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Chignik River System Sockeye Salmon Smolt Sampling Report, 2021–2022

by

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and

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June 2023

Alaska Department of Fish and Game **Division of 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

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ABSTRACT

This report describes the results of the sockeye salmon *Oncorhynchus nerka* smolt monitoring project conducted by the Alaska Department of Fish and Game in the Chignik River system in 2021 and 2022. The research was designed to assess fish body condition and document relative abundance and outmigration timing in the Chignik River watershed. Sockeye salmon smolt were captured using a beach seine in Chignik Lagoon. In 2021, 1,348 ageable scale samples were collected. Of these, 974 (72.3%) were freshwater-age-1 and 370 (27.5%) were freshwater-age-2 smolt. In 2022, 1,378 ageable scale samples were collected. Of these, 752 (54.6%) were freshwater-age-1 and 377 (27.4%) were freshwater-age-2 smolt. Sockeye smolt were of above-average body condition in 2021 and 2022 when compared to historical data.

Keywords: sockeye salmon, smolt, *Oncorhynchus nerka*, Chignik River, beach seine, condition factor

INTRODUCTION

Located on the southern side of the Alaska Peninsula in western Alaska, the Chignik River system produces the majority of the sockeye salmon *Oncorhynchus nerka* within the Chignik Management Area (CMA; Burnside and Fuerst 2023). The salmon resources of this area are important for local residents, and all 5 species of North American Pacific salmon common in North America are commercially harvested in the CMA: Chinook *O. tshawytscha,* sockeye *O. nerka*, coho *O. kisutch*, pink *O. gorbuscha*, and chum *O. keta* salmon. Sockeye salmon are the primary commercial and subsistence resource in the area, while Chinook and coho salmon are targeted in area sport fisheries.

The Chignik watershed consists of a lagoon, two large lakes, and several tributaries that provide spawning and rearing habitat for juvenile salmon (Figure 1). Black Lake, at the head of the system, has a surface area of approximately 41.1 km^2 and is shallow (mean depth 1.5 m), is turbid, and surrounded by low relief. Black Lake drains via the Black River into Chignik Lake, which is deeper (maximum depth 64 m), and surrounded by mountains (Bouwens and Finkle 2003). Chignik Lake then drains via the Chignik River into Chignik Lagoon and into the Gulf of Alaska (Chasco et al. 2003; Dahlberg 1968; Narver 1966). Chignik Lagoon is a semi-enclosed estuary with salinities ranging from full marine seawater at the outer spit to nearly freshwater conditions at the head of the lagoon (Simmons et al. 2013) but varies accordingly based on tidal cycle and wind direction.

Black Lake is a highly productive lake which provides excellent potential rearing habitat (Griffiths et al. 2013). However, numerous studies show Black Lake water levels have decreased since the 1960s. Reported decreases in water surface elevation range from 0.5 to 2.2 meters resulting in volume reductions of 23% to 44% (CH2MHILL 1994, Dahlberg 1968, Elhakeem and Papanicolaou 2008; Griffiths et al. 2011; USACE 2012). Black Lake water temperatures are highly influenced by air temperatures (Griffiths et al. 2011), and air temperatures have been consistently above average since 2013 (as recorded at the Cold Bay airport; Figure 2). Although warmer waters can be beneficial to growth rates of juvenile salmon, as summer water temperatures increase past a certain threshold, the metabolic demands on juvenile salmon exceed the benefits provided by Black Lake's productive habitat, and sockeye salmon juveniles migrate to Chignik Lake (Brett et al. 1969; Finkle 2004).

Each lake and associated tributaries maintain their own genetically distinct runs of adult sockeye salmon (Creelman et al. 2011, Templin et al. 1999;). Early-run sockeye salmon are generally bound for the spawning ground tributaries of Black Lake while the late-run sockeye salmon are generally bound for tributaries and shoals of Chignik Lake (Narver 1963). Juvenile early-run sockeye salmon generally do not overwinter in Black Lake and thus must migrate downstream at

variable times in the summer (Bouwens and Finkle 2003, Ruggerone 1993) to rear and then overwinter in Chignik Lake as well as utilize Chignik Lagoon where the continual presence of juvenile sockeye is documented throughout the summer months (Simmons et al. 2013, Walsworth et al. 2015). Furthermore, Westley (et al. 2008) indicated fry emigration was earlier during warm er years than cooler years. Consequently, food and habitat resources can become highly exploited by juvenile salmon within Chignik Lake (Perez-Fuentetaja et al. 1999). While spawn timing and spawn locations tend to be separate, the early and late-run life histories converge within Chignik Lake and Lagoon. Estimating the number and distribution of juvenile sockeye salmon rearing in Chignik Lake and determining their age and condition are particularly important metrics in assessing the habitat productivity of the watershed as a whole.

Interest in smolt data increased in the mid-2000s with the adoption of the Policy for the Statewide Escapement Goals (5 AAC 39.223). In the last 15 years, juvenile salmon projects have increasingly been recognized as priority research programs throughout Alaska and the Pacific Northwest, as scientists and other stakeholder groups have identified the need for freshwater investigations and data on salmon early life stages (e.g. DeCino 2014; Duesterloh 2007; Gerken, J. and S. Sethi. 2013; Loewen and Baechler 2014; Nemeth et al. 2014; Thomsen and Ruhl 2015) and data on salmon early life stages.

Smolt research provides information used in life-history brood tables needed to improve forecasts, evaluate escapement goals, and examine effects of ocean conditions on stock productivity. The Alaska Department of Fish and Game (ADF&G) monitored the sockeye salmon smolt outmigration in the Chignik River annually from 1994 to 2016, and collected data was used to gauge the health of smolt leaving the system, estimate age composition of the outmigrating population, and estimate marine survival (Loewen and Henslee 2017). After the project was discontinued and not conducted in 2017 and 2018, the Chignik River system sockeye salmon smolt project was reinitiated in 2019 in order to resume smolt outmigration monitoring efforts.

Salmon smolt outmigration may be triggered by warming springtime water temperatures (>4 °C), increased photoperiod (Clarke and Hirano 1995), and smolt size (Rice et al. 1994). In the Chignik watershed, outmigration typically occurs between April and July. Sockeye salmon rearing in Chignik and Black Lakes are exposed to different types and levels of environmental stress that may influence their life history strategies such as outmigration timing. Variables affecting growth in juvenile salmon include temperature, competition, food quality and availability, and water chemistry characteristics (Edmundson and Mazumder 2001; Moyle and Cech 1988, Quinn 2005). Smolt age, weight, and length (AWL) data are crucial elements of the freshwater production of salmon in helping to understand the overall health of the population leaving fresh water and to make inferences about survival during the early marine stages of the life cycle (Groot and Margolis 1991). Over the course of the original Chignik watershed smolt project, changes in outmigration timing and smolt condition were observed, highlighting the variable nature of the freshwater habitat and the need to distinguish freshwater factors and marine drivers of overall salmon productivity (Loewen and Henslee 2017, St. Saviour and Shedd 2014).

The 2021 and 2022 field seasons were the 3rd and 4th year of the ADF&G Chignik River system sockeye salmon smolt sampling project (Olson 2020). This project diverges from previous smolt sampling efforts in Chignik as all smolt were captured by beach seine in Chignik Lagoon whereas, from 1994–2016, smolt were primarily captured using rotary screw traps in Chignik River and monthly beach seining in the lagoon (Loewen and Henslee 2017; Figure 3). This report presents data collected in 2021 and 2022 and compares the results to previous years smolt data.

OBJECTIVES

The objectives for the 2021 and 2022 seasons were as follows:

Describe sockeye salmon smolt growth characteristics (length, weight, and condition factor), by age class within Chignik River.

Document juvenile salmon relative abundance and timing within the Chignik watershed.

METHODS

STUDY SITE AND BEACH SEINE DESCRIPTION

Juvenile salmon rearing in Chignik Lagoon were sampled 3 times per week (late May through June) using a 3 mm mesh, 15 m long, 1 m deep beach seine. Seine sets were conducted at Beach Seine site 1 (locally known as Peter's Point (56°16.275 N 158°40.459 W [North American Datum 1983]; Figure 4), located approximately 5.2 km downstream from the outlet of Chignik Lake (Olson 2020). This site features minimal current around a small, heavily-vegetated peninsula that is regularly inundated on high tides. Beach seine methodology is outlined in Olson (2020).

SMOLT ENUMERATION AND IDENTIFICATION

Juvenile sockeye salmon greater than 45 mm fork length (FL; measured from tip of snout to fork of tail) were considered smolt (Thedinga et al. 1994). All fish caught in the beach seine were transferred to a sorting tote, identified to species (McConnell and Snyder 1972; Pollard et al. 1997), enumerated, and released, except for those retained for AWL samples. In addition to sockeye salmon smolt, sockeye salmon fry (<45 mm FL), coho salmon smolt, coho salmon fry, Chinook salmon fry, pink salmon fry, Dolly Varden *Salvelinus malma*, stickleback of the family *Gasterosteidae*, pond smelt *Hypomesus olidus*, pygmy whitefish *Prosopium coulteri*, and starry flounder *Platichthys stellatus*, (Merrit and Cummings 1984; Pennak 1989) were captured and enumerated in the seine. All beach seining efforts started approximately 2 hours before high tide.

AGE, WEIGHT, AND LENGTH SAMPLING

At least 240 sockeye salmon smolt were randomly collected for over 3 sampling sessions per week and sampled for AWL. This sample size (n=240) enables all age classes to be simultaneously estimated within ± 6.5% of the true proportions with 90% confidence (Thompson 1987). Retained smolt were anesthetized individually in a weak Tricane Methanesulfonate (MS-222) solution (about 1 gram per 2 liters of water) and fork length was measured to the nearest 1 mm. Sampled smolt were also weighed to the nearest 0.1 g, and scales were removed from the preferred area (INPFC 1963), mounted on a microscope slide, and later examined for age determination. Age was estimated from scales under 60X magnification and described using the European notation (Koo 1962). Fulton's condition factor (*K*; Bagenal and Tesch 1978) was determined for each smolt sampled using

$$K = \frac{W}{L^3} 10^5$$

where *K* is smolt condition factor, *W* is weight in g, and *L* is FL in mm. All sampled fish were marked with a caudal fin clip to prevent double resampling. After sampling, live fish were held in aerated water until they completely recovered from the anesthetic and were released at the weir site.

HABITAT MONITORING AND PHYSICAL DATA

Water depth (ft; at the weir bulkhead), air and surface water temperatures (°C), estimated cloud cover (%), and estimated wind velocity (miles per hour) and direction were recorded on sampling days at the weir site. Water temperature (°C) was separately measured and recorded at Beach Seine Site 1 prior to smolt capture efforts. Water depth at Chignik River weir was also retrospectively download from the USGS water stage height observation database: (https://waterdata.usgs.gov/ak/nwis/inventory/?site_no=15297585&agency_cd=USGS&).

RESULTS

SAMPLING CATCH AND EFFORT

In 2021, a total of 3,395 sockeye salmon smolt were captured in 32 beach seine sets over 16 sampling events between May 23 and June 30 (Appendix A1). 2,961 sockeye salmon fry, 849 coho salmon smolt, and 376 coho salmon fry were also captured over the course of the season. Total catch, by date, is reported in Appendix A1.

In 2022, a total of 3,175 sockeye salmon smolt were captured in 35 beach seine sets over 18 sampling sessions between May 23 and June 29 (Appendix A2). 7,819 sockeye salmon fry, 469 coho salmon smolt, and 445 coho salmon fry were also captured over the course of the season. Total catch, by date, is reported in Appendix A2.

AGE, WEIGHT, AND LENGTH DATA

In 2021, a total of 1,348 ageable samples were collected from sockeye salmon smolt for AWL data (Table 1). Freshwater-age-1 (974 fish, 72.3%) and age-2 (370 fish, 27.5%) smolt made up the vast majority of the sampled smolt (Table 2, Figure 5).

In 2022, a total of 1,378 ageable samples were collected from sockeye salmon smolt for AWL data (Table 1). Freshwater-age-1 (752 fish, 54.6%) and age-2 (377 fish, 27.4%) and age-0 (249 fish, 18.0%) smolt made up the majority of the sampled smolt (Table 3, Figure 5).

The mean length, weight, and condition factor *K* of sampled smolt is shown in tables 2 through 4 and Figures 6 and 7. Overall mean condition factor increased from 2020 to 2022 (Figure 7). Weekly mean condition factor generally increased throughout the season for sampled fish of all age classes (Tables 2 and 3).

PHYSICAL DATA

In 2021, water temperatures measured at Beach Seine Site 1 varied from a low of 7°C on June 3 to a high of 11°C on June 26 and June 28 (Appendix B1). In 2022, water temperatures varied from a low of 7°C on May 23 to a high of 13°C between June 24 and June 29 (Appendix B2). Average water levels throughout the 2022 season were consistently 0.5 meters higher than in 2021 (Appendix B3) and 2020 (Olson 2022).

DISCUSSION

More sockeye smolt were captured in 2021 and 2022 (Appendix A) than in 2020 but was similar to the 2019 catch (Figure 8 and Tables 1 and 4; Olson 2022). Sockeye smolt catches can vary

widely on individual sampling days (Appendix A; Olson 2022). Standardized to a specific timeframe (May 27–June 30) 2022 sampling events demonstrated an increase in mean catch per set of sockeye salmon smolt compared to 2020–2021 (Figure 9), but was similar to 2019. Overall differences in mean, median, distribution, and outliers of mean catch per set were variable and complex and are not necessarily easily explained but could be due to a multitude of factors including climate, timing, and relative abundance. However, the catch per set of sockeye fry in 2022 was a marked increase compared to 2019–2021 and could therefore be indicative of increased abundance of sockeye fry in the lagoon.

Historically, the outmigration has been predominantly composed of freshwater-age-1 and freshwater-age-2 individuals (Figure 5). Freshwater-age-0 smolt were observed in noticeably high numbers from 2004 to 2009, 2019 and 2022, but were largely absent in 2021, but again present in 2022 (Figure 5). In 2022, freshwater-age-1 and -2 fish both decreased in average length and weight compared to 2021 (Figure 6) but overall have shown an increase in condition factor since 2020 (Figure 7).

It is important to understand the differences in timeframe and smolt capture methods of smolt throughout the project's history to understand the variation in the results. Changes in smolt sampling methods between different iterations of the Chignik smolt project have shown greater average annual condition factor in beach seine captured smolt (Figure 7). A major difference is timeframe and location; screw trapping was conducted upstream of the Chignik River weir and began roughly 2 to 3 weeks earlier than beach seining efforts conducted in Chignik Lagoon, thus variability could be explained by the timing and movement of smolt into new rearing habitat later in the spring and summer (Loewen and Henslee 2017, Figure 3). Furthermore, differences in gear type selectivity between these two methods is unknown. However, the rotary screw trap is a passive mechanism that juvenile smolt can technically swim away from depending on their swimming fitness. The beach seine method is an active method of capture wherein swimming fitness does not appear to have a distinct advantage in altering capture rates at the location used in Chignik Lagoon.

Various studies have demonstrated the potential advantages of increased size in sockeye salmon smolt. For instance, Henderson and Cass (1991) showed that larger smolt have a higher smolt-to-adult survival rate; for example, in Chilko Lake, they observed that a 14% increase in smolt FL resulted in a two- to threefold increase in smolt-to-adult survival in one brood year. Additionally, Wilson et al. (2021) found that wild sockeye salmon smolt with a Fulton's condition factor of 0.69 or less had a less than 50% probability of completing a 90 min swim test at 0.50 m/sec in a laboratory setting. In a natural setting, having lower condition factor (i.e., swimming fitness) might result in increased mortality due to predation. Thus, both studies underscore the potential impact of smolt condition on marine survival and on the commercial viability of future runs. Investigations of adult returns by smolt fork length or condition factor would be an excellent component to include in future analyses of Chignik smolt.

The sockeye salmon smolt sampling project provides important insight into the relative abundance and health associated with the freshwater portion of the sockeye salmon life cycle and is increasingly valuable as a potential indicator of changing conditions within the Chignik watershed. Continued monitoring of smolt outmigration and limnology is an effective way to detect changes in early life history strategies that may be deleterious to Chignik sockeye salmon fisheries.

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TABLES AND FIGURES

Table 1.–Estimated age composition of Chignik watershed sockeye salmon smolt samples, 1994–2022.

Year	Dates	Sample Size		Proportion of Smolt by Age					Total
				Age-0.	Age-1.	Age-2.	Age-3.	Age-4.	
1994	5/6–6/30	2,806	Percent	0.0	61.1	38.9	0.0	0.0	100.0
			Numbers	0	1,715	1,091	0	0	2,806
1995	5/6–6/29	2,557	Percent	10.7	49.8	39.5	0.0	0.0	100.0
			Numbers	273	1,274	1,010	0	0	2,557
1996	5/6–7/28	2,099	Percent	6.0	67.8	26.1	0.1	0.0	100.0
			Numbers	125	1,423	548	3	0	2,099
1997	5/4 – 7/22	2,657	Percent	7.3	63.1	29.1	0.5	0.0	100.0
			Numbers	195	1,676	774	12	0	2,657
1998	5/2–7/30	2,745	Percent	0.5	28.6	70.1	0.7	0.0	100.0
			Numbers	15	785	1,925	20	0	2,745
1999	5/10–7/3	2,180	Percent	1.8	61.7	36.1	0.3	0.0	100.0
			Numbers	40	1,345	788	7	0	2,180
2000	4/22–7/20	1,915	Percent	11.6	61.4	26.3	0.7	0.0	100.0
			Numbers	223	1,175	503	14	0	1,915
2001	4/29–7/12	2,195	Percent	4.4	75.0	17.7	2.8	0.0	100.0
			Numbers	96	1,647	389	62	1	2,195
2002	5/01–7/8	2,038	Percent	10.6	77.9	11.1	0.3	0.0	100.0
			Numbers	217	1,588	227	6	0	2,038
2003	4/25–7/8	2,098	Percent	7.1	79.6	13.3	0.0	0.0	100.0
			Numbers	149	1,670	279	0	0	2,098
2004	5/6–7/1	1,651	Percent	21.0	62.4	16.6	0.0	0.0	100.0
			Numbers	347	1,030	274	0	0	1,651
2005	4/26–7/8	1,950	Percent	33.5	45.7	20.4	0.4	0.0	100.0
			Numbers	654	892	397	7	0	1,950
2006	4/27–7/9	1,644	Percent	26.2	40.3	31.6	1.9	0.0	100.0
			Numbers	430	663	519	32	0.0	1,644
2007	5/9–7/8	1,087	Percent	0.6	74.4	25.0	0.0	0.0	100.0
			Numbers	6	809	272	0	0	1,087
2008	5/9 – 7/9	1,717	Percent	33.1	49.2	16.8	1.0	0.0	100.0
			Numbers	568	844	288	17	0	1,717
2009	5/6–7/7	1,201	Percent	16.6	49.0	34.4	0.0	0.0	100.0
			Numbers	199	589	413	0	0	1,201
2010	5/12–7/9	1,694	Percent	7.7	69.9	22.3	0.1	0.0	100.0
			Numbers	128	1,205	359	2	0	1,694
2011	5/2–7/4	1,660	Percent	6.0	84.4	9.6	0.0	0.0	100.0
			Numbers	100	1,401	159	0	0	1,660
2012	5/10–7/9	1,583	Percent	8.0	57.4	34.1	0.3	0.0	100.0
			Numbers	130	909	539	5	0	1,583
2013	5/12–7/3	1,473	Percent	2.0	53.8	42.9	1.1	0.0	100.0
			Numbers	32	793	632	16	0	1,473
2014	5/1–7/4	1,593	Percent	7.0	66.1	26.2	0.4	0.0	100.0
			Numbers	115	1,053	418	7	0	1,593

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Table 1.–Page 2 of 2.

Year	Dates	Sample Size		Proportion of Smolt by Age					Total
				Age-0.	Age-1.	Age-2.	Age-3.	Age-4.	
2015	4/17–6/12	1,716	Percent	3.0	73.6	23.7	0.1	0.0	100.0
			Numbers	45	1,263	406	2	0	1,716
2016	4/21–6/11	1,345	Percent	1.0	49.1	50.1	0.2	0.0	100.0
			Numbers	8	661	674	2	0	1,345
2017 [a]	N/A	–	Percent	–	–	–	–	–	–
			Numbers	–	–	–	–	–	–
2018 [a]	N/A	–	Percent	–	–	–	–	–	–
			Numbers	–	–	–	–	–	–
2019	6/2–7/2	1,221	Percent	45.4	52.5	2.1	0.0	0.0	100.0
			Numbers	554	641	26	0	0	1,221
2020	5/17–7/2	1,663	Percent	3.4	94.3	2.3	0.0	0.0	100.0
			Numbers	56	1,569	38	0	0	1,663
2021	5/23–6/30	1,348	Percent	0.0	72.3	27.5	0.0	0.0	100.0
			Numbers	4	974	370	0	0	1,348
2022	5/23–6/29	1,378	Percent	18.0	54.6	27.4	0.0	0.0	100.0
			Numbers	249	752	377	0	0	1,378

[a] AWL sampling did not occur in 2017 and 2018.

Table 2.–Mean length, weight, condition factor and SE of sockeye smolt by age and statistical week, Chignik Lagoon 2021.

				Length (mm)		Weight (g)		Condition Factor	
Age	Stat Week	Starting Date	Sample Size	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
0	21	5/17	1	54.0	0.00	1.1	0.00	0.70	0.00
0	23	5/31	2	54.0	0.00	1.3	0.00	0.83	0.00
0	24	6/7	1	58.0	0.00	1.9	0.00	0.97	0.00
Total			4	55.0	1.00	1.4	0.17	0.83	0.06
1	21	5/17	78	75.8	0.75	3.5	0.11	0.79	0.007
1	22	5/24	87	70.2	0.75	3.0	0.11	0.84	0.008
1	23	5/31	203	65.1	0.47	2.4	0.07	0.85	0.006
1	24	6/7	153	75.3	0.75	4.1	0.13	0.91	0.006
1	25	6/14	159	80.5	0.89	5.4	0.20	0.96	0.007
1	26	6/21	193	84.2	0.71	6.2	0.17	0.99	0.005
1	27	6/28	101	82.3	0.98	5.7	0.22	0.98	0.008
Total			974	76.1	0.36	4.4	0.07	0.91	0.003
2	21	5/17	41	81.0	0.82	4.2	0.15	0.77	0.007
2	22	5/24	33	78.6	0.87	4.0	0.14	0.83	0.009
2	23	5/31	44	76.5	0.93	3.9	0.16	0.86	0.014
2	24	6/7	99	83.5	0.81	5.6	0.20	0.93	0.007
2	25	6/14	82	89.4	0.79	7.1	0.23	0.97	0.008
2	26	6/21	60	92.2	0.72	8.0	0.22	1.00	0.010
2	27	6/28	11	93.4	1.3	8.0	0.4	0.97	0.019
Total			370	84.9	0.44	5.9	0.12	0.92	0.005

Table 3.–Mean length, weight, condition factor and SE of sockeye smolt by age and statistical week, Chignik Lagoon 2022.

				Length (mm)		Weight (g)		Condition Factor	
Age	Stat Week	Starting Date	Sample Size	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
0	21	5/17	26	49.8	0.93	1.2	0.09	0.95	0.032
0	22	5/24	39	52.6	0.68	1.7	0.11	1.13	0.070
0	23	5/31	33	54.5	0.42	1.4	0.04	0.88	0.015
0	24	6/7	102	54.3	0.43	1.5	0.04	0.91	0.010
0	25	6/14	9	58.0	1.59	1.9	0.17	0.98	0.055
0	26	6/21	32	55.9	0.81	1.7	0.07	0.94	0.014
0	27	6/28	8	56.6	3.06	1.8	0.23	0.96	0.032
Total			249	54.0	0.30	1.5	0.03	0.95	0.014
1	21	5/17	2	71.0	2.00	3.4	0.45	0.93	0.047
1	22	5/24	152	72.6	0.39	3.7	0.06	0.96	0.010
1	23	5/31	130	73.1	0.51	3.6	0.09	0.91	0.006
1	24	6/7	82	72.5	0.90	3.8	0.14	0.98	0.041
1	25	6/14	110	75.8	0.75	4.6	0.15	1.02	0.010
1	26	6/21	176	75.3	0.65	4.2	0.13	0.94	0.006
1	27	6/28	100	75.9	0.68	4.4	0.13	0.98	0.008
Total			752	74.2	0.26	4.1	0.05	0.96	0.006
2	22	5/24	66	75.3	0.82	4.2	0.16	0.97	0.020
2	23	5/31	88	75.6	0.57	4.0	0.12	0.91	0.007
2	24	6/7	43	75.0	0.71	4.1	0.14	0.96	0.012
2	25	6/14	85	78.2	0.64	5.0	0.14	1.02	0.012
2	26	6/21	70	82.2	1.07	5.8	0.28	1.00	0.009
2	27	6/28	25	85.3	2.3	6.5	0.6	1.00	0.019
Total			377	77.9	0.39	4.8	0.09	0.97	0.006

Table 4.–Mean length, weight, and condition factor and SE of sockeye salmon smolt samples, by year and freshwater-age, Chignik Lagoon 2019–2022.

		Length (mm)			Weight (g)			Condition Factor		
Year	Age	n	Mean	SE	n	Mean	SE	n	Mean	SE
2019	0	504	55.0	0.21	504	1.6	0.02	504	0.94	0.004
2020	0	56	53.6	0.61	56	1.4	0.05	56	0.91	0.010
2021	0	4	55.0	1.00	4	1.4	0.17	4	0.83	0.056
2022	0	249	54.0	0.30	249	1.5	0.03	249	0.95	0.014
2019	1	645	73.6	0.25	645	3.8	0.04	645	0.93	0.003
2020	1	1,569	70.1	0.10	1,569	2.7	0.02	1,569	0.78	0.002
2021	1	974	76.1	0.36	974	4.4	0.07	974	0.91	0.003
2022	1	752	74.2	0.26	752	4.1	0.05	752	0.96	0.006
2019	2	26	85.2	1.70	26	6	0.40	26	0.94	0.012
2020	2	38	83.3	1.07	38	4.9	0.19	38	0.83	0.010
2021	2	370	84.9	0.44	370	5.9	0.12	370	0.92	0.005
2022	2	377	77.9	0.39	370	4.8	0.09	370	0.97	0.006

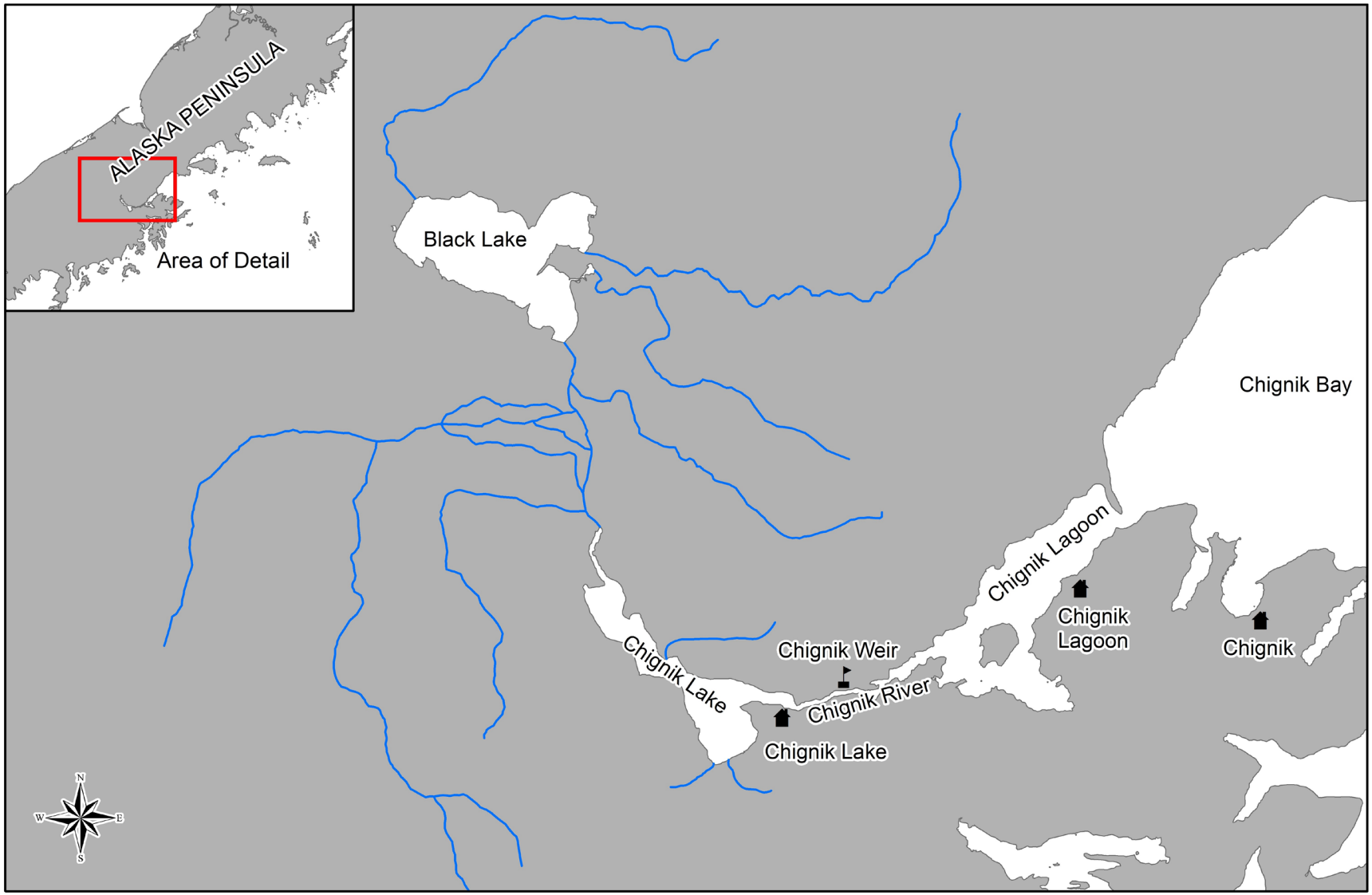

Figure 1.–Map of the Chignik watershed.

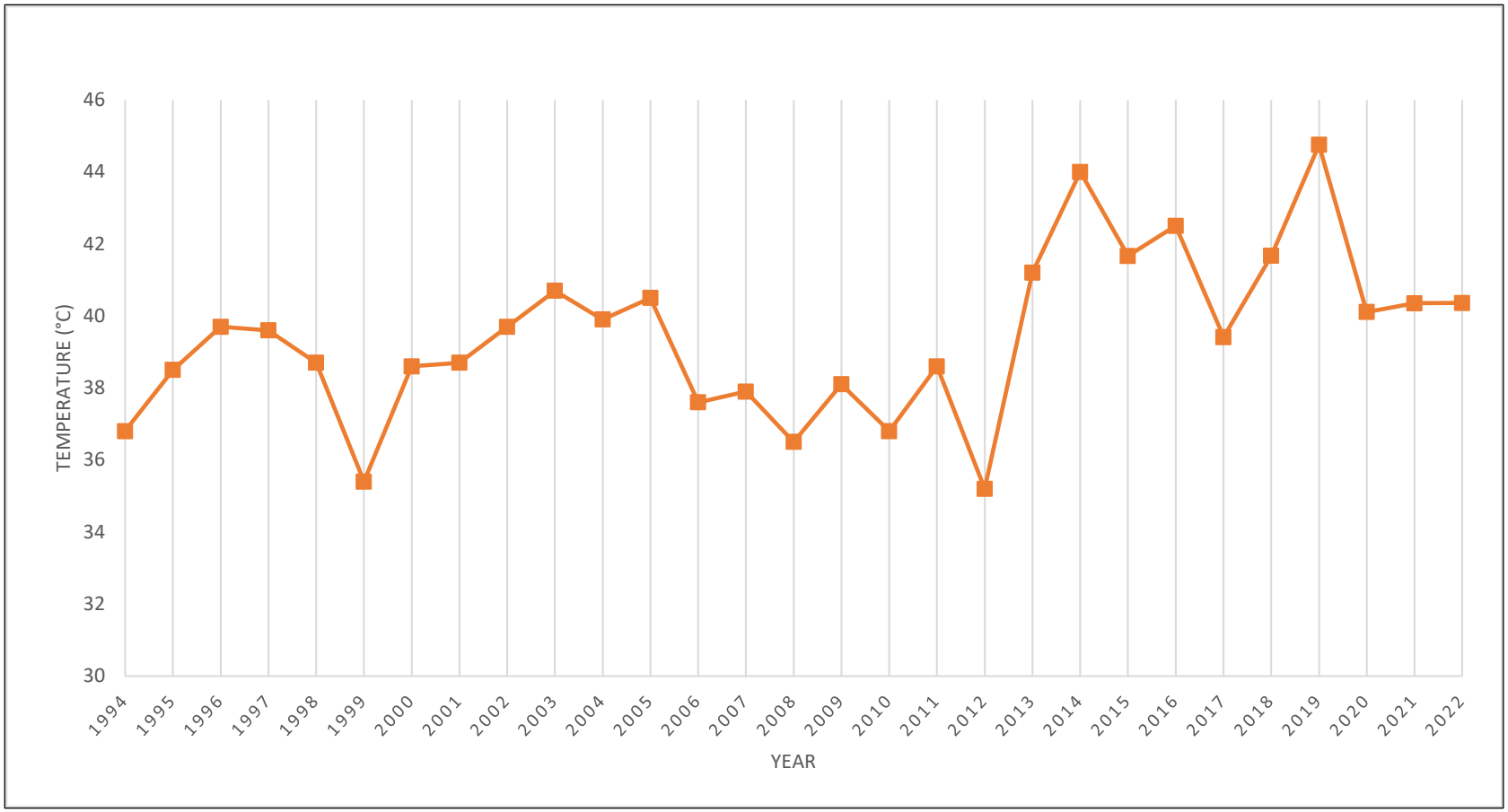

Figure 2.–Mean annual air temperatures, as measured at the Cold Bay Airport from 1994 through 2022.

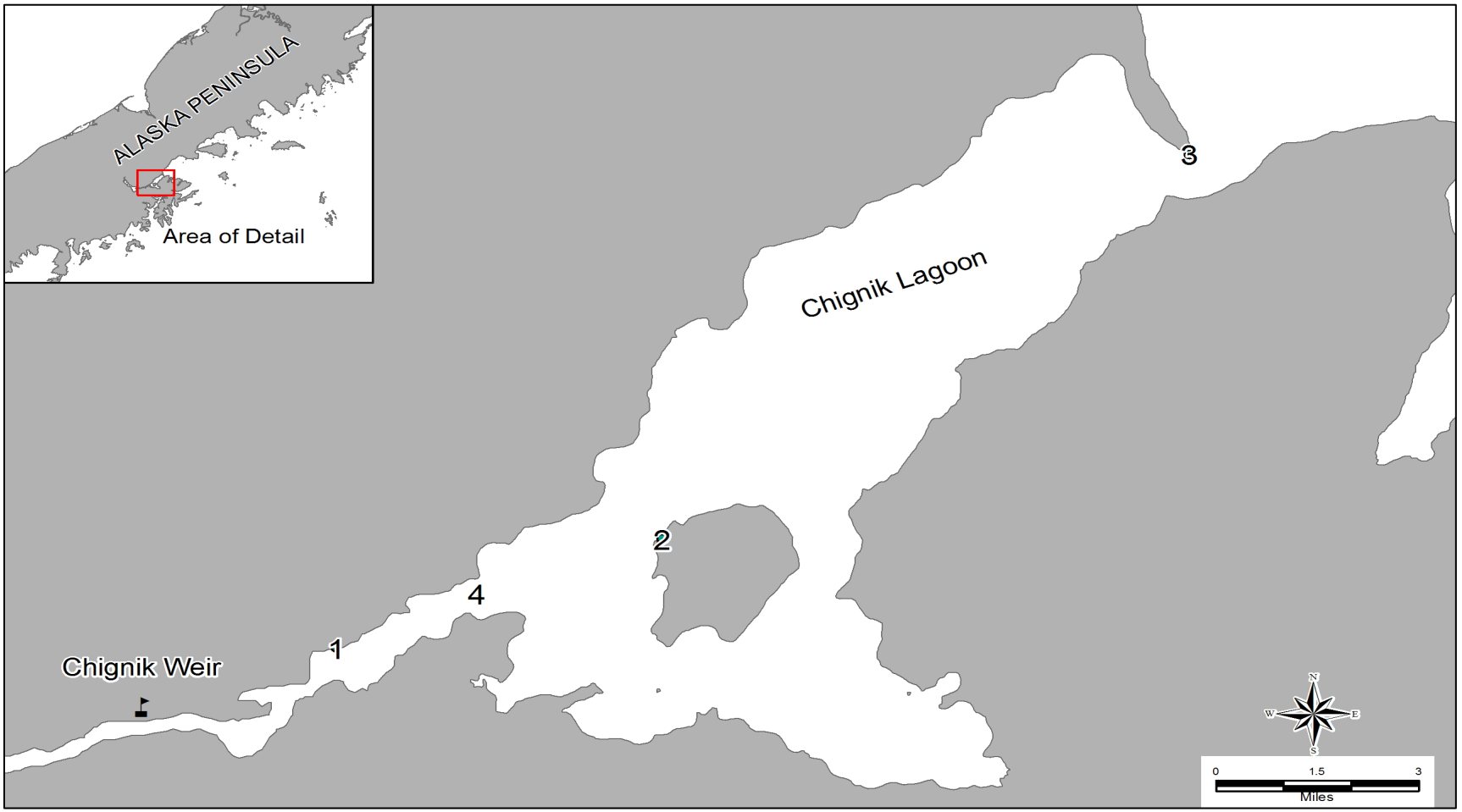

Figure 3.–Location of historical beach seine sites in Chignik Lagoon, 1994–2016.

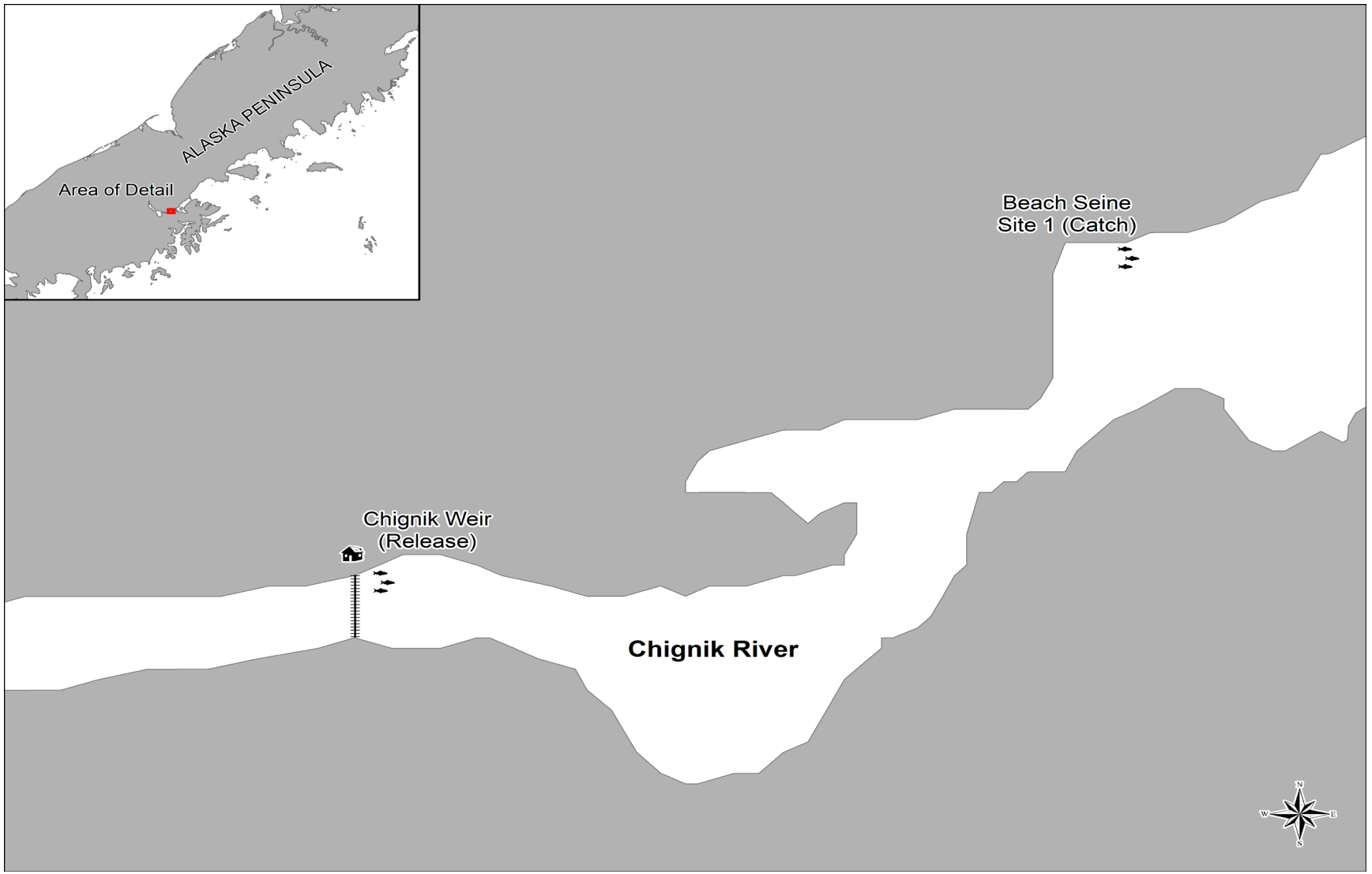

Figure 4.–Location of catch and release sites and the release site of sampled smolt in the Chignik River, Alaska, 2021–2022.

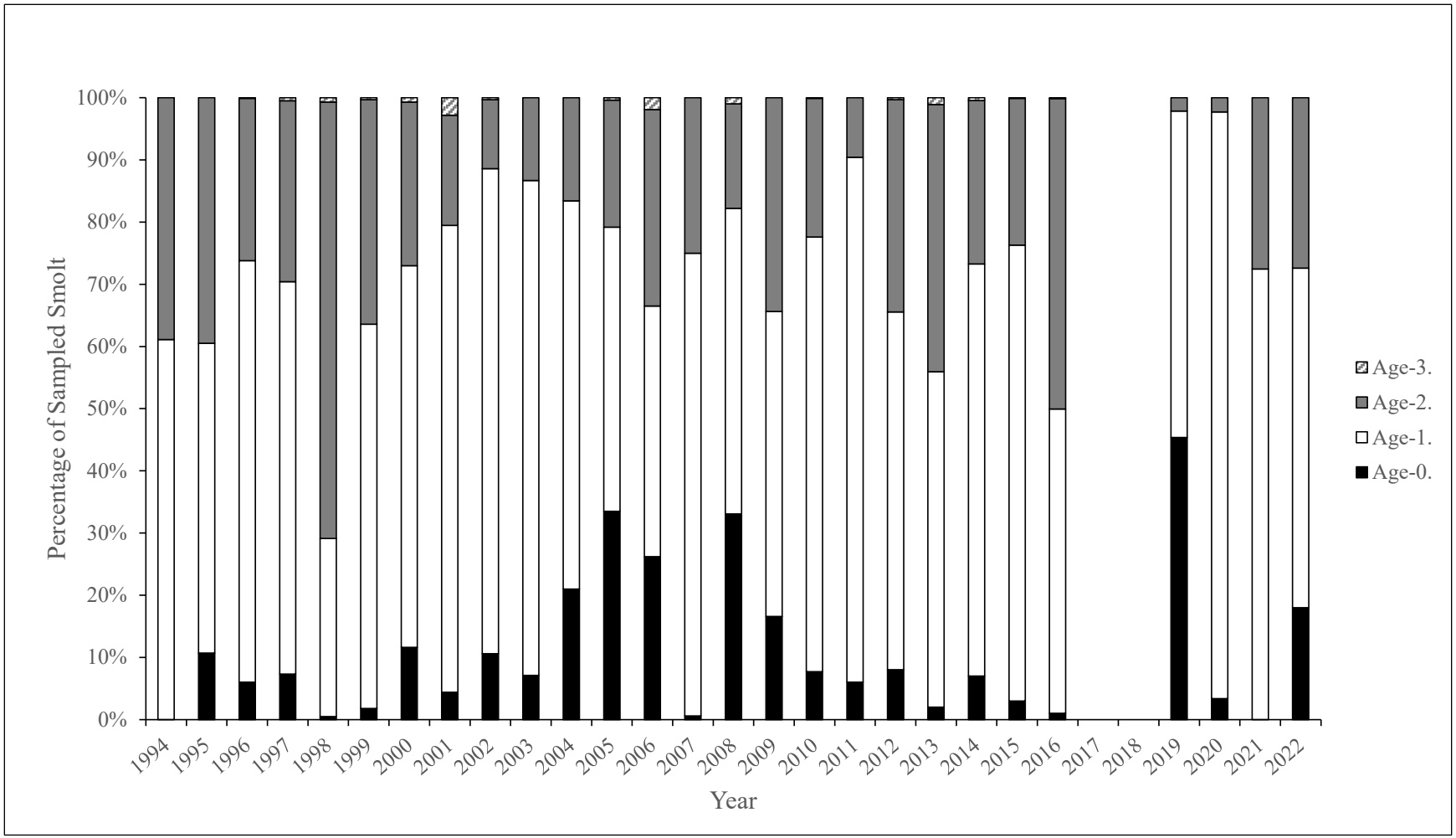

Figure 5.–Comparison of the estimated age structure of sampled freshwater-age-0 to freshwater-age-3 sockeye salmon smolt from Chignik watershed, 1994–2022.

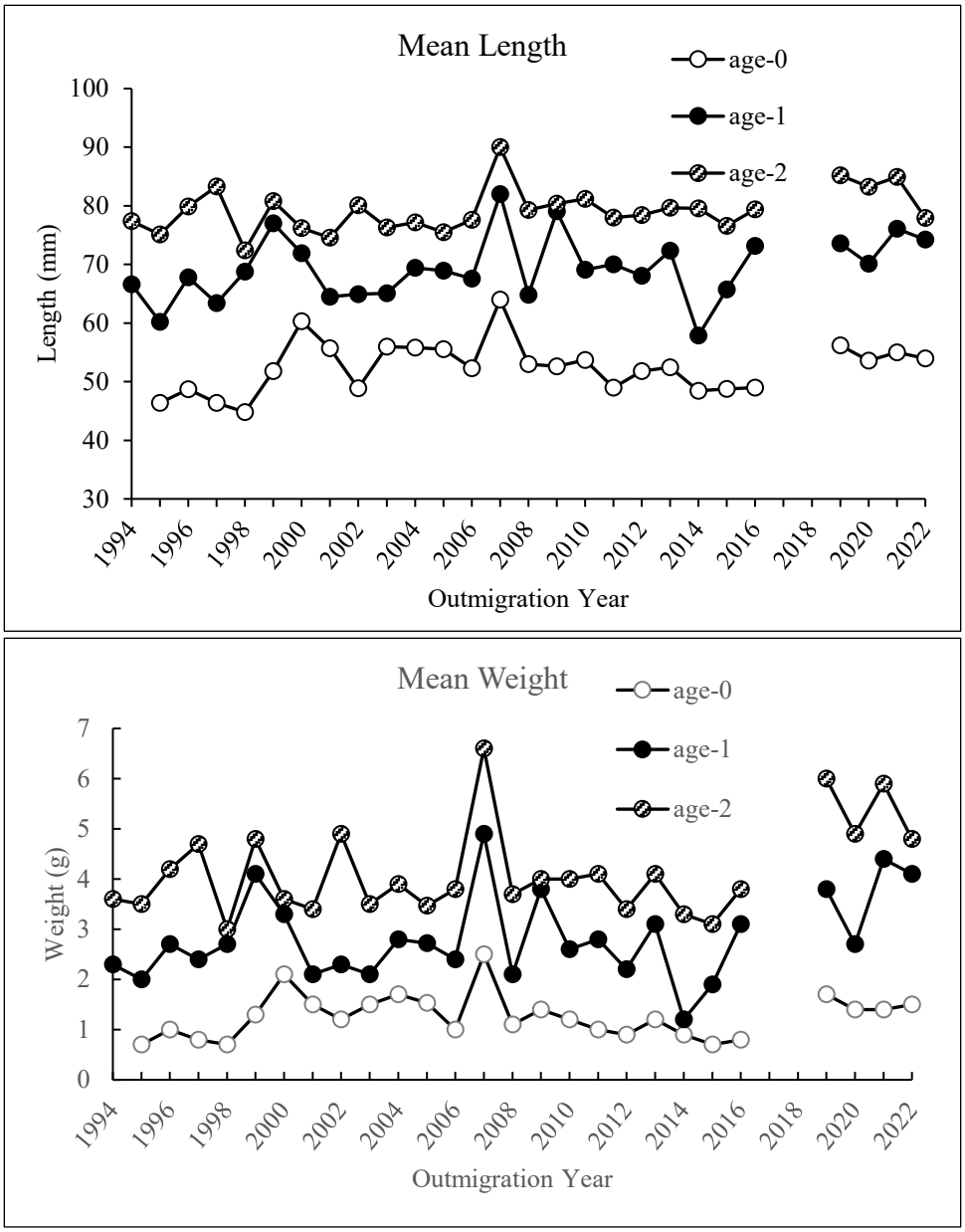

Figure 6.–Mean length and weight of sampled freshwater-age-0, freshwater-age-1, and freshwater-age-2 sockeye salmon smolt, by year, 1994–2022.

Note: AWL sampling did not occur in 2017 and 2018.

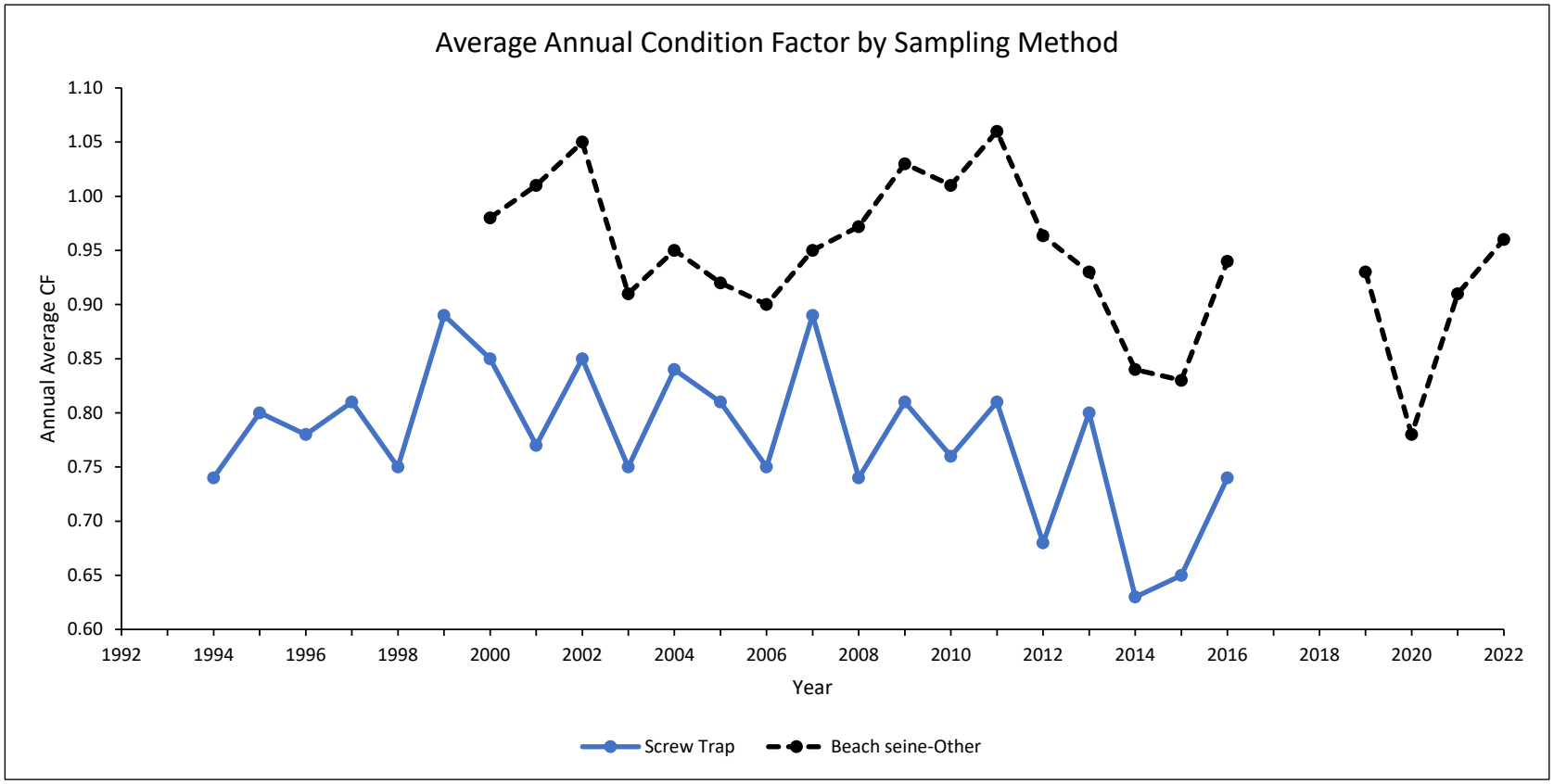

Figure 7.–Average annual condition factor by sampling method of outmigrating sockeye salmon smolt, Chignik, 1994–2022.

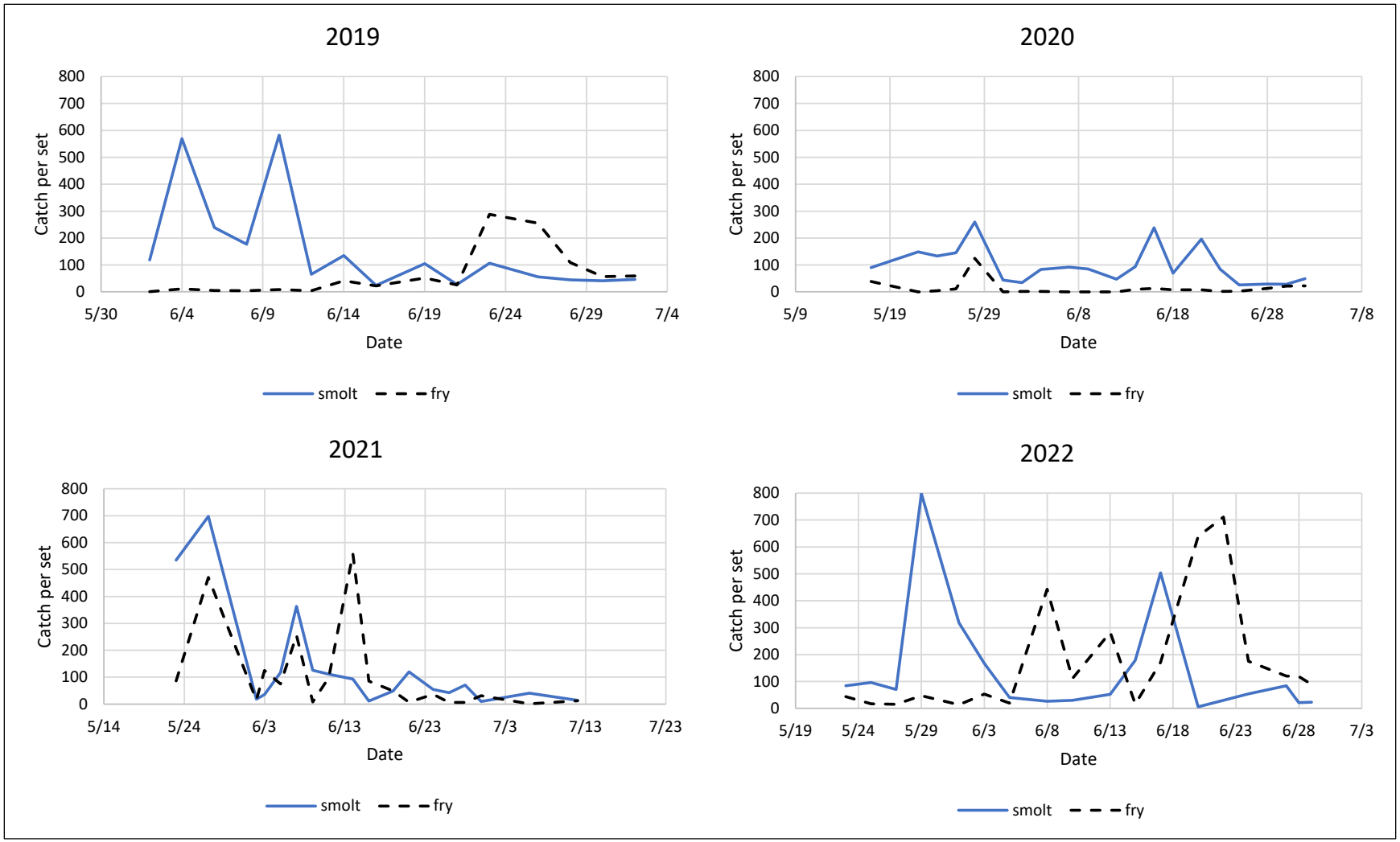

Figure 8.–Juvenile sockeye salmon catch per set in standardized beach seine project by day and life stage (smolt or fry), Chignik Lagoon, 2019–2022.

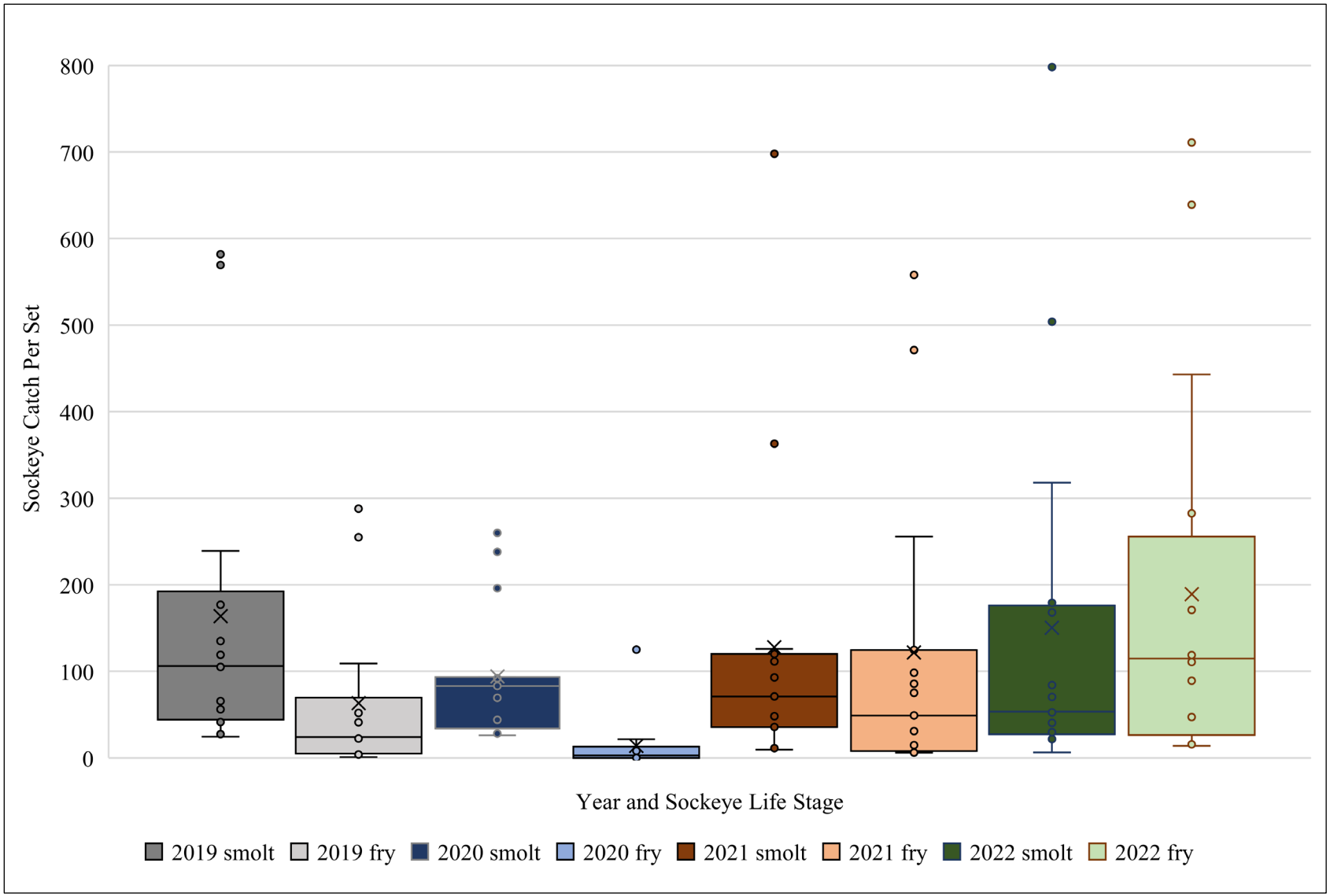

Figure 9.–Box plots showing mean, median, percentiles and range (standardized May 27–June 30 only) of sockeye salmon catch per set by year and life history stage, Chignik Lagoon 2019–2022.

APPENDIX A. BEACH SEINE CATCH DATA

Appendix A1.–Beach seine catch by species and day, Chignik Lagoon 2021.

Date	No. of Sets	Sockeye Smolt	Sockeye Fry	Coho	Coho Fry	Pink	Chn	Chum	DV	SB	SF	PS	PW	Other
5/23	1	535	86	3	20	0	0	0	0	583	0	0	8	1 Chn Fry
5/27	1	698	471	3	41	0	0	0	0	1,113	0	0	1	0
6/2	3	55	44	1	11	0	0	0	0	270	0	0	0	0
6/3	3	107	374	4	84	0	0	0	0	1,938	0	1	0	0
6/5	1	117	75	3	41	0	0	0	3	1,384	3	1	0	1 DV Fry
6/7	2	726	511	71	21	0	0	0	2	2,475	0	4	0	1 DV Fry
6/9	1	126	8	4	15	0	0	0	6	1,067	0	0	0	1 Chn Fry
6/11	2	223	197	46	33	0	0	0	11	4,900	1	0	2	1 Chn Fry
6/14	1	93	558	68	66	0	0	0	3	1,050	1	0	0	3 Chn Fry
6/16	3	34	257	41	2	0	0	0	2	143	0	0	0	0
6/19	3	144	147	121	18	0	0	0	6	2,485	0	0	2	0
6/21	1	120	7	380	5	0	0	0	3	816	0	0	0	0
6/24	3	162	109	46	7	1	0	0	0	297	0	0	0	0
6/26	2	85	12	15	8	0	0	0	1	895	0	0	0	1 Chn Fry
6/28	2	142	12	29	3	0	0	0	1	427	0	1	1	1 Chn Fry
6/30	3	28	93	14	1	0	0	0	0	1,445	0	0	0	0
Total	32	3,395	2,961	849	376	1	0	0	38	21,288	5	7	14	8 Chn Fry, 2 DV Fry

Note: Coho = juvenile coho salmon, Pink = juvenile pink salmon, Chn = juvenile Chinook salmon, Chum = juvenile chum salmon, DV = Dolly Varden, SB = stickleback, SC = sculpin, SF = starry flounder, PS =pond smelt, and PW = pygmy whitefish.

Appendix A2.–Beach seine catch by species and day, Chignik Lagoon 2022.

Date	No. of Sets	Sockeye Smolt	Sockeye Fry	Coho	Coho Fry	Pink	Chn	Chum	DV	SB	SF	PS	PW	Other
5/23	1	84	44		9	1	0	0		10				
5/25	2	193	34	8	32	22	2	0	2	757	1	1		
5/27	2	141	31	5	6	6	0	0	5	796	2			
5/29	1	798	47	11	28	1	0	0	6	1,067		5	2	
6/1	1	318	14	16	7	0	0	0	11	158	1	5	8	
6/3	1	168	53	8	17	0	0	0	8	144		1	1	
6/5	2	81	39	5	3	0	0	0	2	1,664	2	2	2	
6/8	3	80	1,329	1	53	1	0	0	4	1,359	6		2	
6/10	3	89	332	12	16	0	0	0	4	657	7	1	1	
6/13	2	105	565	20	19	0	2	0	4	1,408	1			
6/15	1	179	16	19	6	0	1	0	5	4,300	2		2	
6/17	1	504	171	54	37	4	1	0	8	1,037		7	6	
6/20	3	19	1,917		26	0	0	0		138				
6/22	3	89	2,133	15	72	1	0	0	2	1,029	3		4	
6/24	2	109	351	51	25	2	0	0	3	921	1	80	4	
6/27	1	84	120	41	31	2	19	0	3	1,210		4	9	
6/28	3	65	356	114	23	0	20	0	5	1,668	2	18	25	
6/29	3	69	267	89	35	0	3	0	7	4,340	3	7	22	
Total	35	3,175	7,819	469	445	40	48	0	79	22,663	31	131	88	

Note: Coho = juvenile coho salmon, Pink = juvenile pink salmon, Chn = juvenile Chinook salmon, Chum = juvenile chum salmon, DV = Dolly Varden, SB = stickleback, SC = sculpin, SF = starry flounder, PS =pond smelt, and PW = pygmy whitefish.

APPENDIX B. PHYSICAL DATA

Appendix B1.–Physical observations on Chignik River by sampling day, 2021.

2021 Physical Observations

		Temperature		Cloud Cover	Wind		Stream Gauge	
Date	Time	Air (°C)	Water (°C)	(%)	Dir	Vel. (mph)	(ft)	Comments
5/23	1200	6	7	25	S	9	4.22	Sunny/Windy
5/27	1600	8	7	100	SE	4	4.25	Cloudy/Breezy
6/2	0800	5	7	90	SE	3	4.64	Overcast
6/3	0815	3	7	60	E	1	4.50	Partly Cloudy
6/5	1115	4	7	100	NW	11	4.42	Cloudy
6/7	1330	12	8	50	NW	8	4.40	Partly Cloudy/Windy
6/9	1440	9	8	100	NW	11	4.36	Overcast/Windy
6/11	1545	10	9	100	W	2	4.40	Overcast/Breezy
6/14	1715	7	8	100	SE	11	4.18	Overcast/Windy
6/16	0745	6	8	95	SE	5	5.04	Overcast/Breezy
6/19	0900	8	9	100	NE	6	4.20	Overcast/Breezy
6/21	1130	12	10	90	SE	7	4.16	Overcast/Breezy
6/24	1450	9	9	95	SE	10	4.40	Overcast/Rain/Windy
6/26	1615	9	11	95	S	9	4.92	Sunny/Windy
6/28	1730	11	11	95	S	5	4.86	Overcast/Windy
6/30	0630	7	10	100	SE	11	4.62	Overcast/Windy

Appendix B2.–Physical observations on Chignik River by sampling day, 2022.

2022 Physical Observations

		Temperature		Cloud Cover	Wind		Stream Gauge	
Date	Time	Air (°C)	Water (°C)	(%)	Dir	Vel. (mph)	(ft)	Comments
5/23	910		7	100	NW	10	N/A	OVC NW10
5/25	1030	13	8	50	SE	10	N/A	Part Cloudy SE10
5/27	1230		8	50	NW	25	N/A	Part Cloudy NW 20-25
5/29	1430	12		0	SW	20	N/A	Clear SW 20
6/1	1615	10	10	0	E	15	N/A	Clear E15
6/3	1800	13	7	0	SE	20	N/A	Clear SE20
6/5	1930	16	10	0	SE	5	N/A	Clear SE5
6/8	830	10	7	100	NW	5	N/A	OVC NW5
6/10	1100	12	11	100	SW	20	N/A	Smoke OVC SW15-20
6/13	1345	9	10	100	SW	20	N/A	OVC SW20
6/15	1500	15	12	50	SW	15	N/A	Part Cl SW15
6/17	1730	12	11	100	S	15	N/A	OVC S15
6/20	630	8	9	50	W	5	N/A	Part Cl W5
6/22	930	9	10	50	SW	20	N/A	Part Cl SW20
6/24	1245	14	13	50	E	20	N/A	Part Cl E20
6/27	1500	14	13	100	E	5	N/A	OVC E5
6/28	1515	14	13	50	SE	15	N/A	Part CL SE15
6/29	1545	15	13	50	E	15	N/A	Part CL E15

Appendix B3.–Chignik River stage height recorded at the ADF&G weir bulkhead by National Weather Service during smolt project duration, 2021–2022.