Fishery Management Report No. 14-26

Frazer Lake Fish Pass Season Report, 2013

by

Steven Thomsen

May 2014

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

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

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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FRAZER LAKE FISH PASS SEASON REPORT, 2013

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May 2014

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This document should be cited as:
Thomsen, S. 2014. Frazer Lake fish pass season report, 2013. Alaska Department of Fish and Game, Fishery Management Report No. 14-26, Anchorage.

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ABSTRACT

Frazer Lake is located on the southwestern side of Kodiak Island, about 113 km from the city of Kodiak, and drains into Dog Salmon Creek. Frazer Lake did not historically support runs of anadromous fish due to a 10 m barrier waterfall that prevented access to spawning habitat. From 1951 to 1971, sockeye salmon *Oncorhynchus nerka* were planted into Frazer Lake, and in 1962, a fish pass was constructed for adult salmon to bypass the falls and access Frazer Lake.

The Alaska Department of Fish and Game has been responsible for the operation and maintenance of the fish pass since 1959. These responsibilities include the enumeration and biological sampling of sockeye salmon adults and smolt. In addition to collecting biological data from sockeye salmon, ADF&G has collected limnological data on Frazer Lake since 1985.

The 2013 sockeye salmon escapement through Dog Salmon weir was 129,369 fish, and 136,059 fish were counted through the Frazer Fish Pass. The total estimated commercial harvest was 134,784 fish, which was below the ten-year average (218,343 fish), with a total run of 270,843 sockeye salmon. The adult sockeye salmon run was composed mostly of age-2.2 (47%) and 2.3 (29%) fish. In 2013, an estimated 1,644,166 sockeye salmon smolt outmigrated from Frazer Lake, of which 81% were age-2 sockeye salmon smolt.

Key words: Frazer Lake, Olga Bay, Dog Salmon Creek, Kodiak Management Area, *Oncorhynchus nerka*, sockeye salmon, fish pass, limnology, zooplankton

INTRODUCTION

BACKGROUND

Historically, a 10 m barrier waterfall blocked anadromous fish upstream access to Frazer Lake, prompting Alaska Territorial Department of Fisheries biologists to investigate the Frazer Lake drainage and determine the feasibility of an engineered fish pass to allow salmon access to Frazer Lake (Ziemer 1962; Figure 1). Sockeye salmon (*Oncorhynchus nerka)* were introduced into Frazer Lake beginning in 1951 using donor stocks from three lakes (Blackett 1979; Appendix A1). In 1962 an engineered fish pass was completed providing anadromous fish access into Frazer Lake (Ziemer 1962; Figures 1 and 3).

The run is now an important contributor to Kodiak Island's commercial salmon fishery with an estimated sockeye salmon run size ranging from approximately 118,000 to 712,000 fish for the most recent 10-year period (2003-2012; Table 1; Appendix C7). The Alaska Department of Fish and Game (ADF&G) has established an escapement goal range of 75,000 to 170,000 sockeye salmon for Frazer Lake (Sagalkin et al. 2013; Appendix A2).

In addition to being an important species to the commercial fishery, sockeye salmon are an important food source for the Kodiak brown bear (*Ursus arctos middendorfii*) and other wildlife on Kodiak Island. The creation of a sockeye salmon run at Frazer Lake has dramatically increased brown bear densities in the Frazer Lake area by providing a stable protein food source (Barnes 1990). As a result, the Kodiak National Wildlife Refuge initiated public bear-viewing at the Frazer Fish Pass.

Presently, the fish pass is operated each year from May through August to count salmon and ensure fish are moving through it efficiently. Other studies are done according to need and funding availability, and may include limnological sampling, estimating the abundance of sockeye salmon smolt outmigrating from the lake in the spring, renovating the fish pass structure, and counting other species of adult salmon that ascend the fish pass.

The intent of this report is to describe investigations in 2013. Historical data are included in appendices.

STUDY AREA

Frazer Lake (57°12'13.03"N latitude, 154°03'29.30"W longitude) is at an elevation of 108 m and is located approximately 113 km southwest of the City of Kodiak, within the Kodiak National Wildlife Refuge (Figure 1). The lake is the second largest on Kodiak Island (by volume and area) at 14.2 km long and 1.6 km wide, and it has a surface area of 16.1 km^2. Frazer Lake has a mean depth of 37.5 m, a maximum depth of 63.4 m, and a volume of approximately 527 km^3 (Figure 2; Finkle and Ruhl 2012b). The lake drains into Dog Salmon Creek, which is approximately 16.0 km long and empties into Olga Bay. A 10 m barrier waterfall is located approximately 1.0 km downstream of Frazer Lake on Dog Salmon Creek (Figure 3). In 1983, a weir was installed on Dog Salmon Creek 0.7 km upstream from Olga Bay to provide timely salmon escapement counts for more effective management of the commercial fishery in Olga Bay (Figure 1).

The only known resident fish in Frazer Lake are rainbow trout *O. mykiss*, Dolly Varden char *Salvenlinus malma*, threespine stickleback *Gasterosteus aculeatus,* and freshwater sculpin *Cottus aleuticus* (Blackett 1979).

HISTORY OF SALMON POPULATIONS IN FRAZER LAKE

Frazer Lake was barren of sockeye salmon until 1951. Sockeye salmon were introduced into Frazer Lake from three different donor stocks (Karluk and Red lakes on Kodiak Island, and Hidden Lake draining into Becharof Lake on the Alaska Peninsula). Transplants into the lake continued through 1971 (Blackett 1984; Burger et al. 2000; Appendix A1). The run was fully established by the late 1970s and is now managed for harvest and escapement in the Kodiak Management Area. Burger et al. (2000) found detectable genetic contributions from all three donor stocks from samples collected at Frazer Lake in 1995, although the Hidden Lake contribution was minimal. Preliminary data from more recent genetic sampling (2008 and 2011) conducted in Frazer Lake suggests Frazer fish are most similar to shoal spawners from Red Lake (M. Birch Foster, Fishery Biologist, ADF&G, Kodiak, unpublished data).

Chinook salmon (*O. tshawytscha*) fry were also transplanted into Dog Salmon Creek from 1966 through 1969, using Karluk River spawners as the donor stock (Appendix A1). This stock has produced small runs with a 10-year average of 109 adult Chinook salmon enumerated through the fish pass (2003-2012; Appendices C1 and C6), which is an increase from data reported in the late 1970s (70 fish; Blackett 1979) and the 1980s (100 fish; Barrett 1988).

Steelhead (*O. mykiss*), pink (*O. gorbushca*), and chum salmon (*O. keta*) are naturally present in the river below the falls (Blackett 1979). Steelhead have only been counted through the fish pass in 1995 (1 fish) and 2012 (6 fish; Appendix C1). Since completion of the fish pass, pink salmon have slowly colonized spawning habitat above the falls. Pink salmon counts through the fish pass have fluctuated considerably corresponding to fish pass closure dates and even versus odd years. For the recent 10-year period from 2003 through 2012, a median of 5 pink salmon and an average of 1,706 pink salmon have been counted through the fish pass each year (Appendices C1 and C5). The average number of pink salmon passing Dog Salmon weir during the same 10-years was 112,634 fish (Jackson and Keyse 2013). The number of chum salmon ascending the fish pass has decreased over time, averaging 1 fish in the last 10 years (Appendix C1).

HISTORY OF THE FISH PASS

Adult sockeye salmon began returning to the base of the barrier waterfall in Dog Salmon Creek in 1956 and were backpacked around the falls and released to continue their migration to the lake. Counts prior to 1962 represented the number of sockeye salmon backpacked around the falls, and not the total number that may have returned. In 1962, a pair of 64 m long fish passes were constructed to expedite fish passage (Blackett 1987; Figure 3).

Attempts to increase adult fish passage at Frazer Fish Pass have led to various redesigns of the fish pass and entrance structures (Blackett 1987; Barrett 1988; Sagalkin 2003). In the early 1970s, the entrance to the fish pass was realigned to face downstream to facilitate fish entrance and ascension. In addition to the entrance realignment, a fish diversion weir was installed to guide salmon toward the downstream entrance. Another pair of fish passes were added in 1979 to increase total fish passage. Citing design deficiencies, Barrett (1988) discontinued use of the newer fish passes. To maintain sufficient entrance attractant flow, only the original pair of fish passes, from 1962, have been used to pass fish in recent years.

By 2002 the fish diversion weir, entrance chute, upper sampling deck, and fish pass covers had aged and were in poor condition. In 2003 a permanent steel walkway was installed, an aluminum entrance chute was added, concrete repairs were made, rotten wood structures were rebuilt, and wooden fish pass covers were replaced with aluminum covers (Sagalkin 2003).

Although the fish pass was necessary to pass fish into the lake, it was located too far upriver from the ocean to be useful for inseason management of the newly developed commercial sockeye salmon fishery. In addition, the fish pass was not useful for chum or pink salmon inseason management because most of these populations spawned downstream of the pass. To improve inseason salmon management, a weir was installed near the mouth of Dog Salmon Creek in 1983, only 0.7 km upstream from Lower Olga Bay. The Dog Salmon weir has been operated annually since then, with travel time of sockeye salmon from the Dog Salmon weir through the top of the Frazer Fish Pass estimated at approximately 7 days (Barrett 1988).

Since the first year the Dog Salmon weir was installed, there have been discrepancies between the final Dog Salmon weir and Frazer Fish Pass counts. Notably, as many as 105,602 (2004) sockeye salmon have been counted through Dog Salmon weir but did not ascend the fish pass (Appendix C7). These count differences have been the subject of extensive speculation and have been variously attributed to fish spawning in the river before reaching the fish pass, predation by Kodiak brown bears, and an inability to ascend the fish pass. The fish pass infrastructure currently consists of a diversion weir below the falls that guides returning spawners to one side of the river, where they encounter an aluminum chute at the bottom of the fish pass. Both the weir and the chute are effective at orienting fish to the pass but are also places of high fish congestion and subsequent exploitation by bears.

Because salmon entry and passage rates through the fish pass are dependent on the volume of water flowing through or next to the fish pass (Blackett 1987), a small water diversion weir (4 feet in length) was installed perpendicular to the fish diversion weir to redirect flow toward the fish pass entrance in 2006. In 2012 and 2013, the length of the small water diversion weir was extended to 16 feet (Figure 4). Increasing the length of the extension appears to have improved fish passage and helped reduce the number of sockeye salmon remaining in Dog Salmon Creek that do not ascend the fish pass (Appendix C7).

ESCAPEMENT GOALS

The Frazer Lake sockeye salmon escapement goal has been reviewed and modified several times since the 1950s (ADF&G 1999; Nelson and Lloyd 2001; Nelson et al. 2005; Honnold et al. 2007; Nemeth et. al 2010; Sagalkin et al. 2013; Appendix A2). The current sockeye salmon biological escapement goal (BEG) for Frazer Lake was established in 2007 (75,000–170,000 fish; Nemeth et. al 2010; Sagalkin et al. 2013; Appendix A2). The S_{msy} (maximum sustainable yield) is estimated at 117,000 sockeye salmon.

The addition of Dog Salmon Weir counts created confusion about which count (Dog Salmon Weir or Frazer Fish Pass) to use for the escapement goal. Although inconsistently applied when first established, the sockeye salmon count through Frazer Fish Pass was accepted as the Frazer Lake escapement (ADF&G 1999). Consequently, counts through the Dog Salmon Weir are utilized for management purposes only (determining fishing periods).

FERTILIZATION

Colonizing Frazer Lake with sockeye salmon resulted in substantial changes in the plankton community (Kyle et al. 1988). In an effort to maintain and increase the survival rates of sockeye salmon smolt by enhancing the productivity of the zooplankton community, a lake nutrient enhancement project was implemented between 1988 and 1992 (Schrof et al. 2000; Schrof and Honnold 2003). From mid-June to mid-August during these five years, an average of 7.6 tons/week of nitrogen-phosphorous fertilizer was aerially deposited over a 10 km^2 area of the lake. The phosphorous added was in the form of inorganic phosphate and the nitrogen was a mixture of ammonium, nitrate, and urea (Kyle 1994).

HISTORICAL SPAWNING, HABITAT USE, AND AERIAL SURVEYS

From 1965 through 1986, surveys were frequently conducted on Frazer Lake and its tributaries to learn more about the ecology and life history of the newly established sockeye salmon run. During this time, as much as 74% of the run spawned in 4 tributary streams and along the lake shoreline. Pinnell Creek, and the upper end of the lake, accounted for the majority of the spawners. Barrett (1988) noted an increase in the proportion of lake shore spawners and suggested the run was still colonizing and adapting to local habitat, with potential ramifications for future run timing and sub-population composition. Burger et al. (2000) agreed with this assessment, 14 years later, stating that Frazer Lake sockeye salmon population probably had not reached a demographic or genetic equilibrium and noting substantial changes in run timing, age structure, and spawning site use over the past 20 years. Burger et al. (2000) also found that reproductive adaptations from the donor stocks were preserved in Frazer Lake sockeye salmon progeny, with donors from the shoreline (Karluk Lake) spawning on the shoreline, donors from tributaries (Red Lake) spawning in tributaries, and donors from the outlet (Hidden Lake) spawning in the outlet. Preliminary results from more recent genetic sampling (2008−2013) indicate that Frazer sockeye salmon are more closely related to Red Lake stock (Birch Foster, Fishery Biologist, ADF&G, Kodiak, personal communication).

2013 SEASON

The overall Frazer Lake project goal was to optimize natural sockeye salmon production by providing unobstructed and timely adult fish passage into Frazer Lake, and to collect adult, smolt, and limnological data relevant to generating accurate preseason run forecasts, escapement goal evaluations, and monitoring the health of the sockeye salmon run and the ecosystem they utilize.

To achieve the overall project goal, ADF&G research personnel collected data to fulfill the following objectives:

<u>Smolt</u>

1. Estimate the abundance (*N*) of outmigrating sockeye salmon smolt within 30% (relative error) of the true value with 95% confidence;
2. Estimate the age composition of outmigrating sockeye salmon smolt within *d* = 0.05 of the true proportion (for each major age group within each stratum) with 95% confidence;
3. Estimate the average length (mm) and weight (g) by smolt age group and stratum;

<u>Adult salmon</u>

4. Enumerate the escapement of adult sockeye salmon returns through the fish pass while providing unobstructed and timely fish passage of adults to Frazer Lake;
5. Estimate the age and sex composition of adult sockeye salmon returns where estimates are within *d* = 0.07 of the true proportion (for each age group within each stratum) with 95% confidence;
6. Estimate the average length (mm) by age and sex; and

<u>Limnology</u>

7. Evaluate water chemistry, nutrients, phytoplankton, and zooplankton levels in Frazer Lake.

METHODS

Smolt Assessment

Trap Deployment and Assembly

A single inclined plane trap (Todd 1994; Figure 5) was operated 3 m upstream of the falls in the river's thalweg from May 7 through June 26, 2013. A catch box was attached to the cod-end of the trap, and the entire trapping system was connected to cables attached to each stream bank by come-along cable pullers. The trap was secured to an aluminum pipe frame, which allowed the trap to be adjusted in response to fluctuations in water level. The trapping system was removed when smolt counts diminished to fewer than 100 smolt for three consecutive days. Detailed methods of trap installation are described in the 2013 Frazer Operational Plan (Thomsen et al. 2013a).

Smolt Capture, Handling, and Sampling

The inclined-plane trap fished continuously throughout the season. A sampling day was designated as the 24-hour period from noon to noon with the sampling date corresponding with the first day. Smolt were collected throughout the migration and held in the catch box until they were counted or selected for sampling. During the night (2200 to 0800 hours), the live box was checked every 1 to 2 hours, depending on smolt abundance. During the day (0801 to 2159 hours), the live box was checked every 3 to 4 hours. All fish were removed from the live box with a dip net, identified, counted, and either released downstream of the trap or transferred to an instream holding box for sampling or marking. All smolt were visually identified and enumerated using a hand-held tally denominator, except when catch rates exceeded the crew's ability to count every smolt, in which case smolt numbers were estimated using a catch-weight method (Sagalkin 1999). Species identification was made by visual examination of external characteristics (Pollard et al. 1997). All data, including mortality counts, were entered on a reporting form each time the trap was checked. All fish were visually inspected for marks during mark-recapture, events including those encountered during catch-weight estimates.

For catch-weight estimates, the crew first recorded the weight of an empty perforated 5-gallon bucket. Smolt were then transferred to the bucket using a dip net. After excess water had drained from the bucket, the weight of the apparatus was recorded, and then all fish within the bucket were identified, enumerated, and released. This served as the reference measure. Subsequent buckets of fish were weighed, but not counted, before release. Every 10 catch weights, the bucket with smolt was weighed and all fish again identified and enumerated before release to establish new reference weights and species compositions.

On 5 days each week, 40 fish per day were randomly selected from the catch box, held in an instream live box, and sampled for age, weight, and length (AWL) data. Smolt were anesthetized using tricaine methanesulfonate (MS-222) prior to being sampled. Fork length was measured to the nearest 1 mm, and each smolt was weighed to the nearest 0.1 g. Scales were removed from the preferred area (International North Pacific Fisheries Commission 1963) and mounted on a microscope slide for age determination. After sampling, smolt were held in aerated buckets of water until they recovered from the anesthetic and then released downstream from the trap.

Additionally, the overall health or condition coefficient (Bagenal and Tesch 1978), which is a quantitative measure of the isometric growth of a fish and a relative index of fish health, was determined for each smolt sampled using

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

Detailed methods for smolt capture, handling, and sampling are provided in Thomsen et al. (2013a).

Trap Efficiency and Mark-Recapture Abundance Estimation

Total smolt abundance was estimated using single-site mark-recapture procedures (Carlson et al. 1998). Trap efficiency was estimated using mark-recapture trials within specific recapture periods (strata), generally weekly, when smolt numbers were sufficient. Trap efficiencies were adjusted to reflect delayed mortality testing data (described below) and then used to estimate the number of smolt outmigrating from the watershed during each stratum.

Releases of sockeye salmon smolt marked with Bismarck Brown Y dye were made once per stratum, as well as when changes were made to the trapping system. Based on prior smolt studies at Frazer Lake, an effort was made to achieve a trap efficiency of 5%. To estimate total smolt abundance each week with a 5% probability of exceeding a relative error (r) of 30%, 450 (10% trap efficiency) to 900 (5% trap efficiency) smolt would need to be marked and released for each experiment (Carlson et al. 1998; Robson and Regier 1964). Smolt utilized for the dye release were captured in the trap, transported to the release site 1.2 km upstream, and released at 2200 hours to coincide more closely with the natural outmigration.

To estimate any mortality associated with the marking and holding process, 150 (100 marked and 50 unmarked) fish were retained and monitored for 4 days. Marked and unmarked fish were retained separately in a live box under identical conditions to separate marking and holding mortality. Trap efficiency was adjusted using the mortality tests, reducing the number of smolt released to reflect marking mortality. Therefore, a total sample size of 1,050 was set as the goal for each experiment to account for any marking mortality. Actual numbers of fish marked, released, and retained for mortality testing varied by release event (Tables 2 and 3). Past mark retention and delayed mortality experiments on other smolt enumeration projects indicated that most of the captured smolt mortalities occurred within the first three days of capture (Bouwens and Newland 2003).

All smolt data collected were categorized into strata and statistical weeks to help recreate the smolt run. The statistical week is a perennial tool and was defined by a span of 7 days that is numbered consistently and used as an index. The stratum was defined as the period of time between dye-release tests. Additional methods for trap efficiency and mark-recapture abundance estimation are provided in Thomsen et al. (2013a).

Trap efficiency E_h for stratum h was calculated as

$$E_h = \frac{m_h + 1}{M_h + 1}, \tag{1}$$

where

m_h = number of marked smolt recaptured in stratum h

M_h = number of marked smolt released in stratum h

A modification of the stratified Petersen estimator (Carlson et al. 1998) was used to estimate the number of unmarked smolt U_h emigrating within each stratum h as

$$\hat{U}_h = \frac{u_h(M_h + 1)}{m_h + 1}, \tag{2}$$

where

u_h = number of unmarked smolt captured in stratum h.

Variance of the smolt abundance estimate was estimated as

$$\widehat{\mathrm{var}}\left(\hat{U}_h\right) = \frac{(M_h + 1)(u_h + m_h + 1)(M_h - m_h)u_h}{(m_h + 1)^2(m_h + 2)}. \tag{3}$$

Total abundance of U of unmarked smolt over all strata was estimated by

$$\hat{U} = \sum_{h=1}^{L} \hat{U}_h, \tag{4}$$

where L is the number of strata. Variance for $\hat{U}$ was estimated by

$$\widehat{\mathrm{var}}\left(\hat{U}\right) = \sum_{h=1}^{L} v\left(\hat{U}_h\right), \tag{5}$$

and 95% confidence intervals were estimated using

$$\hat{U} \pm 1.96\sqrt{v\left(\hat{U}\right)}, \tag{6}$$

which assumes that $\hat{U}$ is approximately normally distributed.

Within each stratum *h*, the total population size by age class *j* was estimated as,

$$\hat{U}_{jh} = \hat{U}_h \hat{\theta}_{jh}, \qquad (7)$$

where $\hat{\theta}_{jh}$ is the observed proportion of age class *j* in stratum *h*. Variance of $\hat{\theta}_{jh}$ was estimated using the standard variance estimate of a population proportion (Thompson 1987). The variance of $\hat{U}_{jh}$ was then estimated by

$$\hat{\text{var}}\left(\hat{U}_{jh}\right) = \hat{U}_h^{\,2} v\left(\hat{\theta}_{jh}\right) + \hat{U}_h v\left(\hat{\theta}_{jh}\right)^2 . \qquad (8)$$

The total number of outmigrating smolt within each age class was estimated by summing the individual strata estimates where the following assumptions were not violated (Carlson et al. 1998):

- The population was unchanging (i.e., it is a closed population with no immigration or emigration),
- all smolt had the same probability of being marked (i.e., trap is not selective and strata are consistent),
- all marked and unmarked smolt had the same probability of capture (i.e., marking fish does not affect their behavior or ability to be captured),
- all marked smolt released can be recovered (i.e., marking mortality is accurate),
- all marked smolt were identifiable (i.e., crew members are well trained and strata are discrete),
- and marks were retained after marking. (i.e., fish are effectively stained).

Adult Assessment

Fish Pass Operation and Adult Enumeration

The fish pass was operated continuously from June 9 through August 17. Many major components of the fish pass are permanently assembled and require minimal assembly (Figure 3). Major assembled components include two steeppasses, a cement entrance and exit (counting tank) structure, the cement portion of the upper water diversion above the falls, and the framework and walkway of the fish diversion weir (Figure 3). Major components needing assembly include weir panels and boards on the fish diversion weir, panels and stop logs on the upper water diversion, and the entire secondary lower water diversion assembly (Figures 3 and 4). Detailed methods of fish pass installation, operation, and maintenance are described in the 2013 Frazer Operational Plan (Thomsen et al. 2013a) and Blackett (1987).

Fish freely moved up the steeppass into a counting tank at the top of the fish pass upstream of the falls, where they remained until a gate was opened by personnel. Adult salmon were enumerated by personnel with hand-held tally denominators while exiting the counting tank. Counting frequency was dependent on the rate of fish passage.

Salmon entry and passage rates through the fish pass are dependent on the volume of water flowing through the fish pass (Blackett 1987). Water flow through the fish pass was adjusted by adding or taking away stop logs placed in the upper water diversion. In an effort to further expedite fish passage into the lake, water flow was redirected from the falls to the fish pass entrance by using a lower flow diversion placed perpendicular to the fish diversion weir (Figure 4).

Adult ASL Sampling

Adult sockeye salmon were randomly captured and sampled as they exited through the counting gate throughout the season. Eighty sockeye salmon per day were sampled for ASL data 3 times per week for a total of 240 fish per week. Detailed adult sampling methods are described in the 2013 Frazer Operational Plan (Thomsen et al. 2013a and b).

Scales were collected from the preferred area of each fish (INPFC 1963) and mounted on scale "gum" cards (Clutter and Whitesel 1956). Ages were assigned by criteria established by Mosher (1968). Ages were recorded using European notation (Koo 1962), sex was determined from external morphological characteristics, and length measurements were from mid-eye to tail fork to nearest 1 mm.

Limnological Assessment

In 2013, limnological assessment of Frazer Lake was conducted at two stations at approximately 4-week intervals from May to October. Parameters measured include temperature, dissolved oxygen, light attenuation, water clarity, pH, alkalinity, total phosphorus (TP), total filterable phosphorus (TFP), filterable reactive phosphorus (FRP), nitrate + nitrite (NO_3^- + NO_2^-; N+N), ammonia (NH_4^+; TA), total Kjeldahl nitrogen (TKN), chlorophyll-*a* (chl-*a*), and pheophytin-*a*. Also included were phytoplankton density, biomass, and size (by phylum); and zooplankton density, biomass, and size (to lowest possible taxonomic level). A temperature data logger was also positioned in the lake all season at limnology Station 3 (Figure 2). Detailed methods for sample collection are provided in Thomsen et al. (2013c), and detailed sample processing methods are provided in Ruhl (2013).

RESULTS

Smolt Assessment

Smolt Capture, Handling, and Sampling

Trapping took place for a total of 51 days beginning on 7 May and ended on 26 June. Few smolt were observed until 15 May, when 533 smolt were captured. Peak capture of smolt leaving Frazer Lake occurred between 26 May and 3 June, when 51,285 fish (56%) were counted (Tables 2 and 3; Figure 6). The trap was removed after 3 consecutive daily sockeye salmon smolt counts under 100. A total of 89,014 sockeye salmon smolt were captured in the trap in 2013.

Trap Efficiency and Mark-Recapture Abundance Estimation

Mark-recapture experiments were conducted on 6 occasions throughout the 2013 trapping season (Tables 2 and 3). Small daily catches of smolt at the beginning of the emigration delayed the first mark-recapture test until 19 May. As a result, the first strata encompassed the largest time frame, 7 May to 24 May. After adjusting for mortality, an estimated 4,752 sockeye salmon smolt were marked and released for the season. Of these, 250 smolt were recaptured, and the majority of marked smolt were recaptured within 2 days of being released. Trap efficiency estimates per stratum ranged between 5.0% and 5.8%. Mean estimated trap efficiency for the total emigration was 5.4%. Based upon mark-recapture estimates and trap counts, an estimated 1,644,166 (95% CI 1,203,189–2,085,144) sockeye salmon smolt outmigrated from Frazer Lake during 2013.

Smolt AWL and Condition Factor

Age-2 sockeye salmon smolt composed 78% of sampled sockeye salmon smolt, followed by 19% age-3 smolt and 4% age-1 smolt (Table 4; Appendices B1 and B3). One age-4 smolt and no age-0 smolt were captured in 2013 (Appendix B2). In comparison, the 5-year (2008–2012) average age composition of sampled sockeye salmon smolt was 14% age-1, 80% age-2, and 6% age-3 smolt, and the 10-year (2003–2012) average age composition of sampled sockeye salmon smolt was 18% age-1, 70% age-2, and 12% age-3 smolt (Appendix B1).

In 2013, the average condition factor (K) was 0.70 for age-1 sockeye salmon smolt, 0.73 for age-2 smolt, and 0.72 for age-3 smolt (Table 5). Sampled age-1 smolt had a mean weight of 4.4 g and a mean length of 84.2 mm. Sampled age-2 smolt had a mean weight of 6.1 g and a mean length of 93.9 mm. Sampled age-3 smolt had a mean weight of 7.9 g and a mean length of 102.8 mm. The five year (2008–2012) average K was 0.72 for age-1 smolt, 0.70 for age-2 smolt, and 0.71 for age-3 smolt. (Appendix B1). The 5-year (2008–2012) mean weight was 4.0 g for age-1 smolt, 6.0 g for age-2 smolt, and 9.7 g for age-3 smolt. The 5-year (2008–2012) mean length was 81 mm for age-1 smolt, 94 mm for age-2 smolt, and 108 mm for age-3 smolt (Appendix B1).

Interpolated for the total estimated sockeye salmon smolt outmigration, in 2013, age-2 smolt were most common (81%), while age-3 smolt composed 19% and age-1 smolt composed 1% of the total population (Table 3). In 2012, age-2 smolt composed 96% of the outmigration, while age-1 smolt composed 4% and age-3 smolt composed less than 1% (Thomsen et al. 2013d).

Adult Assessment

Fish Enumeration

Frazer Fish Pass Escapement

In 2013, the Frazer Fish Pass was operated from 8 June through 17 August. Sockeye salmon began ascending the fish pass on 9 June, and the last count of fish through the fish pass occurred on 17 August. The peak sockeye salmon escapement count occurred on 25 June (21,002; Table 6). A total of 136,059 adult sockeye salmon were counted through the fish pass in 2013 (Table 6; Figures 7 and 8). The 5-year (2008–2012) average escapement for sockeye salmon entering Frazer Lake is 117,083 fish (Table 1; Appendices C1, C3, and C7). The 10-year (2003–2012) and the 20-year (1993–2012) average escapement for sockeye salmon entering Frazer Lake is 125,441 and 154,361 fish respectively (Table 1; Appendix C1).

In addition, a total of 42 Chinook and 19 pink salmon were counted through the fish pass (Table 6). The 5- and 10-year averages for Chinook salmon are 34 fish and 109 fish, and the 5- and 10-year averages for pink salmon are 2,349 fish and 1,706 fish respectively (2008−2012; 2003−2012; Appendices C5 and C6; Jackson and Keyse 2013).

Dog Salmon Escapement

A total of 129,369 adult sockeye salmon were counted through Dog Salmon weir between 5 June and 16 August, 2013 (Table 1; Figure 9; Appendices C4 and C7). The 5-year (2008–2012) average passage through Dog Salmon Weir was 154,239.

Number of Sockeye Salmon Remaining in Dog Salmon Creek

In 2013, 6,690 more fish ascended Frazer fish pass than were counted through Dog Salmon weir (Table 1; Figure 10; Appendix C7). The average number of sockeye salmon left in Dog Salmon River from 1983 to 2012 was 27,179 (14.0%; Appendix C7). Prior to 2003, the average number of sockeye salmon remaining in Dog Salmon River (1983 to 2002) was 20,423 (9.3%; Appendix C7). After 2002, the average number of sockeye salmon remaining in Dog Salmon River (2003 to 2012) was 40,689 (23.3%; Table 1; Figure 10; Appendix C7). The greatest number of sockeye salmon left remaining in Dog Salmon Creek occurred in 2004 (105,602) and the fewest occurred in 2013 (-6,690; Table 1; Figure 10; Appendix C7).

Run Timing

In 2013, the run timing for Dog Salmon weir and Frazer Fish Pass sockeye salmon was slightly earlier than average when compared to the last 10 years (Figures 8 and 9; Appendices C3 and C4).

Jack Percentage

In 2013, jack (ocean-age-1) sockeye salmon made up 3.9% of the total escapement into Frazer Lake (Table 7; Figure 11). This jack percentage was less than the 5-year average of 22.4% (Table 7).

Adult ASL

Of the 2,080 adult sockeye salmon scales samples collected at Frazer Fish Pass in 2013, 1,757 were readable. The age composition of sockeye salmon escapement into Frazer Lake was calculated by interpolating the weekly age composition of sampled fish (Table 8) to weekly escapement counts. When applied to the entire escapement, age-2.2 fish composed 47% of the total population, age-2.3 fish composed 29%, and age-1.3 fish composed 15% of the total escapement. In the first three statistical weeks, age-2.3 fish were the predominant age class. Age-2.2 fish were the predominant age class for the remainder of the run (Table 8). Between 2003 and 2012, age-2.2 fish have composed an average of 32% of the total annual escapement, age-2.3 have composed 17%, and age-2.1 have composed 21% (Appendix C2).

Of the sockeye salmon sampled, 61% were female (Table 8). The range of lengths measured for male fish was greater than for females (290-620 mm and 400-615 mm, respectively). Mean length for females was 511 mm and 488 mm for males.

Run Reconstruction and Exploitation

Harvest estimates of sockeye salmon bound for Frazer Lake were based on catches within the Alitak Bay district and Humpy-Deadman sections. Detailed methods for calculating the catch estimate for Frazer Lake sockeye salmon are provided in Moore (2014). In 2013, the total commercial harvest apportioned to Frazer Lake sockeye salmon was estimated at 134,784 fish. The 2013 harvest was below the 5-year average of 226,994 fish (Table 1). The total run for Frazer Lake sockeye salmon in 2013 was estimated at 270,843 fish, which was below the 5-year average of 381,033 fish and the 10-year average of 384,374 fish.

Limnological Assessment

Lake Temperature and Physical Parameters

Mean 1 m temperatures for Frazer Lake increased from 3.6°C in May to 14.3° C in July before cooling to 8.2° C in October (Table 10; Figure 12). In all months sampled, 1 m temperatures in 2013 were warmer than the most recent 5-year average temperature (2008–2012; Appendix D2).

Dissolved oxygen levels for Frazer Lake at 1 m were highest in May (13.5 mg/L) and then began decreasing in September and October (Table 10). In May and June, 1 m dissolved oxygen measurements in 2013 were greater than the 5-year average, although July through October measurements were less than average (2008-2012; Appendix D2).

Frazer Lake was well mixed in May of 2013 and began stratifying in June (Figure 12), with the greatest stratification occurring in August. By October the lake had returned to a mixed state.

Zooplankton

All zooplankton identified were crustaceans commonly referred to as either cladocerans (order Anomopoda and Ctenopoda) or copepods (order Calanoida, Cyclopoida, and Harpacticoida). Copepods were more abundant (66.0% of mean density) than cladocerans (34.0%; Tables 11–14). The two most abundant groups of copepods were *Cyclops* (58.3%) and the pooled category of "other copepods" (7.5%), which was made up mostly of the genus *Harpaticus* and various unidentified nauplii (larvae). The other copepod genera included *Diaptomus* (0.1%) and *Epischura* (0.2%). Among the cladocerans, the most abundant group was *Bosmina* (22.9%). A pooled category of "other cladocerans" (6.6%), consisted of various unidentified immature cladocerans (stations 1 and 3 averaged; Tables 11-14). Other observed cladoceran genera were *Daphnia* (4.3%) and *Holopedium* (0.2%).

Mean total zooplankton biomass was 359.3 mg m^2 and was mostly composed (74.3% of mean total biomass) of copepods (Tables 11-14). The copepod genus *Cyclops* (73.3%) represented most of the biomass, followed by the cladoceran genus *Bosmina* (21.5%). The remaining biomass was composed of *Daphnia* (3.4%), *Holopedium* (0.8%), *Epischura* (0.5%), and *Diaptomus* (0.2%).

The copepod *Epischura* was the largest average zooplankton measured, with a weighted mean length of 1.00 mm (Table 14; Appendix D8). Weighted mean lengths of the remaining zooplankton measured, in decreasing size, were 0.87 mm for the copepod *Diaptomus*, 0.69 mm for *Cyclops* and for the cladoceran *Holopedium*, 0.50 mm for *Daphnia*, and 0.37 mm for *Bosmina*.

For historical comparison, using only the predominant crustaceans at stations 1 and 3, the 10-year (2003−2012) average weighted mean zooplankton density was 232,201 no/m^2 (Appendices D6−D7). This compares with the 2013 average weighted mean zooplankton density at stations 1 and 3 of 242,296 no/m^2 and a 5-year average of 200,206 no/m^2.

Phytoplankton

Phytoplankton samples were collected from stations 1 and 3 in 2013. Mean seasonal phytoplankton biomass was 426.2 mg/m^3 (Table 15; Appendix D11). The historical mean biomass was 955.4 mg/m^3 (2011–2013; Appendix D11). Mean seasonal biomass was consistent between stations (1 and 3).

In all 3 years, phytoplankton biomass was predominately composed of Bacillariophyta and Pyrrhophyta (68% and 8% respectively; Appendix D11). The biomass of Chlorophyta (Green algae) and Cyanobacteria (Blue-green algae) varied among years.

General Lake Chemistry and Nutrients

Frazer Lake stations 1 and 3 averaged seasonal, pH (7.6), alkalinity (14.5), TA (13.4 μg/L), and TKN (481.3 μg/L) were above the 5-year average as measured at the epilimnion (Tables 16–18; Appendices D3 and D4). TP (4.2 μg/L) and chlorophyll-*a* (0.80 μg/L) values were below the 5-year average as measured at the epilimnion (Tables 16–18; Appendices D3 and D4). N+N (30.9 μg/L), TFP (1.7 μg/L), and FRP (1.3 μg/L) measurements were similar to the 5-year average at the epilimnion.

DISCUSSION

SMOLT ASSESSMENT

A variety of smolt capture methods have been utilized since the sockeye salmon introduction program began in Frazer Lake. Specific capture methods are chronicled in Thomsen et al. (2013a). For the past twenty years, smolt abundance or age composition was estimated using an inclined plane trap placed above the falls (Appendix A3). During this time, annual age composition of outmigrating smolt have been consistently determined, although smolt abundance estimates have been inconsistently undertaken (Appendix B3).

The low mortality associated with transporting sockeye salmon smolt to the release site for mark-recapture tests allowed the use of single-site mark-recapture methods in 2013. The average trap efficiency of 5.4% (range, 5.0% to 5.8%; Table 3) was above the targeted goal of 5.0% and was achieved without installing wings to increase the trap capture area. Given the consistency in trap efficiency and the negligible variance between strata (coefficient of variation = 0.07), confidence in the population estimate is considered satisfactory.

The Frazer Lake sockeye salmon smolt outmigration typically begins in early May, peaks in late May, and ends around early July. In 2013, the timing of the smolt outmigration began and ended 5 days earlier than the outmigration of 2012, corresponding with the warmer spring temperatures of 2013.

The 2013 estimated sockeye salmon smolt outmigration (1,644,166; Table 2; Appendix B3) was less than an 8-year average of 3,683,687 (data from 2000 to 2006 and 2012) and a 16-year average of 4,432,266 (data from 1991 to 1997, 1999 to 2006, and 2012). The 2013 sockeye salmon smolt outmigration is approximately half the median value (8-year median of 3,308,018) and the 3rd lowest estimate since 1991. Estimates prior to 1970 were excluded because the run had not yet been established. Estimates from 1987 through 1990 were excluded when calculating means based on recommendations from Coggins (1997, page 2) and Carlson et al. (1988, pages 89 and 90). Their recommendations were based on formula errors found in Rawson (1984), which was used to calculate smolt outmigration estimates.

The outmigration age for Frazer Lake sockeye salmon smolt is highly variable but is typically dominated by freshwater-age-2 fish (Appendix B3). Age-2 sockeye salmon smolt typically composed 70% of the outmigration, with a median value of 82% (10-year mean and median). Age-1 sockeye salmon smolt average 17% of the outmigration with a median value of 6% (10-year mean and median). Age-3 sockeye salmon smolt average 12% of the outmigration with a median value of 5% (10-year mean and median). Differences between the mean and median values illustrate the variability in age at outmigration in Frazer Lake smolt. Age-0 and age-4 smolt occur infrequently.

On average, sockeye salmon smolt outmigrating from Frazer Lake within the last 5 years are smaller, lighter, and less fit (*K*) when compared to smolt leaving the lake in the past (Figure 13; Appendix B1). Median values reflect similar trends in the weight, length, and *K* of sockeye salmon smolt outmigrating from Frazer Lake.

To improve the accuracy of smolt abundance estimates, a smolt bypass system is currently under development, which will potentially capture up to 100% of outmigrating smolt. Testing of the smolt bypass system will continue in 2014.

ADULT ASSESSMENT

As in Frazer Lake, introduced sockeye salmon runs have often not attained initial expectations in run size (Burger et al. 2000). In fact, only three major systems (total run size over 200,000) on the west coast have met with success in establishing self-sustaining runs into new environments (Burger et al. 2000). Unsuitable donor life history adaptations and the inability of the zooplankton community to adapt to the introduction of fish are common causes of poor success (Burger et al. 2000 and Kyle et al. 1988). Introduction of multiple donor stocks with different spawning habitat preferences are probably one reason for the successful run propagation in Frazer Lake. However, the zooplankton community is still adjusting to the additional predation produced by the introduction of sockeye salmon.

In 1975, Blackett (1979) estimated the Frazer Lake sockeye salmon escapement goal at approximately 400,000 fish. Blackett's estimate was based on rearing habitat (365,000 fish) and available spawning area (400,000 fish; Blackett 1979). Successive reviews and additional spawner-recruit and limnological data have led to refinements in Frazer Lake's escapement goal (ADF&G 1999; Nelson and Lloyd 2001; Nelson et al. 2005; Honnold et al. 2007; Nemeth et. al 2010; Sagalkin et al. 2013; Appendix A2).

Density dependence of juvenile sockeye salmon abundance on the secondary trophic level (zooplankton community) is well documented for Frazer Lake (Kyle et al 1988). As a longer time series of limnological data has been developed, these data continue to be used in escapement goal reviews and zooplankton biomass models, where it has become evident that limitations in the zooplankton community are regulating sockeye salmon production. Lower sockeye salmon rearing densities should allow for a greater abundance and larger sizes of preferred zooplankton species (cladocerans), improving juvenile survival.

The BEG range for Frazer Lake (75,000−170,000 fish) corresponds to a range of escapement that provides the greatest potential for maximum sustainable yield or harvest (S_{msy} of 117,000; Sagalkin et al. 2013). S_{msy} strives for the highest growth rate or return per spawner (R/s) within the population. ADF&G manages for S_{msy} to ensure optimal escapement while producing a harvestable surplus. The carrying capacity (S_{eq}) for Frazer Lake is estimated at 321,000 sockeye salmon. S_{eq} corresponds to a maximum population size where growth is zero (or R/s = 1) and there is no harvest.

Since 2003, the adult sockeye salmon escapement at Frazer Lake has consistently achieved S_{msy} and been within the escapement range (Appendix C7; Nemeth et. al 2010). The 5-year average sockeye salmon escapement is 117,083 fish, and the 10-year average escapement is 125,441 fish.

While not mandated to do so by regulation, managers take age and sex composition into consideration when assessing escapement into Frazer Lake. For instance, 50% of the escapement, or 58,500 fish, ideally should be composed of females, and when jack (one-ocean sockeye salmon) numbers are high (above 10%), managers allow for greater total escapement into the lake.

Concerns over recent trends in the number of jacks escaping into Frazer Lake have been voiced by members of the public. The prevalence of jacks was the highest in 2003, when 70.2% of the sockeye salmon escapement was composed of jacks. Since 2000, the frequency of jacks in the Frazer Lake escapement has fluctuated, with 2 years of high jack percentage followed by 2 years of low jack percentage (Appendices C9 and C10). This recent cyclic nature from 2000 through 2012 is composed of years of low jack abundance (2000, 2001, 2004, 2005, 2008, 2009, 2012, and 2013) and years of high jack abundance (2002, 2003, 2006, 2007, 2010, and 2011). Heath et al. (2002) suggests the cyclic nature of the jacks in Frazer Lake may be driven by genetics.

The percentage of jacks in the Frazer Lake total run (including harvest) follows the same cyclic pattern as that found in the escapement. However, the average proportion of jacks in the total run (13.1%) is lower than that in the escapement (19.4%; 1986 to 2012; Appendices C9 and C10). The difference between escapement and total run proportions can be attributed to gear selectivity (set gillnet) in harvest methods within Olga Bay.

At first glance, the percentage of jacks returning by brood year does not appear to follow a cyclic pattern as found in the escapement and total run. The cyclic pattern is evident in age-2.1 jacks as a 4-year cycle. The percentage of jacks produced from a particular brood year is lower than that observed in the escapement. For comparison, the jack percentage produced by brood year for a comparable time frame (27 years; 1980−2006) averaged 9% and ranged from 1% to 17% (Appendices C8 and C11). Recent 5- and 10-year jack averages produced by brood year are 13%. Fertilization appears to have influenced the percentage of jacks returning to Frazer (1988 to 1992; Appendix C11). Prior to fertilization, jacks composed an average of 4% of the return in a brood year, and after fertilization jacks composed an average of 12% of the return in a brood year.

As previously mentioned, comparisons between Dog Salmon Weir and Frazer Fish Pass escapement counts led to concerns about the number of adult sockeye salmon left remaining in Dog Salmon Creek instead of ascending Frazer Fish Pass to spawn at the end of the season. These comparisons indicated further modifications to the fish pass were needed to improve fish passage and reduce the number of sockeye salmon left in Dog Salmon Creek.

Following recommendations by Blackett (1987), modifications were made to the entrance to increase attractant water flow. Water flow was redirected from the falls to the fish pass entrance using a secondary diversion weir placed perpendicular to the fish diversion weir (Figure 4). In 2013, the secondary diversion weir was maintained at 16 feet long and appears to have again improved fish passage, decreasing the build-up of fish below the pass and reducing the number of sockeye salmon left in Dog Salmon River to the lowest recorded (-6,690; -5.2%).

In 2013, more sockeye salmon were counted through Frazer fish pass than were counted through Dog Salmon weir. The discrepancy in counts can probably be attributed to the occurrence of holes within Dog Salmon weir and the subsequent conservative fish passage estimates added to the Dog Salmon weir count. In 2013, holes were observed on several occasions and were largely created by bear activity and undermining generated by high water levels (Fuerst 2014).

LIMNOLOGICAL ASSESSMENT

Limnological data has been collected at Frazer Lake by ADF&G since 1985 (with the exception of 1997–2000; Appendix D1), chiefly as part of a standard suite of lakes sampled each year. Limnological descriptions have been intermittently reported as part of salmon escapement reports and, more recently, in specific limnology reports by Finkle and Ruhl (2011, 2012a, 2012b; data from 2009–2011).

Seasonal means of lake physical properties (temperature, dissolved oxygen, light, and water clarity) in 2013 were consistent with measurements taken in recent years in Frazer Lake (Appendix D2). Temperatures in the lake were near the 19-year average (1989–2011; Appendices D9 and D10).

Seasonal measurements of mean nutrient and algal pigment concentrations generally showed little variation over the sampling season, with the exception of nitrogen components (Tables 16–18). From a historical perspective, pH and alkalinity were above average (Appendix D4), phosphorus, nitrogen, and algal components were average (Appendix D3), except TKN, which was roughly 4 times the historical average and the highest value ever observed (possibly due to increased terrestrial input from near record snow pack runoff; Heather Finkle, Fishery Biologist, ADF&G, Kodiak, personal communication).

Typically, phytoplankton communities are dominated by either diatoms or flagellates (Officer and Ryther 1980). Diatoms are the preferred phytoplankton prey for most zooplankton taxa in northern lakes, and they tend to dominate in oligotrophic systems with sufficient silicon concentration (Officer and Ryther 1980). Low phosphorus levels in oligotrophic lakes favor some diatom species because they can store phosphorous (Wehr and Sheath 2003). Several of the larger lakes in Kodiak, such as Karluk and Spiridon lakes, are predominated by diatoms (Finkle 2013; Thomsen 2011). Considering available data, Frazer Lake may be well suited to have a phytoplankton community predominated by diatoms because of its abundance of silicon and the ability of diatoms to thrive in low phosphorous conditions (Wehr and Sheath 2003; Appendix D11).

Mean phytoplankton biomass in Frazer Lake has varied in the three years of data collection with the 2013 biomass nearly half the average (2011–2013; Appendix D11). Mean nitrogen (TKN) concentration has increased significantly in the last two years, ranging from 270.9 µg/L in 2012 to 481.3 µg/L in 2013. This combined with increasing phosphorous concentration suggests that the phytoplankton in Frazer Lake may not be able to efficiently utilize nutrients. Additional phytoplankton monitoring and species evaluation may corroborate possible trophic inefficiencies.

In the mid-1980s, Kyle et al. (1988) conducted extensive studies in Frazer Lake to assess trophic responses to the salmon population and the rearing habitat capacity for juvenile sockeye salmon. The authors found strong density-dependent effects due to large spawning escapements (e.g., > 400,000 fish), with large escapements correlated with lower zooplankton densities, smaller *Bosmina* body size, a decrease in the ratio of copepods to cladocerans, and a reduced body length of age-1 smolts (Figures 14 and 15). Based on these results, the authors concluded that sockeye salmon production in Frazer Lake was limited by rearing habitat, and recommended escapements be kept below the estimated spawning habitat capacity of 400,000 fish (Kyle et al. 1988). Kyle et al. (1988) also noted sharp declines in zooplankton density as sockeye salmon escapement exceeded 300,000 fish. Density-dependent effects are also evident when the Frazer Lake escapement drops below 90,000 fish. Sockeye salmon escapements into Frazer Lake below this level yield a greater cladoceran-to-copepod ratio, indicating a decrease in juvenile sockeye salmon foraging (Appendix D12).

Sockeye salmon escapements into Frazer Lake have been well under this threshold and have consistently averaged around 120,000 fish within the last 10 years. Maintaining escapement levels around S_{msy} has decreased seasonal variation in zooplankton density but has not appreciably increased total zooplankton density. Frazer Lake's modest capacity to rebound may suggest a poor transfer of nutrients up the food web (Lampman and Makarewicz 1999).

OUTLOOK FOR 2014

Project activities at Frazer Lake in 2014 will be similar to the 2013 field season for adult monitoring. Extensive fish pass renovations are scheduled to begin in the fall of 2014. Single-site mark-recapture methods will again be utilized to estimate smolt outmigration numbers in 2014. Mortality testing of the smolt bypass trapping system will be conducted in 2014, with operation beginning once testing is complete.

ACKNOWLEDGMENTS

I would like to acknowledge and thank ADF&G personnel Mary Beth Loewen, Natura Richardson, Brad Fuerst, Steve Schrof, and Nick Sagalkin for their thorough review of this document, and Kathy Greer for publications formatting and assistance. Great appreciation is given to the field crew—Theresa Woldstad, Tyler Block, and Jenell de la Pena—for their attention to detail in achieving the project objectives. Funding and support of this project were provided by ADF&G, with assistance from Kodiak Regional Aquaculture Association.

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TABLES AND FIGURES

Table 1.–Frazer Fish Pass and Dog Salmon Weir (DS) sockeye salmon counts, total run, commercial harvest, and sockeye salmon remaining in DS Creek, 2003–2013.

Year	Dog Salmon (DS) Weir Count	Commercial Harvest	Total Run	Frazer Fish Pass Count	Sockeye Remaining in DS Creek	
					no.	%
2003	262,731	51,183	313,914	201,679	61,052	23.2
2004	226,266	485,985	712,251	120,664	105,602	46.7
2005	152,959	472,978	625,937	136,948	16,011	10.5
2006	108,343	9,557	117,900	89,516	18,827	17.4
2007	139,808	28,763	168,571	120,186	19,622	14.0
2008	153,276	367,327	520,603	105,363	47,913	31.3
2009	147,798	327,178	474,976	101,845	45,953	31.1
2010	135,100	30,012	165,112	94,680	40,420	29.9
2011	180,603	192,820	372,423	134,642	45,961	25.4
2012	154,416	217,631	372,049	148,884	5,532	3.6
2013	129,369	134,784	270,843	136,059	-6,690	-5.2
5-yr Average (2008–2012)	154,239	226,994	381,033	117,083	37,156	24.3
10-yr Average (2003–2012)	166,130	218,343	384,374	125,441	40,689	23.3

Table 2.–Estimated abundance of sockeye salmon smolt outmigrating from Frazer Lake, 2013.

Stratum (h)	Beginning Date	Ending Date	Unmarked (u_h)	Released (M_h)	Recovered (m_h)	Estimate (U_h)	Variance (U_h)	95% C. I. lower	95% C. I. upper
1	5/7	5/24	6,743	858	42	134,724	394,362,539	95,801	173,646
2	5/25	5/30	34,690	956	55	593,022	5,818,213,693	443,519	742,526
3	5/31	6/6	30,330	925	46	597,643	7,074,500,176	432,787	762,499
4	6/7	6/11	12,807	1,041	56	234,121	897,324,830	175,408	292,833
5	6/12	6/20	4,204	612	31	80,542	187,734,150	53,687	107,397
6	6/21	6/25	240	359	20	4,114	1,178,626	1,986	6,242
			89,014	4,752	250	1,644,166	14,373,314,015	1,203,189	2,085,144
						SE= 119,889			

Note: The parameters h, u_h, M_h, m_h, U_h, and U_h are used to calculate the outmigration estimate and are defined on page 7.

Table 3.–Daily and cumulative sockeye salmon trap catch, AWL samples, mark-recapture, trap efficiencies, outmigration estimates, and age composition estimates for Frazer Lake, 2013.

	Daily	AWL	Marked	Marked	Trap	Outmigration Estimate		Freshwater Age			
Date	Catch	Samples	Releases	Recoveries	Efficiency	Daily	Cumulative	1	2	3	4
					Stratum 1						
7-May	6	2	0	0	5.0%	120	120	0	120	0	0
8-May	2	1	0	0	5.0%	40	160	0	40	0	0
9-May	1	1	0	0	5.0%	20	180	0	20	0	0
10-May	5	5	0	0	5.0%	100	280	20	60	20	0
11-May	39	39	0	0	5.0%	779	1,059	60	619	100	0
12-May	19	18	0	0	5.0%	380	1,439	0	316	63	0
13-May	37	36	0	0	5.0%	739	2,178	41	534	164	0
14-May	65	61	0	0	5.0%	1,299	3,476	0	724	575	0
15-May	533	40	0	0	5.0%	10,649	14,126	0	7,721	2,929	0
16-May	1,485	40	0	0	5.0%	29,670	43,796	0	17,802	11,868	0
17-May	625	40	0	0	5.0%	12,487	56,283	0	7,180	5,307	0
18-May	1,542	40	0	0	5.0%	30,809	87,092	0	19,256	11,553	0
19-May	440	0	943	35	5.0%	8,791	95,883	183	5,819	2,776	14
20-May	33	0	0	7	5.0%	659	96,542	14	436	208	1
21-May	84	40	0	0	5.0%	1,678	98,221	0	923	713	42
22-May	54	20	0	0	5.0%	1,079	99,299	0	324	755	0
23-May	46	20	0	0	5.0%	919	100,219	0	145	774	0
24-May	1,727	80	0	0	5.0%	34,505	134,724	0	18,978	15,527	0
Total Stratum 1	6,743	483	943	42	5.0%	134,724		317	81,017	53,333	57
					Stratum 2						
25-May	4,426	40	991	53	5.8%	75,662	210,386	1,892	43,506	30,265	0
26-May	12,957	40	0	2	5.8%	221,499	431,884	0	149,512	71,987	0
27-May	9,906	0	0	0	5.8%	169,342	601,227	2,117	119,598	47,627	0
28-May	2,857	0	0	0	5.8%	48,840	650,067	611	34,493	13,736	0
29-May	2,749	40	0	0	5.8%	46,994	697,061	0	35,245	11,748	0
30-May	1,795	40	0	0	5.8%	30,685	727,746	767	25,315	4,603	0
Total Stratum 2	34,690	160	991	55	5.8%	593,022		5,386	407,669	179,967	0
					Stratum 3						
31-May	1,234	40	944	24	5.1%	24,316	752,062	0	20,668	3,647	0
1-Jun	3,504	40	0	16	5.1%	69,045	821,107	0	62,141	6,905	0
2-Jun	1,835	0	0	5	5.1%	36,158	857,265	0	32,542	3,616	0
3-Jun	14,448	40	0	1	5.1%	284,693	1,141,958	0	249,107	35,587	0
4-Jun	3,496	0	0	0	5.1%	68,888	1,210,846	0	61,999	6,889	0
5-Jun	2,239	40	0	0	5.1%	44,119	1,254,964	0	40,810	3,309	0
6-Jun	3,574	40	0	0	5.1%	70,425	1,325,389	0	66,903	3,521	0
Total Stratum 3	30,330	200	944	46	5.1%	597,643		0	534,170	63,473	0
					Stratum 4						
7-Jun	2,815	40	1,041	53	5.5%	51,460	1,376,849	0	50,174	1,287	0
8-Jun	3,651	40	0	3	5.5%	66,743	1,443,592	1,669	63,406	1,669	0
9-Jun	3,152	40	0	0	5.5%	57,621	1,501,213	0	54,740	2,881	0
10-Jun	1,262	0	0	0	5.5%	23,070	1,524,283	192	22,109	769	0
11-Jun	1,927	0	0	0	5.5%	35,227	1,559,510	294	33,759	1,174	0
Total Stratum 4	12,807	120	1,041	56	5.5%	234,121		2,154	224,187	7,779	0

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Table 3.–Page 2 of 2.

Date	Daily Catch	AWL Samples	Marked Releases	Marked Recoveries	Trap Efficiency	Outmigration Estimate		Freshwater Age			
						Daily	Cumulative	1	2	3	4
					Stratum 5						
12-Jun	719	40	631	28	5.2%	13,775	1,573,285	0	13,086	689	0
13-Jun	560	34	0	3	5.2%	10,729	1,584,014	0	10,729	0	0
14-Jun	760	46	0	0	5.2%	14,560	1,598,574	950	12,978	633	0
15-Jun	712	40	0	0	5.2%	13,641	1,612,215	682	11,595	1,364	0
16-Jun	503	40	0	0	5.2%	9,637	1,621,851	1,205	8,432	0	0
17-Jun	444	0	0	0	5.2%	8,506	1,630,358	413	7,858	235	0
18-Jun	266	0	0	0	5.2%	5,096	1,635,454	248	4,708	141	0
19-Jun	185	40	0	0	5.2%	3,544	1,638,998	89	3,456	0	0
20-Jun	55	40	0	0	5.2%	1,054	1,640,052	79	975	0	0
Total Stratum 5	4,204	280	631	31	5.2%	80,542		3,665	73,815	3,062	0
					Stratum 6						
21-Jun	55	40	359	18	5.8%	943	1,640,995	71	872	0	0
22-Jun	16	16	0	2	5.8%	274	1,641,269	69	206	0	0
23-Jun	72	40	0	0	5.8%	1,234	1,642,503	190	1,013	32	0
24-Jun	59	40	0	0	5.8%	1,011	1,643,515	104	908	0	0
25-Jun	38	38	0	0	5.8%	651	1,644,166	223	429	0	0
Total Stratum 6	240	174	359	20	5.8%	4,114		656	3,427	32	0
					Total						
	89,014	1,417	4,909	250	5.4%	1,644,166		12,178	1,324,285	307,646	57

Table 4.–Age composition of Frazer Fish Pass sockeye salmon interpolated to escapement, 2013.

			Age									
Stat Week	Sample Size		1.1	1.2	1.3	2.1	2.2	2.3	2.4	3.2	3.3	Total Fish
24	0	Percent	0.0	1.0	15.0	2.0	24.0	56.0	0.0	0.0	2.0	100.0
		Numbers	0	2	25	3	40	93	0	0	3	166
25	100	Percent	0.0	1.1	15.4	1.9	24.3	55.2	0.0	0.1	2.0	100.0
		Numbers	0	33	447	55	704	1,602	1	2	57	2,901
26	210	Percent	0.0	3.0	19.9	0.8	28.9	44.9	0.3	0.7	1.5	100.0
		Numbers	0	1,338	8,273	204	11,581	16,828	171	341	545	39,281
27	213	Percent	0.0	5.2	18.3	0.4	43.6	31.5	0.1	0.1	0.7	100.0
		Numbers	0	1,135	3,903	84	9,487	6,694	27	23	154	21,508
28	236	Percent	0.4	4.8	13.9	1.7	49.6	28.3	0.3	0.1	1.0	100.0
		Numbers	232	1,451	4,065	1,045	17,363	8,541	92	58	275	33,122
29	197	Percent	1.6	3.3	8.0	7.9	61.7	16.9	0.0	0.4	0.2	100.0
		Numbers	199	401	1,027	1,057	8,071	2,019	2	45	24	12,845
30	198	Percent	0.6	2.6	9.8	7.5	63.8	15.2	0.0	0.1	0.4	100.0
		Numbers	68	366	1,435	1,028	9,006	2,141	0	2	69	14,115
31	199	Percent	0.0	0.3	8.0	8.6	65.5	16.6	0.0	0.2	0.7	100.0
		Numbers	2	16	401	431	3,285	835	0	10	35	5,016
32	197	Percent	0.1	0.6	5.4	11.9	65.6	14.2	0.0	0.8	1.4	100.0
		Numbers	4	25	244	524	2,909	636	0	37	63	4,443
33	207	Percent	0.5	0.9	5.8	15.2	55.9	19.8	0.0	0.5	1.5	100.0
		Numbers	9	19	116	305	1,129	397	0	11	29	2,014
34	0	Percent	0.5	1.0	5.8	15.5	55.1	20.3	0.0	0.5	1.4	100.0
		Numbers	3	6	38	100	357	131	0	3	9	648
Totals	1,757	Percent	0.4	3.5	14.7	3.6	47.0	29.3	0.2	0.4	0.9	100.0
		Numbers	518	4,792	19,974	4,837	63,932	39,917	293	533	1,265	136,059

Table 5.–Length, weight, and condition of Frazer Lake sockeye salmon smolt samples, by freshwater age and statistical week, 2013.

Stat Week	Sample Size	Length (mm) Mean	Length (mm) Std Error	Weight (g) Mean	Weight (g) Std Error	Condition Mean	Condition Std Error
Age-1							
20	6	72.3	4.74	2.7	0.59	0.64	0.02
21	0	0.0	0.00	0.0	0.00	0.00	0.00
22	2	85.5	1.50	4.3	0.90	0.68	0.11
23	0	0.0	0.00	0.0	0.00	0.00	0.00
24	1	88.0	0.00	4.9	0.00	0.72	0.00
25	14	85.8	2.05	4.6	0.31	0.71	0.02
26	30	85.6	1.64	4.7	0.27	0.71	0.01
Totals	53	84.2	1.31	4.4	0.20	0.70	0.01
Age-2							
19	4	88.3	2.53	5.1	0.45	0.73	0.01
20	162	95.0	0.41	6.0	0.10	0.69	0.00
21	79	95.0	0.56	6.1	0.11	0.71	0.01
22	157	96.5	0.31	6.4	0.07	0.71	0.00
23	180	94.0	0.28	6.0	0.06	0.72	0.00
24	187	92.0	0.31	5.7	0.07	0.73	0.00
25	186	92.6	0.34	6.1	0.08	0.76	0.00
26	141	93.7	0.32	6.4	0.08	0.77	0.01
Totals	1,096	93.9	0.14	6.1	0.03	0.73	0.00
Age-3							
20	71	102.3	0.52	7.7	0.13	0.72	0.01
21	79	102.2	0.52	7.6	0.13	0.71	0.01
22	81	103.5	0.45	8.0	0.13	0.72	0.01
23	20	102.8	0.99	7.8	0.31	0.71	0.01
24	6	105.2	3.11	9.4	1.20	0.79	0.03
25	6	105.0	5.45	9.8	1.33	0.81	0.02
26	1	107.0	0.00	10.0	0.00	0.82	0.00
Totals	264	102.8	0.29	7.9	0.08	0.72	0.00
Age-4							
21	1	128.0	0.00	16.4	0.00	0.78	0.00

Table 6.–Frazer Fish Pass daily escapement counts, by species, 2013.

Date	Sockeye	Chinook	Pink	Steelhead Down	Steelhead Up
9-Jun	4	0	0	0	0
10-Jun	5	0	0	0	0
11-Jun	92	0	0	0	0
12-Jun	61	1	0	0	0
13-Jun	4	0	0	0	0
14-Jun	14	2	0	0	0
15-Jun	54	0	0	0	0
16-Jun	127	0	0	0	0
17-Jun	149	0	0	0	0
18-Jun	1,539	3	0	0	0
19-Jun	800	1	0	0	0
20-Jun	218	0	0	0	0
21-Jun	9	0	0	0	0
22-Jun	47	0	0	0	0
23-Jun	27	0	0	0	0
24-Jun	7,486	3	0	0	0
25-Jun	21,002	9	0	0	0
26-Jun	7,360	2	0	0	0
27-Jun	3,350	1	0	0	0
28-Jun	4,169	2	0	0	0
29-Jun	1,002	1	0	0	0
30-Jun	293	0	0	0	0
1-Jul	112	0	0	0	0
2-Jul	9,901	1	0	0	0
3-Jul	6,005	2	0	0	0
4-Jul	26	0	0	0	0
5-Jul	47	0	0	0	0
6-Jul	266	0	0	0	0
7-Jul	457	0	0	0	0
8-Jul	1,361	1	0	0	0
9-Jul	14,721	3	0	0	0
10-Jul	4,454	1	0	0	0
11-Jul	11,816	3	6	0	0
12-Jul	521	0	4	0	0
13-Jul	856	0	0	0	0
14-Jul	805	0	0	0	0
15-Jul	140	1	0	0	0
16-Jul	646	0	0	0	0
17-Jul	6,640	0	4	0	0

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Table 6.–Page 2 of 2.

Date	Sockeye	Chinook	Pink	Steelhead Down	Steelhead Up
18-Jul	3,237	1	0	0	0
19-Jul	442	0	0	0	0
20-Jul	990	0	3	0	0
21-Jul	105	1	0	0	0
22-Jul	1,086	0	0	0	0
23-Jul	10,980	1	1	0	0
24-Jul	242	0	1	0	0
25-Jul	270	0	0	0	0
26-Jul	96	0	0	0	0
27-Jul	2,022	0	0	0	0
28-Jul	288	0	0	0	0
29-Jul	791	0	0	0	0
30-Jul	141	0	0	0	0
31-Jul	731	0	0	0	0
1-Aug	947	0	0	0	0
2-Aug	592	0	0	0	0
3-Aug	1,279	0	0	0	0
4-Aug	421	0	0	0	0
5-Aug	39	0	0	0	0
6-Aug	131	0	0	0	0
7-Aug	1,848	0	0	0	0
8-Aug	133	0	0	0	0
9-Aug	352	0	0	0	0
10-Aug	337	0	0	0	0
11-Aug	748	0	0	0	0
12-Aug	166	2	0	0	0
13-Aug	113	0	0	0	0
14-Aug	187	0	0	0	0
15-Aug	111	0	0	0	0
16-Aug	57	0	0	0	0
17-Aug	591	0	0	0	0
Total	136,059	42	19	0	0

Table 7.–Number and percentage of sockeye salmon escapement into Frazer Lake, by year, and ocean age, 2000–2013.

	Ocean Age								
Year	1	%	2	%	3	%	4	%	Total Fish
1994	16,601	8.1	123,919	60.1	65,505	31.8	46	0.0	206,071
1995	41,321	21.0	94,150	47.9	60,868	31.0	24	0.0	196,362
1996	76,246	38.4	76,277	38.4	46,172	23.2	0	0.0	198,695
1997	26,768	13.0	119,137	58.0	59,005	28.7	354	0.2	205,264
1998	38,366	16.4	141,990	60.7	53,399	22.8	0	0.0	233,755
1999	68,320	31.5	108,918	50.3	39,328	18.2	0	0.0	216,565
2000	24,529	15.5	83,051	52.5	50,416	31.9	48	0.0	158,044
2001	1,969	1.3	16,642	10.8	135,726	87.9	12	0.0	154,349
2002	21,907	25.7	11,738	13.8	49,832	58.4	1,840	2.2	85,317
2003	141,449	70.1	54,369	27.0	5,589	2.8	272	0.1	201,679
2004	8,366	6.9	104,679	86.8	7,619	6.3	0	0.0	120,664
2005	624	0.5	56,535	41.3	79,663	58.2	125	0.1	136,948
2006	33,650	37.6	5,694	6.4	49,441	55.2	730	0.8	89,516
2007	70,482	58.6	42,359	35.2	7,036	5.9	309	0.3	120,186
2008	11,376	10.8	71,889	68.2	22,036	20.9	61	0.1	105,363
2009	4,636	4.6	51,035	50.1	45,853	45.0	321	0.3	101,845
2010	49,546	52.3	16,852	17.8	28,012	29.6	184	0.2	94,680
2011	57,177	42.5	67,498	50.1	9,806	7.3	184	0.1	134,642
2012	2,789	1.9	103,139	69.3	42,843	28.8	184	0.1	148,884
2013	5,354	3.9	69,256	50.9	61,155	44.9	293	0.2	136,059
Mean (2008-2012)	25,105	22.4	62,083	51.1	29,710	26.3	187	0.1	
Mean (2003-2012)	38,010	28.6	57,405	45.2	29,790	26.0	237	0.2	
Mean (00,01,04,05,08,09,12,13)[a]	7,455	5.7	69,528	53.7	55,664	40.5	131	0.1	
Mean (02,03,06,07,10,11)[b]	53,459	41.0	28,359	21.5	21,388	22.7	503	0.5	

[a] Averages grouped to better reflect cyclic ocean-age-1 patterns (years 00,01,04,05,08,09,12,13).
[b] Averages grouped to better reflect cyclic ocean-age-1 patterns (years 02,03,06,07,10,11).

Table 8.–Length composition of Frazer Lake sockeye salmon escapement samples by age and sex, 2013.

	Age									
	1.1	1.2	1.3	2.1	2.2	2.3	2.4	3.2	3.3	Total
Females										
Mean Length	0	492	542	0	491	535	550	523	532	511
Standard Error	0	4.31	1.95	0.00	1.00	1.39	10.00	27.50	4.21	2.29
Range	0	460-525	435-595	0	400-585	435-615	540-560	495-550	515-560	400-615
Sample Size	0	21	137	0	579	320	2	2	12	1,073
Males										
Mean Length	335	503	557	348	496	549	0	516	547	488
Standard Error	15.97	6.82	3.44	3.64	1.90	2.59	0.00	18.53	14.65	2.87
Range	305-410	431-575	460-610	290-480	405-590	432-620		475-565	510-590	290-620
Sample Size	6	26	70	106	341	123	0	4	5	681
All										
Mean Length	335	498	547	348	493	539	550	518	536	502
Standard Error	15.97	4.27	1.80	3.64	0.95	1.27	10.00	13.76	5.25	1.30
Range	305-410	431-575	435-610	290-480	400-590	432-620	540-560	475-565	510-590	290-620
Sample Size	6	47	207	106	920	443	2	6	17	1,754
Percent										
Females	0.0%	2.0%	12.8%	0.0%	54.0%	29.8%	0.2%	0.2%	1.1%	61.2%
Males	0.9%	3.8%	10.3%	15.6%	50.1%	18.1%	0.0%	0.6%	0.7%	38.8%
All	0.3%	2.7%	11.8%	6.0%	52.5%	25.3%	0.1%	0.3%	1.0%	100.0%

Table 9.–Age composition of sampled sockeye salmon smolt outmigrating from Frazer Lake by statistical week, 2013.

Stat	Sample	Age							
Week	Size	1	%	2	%	3	%	4	%
19	4	0	0.00	4	1.00	0	0.00	0	0.00
20	239	6	0.03	162	0.68	71	0.30	0	0.00
21	159	0	0.00	79	0.50	79	0.50	1	0.01
22	240	2	0.01	157	0.65	81	0.34	0	0.00
23	200	0	0.00	180	0.90	20	0.10	0	0.00
24	194	1	0.01	187	0.96	6	0.03	0	0.00
25	206	14	0.07	186	0.90	6	0.03	0	0.00
26	172	30	0.17	141	0.82	1	0.01	0	0.00
Total	1,414	53	0.04	1,096	0.78	264	0.19	1	0.00

Table 10.–Monthly and seasonal averages of 1 m temperature, dissolved oxygen, light, and Secchi disk measurements from Frazer Lake, 2013.

Station		Month						Seasonal
		May	June	July	August	September	October	Average
Station 1								
	1 m Temperature (°C)	3.9	8.5	13.7	12.9	11.3	8.1	9.7
	1 m Dissolved oxygen (mg/L)	13.4	12.7	11.0	10.6	10.8	11.3	11.6
	Light (Klux)	731.0	1346.0	1042.0	218.9	126.0	123.0	597.8
	Secchi depth (m)	8.0	7.5	7.0	4.8	8.0	7.0	7.0
Station 3								
	1 m Temperature (°C)	3.3	8.1	14.8	12.9	11.5	8.2	9.8
	1 m Dissolved oxygen (mg/L)	13.6	12.9	10.7	10.6	10.8	11.3	11.6
	Light (Klux)	787.0	1204.0	979.0	178.5	66.1	63.0	546.3
	Secchi depth (m)	9.0	9.3	6.5	4.0	7.8	7.5	7.3
Stations 1 and 3 (Mean)								
	1 m Temperature (°C)	3.6	8.3	14.3	12.9	11.4	8.2	9.8
	1 m Dissolved oxygen (mg/L)	13.5	12.8	10.8	10.6	10.8	11.3	11.6
	Light (Klux)	759.0	1275.0	1010.5	198.7	96.1	93.0	572.0
	Secchi depth (m)	8.5	8.4	6.8	4.4	7.9	7.3	7.2

Table 11.–Monthly and seasonal averages of zooplankton abundance (number/m^2) for Frazer Lake, station 1, 2013.

Taxon		May	June	July	August	Sept	Oct	Seasonal Mean
Copepods	*Epischura*	-	-	-	-	1,274	-	212
	Ovig Epischura	-	-	-	-	-	-	-
	Diaptomus	-	1,327	-	-	-	-	221
	Ovig Diaptomus	-	-	-	-	-	-	-
	Cyclops	153,928	388,800	102,176	36,624	46,497	8,917	122,824
	Ovig. *Cyclops*	-	-	6,635	1,592	1,911	1,672	1,968
	Harpaticus	-	-	-	-	-	1,115	186
	Nauplii	35,032	14,597	2,654	3,981	6,369	36,226	16,476
Total Copepods		188,960	404,724	111,465	42,197	56,051	47,930	141,888
	Bosmina	5,308	31,847	99,522	113,057	142,038	47,930	73,284
	Ovig. *Bosmina*	-	1,327	6,635	4,777	3,822	2,229	3,132
	Daphnia L.	-	-	2,654	2,389	17,834	41,242	10,686
	Ovig Daphnia L.	-	-	-	-	1,911	6,131	1,340
	Holopedium	-	-	1,327	796	-	557	447
	Ovig Holopedium	-	-	1,327	-	-	-	221
	Chydorinae	-	-	-	-	-	-	-
	Eurytemora	-	-	-	-	-	-	-
	Immature Cladocera	-	2,654	57,059	20,701	32,484	6,131	19,838
Total Cladocerans		5,308	35,828	168,524	141,720	198,089	104,220	108,948
Total Copepods + Cladocerans		194,268	440,552	279,989	183,917	254,140	152,150	250,836

Table 12.–Monthly and seasonal averages of zooplankton abundance (number/m^2) for Frazer Lake, station 3, 2013.

Taxon		May	June	July	August	Sept	Oct	Seasonal Mean
Copepods	*Epischura*	-	1,062	1,327	796	1,274	438	816
	Ovig Epischura	-	-	-	-	-	-	-
	Diaptomus	1,062	-	-	796	-	-	310
	Ovig Diaptomus	-	-	-	-	-	-	-
	Cyclops	497,877	509,554	115,446	62,102	16,561	13,575	202,519
	Ovig. *Cyclops*	-	10,616	2,654	2,389	-	-	2,610
	Harpaticus	-	-	-	-	1,274	-	212
	Nauplii	93,418	-	6,635	7,166	10,828	34,156	25,367
Total Copepods		592,357	521,231	126,062	73,248	29,936	48,169	231,834
	Bosmina	5,308	3,185	23,885	122,611	87,261	60,430	50,447
	Ovig. *Bosmina*	2,123	-	2,654	9,554	1,911	2,189	3,072
	Daphnia L.	-	1,062	1,327	7,962	12,739	41,600	10,782
	Ovig Daphnia L.	1,062	-	-	796	1,274	5,255	1,398
	Holopedium	-	-	1,327	-	1,911	-	540
	Ovig Holopedium	-	-	-	-	-	-	-
	Chydorinae	-	-	-	-	-	-	-
	Eurytemora	-	-	-	-	-	-	-
	Immature Cladocera	1,062	-	29,193	45,382	21,019	7,882	17,423
Total Cladocerans		9,554	4,246	58,386	186,306	126,115	117,357	83,661
Total Copepods + Cladocerans		601,911	525,478	184,448	259,554	156,051	165,525	315,495

Table 13.–Monthly and seasonal averages of zooplankton abundance (number/m^2) for Frazer Lake, stations 1 and 3 averaged, 2013.

Taxon		May	June	July	August	Sept	Oct	Seasonal Mean
Copepods	*Epischura*	-	531	663	398	1,274	219	514
	Ovig Epischura	-	-	-	-	-	-	-
	Diaptomus	531	663	-	398	-	-	265
	Ovig Diaptomus	-	-	-	-	-	-	-
	Cyclops	325,902	449,177	108,811	49,363	31,529	11,246	162,671
	Ovig. *Cyclops*	-	5,308	4,644	1,990	955	836	2,289
	Harpaticus	-	-	-	-	637	557	199
	Nauplii	64,225	7,298	4,644	5,573	8,599	35,191	20,922
Total Copepods		390,658	462,978	118,763	57,723	42,994	48,049	186,861
	Bosmina	5,308	17,516	61,704	117,834	114,650	54,180	61,865
	Ovig. *Bosmina*	1,062	663	4,644	7,166	2,866	2,209	3,102
	Daphnia L.	-	531	1,990	5,175	15,287	41,421	10,734
	Ovig Daphnia L.	531	-	-	398	1,592	5,693	1,369
	Holopedium	-	-	1,327	398	955	279	493
	Ovig Holopedium	-	-	663	-	-	-	111
	Chydorinae	-	-	-	-	-	-	-
	Eurytemora	-	-	-	-	-	-	-
	Immature Cladocera	531	1,327	43,126	33,041	26,752	7,006	18,631
Total Cladocerans		7,431	20,037	113,455	164,013	162,102	110,788	96,304
Total Copepods + Cladocerans		398,089	483,015	232,219	221,736	205,096	158,838	283,165

Table 14.–Seasonal weighted mean zooplankton density, biomass, and size by individual station from Frazer Lake, 2013.

Station	*n*		*Epischura*	*Diaptomus*	*Cyclops*	Other Copepods	*Bosmina*	*Daphnia*	*Holopedium*	Other Cladocerans	Total Copepods	Total Cladocerans	Total all zooplankton
1	5	density (no. m^2)	212	221	124,792	16,662	76,415	12,027	668	19,838	141,888	108,948	250,836
		%	0.1%	0.1%	49.8%	6.6%	30.5%	4.8%	0.3%	7.9%	56.6%	43.4%	100.0%
		biomass (mg m^2)	1.4	0.4	213.7	–[a]	88.3	12.8	2.6	–[a]	215.6	103.8	319.4
		%	0.5%	0.1%	66.9%	–[a]	27.7%	4.0%	0.8%	–[a]	67.5%	32.5%	100.0%
		size (mm)	1.16	0.75	0.70	–[a]	0.36	0.51	0.63	–[a]			
3	5	density (no. m^2)	816	310	205,129	25,579	53,519	12,179	540	17,423	231,834	83,661	315,495
		%	0.3%	0.1%	65.0%	8.1%	17.0%	3.9%	0.2%	5.5%	73.5%	26.5%	100.0%
		biomass (mg m^2)	2.3	1.3	314.6	–[a]	66.3	11.8	3.0	–[a]	318.1	81.1	399.2
		%	0.6%	0.3%	78.8%	–[a]	16.6%	3.0%	0.7%	–[a]	79.7%	20.3%	100.0%
		size (mm)	0.84	0.98	0.67	–[a]	0.37	0.48	0.74	–[a]			
All Data		density (no. m^2)	514	265	164,960	21,121	64,967	12,103	604	18,631	186,861	96,304	283,165
		%	0.2%	0.1%	58.3%	7.5%	22.9%	4.3%	0.2%	6.6%	66.0%	34.0%	100.0%
		biomass (mg m^2)	1.9	0.8	264.1	–[a]	77.3	12.3	2.8	–[a]	266.8	92.4	359.3
		%	0.5%	0.2%	73.5%	–[a]	21.5%	3.4%	0.8%	–[a]	74.3%	25.7%	100.0%
		size (mm)	1.00	0.87	0.69	–[a]	0.37	0.50	0.69	–[a]			

[a] Other copepods and cladocerans are composed of immature species that are too small to measure and generate a biomass estimate.

Table 15.–Summary of Frazer Lake phytoplankton biomass, by sample date and phylum, 2013.

		Phylum							
		Chlorophyta (Green Algae)	Chrysophyta (Golden-brown Algae)	Bacillariophyta (Diatoms)	Cryptophyta (crytomonads)	Pyrrhophyta (Dinoflagellate)	Cyanobacteria (Blue-green Algae)	Euglenophyta (Other Algae)	Total
Date	Station	Biomass (mg/m^3)	Biomass (mg/m^3)	Biomass (mg/m^3)	Biomass (mg/m^3)	Biomass (mg/m^3)	Biomass (mg/m^3)	Biomass (mg/m^3)	Biomass (mg/m^3)
5/14/2013	1	0.01	0.00	38.33	0.00	0.00	1.16	0.00	39.49
5/14/2013	3	5.65	0.00	419.32	9.11	2.71	0.00	0.00	436.79
6/10/2013	1	0.91	0.00	891.46	0.00	40.89	2.00	0.00	935.26
6/10/2013	3	659.43	0.00	127.73	0.15	0.00	0.26	0.00	787.57
7/19/2013	1	5.22	0.63	699.62	0.00	2.63	14.12	2.54	724.75
7/19/2013	3	9.91	0.41	356.94	0.00	0.00	26.05	0.00	393.31
8/12/2013	1	0.93	0.09	8.93	0.31	10.74	0.02	0.00	21.01
8/12/2013	3	53.02	8.68	247.95	0.00	40.46	16.47	0.00	366.58
9/11/2013	1	11.45	9.43	274.37	92.92	156.73	4.20	0.00	549.10
9/11/2013	3	3.19	0.13	37.63	8.21	16.75	0.35	0.08	66.35
10/14/2013	1	2.78	0.06	176.03	2.57	0.35	0.32	0.00	182.10
10/14/2013	3	1.59	0.07	579.92	17.97	5.63	6.49	0.00	611.67
Mean (St1)		3.55	1.70	348.12	15.97	35.22	3.64	0.42	408.62
Mean (St3)		122.13	1.55	294.91	5.91	10.92	8.27	0.01	443.71
Mean (St 1 and 3)		62.84	1.62	321.52	10.94	23.07	5.95	0.22	426.16

Table 16.–Monthly and seasonal averages of water chemistry components, photosynthetic pigment concentrations, and nutrient concentrations for Frazer Lake, station 1, 2013.

Depth	Sample type	May	June	July	August	September	October	Seasonal Average	Std Error
1 meter									
	pH	7.4	7.7	7.9	7.7	7.6	7.4	7.6	0.03
	Alkalinity (mg/L $CaCO_3$)	13.3	16.8	14.3	14.0	14.5	14.0	14.5	0.20
	Total phosphorous (µg/L P)	4.4	3.7	2.8	3.7	8.0	4.8	4.6	0.30
	Total filterable phosphorous (µg/L P)	2.4	1.1	1.5	1.7	1.7	1.9	1.7	0.07
	Filterable reactive phosphorous (µg/L P)	1.1	1.0	1.0	1.5	1.1	1.6	1.2	0.04
	Total Kjeldahl nitrogen (µg/L N)	149.0	591.0	322.0	636.0	645.0	687.0	505.0	36.32
	Ammonia (µg/L N)	6.0	4.9	25.0	17.6	8.6	18.6	13.5	1.35
	Nitrate + nitrite (µg/L N)	48.4	48.4	12.6	12.7	16.7	40.3	29.9	2.95
	Organic silicon (µg/L)	2,596.6	2,239.0	2,327.3	2,386.8	2,397.6	2,188.5	2356.0	23.94
	Chlorophyll *a* (µg/L)	0.64	0.64	0.64	0.64	0.96	0.80	0.72	0.02
	Phaeophytin *a* (µg/L)	0.03	0.26	0.03	0.14	0.83	0.43	0.29	0.05
30 meters									
	pH	7.5	7.3	7.7	7.7	7.4	7.6	7.5	0.03
	Alkalinity (mg/L $CaCO_3$)	13.5	16.0	14.0	14.5	14.5	14.3	14.5	0.14
	Total phosphorous (µg/L P)	3.9	3.4	3.2	2.9	3.8	4.9	3.7	0.12
	Total filterable phosphorous (µg/L P)	1.3	1.0	1.3	1.3	1.5	1.8	1.4	0.04
	Filterable reactive phosphorous (µg/L P)	0.8	1.4	1.3	0.9	0.4	1.1	1.0	0.06
	Total Kjeldahl nitrogen (µg/L N)	247.0	500.0	428.0	568.0	635.0	757.0	522.5	29.35
	Ammonia (µg/L N)	5.3	5.8	34.6	33.7	17.4	16.8	18.9	2.15
	Nitrate + nitrite (µg/L N)	64.2	58.3	53.4	50.7	41.3	40.4	51.4	1.56
	Organic silicon (µg/L)	2,539.4	2,315.4	2,369.7	2,221.0	2,232.2	2,194.9	2,312.1	21.53
	Chlorophyll *a* (µg/L)	0.53	0.64	0.6	0.96	0.64	0.96	0.73	0.03
	Phaeophytin *a* (µg/L)	0.21	0.26	0.26	0.61	0.48	0.16	0.33	0.03

Table 17.–Monthly and seasonal averages of water chemistry components, photosynthetic pigment concentrations, and nutrient concentrations for Frazer Lake, station 3, 2013.

Depth	Sample type	May	June	July	August	September	October	Seasonal Average	Std Error
1 meter									
	pH	7.7	7.6	7.9	7.6	7.6	7.5	7.6	0.02
	Alkalinity (mg/L $CaCO_3$)	13.0	16.0	14.5	14.5	15.5	14.3	14.6	0.17
	Total phosphorous (µg/L P)	4.1	3.1	2.6	3.9	5.2	4.6	3.9	0.16
	Total filterable phosphorous (µg/L P)	1.5	1.4	1.3	1.4	2.3	1.6	1.6	0.06
	Filterable reactive phosphorous (µg/L P)	0.8	1.6	1.2	1.2	1.8	1.2	1.3	0.06
	Total Kjeldahl nitrogen (µg/L N)	21.0	478.0	331.0	631.0	674.0	610.0	457.5	41.31
	Ammonia (µg/L N)	6.8	4.2	24.3	18.7	8.9	17.7	13.4	1.32
	Nitrate + nitrite (µg/L N)	63.3	52.8	10.2	12.3	13.8	38.7	31.9	3.84
	Organic silicon (µg/L)	2,606.1	2,102.3	2,546.8	2,346.4	2,133.3	2,259.9	2,332.5	34.9
	Chlorophyll *a* (µg/L)	0.64	0.64	0.96	0.96	1.28	0.80	0.88	0.04
	Phaeophytin *a* (µg/L)	0.26	0.03	0.16	0.16	0.29	0.43	0.22	0.02
50 meters									
	pH	7.6	7.5	7.6	7.7	7.4	7.6	7.6	0.02
	Alkalinity (mg/L $CaCO_3$)	12.8	16.3	14.5	14.8	14.3	14.0	14.4	0.19
	Total phosphorous (µg/L P)	3.9	3.0	3.4	3.4	4.1	5.1	3.8	0.12
	Total filterable phosphorous (µg/L P)	1.1	0.9	1.3	1.1	1.4	1.7	1.3	0.05
	Filterable reactive phosphorous (µg/L P)	1.0	0.8	1.2	1.1	0.5	0.7	0.9	0.04
	Total Kjeldahl nitrogen (µg/L N)	264.0	359.0	201.0	776.0	544.0	738.0	480.3	40.65
	Ammonia (µg/L N)	3.7	9.0	36.3	43.2	24.4	17.2	22.3	2.57
	Nitrate + nitrite (µg/L N)	63.4	62.4	59.0	56.4	54.2	39.4	55.8	1.46
	Organic silicon (µg/L)	2,384.6	2,251.9	2,463.7	2,232.7	2,152.4	2,348.7	2,305.7	19.0
	Chlorophyll *a* (µg/L)	0.64	0.64	0.64	0.48	0.64	0.48	0.59	0.01
	Phaeophytin *a* (µg/L)	0.26	0.03	0.03	0.08	0.03	0.30	0.12	0.02

Table 18.–Monthly and seasonal averages of water chemistry components, photosynthetic pigment concentrations, and nutrient concentrations for Frazer Lake, stations 1 and 3 averaged, 2013.

Depth	Sample type	May	June	July	August	September	October	Seasonal Average	Std Error
1 meter									
	pH	7.5	7.6	7.9	7.7	7.6	7.4	7.6	0.02
	Alkalinity (mg/L $CaCO_3$)	13.1	16.4	14.4	14.3	15.0	14.1	14.5	0.18
	Total phosphorous (µg/L P)	4.3	3.4	2.7	3.8	6.6	4.7	4.2	0.22
	Total filterable phosphorous (µg/L P)	2.0	1.3	1.4	1.6	2.0	1.8	1.7	0.05
	Filterable reactive phosphorous (µg/L P)	1.0	1.3	1.1	1.4	1.5	1.4	1.3	0.03
	Total Kjeldahl nitrogen (µg/L N)	85.0	534.5	326.5	633.5	659.5	648.5	481.3	38.49
	Ammonia (µg/L N)	6.4	4.6	24.7	18.2	8.8	18.2	13.4	1.33
	Nitrate + nitrite (µg/L N)	55.9	50.6	11.4	12.5	15.3	39.5	30.9	3.37
	Organic silicon (µg/L)	2,601.4	2,170.7	2,437.1	2,366.6	2,265.5	2,224.2	2,344.2	26.45
	Chlorophyll *a* (µg/L)	0.64	0.64	0.8	0.8	1.12	0.8	0.80	0.03
	Phaeophytin *a* (µg/L)	0.15	0.15	0.10	0.15	0.56	0.43	0.25	0.03
Hypolimnion									
	pH	7.5	7.4	7.7	7.7	7.4	7.6	7.5	0.02
	Alkalinity (mg/L $CaCO_3$)	13.1	16.1	14.3	14.6	14.4	14.1	14.4	0.16
	Total phosphorous (µg/L P)	3.9	3.2	3.3	3.2	4.0	5.0	3.8	0.12
	Total filterable phosphorous (µg/L P)	1.2	1.0	1.3	1.2	1.5	1.8	1.3	0.05
	Filterable reactive phosphorous (µg/L P)	0.9	1.1	1.3	1.0	0.5	0.9	0.9	0.05
	Total Kjeldahl nitrogen (µg/L N)	255.5	429.5	314.5	672.0	589.5	747.5	501.4	33.17
	Ammonia (µg/L N)	4.5	7.4	35.5	38.5	20.9	17.0	20.6	2.34
	Nitrate + nitrite (µg/L N)	63.8	60.4	56.2	53.6	47.8	39.9	53.6	1.45
	Organic silicon (µg/L)	2,462.0	2,283.7	2,416.7	2,226.9	2,192.3	2,271.8	2,308.9	17.86
	Chlorophyll *a* (µg/L)	0.59	0.64	0.64	0.72	0.64	0.72	0.66	0.01
	Phaeophytin *a* (µg/L)	0.24	0.15	0.15	0.35	0.26	0.23	0.23	0.01

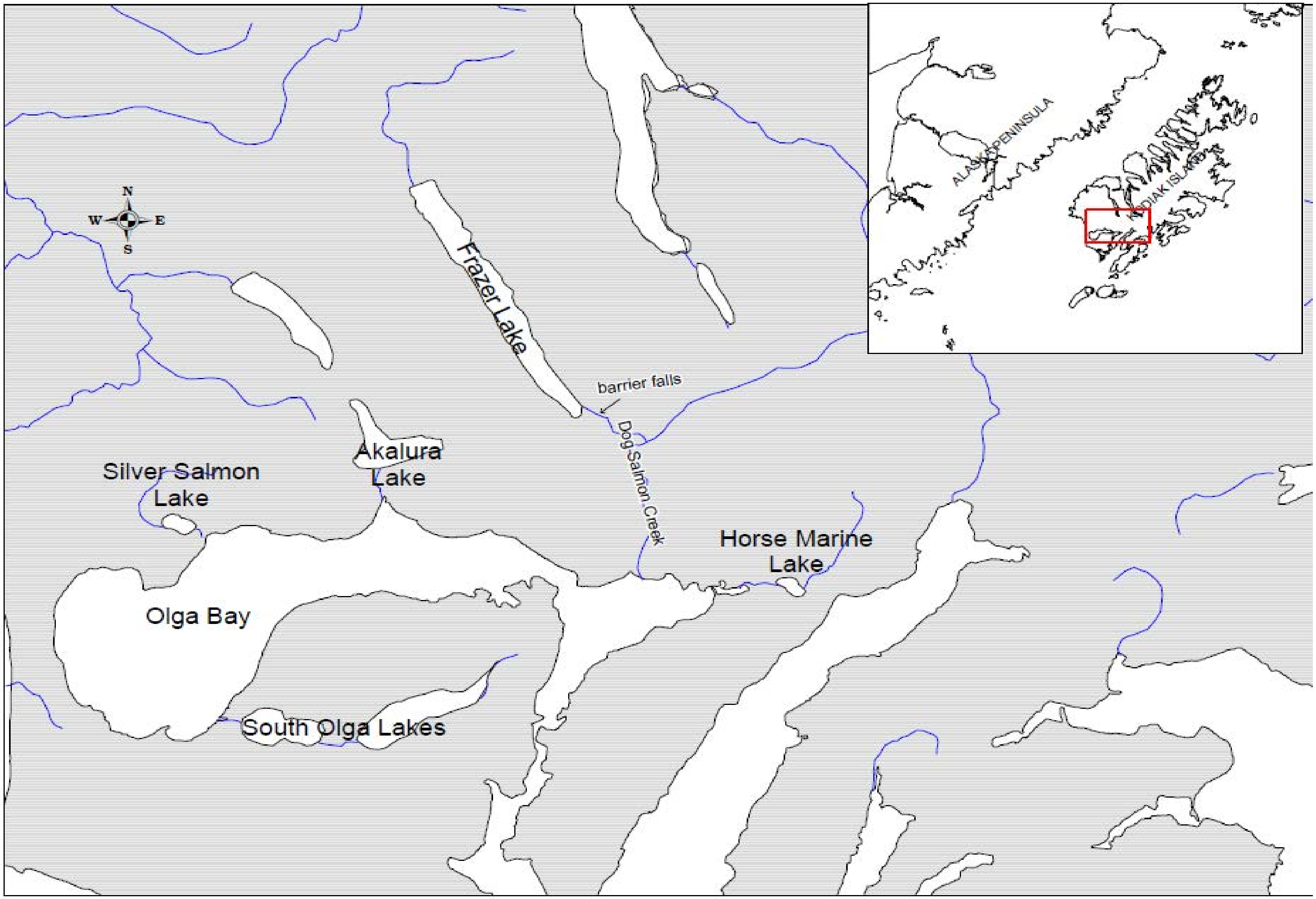

Figure 1.–Locations of Frazer Lake, Dog Salmon Creek, barrier falls, and Olga Bay on Kodiak Island.

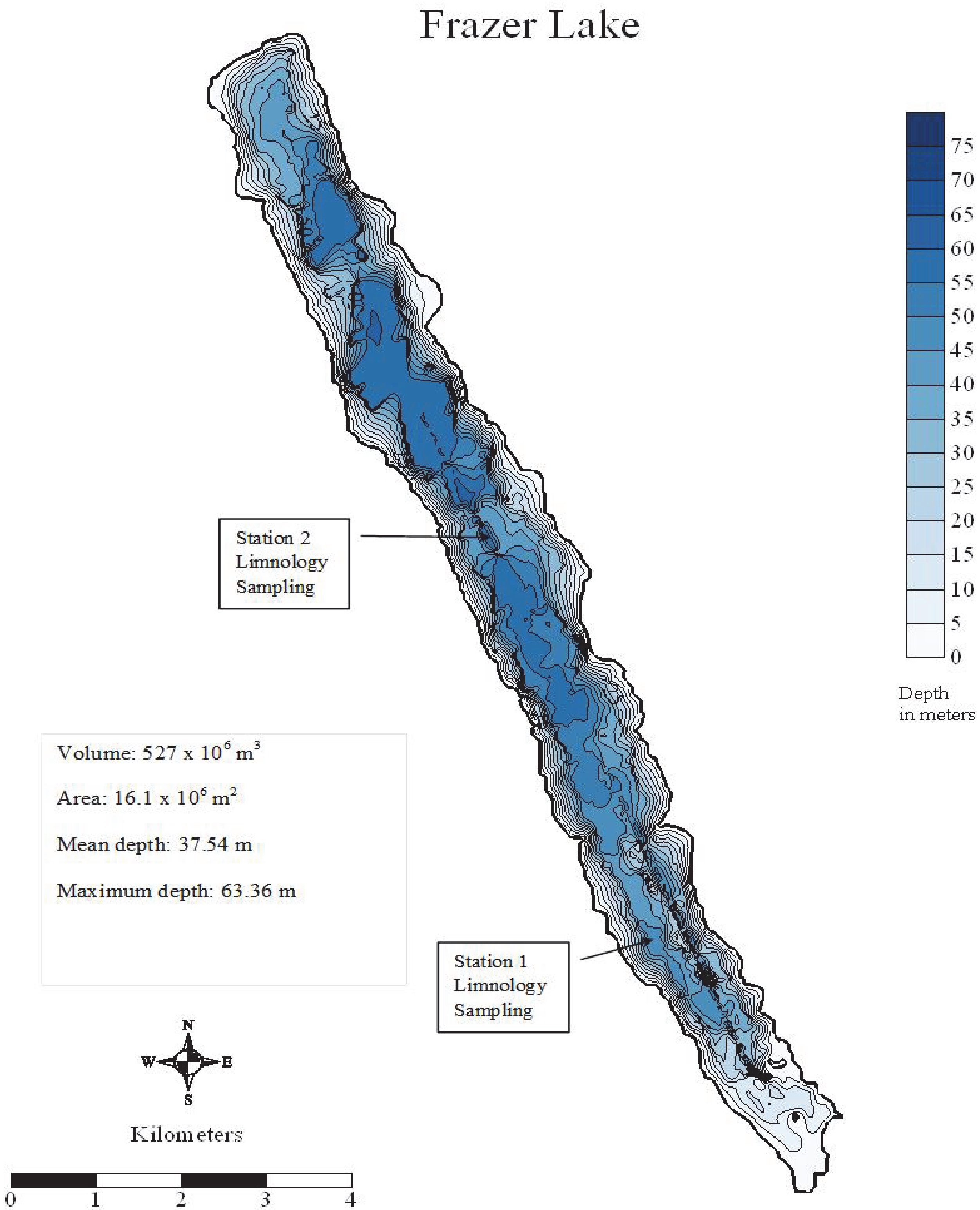

Figure 2.–Morphometric map showing the location of limnology sampling stations on Frazer Lake.

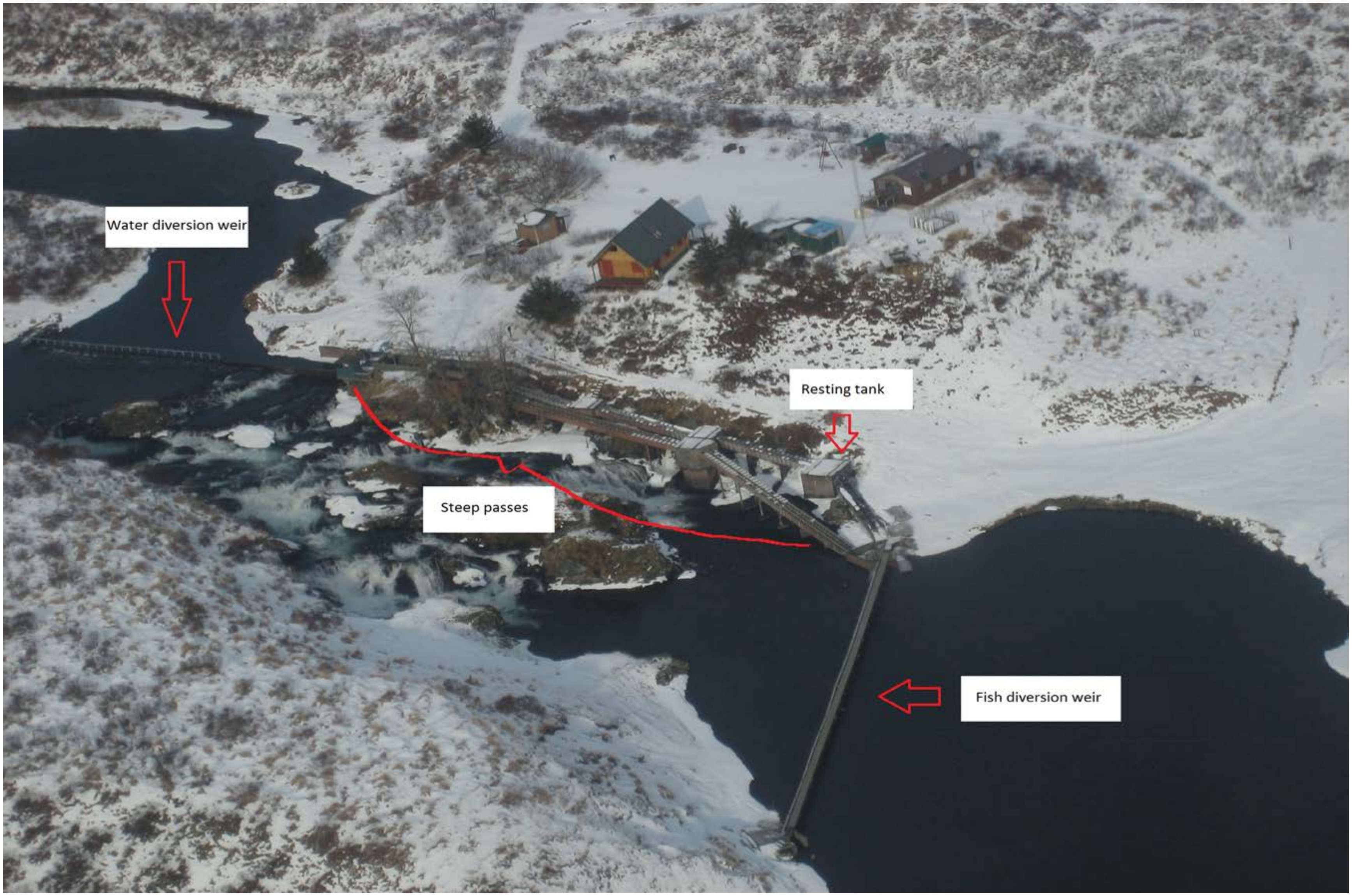

Figure 3.–Aerial view of Frazer Fish Pass.

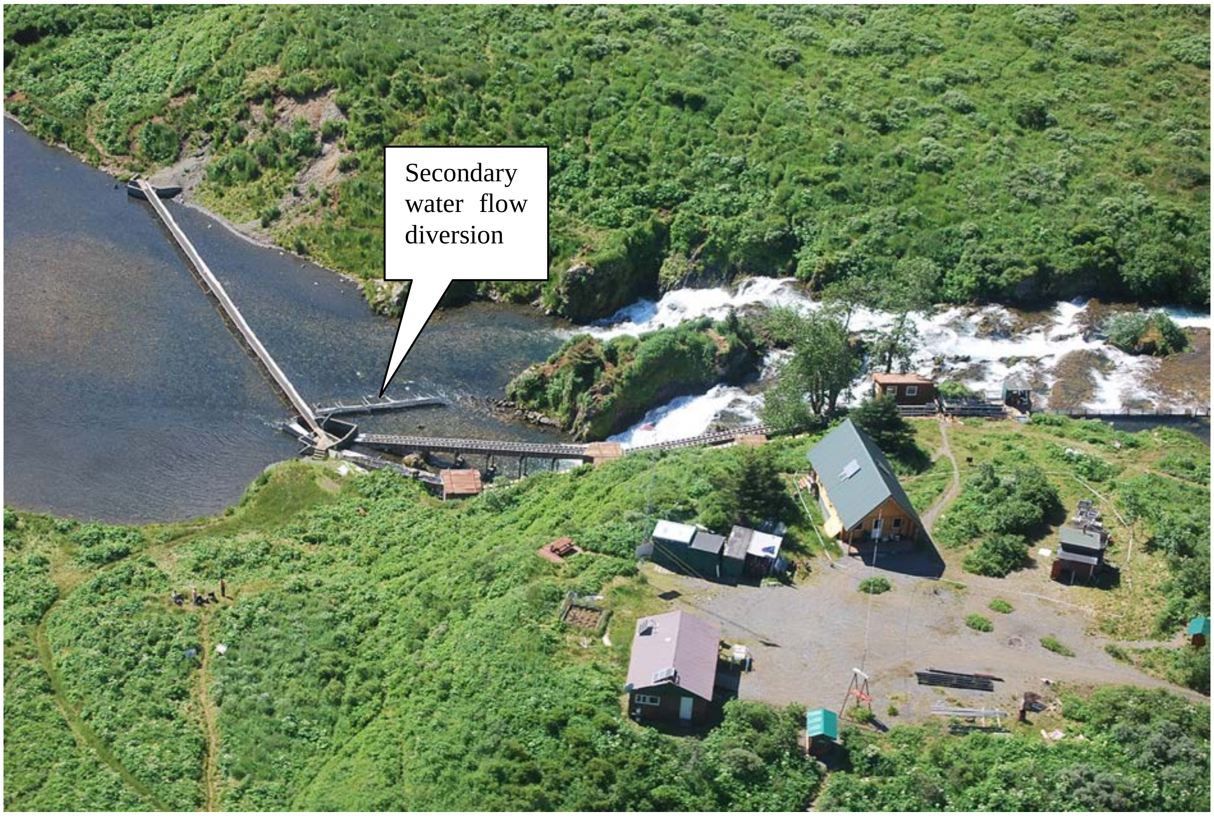

Figure 4.–Aerial view of secondary water flow diversion at Frazer Fish Pass entrance.

Figure 5.–Dog Salmon Creek smolt trapping system.

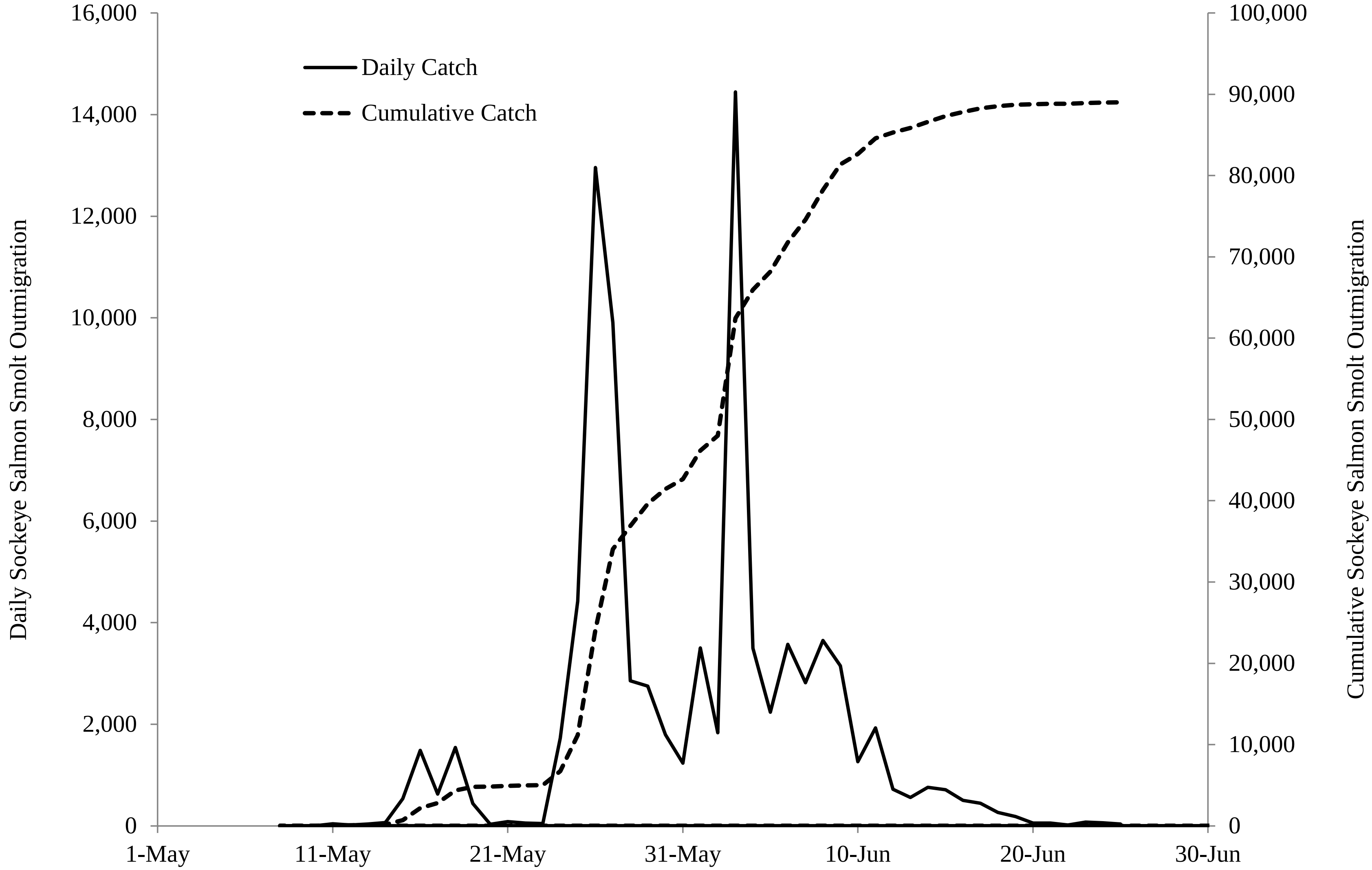

Figure 6.–Daily and cumulative sockeye salmon smolt catch, Frazer Lake, 2013.

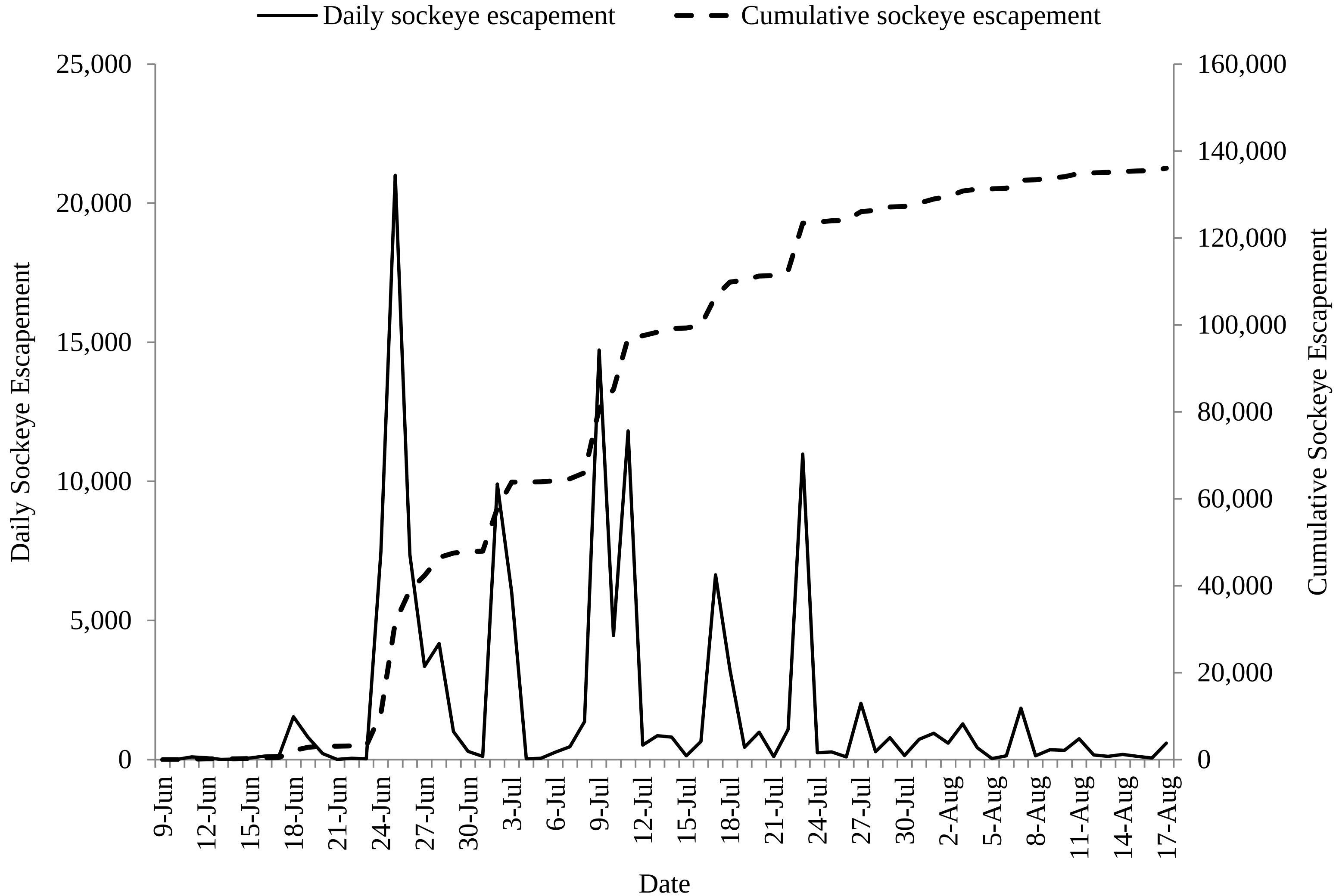

Figure 7.–Daily and cumulative sockeye salmon escapement, Frazer Lake, 2013.

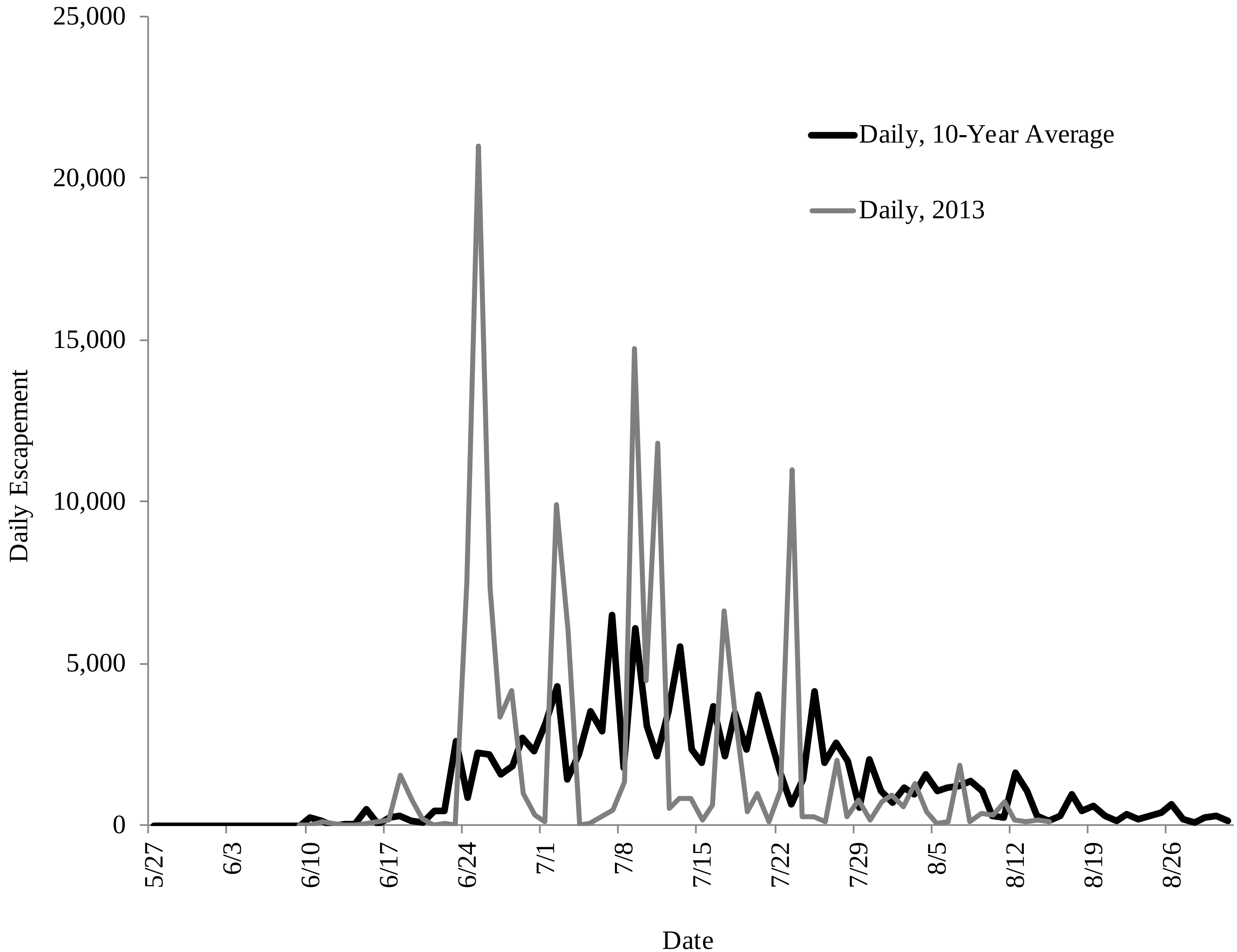

Figure 8.–Daily and 10-year average sockeye salmon escapement, Frazer Fish Pass, 2013.

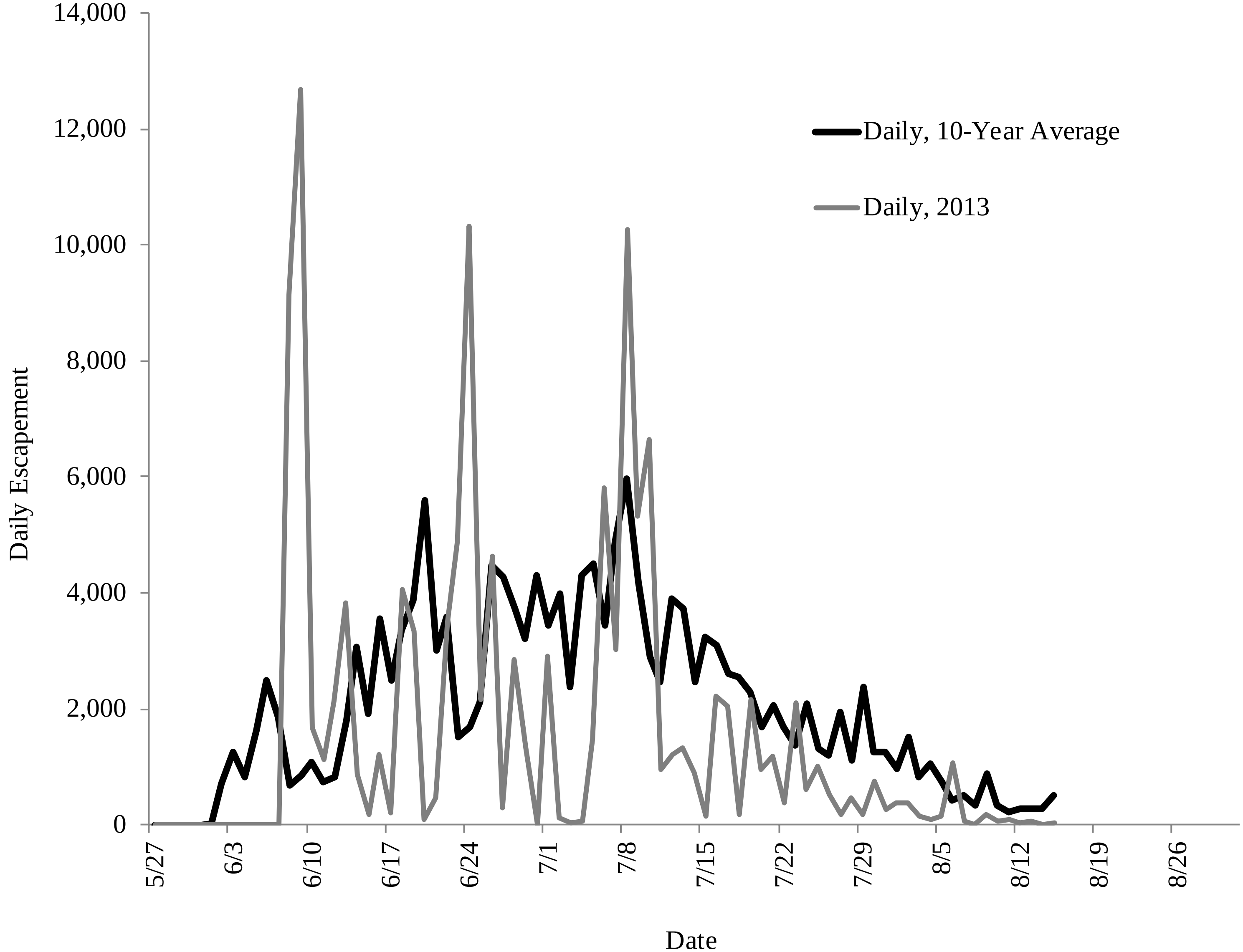

Figure 9.–Daily and 10-year average sockeye salmon escapement, Dog Salmon weir, 2013.

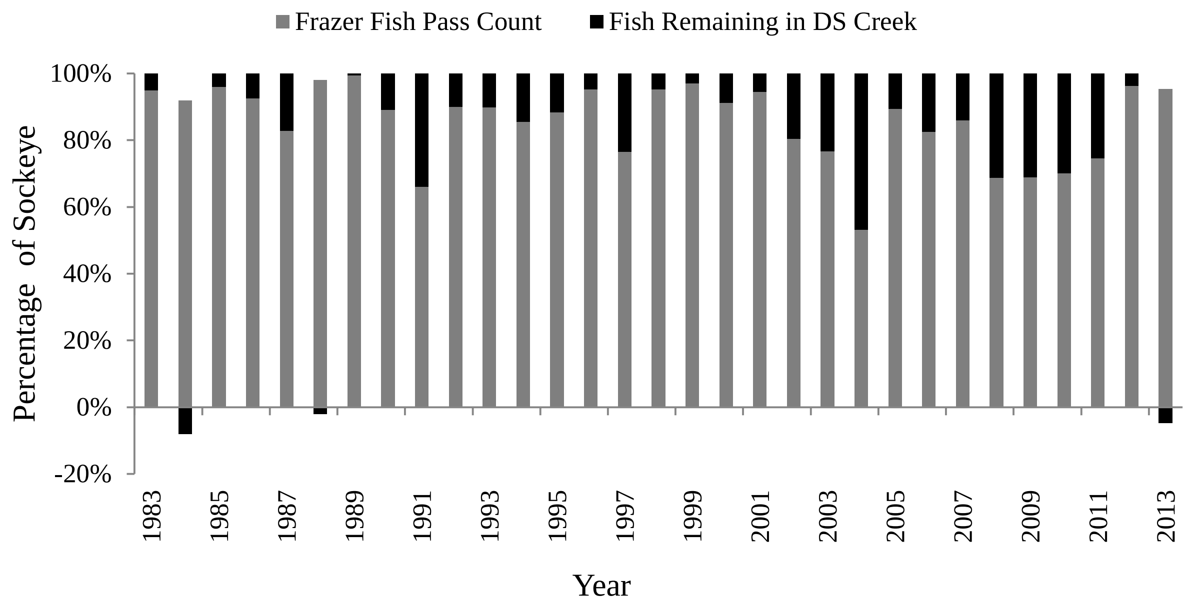

Figure 10.–Percentage of sockeye salmon remaining in Dog Salmon Creek, 1983-2013.

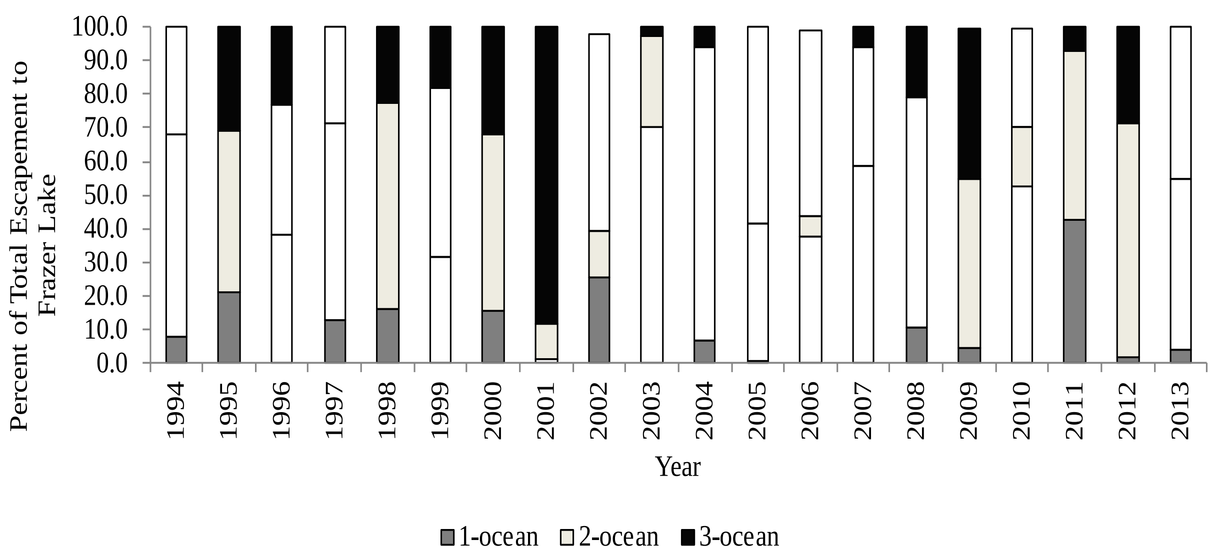

Figure 11.–Percentage of sockeye salmon escapement into Frazer Lake, by ocean age and year, 1994-2013.

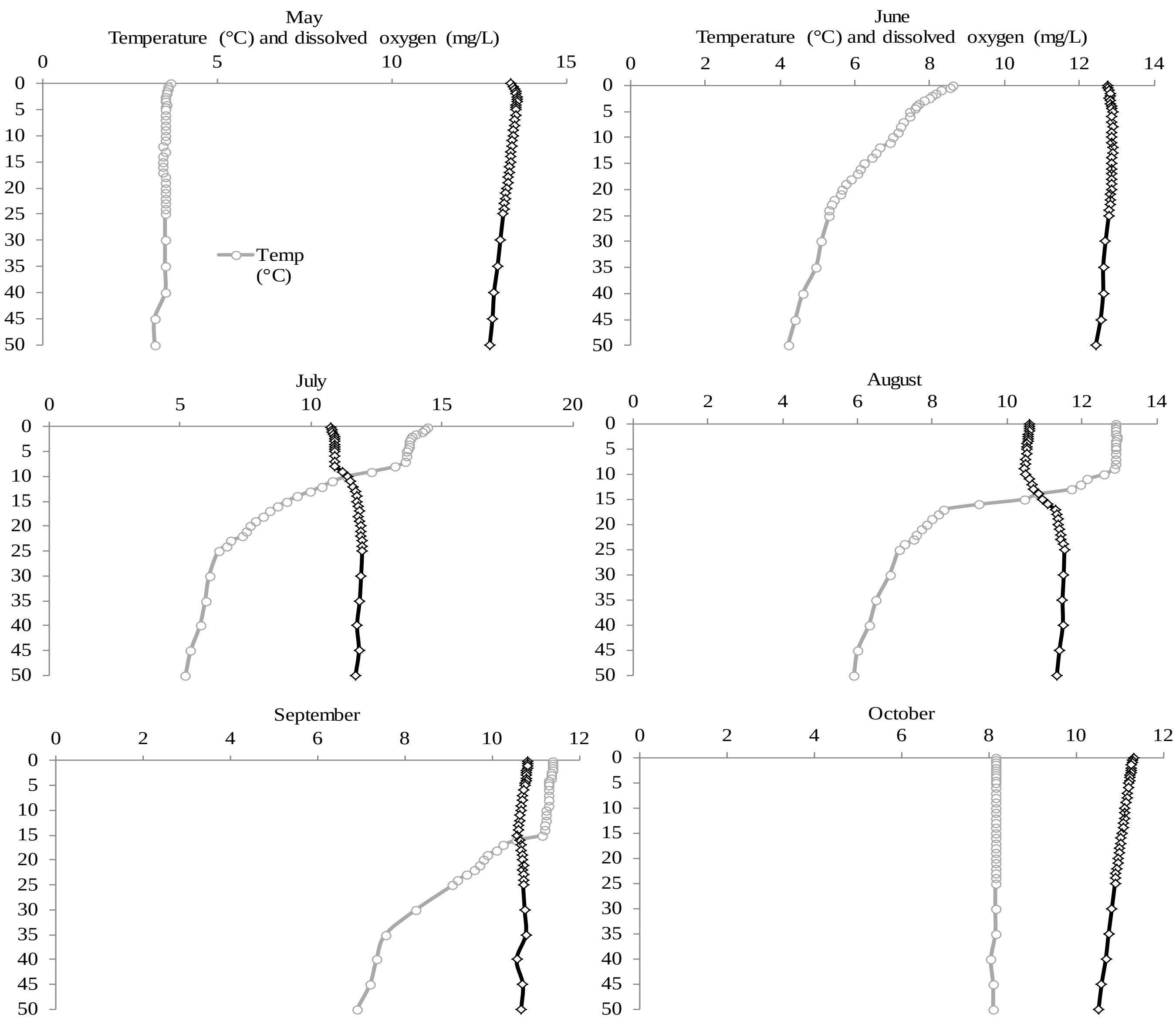

Figure 12.–Temperature and dissolved oxygen depth profiles by month from Frazer Lake, 2013.

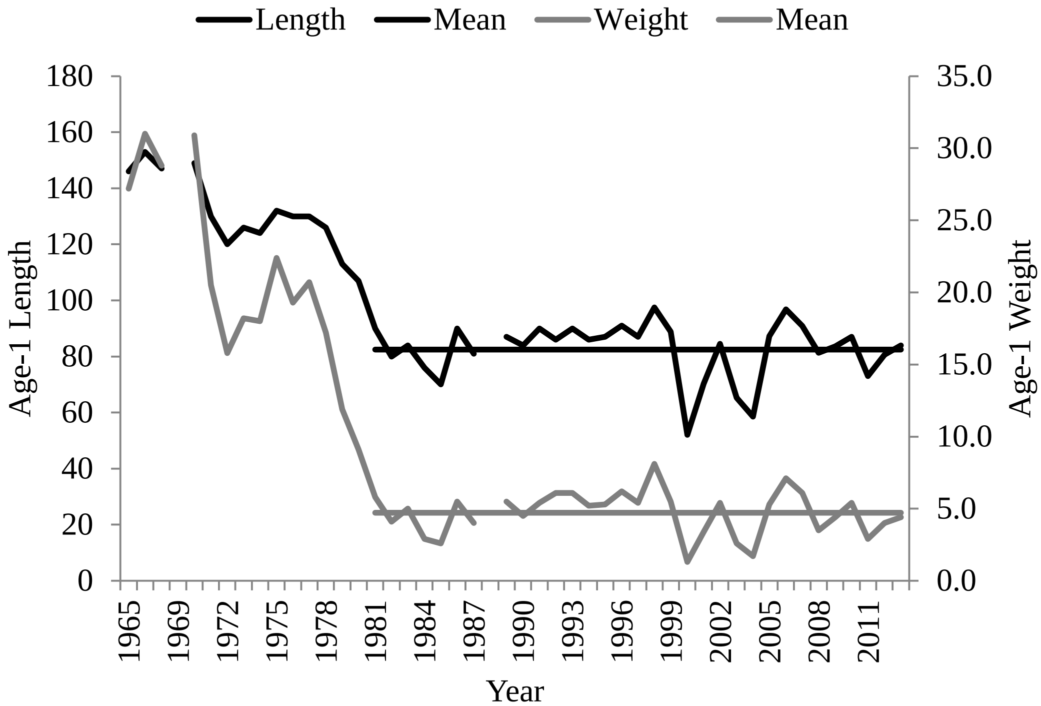

Figure 13.–Frazer Lake age-1 smolt mean weight and length, 1965−2013.

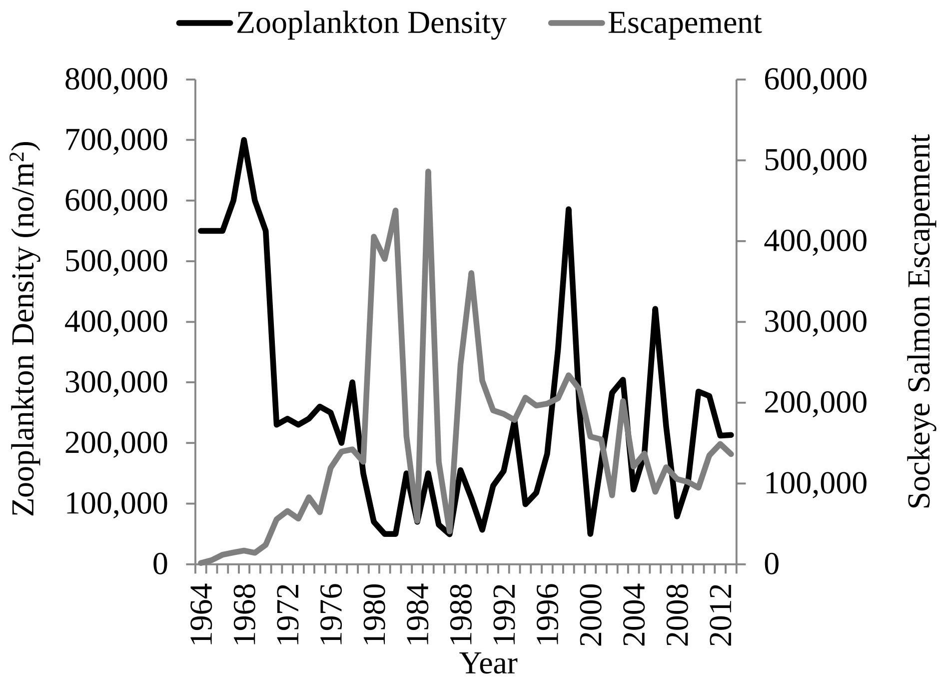

Figure 14.–Sockeye salmon Escapement and zooplankton density, 1964−2013.

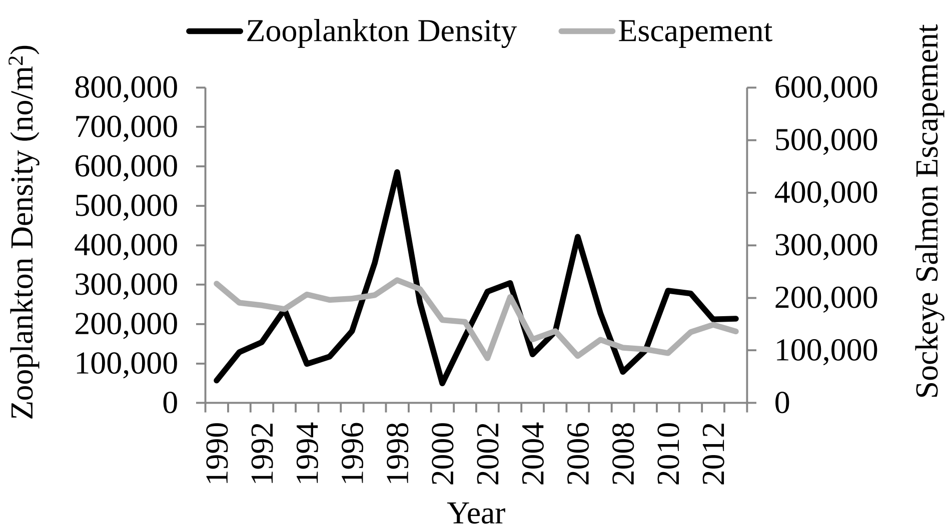

Figure 15.–Sockeye salmon Escapement and zooplankton density, 1990−2013.

APPENDIX A: HISTORICAL STOCKING, ESCAPEMENT GOALS, AND SMOLT SAMPLING METHODS AND LOCATIONS

Appendix A1.–Salmon stocking in Frazer Lake by species, life stages, donor source, and location of planting events, 1951-1971.

		Lifestage				
Year	Species	Adults	Fry	Eggs	Donor source	Location of planting in Frazer Lake
1951	*O. nerka*			200,000	Karluk Lake	Stumble Creek
1952	*O. nerka*			313,000	Karluk Lake	Linda Creek
1953	*O. nerka*			1,092,000	Karluk Lake	Pinnell, Westside, Linda, Midway Creeks
1954	*O. nerka*			541,000	Karluk Lake	Linda Creek
1955	*O. nerka*			320,000	Karluk Lake	Linda and Stumble Creeks
1956	*O. nerka*			504,000	Red Lake	Linda and Stumble Creeks
1958	*O. nerka*	42			Red Lake	Midway Creek
1961	*O. nerka*	600	87,000		Red Lake	Lake
1962	*O. nerka*	1,839			Red Lake	Lake
1963	*O. nerka*	9,500			Red Lake	Lake
1964	*O. nerka*	1,800			Red Lake	Lake
1965	*O. nerka*	4,000		830,000	Red Lake	Lake (adults); tributaries (eggs)
1966	*O. nerka*	4,728	504,300	600,000	Red Lake	Lake (adults, fry); Stumble Creek (eggs)
1966	*O. tshawytscha*		42,000		Karluk Lake	Lower lake outlet below Frazer falls
1967	*O. nerka*	7,334		1,190,000	Red Lake	Lake (adults); Midway, Pinnell, and Linda creeks (eggs)
1967	*O. tshawytscha*		56,000		Karluk Lake	Lower lake outlet below Frazer falls
1968	*O. nerka*	30	311,000	3,387,000	Red Lake	Lake (adults, fry); Midway, Pinnell, and Linda creeks (eggs)
1968	*O. tshawytscha*		46,000		Karluk Lake	Lower lake outlet below Frazer falls
1969	*O. nerka*	60			Red Lake	Lake
1969	*O. nerka*		599,760	1,963,000	Ruth or Becharof Lake	Lake (fry); Midway and Linda Creeks (eggs)
1969	*O. tshawytscha*		16,000		Karluk Lake	Lower lake outlet below Frazer falls
1970	*O. nerka*		945,000		Red Lake	Pinnell Creek
1971	*O. nerka*		527,000		Red Lake	Pinnell Creek
Totals	*O. nerka*	29,933	2,974,060	7,970,000		
	O. tshawytscha	0	160,000	0		

Appendix A2.–Frazer Lake Escapement Goals (1950–2012).

Escapement Goal (Range)	Type	SMSY	SEQ	Reference	Dates of Use
75,000 – 170,000	BEG	117,000	321,000	Nemeth et al. 2010	Current
75,000 – 170,000	BEG	118,000		Honnold et al. 2007	
70,000 – 150,000	BEG	105,000		Nelson et al. 2005	
140,000 – 200,000	BEG			Nelson and Lloyd 2001	
Lake goal 124,000 – 181,000	BEG			Malloy and Prokopowich 1992	
200,000 – 275,000					1986-1988
350,000 – 400,000					1981-1985
175,000					1950’s to 1970’s

Appendix A3.–Frazer Lake/Dog Salmon Creek smolt capture locations and methods, 1965–2013.

Year	Smolt Sampling Method	Location
1965-1971	Smolt weir	1/4 mile below lake outlet
1972-1974	Index netting	Varied
1975-1978	Seining	Below Frazer falls
1985-1993	Incline plane and concrete trap	Incline plane trap: between unipod 6 and 8 of lower adult salmon weir. Concrete trap: north bank of lower adult salmon weir
1994-1998	Incline plane trap	76 meters upriver from upper diversion weir adjacent to small island.
2001-2004	Incline plane trap	75 meters upriver from upper diversion weir adjacent to small island.
2005	Incline plane trap	Above falls, 30 feet downstream of tip of second island
2006-2007	Floating smolt and incline plane trap	Fan trap: Above falls, 30 feet downstream of tip of second island. Floating trap: above falls upriver of second island.
2008-2013	Incline plane Trap	Upstream of waterfall and concrete water diversion weir

APPENDIX B: HISTORICAL SMOLT DATA

Appendix B1.–Mean length, weight, and condition coefficient by year and age (age-1, 2, & 3) of sockeye smolt outmigrating from Frazer Lake, 1965–2013.

		Age-1					Age-2					Age-3				
Year	Total smolt sampled	N	Age composition (%)	Length (mm)	Weight (g)	Condition Coefficient (K)	N	Age composition (%)	Length (mm)	Weight (g)	Condition Coefficient (K)	N	Age composition (%)	Length (mm)	Weight (g)	Condition Coefficient (K)
1965	1,057	698	66.0	146	27.2	0.91	346	32.7	174	48.0	0.89	13	1.2	-	-	
1966	1,916	542	28.3	163	31.0	0.93	1,358	70.9	180	53.1	0.91	15	0.8	-	-	
1967	1,938	1,196	61.7	147	28.8	0.90	680	35.1	177	53.2	0.97	62	3.2	-	-	
1968	1,789	1,517	84.8	154	36.3	0.92	265	14.8	185	62.0	0.94	7	0.4	-	-	
1969	0	0		-	-		0		-	-		0		-	-	
1970	2,537	1,878	74.0	149	30.9	0.93	649	25.6	180	54.0	0.93	10	0.4	-	-	
1971	470	130	27.7	130	20.5	0.93	334	71.1	173	44.5	0.86	6	1.3	-	-	
1972	474	452	95.4	120	15.8	0.91	22	4.6	151	31.7	0.92	0	0.0	-	-	
1973	120	46	38.3	126	18.2	0.91	74	61.7	142	25.6	0.88	0	0.0	-	-	
1974	875	227	24.9	124	18.0	0.95	573	66.3	151	29.9	0.89	75	8.8	-	-	
1975	1,304	328	27.7	132	22.4	0.97	972	71.9	149	29.5	0.89	4	0.3	-	-	
1976	924	479	52.5	130	19.3	0.88	418	44.6	157	34.0	0.87	27	2.9	-	-	
1977	788	385	48.9	130	20.7	0.95	403	51.1	154	32.0	0.88	0	0.0	-	-	
1978	330	107	32.4	126	17.2	0.87	223	67.6	145	26.0	0.86	0	0.0	-	-	
1979	831	460	55.4	113	11.9	0.83	371	44.6	143	23.4	0.80	0	0.0	-	-	
1980	439	349	79.5	107	9.1	0.75	90	20.5	109	9.8	0.75	0	0.0	-	-	
1981	318	250	78.6	90	5.8	0.78	68	21.4	108	10.2	0.79	0	0.0	-	-	
1982	327	64	19.6	80	4.1	0.77	248	75.8	95	7.0	0.78	15	4.6	-	-	
1983	519	23	4.4	84	5.0	0.82	495	95.4	95	6.9	0.81	1	0.2	-	-	
1984	1,261	1,189	94.3	76	2.9	0.64	50	4.0	99	7.1	0.68	3	0.2	-	-	
1985	2,555	2,389	93.5	70	2.6	0.73	51	2.0	84	4.7	0.80	0	0.0	-	-	
1986	1,525	85	5.6	90	5.5	0.76	1,438	94.3	98	7.4	0.79	2	0.1	-	-	
1987	1,164	196	16.8	81	4.0	0.74	761	65.4	104	8.2	0.73	207	17.8	-	-	
1988	0	0		-	-		0	-	-	-		0		-	-	
1989	644	22	3.4	87	5.5	0.84	622	96.6	101	8.0	0.78	0		-	-	
1990	1,172	574	49.0	84	4.5	0.74	554	47.3	104	9.0	0.79	44	3.8	112	11.7	0.82
1991	2,096	747	35.6	90	5.4	0.74	1,345	64.2	90	5.6	0.77	4	0.2	121	15.7	0.85
1992	3,205	49	1.5	86	6.1	0.94	2,961	92.4	84	5.4	0.91	195	6.1	89.2	7.1	0.91
1993	1,612	8	0.5	90	6.1	0.83	685	42.5	100	8.3	0.82	916	56.8	103.8	9.0	0.81
1994	2,472	713	28.8	86	5.2	0.81	1,457	58.9	103	8.1	0.75	302	12.2	112.8	10.7	0.74
1995	2,213	39	1.8	87	5.3	0.74	2,154	97.3	91	5.6	0.73	20	0.9	115.2	13.6	0.79

-continued-

Appendix B1.–Page 2 of 2.

		Age-1					Age-2					Age-3				
Year	Total smolt sampled	N	Age composition (%)	Length (mm)	Weight (g)	Condition Coefficient (K)	N	Age composition (%)	Length (mm)	Weight (g)	Condition Coefficient (K)	N	Age composition (%)	Length (mm)	Weight (g)	Condition Coefficient (K)
1996	1,915	42	2.2	91	6.2	0.78	1,747	91.2	86	5.1	0.76	126	6.6	95	9.0	0.74
1997	2,652	599	22.6	89	5.5	0.78	1,395	52.6	93	6.4	0.77	638	24.1	106	9.5	0.79
1998	1,841	618	33.6	98	8.1	0.86	1,205	65.5	110	10.4	0.79	18	1.0	114	11.8	0.78
1999	2,345	1,357	57.9	89	5.5	0.78	793	33.8	121	13.7	0.77	196	8.4	126	15.3	0.77
2000	3,517	29	0.8	52	1.3	1.07	3,385	96.2	86	4.3	0.67	90	2.6	113	11.7	0.80
2001	2,604	77	3.0	70	3.4	0.86	2,444	93.9	77	3.8	0.82	79	3.0	109	11.4	0.84
2002	2,183	961	44.0	85	5.4	0.89	937	42.9	95	7.5	0.87	279	12.8	100	8.7	0.87
2003	749	7	0.9	65	2.6	0.87	740	98.8	86	4.8	0.77	2	0.3	134	20.9	0.86
2004	912	2	0.2	59	1.7	0.82	909	99.7	75	3.2	0.76	1	0.1	129	18.0	0.84
2005	1,083	30	2.8	87	5.3	0.81	277	25.6	90	5.8	0.79	776	71.7	93	6.1	0.75
2006	1,356	967	71.3	97	7.1	0.78	206	15.2	104	8.7	0.76	127	9.4	110	10.1	0.76
2007	920	273	29.7	91	6.1	0.80	572	62.2	108	9.2	0.74	75	8.2	109	9.3	0.71
2008	580	6	1.0	81	3.5	0.61	573	98.8	88	4.1	0.60	1	0.2	100	5.6	0.56
2009	487	43	8.8	84	4.4	0.73	354	72.7	94	6.3	0.75	90	18.5	94	6.4	0.76
2010	891	431	48.4	87	5.4	0.78	361	40.5	98	7.2	0.74	98	11.0	104	8.5	0.75
2011	1,487	38	2.6	71	2.8	0.73	1,376	92.5	96	6.1	0.69	26	1.7	114	10.4	0.68
2012	1,580	140	8.9	81	4.0	0.74	1,438	91.0	95	6.3	0.74	2	0.1	129	17.7	0.80
2013	1,414	53	3.7	84	4.4	0.70	1,096	77.5	94	6.1	0.73	264	18.7	103	7.9	0.72
Average (2008-2012)	1,005	132	13.9	81	4.0	0.72	820	79.1	94	6.0	0.70	43	6.3	108	9.7	0.71
Average (2003-2012)	1,005	194	17.5	80	4.3	0.77	681	69.7	93	6.2	0.73	120	12.1	112	11.3	0.75
Average (1992-2012)	1,743	306	17.7	82	4.8	0.81	1,237	69.7	94	6.7	0.76	193	12.2	110	11.0	0.78

Appendix B2.–Mean length, weight, and condition coefficient by year and age (age-0, 4) of sockeye smolt outmigrating from Frazer Lake, 1992–2013.

	Age-0					Age-4				
Year	N	compostion	(mm)	(g)	Coefficient	N	compostion	(mm)	(g)	Coefficient
1992	0	0.0	–	–	–	0	0.0	–	–	–
1993	0	0.0	–	–	–	3	0.2	121.3	11.8	0.57
1994	0	0.0	–	–	–	0	0.0	–	–	–
1995	0	0.0	–	–	–	0	0.0	–	–	–
1996	0	0.0	–	–	–	0	0.0	–	–	–
1997	0	0.0	–	–	–	9	0.3	112.6	11.9	0.81
1998	0	0.0	–	–	–	0	0.0	–	–	–
1999	0	0.0	–	–	–	0	0.0	–	–	–
2000	0	0.0	–	–	–	13	0.4	138.3	24.3	0.90
2001	3	0.1	52.7	1.4	0.93	1	0.0	155.0	33.5	0.90
2002	0	0.0	–	–	–	6	0.3	99.5	9.2	0.93
2003	0	0.0	–	–	–	0	0.0	–	–	–
2004	0	0.0	–	–	–	0	0.0	–	–	–
2005	0	0.0	–	–	–	0	0.0	–	–	–
2006	12	0.9	80.0	3.4	0.66	44	3.2	112.0	10.8	0.76
2007	0	0.0	–	–	–	0	0.0	–	–	–
2008	0	0.0	–	–	–	0	0.0	–	–	–
2009	0	0.0	–	–	–	0	0.0	–	–	–
2010	0	0.0	–	–	–	1	0.1	140.0	22.1	0.81
2011	0	0.0	–	–	–	0	0.0	–	–	–
2012	0	0.0	–	–	–	0	0.0	–	–	–
2013	0	0.0	–	–	–	1	0.1	102.8	7.9	0.72
(1992-2012)	1	0.0	66.3	2.4	0.80	4	0.2	125.5	17.7	0.81
(2008-2012)	0	0.0	–	–	–	0	0.0	140.0	22.1	0.81

Appendix B3.–Estimated sockeye salmon smolt outmigration by age class and year for Frazer Lake, 1965–2013.

Year	Estimated Outmigration	Sample Total	Age 0 no.	Age 0 %	Age 1 no.	Age 1 %	Age 2 no.	Age 2 %	Age 3 no.	Age 3 %	Age 4 no.	Age 4 %
1965	26,945	1,057	0	0%	698	66%	346	33%	13	1%	0	0%
1966	157,291	1,916	0	0%	542	28%	1,358	71%	15	1%	0	0%
1967	134,123	1,938	0	0%	1,196	62%	680	35%	62	3%	0	0%
1968	93,793	1,789	0	0%	1,517	85%	265	15%	7	0%	0	0%
1969	[b]	0	-		-		-		-		-	
1970	44,808	2,537	0	0%	1,878	74%	649	26%	10	0%	0	0%
1971	[b]	470	0	0%	130	28%	334	71%	6	1%	0	0%
1972	[b]	474	0	0%	452	95%	22	5%	0	0%	0	0%
1973	[b]	120	0	0%	46	38%	74	62%	0	0%	0	0%
1974	[b]	875	0	0%	227	26%	573	65%	75	9%	0	0%
1975	[b]	1,304	0	0%	328	25%	972	75%	4	0%	0	0%
1976	[b]	924	0	0%	479	52%	418	45%	27	3%	0	0%
1977	[b]	788	0	0%	385	49%	403	51%	0	0%	0	0%
1978	[b]	330	0	0%	107	32%	223	68%	0	0%	0	0%
1979	[b]	831	0	0%	460	55%	371	45%	0	0%	0	0%
1980	[b]	439	0	0%	349	79%	90	21%	0	0%	0	0%
1981	[b]	318	0	0%	250	79%	68	21%	0	0%	0	0%
1982	[b]	327	0	0%	64	20%	248	76%	15	5%	0	0%
1983	[b]	519	0	0%	23	4%	495	95%	1	0%	0	0%
1984	[b]	1,261	19	2%	1,189	94%	50	4%	3	0%	0	0%
1985	[b]	2,555	117	5%	2,389	94%	51	2%	0	0%	0	0%
1986	[b]	1,525	1	0%	85	6%	1,438	94%	2	0%	0	0%
1987	3,786 [a]	1,164	0	0%	196	17%	761	65%	207	18%	0	0%
1988	4,335,622 [a]	0	-		-		-		-		-	
1989	12,979,068 [a]	644	0	0%	22	3%	622	97%	0	0%	0	0%
1990	5,186,355 [a]	1,172	0	0%	574	49%	554	47%	44	4%	0	0%
1991	4,818,501	2,096	0	0%	747	36%	1,345	64%	4	0%	0	0%
1992	5,365,777	3,205	0	0%	49	2%	2,961	92%	195	6%	0	0%
1993	7,434,298	1,612	0	0%	8	0%	685	42%	916	57%	3	0%
1994	5,661,489	2,472	0	0%	713	29%	1,457	59%	302	12%	0	0%
1995	8,823,777	2,213	0	0%	39	2%	2,154	97%	20	1%	0	0%
1996	3,820,604	1,915	0	0%	42	2%	1,747	91%	126	7%	0	0%
1997	3,069,352	2,652	11	0%	599	23%	1,395	53%	638	24%	9	0%
1998	[b]	1,841	0	0%	618	34%	1,205	65%	18	1%	0	0%
1999	2,452,962	2,345	0	0%	1,357	58%	793	34%	196	8%	0	0%

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Year	Estimated Outmigration	Sample Total	Age 0 no.	Age 0 %	Age 1 no.	Age 1 %	Age 2 no.	Age 2 %	Age 3 no.	Age 3 %	Age 4 no.	Age 4 %
2000	4,734,647	3,517	0	0%	29	1%	3,385	96%	90	3%	13	0%
2001	941,578	2,604	3	0%	77	3%	2,444	94%	79	3%	1	0%
2002	2,168,537	2,183	0	0%	961	44%	937	43%	279	13%	6	0%
2003	7,869,881	749	0	0%	7	1%	740	99%	2	0%	0	0%
2004	4,194,210	912	0	0%	2	0%	909	100%	1	0%	0	0%
2005	1,572,049	1,083	0	0%	30	3%	277	26%	776	72%	0	0%
2006	2,421,826	1,356	12	1%	967	71%	206	15%	127	9%	44	3%
2007	[b]	920	0	0%	273	30%	572	62%	75	8%	0	0%
2008	[b]	580	0	0%	6	1%	573	99%	1	0%	0	0%
2009	[b]	487	0	0%	43	9%	354	73%	90	18%	0	0%
2010	[b]	891	0	0%	431	48%	361	41%	98	11%	1	0%
2011	[b]	1,487	47	3%	38	3%	1,376	93%	26	2%	0	0%
2012	5,566,771	1,580	0	0%	140	9%	1,438	91%	2	0%	0	0%
2013	1,644,166	1,414	0	0%	53	4%	1,096	78%	264	19%	1	0%
Mean (1991-2012)	4,432,266	1,743	3	0%	306	18%	1,237	70%	193	12%	4	0%
Mean (2000-2012)	3,683,687	1,411	5	0%	231	17%	1,044	72%	127	11%	5	0%

[a] Outmigration estimates shown are from Barrett and not reliable, per Coggins 1997 (4K97-50 pg. 2).

[b] Outmigration estimates not available.

APPENDIX C: HISTORICAL ADULT DATA

Appendix C1.–Frazer Fish Pass cumulative escapement counts by year and species, 1964–2013.

Year	Sockeye	Chinook	Pink	Chum	Steelhead Down	Steelhead Up	All Species
1964	1,351	0	0	18	0	0	1,369
1965	5,074	0	1,698	9	0	0	6,781
1966	11,728	0	0	243	0	0	11,971
1967	14,500	0	0	0	0	0	14,500
1968	16,708	0	3	499	0	0	17,210
1969	13,981	0	2,390	4	0	0	16,375
1970	24,081	2	1	117	0	0	24,201
1971	55,366	22	2,788	116	0	0	58,292
1972	65,844	111	1	216	0	0	66,172
1973	56,255	35	1,607	206	0	0	58,103
1974	82,709	12	0	55	0	0	82,776
1975	64,199	7	3,508	126	0	0	67,840
1976	119,321	28	3	89	0	0	119,441
1977	139,475	205	11,061	87	0	0	150,828
1978	142,281	131	2	33	0	0	142,447
1979	126,742	53	10,178	60	0	0	137,033
1980	405,535	66	6	28	0	0	405,635
1981	377,716	22	11,124	85	0	0	388,947
1982	437,772	47	0	56	0	0	437,875
1983	158,340	86	1,414	63	0	0	159,903
1984	53,524	85	1	79	0	0	53,689
1985	485,835	165	641	25	0	0	486,666
1986	126,529	127	0	9	0	0	126,665
1987	40,544	94	285	5	0	0	40,928
1988	246,704	212	0	6	0	0	246,922
1989	360,373	85	516	0	0	0	360,974
1990	226,960	183	0	5	0	0	227,148
1991	190,358	127	0	0	0	0	190,485
1992	185,825	128	0	510	0	0	186,463
1993	178,391	211	14	1	0	0	178,617
1994	206,071	189	0	3	0	0	206,263
1995	196,362	296	156	0	1	0	196,815
1996	198,695	485	3	0	0	0	199,183
1997	205,264	454	0	0	0	0	205,718
1998	233,755	147	0	0	0	0	233,902
1999	216,565	126	0	0	0	0	216,691

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Year	Sockeye	Chinook	Pink	Chum	Steelhead Down	Steelhead Up	All Species
2000	158,044	121	0	0	0	0	158,165
2001	154,349	166	0	0	0	0	154,515
2002	85,317	211	1	0	0	0	85,529
2003	201,679	443	1	0	0	0	202,123
2004	120,664	204	4,869	0	0	0	125,737
2005	136,948	156	2	0	0	0	137,106
2006	89,516	59	447	0	0	0	90,022
2007	120,186	57	0	5	0	0	120,248
2008	105,363	19	283	0	0	0	105,665
2009	101,845	42	2	0	0	0	101,889
2010	94,680	41	11,451	2	0	0	106,174
2011	134,642	27	7	0	0	0	134,676
2012	148,884	39	2	0	0	6	148,937
2013	136,059	42	19	0	0	0	136,120
5-yr Average (2008-2012)	117,083	34	2,349	0	0	1	119,468
10-yr Average (2003-2012)	125,441	109	1,706	1	0	1	127,258
20-yr Average (1993-2012)	154,361	175	862	1	0	0	155,399

Appendix C2.–Frazer Lake interpolated adult sockeye salmon escapement age composition, 1986–2013.

Year	No. Fish Sampled		Age 1.1	1.2	1.3	1.4	2.1	2.2	2.3	3.1	3.2	3.3	Total Fish
1986	967	Numbers	10	17,231	1,639	0	282	5,545	99,724	0	465	1,632	126,529
		Percent	0.0	13.6	1.3	0.0	0.2	4.4	78.8	0.0	0.4	1.3	
1987	868	Numbers	752	5,023	19,852	53	7,501	2,959	4,098	69	0	89	40,544
		Percent	1.9	12.4	49.0	0.1	18.5	7.3	10.1	0.2	0.0	0.2	
1988	1,098	Numbers	124	3,189	6,540	374	20,765	202,514	6,081	1,164	5,494	461	246,704
		Percent	0.1	1.3	2.7	0.2	8.4	82.1	2.5	0.5	2.2	0.2	
1989	1,335	Numbers	9,359	5,611	3,477	0	601	91,433	249,645	0	0	0	360,373
		Percent	2.6	1.6	1.0	0.0	0.2	25.4	69.3	0.0	0.0	0.0	
1990	1,727	Numbers	505	168,915	11,212	0	10,071	12,251	15,187	36	473	8,310	226,960
		Percent	0.2	74.4	4.9	0.0	4.4	5.4	6.7	0.0	0.2	3.7	
1991	1,077	Numbers	934	312	32,436	0	15,628	139,818	245	0	984	0	190,358
		Percent	0.5	0.2	17.0	0.0	8.2	73.5	0.1	0.0	0.5	0.0	
1992	1,412	Numbers	16,072	10,029	1,941	0	8,171	76,358	67,784	0	3,869	930	185,825
		Percent	8.6	5.4	1.0	0.0	4.4	41.1	36.5	0.0	2.1	0.5	
1993	1,908	Numbers	1,154	83,475	5,940	0	15,622	45,741	24,979	190	23	1,073	178,391
		Percent	0.6	46.8	3.3	0.0	8.8	25.6	14.0	0.1	0.0	0.6	
1994	1,674	Numbers	530	5,492	45,993	0	11,160	112,302	19,239	4,910	6,125	273	206,071
		Percent	0.3	2.7	22.3	0.0	5.4	54.5	9.3	2.4	3.0	0.1	
1995	2,082	Numbers	2,714	905	1,393	0	37,690	70,972	58,993	918	22,273	482	196,362
		Percent	1.4	0.5	0.7	0.0	19.2	36.1	30.0	0.5	11.3	0.2	
1996	2,258	Numbers	1,153	1,683	220	0	74,652	69,315	28,224	441	5,279	17,728	198,695
		Percent	0.6	0.8	0.1	0.0	37.6	34.9	14.2	0.2	2.7	8.9	
1997	1,440	Numbers	1,765	4,233	7,636	0	22,593	114,771	47,149	2,409	133	4,220	205,264
		Percent	0.9	2.1	3.7	0.0	11.0	55.9	23.0	1.2	0.1	2.1	
1998	1,377	Numbers	16,080	10,707	5,274	0	20,213	130,299	48,125	2,074	984	0	233,755
		Percent	6.9	4.6	2.3	0.0	8.6	55.7	20.6	0.9	0.4	0.0	
1999	1,136	Numbers	27,954	36,827	15,299	0	39,374	65,894	23,996	991	6,197	33	216,565
		Percent	12.9	17.0	7.1	0.0	18.2	30.4	11.1	0.5	2.9	0.0	
2000	1,259	Numbers	907	18,479	21,565	0	22,402	57,850	23,990	1,220	6,722	4,862	158,044
		Percent	0.6	11.7	13.6	0.0	14.2	36.6	15.2	0.8	4.3	3.1	
2001	1,487	Numbers	454	1,218	28,871	0	1,468	11,475	100,474	36	3,948	6,382	154,349
		Percent	0.3	0.8	18.7	0.0	1.0	7.4	65.1	0.0	2.6	4.1	

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Year	No. Fish Sampled		Age 1.1	1.2	1.3	1.4	2.1	2.2	2.3	3.1	3.2	3.3	Total Fish
2002	1,453	Numbers	954	797	6,486	1,182	20,784	10,865	39,145	169	75	4,201	85,317
		Percent	1.1	0.9	7.6	1.4	24.4	12.7	45.9	0.2	0.1	4.9	
2003	1,443	Numbers	27,029	331	237	248	102,817	54,037	5,352	11,603	0	0	201,679
		Percent	13.4	0.2	0.1	0.1	51.0	26.8	2.7	5.8	0.0	0.0	
2004	635	Numbers	399	20,391	41	0	7,967	72,333	7,578	0	11,955	0	120,664
		Percent	0.3	16.9	0.0	0.0	6.6	59.9	6.3	0.0	9.9	0.0	
2005	942	Numbers	251	6,037	28,913	0	373	50,427	46,170	0	71	4,581	136,948
		Percent	0.2	4.4	21.1	0.0	0.3	36.8	33.7	0.0	0.1	3.3	
2006	1,293	Numbers	2,736	2,448	3,109	415	11,382	3,023	45,301	19,532	223	1,031	89,516
		Percent	3.1	2.7	3.5	0.5	12.7	3.4	50.6	21.8	0.2	1.2	
2007	1,907	Numbers	12,714	3,953	460	264	49,654	13,483	6,481	7,933	24,887	95	120,186
		Percent	10.6	3.3	0.4	0.2	41.3	11.2	5.4	6.6	20.7	0.1	
2008	1,688	Numbers	1,051	29,190	614	0	8,782	36,516	7,474	1,544	5,870	13,792	105,363
		Percent	1.0	27.7	0.6	0.0	8.3	34.7	7.1	1.5	5.6	13.1	
2009	1,953	Numbers	78	9,125	18,862	0	4,559	33,932	20,144	0	7,978	6,707	101,845
		Percent	0.1	9.0	18.5	0.0	4.5	33.3	19.8	0.0	7.8	6.6	
2010	1,975	Numbers	3,784	2,841	17,666	95	39,988	13,990	9,889	5,774	21	457	94,680
		Percent	4.0	3.0	18.7	0.1	42.2	14.8	10.4	6.1	0.0	0.5	
2011	2,251	Numbers	3,371	3,604	2,183	123	48,300	62,700	7,623	5,442	1,194	0	134,642
		Percent	2.5	2.7	1.6	0.1	35.9	46.6	5.7	4.0	0.9	0.0	
2012	1,985	Numbers	25	20,393	3,795	0	2,763	80,265	38,918	0	2,402	130	148,884
		Percent	0.0	13.7	2.5	0.0	1.9	53.9	26.1	0.0	1.6	0.1	
2013	1,757	Numbers	518	4,792	19,974	0	4,837	63,932	39,917	0	533	1,265	136,059
		Percent	0.4	3.5	14.7	0.0	3.6	47.0	29.3	0.0	0.4	0.9	
Average (1986–2012)		Numbers	4,921	17,498	10,802	102	22,428	60,780	38,963	2,461	4,357	2,869	
		Percent	2.8	10.4	8.3	0.1	14.7	33.7	23.0	2.0	2.9	2.0	
Average (2003–2012)		Numbers	5,144	9,831	7,588	114	27,659	42,071	19,493	5,183	5,460	2,679	
		Percent	3.5	8.4	6.7	0.1	20.5	32.1	16.8	4.6	4.7	2.5	
Average (2008–2012)		Numbers	1,662	13,030	8,624	44	20,879	45,481	16,810	2,552	3,493	4,217	
		Percent	1.5	11.2	8.4	0.0	18.6	36.6	13.8	2.3	3.2	4.0	

Appendix C3.–Cumulative and average sockeye salmon escapement counts, Frazer Fish Pass, 2000–2013.

	Year														Average	
Date	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	5-Year (2008–2012)	10-Year (2003–2012)
31-May	-	8	-	-	-	-	-	-	-	-	-	-	-	0	-	-
1-Jun	-	21	-	-	-	-	-	-	-	-	-	-	-	0	-	-
2-Jun	-	21	-	-	-	-	-	-	-	-	-	-	-	0	-	-
3-Jun	-	23	-	-	-	-	-	-	-	-	-	-	-	0	-	-
4-Jun	-	24	-	-	-	28	-	-	-	-	-	-	-	0	-	3
5-Jun	-	37	-	-	-	28	-	-	-	-	-	-	-	0	-	3
6-Jun	-	53	-	-	-	29	-	-	-	-	-	-	-	0	-	3
7-Jun	-	101	-	-	-	29	-	-	-	-	-	-	-	0	-	3
8-Jun	-	305	-	-	2	29	-	-	-	-	-	-	-	0	-	3
9-Jun	-	369	-	-	2	35	-	-	-	-	-	-	-	4	-	4
10-Jun	-	427	-	-	2	2,301	-	-	-	-	-	-	-	9	-	230
11-Jun	1	1,234	-	-	2	3,676	-	-	-	31	-	-	19	101	10	373
12-Jun	6	2,629	-	-	2	3,678	-	-	-	42	-	-	24	162	13	375
13-Jun	7	5,479	43	-	3	3,758	-	-	1	54	-	1	24	166	16	384
14-Jun	14	25,026	178	1	3	4,103	-	-	2	54	-	1	24	180	16	419
15-Jun	19	45,385	1,179	79	12	8,678	-	-	24	80	-	8	24	234	27	891
16-Jun	51	62,128	3,272	109	104	8,907	-	2	28	106	-	8	54	361	39	932
17-Jun	526	63,772	13,101	535	740	9,912	26	3	33	107	-	8	191	510	68	1,156
18-Jun	3,105	65,691	14,546	1,174	1,044	11,682	28	4	37	111	-	9	193	2,049	70	1,428
19-Jun	5,167	72,708	16,118	1,535	1,511	11,742	60	19	37	120	-	49	438	2,849	129	1,551
20-Jun	10,445	103,240	20,529	1,632	1,695	11,748	60	48	37	172	438	105	552	3,067	261	1,649
21-Jun	14,382	119,709	21,897	5,223	2,346	11,769	60	50	37	209	583	221	558	3,076	322	2,106
22-Jun	20,149	123,540	23,381	5,385	2,831	11,845	115	1,770	85	1,751	671	510	566	3,123	717	2,553
23-Jun	25,411	124,833	26,591	9,966	2,904	31,960	135	2,383	130	1,841	689	929	605	3,150	839	5,154
24-Jun	30,809	125,639	29,786	10,376	3,154	35,755	135	2,572	147	2,858	2,914	1,335	606	10,636	1,572	5,985
25-Jun	45,969	126,577	32,173	10,644	10,945	35,809	135	2,716	148	11,918	2,990	1,406	5,493	31,638	4,391	8,220
26-Jun	56,068	130,331	32,691	11,331	27,761	36,768	147	3,944	148	12,158	3,017	2,146	6,642	38,998	4,822	10,406
27-Jun	64,316	131,408	35,884	12,965	29,301	37,935	149	4,126	540	14,263	3,470	2,245	14,623	42,348	7,028	11,962
28-Jun	69,769	132,246	39,682	14,265	30,868	38,349	155	4,509	915	15,412	4,790	2,485	26,425	46,517	10,005	13,817
29-Jun	80,126	133,388	40,440	14,565	32,669	38,852	155	4,623	1,309	28,826	4,820	8,718	30,852	47,519	14,905	16,539
30-Jun	88,164	133,666	42,462	17,899	37,254	39,135	156	4,698	1,404	29,608	4,887	20,062	32,986	47,812	17,789	18,809

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Date	Year 2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average 5-Year (2008–2012)	10-Year (2003–2012)
1-Jul	90,790	133,707	43,326	19,465	43,342	43,124	156	4,994	1,445	31,686	4,887	22,584	47,962	47,924	21,713	21,965
2-Jul	93,614	134,478	44,056	37,256	48,642	44,415	174	10,897	1,478	32,689	4,952	27,530	54,506	57,825	24,231	26,254
3-Jul	95,320	134,624	48,850	42,845	50,966	44,450	224	13,161	2,973	33,284	5,198	28,511	55,338	63,830	25,061	27,695
4-Jul	96,497	134,676	52,588	42,978	56,544	44,738	232	14,280	8,674	33,445	9,064	33,340	55,378	63,856	27,980	29,867
5-Jul	96,564	138,700	54,668	43,065	66,816	45,974	319	20,830	10,430	40,392	10,218	40,253	55,516	63,903	31,362	33,381
6-Jul	97,320	138,706	55,717	43,934	68,055	50,246	358	23,143	12,422	45,103	10,293	41,594	67,572	64,169	35,397	36,272
7-Jul	100,381	139,205	56,329	59,388	77,015	68,684	672	38,183	14,512	45,333	10,293	41,961	71,861	64,626	36,792	42,790
8-Jul	101,100	141,546	57,173	61,844	80,718	77,871	682	39,210	14,793	45,573	10,392	42,588	72,088	65,987	37,087	44,576
9-Jul	101,643	142,443	57,998	80,801	83,726	79,361	6,364	40,437	17,902	45,663	18,348	61,697	72,257	80,708	43,173	50,656
10-Jul	102,811	143,964	58,373	86,121	85,489	86,880	7,876	41,802	18,883	46,007	18,563	62,975	82,564	85,162	45,798	53,716
11-Jul	104,286	144,295	58,657	87,115	93,293	95,013	7,928	42,382	18,954	48,009	18,963	63,188	83,642	96,978	46,551	55,849
12-Jul	107,741	144,461	59,337	97,556	97,163	96,690	8,296	44,556	32,410	48,476	19,654	65,153	83,732	97,499	49,885	59,369
13-Jul	113,563	144,976	59,411	107,373	97,213	103,774	11,200	45,266	36,444	48,847	20,134	76,757	101,882	98,355	56,813	64,889
14-Jul	113,846	145,328	60,246	117,366	99,739	105,193	11,775	45,413	36,598	49,245	20,421	84,353	102,170	99,160	58,557	67,227
15-Jul	114,017	145,706	61,881	125,207	101,020	105,606	12,396	45,650	38,646	52,421	22,354	85,976	102,352	99,300	60,350	69,163
16-Jul	116,698	145,901	62,539	140,002	101,828	106,117	14,346	46,379	38,694	68,457	22,495	87,557	102,548	99,946	63,950	72,842
17-Jul	120,775	147,079	63,375	141,202	102,696	106,499	14,633	57,409	38,734	69,821	23,771	91,991	102,980	106,586	65,459	74,974
18-Jul	122,048	147,235	65,510	141,587	105,422	106,735	14,669	60,967	54,028	70,500	23,785	92,891	114,029	109,823	71,047	78,461
19-Jul	126,964	147,436	65,760	151,806	106,687	107,128	14,869	61,350	58,499	70,840	25,001	93,883	118,188	110,265	73,282	80,825
20-Jul	130,849	149,188	65,904	158,463	109,705	107,168	24,727	61,862	58,829	71,725	28,047	110,076	118,242	111,255	77,384	84,884
21-Jul	131,444	149,528	66,331	167,199	110,625	107,350	26,187	64,390	59,777	71,860	38,495	111,811	118,709	111,360	80,130	87,640
22-Jul	136,589	149,666	67,540	171,667	111,181	107,571	26,624	65,172	60,238	72,092	45,545	113,512	119,330	112,446	82,143	89,293
23-Jul	148,663	149,763	70,995	173,039	112,496	107,691	27,224	65,677	60,501	72,511	46,060	114,024	120,233	123,426	82,666	89,946
24-Jul	149,386	149,813	74,123	175,837	113,082	107,769	29,365	65,778	61,431	79,429	46,222	114,090	120,657	123,668	84,366	91,366
25-Jul	150,254	150,045	74,362	182,046	113,097	108,204	36,625	81,228	61,612	81,856	46,248	114,363	129,645	123,938	86,745	95,492
26-Jul	150,873	150,233	74,648	183,430	113,442	115,480	36,842	88,877	62,080	82,034	46,255	114,541	131,418	124,034	87,266	97,440
27-Jul	153,770	150,801	76,171	185,976	113,554	118,119	37,501	89,443	68,249	82,071	58,202	115,262	131,631	126,056	91,083	100,001
28-Jul	154,081	150,882	78,230	187,155	113,646	119,502	37,848	90,510	77,624	82,288	63,287	115,629	132,182	126,344	94,202	101,967
29-Jul	154,596	151,009	79,015	188,064	114,435	119,581	38,972	91,566	78,331	82,370	63,289	115,871	132,463	127,135	94,465	102,494
30-Jul	154,927	151,341	81,643	191,858	114,641	122,779	39,609	94,183	79,096	90,651	63,454	116,413	132,557	127,276	96,434	104,524
31-Jul	155,234	151,723	82,064	193,117	115,449	125,224	39,884	94,371	79,826	91,490	63,812	116,777	135,893	128,007	97,560	105,584

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	Year														Average	
Date	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	5-Year (2008–2012)	10-Year (2003–2012)
1-Aug	155,500	152,320	82,074	193,908	115,926	126,149	41,023	94,438	82,820	91,525	64,262	116,867	135,942	128,954	98,283	106,286
2-Aug	155,528	152,768	82,341	194,507	116,089	127,424	48,975	94,581	83,099	91,586	65,181	117,173	135,999	129,546	98,608	107,461
3-Aug	155,966	152,974	82,632	196,454	116,332	128,376	53,909	94,825	83,338	91,685	65,395	117,760	136,133	130,825	98,862	108,421
4-Aug	156,017	152,991	82,878	198,184	116,630	128,674	54,452	97,851	83,826	98,734	66,830	118,377	136,149	131,246	100,783	109,971
5-Aug	156,081	153,182	83,138	199,344	116,787	129,086	55,246	98,453	84,709	99,531	67,199	118,678	141,343	131,285	102,292	111,038
6-Aug	156,155	153,291	83,505	200,175	117,245	131,135	56,643	99,235	89,444	99,564	67,725	118,795	141,897	131,416	103,485	112,186
7-Aug	157,622	153,495	83,681	200,946	117,369	131,633	58,268	100,236	96,532	99,820	68,091	118,885	142,041	133,264	105,074	113,382
8-Aug	157,823	153,764	83,941	201,584	117,897	135,262	62,311	102,576	97,589	99,983	68,826	118,978	142,498	133,397	105,575	114,750
9-Aug	157,902	153,941	84,361	201,679	118,971	136,810	62,624	106,908	98,309	100,126	70,635	119,629	142,667	133,749	106,273	115,836
10-Aug	157,968	154,063	84,434	201,679	119,812	136,899	62,869	107,289	98,779	100,230	70,840	119,763	142,930	134,086	106,508	116,109
11-Aug	158,007	154,152	84,620	201,679	120,455	136,948	62,986	107,518	99,228	100,312	71,471	119,907	143,076	134,834	106,799	116,358
12-Aug	158,044	154,223	84,844	201,679	120,535	136,948	72,139	109,229	99,463	100,824	72,311	120,237	146,425	135,000	107,852	117,979
13-Aug	158,044	154,277	85,131	201,679	120,561	136,948	77,557	111,581	100,026	100,888	73,474	120,639	147,075	135,113	108,420	119,043
14-Aug	158,044	154,349	85,257	201,679	120,596	136,948	77,569	112,148	100,725	100,902	74,446	121,078	147,111	135,300	108,852	119,320
15-Aug	158,044	154,349	85,317	201,679	120,664	136,948	77,628	112,714	100,872	100,919	74,471	121,345	147,347	135,411	108,991	119,459
16-Aug	158,044	154,349	85,317	201,679	120,664	136,948	77,977	114,109	101,066	100,991	74,702	121,905	147,667	135,468	109,266	119,771
17-Aug	158,044	154,349	85,317	201,679	120,664	136,948	81,103	115,482	101,126	101,175	78,639	122,452	148,135	136,059	110,305	120,740
18-Aug	158,044	154,349	85,317	201,679	120,664	136,948	82,310	115,626	101,167	101,395	81,060	122,620	148,589	136,059	110,966	121,206
19-Aug	158,044	154,349	85,317	201,679	120,664	136,948	82,519	115,825	101,332	101,501	82,273	126,520	148,662	136,059	112,058	121,792
20-Aug	158,044	154,349	85,317	201,679	120,664	136,948	82,611	115,929	101,469	101,845	82,337	128,278	148,884	136,059	112,563	122,064
21-Aug	158,044	154,349	85,317	201,679	120,664	136,948	82,616	116,038	101,778	101,845	82,612	128,596	148,884	136,059	112,743	122,166
22-Aug	158,044	154,349	85,317	201,679	120,664	136,948	84,293	116,078	101,962	101,845	83,450	128,746	148,884	136,059	112,977	122,455
23-Aug	158,044	154,349	85,317	201,679	120,664	136,948	84,387	117,295	102,139	101,845	83,610	128,842	148,884	136,059	113,064	122,629
24-Aug	158,044	154,349	85,317	201,679	120,664	136,948	85,058	118,422	102,895	101,845	83,672	128,947	148,884	136,059	113,249	122,901
27-Aug	158,044	154,349	85,317	201,679	120,664	136,948	88,922	119,415	105,363	101,845	86,483	130,414	148,884	136,059	114,598	124,062
28-Aug	158,044	154,349	85,317	201,679	120,664	136,948	89,084	119,499	105,363	101,845	86,793	130,620	148,884	136,059	114,701	124,138
29-Aug	158,044	154,349	85,317	201,679	120,664	136,948	89,427	120,116	105,363	101,845	87,443	130,943	148,884	136,059	114,896	124,331
30-Aug	158,044	154,349	85,317	201,679	120,664	136,948	89,516	120,186	105,363	101,845	88,378	132,401	148,884	136,059	115,374	124,586
31-Aug	158,044	154,349	85,317	201,679	120,664	136,948	89,516	120,186	105,363	101,845	89,486	132,698	148,884	136,059	115,655	124,727
1-Sep	158,044	154,349	85,317	201,679	120,664	136,948	89,516	120,186	105,363	101,845	90,169	132,774	148,884	136,059	115,807	124,803
2-Sep	158,044	154,349	85,317	201,679	120,664	136,948	89,516	120,186	105,363	101,845	91,174	133,226	148,884	136,059	116,098	124,949
3-Sep	158,044	154,349	85,317	201,679	120,664	136,948	89,516	120,186	105,363	101,845	92,001	133,498	148,884	136,059	116,318	125,058
4-Sep	158,044	154,349	85,317	201,679	120,664	136,948	89,516	120,186	105,363	101,845	92,211	133,627	148,884	136,059	116,386	125,092
5-Sep	158,044	154,349	85,317	201,679	120,664	136,948	89,516	120,186	105,363	101,845	92,949	134,058	148,884	136,059	116,620	125,209
6-Sep	158,044	154,349	85,317	201,679	120,664	136,948	89,516	120,186	105,363	101,845	93,508	134,469	148,884	136,059	116,814	125,306
7-Sep	158,044	154,349	85,317	201,679	120,664	136,948	89,516	120,186	105,363	101,845	94,114	134,565	148,884	136,059	116,954	125,376
8-Sep	158,044	154,349	85,317	201,679	120,664	136,948	89,516	120,186	105,363	101,845	94,313	134,642	148,884	136,059	117,009	125,404
9-Sep	158,044	154,349	85,317	201,679	120,664	136,948	89,516	120,186	105,363	101,845	94,680	134,642	148,884	136,059	117,083	125,441

Appendix C4.–Cumulative and average sockeye salmon escapement counts, Dog Salmon Weir, 2000–2013.

	Year														Average	
Date	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	5-Year	10-Year
28-May	-	2,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29-May	-	4,037	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30-May	-	13,601	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31-May	-	14,499	-	-	1	-	-	-	-	-	-	3	-	-	1	0
1-Jun	-	15,413	-	-	1	-	-	-	-	-	12	4	234	-	50	25
2-Jun	-	26,062	-	-	1	6,969	-	-	-	-	12	17	234	-	53	723
3-Jun	-	29,163	-	-	1	19,656	-	-	-	-	12	17	235	-	53	1,992
4-Jun	-	40,222	-	-	1	27,850	-	-	-	-	12	20	235	-	53	2,812
5-Jun	-	44,094	5,060	-	9,816	34,406	-	-	-	-	13	21	235	2	54	4,449
6-Jun	-	47,906	6,858	-	34,677	34,406	-	-	1	2	13	22	244	3	56	6,937
7-Jun	-	63,511	7,364	-	46,535	41,160	-	7	1	4	13	22	244	4	57	8,799
8-Jun	144	71,241	8,019	-	53,026	41,193	-	8	5	6	15	32	244	9,151	60	9,453
9-Jun	144	80,258	12,519	143	54,081	41,577	-	14	141	2,744	15	4,245	317	21,830	1,492	10,328
10-Jun	177	88,362	14,019	144	54,085	41,790	-	36	766	11,196	15	5,809	355	23,499	3,628	11,420
11-Jun	189	91,332	17,579	144	55,391	42,666	-	38	766	13,364	15	6,589	364	24,631	4,220	11,934
12-Jun	280	95,581	22,100	2,451	55,406	42,730	680	56	766	18,895	15	7,388	388	26,753	5,490	12,878
13-Jun	3,909	110,398	26,148	3,502	64,142	47,417	721	60	766	20,275	15	8,470	2,242	30,592	6,354	14,761
14-Jun	14,015	120,891	27,374	3,681	67,894	50,812	721	60	10,412	20,536	53	9,164	15,178	31,455	11,069	17,851
15-Jun	37,912	126,609	29,612	3,690	69,093	51,356	721	97	15,032	22,235	1,346	11,937	17,170	31,629	13,544	19,268
16-Jun	61,926	126,742	32,501	8,699	76,389	53,198	721	149	17,151	24,109	1,347	12,288	34,947	32,828	17,968	22,900
17-Jun	71,934	127,136	34,521	13,050	82,661	54,227	721	184	17,420	29,483	6,694	15,477	38,214	33,030	21,458	25,813
18-Jun	79,624	127,338	36,342	13,272	84,909	57,504	721	7,294	17,846	38,748	9,030	15,921	42,949	37,098	24,899	28,819
19-Jun	81,826	127,635	37,817	16,982	97,345	58,695	721	9,593	19,587	43,033	10,637	19,080	53,800	40,438	29,227	32,947
20-Jun	85,041	127,886	39,738	18,085	101,602	62,017	8,760	12,299	29,061	43,794	14,083	25,312	62,659	40,523	34,982	37,767
21-Jun	90,491	128,002	42,790	27,008	103,924	69,115	10,012	13,066	36,274	43,794	15,216	29,071	64,234	40,998	37,718	41,171
22-Jun	90,820	128,103	45,364	31,987	105,380	71,912	10,266	13,785	48,448	43,799	25,369	35,542	64,250	44,485	43,482	45,074
23-Jun	91,273	129,535	46,138	33,711	106,048	74,802	11,923	13,785	50,131	45,227	25,631	36,829	65,892	49,387	44,742	46,398
24-Jun	93,401	131,897	47,740	37,458	107,771	75,403	12,122	14,217	51,795	52,038	26,442	37,435	68,077	59,696	47,157	48,276
25-Jun	98,163	134,272	49,989	39,349	109,235	76,233	15,353	16,120	56,454	53,359	28,453	38,473	70,273	61,849	49,402	50,330
26-Jun	104,070	134,494	52,385	41,924	109,855	77,398	17,032	20,901	57,085	55,570	36,972	47,910	82,659	66,477	56,039	54,731
27-Jun	104,661	136,651	53,628	45,106	110,610	78,385	17,448	24,106	60,724	66,929	41,536	47,998	86,899	66,762	60,817	57,974
28-Jun	105,984	136,817	56,282	58,458	112,470	78,922	20,900	26,395	60,950	79,199	43,695	49,409	90,233	69,607	64,697	62,063
29-Jun	106,765	137,108	56,791	68,089	112,596	80,037	21,137	27,391	63,195	80,528	46,392	54,478	92,158	70,938	67,350	64,600
30-Jun	106,968	137,169	58,553	84,344	113,802	82,091	21,627	36,592	73,989	83,923	53,739	56,968	94,561	70,946	72,636	70,164

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Appendix C4.–Page 2 of 3.

Date	Year														Average	
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	5-Year	10-Year
1-Jul	107,231	138,456	61,537	88,095	113,926	88,435	26,015	39,938	76,471	85,767	53,739	63,580	96,833	73,854	75,278	73,280
2-Jul	108,795	138,762	63,972	95,188	115,899	90,572	28,075	47,129	76,509	85,890	55,494	77,500	98,653	73,980	78,809	77,091
3-Jul	109,374	138,891	66,215	103,988	117,484	90,861	29,636	52,995	82,832	88,016	58,059	79,908	99,659	74,028	81,695	80,344
4-Jul	111,681	140,867	68,006	104,051	120,235	93,169	34,658	56,425	86,005	90,662	58,270	86,910	100,333	74,105	84,436	83,072
5-Jul	113,559	145,638	68,857	119,780	128,926	93,468	36,897	58,294	86,144	92,919	59,565	103,126	102,377	75,572	88,826	88,150
6-Jul	117,088	147,399	69,486	129,701	134,157	96,392	38,643	68,373	89,466	93,517	60,408	107,479	103,599	81,396	90,894	92,174
7-Jul	117,889	148,080	72,755	133,883	135,262	99,417	41,130	71,686	96,101	98,882	65,833	107,649	109,308	84,408	95,555	95,915
8-Jul	117,908	148,609	74,868	149,402	148,101	112,401	43,368	73,754	104,357	99,133	71,388	109,757	110,619	94,667	99,051	102,228
9-Jul	119,105	148,955	75,504	161,475	149,484	113,925	45,787	77,394	119,773	99,685	72,312	113,924	112,558	100,001	103,650	106,632
10-Jul	120,405	149,083	78,431	171,503	151,103	115,936	45,916	86,173	120,660	100,865	77,512	114,535	114,833	106,633	105,681	109,904
11-Jul	128,418	149,649	79,326	177,801	151,154	116,482	48,524	88,930	120,713	103,918	80,493	119,077	115,213	107,589	107,883	112,231
12-Jul	136,637	150,178	82,786	185,574	152,408	119,008	49,515	93,600	121,670	104,280	88,435	123,329	120,911	108,791	111,725	115,873
13-Jul	145,148	150,390	82,802	196,019	152,412	123,295	53,846	96,062	125,144	107,599	94,074	129,734	121,874	110,107	115,685	120,006
14-Jul	152,315	152,520	84,110	202,384	153,313	124,237	54,358	100,321	126,978	108,646	95,481	134,936	121,892	111,016	117,587	122,255
15-Jul	152,640	153,679	84,775	210,938	156,942	125,686	56,553	102,019	128,593	111,068	102,264	137,157	123,930	111,156	120,602	125,515
16-Jul	153,603	155,464	85,556	219,325	163,932	128,598	58,982	104,826	129,921	111,924	108,808	141,638	124,004	113,374	123,259	129,196
17-Jul	154,128	156,254	87,342	221,909	164,421	128,987	59,227	107,573	132,381	114,079	111,035	145,202	133,343	115,430	127,208	131,816
18-Jul	155,227	156,336	89,025	224,461	172,734	129,267	59,523	112,402	132,586	114,567	111,451	147,916	137,137	115,596	128,731	134,204
19-Jul	158,542	156,336	89,402	228,577	176,004	130,974	62,180	117,165	133,726	116,057	114,231	149,080	137,618	117,755	130,142	136,561
20-Jul	159,955	156,531	90,228	231,922	176,779	131,455	63,334	122,152	135,381	116,059	115,064	152,334	137,727	118,713	131,313	138,221
21-Jul	161,829	156,792	90,941	235,464	183,523	132,020	63,470	122,644	136,491	118,978	117,029	153,352	139,651	119,899	133,100	140,262
22-Jul	162,204	157,149	91,942	239,252	188,795	132,473	64,287	124,319	136,884	119,221	118,555	154,772	139,733	120,283	133,833	141,829
23-Jul	162,322	157,539	92,327	244,117	190,320	133,680	65,787	125,148	139,416	119,241	118,795	158,098	139,781	122,388	135,066	143,438
24-Jul	162,578	157,991	93,180	246,693	193,117	134,071	74,449	125,248	141,314	119,635	120,423	159,277	143,070	123,001	136,744	145,730
25-Jul	163,140	158,338	93,449	247,268	197,250	135,992	74,600	126,779	141,910	121,411	120,752	160,449	144,070	124,017	137,718	147,048
26-Jul	164,254	158,480	93,600	247,882	199,006	136,448	75,646	127,048	142,961	124,104	122,489	160,748	144,434	124,541	138,947	148,077
27-Jul	165,608	158,891	95,087	250,174	203,537	136,742	76,181	127,262	143,524	129,325	123,513	162,317	147,982	124,719	141,332	150,056
28-Jul	166,098	159,275	96,064	252,092	206,489	137,168	77,686	127,843	144,568	130,281	125,144	163,142	148,028	125,198	142,233	151,244
29-Jul	166,559	160,097	97,176	253,292	207,421	137,577	78,636	131,080	146,017	141,762	125,595	166,383	148,538	125,367	145,659	153,630
30-Jul	166,969	160,671	97,876	254,389	208,296	138,005	78,653	133,369	146,527	144,530	128,916	167,035	149,426	126,131	147,287	154,915
31-Jul	167,235	161,345	98,545	255,056	209,839	138,114	83,607	134,072	147,842	144,711	129,156	168,586	149,999	126,407	148,059	156,098

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Date	Year														Average	
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	5-Year	10-Year
1-Aug	167,947	161,418	99,158	256,468	211,193	139,572	87,210	134,219	148,520	144,723	129,628	168,831	150,475	126,786	148,435	157,084
2-Aug	168,385	161,500	99,607	257,619	213,376	141,730	92,565	136,735	148,685	145,166	130,285	169,522	150,759	127,158	148,883	158,644
3-Aug	168,675	161,564	100,500	258,319	217,310	142,419	93,126	136,842	149,235	145,185	130,629	170,250	151,194	127,314	149,299	159,451
4-Aug	168,988	161,632	101,201	259,287	219,567	142,424	98,523	136,859	149,626	145,487	131,514	170,661	151,384	127,397	149,734	160,533
5-Aug	169,193	161,729	101,967	259,843	221,401	143,350	98,870	136,905	150,268	145,612	131,769	172,451	151,561	127,534	150,332	161,203
6-Aug	169,392	161,867	102,315	260,948	222,014	143,538	99,069	137,246	151,222	145,639	132,490	172,685	151,986	128,600	150,804	161,684
7-Aug	169,754	162,008	102,936	261,408	222,759	144,472	99,507	137,338	151,591	145,799	132,742	174,055	152,621	128,657	151,362	162,229
8-Aug	169,851	162,054	103,538	261,535	223,266	145,256	100,056	137,489	151,878	145,839	133,269	174,186	153,019	128,674	151,638	162,579
9-Aug	170,312	162,215	103,934	261,613	226,266	147,760	100,869	138,276	151,952	145,990	133,591	174,478	153,217	128,851	151,846	163,401
10-Aug	170,575	162,305	104,236	262,237	226,266	148,971	101,683	138,340	152,113	145,992	133,775	174,730	153,423	128,928	152,007	163,753
11-Aug	170,947	162,330	104,412	262,564	226,266	149,029	102,362	138,459	152,160	146,172	134,060	175,198	153,621	129,007	152,242	163,989
12-Aug	171,158	162,411	104,582	262,731	226,266	149,708	102,513	138,602	152,165	146,313	135,100	175,708	153,727	129,055	152,603	164,283
13-Aug	171,486	162,462	104,705	262,731	226,266	149,866	103,363	139,074	152,221	146,566	135,100	176,191	153,846	129,118	152,785	164,522
14-Aug	171,602	162,501	104,931	262,731	226,266	150,298	104,114	139,227	152,245	146,648	135,100	177,211	154,005	129,123	153,042	164,785
15-Aug	171,664	162,527	105,057	262,731	226,266	151,215	105,076	139,391	152,433	147,798	135,100	178,215	154,118	129,169	153,533	165,234
16-Aug	171,844	162,682	105,130	262,731	226,266	151,450	105,448	139,391	152,707	147,798	135,100	178,363	154,231	129,369	153,640	165,349
17-Aug	172,160	162,803	105,215	262,731	226,266	151,605	106,110	139,673	152,774	147,798	135,100	178,499	154,310	129,369	153,696	165,487
18-Aug	172,348	162,844	105,367	262,731	226,266	152,066	106,993	139,684	152,794	147,798	135,100	178,594	154,416	129,369	153,740	165,644
19-Aug	172,463	162,879	105,487	262,731	226,266	152,278	108,193	139,706	153,026	147,798	135,100	179,480	154,416	129,369	153,964	165,899
20-Aug	172,542	162,950	105,550	262,731	226,266	152,907	108,343	139,724	153,276	147,798	135,100	179,603	154,416	129,369	154,039	166,016
21-Aug	172,675	162,961	105,579	262,731	226,266	152,959	108,343	139,729	153,276	147,798	135,100	180,553	154,416	129,369	154,229	166,117
22-Aug	172,758	162,992	105,664	262,731	226,266	152,959	108,343	139,808	153,276	147,798	135,100	180,603	154,416	129,369	154,239	166,130
23-Aug	172,808	163,002	105,725	262,731	226,266	152,959	108,343	139,808	153,276	147,798	135,100	180,603	154,416	129,369	154,239	166,130
24-Aug	172,859	163,009	105,770	262,731	226,266	152,959	108,343	139,808	153,276	147,798	135,100	180,603	154,416	129,369	154,239	166,130
25-Aug	172,903	163,309	105,824	262,731	226,266	152,959	108,343	139,808	153,276	147,798	135,100	180,603	154,416	129,369	154,239	166,130
26-Aug	172,912	163,309	105,838	262,731	226,266	152,959	108,343	139,808	153,276	147,798	135,100	180,603	154,416	129,369	154,239	166,130
27-Aug	172,943	163,309	105,988	262,731	226,266	152,959	108,343	139,808	153,276	147,798	135,100	180,603	154,416	129,369	154,239	166,130
28-Aug	173,343	163,309	105,988	262,731	226,266	152,959	108,343	139,808	153,276	147,798	135,100	180,603	154,416	129,369	154,239	166,130
29-Aug	173,343	163,309	105,988	262,731	226,266	152,959	108,343	139,808	153,276	147,798	135,100	180,603	154,416	129,369	154,239	166,130
30-Aug	173,343	163,309	105,988	262,731	226,266	152,959	108,343	139,808	153,276	147,798	135,100	180,603	154,416	129,369	154,239	166,130
31-Aug	173,343	163,309	105,988	262,731	226,266	152,959	108,343	139,808	153,276	147,798	135,100	180,603	154,416	129,369	154,239	166,130

Appendix C5.–Cumulative and average pink salmon escapement counts, Frazer Fish Pass, 2003–2013.

												Average	
Date	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	5-Year	10-Year
9-Jul	1	0	0	0	0	0	0	0	0	0	0	0	0
10-Jul	1	0	0	0	0	0	0	0	0	0	0	0	0
11-Jul	1	0	0	0	0	0	0	0	0	0	6	0	0
12-Jul	1	0	0	0	0	0	0	0	0	0	10	0	0
13-Jul	1	0	0	0	0	0	0	0	0	0	10	0	0
14-Jul	1	0	0	0	0	0	0	0	0	0	10	0	0
15-Jul	1	0	0	0	0	1	0	0	0	0	10	0	0
16-Jul	1	0	0	0	0	1	0	0	0	0	10	0	0
17-Jul	1	0	0	0	0	1	0	0	0	0	14	0	0
18-Jul	1	0	0	0	0	1	0	0	0	0	14	0	0
19-Jul	1	0	0	0	0	1	0	0	0	0	14	0	0
20-Jul	1	0	0	2	0	1	0	0	0	0	17	0	0
21-Jul	1	0	0	2	0	1	0	0	0	0	17	0	0
22-Jul	1	0	0	2	0	1	0	0	0	0	17	0	0
23-Jul	1	0	0	2	0	1	0	0	0	0	18	0	0
24-Jul	1	0	0	2	0	1	0	0	0	0	19	0	0
25-Jul	1	0	0	2	0	1	0	0	0	0	19	0	0
26-Jul	1	0	0	2	0	1	0	0	0	0	19	0	0
27-Jul	1	0	0	2	0	1	0	0	0	0	19	0	0
28-Jul	1	0	0	2	0	1	0	0	0	0	19	0	0
29-Jul	1	0	0	2	0	1	0	0	0	0	19	0	0
30-Jul	1	0	0	2	0	1	0	0	0	0	19	0	0
31-Jul	1	0	0	2	0	1	1	0	0	0	19	0	1
1-Aug	1	0	0	2	0	1	1	0	0	0	19	0	1
2-Aug	1	0	0	2	0	1	1	0	0	0	19	0	1
3-Aug	1	0	0	2	0	1	1	0	0	0	19	0	1
4-Aug	1	0	0	2	0	1	2	0	0	0	19	1	1
5-Aug	1	0	0	2	0	1	2	0	0	0	19	1	1
6-Aug	1	0	0	2	0	1	2	0	0	0	19	1	1
7-Aug	1	0	0	2	0	3	2	0	0	0	19	1	1
8-Aug	1	0	2	2	0	3	2	0	0	0	19	1	1
9-Aug	1	3,058	2	2	0	3	2	0	0	0	19	1	307
10-Aug	1	4,420	2	2	0	3	2	0	0	0	19	1	443

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Date	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average 5-Year	Average 10-Year
11-Aug	1	4,701	2	2	0	3	2	0	0	0	19	1	471
12-Aug	1	4,782	2	2	0	3	2	0	0	0	19	1	479
13-Aug	1	4,825	2	2	0	3	2	0	0	0	19	1	484
14-Aug	1	4,855	2	2	0	3	2	0	0	0	19	1	487
15-Aug	1	4,869	2	2	0	3	2	0	0	0	19	1	488
16-Aug	1	4,869	2	2	0	3	2	0	0	0	19	1	488
17-Aug	1	4,869	2	2	0	3	2	0	0	2	19	1	488
18-Aug	1	4,869	2	2	0	3	2	0	0	2	19	1	488
19-Aug	1	4,869	2	2	0	3	2	0	0	2	19	1	488
20-Aug	1	4,869	2	2	0	3	2	0	0	2	19	1	488
21-Aug	1	4,869	2	2	0	3	2	0	0	2	19	1	488
22-Aug	1	4,869	2	2	0	3	2	0	2	2	19	2	488
23-Aug	1	4,869	2	2	0	3	2	0	5	2	19	2	489
24-Aug	1	4,869	2	2	0	12	2	0	5	2	19	4	490
25-Aug	1	4,869	2	2	0	35	2	0	5	2	19	9	492
26-Aug	1	4,869	2	2	0	249	2	106	7	2	19	73	524
27-Aug	1	4,869	2	5	0	283	2	230	7	2	19	105	540
28-Aug	1	4,869	2	43	0	283	2	362	7	2	19	131	557
29-Aug	1	4,869	2	338	0	283	2	571	7	2	19	173	608
30-Aug	1	4,869	2	447	0	283	2	984	7	2	19	256	660
31-Aug	1	4,869	2	447	0	283	2	1,636	7	2	19	386	725
1-Sep	1	4,869	2	447	0	283	2	2,167	7	2	19	492	778
2-Sep	1	4,869	2	447	0	283	2	3,621	7	2	19	783	923
3-Sep	1	4,869	2	447	0	283	2	5,290	7	2	19	1,117	1,090
4-Sep	1	4,869	2	447	0	283	2	6,175	7	2	19	1,294	1,179
5-Sep	1	4,869	2	447	0	283	2	7,394	7	2	19	1,538	1,301
6-Sep	1	4,869	2	447	0	283	2	8,407	7	2	19	1,740	1,402
7-Sep	1	4,869	2	447	0	283	2	9,760	7	2	19	2,011	1,537
8-Sep	1	4,869	2	447	0	283	2	10,442	7	2	19	2,147	1,606
9-Sep	1	4,869	2	447	0	283	2	10,863	7	2	19	2,231	1,648
10-Sep	1	4,869	2	447	0	283	2	11,288	7	2	19	2,316	1,690
11-Sep	1	4,869	2	447	0	283	2	11,451	7	2	19	2,349	1,706
12-Sep	1	4,869	2	447	0	283	2	11,451	7	2	19	2,349	1,706

Appendix C6.–Daily and average Chinook salmon escapement counts, Frazer Fish Pass, 2003–2013.

												Average	
Date	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	5-Year	10-Year
10-Jun	0	0	1	0	0	0	0	0	0	0	0	0	0
11-Jun	0	0	0	0	0	0	0	0	0	0	0	0	0
12-Jun	0	0	0	0	0	0	0	0	0	0	1	0	0
13-Jun	0	0	0	0	0	0	0	0	0	0	0	0	0
14-Jun	0	1	0	0	0	0	0	0	0	0	2	0	0
15-Jun	2	0	2	0	0	0	0	0	0	0	0	0	0
16-Jun	0	1	0	0	0	1	0	0	0	0	0	0	0
17-Jun	2	0	0	0	0	0	0	1	0	0	0	0	0
18-Jun	17	1	0	0	0	0	0	0	0	0	3	0	2
19-Jun	4	0	0	0	0	0	0	2	0	2	1	1	1
20-Jun	0	0	0	0	0	0	1	0	0	0	0	0	0
21-Jun	7	1	1	0	0	0	1	2	1	0	0	1	1
22-Jun	4	0	0	0	5	0	1	6	0	0	0	1	2
23-Jun	22	0	11	4	4	0	0	2	0	0	0	0	4
24-Jun	1	0	12	0	0	0	0	0	0	1	3	0	1
25-Jun	4	18	0	0	0	0	3	0	0	1	9	1	3
26-Jun	13	62	2	0	1	0	0	0	0	0	2	0	8
27-Jun	23	8	4	1	0	0	1	0	0	1	1	0	4
28-Jun	8	4	4	0	0	0	0	1	0	6	2	1	2
29-Jun	12	4	3	4	0	0	6	0	3	0	1	2	3
30-Jun	15	9	5	1	0	0	3	0	5	6	0	3	4
1-Jul	8	8	8	0	0	0	2	0	1	0	0	1	3
2-Jul	71	17	1	0	4	0	0	0	1	1	1	0	10
3-Jul	34	6	1	6	0	1	0	0	0	0	2	0	5
4-Jul	3	8	4	0	0	1	1	0	0	0	0	0	2
5-Jul	6	7	4	2	11	0	6	0	2	2	0	2	4
6-Jul	7	3	3	1	5	0	3	0	0	0	0	1	2
7-Jul	33	3	9	2	2	0	0	0	0	0	0	0	5
8-Jul	18	0	11	0	3	0	2	0	0	0	1	0	3
9-Jul	24	3	5	1	2	2	1	0	2	2	3	1	4
10-Jul	8	2	10	0	1	2	2	0	0	1	1	1	3

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Date	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average 5-Year	Average 10-Year
11-Jul	4	1	3	0	0	0	1	0	0	0	3	0	1
12-Jul	3	2	8	0	0	0	0	0	0	3	0	1	2
13-Jul	8	0	5	0	0	1	0	0	0	0	0	0	1
14-Jul	5	3	4	3	0	0	1	1	3	0	0	1	2
15-Jul	5	2	0	1	0	0	0	1	0	0	1	0	1
16-Jul	7	1	0	5	0	0	2	0	0	0	0	0	2
17-Jul	3	2	0	0	0	0	0	0	0	0	0	0	1
18-Jul	0	2	0	0	4	1	0	1	1	1	1	1	1
19-Jul	1	2	1	1	0	5	0	1	0	0	0	1	1
20-Jul	4	0	4	0	0	0	0	0	1	2	0	1	1
21-Jul	7	0	2	1	0	1	0	0	0	1	1	0	1
22-Jul	8	3	9	0	0	0	0	2	3	0	0	1	3
23-Jul	0	3	0	0	0	0	0	1	2	0	1	1	1
24-Jul	1	0	0	2	0	0	0	0	0	1	0	0	0
25-Jul	2	1	2	1	1	0	0	0	0	0	0	0	1
26-Jul	0	0	0	0	1	0	0	9	0	0	0	2	1
27-Jul	3	0	3	0	0	0	0	2	0	1	0	1	1
28-Jul	1	0	1	0	1	2	0	1	0	0	0	1	1
29-Jul	1	0	0	1	0	0	0	3	0	0	0	1	1
30-Jul	3	0	0	1	3	0	2	1	0	0	0	1	1
31-Jul	16	2	4	0	0	0	0	1	0	0	0	0	2
1-Aug	2	2	0	0	0	0	0	0	0	0	0	0	0
2-Aug	1	0	2	3	0	0	0	0	0	0	0	0	1
3-Aug	5	1	2	6	0	0	0	0	0	0	0	0	1
4-Aug	5	0	0	0	0	0	2	0	0	0	0	0	1
5-Aug	0	1	2	1	0	0	0	1	0	0	0	0	1
6-Aug	0	1	0	0	0	0	0	0	0	1	0	0	0
7-Aug	2	1	0	0	0	2	0	1	0	3	0	1	1
8-Aug	0	0	3	0	0	0	0	1	0	0	0	0	0
9-Aug	0	4	0	0	1	0	0	0	0	0	0	0	1
10-Aug	0	2	0	0	0	0	0	0	0	0	0	0	0

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												Average	
Date	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	5-Year	10-Year
11-Aug	0	2	0	1	0	0	0	0	1	2	0	1	1
12-Aug	0	0	0	0	1	0	0	0	0	0	2	0	0
13-Aug	0	0	0	0	0	0	0	0	0	0	0	0	0
14-Aug	0	0	0	0	0	0	0	0	0	0	0	0	0
15-Aug	0	0	0	0	0	0	0	0	0	0	0	0	0
16-Aug	0	0	0	0	0	0	0	0	0	1	0	0	0
17-Aug	0	0	0	1	0	0	0	0	0	0	0	0	0
18-Aug	0	0	0	2	0	0	0	0	0	0	0	0	0
19-Aug	0	0	0	1	0	0	0	0	0	0	0	0	0
20-Aug	0	0	0	0	0	0	1	0	0	0	0	0	0
21-Aug	0	0	0	0	0	0	0	0	0	0	0	0	0
22-Aug	0	0	0	1	0	0	0	0	0	0	0	0	0
23-Aug	0	0	0	0	0	0	0	0	0	0	0	0	0
24-Aug	0	0	0	2	0	0	0	0	0	0	0	0	0
25-Aug	0	0	0	1	0	0	0	0	0	0	0	0	0
26-Aug	0	0	0	0	0	0	0	0	0	0	0	0	0
27-Aug	0	0	0	1	1	0	0	0	0	0	0	0	0
28-Aug	0	0	0	0	3	0	0	0	0	0	0	0	0
29-Aug	0	0	0	1	3	0	0	0	0	0	0	0	0
30-Aug	0	0	0	0	0	0	0	0	0	0	0	0	0
31-Aug	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Sep	0	0	0	0	0	0	0	0	1	0	0	0	0
2-Sep	0	0	0	0	0	0	0	0	0	0	0	0	0
3-Sep	0	0	0	0	0	0	0	0	0	0	0	0	0
4-Sep	0	0	0	0	0	0	0	0	0	0	0	0	0
5-Sep	0	0	0	0	0	0	0	0	0	0	0	0	0
6-Sep	0	0	0	0	0	0	0	0	0	0	0	0	0
7-Sep	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	443	204	156	59	57	19	42	41	27	39	42	34	109

Appendix C7.–Dog Salmon Weir and Frazer Fish Pass escapement, commercial harvest, total run, and remainder of sockeye salmon in Dog Salmon Creek, 1983–2013.

Year	Dog Salmon (DS) Weir Count	Commercial Harvest	Total Run	Frazer Fish Pass Count	Sockeye Remaining in DS Creek no.	Sockeye Remaining in DS Creek %
1983	166,655	29,668	196,323	158,340	8,315	5.0
1984	48,844	18,533	67,377	53,524	-4,680	-9.6
1985	506,336	131,535	637,871	485,835	20,501	4.0
1986	136,553	41,652	178,205	126,529	10,024	7.3
1987	48,956	8,626	57,582	40,544	8,412	17.2
1988	248,055	210,406	458,461	246,704	1,351	0.5
1989	362,007	708,864	1,070,871	360,373	1,634	0.5
1990	254,540	725,293	979,833	226,707	27,833	10.9
1991	288,013	980,132	1,268,145	190,358	97,655	33.9
1992	206,406	212,367	418,773	185,825	20,581	10.0
1993	198,412	552,993	751,405	178,391	20,021	10.1
1994	240,913	409,132	650,045	206,071	34,842	14.5
1995	222,170	730,207	952,377	196,323	25,847	11.6
1996	208,638	492,275	700,913	198,695	9,943	4.8
1997	268,328	148,091	416,419	205,264	63,064	23.5
1998	245,409	360,949	606,358	233,755	11,654	4.7
1999	222,964	134,115	357,079	216,565	6,399	2.9
2000	173,340	221,366	394,706	158,044	15,296	8.8
2001	163,455	239,937	403,391	154,349	9,106	5.6
2002	105,989	4,237	110,226	85,317	20,672	19.5
2003	262,731	51,183	313,914	201,679	61,052	23.2
2004	226,266	485,985	712,251	120,664	105,602	46.7
2005	152,959	472,978	625,937	136,948	16,011	10.5
2006	108,343	9,557	117,900	89,516	18,827	17.4
2007	139,808	28,763	168,571	120,186	19,622	14.0
2008	153,276	367,327	520,603	105,363	47,913	31.3
2009	147,798	327,178	474,976	101,845	45,953	31.1
2010	135,100	30,012	165,112	94,680	40,420	29.9
2011	180,603	192,820	372,423	134,642	45,961	25.4
2012	154,416	217,631	372,047	148,884	5,532	3.6
2013	129,369	134,784	270,843	136,059	-6,690	-5.2
Average (2008-2012)	154,239	226,994	381,032	117,083	37,156	24.3
Average (2003-2012)	166,130	218,344	384,373	125,441	40,689	23.3
Average (1983-2002)	215,799	318,019	533,818	195,376	20,423	9.3
Average (1983-2012)	199,243	284,794	484,003	172,064	27,179	14.0

Appendix C8.–Frazer Lake sockeye salmon brood table showing estimated returns from parent escapement by age class, 1966–2013.

Brood		Age																Total	Return/
Year	Escapement	0.2	1.1	0.3	1.2	2.1	1.3	2.2	3.1	1.4	2.3	3.2	4.1	2.4	4.2	3.3	other	Return	Spawner
1966	16,456	0	0	0	11,820	1,732	7,580	16,149	0	0	2,629	0	0	0	0	0	0	39,910	2.4
1967	21,834	0	1,118	0	38,626	395	38,395	11,553	0	0	5,114	0	0	0	0	0	0	95,202	4.4
1968	16,738	0	461	0	15,565	899	15,228	14,998	0	0	10,757	0	0	0	0	0	0	57,910	3.5
1969	14,041	0	138	0	14,654	5,229	9,306	30,137	0	0	6,007	0	0	0	0	512	0	65,984	4.7
1970	24,039	0	2,241	0	17,672	16,989	1,687	51,299	0	0	9,351	3,074	0	0	0	1,691	0	104,005	4.3
1971	55,366	0	512	0	1,417	6,345	769	92,226	0	0	20,151	0	0	0	0	0	0	121,419	2.2
1972	66,419	0	742	0	10,888	11,016	8,032	91,876	0	0	71,167	345	0	0	0	0	0	194,066	2.9
1973	56,255	0	256	0	2,677	5,637	4,825	31,706	345	0	15,969	0	0	0	0	0	0	61,415	1.1
1974	82,609	0	10,850	0	53,591	9,305	28,713	75,084	154	461	30,407	461	0	0	0	0	0	209,026	2.5
1975	64,199	0	1,034	0	22,571	8,906	20,732	173,687	0	0	72,701	0	0	0	0	0	0	299,631	4.7
1976	119,321	0	2,150	0	223,444	8,753	73,677	257,625	0	0	143,383	0	0	0	0	393	0	709,424	5.9
1977	139,548	0	2,764	0	73,189	2,928	92,211	107,917	0	0	146,064	393	0	0	0	0	0	425,466	3.0
1978	141,981	0	7,807	0	162,130	507	24,148	22,970	0	0	16,844	0	0	0	0	638	0	235,043	1.7
1979	126,742	0	507	0	1,374	982	2,965	24,323	0	0	26,791	0	0	0	0	2,165	0	59,106	0.5
1980	405,535	0	0	0	6,064	16,305	7,654	589,393	0	0	141,065	684	0	46	0	52	0	761,264	1.9
1981	377,716	0	876	0	12,120	0	2,455	7,748	0	172	5,239	0	0	0	0	862	0	29,471	0.1
1982	430,423	0	1,276	0	23,647	431	28,624	3,735	24	754	10,870	10,812	0	0	0	0	0	80,172	0.2
1983	158,340	0	10	26	8,935	9,729	13,438	380,531	1,604	0	586,833	0	0	0	0	36,986	0	1,038,092	6.6
1984	53,524	0	1,001	0	5,771	33,628	7,437	386,832	0	0	67,142	2,046	0	0	0	0	0	503,856	9.4
1985	485,835	0	192	0	16,502	4,399	49,290	53,978	151	0	22,578	9,032	0	1,595	0	2,694	0	160,412	0.3
1986	126,529	1,393	67,475	0	727,658	40,794	230,893	972,290	0	0	168,815	9,129	0	0	0	8,584	0	2,227,031	17.6
1987	40,544	0	1,787	1,851	3,019	26,596	3,902	187,581	0	0	159,822	104	0	156	0	882	0	385,701	9.5
1988	246,704	0	1,886	0	21,073	7,793	30,096	210,586	133	0	64,565	20,510	0	16	0	7,994	0	364,652	1.5
1989	360,373	0	16,191	208	327,929	12,847	153,078	373,277	5,752	0	300,182	145,325	0	0	0	40,754	0	1,375,543	3.8
1990	226,707	0	1,096	0	18,217	12,986	33,393	400,750	1,678	0	210,744	15,341	0	455	0	9,340	0	704,000	3.1
1991	190,358	0	621	0	2,031	57,463	1,728	330,834	302	0	105,361	630	0	0	0	0	0	498,970	2.6
1992	185,825	0	3,545	0	20,513	78,168	27,471	211,959	4,666	0	185,148	18,141	0	0	0	2,209	0	551,819	3.0
1993	178,391	0	2,529	45	12,677	41,759	56,178	291,218	4,831	0	64,155	17,867	0	256	0	5,830	0	497,344	2.8
1994	206,071	0	2,056	0	23,034	17,688	39,741	112,849	1,048	0	77,546	15,427	0	187	0	15,733	0	305,309	1.5
1995	196,323	0	10,106	0	59,574	39,574	77,223	152,287	1,251	0	251,356	11,284	0	815	0	5,387	0	608,857	3.1
1996	198,695	0	20,062	0	41,983	22,276	81,667	32,786	26	1,641	50,325	101	0	191	0	201	0	251,259	1.3
1997	205,264	0	626	0	8,327	1,639	9,831	14,560	231	630	15,665	2,251	0	0	0	0	77	53,837	0.3
1998	233,755	0	367	0	1,374	24,808	14,710	87,861	16,454	0	57,957	88,617	0	366	0	33,880	0	326,394	1.4
1999	216,565	0	1,152	0	3,507	136,968	77	481,220	0	0	241,075	1,299	0	496	0	2,090	97	867,981	4.0

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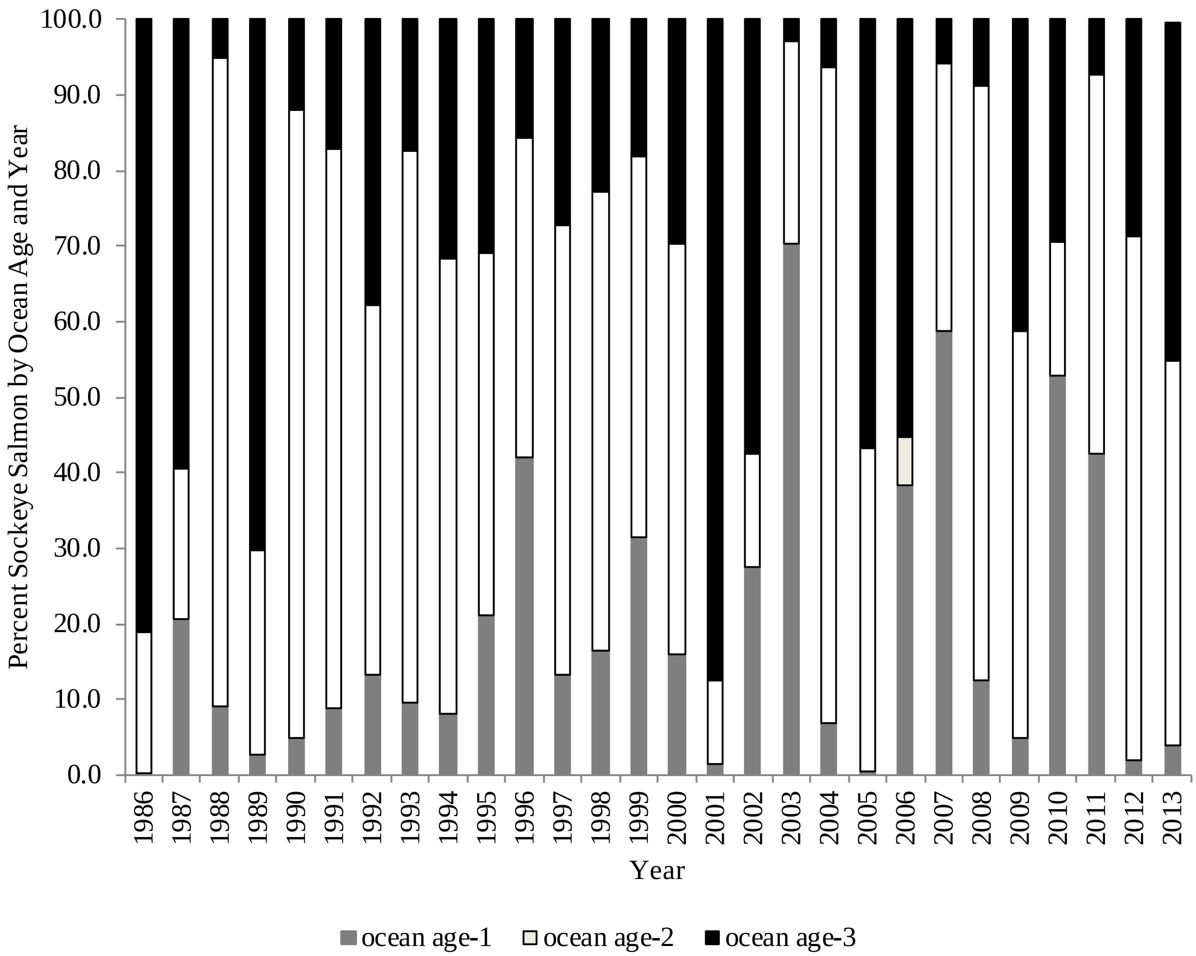
Brood		Age																Total	Return/
Year	Escapement	0.2	1.1	0.3	1.2	2.1	1.3	2.2	3.1	1.4	2.3	3.2	4.1	2.4	4.2	3.3	other	Return	Spawner
2000	158,044	0	35,476	0	68,494	15,072	219,630	107,018	0	521	58,178	330	0	547	233	289	521	506,309	3.2
2001	154,349	0	814	0	21,700	557	5,639	3,657	23,842	131	11,476	29,633	293	776	718	81,003	1,501	181,739	1.2
2002	85,317	0	335	0	5,659	14,124	5,844	27,492	11,173	0	44,559	35,868	0	415	0	29,071	153	174,694	2.0
2003	201,679	0	3,365	0	8,565	58,042	16,372	170,743	2,948	0	81,058	31,271	0	162	0	1,004	0	373,528	1.9
2004	120,664	0	14,757	0	148,241	16,861	90,953	197,458	0	250	20,896	233	0	175	0	0	0	489,822	4.1
2005	136,949	0	1,993	0	34,005	9,131	34,164	29,710	8,606	434	36,619	3,204	90	344	0	506	0	158,806	1.2
2006	89,516	0	113	224	5,281	58,888	21,506	216,074	7,610	0	118,641	5,882	0	715	0	2,772		437,706	4.9
2007	120,185	0	5,543	660	13,247	68,111	21,217	174,630	0	0	91,835	629	0						
2008	105,363	0	4,692	0	46,539	3,757	50,362	106,913	0										
2009	101,845	499	34	0	11,246	5,762													
2010	94,680	0	611																
2011	134,565																		
2012	148,884																		
2013	136,059																		
10-Year Average (1997-2006):		Number	5,900	22	30,515	33,609	41,873	133,579	7,086	196	68,613	19,859	38	400	95	15,061	261	357,082	2.4
10-Year Average (1997-2006):		Percent	1.7	0.0	8.5	9.4	11.7	37.4	2.0	0.1	19.2	5.6	0.0	0.1	0.0	4.2	0.1	100.0	2.4

Appendix C9.–Frazer Lake sockeye salmon escapement by ocean age and year, 1986–2013.

	Ocean Age					
Year	1	%	2	%	3	%
1986	293	0.2	23,242	18.6	101,363	81.2
1987	8,322	20.7	7,982	19.8	23,950	59.5
1988	22,052	9.0	211,196	85.9	12,621	5.1
1989	9,960	2.8	97,044	26.9	253,122	70.3
1990	10,612	4.9	181,639	83.1	26,399	12.1
1991	16,562	8.7	141,114	74.1	32,681	17.2
1992	24,243	13.2	90,256	49.0	69,725	37.8
1993	16,967	9.6	129,240	73.0	30,919	17.5
1994	16,601	8.1	123,919	60.2	65,231	31.7
1995	41,321	21.1	94,149	48.1	60,386	30.8
1996	76,246	42.1	76,277	42.1	28,444	15.7
1997	26,768	13.3	119,137	59.4	54,785	27.3
1998	38,366	16.4	141,990	60.7	53,399	22.8
1999	68,320	31.6	108,918	50.3	39,294	18.1
2000	24,529	16.0	83,051	54.2	45,555	29.7
2001	1,959	1.3	16,642	11.2	129,345	87.4
2002	21,907	27.6	11,738	14.8	45,690	57.6
2003	141,449	70.2	54,369	27.0	5,589	2.8
2004	8,366	6.9	104,679	86.8	7,619	6.3
2005	624	0.5	56,535	42.8	75,082	56.8
2006	33,650	38.3	5,694	6.5	48,415	55.2
2007	70,300	58.8	42,323	35.4	6,941	5.8
2008	11,376	12.5	71,576	78.6	8,088	8.9
2009	4,636	4.9	51,035	53.9	39,005	41.2
2010	49,546	52.7	16,852	17.9	27,555	29.3
2011	57,113	42.5	67,498	50.2	9,806	7.3
2012	2,789	1.9	103,061	69.4	42,713	28.8
2013	5,354	3.9	69,256	50.9	61,155	44.9
Average (1986-2012)	29,810	19.8	82,635	48.1	49,767	32.0
Average (1986-2001)	25,195	13.7	102,862	51.0	64,201	35.3
Average (2002-2012)	36,523	28.8	53,214	43.9	28,773	27.3

Appendix C10.–Percentage of Frazer Lake sockeye salmon escapement by ocean age and year, 1986–2013.



Appendix C11.–Number, percentage, and ages of returning sockeye salmon jacks by brood year, 1980−2006.

Brood	Frazer Lake	Age				Total Adult	Return/	Total Number	Jack
Year	Escapement	1.1	2.1	3.1	4.1	Return	Spawner	of Jacks	Percentage
1980	405,535	0	16,305	0	0	761,264	1.9	16,305	0.02
1981	377,716	876	0	0	0	29,471	0.1	876	0.03
1982	430,423	1,276	431	24	0	80,172	0.2	1,731	0.02
1983	158,340	10	9,729	1,604	0	1,038,092	6.6	11,343	0.01
1984	53,524	1,001	33,628	0	0	503,856	9.4	34,628	0.07
1985	485,835	192	4,399	151	0	160,412	0.3	4,742	0.03
1986	126,529	67,475	40,794	0	0	2,227,031	17.6	108,269	0.05
1987	40,544	1,787	26,596	0	0	385,701	9.5	28,383	0.07
1988	246,704	1,886	7,793	133	0	364,652	1.5	9,812	0.03
1989	360,373	16,191	12,847	5,752	0	1,375,543	3.8	34,790	0.03
1990	226,707	1,096	12,986	1,678	0	704,000	3.1	15,760	0.02
1991	190,358	621	57,463	302	0	498,970	2.6	58,386	0.12
1992	185,825	3,545	78,168	4,666	0	551,819	3.0	86,379	0.16
1993	178,391	2,529	41,759	4,831	0	497,344	2.8	49,119	0.10
1994	206,071	2,056	17,688	1,048	0	305,309	1.5	20,792	0.07
1995	196,323	10,106	39,574	1,251	0	608,857	3.1	50,931	0.08
1996	198,695	20,062	22,276	26	0	251,259	1.3	42,364	0.17
1997	205,264	626	1,639	231	0	53,837	0.3	2,496	0.05
1998	233,755	367	24,808	16,454	0	326,394	1.4	41,629	0.13
1999	216,565	1,152	136,968	0	0	867,981	4.0	138,120	0.16
2000	158,044	35,476	15,072	0	0	506,309	3.2	50,548	0.10
2001	154,349	814	557	23,842	293	181,739	1.2	25,505	0.14
2002	85,317	335	14,124	11,173	0	174,694	2.0	25,632	0.15
2003	201,679	3,365	58,042	2,948	0	373,528	1.9	64,355	0.17
2004	120,664	14,757	16,861	0	0	489,822	4.1	31,618	0.06
2005	136,949	1,993	9,131	8,606	90	158,806	1.2	19,820	0.12
2006	89,516	113	58,888	7,610	0	437,706	4.9	66,611	0.15
2007	120,185	5,543	68,111	0	0				
2008	105,363	4,692	3,757	0					
2009	101,845	34	5,762						
2010	94,680	611							
2011	134,565								
2012	148,884								
2013	136,059								
27-Year Average (1980–2006)		6,775	27,090	3,298	14	515,354	3.4	38,553	0.09
10-Year Average (1996–2006)		11,845	61,871	23,170	154	347,461	2.3	46,245	0.13
5-Year Average (2002–2006)		4,112	31,409	6,067	18	326,911	2.8	41,607	0.13

APPENDIX D: HISTORICAL LIMNOLOGICAL DATA

Appendix D1.–The number of limnological sampling stations and samples collected from Frazer Lake, 1985–1996, 2009–2013.

Year	Sampling Station	Total Samples
1985	1, 3	20
1986	1, 3	28
1987	1, 3	32
1988	1, 3	27
1989	1, 3	24
1990	1, 3	36
1991	1	14
1992	1, 3	26
1993	1	10
1994	1, 2, 3, 4	24
1995	1, 2, 3, 4	24
1996	1, 2, 3, 4	22
2009	1	5
2010	1, 3	20
2011	1, 3	24
2012	1, 3	24
2013	1, 3	24

Note: Map locations for stations 2 and 4 are available in Sagalkin (1999).

Appendix D2.–Annual seasonal averages of 1 m temperature, dissolved oxygen, and light penetration from Frazer Lake, 2001–2013.

		Year													Average	
Month		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	5-yr	10-yr
May																
	Temp (°C)		2.8		10.5	4.2	3.0	3.8	3.8	3.4	2.8	4.1	2.8	3.6	3.3	4.1
	DO (mg/l)		13.0		10.5	12.6	12.7	12.6	12.8	13.2	13.3	13.3	13.1	13.5	13.1	12.7
	Light (Klux)		2,600		1,140	465	470	405	660	2,400	2,200	998	267	759	1,305	1,160
June																
	Temp (°C)				10.7	10.7	9.3	9.0	9.2	8.5	6.9	6.6	8.3	8.3	7.9	8.8
	DO (mg/l)				10.0	10.5	10.3	10.3	12.8	14.8	9.2	12.7	13.1	12.8	12.5	11.5
	Light (Klux)					475	1,950	390	11	1,831	207	331	225	1,275	520.9	677
July																
	Temp (°C)							12.4	10.1	14.7	11.2	10.2	9.9	14.3	11.2	11.4
	DO (mg/l)							9.8	11.5	10.0	10.8	11.9	12.0	10.8	11.2	11.0
	Light (Klux)							1,800	19	3,094	205	433	112	1,011	772.2	944
August																
	Temp (°C)					13.9	11.2	13.5	12.2	12.6	11.0	13.1	11.8	12.9	12.1	12.4
	DO (mg/l)					9.8	9.9	9.2	11.3	10.2	10.9	11.2	11.7	10.6	11.0	10.5
	Light (Klux)					525	285	300	3	3,781	642	129	240	199	959	738
September																
	Temp (°C)	11.2		13.0		12.6	10.1	10.5	10.2	10.8		10.4	10.1	11.4	10.4	11.0
	DO (mg/l)	10.4		10.3		9.9	10.9	10.9	10.7	10.9		11.0	11.6	10.8	11.0	10.8
	Light (Klux)	400		725		255	775	240	525	355		151	76	96	277	388
October																
	Temp (°C)		8.5	10.3							9.7	8.9	7.9	8.2	8.8	9.0
	DO (mg/l)		10.5	11.3							11.2	11.1	11.8	11.3	11.4	11.2
	Light (Klux)		1,050	1,950							115	10	71	93	65	639

Appendix D3.–Summary of seasonal mean epilimnion (1 meter), nutrient concentrations by station for Frazer Lake: 1985–1996, and 2009–2013.

		Depth	Total-P		Total filterable-P		Filterable reactive-P		Total Kjeldahl Nitrogen		Ammonia		Nitrate+ nitrite		Chlorophyll α	
Year	Station	(m)	(µg/L)	SD	(µg/L)	SD	(µg/L)	SD	(µg/L)	SD	(µg/L)	SD	(µg/L)	SD	(µg/L)	SD
1985	1	1	6.1	0.7	2.1	1.0	1.9	0.7	87.4	12.3	6.6	3.7	42.6	8.7	1.1	0.3
	3	1	6.4	1.1	2.2	0.8	2.2	1.2	93.6	18.7	17.3	27.8	47.3	18.1	1.2	0.5
1986	1	1	5.3	0.7	2.9	0.8	2.4	1.0	84.1	10.0	10.9	3.4	59.0	16.4	0.6	0.2
	3	1	5.3	0.9	2.9	0.9	2.1	0.9	79.7	8.2	8.8	3.4	59.5	15.5	0.6	0.2
1987	1	1	5.3	1.2	5.2	2.8	3.7	2.2	100.1	14.0	13.6	9.9	83.2	24.9	1.1	0.7
	3	1	6.5	0.8	3.8	0.6	2.1	0.8	98.7	3.5	9.4	9.3	71.7	24.7	1.2	0.5
1988	1	1	7.1	1.6	5.8	5.6	3.9	4.9	94.4	28.3	10.4	4.2	73.0	24.7	0.7	0.3
	3	1	8.6	5.3	3.6	1.5	2.0	0.6	102.2	49.3	10.5	7.3	72.9	22.7	0.8	0.4
1989	1	1	8.3	3.4	4.0	1.0	2.0	0.3	115.2	25.4	6.1	4.2	57.6	17.2	1.3	1.0
	3	1	10.8	9.3	4.6	1.6	3.1	1.3	124.9	26.4	4.6	3.0	60.9	11.9	1.4	1.0
1990	1	1	5.5	1.2	2.9	0.5	1.2	0.5	63.8	20.4	6.4	4.3	46.8	24.9	1.8	1.1
	3	1	6.3	1.9	3.1	0.6	1.2	0.4	69.0	26.7	6.1	5.1	40.7	21.1	1.6	1.7
1991	1	1	5.2	0.8	3.4	0.6	2.1	0.8	93.6	29.1	6.5	10.6	43.9	24.6	1.4	0.4
	3	1	5.6	1.1	3.7	0.9	2.3	0.9	104.6	26.1	7.2	11.4	46.2	23.4	1.7	0.8
1992	1	1	5.1	2.3	2.6	1.3	1.4	0.6	107.6	40.7	5.4	3.0	64.1	24.7	1.4	1.0
	3	1	5.2	2.2	2.6	1.0	1.2	0.4	119.1	48.0	5.8	2.6	56.7	17.8	1.5	0.5
1993	1	1	5.1	1.0	3.7	1.0	2.1	0.8	97.2	12.4	5.6	1.6	55.5	32.4	1.7	0.6
	3	1	5.3	0.7	3.1	1.3	2.1	0.5	104.3	19.9	7.0	0.0	58.1	28.5	1.7	0.5
1994	1	1	6.3	2.7	1.8	0.2	1.4	0.3	94.9	7.7	5.0	3.9	61.1	16.0	0.7	0.1
	3	1	6.4	3.2	2.4	0.9	1.6	0.6	108.7	22.2	3.6	1.9	57.1	22.0	0.7	0.1
1995	1	1	5.2	0.6	2.1	0.3	1.5	0.2	94.4	14.7	3.4	2.3	70.4	20.9	2.0	0.7
	3	1	5.2	0.8	2.0	0.5	1.4	0.3	96.2	11.7	3.2	2.2	71.4	20.1	1.9	1.1
1996	1	1	4.8	1.7	2.5	1.0	1.9	1.2	114.7	24.8	4.5	3.6	30.4	26.9	0.5	0.1
	3	1	5.3	0.7	2.0	1.0	1.3	0.6	117.9	24.3	3.0	1.7	28.2	22.2	0.5	0.2
2009	1	1	5.0	0.8	1.4	1.4	2.1	0.7	ND	ND	5.4	1.5	29.2	22.1	0.9	0.2
2010	1	1	4.0	0.7	2.0	0.5	1.1	0.2	103.0	88.5	4.5	3.9	32.0	18.0	0.8	0.3
	3	1	3.6	0.5	1.9	0.3	1.2	0.2	ND	ND	4.5	4.9	29.5	19.5	0.7	0.2
2011	1	1	5.2	0.7	2.2	0.6	0.8	0.4	148.3	15.6	5.1	3.0	25.8	17.4	1.3	0.6
	3	1	4.9	1.2	1.9	0.3	0.4	0.1	142.0	33.7	4.3	2.1	23.1	15.5	1.1	0.6
2012	1	1	3.8	1.5	1.6	0.2	1.0	0.4	271.4	14.8	4.1	3.7	30.5	19.4	1.3	0.5
	3	1	2.3	0.4	1.8	0.1	1.1	0.5	270.9	43.9	4.4	4.7	36.0	22.1	1.5	0.5
2013	1	1	4.6	1.8	1.7	0.4	1.2	0.3	505.0	218.0	13.5	8.1	29.9	17.7	0.7	0.1
	3	1	3.9	1.0	1.6	0.4	1.3	0.4	457.5	247.9	13.4	7.9	31.9	23.0	0.9	0.2
Mean St1 (1985–2012)			5.5	1.3	2.9	1.2	1.9	0.9	111.3	23.9	6.5	4.2	50.3	21.2	1.1	0.5
Mean St1 (2009–2013)			4.5	1.1	1.8	0.6	1.2	0.4	256.9	84.2	6.5	4.1	29.5	18.9	1.0	0.3

Appendix D4.–Seasonal mean epilimnion (1 meter), water chemistry parameters by station and depth for Frazer Lake, 1985–1996 and 2009–2013.

		Conductance		pH		Alkalinity		Turbidity		Color		Calcium		Magnesium		Iron		Silicon	
Year	Station	(µmhos/cm)	SD		SD	(µ g L)	SD	(NTU)	SD	units)	SD	(µ g L)	SD	(µ g L)	SD	(µ g L)	SD	(µ g L)	SD
1985	1	48.2	2.7	6.8	0.2	13.0	1.0	0.9	0.2	8.2	2.2	4.8	0.2	0.6	0.5	14.6	9.2	2,327.0	41.6
	3	47.4	3.1	6.9	0.1	13.8	0.4	1.2	0.6	8.6	1.6	4.5	0.4	0.9	0.3	22.0	13.0	2,357.8	47.2
1986	1	48.0	1.5	6.9	0.2	13.6	2.2	0.5	0.2	9.0	1.3	4.7	0.3	1.1	0.6	11.2	7.6	2,300.0	200.3
	3	47.9	1.5	7.0	0.1	13.1	1.6	0.5	0.2	7.9	1.7	4.6	0.4	1.1	0.6	13.2	6.2	2,326.0	179.1
1987	1	46.9	1.6	6.7	0.2	13.4	2.7	0.4	0.1	13.8	5.4	N/A	N/A	N/A	N/A	16.8	8.2	2,196.1	288.1
	3	47.0	1.7	6.9	0.3	13.9	2.4	0.5	0.1	8.0	3.6	N/A	N/A	N/A	N/A	24.1	11.4	2,211.6	310.7
1988	1	46.6	1.3	6.9	0.2	12.1	2.0	0.6	0.3	9.6	7.6	N/A	N/A	N/A	N/A	20.0	13.0	1,769.6	359.5
	3	47.1	0.4	6.9	0.2	12.3	1.4	0.8	0.3	6.7	1.0	N/A	N/A	N/A	N/A	24.9	7.1	1,851.7	283.5
1989	1	50.7	1.2	7.1	0.3	13.8	0.8	0.9	0.7	6.8	2.2	5.3	0.3	1.4	N/A	8.7	8.3	1,847.7	123.5
	3	50.6	1.7	7.0	0.2	13.0	0.7	0.4	0.1	7.9	3.7	5.3	0.6	0.3	N/A	16.3	7.0	1,858.8	150.8
1990	1	50.6	0.9	7.1	0.2	13.9	1.2	0.8	0.3	6.0	2.4	4.4	1.2	0.9	0.3	31.0	23.7	1,673.1	492.7
	3	50.7	0.9	7.1	0.1	14.3	0.8	0.8	0.3	4.7	0.9	4.4	0.7	0.8	0.4	47.8	76.4	1,655.6	542.4
1991	1	52.6	0.8	7.2	0.2	13.1	2.0	0.8	0.5	6.0	2.6	4.7	0.3	0.9	0.6	21.0	20.3	970.0	55.6
	3	52.6	1.1	7.0	0.2	13.1	2.3	1.0	0.5	7.9	3.3	4.5	0.6	0.9	0.6	28.4	23.6	1,014.4	67.3
1992	1	52.9	6.0	7.0	0.2	12.9	1.0	0.6	0.2	6.1	2.5	5.1	0.4	1.2	0.6	17.0	5.3	1,408.9	89.6
	3	51.7	0.8	7.1	0.2	13.3	0.4	0.8	0.3	6.5	1.8	5.0	0.7	1.4	0.9	19.8	5.0	1,436.2	73.1
1993	1	53.4	2.6	6.8	0.1	13.1	0.7	0.8	0.4	6.4	4.7	4.7	0.4	1.5	0.6	19.5	10.6	1,779.8	119.8
	3	53.8	2.6	6.8	0.2	12.8	0.8	0.7	0.4	3.6	0.9	4.9	0.2	1.5	0.6	21.0	9.9	1,803.2	134.8
1994	1	55.5	1.3	7.0	0.4	14.0	1.2	0.6	0.5	5.3	1.0	4.9	0.1	1.3	0.1	8.8	4.2	1,899.5	41.2
	3	55.0	0.8	6.8	0.2	13.1	0.6	0.6	0.3	5.5	1.9	4.9	0.1	1.3	0.1	15.5	14.2	1,957.3	76.8
1995	1	50.0	2.6	6.8	0.2	12.9	0.9	1.3	0.8	7.8	2.1	4.5	0.2	1.0	0.4	28.0	21.8	2,191.8	68.6
	3	50.8	3.2	6.6	0.3	13.8	1.1	1.1	0.5	6.8	2.2	4.5	0.2	1.0	0.4	21.8	11.3	2,238.5	66.5
1996	1	53.3	1.5	6.8	0.2	13.9	0.4	0.5	0.1	7.0	2.4	4.6	0.1	0.7	0.3	13.0	10.4	2,103.7	127.0
	3	53.7	1.2	6.9	0.2	14.0	0.3	0.5	0.1	6.3	1.3	4.6	0.1	0.7	0.3	17.7	9.6	2,204.3	174.5
2009	1	N/A	N/A	7.0	0.2	14.3	0.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NA	NA
2010	1	N/A	N/A	7.1	0.1	13.0	0.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,461.3	267.9
	3	N/A	N/A	7.1	0.2	13.3	0.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,340.3	131.1
2011	1	N/A	N/A	7.5	0.1	14.9	0.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,298.1	629.1
	3	N/A	N/A	7.5	0.1	15.8	0.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,313.1	548.6
2012	1	N/A	N/A	7.6	0.2	14.0	0.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,621.7	238.3
	3	N/A	N/A	7.6	0.2	14.2	0.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,505.2	180.4
2013	1	N/A	N/A	7.6	0.2	14.5	1.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,356.0	143.6
	3	N/A	N/A	7.6	0.1	14.6	1.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,332.5	209.2
Mean St 1 (1985-1990)		48.5		6.9		13.3		0.7		8.9		4.8		1.0		17.0		2,018.9	
Mean St 1 (1985-1996)		50.3		7.0		13.4		0.7		8.0		4.8		1.0		16.9		1,971.7	
Mean St 1 (1985-2013)		N/A		7.1		13.6		N/A		N/A		N/A		N/A		N/A		2,103.9	

Appendix D5.–Frazer Lake weighted mean zooplankton density and biomass, station 1, by species, 1985–2013.

		Diaptomus			Cyclops			Bosmina			Daphnia			TOTALS	
Year	Samples (n)	Density (no/m^2)	Biomass (mg/m^2)	Biomass %	Density (no/m^2)	Biomass (mg/m^2)	Biomass %	Density (no/m^2)	Biomass (mg/m^2)	Biomass %	Density (no/m^2)	Biomass (mg/m^2)	Biomass %	Density (no/m^2)	Biomass (mg/m^2)
1985	5	0	0.0	0.0	716	1.0	0.5	124,735	147.0	79.9	24,655	36.0	19.6	150,106	184.0
1986	7	38	0.0	0.0	1,441	2.0	2.6	48,491	54.0	71.1	15,127	20.0	26.3	65,097	76.0
1987	8	38	1.0	1.4	7,620	13.0	18.6	33,326	43.0	61.4	8,568	13.0	18.6	49,552	70.0
1988	7	0	0.0	0.0	2,540	4.0	2.1	104,261	120.0	63.2	48,485	66.0	34.7	155,286	190.0
1989	6	0	0.0	0.0	7,475	13.0	9.2	78,291	99.0	70.2	23,332	29.0	20.6	109,098	141.0
1990	9	139	1.0	1.3	34,936	51.0	68.0	20,973	22.0	29.3	567	1.0	1.3	56,615	75.0
1991	7	417	1.0	0.8	17,440	23.0	17.7	107,787	101.0	77.7	3,586	5.0	3.8	129,230	130.0
1992	7	15	1.0	0.4	49,651	107.0	45.9	94,359	106.0	45.5	9,539	19.0	8.2	153,564	233.0
1993	5	0	0.0	0.0	58,057	90.0	34.4	170,435	160.0	61.1	8,482	12.0	4.6	236,974	262.0
1994	4	186	1.0	0.7	17,277	30.0	21.7	61,440	72.0	52.2	19,904	35.0	25.4	98,807	138.0
1995	4	0	0.0	0.0	62,128	91.0	61.9	49,125	46.0	31.3	6,422	10.0	6.8	117,675	147.0
1996	4	0	0.0	0.0	50,186	112.5	41.1	100,344	115.6	42.2	31,396	45.6	16.6	181,926	273.7
1997	4	0	0.0	0.0	89,358	298.8	46.1	204,379	263.4	40.6	61,147	86.5	13.3	354,884	648.7
1998	3	302	0.3	0.0	319,083	685.7	62.9	246,200	363.2	33.3	20,059	41.8	3.8	585,643	1,090.9
1999	4	0	0.0	0.0	226,991	394.4	92.1	28,026	31.3	7.3	1,062	2.3	0.5	256,078	428.1
2000	4	0	0.0	0.0	46,129	63.8	63.6	33,838	35.5	35.3	597	1.1	1.1	49,686	100.4
2001	5	0	0.0	0.0	26,575	26.3	8.1	83,921	116.3	35.9	58,235	181.5	56.0	168,731	324.1
2002	5	55	0.1	0.0	26,342	29.7	6.1	110,100	114.3	23.3	146,272	346.7	70.6	282,769	490.8
2003	4	955	3.3	1.0	105,626	113.7	34.7	168,100	175.3	53.4	29,538	35.8	10.9	304,219	328.0
2004	4	0	0.0	0.0	28,981	37.5	25.8	43,127	31.2	21.5	50,876	76.7	52.7	122,984	145.5
2005	4	0	0.0	0.0	37,421	49.1	21.8	124,337	144.5	64.2	19,705	31.4	14.0	181,463	225.0
2006	4	332	0.4	0.1	300,889	538.0	76.8	110,019	149.9	21.4	10,284	12.4	1.8	421,524	700.8
2007	5	318	0.7	0.2	163,142	280.9	80.0	47,941	48.0	13.7	16,178	21.7	6.2	227,579	351.4
2008	5	0	0.0	0.0	18,230	20.7	22.9	54,589	62.4	69.2	6,096	7.1	7.9	78,915	90.2
2009	5	0	0.0	0.0	52,675	144.1	60.4	31,407	38.7	16.2	49,371	55.6	23.3	133,453	238.4
2010	5	467	3.1	0.9	102,463	175.8	48.1	117,134	123.5	33.7	64,968	63.4	17.3	285,032	366.2
2011	6	708	2.2	0.4	194,201	405.8	80.0	43,900	50.9	10.0	38,482	48.4	9.5	277,291	507.2
2012	6	0	0.0	0.0	131,591	276.4	76.9	79,308	81.3	22.6	1,283	1.6	0.4	212,182	359.2
2013	6	221	0.4	0.1	124,792	213.7	67.8	76,415	88.3	28.0	12,027	12.8	4.1	213,455	315.2
Average (1985–2012)	5.2	142	0.5	0.3	77,827	145.7	40.4	89,996	104.1	42.4	27,651	46.6	17.0	194,513	297.0

Appendix D6.–Frazer Lake weighted mean zooplankton density and biomass, station 3, by species, 1985–1997, and 2001–2013.

		Diaptomus			Cyclops			Bosmina			Daphnia			TOTALS	
	Samples	Density	Biomass	Biomass	Density	Biomass	Biomass	Density	Biomass	Biomass	Density	Biomass	Biomass	Density	Biomass
Year	(n)	(no/m^2)	(mg/m^2)	%	(no/m^2)	(mg/m^2)	%	(no/m^2)	(mg/m^2)	%	(no/m^2)	(mg/m^2)	%	(no/m^2)	(mg/m^2)
1985	5	79	<1	0.0	2,308	5.0	2.1	118,756	142.0	58.9	59,855	94.0	39.0	180,998	241.0
1986	7	38	<1	0.0	5,421	11.0	5.9	85,040	112.0	59.9	39,904	64.0	34.2	130,403	187.0
1987	8	152	<1	0.0	18,729	32.0	18.7	62,026	90.0	52.6	27,487	49.0	28.7	108,394	171.0
1988	7			0.0	8,910	33.0	12.4	80,300	116.0	43.4	70,026	118.0	44.2	159,236	267.0
1989	6		<1	0.0	23,987	66.0	20.8	111,125	156.0	49.2	60,952	95.0	30.0	196,064	317.0
1990	9	9		0.0	66,576	161.0	52.1	96,200	141.0	45.6	3,704	7.0	2.3	166,489	309.0
1991	7	38		0.0	92,584	201.0	60.5	115,408	126.0	38.0	2,351	5.0	1.5	210,381	332.0
1992	7			0.0	217,445	683.0	66.9	139,729	231.0	22.6	47,815	107.0	10.5	404,989	1021.0
1993	5	425	2.0	0.3	182,532	393.0	67.0	152,866	168.0	28.6	16,826	24.0	4.1	352,649	587.0
1994	4			0.0	82,325	158.0	35.0	167,359	240.0	53.1	36,386	54.0	11.9	286,070	452.0
1995	4			0.0	56,051	78.0	57.8	30,521	35.0	25.9	14,385	22.0	16.3	100,956	135.0
1996	4	20,966	60.9	13.3	156,783	187.2	40.8	136,092	149.5	32.6	35,974	60.7	13.3	349,815	458.4
1997	4	0	0.0	0.0	82,935	231.3	42.1	154,777	243.7	44.4	55,892	74.4	13.5	293,604	549.5
2001	5	64	0.6	0.2	38,413	52.2	15.5	138,317	230.9	68.7	39,225	52.3	15.6	216,019	335.9
2002	5	0	0.0	0.0	45,886	65.0	20.6	142,038	140.5	44.4	92,118	110.8	35.0	280,042	316.4
2003	4	0	0.0	0.0	52,362	58.3	19.5	170,435	179.7	60.3	51,858	60.2	20.2	274,655	298.2
2004	2	0	0.0	0.0	61,837	66.3	87.4	5,308	5.7	7.5	1,593	3.8	5.0	68,738	75.9
2005	4	0	0.0	0.0	83,201	148.9	46.6	124,472	139.1	43.5	23,819	31.6	9.9	231,492	319.6
2006	4	796	1.1	0.0	294,520	462.6	74.0	113,058	151.0	24.2	8,360	10.1	1.6	416,734	624.8
2007	5	425	3.0	0.6	318,684	449.8	83.5	57,113	62.1	11.5	16,348	24.0	4.4	392,570	538.8
2008	5	318	0.8	0.5	41,858	72.4	47.6	56,119	71.8	47.3	4,892	7.0	4.6	103,187	151.9
2009	5	106	0.0	0.0	55,361	133.5	64.9	22,187	28.4	13.8	34,395	43.8	21.3	112,049	205.7
2010	5	648	3.1	0.6	178,790	315.2	62.3	102,675	141.2	27.9	42,941	46.3	9.2	325,054	505.8
2011	6	354	2.0	0.5	121,798	247.0	56.7	68,046	85.2	19.6	71,320	101.6	23.3	261,518	435.9
2012	6	973	7.4	2.0	124,690	266.3	71.5	86,120	96.5	25.9	1,592	2.4	0.6	213,375	372.6
2013	6	310	1.3	0.3	205,129	314.6	79.8	53,519	66.3	16.8	12,179	11.8	3.0	271,137	394.0
Mean (1985–2012)	5	1,270	5.4	0.7	96,559	183.1	45.3	101,443	131.3	38.0	34,401	50.7	16.0	233,419	368.3

Appendix D7.–Frazer Lake weighted mean zooplankton density and biomass, stations 1 and 3 averaged, by species, 1985–2013.

		Diaptomus			Cyclops			Bosmina			Daphnia			TOTALS	
	Samples	Density	Biomass	Biomass	Density	Biomass	Biomass	Density	Biomass	Biomass	Density	Biomass	Biomass	Density	Biomass
Year	(n)	(no/m^2)	(mg/m^2)	%	(no/m^2)	(mg/m^2)	%	(no/m^2)	(mg/m^2)	%	(no/m^2)	(mg/m^2)	%	(no/m^2)	(mg/m^2)
1985	5	40	0.5	0.2	1,512	3.0	1.4	121,746	144.5	67.9	42,255	65.0	30.5	165,552	213.0
1986	7	38	0.5	0.3	3,431	6.5	4.9	66,766	83.0	62.9	27,516	42.0	31.8	97,750	132.0
1987	8	95	0.9	0.7	13,175	22.5	18.6	47,676	66.5	55.0	18,028	31.0	25.6	78,973	120.9
1988	7	0	0.0	0.0	5,725	18.5	8.1	92,281	118.0	51.6	59,256	92.0	40.3	157,261	228.5
1989	6	0	0.5	0.2	15,731	39.5	17.2	94,708	127.5	55.6	42,142	62.0	27.0	152,581	229.5
1990	9	74	0.5	0.2	50,756	106.0	55.2	58,587	81.5	42.5	2,136	4.0	2.1	111,552	192.0
1991	7	228	0.5	0.2	55,012	112.0	48.5	111,598	113.5	49.1	2,969	5.0	2.2	169,806	231.0
1992	7	8	0.5	0.1	133,548	395.0	63.0	117,044	168.5	26.9	28,677	63.0	10.0	279,277	627.0
1993	5	213	1.0	0.2	120,295	241.5	56.9	161,651	164.0	38.6	12,654	18.0	4.2	294,812	424.5
1994	4	93	0.5	0.2	49,801	94.0	31.9	114,400	156.0	52.9	28,145	44.5	15.1	192,439	295.0
1995	4	0	0.0	0.0	59,089	84.5	59.9	39,823	40.5	28.7	10,403	16.0	11.3	109,315	141.0
1996	4	10,483	30.4	8.3	103,485	149.9	40.9	118,218	132.6	36.2	33,685	53.2	14.5	265,870	366.0
1997	4	0	0.0	0.0	86,146	265.0	44.2	179,578	253.6	42.3	58,519	80.5	13.4	324,244	599.1
2001	5	32	0.3	0.1	32,494	39.3	11.9	111,119	173.6	52.6	48,730	116.9	35.4	192,375	330.0
2002	5	28	0.0	0.0	36,114	47.4	11.7	126,069	127.4	31.6	119,195	228.7	56.7	281,406	403.6
2003	4	478	1.6	0.5	78,994	86.0	27.5	169,268	177.5	56.7	40,698	48.0	15.3	289,437	313.1
2004	4	0	0.0	0.0	45,409	51.9	46.9	24,218	18.5	16.7	26,235	40.3	36.4	95,861	110.7
2005	4	0	0.0	0.0	60,311	99.0	36.3	124,405	141.8	52.1	21,762	31.5	11.6	206,478	272.3
2006	4	564	0.8	0.1	297,705	500.3	75.5	111,539	150.5	22.7	9,322	11.3	1.7	419,129	662.8
2007	4	372	1.8	0.4	240,913	365.4	82.1	52,527	55.1	12.4	16,263	22.8	5.1	310,075	445.1
2008	5	159	0.4	0.3	30,044	46.5	38.4	55,354	67.1	55.4	5,494	7.0	5.8	91,051	121.1
2009	5	53	0.0	0.0	54,018	138.8	62.5	26,797	33.5	15.1	41,883	49.7	22.4	122,751	222.1
2010	5	558	3.1	0.7	140,627	245.5	56.3	109,905	132.4	30.4	53,955	54.8	12.6	305,043	436.0
2011	6	531	2.1	0.4	158,000	326.4	69.2	55,973	68.0	14.4	54,901	75.0	15.9	269,405	471.5
2012	6	487	3.7	1.0	128,140	271.3	74.1	82,714	88.9	24.3	1,437	2.0	0.5	212,778	365.9
2013	6	266	0.9	0.2	164,961	264.2	74.5	64,967	77.3	21.8	12,103	12.3	3.5	242,296	354.6
Mean (1985–2012)		706	3.0	0.5	87,193	164.4	42.8	95,720	117.7	40.2	31,026	48.7	16.5	213,966	332.6
Mean (2003–2012)		320	1.3	0.4	123,416	213.1	56.9	81,270	93.3	30.0	27,195	34.2	12.7	232,201	342.0
Mean (2008–2012)		357	1.9	0.5	102,166	205.7	60.1	66,149	78.0	27.9	31,534	37.7	11.4	200,206	323.3

Note: Station 3 was not sampled from 1997−2000.

Appendix D8.–Seasonal weighted lengths (mm) of zooplankton in Frazer Lake, average of stations 1 and 3, 1985–2013.

Year	*Diaptomus*	*Epishura*	*Cyclops*	*Bosmina*	*Daphnia*	*Holopedium*
1985	0.70	-	0.78	0.36	0.60	-
1986	-	-	0.73	0.37	0.60	-
1987	0.96	-	0.70	0.39	0.64	-
1988	-	-	0.94	0.37	0.61	-
1989	-	-	0.84	0.38	0.59	-
1990	0.82	0.93	0.77	0.39	0.65	-
1991	0.64	-	0.76	0.34	0.62	-
1992	1.24	0.64	0.91	0.39	0.71	-
1993	0.95	-	0.76	0.33	0.59	-
1994	1.04	-	0.73	0.38	0.61	-
1995	-	-	0.65	0.34	0.60	-
1996	0.87	-	0.64	0.35	0.61	-
1997	-	-	0.93	0.39	0.56	-
1998	-	-	0.78	0.40	0.69	-
1999	-	-	0.71	0.35	0.70	-
2000	-	-	0.64	0.34	0.66	-
2001	-	-	0.60	0.41	0.57	0.59
2002	0.70	0.68	0.62	0.33	0.52	0.42
2003	0.92	0.73	0.57	0.34	0.53	-
2004	-	1.21	0.59	0.26	0.59	-
2005	-	0.83	0.69	0.35	0.58	0.46
2006	0.65	0.92	0.69	0.38	0.54	0.35
2007	0.99	0.92	0.67	0.34	0.58	0.45
2008	0.82	1.08	0.67	0.36	0.55	0.30
2009	0.91	0.78	0.85	0.37	0.52	0.51
2010	1.11	0.98	0.72	0.36	0.50	0.52
2011	1.00	1.04	0.77	0.35	0.57	0.54
2012	1.22	0.89	0.78	0.34	0.56	0.57
2013	0.87	1.00	0.69	0.37	0.50	0.69
Average (1985–2012)	0.91	0.89	0.73	0.36	0.59	0.47

Note: Station 3 was not sampled from 1997−2000.

Appendix D9.–Temperatures (°C) measured at the 1 and 50 meter strata in the spring (May–June), summer (July–August), and fall (September–October) for Frazer Lake, 1989–2013.

	Spring		Summer		Fall	
Year	Surface	Bottom	Surface	Bottom	Surface	Bottom
1989	—	—	—	—	11.5	—
1990	8.4	—	14.8	—	11.9	—
1991	5.5	3.8	12.1	6.1	10.1	—
1992	5.8	4.9	12.3	5.3	10.2	7.3
1993	10.4	—	17.6	—	13.5	—
1994	7.3	4.2	11.5	6.0	8.6	8.4
1995	5.0	3.9	11.9	9.3	10.8	12.6
1996	5.7	4.8	12.4	6.3	9.3	7.5
1997	5.3	4.5	14.6	5.4	10.8	6.5
1998	—	—	—	—	—	—
1999	—	—	—	—	—	—
2000	—	—	—	—	—	—
2001	—	—	—	—	11.2	6.7
2002	2.8	2.4	—	—	8.5	6.6
2003	—	—	—	—	11.6	8.2
2004	—	—	—	—	—	—
2005	7.4	4.6	13.9	6.3	12.6	6.8
2006	6.2	4.3	11.2	6.3	10.1	7.6
2007	6.4	4.4	12.9	5.9	10.5	—
2008	6.5	4.1	11.1	6.0	10.2	7.2
2009	5.9	4.4	13.7	6.1	10.8	7.9
2010	4.8	3.8	11.1	7.1	9.7	8.4
2011	5.3	4.5	11.6	6.5	10.4	8.4
2012	5.5	3.4	10.9	5.9	9.0	7.9
2013	6.0	3.7	13.6	5.6	9.8	7.5
Average (1989–2012)	6.1	3.9	12.7	6.3	10.6	7.9

Note: Spring temperature corresponds to the average of May and June temperatures, summer temperature corresponds to the average of July and August temperatures, and fall temperature corresponds to the average of September and October measurements, if available.

Appendix D10.–Temperatures (°C) measured at the 1 and 50 meter strata by month, for Frazer Lake, 1989–2013.

	May		June		July		August		September		October	
Year	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
1989	—	—	—	—	—	—	—	—	11.5	—	—	—
1990	5.0	—	11.8	—	14.3	—	15.3	—	14.7	—	9.0	—
1991	3.5	3.0	7.6	4.5	11.8	6.0	12.4	6.3	10.1	—	—	—
1992	3.7	—	7.9	4.9	11.3	5.5	13.3	5.0	10.2	7.3	—	—
1993	8.0	—	12.9	—	17.3	—	18.0	—	13.5	—	—	—
1994	—	—	7.3	4.2	11.0	5.5	12.0	6.5	—	—	8.6	8.4
1995	5.0	3.9	—	—	12.2	6.0	11.7	12.5	10.8	12.6	—	—
1996	5.7	4.8	—	—	11.9	5.4	13.0	7.2	9.3	7.5	—	—
1997	5.3	4.5	—	—	14.7	5.0	14.4	5.8	10.8	6.5	—	—
2001	—	—	—	—	—	—	—	—	11.2	6.7	—	—
2002	2.8	2.4	—	—	—	—	—	—	—	—	8.5	6.6
2003	—	—	—	—	—	—	—	—	13.0	7.5	10.3	8.8
2005	4.2	3.7	10.7	5.5	—	—	13.9	6.3	12.6	6.8	—	—
2006	3.0	3.0	9.3	5.5	—	—	11.2	6.3	10.1	7.6	—	—
2007	3.8	3.5	9.0	5.3	12.4	5.9	13.5	—	10.5	—	—	—
2008	3.8	3.5	9.2	4.7	10.1	5.5	12.2	6.4	10.2	7.2	—	—
2009	3.4	3.0	8.5	5.7	14.7	5.7	12.6	6.4	10.8	7.9	—	—
2010	2.8	2.5	6.9	5.0	11.2	6.5	11.0	7.6	—	—	9.7	8.4
2011	4.1	3.6	6.6	5.4	10.2	6.0	13.1	6.9	10.4	8.4	8.9	8.8
2012	2.8	2.6	8.3	4.2	9.9	5.4	11.8	6.4	10.1	7.8	7.9	8.0
2013	3.9	3.8	8.5	5.0	13.7	5.9	12.9	6.6	11.3	7.3	8.1	8.0
Average (1989–2012)	4.2	3.4	8.9	5.0	12.3	5.7	13.1	6.9	11.2	7.8	9.0	8.2

Note: Sampling was not conducted from 1998−2000.

Appendix D11.–Summary of Frazer Lake phytoplankton mean biomass, by phylum and year.

		Phylum														
		Chlorophyta (Green Algae)		Chrysophyta (Golden-brown Algae)		Bacillariophyta (Diatoms)		Cryptophyta (crytomonads)		Pyrrhophyta (Dinoflagellate)		Cyanobacteria (Blue-green Algae)		Euglenophyta (Other Algae)		Total
Date	Station	Biomass (mg/m^3)	%	Biomass (mg/m^3)	%	Biomass (mg/m^3)	%	Biomass (mg/m^3)	%	Biomass (mg/m^3)	%	Biomass (mg/m^3)	%	Biomass (mg/m^3)	%	Biomass (mg/m^3)
2011	1	29.69	0.03	59.87	0.07	313.30	0.35	49.04	0.06	78.40	0.09	358.50	0.40	0.00	0.00	888.80
2011	3	12.19	0.01	67.52	0.08	478.57	0.59	37.25	0.05	62.08	0.08	158.57	0.19	0.00	0.00	816.18
2012	1	2.74	0.00	4.26	0.00	1,377.11	0.85	53.80	0.03	173.22	0.11	1.60	0.00	0.00	0.00	1,612.73
2012	3	4.42	0.00	17.09	0.01	1,246.17	0.80	102.38	0.07	187.40	0.12	4.76	0.00	0.00	0.00	1,562.22
2013	1	3.55	0.01	1.70	0.00	348.12	0.85	15.97	0.04	35.22	0.09	3.64	0.01	0.42	0.00	408.62
2013	3	122.13	0.28	1.55	0.00	294.91	0.66	5.91	0.01	10.92	0.02	8.27	0.02	0.01	0.00	443.71
Mean (2011)		20.94	0.02	63.70	0.08	395.94	0.47	43.15	0.05	70.24	0.08	258.54	0.30	0.00	0.00	852.49
Mean (2012)		3.58	0.00	10.68	0.01	1,311.64	0.83	78.09	0.05	180.31	0.11	3.18	0.00	0.00	0.00	1,587.48
Mean (2013)		62.84	0.14	1.62	0.00	321.52	0.76	10.94	0.03	23.07	0.06	5.95	0.01	0.22	0.00	426.16
Mean (2011–2013)		29.12	0.06	25.33	0.03	676.36	0.68	44.06	0.04	91.21	0.08	89.22	0.10	0.07	0.00	955.38

Appendix D12.–Cladoceran to copepod ratio and weighted mean cladoceran and copepod density (station 1) for Frazer Lake, 1985−2013.

	Cladoceran to	Density (no/m^2)	
Year	Copepod ratio	Cladoceran	Copepod
1985	208.6	149,390	716
1986	43.0	63,618	1,479
1987	5.5	41,894	7,658
1988	60.1	152,746	2,540
1989	13.6	101,623	7,475
1990	0.6	21,540	35,075
1991	6.2	111,373	17,857
1992	2.1	103,898	49,666
1993	3.1	178,917	58,057
1994	4.7	81,344	17,463
1995	0.9	55,547	62,128
1996	2.6	131,740	50,186
1997	3.0	265,526	89,358
1998	0.8	266,259	319,385
1999	0.1	29,087	226,991
2000	0.7	34,435	46,129
2001	5.3	142,156	26,575
2002	9.7	256,372	26,397
2003	1.9	197,638	106,581
2004	3.2	94,003	28,981
2005	3.8	144,042	37,421
2006	0.4	120,303	301,221
2007	0.4	64,119	163,460
2008	3.3	60,685	18,230
2009	1.5	80,778	52,675
2010	1.8	182,102	102,930
2011	0.4	82,382	194,909
2012	0.6	80,591	131,591
2013	0.7	88,442	125,013
Average (1985–2012)	13.9	117,647	77,969
Average (2003–2012)	1.7	110,664	113,800
Average (2008–2012)	1.5	97,308	100,067