivers in the tagging section.

Table 9.–Distribution of detections on ocean arrays of Fate 1 chum salmon tagged in Section 4 by river of last detection, 2015 and 2016.

2015	Number of tagged chum salmon detected on:						
	Array 1	Array 2	Array 3	Array 4	Array 5	Array 6	Array 7
Sinuk River	1	2	2	1	0	0	0
Cripple River	0	1	2	2	0	0	0
Penny River	0	0	0	1	0	0	0
Snake River	0	0	0	1	0	0	0
Nome River	0	0	0	5	2	0	0
Flambeau River	0	0	1	2	3	2	1
Eldorado River	0	0	1	3	6	4	0
Bonanza River	1	0	2	4	10	8	1
Solomon	0	0	0	0	0	0	0

2016	Number of tagged chum salmon detected on:						
	Array 1	Array 2	Array 3	Array 4	Array 5	Array 6	Array 7
Sinuk River	0	4	5	6	2	2	1
Cripple River	0	0	2	2	1	1	1
Penny River	0	0	0	0	0	0	0
Snake River	0	0	1	2	0	0	0
Nome River	0	0	1	4	4	2	1
Flambeau River	0	0	0	0	0	0	0
Eldorado River	0	0	1	3	4	2	1
Bonanza River	0	0	0	2	6	8	4
Solomon	0	0	0	1	1	1	0

Table 10.–Distribution of detections on ocean arrays of Fate 1 chum salmon tagged in Sections 1, 2, 3, 5, and 6 by river of last detection, 2015 and 2016.

2015	Number of tagged chum salmon detected on:						
	Array 1	Array 2	Array 3	Array 4	Array 5	Array 6	Array 7
Sinuk River	9	17	2	0	0	0	0
Cripple River	1	3	2	1	1	0	0
Penny River	0	0	7	4	0	0	0
Snake River	0	1	7	9	5	2	0
Nome River	0	2	5	5	5	4	1
Flambeau River	0	0	1	1	3	4	2
Eldorado River	0	0	0	1	2	2	1
Bonanza River	0	0	1	10	12	14	5
Solomon	0	0	0	0	1	2	0

2016	Number of tagged chum salmon detected on:						
	Array 1	Array 2	Array 3	Array 4	Array 5	Array 6	Array 7
Sinuk River	9	23	8	6	1	1	0
Cripple River	0	0	3	2	2	1	1
Penny River	0	0	2	1	0	0	0
Snake River	0	1	3	4	2	1	1
Nome River	0	0	0	10	9	6	2
Flambeau River	0	0	0	1	2	2	0
Eldorado River	0	0	2	7	13	14	2
Bonanza River	0	0	1	3	3	11	5
Solomon	0	0	1	2	2	3	1

Table 11.–Average number of days and standard deviations (in parentheses) that Fate 1 tagged chum salmon spent in marine waters by river of last detection and week, 2015 and 2016.

	2015				
	Week 1	Week 2	Week 3	Week 4	Overall average
Sinuk River	3.67 (2.08)	4.86 (2.27)	3.60 (1.52)	5.50 (1.91)	4.47 (1.98)
Cripple River		14.00 (8.49)	15.00	6.50 (0.71)	11.20 (6.06)
Penny River	17.5 (0.71)	11.33 (3.79)	11.67 (2.08)		13.00 (3.63)
Snake River	6.43 (1.90)	2.25 (0.50)	2.43 (0.53)	2.75 (1.50)	3.73 (2.25)
Nome River	7.00	3.60 (1.95)	3.83 (1.60)	3.50 (1.73)	3.88 (1.78)
Flambeau River	14.20 (3.11)	9.00	8.00 (1.67)	11.00	12.38 (3.54)
Eldorado River	22.00	6.80 (2.17)		8.00 (0.58)	8.80 (5.22)
Bonanza River	11.50 (0.71)	7.33 (3.51)	8.00 (1.79)	7.58 (2.89)	7.90 (2.92)
Solomon River		5.00		3.00	4.00 (1.41)
Overall average	10.20 (5.64)	6.20 (4.14)	5.70 (3.76)	6.40 (3.12)	**6.84 (4.31)**
	2016				
	Week 1	Week 2	Week 3	Week 4	Overall average
Sinuk River	4.14 (1.46)	4.00	4.32 (2.78)	4.00 (2.83)	4.24 (2.46)
Cripple River			7.83 (1.83)		7.83 (1.83)
Penny River			5.00	4.00	4.50 (0.71)
Snake River	3.00 (0.82)	3.00	3.25 (1.50)	3.00	3.10 (0.99)
Nome River	5.50 (2.12)	5.33 (1.15)	4.00 (1.85)	2.67 (0.58)	4.19 (1.76)
Flambeau River	6.00 (1.22)				6.00 (1.22)
Eldorado River	6.80 (1.81)	5.20 (1.09)	4.80 (1.30)	7.20 (2.49)	6.16 (1.93)
Bonanza River	4.00		4.64 (1.02)	2.71 (1.38)	3.58 (1.53)
Solomon River			4.50 (0.71)	7.33 (5.03)	6.20 (3.90)
Overall average	5.31 (2.00)	4.90 (1.20)	4.68 (2.29)	4.10 (2.82)	**4.70 (2.32)**

Note: Bold values indicate the majority of tagged chum salmon were last detected in rivers in the tagging section.

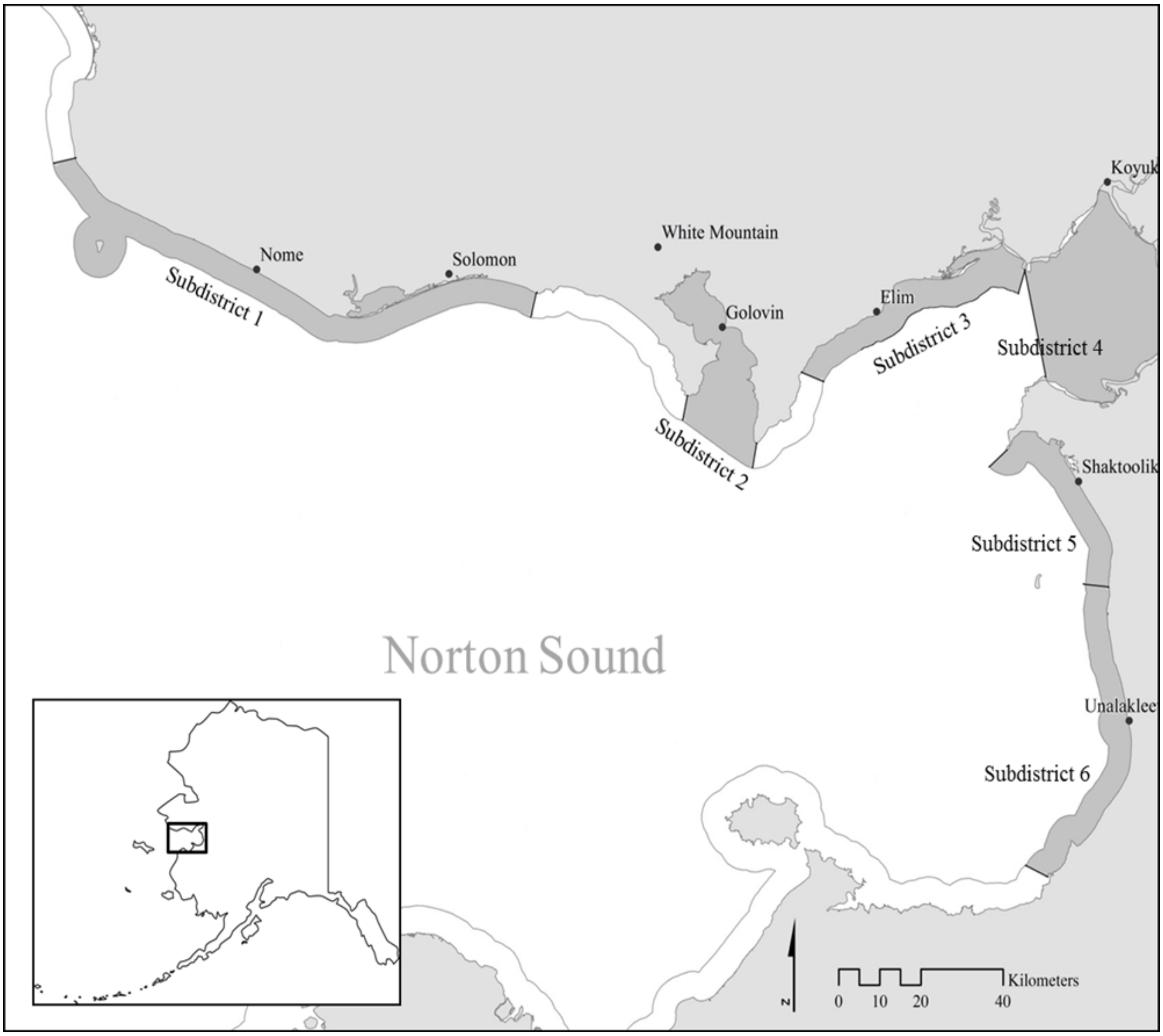

Figure 1.–Commercial salmon subdistricts (dark gray shaded areas) in Norton Sound, AK.

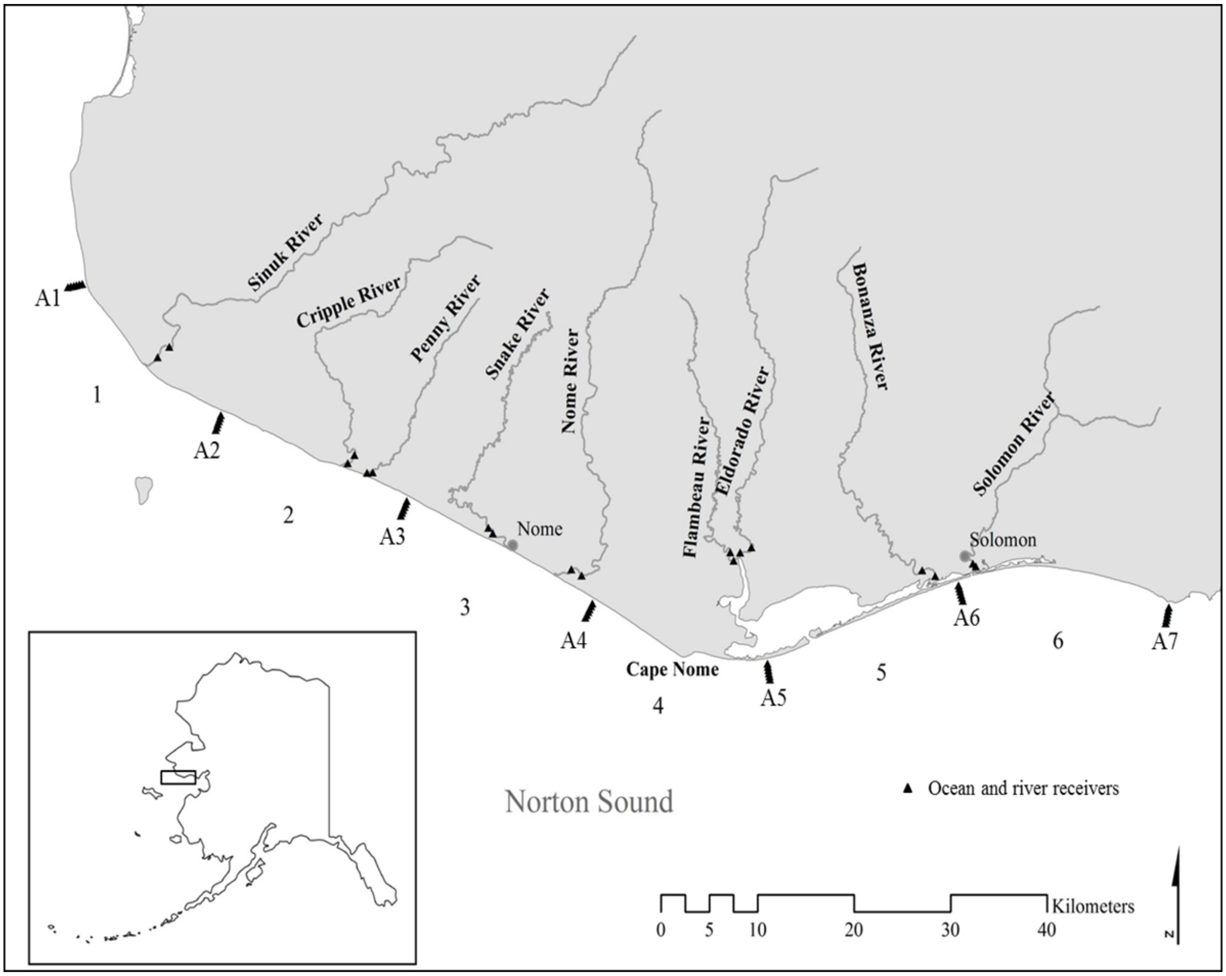

Figure 2.–Locations of river receivers and ocean receivers by array (e.g., A1) in Subdistrict 1, Norton Sound, AK.

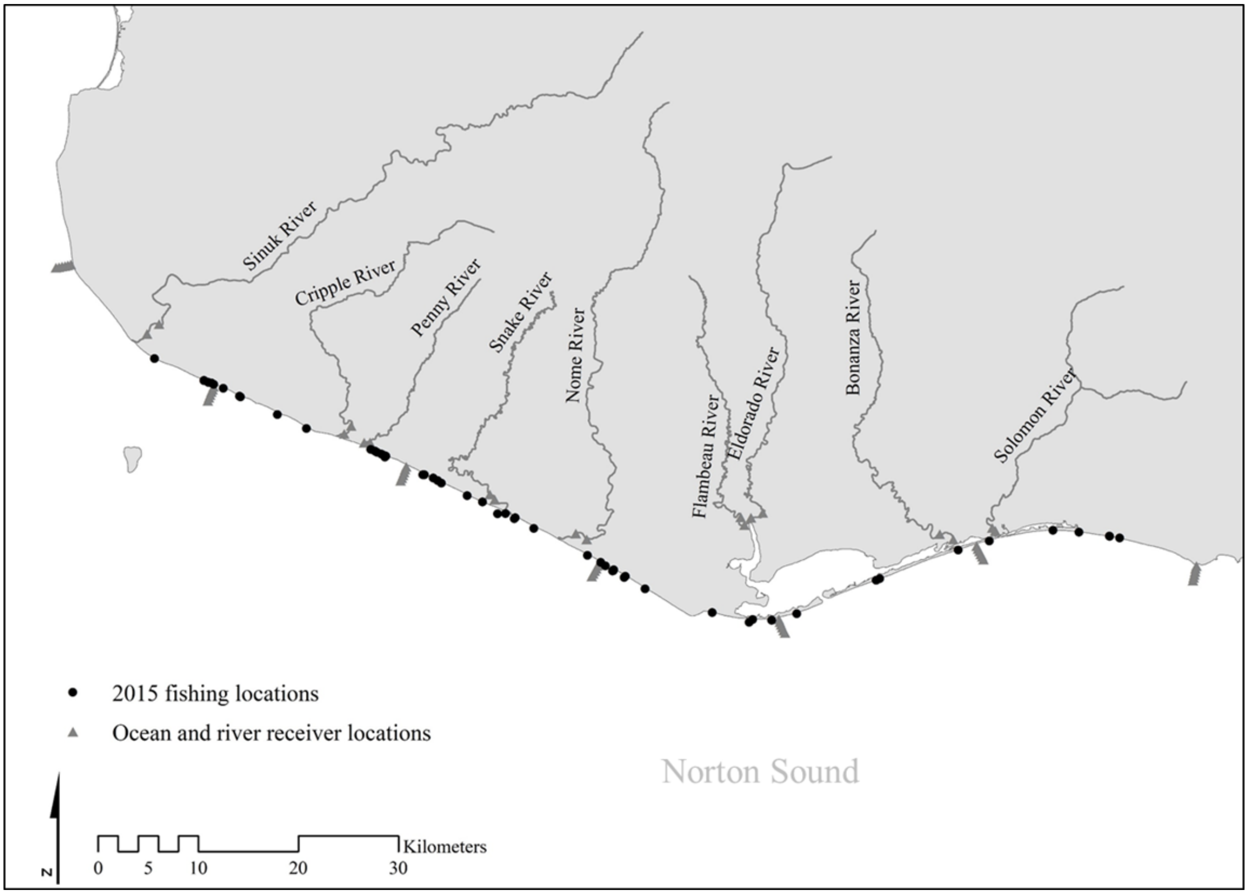

Figure 3.–Subdistrict 1 fishing locations to capture chum salmon for acoustic tagging, 2015.

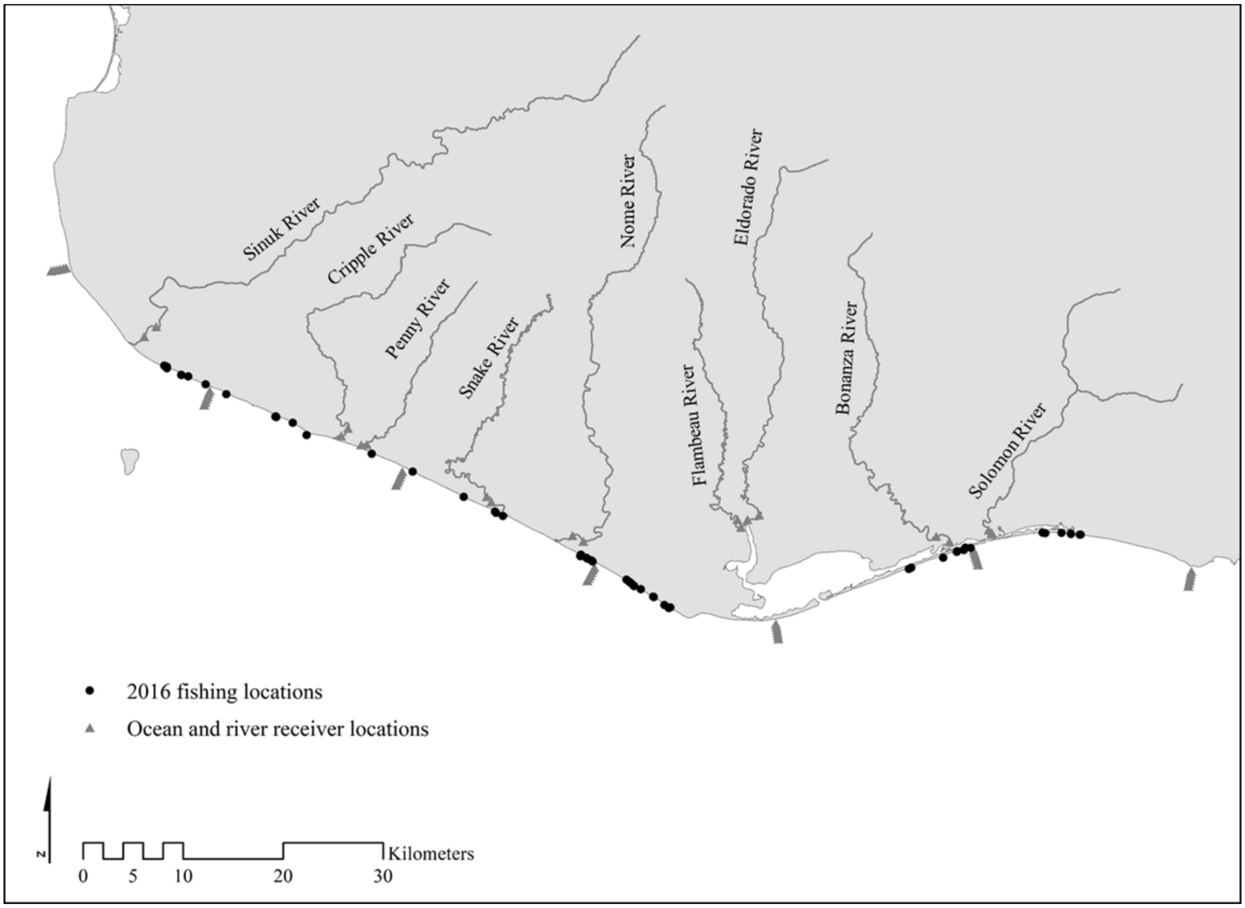

Figure 4.–Subdistrict 1 fishing locations to capture chum salmon for acoustic tagging, 2016.

Figure 5.–A polyvinyl chloride (PVC, 6-inch diameter) tube was filled with seawater and used to hold chum salmon during tagging.

Figure 6.–Methods for external attachment of acoustic tag to chum salmon.

Note: Stainless steel dart through dorsal musculature (left) and threading the wire through dart and removing it from fish (right).

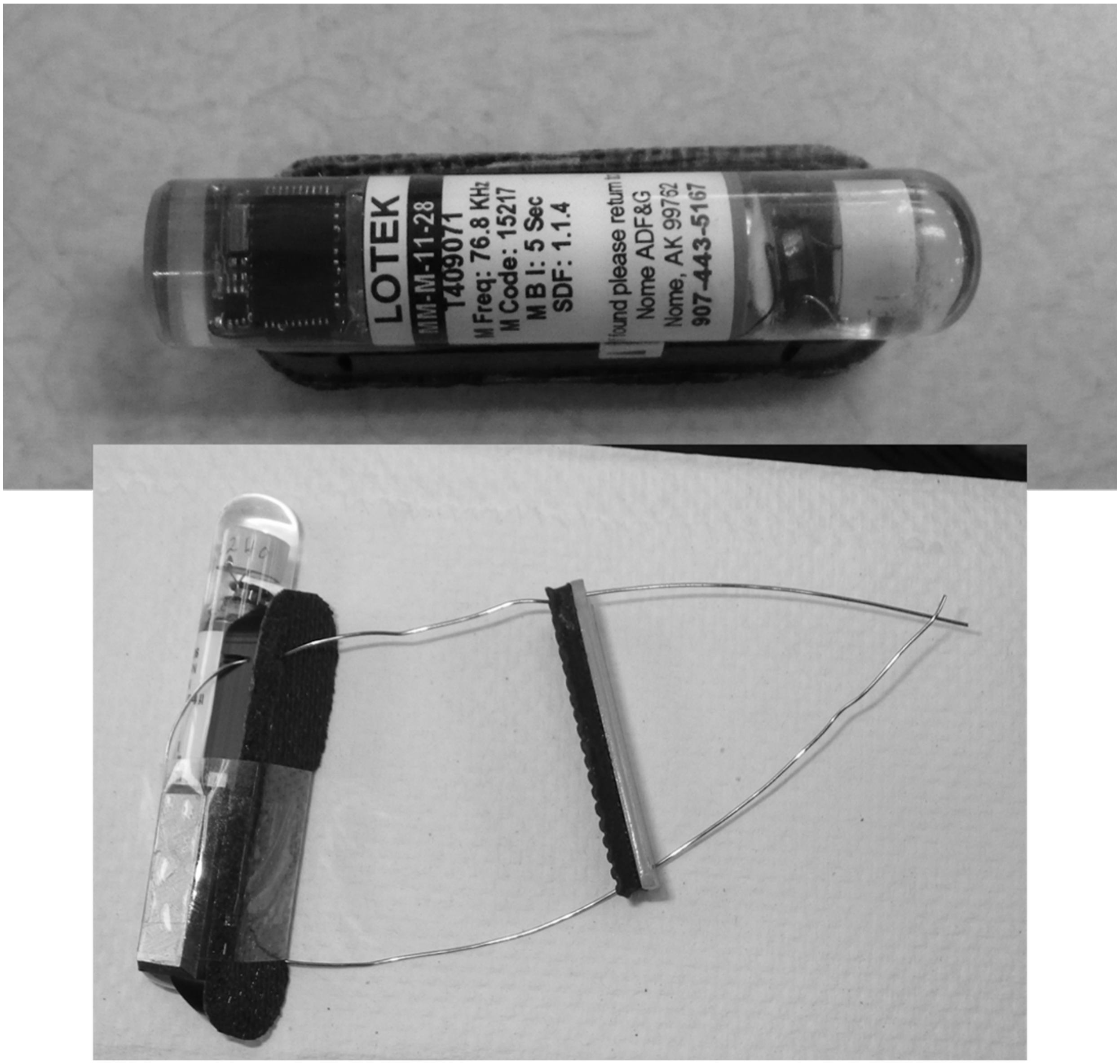

Figure 7.–MM-M-11-28 acoustic tag (top) and with back (bottom).

Figure 8.–Mooring setup for ocean receivers.

Figure 9.–River receiver setup and deployment.

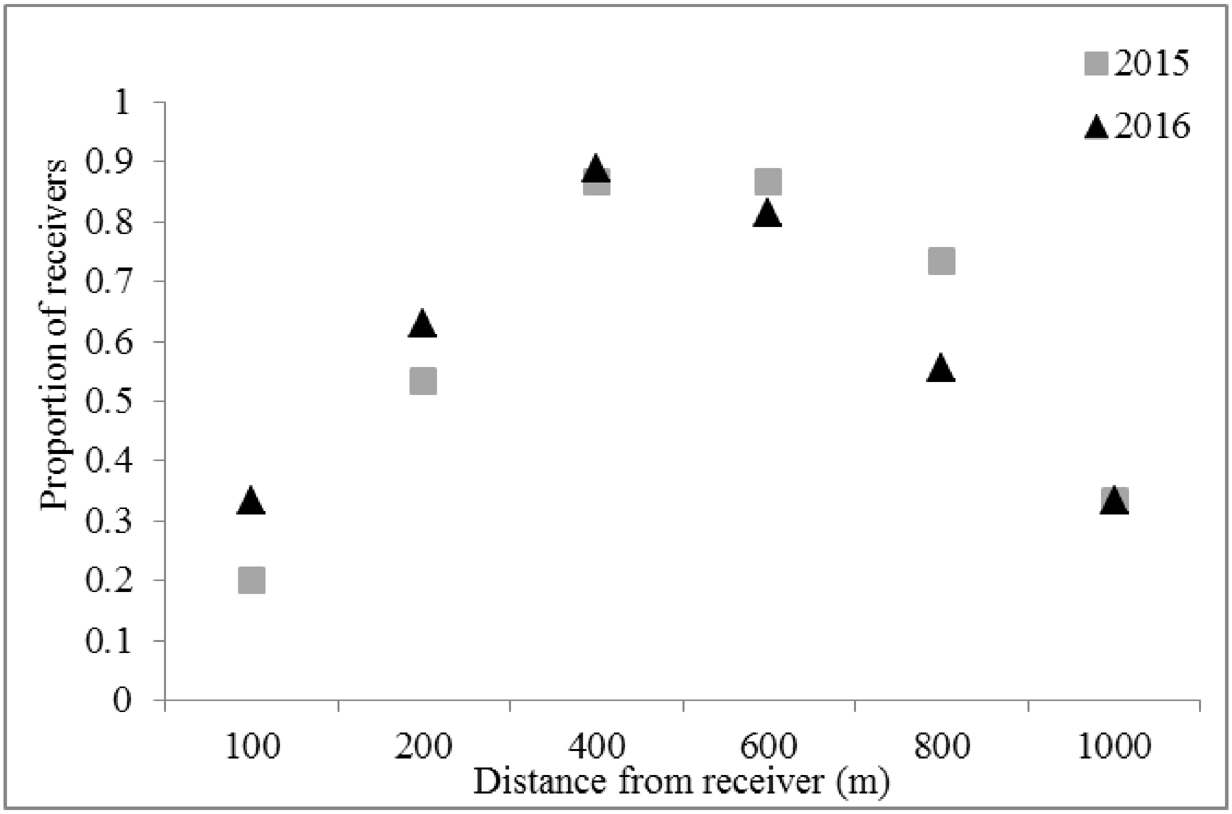

Figure 10.–Proportion of receivers detecting acoustic tags at different distances for range testing, 2015 and 2016.

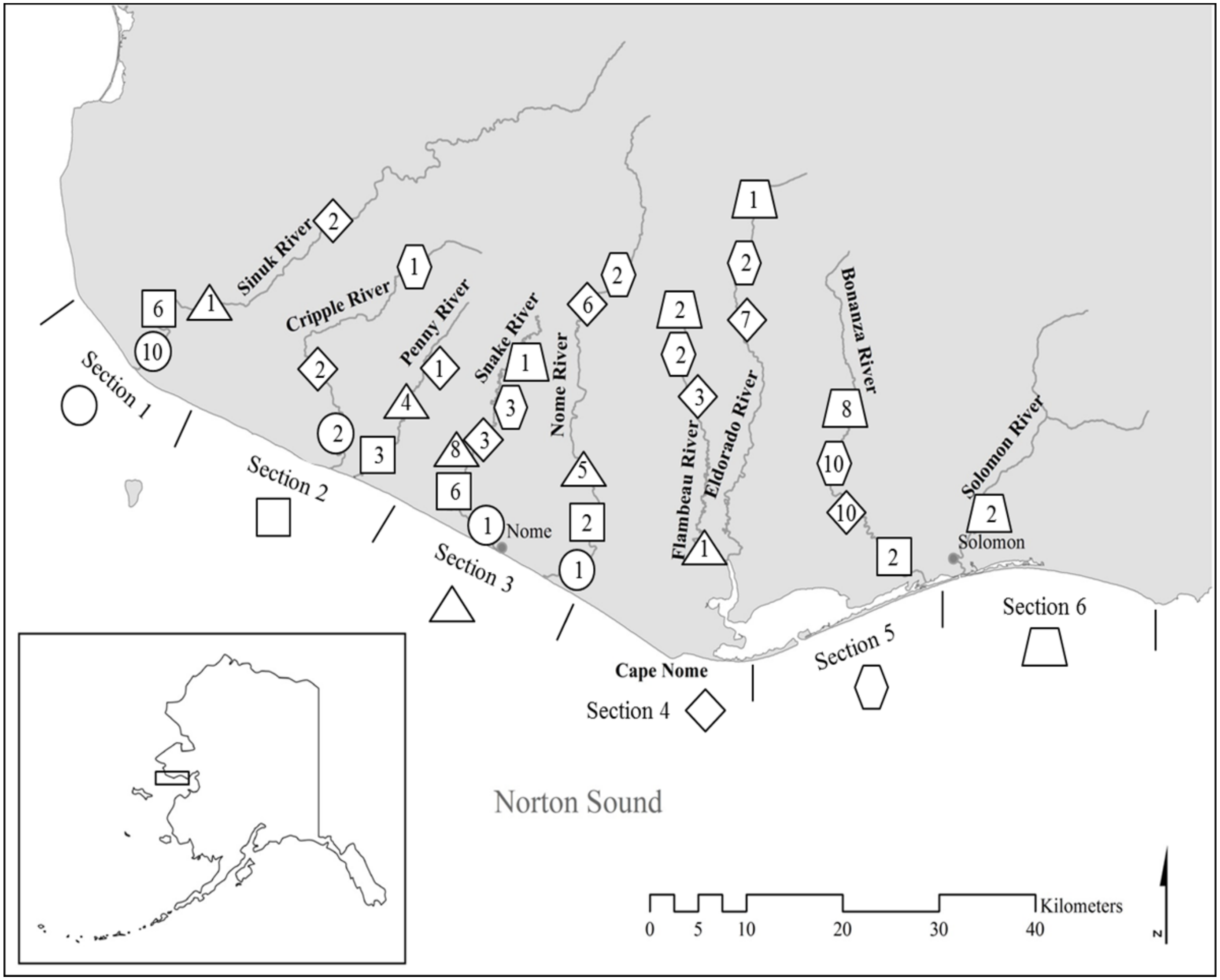

Figure 11.–Number of tagged chum salmon detected in each river by tagging section, 2015.

Note: Location of shape on river does not indicate distance traveled.

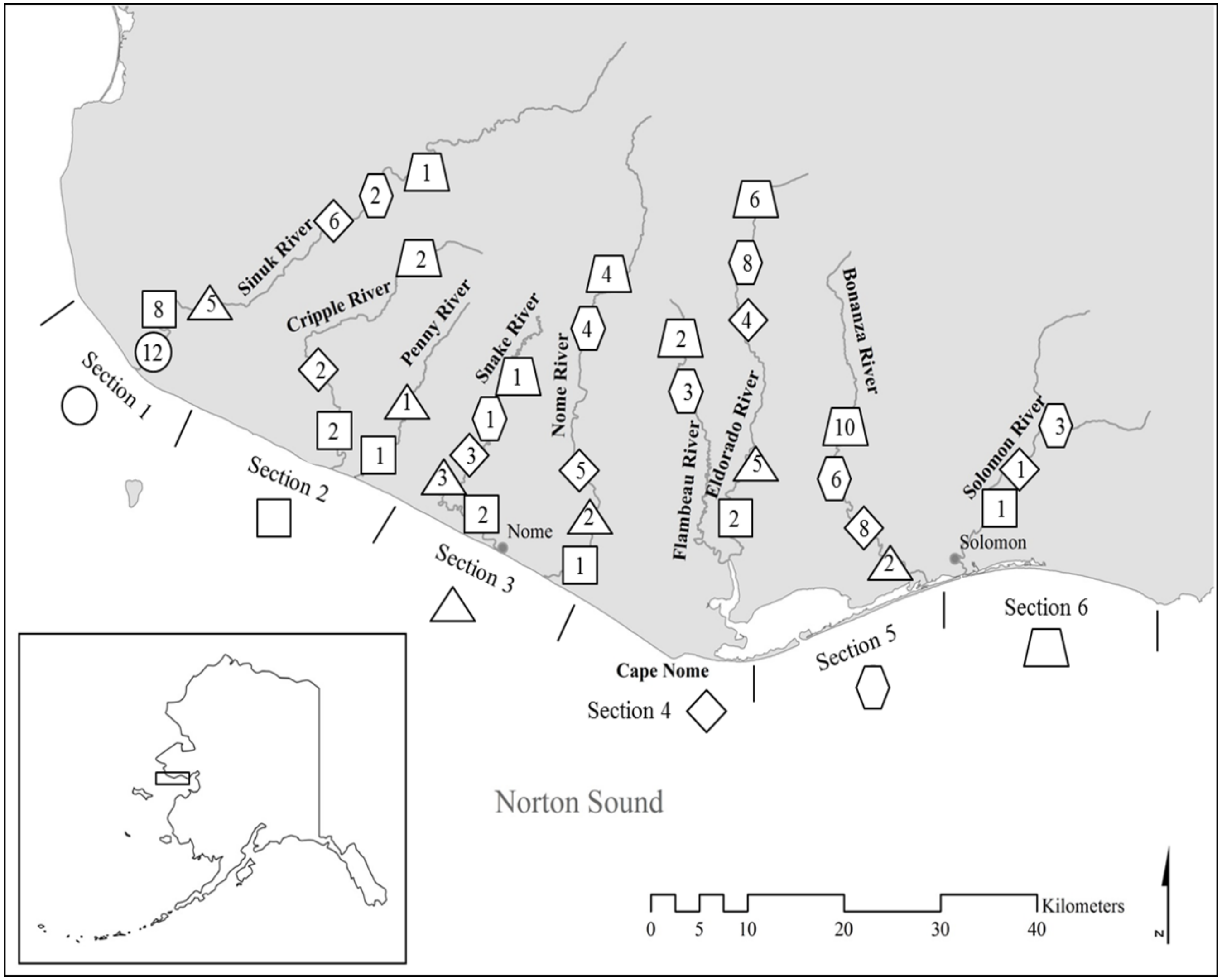

Figure 12.–Number of tagged chum salmon detected in each river by tagging section, 2016.

Note: Location of shape on river does not indicate distance traveled.

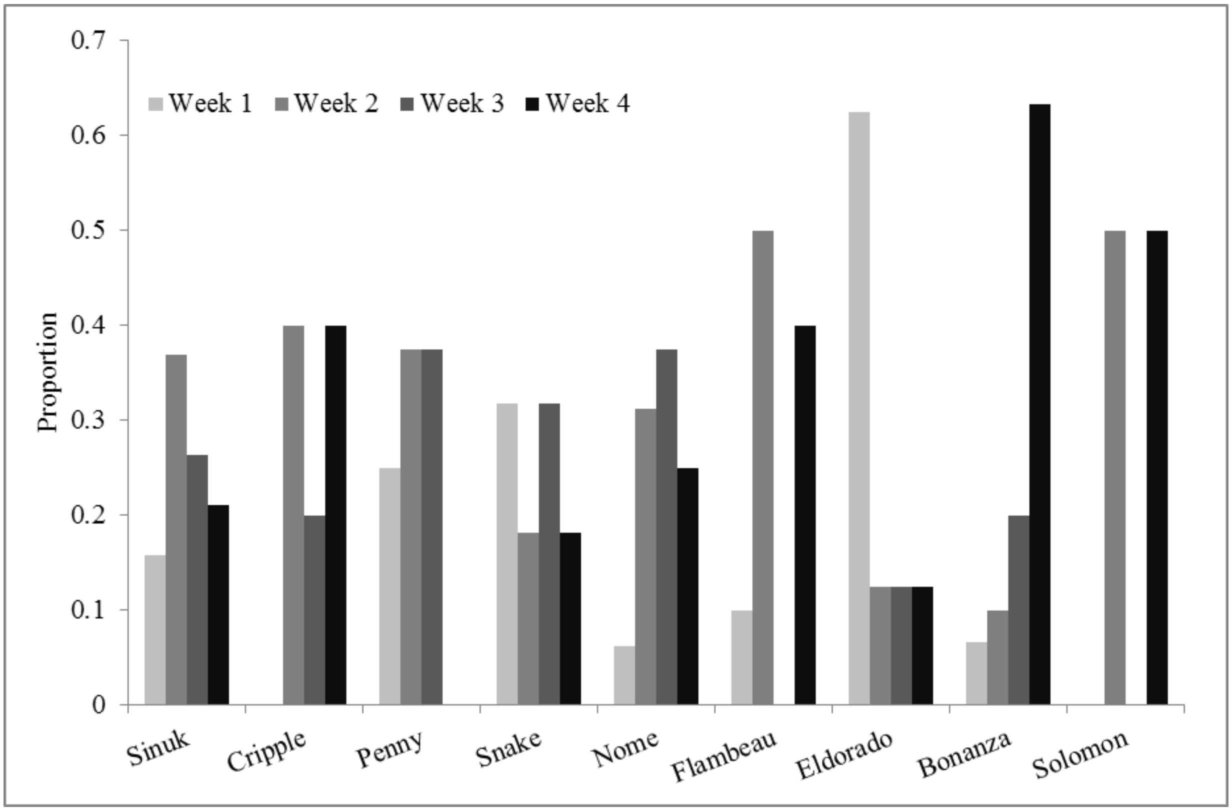

Figure 13.–Proportion of tagged chum salmon detected in Subdistrict 1 rivers by week tagged, 2015.

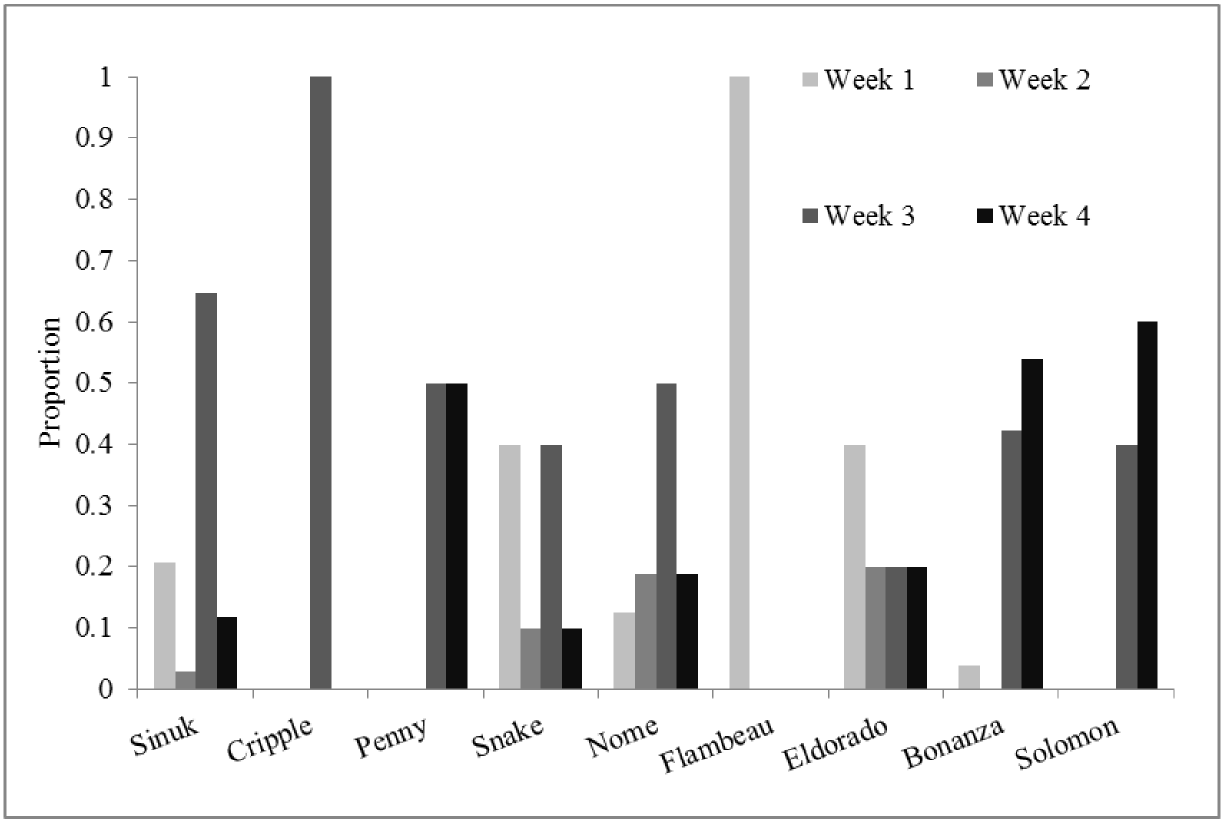

Figure 14.–Proportion of tagged chum salmon detected in Subdistrict 1 rivers by week tagged, 2016.

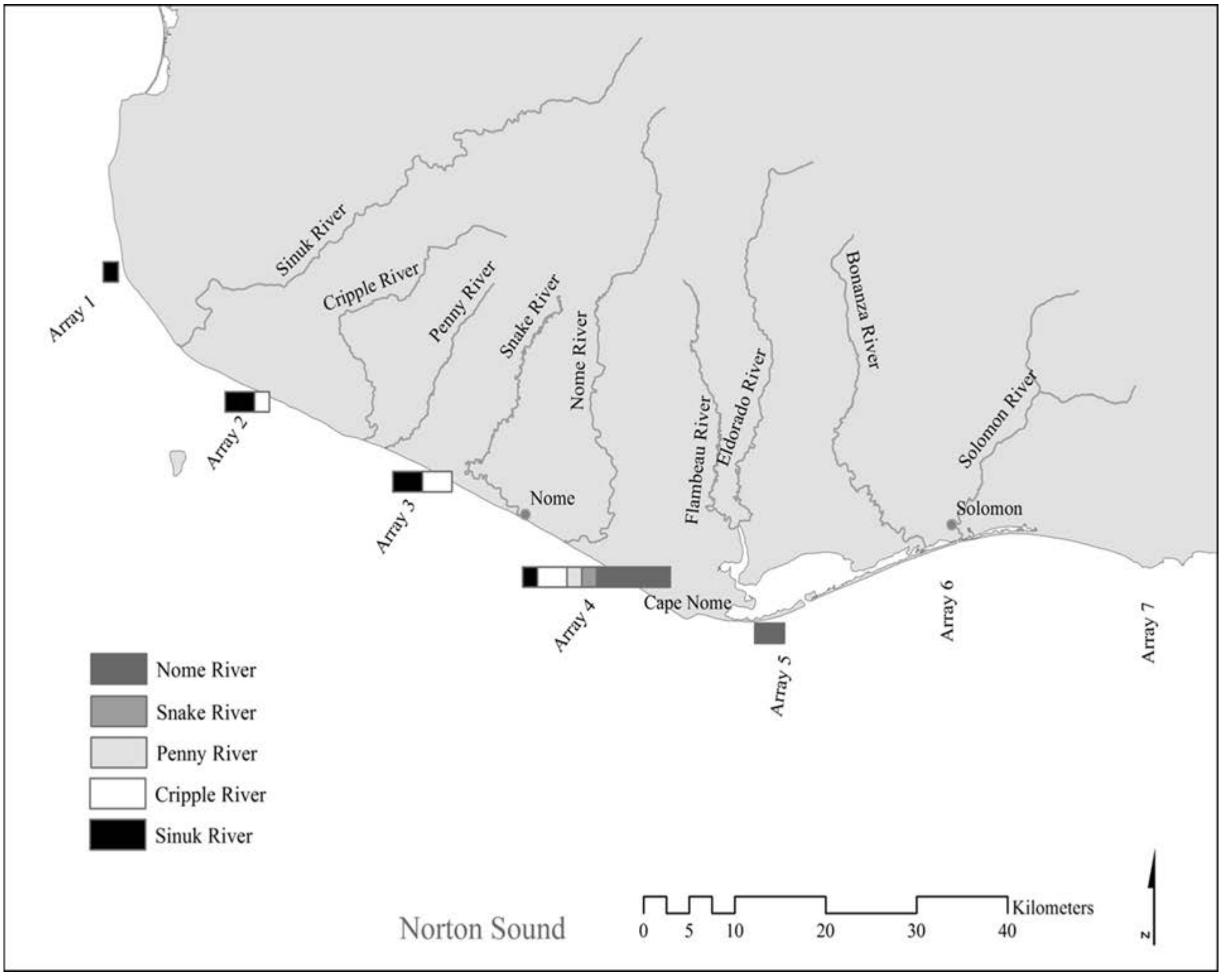

Figure 15.–Distribution of detections on ocean arrays of Fate 1 chum salmon tagged in Section 4 and last detected in rivers west of Cape Nome, 2015.

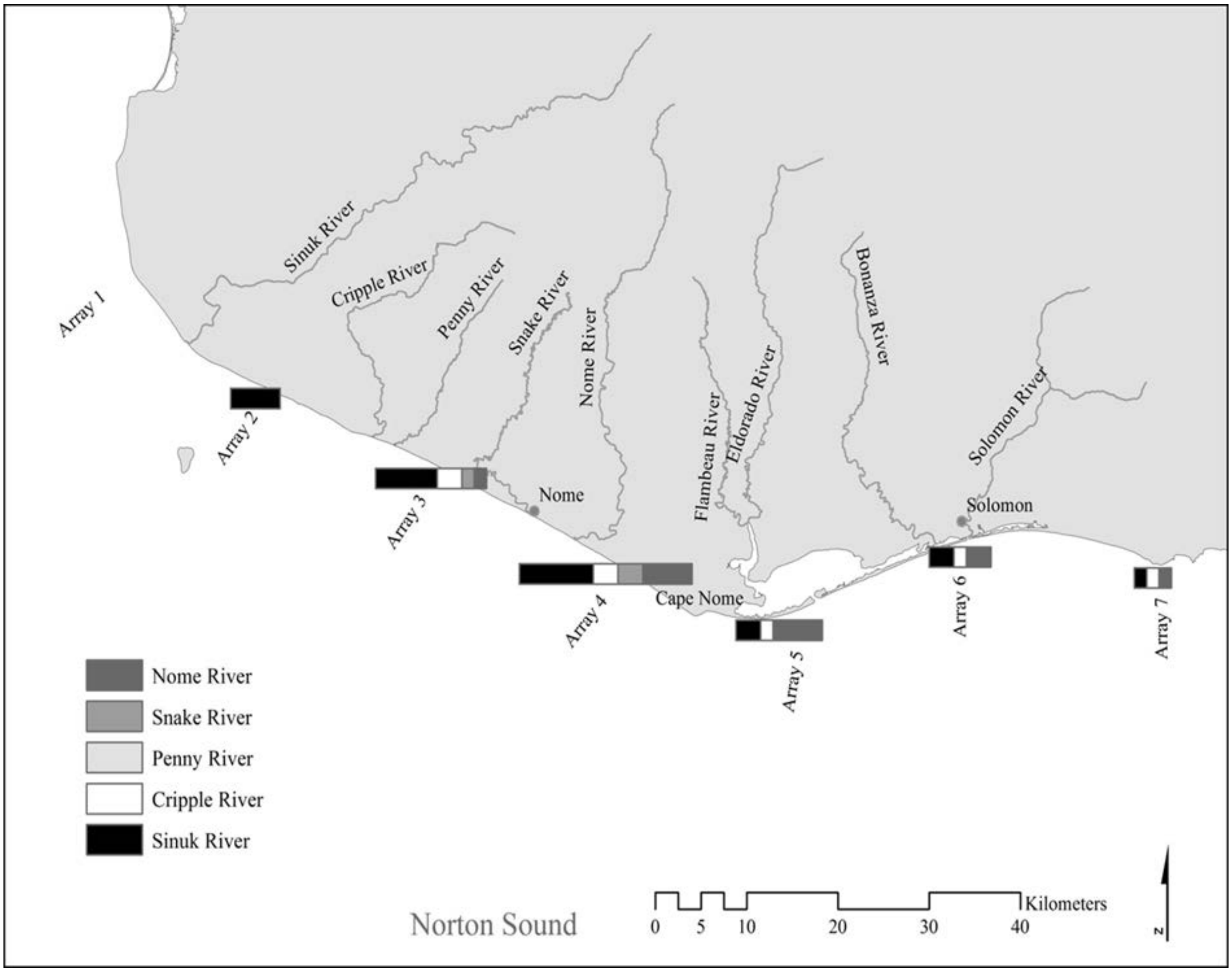

Figure 16.–Distribution of detections on ocean arrays of Fate 1 chum salmon tagged in Section 4 and last detected in rivers west of Cape Nome, 2016.

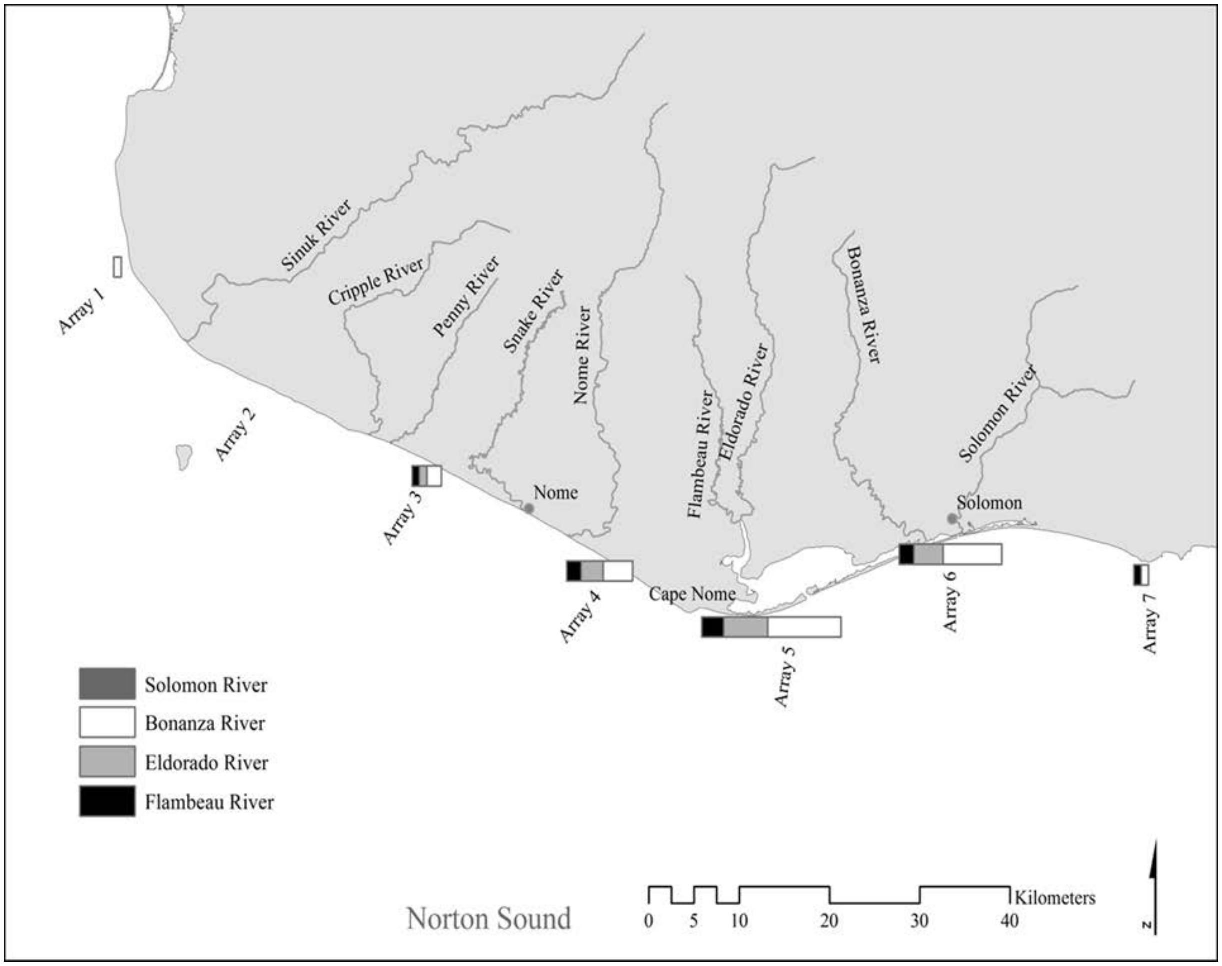

Figure 17.–Distribution of detections on ocean arrays of Fate 1 chum salmon tagged in Section 4 and last detected in rivers east of Cape Nome, 2015.

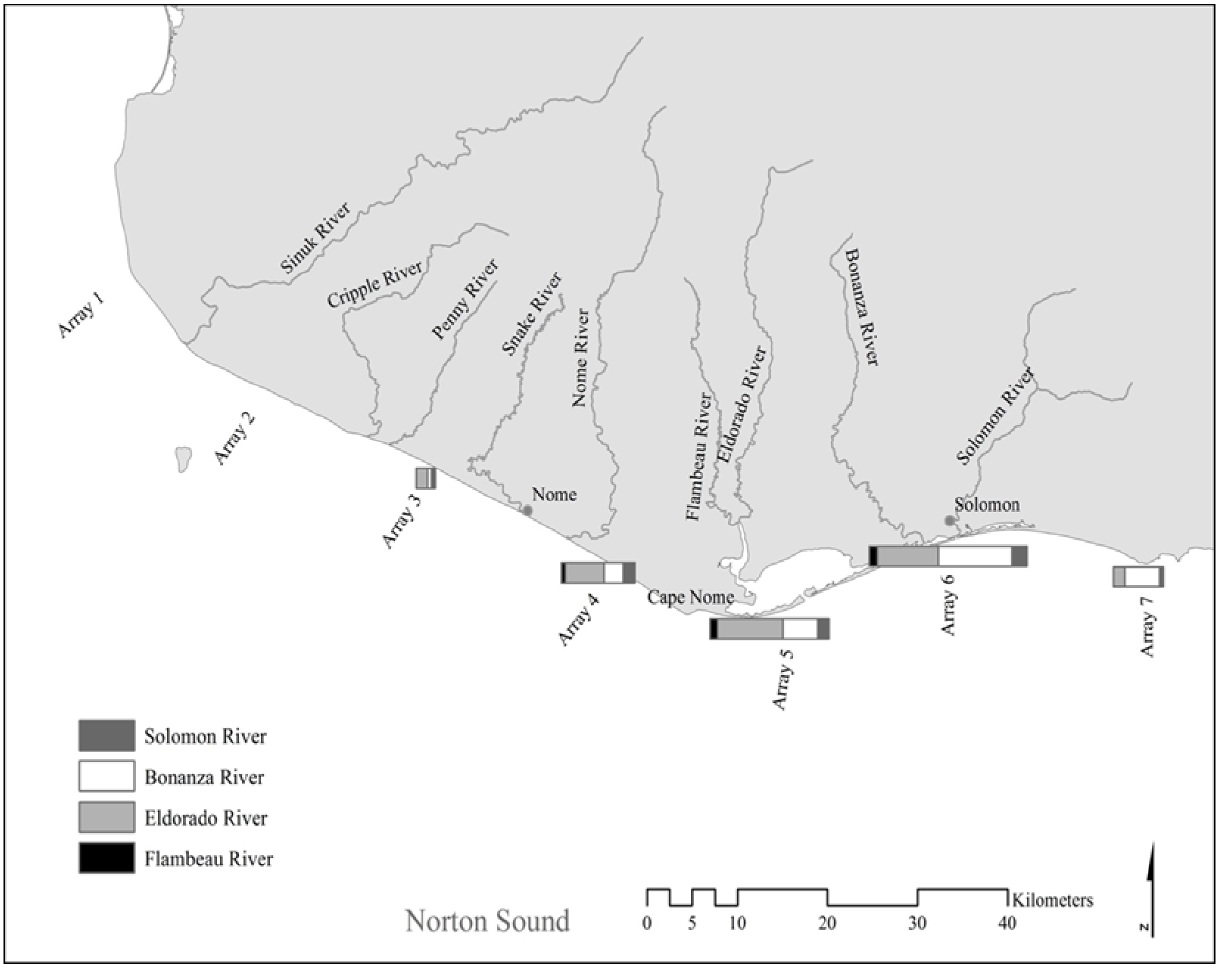

Figure 18.–Distribution of detections on ocean arrays of Fate 1 chum salmon tagged in Section 4 and last detected in rivers east of Cape Nome, 2016.

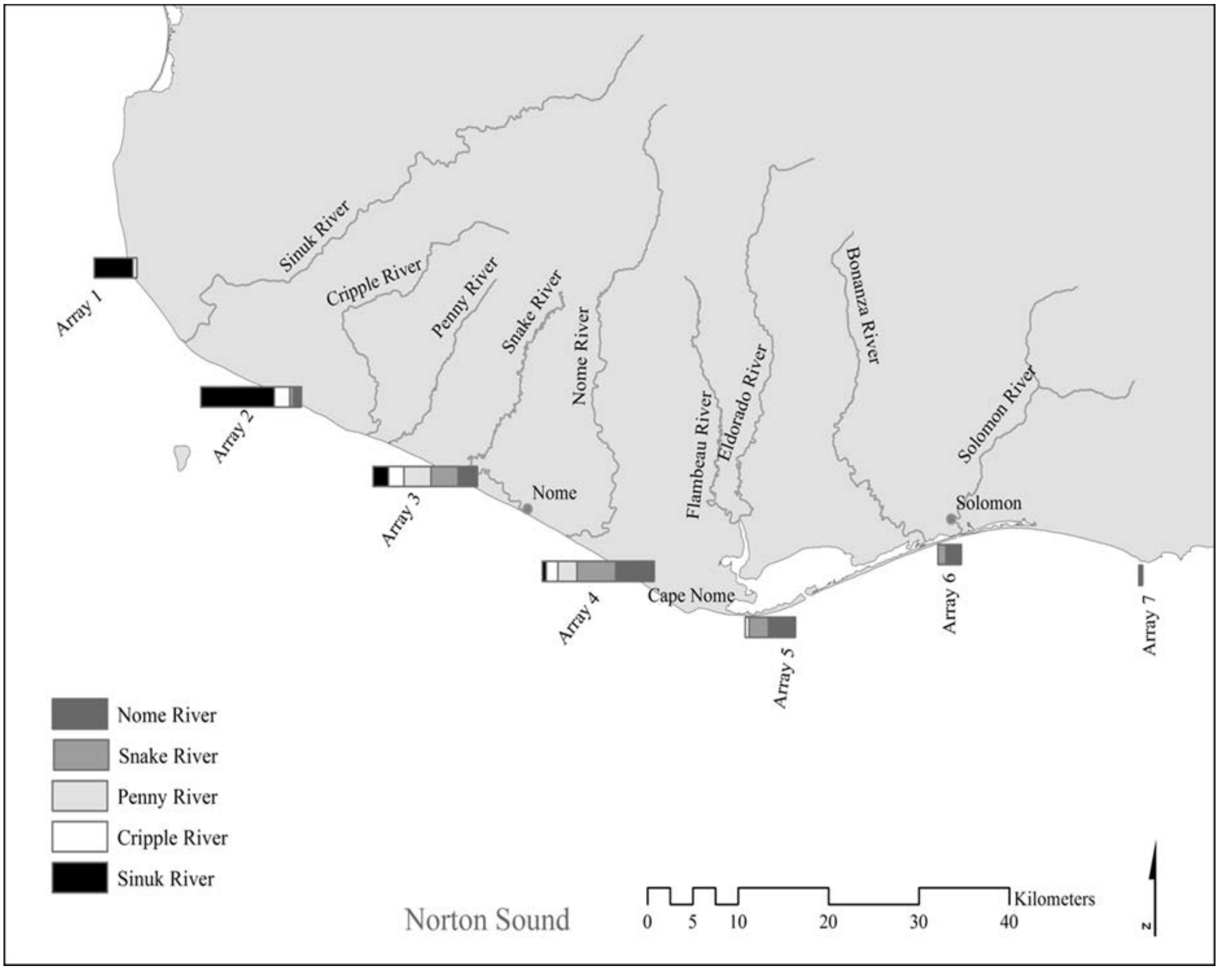

Figure 19.–Distribution of detections on ocean arrays of Fate 1 chum salmon tagged in Sections 1, 2, 3, 5, and 6, and last detected in rivers west of Cape Nome, 2015.

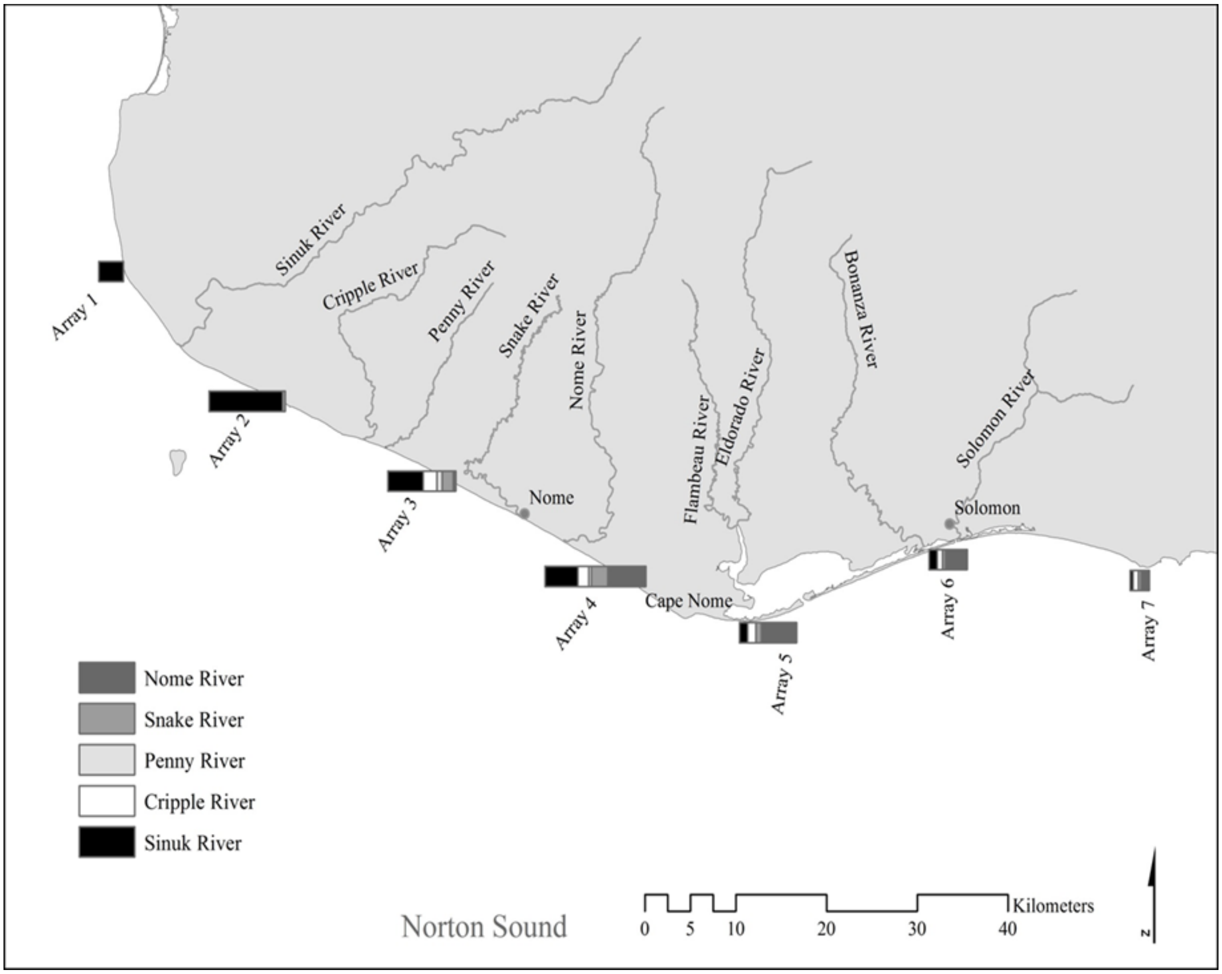

Figure 20.–Distribution of detections on ocean arrays of Fate 1 chum salmon tagged in Sections 1, 2, 3, 5, and 6, and last detected in rivers west of Cape Nome, 2016.

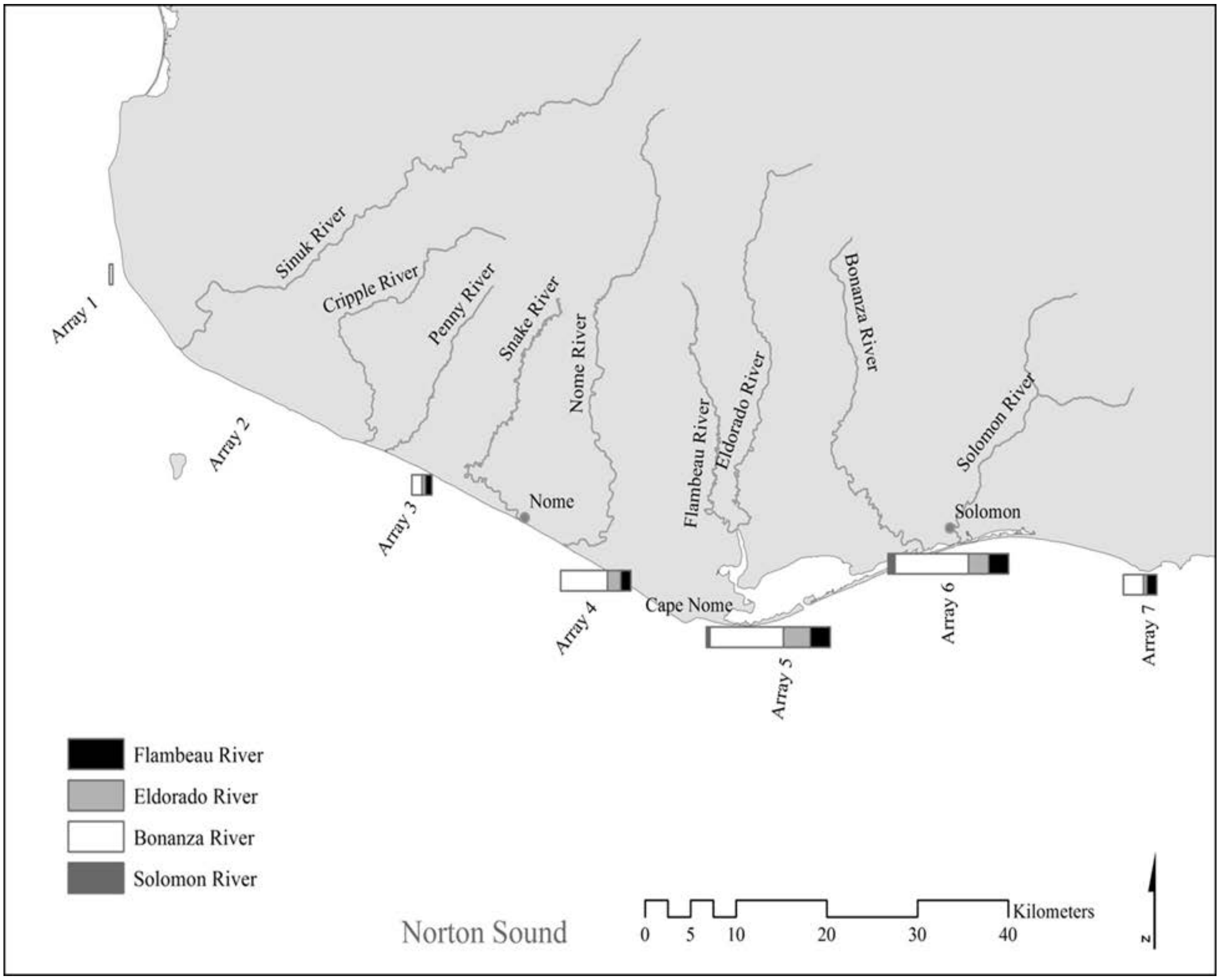

Figure 21.–Distribution of detections on ocean arrays of Fate 1 chum salmon tagged in Sections 1, 2, 3, 5, and 6, and last detected in rivers east of Cape Nome, 2015.

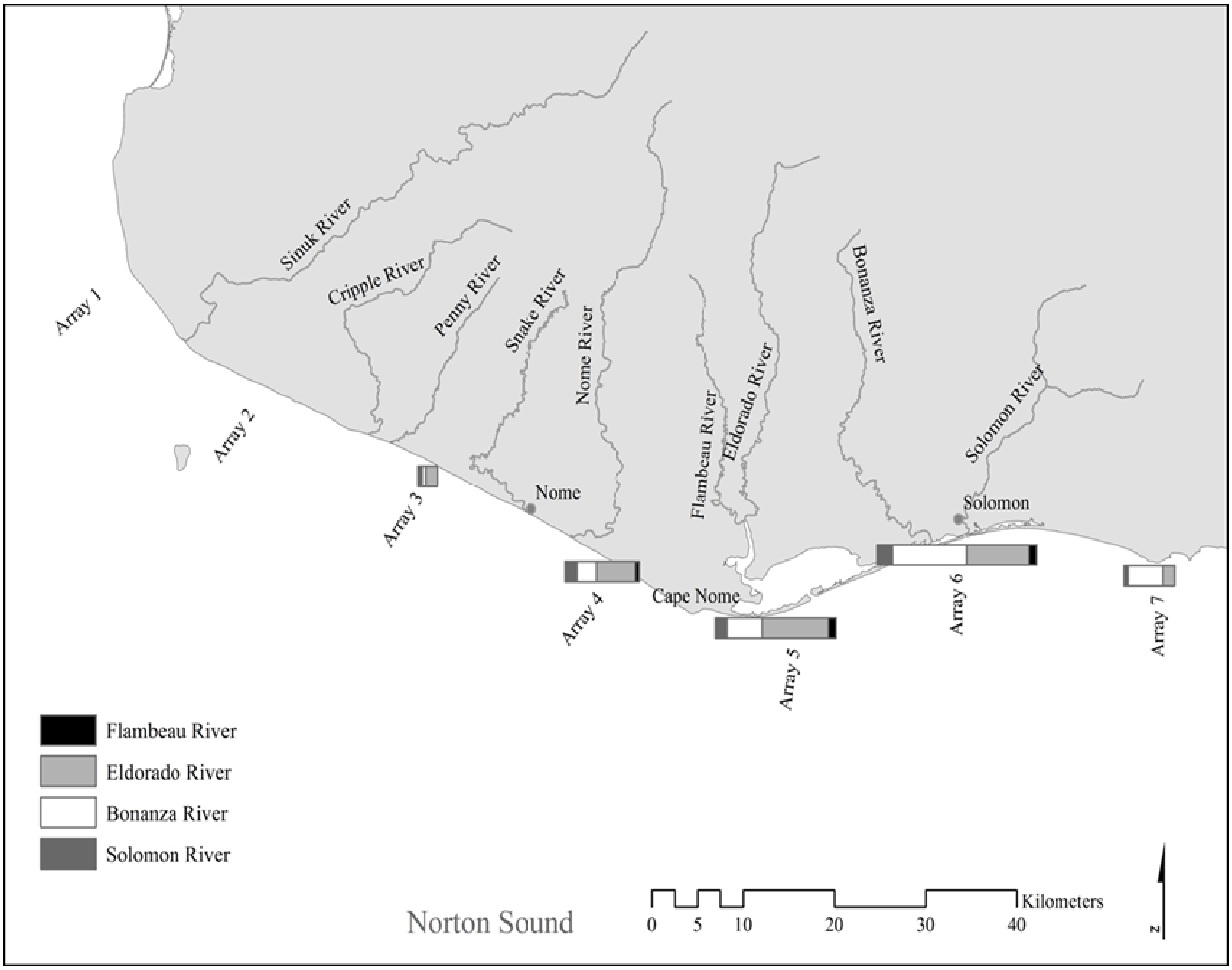

Figure 22.–Distribution of detections on ocean arrays of Fate 1 chum salmon tagged in Sections 1, 2, 3, 5, and 6, and last detected in rivers east of Cape Nome, 2016.

Figure 23.–Locations of captured tagged chum salmon beyond Norton Sound Subdistrict 1, 2015.

Note: Each star represents 1 tagged chum salmon.

APPENDIX: SUMMARY OF TAGGED CHUM SALMON FATES, 2015 AND 2016

Appendix A1.–Summary of tagged chum salmon and their fates, 2015.

Date tagged	Tag number	Week tagged	Section	Tagging latitude	Tagging longitude	Sex	Length (mm)	Age	Fate	Last detection	Notes
6/24	15009	1	5	N 64.49332	W 164.64143	F	532	ND	1	Snake River	
6/24	15012	1	5	N 64.49332	W 164.64143	F	592	ND	3	Array 5	
6/24	15013	1	6	N 64.54408	W 164.42198	F	571	ND	1	Flambeau River	
6/24	15015	1	5	N 64.49332	W 164.64143	F	564	ND	1	Flambeau River	
6/24	15017	1	5	N 64.49332	W 164.64143	F	545	ND	3	Array 2	
6/24	15018	1	5	N 64.49332	W 164.64143	F	604	ND	4		
6/24	15020	1	5	N 64.49332	W 164.64143	F	540	ND	3	Array 2	
7/03	15022	2	4	N 64.46332	W 165.18407	F	581	0.4	2	Array 1	
7/03	15024	2	4	N 64.46332	W 165.18407	F	561	0.4	1	Eldorado River	
7/04	15026	2	3	N 64.50722	W 165.5102	F	584	ND	3	Array 2	
7/10	15029	3	1	N 64.56683	W 166.09225	F	580	0.4	2	Array 1	
7/10	15030	3	1	N 64.56628	W 166.08282	F	603	0.4	1	Nome River	
7/10	15034	3	1	N 64.56628	W 166.08282	F	585	0.4	2	Array 1	
7/12	15036	3	6	N 64.56475	W 164.1756	F	572	0.3	2	Array 7	
7/10	15038	3	1	N 64.56628	W 166.08282	F	578	0.4	3	Array 2	
7/12	15039	3	6	N 64.56475	W 164.1756	F	586	0.3	2	Array 1	
7/10	15040	3	1	N 64.56628	W 166.08282	F	595	0.5	3	Array 2	
7/09	15041	3	4	N 64.4589	W 165.15917	F	541	0.3	1	Flambeau River	
7/09	15042	3	4	N 64.4687	W 165.21287	F	548	0.3	3	Array 2	
7/09	15045	3	4	N 64.46292	W 165.18543	F	548	0.3	3	Array 4	
7/10	15046	3	1	N 64.56628	W 166.08282	F	592	0.4	3	Array 2	
7/08	15047	2	6	N 64.4524	W 164.79345	F	544	0.3	1	Solomon River	
7/12	15049	3	6	N 64.56475	W 164.1756	F	610	0.5	2	Array 1	
7/10	15051	3	2	N 64.55843	W 166.01118	F	574	0.4	2	Array 1	
7/12	15052	3	6	N 64.56475	W 164.1756	F	585	0.3	2	Array 7	Harvested in SD 3 Commercial Fishery
7/12	15053	3	6	N 64.56475	W 164.1756	F	540	ND	4		
7/12	15054	3	6	N 64.56475	W 164.1756	F	585	0.4	3	Array 2	
7/12	15056	3	6	N 64.56475	W 164.1756	F	575	0.3	2	Array 1	
7/12	15057	3	6	N 64.56475	W 164.1756	F	557	0.4	3	Array 3	
7/04	15060	2	3	N 64.50722	W 165.5102	F	555	0.4	1	Penny River	

-continued-

Date tagged	Tag number	Week tagged	Section	Tagging latitude	Tagging longitude	Sex	Length (mm)	Age	Fate	Last detection	Notes
7/04	15066	2	3	N 64.50722	W 165.5102	F	602	0.4	1	Nome River	
7/12	15086	3	5	N 64.4953	W 164.63475	F	585	0.4	2	Array 3	Harvested in SD 4 Commercial Fishery
7/12	15089	3	6	N 64.56475	W 164.1756	F	574	0.4	3	Array 3	
7/11	15091	3	2	N 64.5323	W 165.71538	F	581	0.4	2	Array 7	
7/11	15092	3	2	N 64.5314	W 165.71128	F	602	0.4	1	Snake River	
7/11	15094	3	3	N 64.51745	W 165.58612	F	575	0.4	3	Array 2	
7/11	15097	3	3	N 64.5191	W 165.6054	F	601	0.3	1	Nome River	
7/11	15098	3	3	N 64.49512	W 165.40377	F	592	0.4	2	Array 1	Harvested near Teller, AK
7/11	15101	3	3	N 64.51745	W 165.58612	F	530	0.2	1	Snake River	
7/12	15102	3	5	N 64.4953	W 164.63475	F	573	0.4	3	Array 3	
7/12	15104	3	5	N 64.4953	W 164.63475	F	572	0.3	1	Nome River	
7/12	15105	3	5	N 64.4953	W 164.63475	F	554	0.4	1	Bonanza River	
7/12	15111	3	6	N 64.56475	W 164.1756	F	633	0.5	3	Array 2	
7/12	15112	3	6	N 64.56475	W 164.1756	F	580	0.3	3	Array 2	
7/10	15113	3	2	N 64.54893	W 165.92887	F	533	0.4	4		
7/03	15117	2	4	N 64.46332	W 165.18407	F	542	ND	3	Array 2	
7/03	15118	2	4	N 64.46332	W 165.18407	F	546	0.4	1	Nome River	
7/03	15120	2	4	N 64.46332	W 165.18407	F	562	0.3	1	Sinuk River	
7/03	15122	2	4	N 64.4521	W 165.11288	F	558	0.3	1	Nome River	
7/03	15123	2	4	N 64.46332	W 165.18407	F	684	0.4	3	Array 3	
7/08	15129	2	4	N 64.44115	W 164.96725	F	563	ND	3	Array 6	Harvested in SD 1 Commercial Fishery
7/08	15132	2	4	N 64.44298	W 164.84238	F	547	0.3	3	Array 4	
7/08	15134	2	4	N 64.4408	W 164.88183	F	553	0.4	1	Eldorado River	
7/08	15136	2	5	N 64.4524	W 164.79345	F	585	0.4	2	Array 3	Harvested in Kotzebue Commercial Fishery
7/08	15139	2	5	N 64.4524	W 164.79345	F	566	0.4	1	Bonanza River	
7/09	15145	3	4	N 64.46423	W 165.18345	F	565	0.3	2	Array 1	
7/08	15148	2	5	N 64.4524	W 164.79345	F	580	0.4	1	Bonanza River	
7/06	15150	2	1	N 64.5652	W 166.0707	F	562	0.3	3	Array 2	
7/06	15151	2	1	N 64.5652	W 166.0707	F	583	ND	1	Sinuk River	
7/06	15153	2	1	N 64.5652	W 166.0707	F	549	0.3	1	Cripple River	
7/06	15154	2	1	N 64.56713	W 166.0924	F	611	0.3	1	Cripple River	
7/06	15157	2	1	N 64.56713	W 166.0924	F	565	0.3	3	Array 2	
7/08	15158	2	4	N 64.4408	W 164.88183	F	533	0.4	3	Array 4	Harvested in SD 1 Commercial Fishery
7/04	15161	2	2	N 64.52853	W 165.69273	F	533	0.3	3	Array 2	

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Date tagged	Tag number	Week tagged	Section	Tagging latitude	Tagging longitude	Sex	Length (mm)	Age	Fate	Last detection	Notes
7/04	15164	2	2	N 64.52853	W 165.69273	F	576	0.3	2	Array 1	
7/14	15171	3	4	N 64.46332	W 165.18407	F	575	0.4	2	Array 4	Harvested in SD 3 Commercial Fishery
7/14	15173	3	4	N 64.46332	W 165.18407	F	594	0.4	2	Array 1	
7/14	15174	3	4	N 64.46332	W 165.18407	F	567	0.3	2	Array 1	
7/14	15176	3	4	N 64.46332	W 165.18407	F	589	0.4	3	Array 3	
7/14	15179	3	4	N 64.46332	W 165.18407	F	541	0.4	3	Array 4	
7/14	15187	3	4	N 64.46332	W 165.18407	F	560	0.3	3	Array 2	
7/13	15191	3	3	N 64.51605	W 165.57625	F	565	0.3	1	Nome River	
7/13	15192	3	3	N 64.51605	W 165.57625	F	590	0.4	1	Penny River	
7/16	15193	4	5	N 64.53173	W 164.48292	F	558	0.3	3	Array 6	
7/13	15195	3	3	N 64.51605	W 165.57625	F	591	0.4	1	Snake River	
7/16	15200	4	6	N 64.56242	W 164.294	F	600	0.5	4		
7/14	15201	3	4	N 64.46332	W 165.18407	F	617	0.4	2	Array 1	
7/16	15203	4	5	N 64.53173	W 164.48292	F	556	ND	1	Bonanza River	
7/16	15205	4	5	N 64.53173	W 164.48292	F	605	0.3	1	Bonanza River	
7/16	15207	4	5	N 64.53173	W 164.48292	F	581	ND	3	Array 6	
7/15	15208	4	2	N 64.53053	W 165.70097	F	588	0.3	1	Nome River	
7/15	15210	4	2	N 64.56332	W 166.04988	F	574	0.3	2	Array 1	
7/15	15211	4	2	N 64.56332	W 166.04988	F	555	0.3	3	Array 2	
7/15	15212	4	1	N 64.57825	W 166.20182	F	587	ND	3	Array 4	
7/15	15213	4	1	N 64.57825	W 166.20182	F	559	0.4	3	Array 2	
7/15	15214	4	1	N 64.57825	W 166.20182	F	561	0.3	2	Array 1	
7/15	15215	4	1	N 64.57825	W 166.20182	F	575	0.4	4		
7/15	15218	4	1	N 64.57825	W 166.20182	F	546	0.3	1	Sinuk River	
7/15	15222	4	1	N 64.57825	W 166.20182	F	564	0.4	4		
7/15	15223	4	2	N 64.5589	W 166.01318	F	536	ND	2	Array 1	
7/15	15224	4	2	N 64.53053	W 165.70097	F	604	0.4	1	Bonanza River	
7/15	15225	4	2	N 64.53053	W 165.70097	F	568	0.3	1	Bonanza River	
7/17	15227	4	4	N 64.46008	W 165.15753	F	523	0.4	1	Snake River	
7/17	15234	4	4	N 64.46008	W 165.15753	F	556	0.3	1	Cripple River	
7/17	15241	4	4	N 64.46008	W 165.15753	F	575	0.3	2	Array 1	
7/17	15254	4	4	N 64.46008	W 165.15753	F	565	0.3	3	Array 3	
7/17	15258	4	4	N 64.46008	W 165.15753	F	532	0.2	1	Flambeau River	
7/17	15261	4	4	N 64.46008	W 165.15753	F	533	0.3	1	Bonanza River	
7/16	15268	4	6	N 64.56443	W 164.24013	F	584	0.4	1	Bonanza River	

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Date tagged	Tag number	Week tagged	Section	Tagging latitude	Tagging longitude	Sex	Length (mm)	Age	Fate	Last detection	Notes
7/16	15271	4	6	N 64.56478	W 164.15417	F	520	0.3	2	Array 7	
7/16	15273	4	6	N 64.56478	W 164.15417	F	600	0.3	3	Array 3	
7/17	15276	4	4	N 64.46008	W 165.15753	F	569	0.4	2	Array 1	
7/15	15277	4	1	N 64.57825	W 166.20182	F	580	0.4	1	Sinuk River	
7/15	15281	4	1	N 64.57825	W 166.20182	F	571	0.4	4		
6/24	15001	1	6	N 64.54408	W 164.42198	M	625	ND	1	Eldorado River	
6/24	15002	1	6	N 64.54408	W 164.42198	M	627	ND	3	Array 6	
6/24	15003	1	6	N 64.54408	W 164.42198	M	610	ND	4		
6/24	15004	1	6	N 64.54408	W 164.42198	M	580	ND	4		
6/24	15005	1	6	N 64.54408	W 164.42198	M	604	ND	2	Array 4	Captured at Pilgrim River weir
6/24	15006	1	5	N 64.49332	W 164.64143	M	663	ND	2	Array 7	
6/24	15007	1	5	N 64.49332	W 164.64143	M	589	ND	2	Array 1	
6/24	15008	1	6	N 64.54408	W 164.42198	M	652	ND	2	Array 1	
6/24	15010	1	6	N 64.54408	W 164.42198	M	575	ND	1	Snake River	
6/24	15011	1	5	N 64.49332	W 164.64143	M	611	ND	1	Bonanza River	
6/24	15014	1	6	N 64.54408	W 164.42198	M	545	ND	3	Array 6	
6/24	15016	1	6	N 64.54408	W 164.42198	M	615	ND	1	Flambeau River	
6/24	15019	1	5	N 64.49332	W 164.64143	M	558	ND	1	Flambeau River	
7/03	15021	2	4	N 64.46332	W 165.18407	M	613	0.3	1	Flambeau River	
7/04	15023	2	3	N 64.50722	W 165.5102	M	529	0.4	1	Penny River	
7/03	15028	2	4	N 64.46332	W 165.18407	M	568	0.3	2	Array 4	Harvested in SD 5 Commercial Fishery
7/10	15031	3	1	N 64.56628	W 166.08282	M	622	0.4	3	Nome River	Harvested in SD 1 Commercial Fishery
7/09	15032	3	4	N 64.46423	W 165.18345	M	552	0.4	3	Array 2	
7/09	15033	3	4	N 64.4589	W 165.15917	M	590	0.3	3	Array 4	Harvested in SD 1 Subsistence Fishery
7/10	15035	3	2	N 64.55843	W 166.01118	M	557	0.4	3	Array 2	
7/10	15037	3	2	N 64.55843	W 166.01118	M	579	ND	1	Sinuk River	
7/10	15043	3	2	N 64.55843	W 166.01118	M	566	0.3	1	Sinuk River	
7/10	15044	3	1	N 64.56628	W 166.08282	M	583	0.4	1	Snake River	
7/10	15048	3	2	N 64.54893	W 165.92887	M	559	0.3	1	Penny River	
7/10	15050	3	2	N 64.55843	W 166.01118	M	564	0.4	4		
7/12	15055	3	6	N 64.56475	W 164.1756	M	588	ND	4		
7/03	15058	2	4	N 64.46637	W 165.20205	M	544	0.3	1	Nome River	
7/03	15059	2	3	N 64.49432	W 165.4052	M	550	0.3	3	Array 3	
7/10	15087	3	2	N 64.55843	W 166.01118	M	525	0.3	1	Sinuk River	

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Date tagged	Tag number	Week tagged	Section	Tagging latitude	Tagging longitude	Sex	Length (mm)	Age	Fate	Last detection	Notes
7/06	15088	2	1	N 64.5652	W 166.0707	M	634	0.4	1	Sinuk River	
7/12	15090	3	5	N 64.4953	W 164.63475	M	620	0.4	1	Cripple River	
7/12	15093	3	5	N 64.4953	W 164.63475	M	670	0.4	2	Array 7	
7/12	15095	3	5	N 64.4953	W 164.63475	M	600	0.5	1	Snake River	
7/11	15096	3	3	N 64.5191	W 165.6054	M	609	0.4	1	Sinuk River	
7/12	15099	3	5	N 64.4953	W 164.63475	M	585	0.3	1	Nome River	
7/11	15100	3	3	N 64.51745	W 165.58612	M	581	0.3	1	Nome River	
7/12	15103	3	5	N 64.4953	W 164.63475	M	600	0.3	1	Bonanza River	
7/12	15106	3	6	N 64.56475	W 164.1756	M	614	0.4	1	Bonanza River	
7/12	15107	3	6	N 64.56475	W 164.1756	M	672	0.4	1	Bonanza River	
7/12	15108	3	6	N 64.56475	W 164.1756	M	626	0.4	2	Array 7	
7/08	15109	2	5	N 64.4524	W 164.79345	M	588	0.3	3	Array 6	
7/12	15110	3	5	N 64.4953	W 164.63475	M	606	0.3	1	Bonanza River	
7/03	15114	2	4	N 64.46332	W 165.18407	M	537	0.3	2	Array 1	
7/04	15115	2	3	N 64.50722	W 165.5102	M	608	0.4	4		
7/03	15116	2	4	N 64.46332	W 165.18407	M	561	0.4	1	Nome River	
7/03	15121	2	4	N 64.46332	W 165.18407	M	573	0.4	1	Eldorado River	
7/04	15124	2	3	N 64.50722	W 165.5102	M	580	0.4	1	Snake River	
7/04	15125	2	3	N 64.50722	W 165.5102	M	623	0.4	1	Snake River	
7/03	15128	2	4	N 64.4521	W 165.11288	M	536	ND	1	Snake River	
7/04	15130	2	3	N 64.50722	W 165.5102	M	549	0.4	1	Penny River	
7/08	15131	2	5	N 64.4524	W 164.79345	M	582	0.4	3	Array 6	
7/08	15133	2	4	N 64.44298	W 164.84238	M	642	0.4	1	Eldorado River	
7/08	15135	2	5	N 64.4524	W 164.79345	M	650	0.4	2	Array 2	Harvested in Kotzebue Commercial Fishery
7/08	15137	2	5	N 64.4524	W 164.79345	M	639	0.3	3	Array 2	
7/08	15138	2	4	N 64.4408	W 164.88183	M	577	0.4	1	Bonanza River	
7/08	15140	2	5	N 64.4524	W 164.79345	M	605	0.4	1	Eldorado River	
7/08	15141	2	5	N 64.4524	W 164.79345	M	598	0.4	1	Snake River	
7/09	15142	3	4	N 64.46423	W 165.18345	M	625	0.4	1	Bonanza River	
7/10	15143	3	1	N 64.56628	W 166.08282	M	522	0.4	3	Array 2	
7/10	15144	3	1	N 64.56683	W 166.09225	M	591	0.5	1	Sinuk River	
7/09	15146	3	4	N 64.46423	W 165.18345	M	614	0.4	2	Array 3	Harvested near Wales, AK
7/09	15147	3	4	N 64.46423	W 165.18345	M	565	0.3	1	Snake River	
7/08	15152	2	5	N 64.4524	W 164.79345	M	578	0.4	2	Array 7	

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Date tagged	Tag number	Week tagged	Section	Tagging latitude	Tagging longitude	Sex	Length (mm)	Age	Fate	Last detection	Notes
7/06	15155	2	1	N 64.5652	W 166.0707	M	595	0.4	1	Sinuk River	
7/06	15156	2	1	N 64.56713	W 166.0924	M	589	0.4	3	Array 2	
7/06	15159	2	1	N 64.56612	W 166.0821	M	581	0.3	1	Sinuk River	
7/04	15160	2	2	N 64.52853	W 165.69273	M	605	0.3	1	Sinuk River	
7/04	15163	2	2	N 64.52995	W 165.69615	M	575	0.3	1	Sinuk River	
7/04	15167	2	2	N 64.52853	W 165.69273	M	642	0.4	3	Array 2	
7/14	15170	3	4	N 64.46332	W 165.18407	M	672	0.4	2	Array 1	
7/15	15172	4	2	N 64.53053	W 165.70097	M	555	0.3	1	Snake River	
7/14	15175	3	4	N 64.46332	W 165.18407	M	610	0.4	3	Array 5	
7/14	15177	3	4	N 64.46332	W 165.18407	M	616	0.3	1	Penny River	
7/14	15178	3	4	N 64.46332	W 165.18407	M	606	0.4	3	Array 4	
7/14	15180	3	4	N 64.46332	W 165.18407	M	675	0.4	3	Array 4	
7/16	15181	4	5	N 64.53173	W 164.48292	M	598	0.3	2	Array 3	Harvested in SD 2 Commercial Fishery
7/16	15182	4	5	N 64.53173	W 164.48292	M	585	0.4	1	Bonanza River	
7/14	15183	3	4	N 64.46332	W 165.18407	M	651	0.4	2	Array 3	Captured in Noatak River
7/14	15184	3	4	N 64.46332	W 165.18407	M	612	0.4	3	Array 4	
7/14	15185	3	4	N 64.46332	W 165.18407	M	668	0.4	2	Array 4	Harvested in Kotzebue Commercial Fishery
7/14	15186	3	4	N 64.46332	W 165.18407	M	591	0.3	3	Array 4	
7/14	15188	3	4	N 64.46332	W 165.18407	M	619	0.4	2	Array 1	
7/13	15189	3	3	N 64.51605	W 165.57625	M	611	0.4	1	Snake River	
7/16	15190	4	5	N 64.53173	W 164.48292	M	585	0.3	3	Array 6	
7/13	15194	3	3	N 64.51605	W 165.57625	M	607	0.3	2	Array 1	
7/16	15196	4	6	N 64.56242	W 164.294	M	580	0.3	1	Bonanza River	
7/13	15197	3	3	N 64.51605	W 165.57625	M	586	0.3	3	Array 3	
7/14	15198	3	4	N 64.46332	W 165.18407	M	599	0.3	3	Array 2	
7/14	15199	3	4	N 64.46332	W 165.18407	M	646	0.4	3	Array 4	
7/16	15202	4	5	N 64.53173	W 164.48292	M	604	ND	4		
7/14	15204	3	4	N 64.46332	W 165.18407	M	619	0.4	3	Array 6	
7/15	15206	4	2	N 64.53053	W 165.70097	M	616	0.4	2	Array 7	
7/15	15209	4	1	N 64.57825	W 166.20182	M	565	0.4	2	Array 7	
7/15	15216	4	2	N 64.53297	W 165.72428	M	590	0.4	1	Sinuk River	
7/15	15219	4	2	N 64.53053	W 165.70097	M	590	ND	2	Array 1	
7/16	15220	4	5	N 64.53173	W 164.48292	M	604	0.4	1	Eldorado River	
7/16	15221	4	5	N 64.53173	W 164.48292	M	550	0.4	1	Bonanza River	
7/17	15226	4	4	N 64.46008	W 165.15753	M	574	0.4	1	Bonanza River	

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Date tagged	Tag number	Week tagged	Section	Tagging latitude	Tagging longitude	Sex	Length (mm)	Age	Fate	Last detection	Notes
7/17	15228	4	4	N 64.46008	W 165.15753	M	530	0.3	3	Array 2	
7/17	15229	4	4	N 64.46008	W 165.15753	M	545	0.3	1	Bonanza River	
7/17	15230	4	4	N 64.46008	W 165.15753	M	599	0.4	2	Array 7	
7/17	15231	4	4	N 64.46008	W 165.15753	M	572	0.3	2	Array 1	
7/17	15232	4	4	N 64.46008	W 165.15753	M	667	0.4	1	Eldorado River	
7/17	15233	4	4	N 64.46008	W 165.15753	M	579	0.3	1	Nome River	
7/17	15235	4	4	N 64.46008	W 165.15753	M	612	0.4	2	Array 1	
7/17	15236	4	4	N 64.46008	W 165.15753	M	579	0.4	1	Bonanza River	
7/17	15237	4	4	N 64.46008	W 165.15753	M	600	0.3	1	Bonanza River	
7/17	15238	4	4	N 64.46008	W 165.15753	M	612	0.4	3	Array 6	
7/17	15239	4	4	N 64.46008	W 165.15753	M	644	0.4	1	Bonanza River	
7/17	15242	4	4	N 64.46008	W 165.15753	M	567	0.4	1	Bonanza River	
7/17	15243	4	4	N 64.46008	W 165.15753	M	539	0.3	1	Cripple River	
7/17	15244	4	3	N 64.50407	W 165.47648	M	636	0.4	1	Nome River	
7/21	15245	4	3	N 64.49595	W 165.44122	M	570	0.4	1	Snake River	
7/21	15249	4	3	N 64.52935	W 165.69108	M	516	0.2	1	Snake River	
7/17	15255	4	4	N 64.46008	W 165.15753	M	590	0.4	3	Array 2	
7/17	15256	4	4	N 64.46008	W 165.15753	M	612	0.4	1	Eldorado River	
7/17	15257	4	4	N 64.46008	W 165.15753	M	617	0.4	2	Array 1	
7/17	15259	4	4	N 64.46008	W 165.15753	M	584	0.3	2	Array 1	
7/17	15260	4	4	N 64.46008	W 165.15753	M	544	0.4	1	Nome River	
7/16	15262	4	6	N 64.56242	W 164.294	M	564	0.3	1	Bonanza River	
7/16	15263	4	6	N 64.56242	W 164.294	M	527	0.3	1	Bonanza River	
7/16	15264	4	6	N 64.56242	W 164.294	M	570	0.4	1	Bonanza River	
7/16	15265	4	6	N 64.56443	W 164.24013	M	593	0.3	4		
7/16	15266	4	6	N 64.56242	W 164.294	M	574	0.3	2	Array 6	
7/16	15267	4	6	N 64.56478	W 164.15417	M	594	0.3	2		Harvested in Kotzebue Commercial Fishery
7/16	15269	4	6	N 64.56478	W 164.15417	M	538	0.3	2	Array 7	
7/16	15270	4	6	N 64.56478	W 164.15417	M	572	0.3	1	Bonanza River	
7/16	15272	4	6	N 64.56498	W 164.17597	M	566	0.4	1	Solomon River	
7/17	15274	4	4	N 64.46008	W 165.15753	M	558	0.4	1	Eldorado River	
7/17	15275	4	4	N 64.46008	W 165.15753	M	578	ND	2	Array 1	
7/17	15278	4	4	N 64.46008	W 165.15753	M	583	0.4	1	Sinuk River	
7/17	15279	4	4	N 64.46008	W 165.15753	M	612	0.3	2	Array 1	
7/15	15280	4	1	N 64.57825	W 166.20182	M	663	0.4	2	Array 1	

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Date tagged	Tag number	Week tagged	Section	Tagging latitude	Tagging longitude	Sex	Length (mm)	Age	Fate	Last detection	Notes
7/20	15284	4	3	N 64.49745	W 165.42494	M	564	0.2	2	Array 7	Harvested in SD 2 Commercial Fishery
7/03	15025	2	4	N 64.46332	W 165.18407	ND	582	0.4	2	Array 7	Harvested in SD 3 Commercial Fishery
6/28	15061	1	2	N 64.52955	W 165.69177	ND	625	0.4	1	Snake River	
6/28	15062	1	2	N 64.52955	W 165.69177	ND	566	ND	1	Snake River	
6/28	15063	1	2	N 64.52955	W 165.69177	ND	567	0.4	3	Array 2	
6/28	15064	1	2	N 64.52955	W 165.69177	ND	576	0.3	1	Snake River	
6/26	15068	1	3	N 64.48853	W 165.36187	ND	531	0.4	1	Flambeau River	
6/26	15069	1	4	N 64.43783	W 164.88805	ND	572	ND	1	Bonanza River	
6/28	15070	1	2	N 64.52955	W 165.69177	ND	589	0.4	1	Penny River	
6/28	15071	1	2	N 64.5412	W 165.86433	ND	565	0.3	2	Array 1	Captured in Pilgrim River
6/28	15072	1	1	N 64.5661	W 166.07613	ND	561	0.4	2	Array 1	
6/28	15073	1	1	N 64.5661	W 166.07613	ND	549	0.3	3	Array 3	
6/28	15075	1	2	N 64.52955	W 165.69177	ND	569	0.3	1	Nome River	
6/28	15076	1	2	N 64.52955	W 165.69177	ND	626	0.4	2	Array 1	
6/28	15077	1	2	N 64.52955	W 165.69177	ND	667	0.4	1	Snake River	
6/28	15078	1	1	N 64.5661	W 166.07613	ND	542	ND	1	Sinuk River	
6/28	15081	1	1	N 64.5661	W 166.07613	ND	590	0.4	3	Array 2	
6/28	15082	1	2	N 64.52955	W 165.69177	ND	581	0.4	1	Penny River	
6/28	15083	1	1	N 64.5661	W 166.07613	ND	608	0.5	3	Array 2	
6/28	15084	1	1	N 64.5661	W 166.07613	ND	636	0.4	1	Sinuk River	
6/28	15085	1	1	N 64.5661	W 166.07613	ND	534	ND	1	Sinuk River	
7/01	15127	1	3	N 64.473	W 165.2421	ND	598	0.4	1	Snake River	

Appendix A2.–Summary of tagged chum salmon and their fates, 2016.

Date tagged	Tag number	Week tagged	Section	Tagging latitude	Tagging longitude	Sex	Length (mm)	Age	Fate	Last detection	Notes
7/14	15286	4	5	N 64.52588	W 164.50429	M	582	0.4	4		
7/15	15287	4	4	N 64.44149	W 165.04834	M	610	ND	1	Bonanza River	
7/08	15288	3	1	N 64.57082	W 166.13527	F	563	0.3	3	Array 2	
7/11	15289	3	5	N 64.5323	W 164.47827	M	567	0.4	1	Bonanza River	
7/11	15290	3	6	N 64.56396	W 164.24863	M	530	0.4	3	array 6	
6/24	15293	1	4	N 64.45546	W 165.13031	F	558	0.4	2	Array 1	
7/14	15294	4	5	N 64.52588	W 164.50429	M	557	0.3	1	Solomon River	
7/14	15295	4	5	N 64.52588	W 164.50429	F	546	0.4	1	Sinuk River	
7/06	15296	3	3	N 64.47487	W 165.24979	F	566	0.3	1	Nome River	
7/16	15298	4	2	N 64.53796	W 165.85577	F	567	ND	1	Solomon River	
7/14	15299	4	5	N 64.52588	W 164.50429	M	581	ND	1	Bonanza River	
7/16	15300	4	2	N 64.53796	W 165.85577	M	588	0.3	4		
7/09	15301	3	2	N 64.5495	W 165.92601	F	549	ND	1	Sinuk River	
7/09	15302	3	2	N 64.5495	W 165.92601	M	570	0.3	1	Sinuk River	
7/12	15303	3	4	N 64.45737	W 165.13747	M	586	0.4	3	Array 2	
7/12	15304	3	4	N 64.45827	W 165.14131	M	575	0.4	1	Bonanza River	
7/08	15306	3	1	N 64.57446	W 166.16801	M	578	0.3	1	Sinuk River	
7/16	15307	4	2	N 64.54939	W 165.92676	M	541	0.4	1	Sinuk River	
7/08	15308	3	1	N 64.57549	W 166.17143	M	580	0.4	1	Sinuk River	
7/14	15311	4	5	N 64.52588	W 164.50429	F	555	0.5	4		
7/06	15312	3	3	N 64.5323	W 164.47838	M	559	0.5	1	Eldorado River	
7/09	15313	3	2	N 64.54661	W 165.8889	M	541	0.4	1	Cripple River	
7/11	15316	3	6	N 64.56396	W 164.24863	M	527	0.3	1	Bonanza River	
7/15	15317	4	4	N 64.44149	W 165.04834	M	558	ND	1	Bonanza River	
7/11	15318	3	6	N 64.56396	W 164.24863	M	587	0.3	1	Cripple River	
6/26	15319	1	4	N 64.45522	W 165.13062	M	642	0.4	2	Array 1	
6/24	15320	1	3	N 64.47141	W 165.2267	M	564	ND	1	Sinuk River	
6/24	15321	1	4	N 64.44296	W 165.06104	F	588	0.4	1	Snake River	
6/29	15325	2	5	N 64.53285	W 164.47806	M	533	0.4	2	Array 1	

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Date tagged	Tag number	Week tagged	Section	Tagging latitude	Tagging longitude	Sex	Length (mm)	Age	Fate	Last detection	Notes
7/14	15326	4	5	N 64.52588	W 164.50429	M	579	0.3	1	Eldorado River	
7/07	15327	3	4	N 64.45507	W 165.12982	M	532	0.3	1	Cripple River	
6/23	15328	1	5	N 64.51187	W 164.56703	F	578	0.4	1	Flambeau River	
7/16	15330	4	2	N 64.53796	W 165.85577	M	595	0.4	3	Array 2	
7/11	15331	3	6	N 64.56396	W 164.24863	M	551	0.3	1	Sinuk River	
7/14	15332	4	5	N 64.53474	W 164.46436	M	565	ND	1	Nome River	
7/08	15334	3	1	N 64.57446	W 166.16801	M	540	ND	1	Sinuk River	
7/07	15335	3	4	N 64.45507	W 165.12982	M	574	0.3	1	Bonanza River	
7/12	15336	3	4	N 64.44868	W 165.08693	M	596	0.3	1	Solomon River	
7/14	15337	4	5	N 64.52588	W 164.50429	M	620	0.3	1	Bonanza River	
7/07	15338	3	4	N 64.45507	W 165.12982	F	568	0.3	1	Eldorado River	
6/24	15339	1	4	N 64.45546	W 165.13031	M	587	0.3	1	Sinuk River	
7/11	15340	3	6	N 64.56396	W 164.24863	M	518	ND	1	Cripple River	
7/08	15341	3	1	N 64.57446	W 166.16801	F	556	0.3	2	Array 1	
7/11	15342	3	5	N 64.53708	W 164.46211	M	624	0.4	1	Solomon River	
6/27	15343	1	2	N 64.56115	W 166.03624	M	590	0.4	2	Array 1	
6/29	15344	2	6	N 64.56424	W 164.24944	M	579	0.3	1	Eldorado River	
7/11	15345	3	6	N 64.56396	W 164.24863	M	613	0.3	1	Nome River	
7/09	15346	3	2	N 64.54913	W 165.92493	M	605	0.4	1	Sinuk River	
7/11	15347	3	5	N 64.53708	W 164.46211	M	528	0.3	1	Nome River	
7/09	15348	3	2	N 64.5495	W 165.92601	M	597	0.4	1	Cripple River	
7/09	15350	3	2	N 64.5495	W 165.92601	M	543	0.4	4		
7/09	15351	3	2	N 64.5495	W 165.92601	F	562	0.4	1	Sinuk River	
7/06	15352	3	3	N 64.5323	W 164.47838	F	587	0.3	1	Eldorado River	
7/07	15353	3	4	N 64.45507	W 165.12982	M	584	0.4	1	Sinuk River	
7/09	15354	3	2	N 64.5495	W 165.92601	M	542	0.3	1	Snake River	
7/06	15355	3	3	N 64.47487	W 165.24979	F	569	0.3	4		
7/08	15357	3	1	N 64.57446	W 166.16801	M	558	0.4	1	Sinuk River	
7/06	15358	3	3	N 64.49994	W 165.44173	F	525	0.3	1	Snake River	
7/09	15359	3	2	N 64.54661	W 165.8889	M	572	0.4	1	Sinuk River	
7/08	15360	3	1	N 64.57549	W 166.17143	F	565	0.3	1	Sinuk River	
7/06	15361	3	3	N 64.47487	W 165.24979	F	585	0.4	1	Bonanza River	

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Date tagged	Tag number	Week tagged	Section	Tagging latitude	Tagging longitude	Sex	Length (mm)	Age	Fate	Last detection	Notes
7/06	15362	3	3	N 64.47487	W 165.24979	F	547	0.3	1	Nome River	
7/07	15363	3	4	N 64.45507	W 165.12982	M	565	0.2	1	Eldorado River	
7/06	15364	3	3	N 64.47405	W 165.25076	F	562	ND	1	Bonanza River	
7/09	15365	3	2	N 64.54661	W 165.8889	M	594	0.4	3	Array 2	
6/27	15366	1	2	N 64.56115	W 166.03624	F	518	0.4	2	Array 1	
6/29	15367	2	5	N 64.53285	W 164.47806	M	545	0.3	1	Snake River	
6/26	15368	1	4	N 64.45522	W 165.13062	M	588	0.3	2	Array 1	
7/07	15369	3	3	N 64.50815	W 165.511	F	528	0.3	1	Sinuk River	
6/29	15370	2	6	N 64.56424	W 164.24944	M	662	0.5	3	Array 3	
6/24	15372	1	4	N 64.45546	W 165.13031	M	603	0.3	1	Snake River	
6/24	15373	1	4	N 64.45546	W 165.13031	F	595	0.3	1	Nome River	
6/29	15375	2	6	N 64.56424	W 164.24944	M	561	0.3	3	Array 4	
6/27	15376	1	2	N 64.56115	W 166.03624	F	583	0.4	4		
6/24	15377	1	4	N 64.45546	W 165.13031	M	589	0.4	1	Sinuk River	
6/26	15378	1	4	N 64.45522	W 165.13062	F	562	0.3	2	Array 1	
6/24	15380	1	4	N 64.45546	W 165.13031	F	625	0.4	2	Array 1	
6/29	15381	2	5	N 64.53285	W 164.47806	F	535	0.4	1	Nome River	
6/22	15382	1	6	N 64.5612	W 164.30229	F	543	0.3	2	Array 7	
6/26	15383	1	4	N 64.45522	W 165.13062	F	564	0.3	3	Array 3	
6/26	15384	1	4	N 64.45522	W 165.13062	F	588	0.4	2	Array 7	
6/22	15385	1	6	N 64.56371	W 164.26839	F	644	ND	1	Flambeau River	
6/27	15386	1	2	N 64.56115	W 166.03624	F	559	0.3	3	Array 2	
6/22	15387	1	6	N 64.5612	W 164.30229	F	560	0.3	3	Array 5	
6/22	15388	1	6	N 64.56371	W 164.26839	F	594	0.4	1	Flambeau River	
6/22	15389	1	6	N 64.56371	W 164.26839	M	593	ND	1	Bonanza River	
6/22	15390	1	6	N 64.5612	W 164.30229	F	591	0.4	2	Array 7	
6/20	15391	1	3	N 64.49721	W 165.42348	M	580	0.4	2	Array 7	
6/27	15392	1	1	N 64.57626	W 166.17433	M	614	0.3	1	Sinuk River	
6/26	15393	1	3	N 64.49891	W 165.43861	F	566	0.3	1	Snake River	
6/22	15394	1	6	N 64.56371	W 164.26839	M	631	0.3	2	Array 7	
6/22	15395	1	6	N 64.56371	W 164.26839	F	558	0.4	1	Eldorado River	
6/29	15396	2	5	N 64.53285	W 164.47806	M	511	0.4	3	Array 3	
6/26	15397	1	4	N 64.45522	W 165.13062	M	595	0.3	4		

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Date tagged	Tag number	Week tagged	Section	Tagging latitude	Tagging longitude	Sex	Length (mm)	Age	Fate	Last detection	Notes
7/14	15398	4	5	N 64.53474	W 164.46436	M	605	0.4	1	Bonanza River	
6/22	15399	1	6	N 64.56113	W 164.30754	F	568	0.4	1	Eldorado River	
6/22	15400	1	6	N 64.56371	W 164.26839	F	566	0.3	1	Eldorado River	
6/26	15401	1	4	N 64.45522	W 165.13062	F	575	0.4	1	Sinuk River	
7/14	15402	4	5	N 64.53762	W 164.45116	F	561	0.4	2	Array 7	
6/23	15403	1	5	N 64.51187	W 164.56703	F	550	ND	2	Array 1	
6/27	15404	1	2	N 64.56115	W 166.03624	M	568	0.3	4		
6/24	15405	1	3	N 64.47227	W 165.23521	F	565	0.3	1	Snake River	
6/29	15406	2	5	N 64.53285	W 164.47806	M	572	0.3	3	Array 3	
6/23	15407	1	5	N 64.51025	W 164.57158	F	546	ND	2	Array 7	
6/23	15408	1	5	N 64.51187	W 164.56703	F	523	0.4	1	Flambeau River	
6/23	15409	1	5	N 64.51025	W 164.57158	F	583	0.3	1	Eldorado River	
6/23	15410	1	5	N 64.51187	W 164.56703	M	610	0.3	1	Flambeau River	
6/26	15411	1	3	N 64.47057	W 165.2235	F	484	0.2	1	Sinuk River	
7/11	15412	3	6	N 64.56396	W 164.24863	M	572	0.3	1	Nome River	
6/29	15413	2	5	N 64.53285	W 164.47806	F	547	0.4	1	Nome River	
6/23	15414	1	5	N 64.51187	W 164.56703	F	554	0.4	1	Eldorado River	
6/23	15415	1	5	N 64.51187	W 164.56703	F	540	0.3	1	Eldorado River	
7/11	15417	3	6	N 64.56396	W 164.24863	M	556	0.4	1	Bonanza River	
6/29	15418	2	5	N 64.53285	W 164.47806	M	645	0.4	1	Eldorado River	
6/27	15419	1	2	N 64.56115	W 166.03624	M	668	0.4	4		
6/24	15420	1	3	N 64.47227	W 165.23521	M	597	0.3	1	Eldorado River	
6/26	15421	1	4	N 64.45522	W 165.13062	M	584	0.4	2	Array 7	
6/29	15422	2	6	N 64.56424	W 164.24944	F	573	ND	1	Eldorado River	
6/22	15423	1	6	N 64.5612	W 164.30229	M	625	0.4	3	Array 2	
7/11	15424	3	6	N 64.56396	W 164.24863	F	562	0.3	1	Bonanza River	
7/14	15425	4	6	N 64.56473	W 164.22841	M	579	0.3	1	Bonanza River	
7/08	15426	3	1	N 64.57082	W 166.13527	F	564	0.4	1	Sinuk River	
6/26	15427	1	4	N 64.45522	W 165.13062	M	608	0.3	2	Array 1	
7/11	15428	3	6	N 64.56396	W 164.24863	M	522	0.4	1	Snake River	
7/11	15429	3	5	N 64.5323	W 164.47827	M	532	0.3	2	Array 7	
6/26	15430	1	4	N 64.45522	W 165.13062	F	565	0.3	3	Array 3	

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Date tagged	Tag number	Week tagged	Section	Tagging latitude	Tagging longitude	Sex	Length (mm)	Age	Fate	Last detection	Notes
6/23	15431	1	5	N 64.51025	W 164.57158	M	609	ND	1	Eldorado River	
7/06	15432	3	3	N 64.47405	W 165.25076	F	570	ND	1	Eldorado River	
6/25	15433	1	1	N 64.57065	W 166.12108	M	580	0.3	1	Sinuk River	
6/24	15434	1	3	N 64.47141	W 165.2267	M	598	0.5	2	Array 1	
7/07	15435	3	4	N 64.45507	W 165.12982	M	542	0.4	1	Sinuk River	
7/08	15436	3	1	N 64.57082	W 166.13527	M	590	0.3	1	Sinuk River	
6/26	15437	1	4	N 64.45522	W 165.13062	M	600	ND	2	Array 1	
6/27	15438	1	2	N 64.56115	W 166.03624	F	604	0.4	2	Array 1	
6/29	15439	2	5	N 64.53285	W 164.47806	M	605	0.3	1	Sinuk River	
7/08	15440	3	1	N 64.56657	W 166.0822	M	616	0.3	1	Sinuk River	
6/29	15441	2	6	N 64.56424	W 164.24944	F	540	0.4	1	Nome River	
7/14	15443	4	5	N 64.53762	W 164.45116	M	560	0.3	1	Eldorado River	
7/14	15444	4	6	N 64.56473	W 164.22841	M	600	0.3	1	Bonanza River	
7/14	15448	4	6	N 64.56458	W 164.23021	M	573	0.3	2	Array 7	
7/16	15451	4	3	N 64.5225	W 165.62485	M	580	0.5	3	Array 3	
7/14	15452	4	6	N 64.56473	W 164.22841	M	551	0.4	3	array 6	
7/13	15457	4	2	N 64.53176	W -165.71555	F	600	0.3	1	Snake River	
7/14	15476	4	6	N 64.56473	W 164.22841	M	620	0.4	1	Nome River	
7/06	15482	3	3	N 64.47405	W 165.25076	F	555	0.4	3	Array 2	
6/27	15485	1	2	N 64.56115	W 166.03624	M	548	0.4	1	Eldorado River	
6/29	15486	2	6	N 64.56424	W 164.24944	M	546	0.4	1	Eldorado River	
6/29	15487	2	6	N 64.56424	W 164.24944	F	543	0.4	3	Array 5	
7/09	15488	3	2	N 64.5495	W 165.92601	M	568	0.3	3	Array 2	
6/29	15489	2	6	N 64.56424	W 164.24944	M	642	0.4	3	Array 5	
7/09	15490	3	2	N 64.5495	W 165.92601	M	585	0.3	2	Array 1	
6/26	15491	1	3	N 64.47057	W 165.2235	F	563	0.4	1	Eldorado River	
6/29	15492	2	5	N 64.53285	W 164.47806	M	613	0.5	3	Array 2	
7/14	15493	4	5	N 64.53762	W 164.45116	M	571	0.3	1	Bonanza River	
7/14	15500	4	6	N 64.56473	W 164.22841	M	520	0.2	1	Bonanza River	
7/14	15503	4	5	N 64.53474	W 164.46436	M	563	0.3	1	Solomon River	
7/14	15504	4	6	N 64.56458	W 164.23021	M	548	0.3	1	Bonanza River	
7/12	15505	3	3	N 64.47343	W 165.25061	M	580	0.4	1	Sinuk River	

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Date tagged	Tag number	Week tagged	Section	Tagging latitude	Tagging longitude	Sex	Length (mm)	Age	Fate	Last detection	Notes
6/29	15510	2	6	N 64.56424	W 164.24944	M	584	0.4	3	Array 2	
6/23	15511	1	5	N 64.51187	W 164.56703	F	579	0.5	3	Array 5	
7/12	15512	3	4	N 64.45333	W 165.11511	M	566	0.3	1	Cripple River	
7/14	15513	4	6	N 64.56473	W 164.22841	M	542	0.3	1	Bonanza River	
6/29	15514	2	5	N 64.53285	W 164.47806	M	588	0.4	1	Eldorado River	
6/26	15515	1	3	N 64.49891	W 165.43861	M	569	0.3	3	Array 3	
7/15	15516	4	4	N 64.44831	W 165.08551	M	556	0.3	1	Eldorado River	
6/27	15518	1	2	N 64.56115	W 166.03624	M	587	0.3	1	Nome River	
6/26	15519	1	4	N 64.45522	W 165.13062	M	600	0.4	3	Array 3	
7/09	15522	3	2	N 64.5495	W 165.92601	F	546	0.3	1	Penny River	
7/15	15523	4	4	N 64.45947	W 165.14763	F	591	0.4	1	Nome River	
7/14	15524	4	5	N 64.53762	W 164.45116	F	554	0.3	1	Bonanza River	
7/15	15525	4	4	N 64.44831	W 165.08551	F	614	0.5	1	Bonanza River	
7/12	15527	3	4	N 64.44868	W 165.08693	M	560	0.3	1	Nome River	
7/08	15529	3	2	N 64.57088	W 166.136	M	545	0.3	1	Sinuk River	
7/14	15530	4	5	N 64.53474	W 164.46436	M	554	0.3	3	Array 2	
7/08	15531	3	1	N 64.57446	W 166.16801	F	540	0.4	1	Sinuk River	
7/09	15532	3	2	N 64.5495	W 165.92601	F	603	0.4	1	Sinuk River	
7/14	15534	4	6	N 64.56458	W 164.23021	M	558	ND	1	Bonanza River	
7/12	15537	3	4	N 64.45333	W 165.11511	M	587	0.3	1	Bonanza River	
7/12	15538	3	4	N 64.44868	W 165.08693	M	554	0.3	1	Bonanza River	
7/13	15540	4	2	N 64.53176	W -165.71555	M	597	0.3	1	Eldorado River	
7/12	15543	3	4	N 64.44868	W 165.08693	F	571	0.3	1	Nome River	
7/12	15549	3	4	N 64.45737	W 165.13747	M	570	0.3	1	Sinuk River	
7/12	15552	3	4	N 64.45333	W 165.11511	M	569	0.3	1	Snake River	
7/13	15555	4	1	N 64.57581	W 166.16832	M	568	0.4	1	Sinuk River	
7/15	15556	4	4	N 64.44149	W 165.04834	F	525	0.2	1	Eldorado River	
7/16	15558	4	3	N 64.5225	W 165.62485	M	548	0.4	1	Sinuk River	
7/09	15559	3	2	N 64.5495	W 165.92601	M	560	0.3	2	Array 1	
7/15	15561	4	4	N 64.44079	W 164.0511	F	566	0.3	3	Array 2	
7/12	15562	3	4	N 64.44868	W 165.08693	M	560	0.4	1	Nome River	
7/12	15563	3	4	N 64.45333	W 165.11511	F	528	0.4	3	Array 5	
7/12	15564	3	4	N 64.44868	W 165.08693	M	540	0.3	1	Bonanza River	
7/14	15568	4	6	N 64.56458	W 164.23021	M	628	0.4	2	Array 7	
7/16	15569	4	2	N 64.53796	W 165.85577	F	569	0.5	4		
7/15	15570	4	3	N 64.47286	W 165.23778	F	565	0.3	1	Penny River	