Fishery Data Series No. 13-45

Hugh Smith Lake Sockeye Salmon Studies, 2012

by

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and

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

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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HUGH SMITH LAKE SOCKEYE SALMON STUDIES, 2012

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ABSTRACT

In 2012, we continued long-term population studies at Hugh Smith Lake designed to evaluate adult sockeye salmon abundance and juvenile production. A smolt weir was operated at the outlet of the lake from 19 April to 3 June, during which time an estimated 179,000 sockeye salmon smolt passed through the weir. We estimated 72% of the emigrating sockeye salmon smolt were freshwater age 1 and 28% were freshwater age 2. From 16 June to 10 November, we enumerated the adult salmon escapement through a weir, conducted a secondary mark-recapture estimate to confirm the weir count, and collected biological information to estimate the age, length, and sex composition of the Hugh Smith Lake sockeye salmon escapement. The 2012 weir count of 13,353 adult sockeye salmon was the ninth escapement in the past ten years to meet the optimal escapement goal range of 8,000–18,000 adult sockeye salmon. Age-2.3 fish were the dominant returning age group, representing an estimated 57% of the total spawning population composed of 13% 2-ocean and 87% 3-ocean fish. Peak counts of live fish were observed on 11 September in Buschmann Creek (1,582 fish) and on 18 September 2012 in Cobb Creek (294 fish). No area closures or time restrictions were implemented in nearby commercial fisheries as the projected escapement of Hugh Smith Lake sockeye salmon was above the lower bound of the optimal escapement goal range throughout the season.

Key words: escapement, Hugh Smith Lake, mark-recapture, *Oncorhynchus nerka*, optimal escapement goal, sockeye salmon, stock of concern, Southeast Alaska

INTRODUCTION

Located southeast of Ketchikan, Alaska, in Boca de Quadra Inlet, Hugh Smith Lake has been an important sockeye salmon (*Oncorhynchus nerka*) contributor to Southeast Alaska commercial fisheries for over a century. Intense fisheries in the late 1800s and early 1900s supplied two canneries in Boca de Quadra Inlet and a saltery adjacent to the estuary of Hugh Smith Lake (Rich and Ball 1933; Roppel 1982). A private hatchery was operated at the head of the lake from 1901 to 1903 and again from 1908 to 1935, but numbers of adult sockeye salmon returning to the lake were not recorded (Roppel 1982). Egg take records suggest 3,000–6,000 females were collected annually for broodstock from Buschmann Creek, one of the primary spawning tributaries (Roppel 1982). Moser (1898) concluded that despite overfishing, Hugh Smith Lake should produce annual runs of 50,000 sockeye salmon under average conditions.

The Alaska Department of Fish and Game (ADF&G) has maintained a weir at the outlet of Hugh Smith Lake from 1967 to 1971 and annually since 1980. Beginning in the early 1980s, the lake was the subject of ADF&G enhancement and rehabilitation efforts which included nutrient enrichment from 1981 to 1984, and fry plants from 1986 to 1997 (Geiger et al. 2003). The vast majority of juveniles from these early stocking programs were not marked so detailed information on the proportion of stocked fish in subsequent escapements is unavailable. Despite rehabilitation efforts, total escapements declined from an average of 17,500 fish in the 1980s, to 12,000 in the 1990s, and 3,500 fish from 1998 to 2002, including the lowest recorded escapement of 1,138 fish in 1998.

In 2003, the Alaska Board of Fisheries classified Hugh Smith Lake sockeye salmon a stock of management concern (5 AAC 39.222) due to the long-term decline in escapement (Geiger et al. 2003). The board set an optimal escapement goal of 8,000–18,000 sockeye salmon (5 AAC 33.390) that includes spawning salmon of wild and hatchery origin, and was based on escapement goal analyses outlined in Geiger et al. (2003). They also adopted an action plan that directed ADF&G to review stock assessment and rehabilitation efforts at the lake and contained measures to reduce commercial harvests of Hugh Smith Lake sockeye salmon when the escapement was projected to be below the lower end of the escapement goal range. Fishery restrictions, in the form of time and area closures, affected the subdistrict 101-11 drift gillnet fishery and subdistrict 101-23 purse seine fishery near the entrance to Boca de Quadra (Figure 1). The rehabilitation effort included an existing hatchery stocking program for which eggs were collected from Buschmann Creek and brought to Southern Southeast Regional Aquaculture Association's Burnett Inlet hatchery where they were hatched and thermally marked. Fry were transported back to Hugh Smith Lake in the spring, fed to pre-smolt size in net pens through July, and released from 1999 through 2003. When these fish returned as adults from 2003 to 2007, ADF&G estimated the contribution, run timing, and distribution of stocked Hugh Smith Lake sockeye salmon in the commercial net fisheries (Heinl et al. 2007).

The Hugh Smith Lake sockeye salmon run was removed from stock of concern status in 2006 as a result of improved escapements (Geiger et al. 2005). Total adult escapements have steadily improved from a low of 1,138 in 1998 and surpassed the lower bound of the escapement goal in eight of nine years, 2003–2011 (Appendix B; Brunette and Piston 2012). Stocked fish made up a significant portion of the escapements from 2003 to 2007 (Piston et al. 2006, 2007). ADF&G conducted studies to identify factors that might limit sockeye salmon survival at various stages of their life history from 2004 to 2007 (Piston et al. 2006, 2007; Piston 2008). These studies did not identify any factors in the freshwater environment that would result in increased juvenile sockeye salmon mortality. In addition, commercial fisheries sampling results from 2004 to 2006 showed that management restrictions outlined in the action plan were appropriately timed and located to reduce harvests on this stock (Heinl et al. 2007).

Population studies at Hugh Smith Lake constitute the longest time series of escapement and age, sex, and length (ASL) information for both sockeye and coho (*O. kisutch*) salmon (Shaul et al. 2009) in southern Southeast Alaska. As a result, they are important indicator stocks and provide information useful for management of Southeast Alaska fisheries. Here we report on sockeye salmon studies conducted in 2012. We estimated the annual sockeye salmon escapement through the adult salmon counting weir to determine if the escapement goal was met. As in previous years, we conducted a secondary mark-recapture study as a backup escapement estimate in the event of a weir failure. ASL information was collected from a sub-set of sockeye salmon at the weir and bi-weekly foot surveys were conducted on both inlet streams to count spawning salmon in conjunction with mark-recapture efforts. Sockeye salmon smolt abundance was estimated at the smolt weir in the spring, operated by a separate coho salmon coded-wire tagging project (Shaul et al. 2009), and ASL information was collected from a sub-set of sockeye salmon smolt.

STUDY SITE

Hugh Smith Lake (55° 06' N, 134° 40' W; Orth 1967) is located on mainland Southeast Alaska, 67 km southeast of Ketchikan in Misty Fjords National Monument (Figure 1). The lake is organically stained and covers a surface area of 320 ha. It has a mean depth of 70 m, a maximum depth of 121 m, and a volume of $222.7 \cdot 10^6$ m^3 (Figure 2). Hugh Smith Lake empties into Boca de Quadra Inlet via 50-m-long Sockeye Creek (*ADF&G Anadromous Waters Catalog* number 101-30-10750). Sockeye salmon spawn in two inlet streams: Buschmann Creek flows northwest 4 km to the head of the lake (*ADF&G Anadromous Waters Catalog* number 101-30-10750-2006, "Beaver Pond Channel" 101-30-10750-3003); and Cobb Creek flows north 8 km to the southeast head of the lake (*ADF&G Anadromous Waters Catalog* number 101-30-10750-2004; Figure 2). Cobb Creek has a barrier to anadromous migration approximately 0.8 km upstream from the lake. Hugh Smith Lake is meromictic and a layer of saltwater located below 60 m does not interact with the upper freshwater layer of the lake.

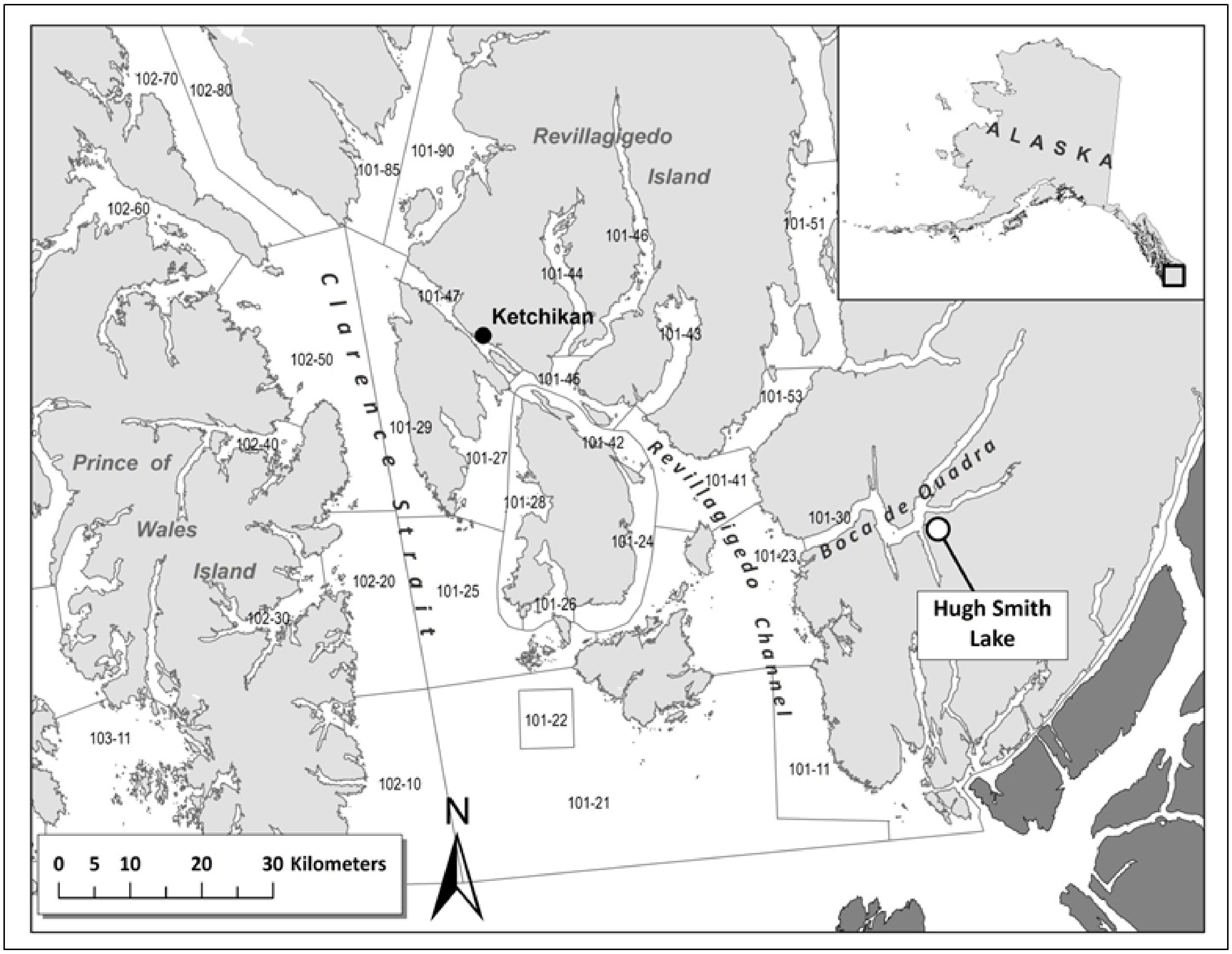

Figure 1.–The location of Hugh Smith Lake in Southeast Alaska.

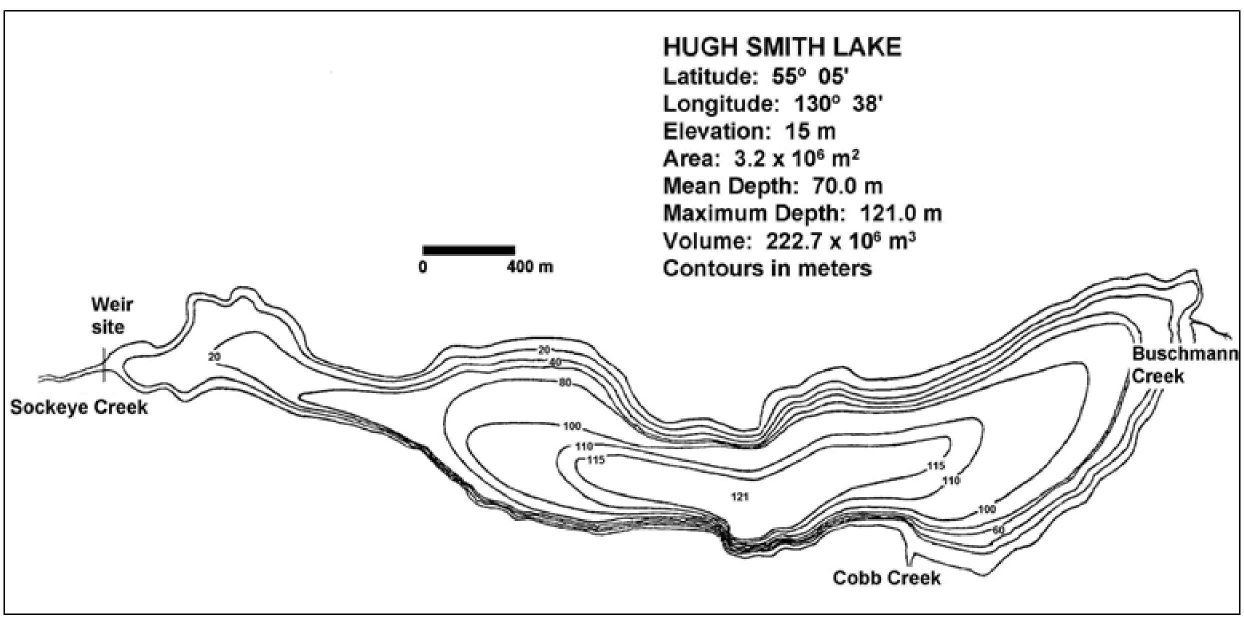

Figure 2.–Bathymetric map of Hugh Smith Lake, Southeast Alaska, showing the location of the weir, the two primary inlet streams, and other features of the lake system.

METHODS

SMOLT EMIGRATION

Since 1982, coho and sockeye salmon smolt have been counted and sampled through a smolt weir as they emigrate from Hugh Smith Lake each spring (Shaul et al. 2009 provided a physical description of weir). In 2012, the smolt weir was operated from 19 April to 3 June. Fish were counted through the weir by species and scale samples and length-weight data were collected from sockeye salmon smolt. Sixteen scale samples were collected on days when fewer than 100 fish were captured at the weir and 28 scale samples were collected on days when greater than 100 fish were captured. The length (snout-to-fork in mm) and weight (to the nearest 0.1 g) were recorded for each fish sampled. A preferred-area scale smear (Clutter and Whitesel 1956) was taken from each fish and mounted on a 2.5 cm x 7.5 cm glass slide, four fish per slide. A video-linked microscope was used to age sockeye salmon smolt scales at the Ketchikan office.

Total smolt weir counts have tended to underestimate the true smolt population size due to fish passage before and after the weir was installed and because fish escaped past the weir uncounted. An unknown, but presumably small, number of smolt also passed through a small opening designed to allow free upstream passage of adult steelhead. Hugh Smith Lake coho salmon smolt tagging data from 1982 to 2006 showed that capture rate at the smolt weir was highly variable, ranging from 14% to 84%. Improvements were made in the mid-1990s to prevent smolt from passing the weir uncounted, and capture efficiency improved to an average of 70% for coho salmon smolt from 1996 to 2006 (Shaul et al. 2009).

ADULT ESCAPEMENT

Weir counts

ADF&G operated an adult salmon counting weir at the outlet of the lake, approximately 50 m from saltwater, from 1967 to 1971 and from 1980 to 2012. The weir is an aluminum bi-pod channel-and-picket design with an upstream trap for enumerating and sampling salmon. In 2012, the weir was operated from mid-June to early November and fish were counted in a way that minimized handling as much as possible. Integrity of the weir was verified by periodic underwater inspections and a secondary mark-recapture study.

Adjacent to the primary upstream trap, we built a secondary trap/counting station designed for hands-free fish passage into the lake. The secondary trap was fitted with a drop-closing door which allowed us to immediately stop fish passage whenever a fish of interest entered the secondary trap. Hugh Smith Lake coho salmon are an important indicator stock in Southeast Alaska so it was imperative that all coho salmon were examined for clipped adipose fins and the presence of coded-wire tags before they entered the lake (Shaul et al. 2005, 2009). The secondary trap and drop-closing door facilitated easy sockeye salmon enumerating and passage through the weir while continuing to meet the goals of the ongoing coho salmon study.

A white board was placed on the streambed at the secondary trap/counting station to facilitate fish identification. Fish passage was also monitored with an underwater video camera so that if a coho salmon passed through the weir unexamined, we were still able to identify it as adipose-clipped or unclipped by reviewing the video recording. Additionally, during periods of low water we applied 4–6 mil plastic sheeting to the face of the weir to concentrate the stream flow through the fish passing station and reduce the incidence of fish holding below the weir for extended periods (Piston and Brunette 2010).

Mark-Recapture

Two-sample mark-recapture studies are an essential component of estimating the adult sockeye escapement at Hugh Smith Lake. Mark-recapture estimates are used to verify the weir count if fish passed the weir uncounted in the event of extreme flooding, or if substantial numbers of sockeye salmon entered the lake before the weir was fish tight in mid-June. Adult sockeye salmon (fish >400 mm in length) were marked at a rate of 10% with a readily identifiable fin clip at the weir. Those fish were anesthetized in a clove oil solution (Woolsey et al. 2004), fin-clipped, sampled for scales, and released upstream next to the trap. Fish that did not appear healthy were not marked with a fin clip. Marking was stratified through time by applying fin clips on the following schedule: right ventral fin clip from 16 June to 18 July, left ventral fin clip from 19 July to 15 August, and a partial dorsal fin clip from 16 August to 8 November. We did not conduct a mark-recapture study for jack sockeye salmon (<400 mm) because most jacks pass freely through the weir pickets and are not as accessible for sampling. In previous years, we have been unable to mark and recover enough fish to obtain a valid population estimate for jack sockeye salmon.

Weekly surveys were conducted at Buschmann and Cobb creeks beginning statistical week 34 (generally the third week of August), to sample spawners for marks. Live fish were captured and examined for marks using a beach seine off the creek mouth or dip nets in the spawning channels. All carcasses found on stream surveys, floating in the lake, or that washed up on the weir were also examined for marks. Each fish examined was recorded by the appropriate mark (right ventral, left ventral, or dorsal fin clip) or as unmarked (no fin-clip). Each examined fish was given a secondary mark (a left operculum hole punch for live fish or removal of the entire tail for dead fish) to prevent double sampling on subsequent sampling events. Our goal was to examine at least 600 sockeye salmon over the entire spawning season. A sample size of 600 fish in the second sampling event should yield a population estimate with a coefficient of variation less than 15%, when a population of nearly 5,000 is marked at a rate of 10% (Robson and Regier 1964).

We used Stratified Population Analysis System (SPAS) software (Arnason et al. 1996) to generate mark-recapture estimates of the total spawning population of sockeye salmon. SPAS was designed for analysis of two-sample mark-recapture data where marks and recoveries take place over a number of strata. This program was based on work by Chapman and Junge (1956), Darroch (1961), Seber (1982), and Plante (1990). We used this software to calculate: 1) maximum likelihood (ML) Darroch estimates and pooled-Petersen (Chapman's modified) estimates, and their standard errors; 2) χ^2 tests for goodness-of-fit based on the deviation of predicted values (fitted by the ML Darroch estimate) from the observed values; and 3) two χ^2 tests of the validity of using fully pooled data—a test of complete mixing of marked fish between release and recovery strata, and a test of equal proportions of marked fish in the recovery strata. We chose full pooling of the data (i.e., the pooled-Petersen estimate) if the result of either of these tests was not significant (P>0.05). Our goal was to estimate the escapement such that the coefficient of variation was no greater than 15% of the point estimate. The manipulation of release and recovery strata in calculating estimates (the method used in SPAS) was presented and discussed at length by Schwarz and Taylor (1998).

The weir count was deemed “verified” and entered as the official escapement estimate if it fell within the 95% confidence interval of the mark-recapture estimate for adult sockeye salmon. This was the same criterion used in previous years (Geiger et al. 2003). The escapement goal was judged to have been met if the weir count fell within the escapement goal range and within the 95% confidence interval of the mark-recapture estimate for adult sockeye salmon. If both the weir count and the mark-recapture estimate were below the lower bound of the escapement goal range, the escapement goal would be deemed to have not been met. In the case where one or the other estimate fell within the escapement goal range, the weir count would be used, unless the weir count was below the lower bound of the 95% confidence interval of the mark-recapture estimate. Prior to the study we agreed to use the mark-recapture “point” estimate, and not one or the other end of a confidence interval, for the purpose of judging the escapement objective.

Adult Length, Sex, and Scale Sampling

The age composition of adult sockeye salmon at Hugh Smith Lake was determined from a minimum of 600 scale samples collected from live fish at the weir. This sample size was selected based on work by Thompson (1992) for calculating a sample size to estimate several proportions simultaneously. A sample size of 510 fish was needed to ensure the estimated proportion of each adult sockeye salmon age class would be within 5% of the true value 95% of the time. We increased our scale sampling goal to 600 samples to guarantee the sample size target would be met, even if 15% of the scales were unreadable. We began by collecting scale samples from 1 out of every 20 fish (5%) and adjusted the sampling rate based on inseason escapement projections. Length from mideye to tail fork and sex was recorded for each fish sampled. Fish shorter than 400 mm were not included in the adult sockeye salmon age composition sample and were counted as jacks. Three scales were collected from the preferred area (i.e., the left side of the fish, two scale rows above the lateral line on the diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin; INPFC 1963), placed on a gum card, and prepared for analysis as described by Clutter and Whitesel (1956). Scales were analyzed in the fall at the ADF&G salmon-aging laboratory in Douglas, Alaska. The weekly age distribution, seasonal age distribution weighted by week, and the mean length by age and sex weighted by week were calculated using equations from Cochran (1977; Appendix A).

STREAM COUNTS

The number of live and dead salmon was estimated, by species, during each survey of Buschmann and Cobb creeks. Cobb Creek was surveyed from the mouth to the barrier falls (0.8 km; 55° 05.35 N, 130° 38.673 W). Buschmann Creek was typically surveyed to the top of the Hatchery Channel on the right fork, and to the beaver ponds on the left fork (Figure 3). We attempted to survey all of Buschmann Creek’s stream channels at least twice each week near the peak of the run.

What we have generally referred to as Buschmann Creek actually consists of two separate creeks, draining two separate valleys, which meet in their lower reaches. The stream flowing from the southeast valley is Buschmann Creek and the tributary flowing out of the northeast valley that meets Buschmann Creek, at what we call the Main Fork, is referred to as the “Beaver Pond Channel” (Figure 3). The Beaver Pond Channel was named for the beaver dams and ponds along its length.

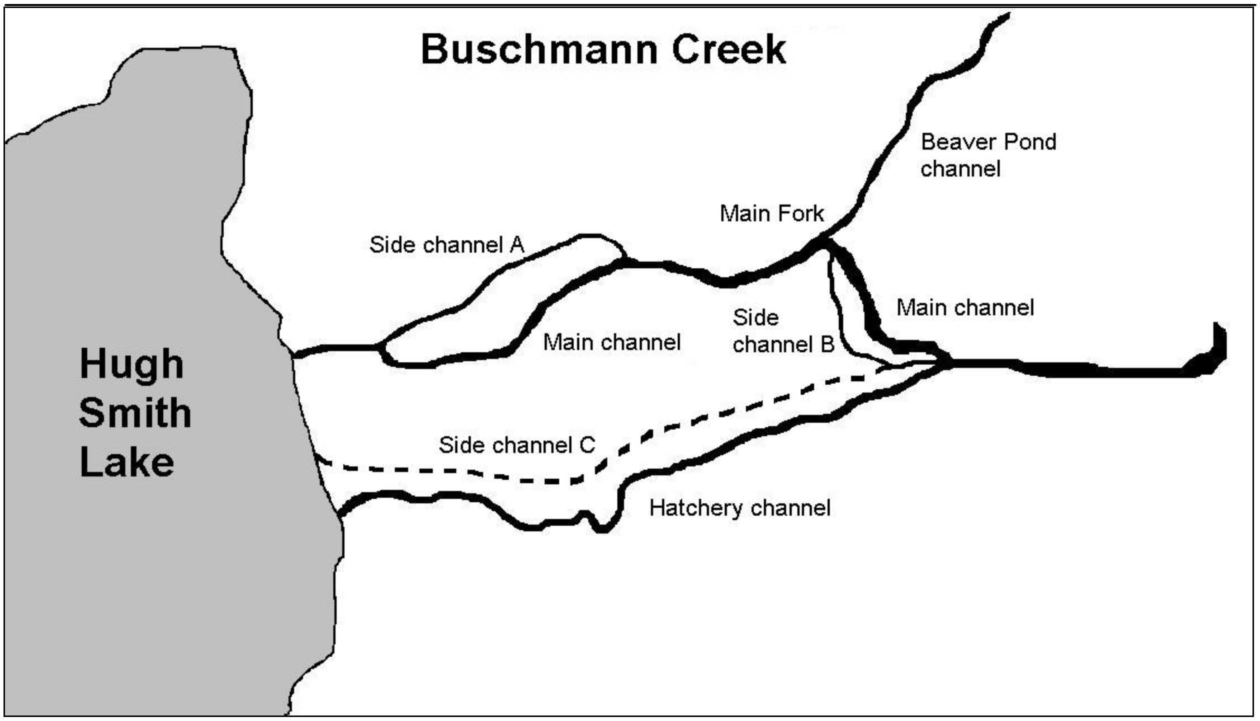

Figure 3.–Schematic diagram of the main channels of lower Buschmann Creek, as of September, 2012. Dashed lines indicate channels that were accessible in the past but are now either blocked by beaver dams or did not have adequate water flow to accommodate spawning salmon in 2012.

RESULTS

SMOLT EMIGRATION

An estimated 179,000 sockeye salmon smolt were counted through the smolt weir between 22 April and 3 June (Table 1; Figure 4). Emigration began the first week of May; however, snow melt from the mountains and several days of heavy rainfall increased the lake level such that the weir was breeched from 7 to 9 May. The crew passed more than 10,000 sockeye salmon smolt through the weir on 9 May so it is likely that thousands more passed the weir uncounted during the previous days' flood. Smolt passage peaked during the second and third weeks of May with more than 55,000 sockeye salmon smolt passing the weir on 13 May. Fish passage declined to low levels during the first week of June when the smolt weir was removed.

We sampled 891 sockeye salmon smolt for scales and determined the freshwater age composition, weighted by week, to be 72% age 1 and 28% age 2 (Figure 5; Table 1). The mean lengths by age class were 68 mm (age 1) and 93 mm (age 2) and the mean weights were 2.5 g (age 1) and 6.3 g (age 2; Table 2). Only two samples were identified as age 3 fish, less than 0.5% of the total.

Table 1.–Hugh Smith Lake weir counts of sockeye salmon smolt by smolt year, and stocked fry and pre-smolt releases by release year, 1981–2012. Proportions of stocked smolt were determined from otolith samples.

Release Year	Hatchery Release Numbers	Release Type	Smolt Year	Total Smolt Counted	Freshwater Age Percent of Total Age 1	Age 2	Age 3	Wild Smolt	Stocked Smolt	Percent Stocked
1980	-	-	1981	319,000	71%	29%	0%	319,000	-	-
1981	-	-	1982	90,000	83%	18%	0%	90,000	-	-
1982	-	-	1983	77,000	60%	40%	0%	77,000	-	-
1983	-	-	1984	330,000	92%	8%	0%	330,000	-	-
1984	-	-	1985	40,000	51%	48%	1%	40,000	-	-
1985	-	-	1986	58,000	73%	24%	3%	58,000	-	-
1986	273,000	Unfed Fry	1987	105,000	42%	57%	1%	-------	No data	-------
1987	250,000	Unfed Fry	1988	54,000	65%	35%	0%	-------	No data	-------
1988	1,206,000	Unfed Fry	1989	427,000	83%	17%	0%	-------	No data	-------
1989	532,800	Unfed Fry	1990	137,000	31%	68%	2%	-------	No data	-------
1990	1,480,800	Unfed Fry	1991	75,000	64%	36%	0%	-------	No data	-------
1991	-	-	1992	15,000	42%	57%	1%	-------	No data	-------
1992	477,500	Fed Fry	1993	36,000	63%	36%	2%	-------	No data	-------
1993	-	-	1994	43,000	75%	21%	4%	-------	No data	-------
1994	645,000	Unfed Fry	1995	19,000	38%	62%	0%	-------	No data	-------
1995	418,000	Unfed Fry	1996	16,000	44%	40%	16%	-------	No data	-------
1996	358,000	Unfed Fry/ Pre-Smolt[a]	1997	44,000	52%	40%	8%	26,000	18,000	40%
1997	573,000	Unfed Fry[a]	1998	65,000 [b]	81%	18%	1%	34,000	30,000	47%
1998	-	-	1999	42,000	68%	32%	0%	39,000	3,000	4%
1999	202,000	Pre-smolt[c]	2000	72,000	77%	22%	1%	-------	No data	-------
2000	380,000	Pre-smolt[c]	2001	189,000	91%	8%	1%	44,000	145,000	77%
2001	445,000	Pre-smolt[c]	2002	297,000	88%	12%	0%	134,000	163,000	55%
2002	465,000	Pre-smolt[c]	2003	261,000	86%	14%	0%	76,000	185,000	71%
2003	420,000	Pre-smolt[c]	2004	364,000	88%	12%	0%	194,000	170,000	47%
2004	-	-	2005	77,000	54%	46%	0%	77,000	-	-
2005	-	-	2006	119,000	63%	36%	1%	119,000	-	-
2006	-	-	2007	89,000	71%	27%	2%	89,000	-	-
2007	-	-	2008	59,000	62%	37%	1%	59,000	-	-
2008	-	-	2009	116,000	40%	59%	1%	116,000	-	-
2009	-	-	2010	64,000	19%	79%	2%	64,000	-	-
2010	-	-	2011	244,000	89%	10%	1%	244,000	-	-
2011	-	-	2012	179,000	72%	28%	0%	179,000	-	-

[a] In 1996, Southern Southeast Regional Aquaculture Association released 251,123 unfed fry into the lake in May and 106,833 pre-smolt in October. All fish released in 1996 and 1997 were otolith marked.

[b] In 1998, the total smolt count does not equal the sum of wild and stocked smolt due to rounding.

[c] From 1999 to 2003, fry were pen-reared at the outlet of the lake beginning in late May and released as pre-smolt in late July and early August. All fish from those releases were otolith marked.

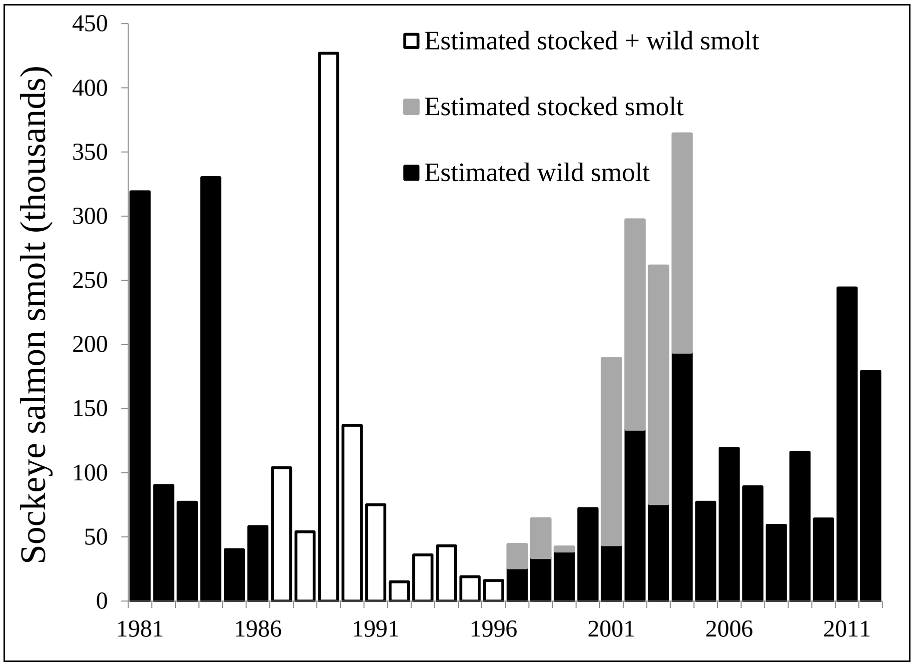

Figure 4.–Annual smolt weir counts at Hugh Smith Lake, 1981–2012. Divided bars show estimates of wild (black) and stocked (grey) smolt for years in which proportions of stocked smolt were estimated from otoliths collected at the weir (1997–1999 and 2001–2004). Stocked fish released prior to 1996 were unmarked.

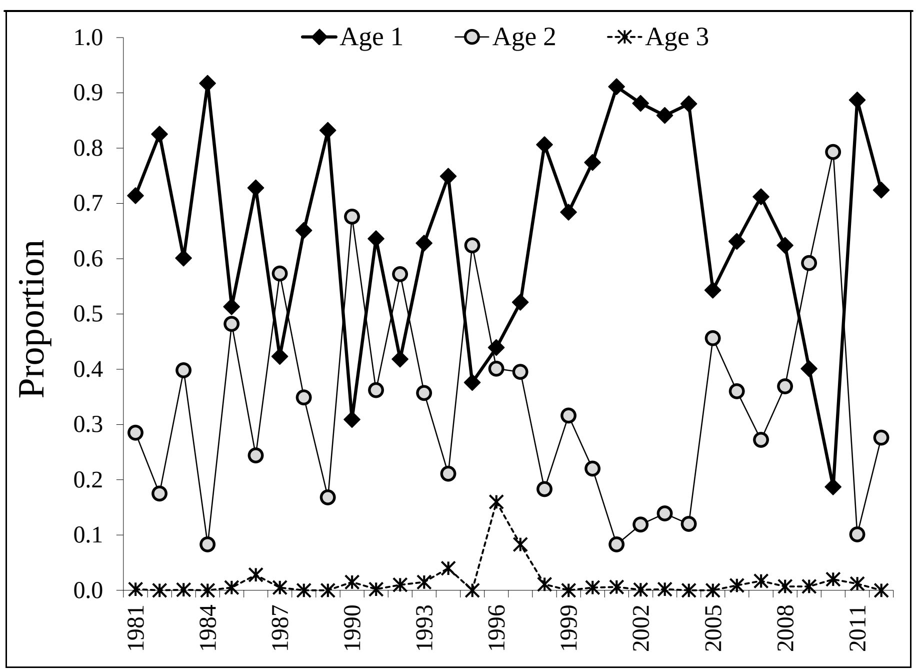

Figure 5.–Age composition of sockeye salmon smolt at Hugh Smith Lake, 1981–2012.

Table 2.–Lengths and weights of sockeye salmon smolt by freshwater age, weighted by week, 2012.

	Freshwater Age		
	1	2	3
Number sampled	619	269	2
Mean Length (mm)	68	93	99
Standard Error (mm)	0.3	0.5	5.0
Maximum Length (mm)	91	118	106
Minimum Length (mm)	54	72	91
Number sampled	620	269	2
Mean Weight (g)	2.5	6.3	7.3
Standard Error (g)	0.0	0.1	1.1
Maximum Weight (g)	8.0	16.4	9.0
Minimum Weight (g)	1.2	3.0	5.6

ADULT ESCAPEMENT

Weir and Stream Counts

The adult weir was operated from 16 June to 10 November and during that time 13,353 adult sockeye salmon and 46 jacks were counted through the weir into the lake (Appendix B). The optimal escapement goal range of 8,000–18,000 sockeye salmon was met exclusively with wild fish for the seventh time in the past eight years (Figure 6). The midpoint of the run occurred on 22 July and the 75th percentile occurred on 1 August. No handling mortalities were observed at the weir in 2012. Peak counts of live sockeye salmon were observed in the spawning tributaries on 11 September at Buschmann Creek (1,582 fish; Table 3) and on 18 September at Cobb Creek (294 fish; Table 4).

Table 3.–Mouth and stream counts of adult sockeye salmon in Buschmann Creek by section, 2012.

Date	Condition	Mouth[a]	Main Channel	Beaver Pond Channel	Hatchery Channel	Side Channel A	Side Channel B	Stream Total
25-Aug	Live	100	2	ND[b]	ND	7	ND	9
	Dead	0	0	ND	ND	0	ND	0
30-Aug	Live	400	790	ND	7	270	60	1,127
	Dead	0	108	ND	11	1	20	140
11-Sep	Live	ND	1,266	ND	0	256	60	1,582
	Dead	ND	67	ND	0	13	0	80
19-Sep	Live	1,200	305	152	ND	361	ND	818
	Dead	3	56	28	ND	59	ND	143
20-Sep	Live	1,500	884	ND	ND	ND	46	930
	Dead	1	83	ND	ND	ND	2	85
28-Sep	Live	50	1,161	ND	ND	227	156	1,544
	Dead	0	62	ND	ND	20	2	84
4-Oct	Live	ND	539	ND	ND	103	23	665
	Dead	ND	32	ND	ND	5	5	42

[a] Mouth counts are difficult to estimate and are not included in the stream total.

[b] ND = no data; section not surveyed.

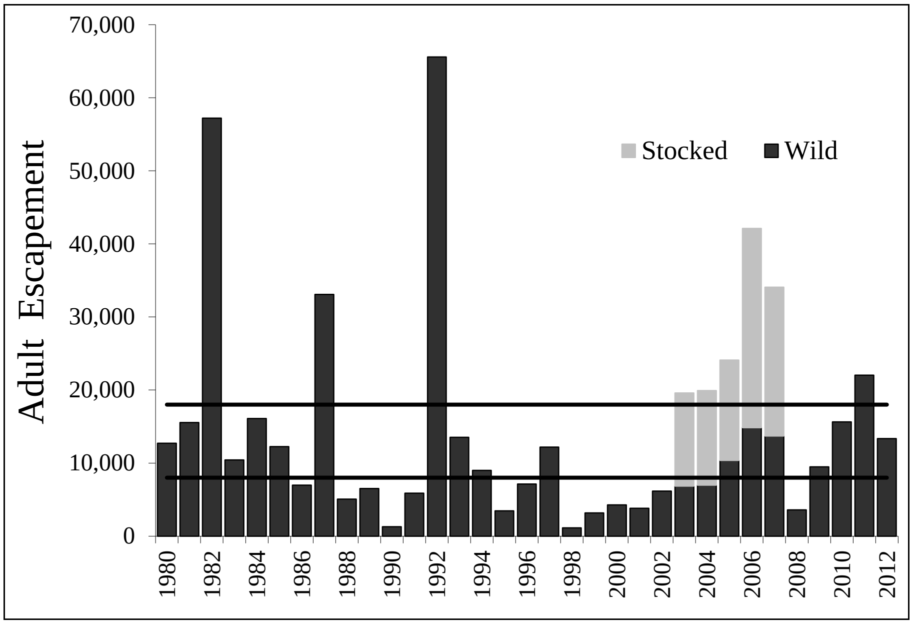

Figure 6.–Annual sockeye salmon escapement at Hugh Smith Lake, 1980–2012. Black horizontal lines indicate the current optimal escapement goal range of 8,000–18,000 adult sockeye salmon, which includes both wild and hatchery stocked fish. From 2003 to 2007, the bars are divided to show our estimate of wild (black) and stocked fish (grey) in the escapement. Fry stocked from 1986 to 1997 were thought to have experienced very low survival rates with few surviving to emigrate from the lake (Geiger et al. 2003). Contribution estimates of wild and stocked fish are not available for years prior to 2003.

Table 4.–Mouth and stream counts of adult sockeye salmon in Cobb Creek, 2012.

Date	Condition	Mouth	Stream Count
25-Aug	Live	90	0
	Dead	0	0
4-Sep	Live	ND[a]	238
	Dead	ND	1
18-Sep	Live	ND	294
	Dead	ND	57
20-Sep	Live	200	ND
	Dead	0	ND
25-Sep	Live	0	109
	Dead	0	66

[a] ND = no data; section not surveyed.

Mark-Recapture

A total of 1,335 adult sockeye salmon were marked at the weir over three marking strata: 605 were marked with a right ventral fin clip (18 June–18 July), 663 were marked with a left ventral fin clip (19 July–15 August), and 67 were marked with a partial dorsal fin clip (16 August–27 September). Recapture sampling was conducted on the spawning grounds from 30 August to 28 September. All sockeye salmon carcasses that washed up on the weir were also inspected for marks through 10 November. A total of 2,199 fish were sampled for fin clips, of which 196 fish were marked (Table 5; Appendix C). The result of the χ^2 test for complete mixing of marked fish between the marking and recapture events was significant (P<0.01); however, the result of the χ^2 test for equal proportions of marked fish on the spawning grounds was not significant (P=0.84), therefore, the pooled-Petersen estimate was used. The 2012 mark-recapture estimate was 14,919 adult sockeye salmon (SE=934; 95% CI=13,088–16,750 fish; Appendix C). Since the weir count (13,353 fish) fell within the 95% confidence interval of the mark-recapture estimate, it was used as the official escapement estimate in accordance with our established methods. The 6% coefficient of variation satisfied our objective for a coefficient of variation less than 15%.

Table 5.–Daily number of fish inspected for marks by release stratum for the adult sockeye salmon mark-recapture study, 2012.

		Marked Fish				
Date	Sampling Area	Right Ventral	Left Ventral	Dorsal	Number Unmarked	Total Sampled
30-Aug	Buschmann Creek	33	3	0	414	450
4-Sep	Cobb Creek	1	0	0	11	12
4-Sep	Buschmann Creek	8	0	0	124	132
11-Sep	Buschmann Creek	19	13	0	303	335
18-Sep	Cobb Creek	10	4	0	104	118
19-Sep	Buschmann Creek	22	18	0	396	436
20-Sep	Buschmann Creek	18	12	0	314	344
25-Sep	Cobb Creek	4	3	0	92	99
28-Sep	Buschmann Creek	7	19	1	236	263
28-Sep	Weir	0	0	0	1	1
2-Oct	Weir	0	0	0	1	1
6-Oct	Weir	0	0	0	1	1
7-Oct	Weir	0	0	0	1	1
9-Oct	Weir	1	0	0	0	1
16-Oct	Weir	0	0	0	1	1
17-Oct	Weir	0	0	0	1	1
18-Oct	Weir	0	0	0	2	2
31-Oct	Weir	0	0	0	1	1
	Total	123	72	1	2,003	2,199

Adult Length, Sex, and Scale Sampling

Scale pattern analysis indicated 87% of the 2012 sockeye salmon escapement was 3-ocean fish, representing an estimated 11,500 sockeye salmon. The remaining 13%, or 1,700 sockeye salmon, were 2-ocean fish (Figures 7 and 8). The most abundant age group in 2012 was age-2.3 fish (57%), followed by age-1.3 fish (29%; Table 6). Of the 587 readable scale samples collected at the weir, two fish had spent three years in freshwater and three were identified as 4-ocean fish (Table 6).

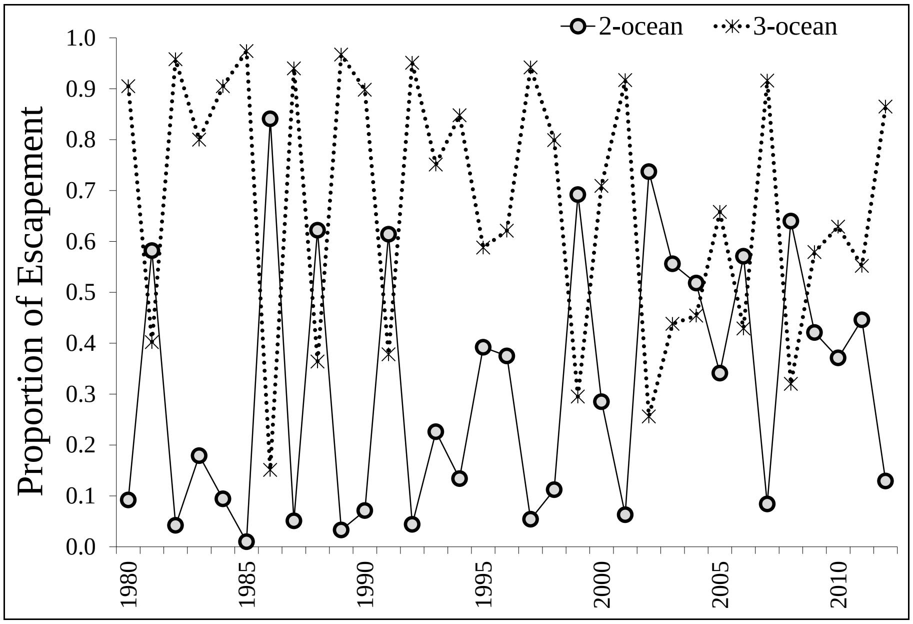

Figure 7.–Annual proportions of 2-ocean and 3-ocean aged sockeye salmon in the Hugh Smith Lake escapement, 1980–2012.

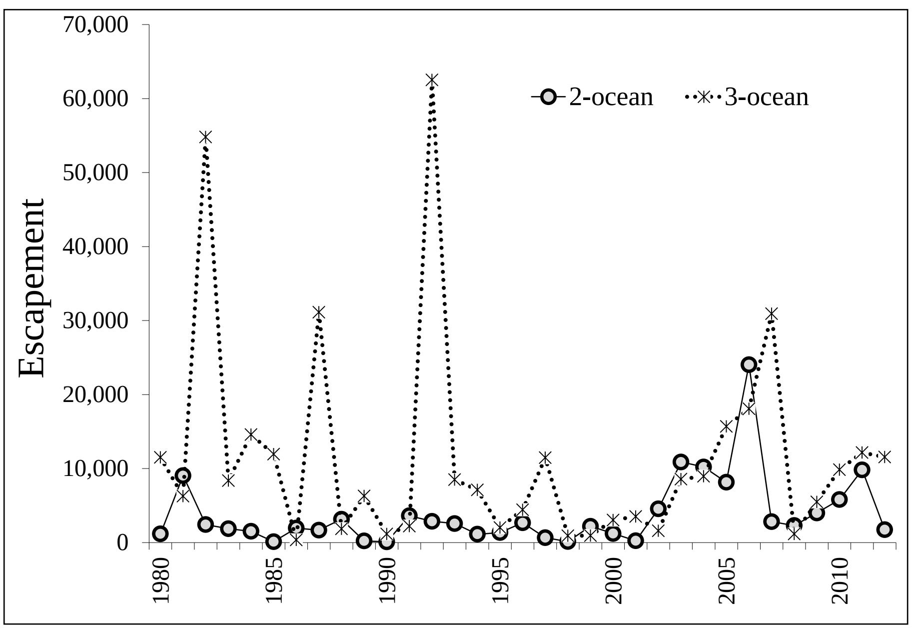

Figure 8.–Annual numbers of 2-ocean and 3-ocean aged sockeye salmon in the Hugh Smith Lake escapement, 1980–2012.

Table 6.–Age composition of the 2012 adult sockeye salmon escapement at Hugh Smith Lake based on scale samples, weighted by statistical week.

Stat		Age Class							
Week		1.2	2.2	3.2	1.3	2.3	1.4	2.4	Total
24–25	Sample Size		1		7	10			18
	Proportion		6%		39%	56%			
	Esc. Age Class		22		154	220			
	SE of %		5%		12%	12%			
26	Sample Size		1		19	19			39
	Proportion		3%		49%	49%			
	Esc. Age Class		22		410	410			
	SE of %		3%		8%	8%			
27	Sample Size				22	31			53
	Proportion				42%	58%			
	Esc. Age Class				457	644			
	SE of %				7%	7%			
28	Sample Size		4		37	87			128
	Proportion		3%		29%	68%			
	Esc. Age Class		90		831	1953			
	SE of %		2%		4%	4%			
29	Sample Size	1	6		20	24			51
	Proportion	2%	12%		39%	47%			
	Esc. Age Class	22	129		431	517			
	SE of %	2%	4%		7%	7%			
30	Sample Size	4	16		36	53			109
	Proportion	4%	15%		33%	49%			
	Esc. Age Class	90	360		809	1,191			
	SE of %	2%	3%		4%	5%			
31	Sample Size	4	16		22	60	2		104
	Proportion	4%	15%		21%	58%	2%		
	Esc. Age Class	100	399		549	1,497	50		
	SE of %	2%	3%		4%	5%	1%		
32	Sample Size	1	10	2	5	30		1	49
	Proportion	2%	20%	4%	10%	61%		2%	
	Esc. Age Class	22	217	43	108	651		22	
	SE of %	2%	6%	3%	4%	7%		2%	
33	Sample Size	2	2		4	8			16
	Proportion	13%	13%		25%	50%			
	Esc. Age Class	56	56		112	224			
	SE of %	8%	8%		11%	13%			
34	Sample Size	1			1	8			10
	Proportion	10%			10%	80%			
	Esc. Age Class	24			24	191			
	SE of %	10%			10%	13%			
35–44	Sample Size		3		2	5			10
	Proportion		30%		20%	50%			
	Esc. Age Class		75		50	125			
	SE of %		15%		13%	16%			
Total	Escapement by Age Class	313	1,369	43	3,934	7,622	50	22	13,353
	SE of Number	84	163	30	242	266	34	0	
	Proportion by Age Class	2%	10%	0%	30%	57%	0%	0%	
	SE of %	1%	1%	0%	2%	2%	0%	0%	
	Sample Size	13	59	2	175	335	2	1	587

DISCUSSION

The 2012 weir count of 13,353 adult sockeye salmon met the Hugh Smith Lake optimal escapement goal exclusively with wild fish for the seventh time in the past eight years (Figure 6). The optimal escapement goal, which included fish returning from the discontinued stocking program, has now been met in nine of the last ten years. Run timing at the weir was earlier in 2012 than the historical average. By the 30-year average midpoint date (5 August), over 85% of the total sockeye salmon escapement had already passed through the weir. In only four of the previous 30 years had the 25th or 50th percentiles of the run been reached earlier than in 2012 (Appendix B). Escapements in prior years with earlier run timing (1982, 1986, 2000, and 2009) ranged from 4,200 to 57,000 fish, and the 3-ocean component of those escapements varied considerably, from 15% to 96% (Appendix D). Although there has been considerable variation in run timing over the past three decades, no discernible long-term trends are apparent for the 25th, 50th, and 75th percentile dates of the escapement (Figure 9).

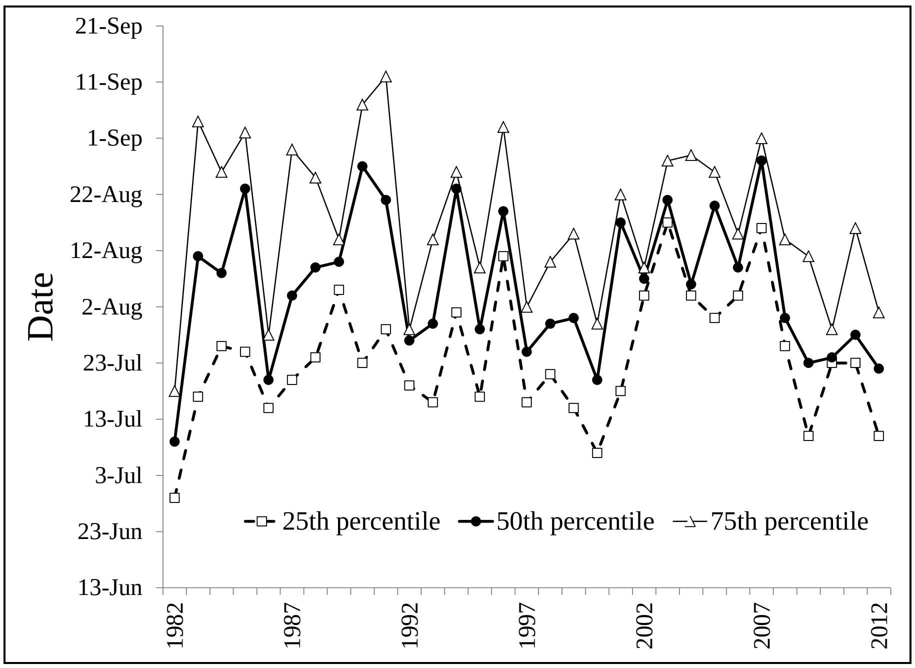

Figure 9.–Dates of the 25th, 50th, and 75th percentiles of the total escapement were reached, 1982–2012.

Following one of the largest recorded escapements of 2-ocean adults in 2011, the estimated number of 3-ocean fish in 2012 ranked in the top 25% for escapements of that age class in years without returns from the 1999–2003 pre-smolt stocking program. In particular, the estimated number of age-2.3 fish was the largest in the time series (7,600) and comprised the highest proportion of the total escapement for that age group (57%; Appendix D). Generally, age-2.3 sockeye salmon have averaged less than 1,500 fish and only 15% of the total escapement since 1980. Although a forecast based solely on the linear relationship of 2-ocean to 3-ocean fish shown by Brunette and Piston (2012) would have predicted a much larger return of 3-ocean fish in 2012 than actually occurred, the simple model did provide a pre-season indication of an above average escapement of 3-ocean fish. This simple tool (or other basic models) may provide useful information about potential returns in the absence of detailed harvest information from which to create estimates of total return for use in more rigorous forecast models. Excluding years without returns from the 1999 to 2003 pre-smolt stocking program, the five largest escapements of 2-ocean fish since 1980 were all followed by escapements of 3-ocean fish in excess of 8,000.

The 2012 sockeye salmon smolt estimate of 179,000 fish was one of only five annual estimates to exceed 150,000 wild smolt in the last 32 years and followed the large 2011 count of 244,000 smolt (Table 1; Figure 4). Average weir counts for wild smolt over the past decade (122,000) have nearly tripled the average total smolt count from 1991 to 2000 (43,000; Table 1). Although smolt weir counts have increased considerably since the 1990s, the typically dominant 3-ocean component of the 2013 adult sockeye salmon return will be the product of a low smolt count of 64,000 in 2010. The 2010 smolt emigration was weak primarily due to the low numbers of freshwater age-1 fish originating from the poor 2008 adult escapement of 3,590 (Appendix B). An above average return of 2-ocean fish from the large 2011 smolt emigration may be necessary to meet escapement objectives in 2013.

Although no longer a stock of concern, ADF&G may manage the District 101 fisheries in a manner consistent with the Hugh Smith Lake Sockeye Salmon Action Plan if conditions warrant. For the fourth consecutive year, no fishing restrictions were necessary in the District 101-23 purse seine or District 101-11 gillnet fisheries in the vicinity of Boca de Quadra, because inseason escapement projections for the Hugh Smith Lake run were consistently above the lower bound of the escapement goal all season. Participation in both of these fisheries has declined over the past two decades, effectively reducing sockeye salmon harvests and minimizing commercial exploitation of Hugh Smith Lake stock. Harvests of sockeye salmon in the District 101-23 purse seine fishery have been very low over the last 10 years (2002–2011), averaging only 25% of the 20-year average of 18,000 fish (1980–1999). The 2012 sockeye salmon harvest in this fishery was the sixth lowest since 1980 (Figure 10). Similarly, the District 101-11 sockeye harvest was the second lowest since 1980, comparable to the harvest during the extremely poor sockeye salmon runs of 2008 (Heinl et al. 2011; Figure 11).

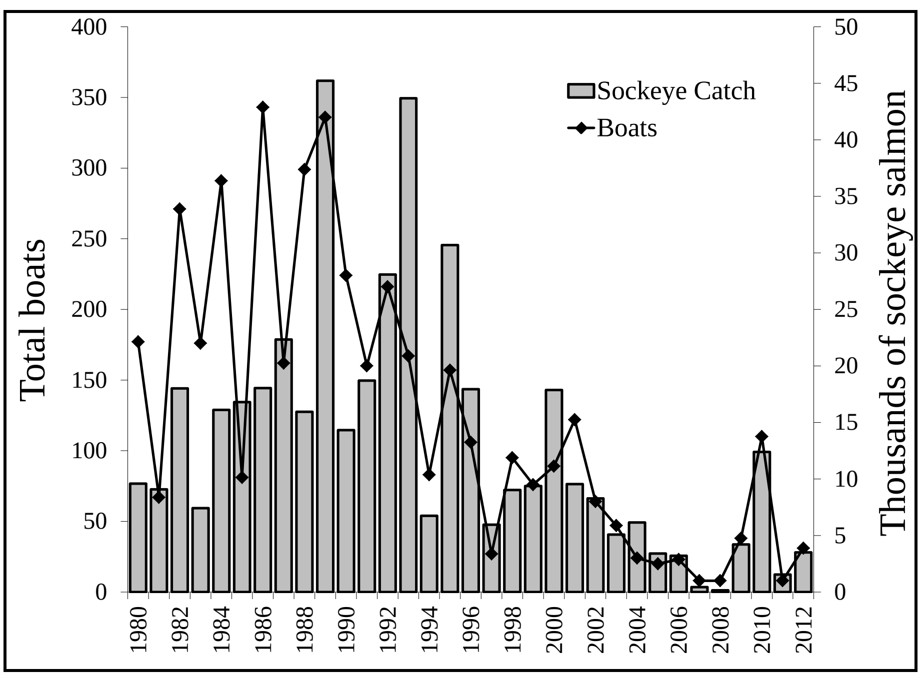

Figure 10.–Fishing effort in number of boats and sockeye salmon catch in District 101-23 purse seine fishery, 1980–2012.

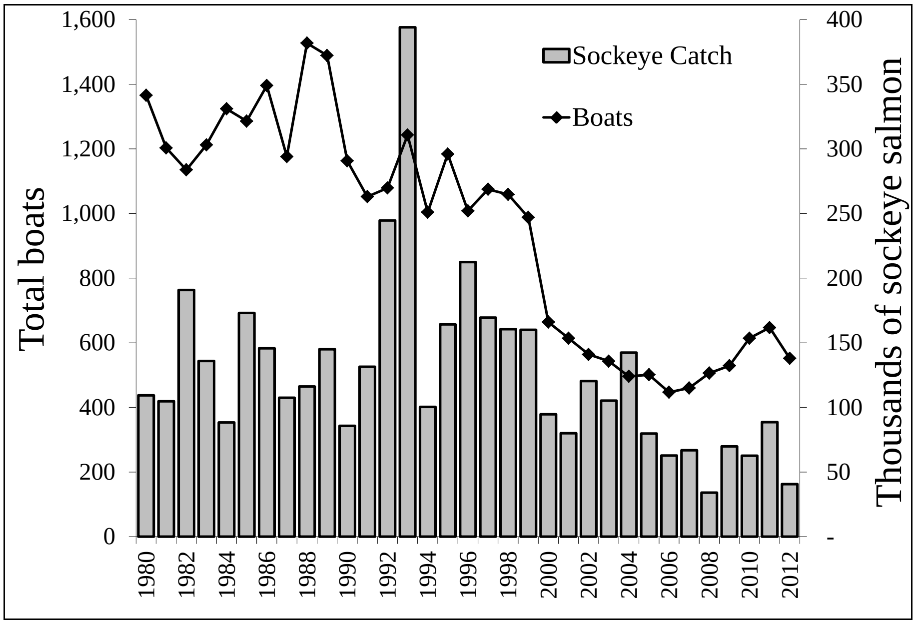

Figure 11.–Fishing effort in number of boats and sockeye salmon catch in the District 101-11 drift gillnet fishery, 1980–2012.

ACKNOWLEDGEMENTS

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APPENDICES

The weekly age-sex distribution, the seasonal age-sex distribution weighted by week, and the mean length by age and sex weighted by week, for smolt and adults, were calculated using equations from Cochran (1977; pages 52, 107–108, and 142–144).

Let

h	=	index of the stratum (week),
j	=	index of the age class,
p_{hj}	=	proportion of the sample taken during stratum h that is age j,
n_h	=	number of fish sampled in week h, and
n_{hj}	=	number observed in class j, week h.

Then the age distribution was estimated for each week of the escapement in the usual manner:

$$\hat{p}_{hj} = n_{hj} / n_h \ . \qquad (1)$$

If N_h equals the number of fish in the escapement in week h, standard errors of the weekly age class proportions are calculated in the usual manner (Cochran 1977, page 52, equation 3.12):

$$SE(\hat{p}_{hj}) = \sqrt{\left[\frac{(\hat{p}_{hj})(1-\hat{p}_{hj})}{n_h - 1}\right][1 - n_h / N_h]} \ . \qquad (2)$$

The age distributions for the total escapement were estimated as a weighted sum (by stratum size) of the weekly proportions. That is,

$$\hat{p}_j = \sum_h p_{hj} (N_h / N), \qquad (3)$$

such that N equals the total escapement. The standard error of a seasonal proportion is the square root of the weighted sum of the weekly variances (Cochran 1977, pages 107–108):

$$SE(\hat{p}_j) = \sqrt{\sum_j^h [SE(\hat{p}_{hj})]^2 (N_h / N)^2} \ . \qquad (4)$$

The mean length, by sex and age class (weighted by week of escapement), and the variance of the weighted mean length, were calculated using the following equations from Cochran (1977, pages 142–144) for estimating means over subpopulations. That is, let i equal the index of the individual fish in the age-sex class j, and y_{hij} equal the length of the ith fish in class j, week h, so that,

$$\hat{\bar{Y}}_j = \frac{\sum_h (N_h / n_h) \sum_i y_{hij}}{\sum_h (N_h / n_h) n_{hj}} \text{, and} \qquad (5)$$

$$\hat{V}\left(\hat{\bar{Y}}_j\right) = \frac{1}{\hat{N}_j^2} \sum_h \frac{N_h^2 (1 - n_h / N_h)}{n_h (n_h - 1)} \left[\sum_i \left(y_{hij} - \bar{y}_{hj}\right)^2 + n_{hj} \left(1 - \frac{n_{hj}}{n_h}\right) \left(\bar{y}_{hj} - \hat{\bar{Y}}_j\right)^2 \right].$$

Appendix B.–Escapement and run timing for Hugh Smith Lake sockeye salmon, 1967–2012.

Year	1967	1968	1969	1970	1971	1980	1981	1982	1983	1984	1985	1986	1987
Weir Count	6,754	1,617	10,357	8,755	22,096	12,714	15,545	57,219	10,429	16,106	12,245	2,312	33,097
Total Escapement[a]	ND[b]	ND	ND	ND	ND	12,714	ND	57,219	10,429	16,106	12,245	6,968[c]	33,097
Wild fish	6,754	1,617	10,357	8,755	22,096	12,714	15,545	57,219	10,429	16,106	12,245	6,968	33,097
Stocked fish	0	0	0	0	0	0	0	0	0	0	0	0	0
Weir Mortalities	ND	ND	ND	ND	ND	ND	ND	81	45	134	201	12	0
Adults used for egg takes	0	0	0	0	0	0	0	0	0	439	798	619	1,902
Spawning Escapement[d]	ND	ND	ND	ND	ND	ND	ND	57,138	10,384	15,533	11,246	6,337	31,195
Jacks (not included in weir count)[e]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Starting Date	1-Jun	13-Jun	11-Jun	9-Jun	20-Jun	5-Jun	7-Jun	4-Jun	30-May	1-Jun	1-Jun	17-Jun	3-Jun
Ending Date	3-Sep	21-Aug	14-Aug	1-Sep	22-Aug	4-Oct	8-Sep	27-Nov	30-Nov	26-Nov	11-Nov	29-Oct	21-Oct
Days Elapsed	94	69	64	84	63	121	93	176	184	178	163	134	140
Date of First Sockeye	13-Jun	14-Jun	11-Jun	11-Jun	20-Jun	6-Jun	8-Jun	7-Jun	1-Jun	6-Jun	5-Jun	18-Jun	8-Jun
Date of Last Sockeye	3-Sep	21-Aug	14-Aug	1-Sep	22-Aug	4-Oct	8-Sep	25-Oct	25-Oct	19-Nov	29-Oct	3-Oct	4-Oct
Days Elapsed for sockeye caught	82	68	64	82	63	120	92	140	146	166	146	107	118
10th Percentile Run Date	22-Jun	2-Jul	26-Jun	26-Jun	1-Jul	4-Jul	28-Jun	20-Jun	11-Jul	14-Jul	12-Jul	11-Jul	18-Jul
25th Percentile Run Date	28-Jun	11-Jul	9-Jul	6-Jul	9-Jul	20-Jul	7-Jul	29-Jun	17-Jul	26-Jul	25-Jul	15-Jul	20-Jul
50th Percentile Run Date	7-Jul	15-Aug	20-Jul	27-Jul	20-Jul	6-Aug	27-Jul	9-Jul	11-Aug	8-Aug	23-Aug	20-Jul	4-Aug
75th Percentile Run Date	18-Jul	19-Aug	7-Aug	6-Aug	19-Aug	26-Aug	24-Aug	18-Jul	4-Sep	26-Aug	2-Sep	28-Jul	30-Aug
90th Percentile Run Date	28-Jul	21-Aug	9-Aug	13-Aug	20-Aug	9-Sep	3-Sep	7-Aug	24-Sep	10-Sep	13-Sep	8-Aug	31-Aug

-continued-

Appendix B.–Page 2 of 3.

Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Weir Count	5,056	6,513	1,285	5,885	65,737	11,312	8,386	3,424	7,123	12,182	1,138	3,174	4,281
Total Escapement[a]	5,056	6,513	1,285	5,885	65,737	13,532	8,992	3,452	7,123	12,182	1,138	3,174	4,281
Wild fish[b]	5,056	ND[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND[c]
Stocked fish[b]	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Weir Mortalities	28	32	28	33	151	278	42	11	57	28	23	20	12
Adults used for egg takes	424	1,547	0	357	178	1,460	763	312	513	0	218	276	280
Spawning Escapement[d]	4,604	4,934	1,257	5,495	65,408	11,794	8,187	3,129	6,553	12,154	897	2,878	3,989
Jacks (not included in weir count)[e]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Starting Date	5-Jun	3-Jun	8-Jun	17-Jun	16-Jun	17-Jun	20-Jun	17-Jun	17-Jun	18-Jun	17-Jun	16-Jun	17-Jun
Ending Date	22-Oct	25-Oct	31-Oct	9-Oct	25-Oct	4-Nov	1-Nov	3-Nov	4-Nov	5-Nov	11-Nov	8-Nov	11-Nov
Days Elapsed	139	144	145	114	131	140	134	139	140	140	147	145	147
Date of First Sockeye	12-Jun	11-Jun	13-Jun	19-Jun	16-Jun	20-Jun	20-Jun	19-Jun	20-Jun	18-Jun	19-Jun	22-Jun	19-Jun
Date of Last Sockeye	16-Oct	18-Oct	21-Oct	11-Oct	18-Oct	3-Nov	26-Oct	1-Nov	20-Oct	1-Nov	12-Oct	4-Oct	27-Oct
Days Elapsed for sockeye caught	126	129	130	114	124	136	128	135	122	136	115	104	130
10th Percentile Run Date	19-Jul	30-Jul	8-Jul	22-Jul	12-Jul	2-Jul	20-Jul	7-Jul	25-Jul	3-Jul	8-Jul	7-Jul	29-Jun
25th Percentile Run Date	24-Jul	5-Aug	23-Jul	29-Jul	19-Jul	16-Jul	1-Aug	17-Jul	11-Aug	16-Jul	21-Jul	15-Jul	7-Jul
50th Percentile Run Date	9-Aug	10-Aug	27-Aug	21-Aug	27-Jul	30-Jul	23-Aug	29-Jul	19-Aug	25-Jul	30-Jul	31-Jul	20-Jul
75th Percentile Run Date	25-Aug	14-Aug	7-Sep	12-Sep	29-Jul	14-Aug	26-Aug	9-Aug	3-Sep	2-Aug	10-Aug	15-Aug	30-Jul
90th Percentile Run Date	1-Sep	22-Aug	16-Sep	22-Sep	11-Aug	31-Aug	3-Sep	21-Aug	13-Sep	15-Aug	18-Aug	22-Aug	6-Aug

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Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Weir Count	3,665	6,166	19,588	19,930	24,108	42,529	34,077	3,590	9,483	15,646	22,029	13,353
Total Escapement[a]	3,825	6,166	19,588	19,930	24,108	42,529	34,077	3,590	9,483	15,646	22,029	13,353
Wild fish[b]	ND	ND	6,856	6,976	10,366	14,993	13,713	3,590	9,483	15,646	22,029	13,353
Stocked fish[b]	ND	ND	12,732	12,955	13,742	27,537	20,364	0	0	0	0	0
Weir Mortalities	6	0	20	196	236	417	334	2	0	0	0	0
Adults used for egg takes	268	286	0	0	0	0	0	0	0	0	0	0
Spawning Escapement[b]	3,551	5,880	19,568	19,734	23,872	42,112	33,743	3,588	9,483	15,646	22,029	13,353
Jacks (not included in weir count)	ND	167	1,356	147	331	4	236	260	301	158	46	46
Starting Date	16-Jun	17-Jun	17-Jun	17-Jun	17-Jun	17-Jun	17-Jun	17-Jun	16-Jun	16-Jun	17-Jun	16-Jun
Ending Date	11-Nov	4-Nov	7-Nov	7-Nov	4-Nov	7-Nov	4-Nov	3-Nov	8-Nov	8-Nov	11-Nov	10-Nov
Days Elapsed	148	140	146	142	143	143	140	139	145	146	147	147
Date of First Sockeye	19-Jun	19-Jun	19-Jun	18-Jun	19-Jun	19-Jun	18-Jun	19-Jun	18-Jun	18-Jun	19-Jun	18-Jun
Date of Last Sockeye	6-Oct	17-Oct	2-Nov	31-Oct	22-Oct	3-Nov	26-Oct	28-Oct	5-Oct	4-Oct	8-Nov	1-Nov
Days Elapsed for sockeye caught	109	120	136	135	125	137	130	131	110	110	142	137
10th Percentile Run Date	2-Jul	10-Jul	2-Aug	8-Jul	17-Jul	1-Aug	19-Jul	16-Jul	4-Jul	5-Jul	11-Jul	1-Jul
25th Percentile Run Date	18-Jul	4-Aug	17-Aug	4-Aug	31-Jul	4-Aug	16-Aug	26-Jul	10-Jul	23-Jul	23-Jul	10-Jul
50th Percentile Run Date	17-Aug	7-Aug	21-Aug	6-Aug	20-Aug	9-Aug	28-Aug	31-Jul	23-Jul	24-Jul	28-Jul	22-Jul
75th Percentile Run Date	22-Aug	9-Aug	28-Aug	29-Aug	26-Aug	15-Aug	1-Sep	14-Aug	11-Aug	29-Jul	16-Aug	1-Aug
90th Percentile Run Date	23-Aug	12-Aug	2-Sep	2-Sep	3-Sep	26-Aug	7-Sep	24-Aug	13-Aug	11-Aug	19-Aug	8-Aug

[a] The total escapement equals the weir count or mark-recapture estimate (2001) plus weir mortalities.

[b] Escapements were not separated into numbers of wild and stocked fish from 2000 to 2002.

[c] ND = no data.

[d] The spawning escapement equals the total estimated escapement minus weir mortalities, samples (otolith samples), and fish killed for egg takes.

[e] Separate counts of jacks were not kept from 1967 to 2002, so those weir counts include an unknown number of jacks.

Appendix C.–Mark-recapture estimates for Hugh Smith Lake sockeye salmon, 1992–2012.

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Live Weir Count[a]	**65,586**[b]	11,034	8,344	3,413	**7,066**	**12,154**	**1,115**	**3,154**	**4,269**	3,629	**5,999**[b]
Proportion Marked	36%	99%	97%	100%	99%	67%	67%	67%	67%	50%	50%
Number Marked	23,790	10,973	8,126	3,396	6,995	8,100	745	2,103	2,846	1,807	2,999
Number Sampled for Marks	1,974	2,377	1,152	1,028	374	934	226	323	443	484	908
Number of Marks Recovered	814	2,029	1,041	1,006	369	638	157	221	299	230	449
Pooled Petersen Estimate[c,d]	57,652	12,854	8,992	3,470	7,090	11,853	1,071	3,070	4,213	**3,789**	6,059
se	1,520	99	81	13	41	253	42	109	131	168	187
+/-95% CI	2,979	194	159	25	80	496	82	214	257	329	367
CV	3%	1%	1%	0%	1%	2%	4%	4%	3%	4%	3%
ML Darroch Estimate[c]	Failed	**13,254**	Failed	Failed	Failed	12,312	1,015	3,038	4,050	–	Failed
se	–[e]	134	–	–	–	849	46	138	145	–	–
+/-95% CI	–	263	–	–	–	1,664	90	270	284	–	–
CV	–	1%	–	–	–	7%	5%	5%	4%	–	–
ML Darroch - Pooled Strata[f]	58,712	–	**8,925**	**3,441**	7,090	–	–	–	–	3,641	6,047
se	1,823	–	77	70	42	–	–	–	–	205	194
+/-95% CI	3,573	–	151	137	82	–	–	–	–	402	380
CV	3%	–	1%	2%	1%	–	–	–	–	6%	3%

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Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Live Weir Count[a]	**5,999**[b]	**19,568**	**19,734**	**23,872**	**42,112**	**33,743**	**3,588**	**9,483**	**15,646**	**22,029**	**13,353**
Proportion Marked	50%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Number Marked	2,999	1,945	1,979	2,278	4,208	3,414	358	949	1,565	2,202	1,335
Number Sampled for Marks	908	2,057	1,547	1,244	2,187	1,764	659	1,271	3,652	2,490	2,199
Number of Marks Recovered	449	194	136	115	229	176	50	123	339	242	196
Pooled Petersen Estimate [c,d]	6,059	20,537	22,372	24,459	40,039	34,053	4,645	9,744	16,824	22,582	14,919
se	187	1,324	1,754	2,098	2,423	2,357	573	772	768	1,295	934
+/-95% CI	367	2,595	3,438	4,112	4,749	4,621	1,123	1,513	1,505	2,539	1,831
CV	3%	6%	8%	9%	6%	7%	12%	8%	5%	6%	6%
ML Darroch Estimate[c]	Failed	19,147	21,950	–[e]	–	–	–	–	–	–	–
se	–	1,526	1,991	–	–	–	–	–	–	–	–
+/-95% CI	–	2,990	4,000	–	–	–	–	–	–	–	–
CV	–	8%	9%	–	–	–	–	–	–	–	–
ML Darroch - Pooled Strata[f]	6,047	–	–	–	–	–	–	–	–	–	–
se	194	–	–	–	–	–	–	–	–	–	–
+/-95% CI	380	–	–	–	–	–	–	–	–	–	–
CV	3%	–	–	–	–	–	–	–	–	–	–

[a] The weir count used for the mark-recapture calculations was the number of live fish passed through the weir (weir count minus weir mortalities).

[b] Boldfaced estimates were used as the official escapement estimate for that year.

[c] Pooled Petersen, and ML Darroch estimates and their standard errors were calculated using Stratified Population Analysis Software. Release data were stratified into three release periods and recovery data were stratified by recovery days.

[d] Chi-square tests for goodness of fit and complete mixing in 1993, 1994, and 1995 were highly significant and suggest that the ML Darroch estimates should be used rather than a Pooled Petersen estimate.

[e] Dashes (–) indicate no calculation was made.

[f] When ML Darroch estimates failed to converge, data were pooled until an estimate was obtained.

Appendix D.–Age distribution of the Hugh Smith Lake sockeye salmon escapement, weighted by week, 1980–2012.

		Age Class																
Return Year		0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	1.5	2.5	Total
1980	Number by Age Class		37				1,055	113			9,380	2,129						12,714
	SE of Number		21				139	33			200	156						
	Proportion by Age Class		0.3%				8.3%	0.9%			73.8%	16.7%						
	SE of Proportion		0.2%				1.1%	0.3%			1.6%	1.2%						
	Sample Size		3				72	12			719	175						981
1981	Number by Age Class		250				7,216	1,826			4,598	1,655						15,545
	SE of Number		55				208	126			204	119						
	Proportion by Age Class		1.6%				46.4%	11.7%			29.6%	10.6%						
	SE of Proportion		0.4%				1.3%	0.8%			1.3%	0.8%						
	Sample Size		19				502	149			338	137						1,145
1982	Number by Age Class						1,613	805		12	52,124	2,665						57,219
	SE of Number						155	115		11	205	118						
	Proportion by Age Class						2.8%	1.4%		0.0%	91.1%	4.7%						
	SE of Proportion						0.3%	0.2%		0.0%	0.4%	0.2%						
	Sample Size						174	122		1	2,305	407						3,009
1983	Number by Age Class		14	8			1,375	495		12	5,501	2,843		182				10,429
	SE of Number		14	7			98	62		8	169	157		38				
	Proportion by Age Class		0.1%	0.1%			13.2%	4.7%		0.1%	52.7%	27.3%		1.7%				
	SE of Proportion		0.1%	0.1%			0.9%	0.6%		0.1%	1.6%	1.5%		0.4%				
	Sample Size		1	1			157	57		2	565	301		23				1,107
1984	Number by Age Class		9				966	551			10,436	4,144						16,106
	SE of Number		9				77	70			153	137						
	Proportion by Age Class		0.1%				6.0%	3.4%			64.8%	25.7%						
	SE of Proportion		0.1%				0.5%	0.4%			0.9%	0.9%						
	Sample Size		1				149	56			1,007	378						1,591
1985	Number by Age Class			15			76	43			8,935	2,997	13	74	70		23	12,245
	SE of Number			14			23	17			151	147	9	31	28		13	
	Proportion by Age Class			0.1%			0.6%	0.3%			73.0%	24.5%	0.1%	0.6%	0.6%		0.2%	
	SE of Proportion			0.1%			0.2%	0.1%			1.2%	1.2%	0.1%	0.3%	0.2%		0.1%	
	Sample Size			1			10	6			856	279	2	6	7		3	1,170
1986	Number by Age Class		5			4	5,076	780			745	305		49		5		6,968
	SE of Number	0	3			1	28	25			25	18		6		3		
	Proportion by Age Class		0.1%			0.1%	72.8%	11.2%			10.7%	4.4%		0.7%		0.1%		
	SE of Proportion		0.0%			0.0%	0.4%	0.4%			0.4%	0.3%		0.1%		0.0%		
	Sample Size		1			1	1,389	191			195	77		13		1		1,868

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Return Year		Age Class 0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	1.5	2.5	Total
1987	Number by Age Class		147	130			626	1,030	24		29,329	1,733	61	17				33,097
	SE of Number		68	49			112	133	11		257	187	45	17				
	Proportion by Age Class		0.4%	0.4%			1.9%	3.1%	0.1%		88.6%	5.2%	0.2%	0.1%				
	SE of Proportion		0.2%	0.1%			0.3%	0.4%	0.0%		0.8%	0.6%	0.1%	0.1%				
	Sample Size		9	18			66	132	4		3,374	278	6	1				3,888
1988	Number by Age Class		5	3			1,907	1,237			1,054	782	2	67				5,056
	SE of Number		2	1			31	27			26	21	2	6				
	Proportion by Age Class		0.1%	0.1%			37.7%	24.5%			20.8%	15.5%	0.0%	1.3%				
	SE of Proportion		0.0%	0.0%			0.6%	0.5%			0.5%	0.4%	0.0%	0.1%				
	Sample Size		3	2			1,076	727			624	499	1	46				2,978
1989	Number by Age Class						163	52	1		5,808	486	1		2			6,513
	SE of Number						11	11	0		37	35	0		2			
	Proportion by Age Class						2.5%	0.8%	0.0%		89.2%	7.5%	0.0%		0.0%			
	SE of Proportion						0.2%	0.2%	0.0%		0.6%	0.5%	0.0%		0.0%			
	Sample Size						116	24	1		1,489	184	1		1			1,816
1990	Number by Age Class		12	1			52	38			658	495	1	27				1,285
	SE of Number		3	1			6	4			14	14	0	2				
	Proportion by Age Class		0.9%	0.1%			4.1%	3.0%			51.2%	38.5%	0.1%	2.1%				
	SE of Proportion		0.2%	0.0%			0.4%	0.3%			1.1%	1.1%	0.0%	0.1%				
	Sample Size		8	1			39	29			537	294	1	24				933
1991	Number by Age Class		2	26	4		1,588	2,028	2		781	1,442			13			5,885
	SE of Number		0	8	3		16	31	1		15	30			4			
	Proportion by Age Class		0.0%	0.4%	0.1%		27.0%	34.5%	0.0%		13.3%	24.5%			0.2%			
	SE of Proportion		0.0%	0.1%	0.1%		0.3%	0.5%	0.0%		0.3%	0.5%			0.1%			
	Sample Size		2	11	1		1,274	1,103	1		629	998			8			4,027
1992	Number by Age Class		3	3			1,587	1,262	15		60,690	1,824		336	15			65,737
	SE of Number		3	3			436	156	15		628	360		286	13			
	Proportion by Age Class		0.0%	0.0%			2.4%	1.9%	0.0%		92.3%	2.8%		0.5%	0.0%			
	SE of Proportion		0.0%	0.0%			0.7%	0.2%	0.0%		1.0%	0.5%		0.4%	0.0%			
	Sample Size		1	1			63	105	1		914	135		2	2			1,224
1993	Number by Age Class			13			1,137	1,916	10		3,055	7,038	66	285	13			13,532
	SE of Number			7			142	159	8		167	215	44	48	10			
	Proportion by Age Class			0.1%			8.4%	14.2%	0.1%		22.6%	52.0%	0.5%	2.1%	0.1%			
	SE of Proportion			0.1%			1.3%	1.4%	0.1%		1.5%	1.9%	0.4%	0.4%	0.1%			
	Sample Size			2			62	163	1		279	564	2	31	1			1,105

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		Age Class																
Return Year		0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	1.5	2.5	Total
1994	Number by Age Class		51	41			572	625	6		6,546	1,079		66	5	2		8,992
	SE of Number		23	14			73	88	4		139	95		18	3	1		
	Proportion by Age Class		0.6%	0.5%			6.4%	7.0%	0.1%		72.8%	12.0%		0.7%	0.1%	0.0%		
	SE of Proportion		0.3%	0.2%			0.8%	1.0%	0.0%		1.5%	1.1%		0.2%	0.0%	0.0%		
	Sample Size		12	13			148	91	2		966	243		18	2	1		1,496
1995	Number by Age Class			25			902	451			802	1,226		44	1			3,452
	SE of Number			6			47	38			44	49		14	0			
	Proportion by Age Class			0.7%			26.1%	13.1%			23.2%	35.5%		1.3%	0.0%			
	SE of Proportion			0.2%			1.4%	1.1%			1.3%	1.4%		0.4%	0.0%			
	Sample Size			16			299	133			263	408		13	1			1,133
1996	Number by Age Class		12				1,012	1,654	6		3,519	904			16			7,123
	SE of Number		8				125	176	5		175	139			16			
	Proportion by Age Class		0.2%				14.2%	23.2%	0.1%		49.4%	12.7%			0.2%			
	SE of Proportion		0.1%				1.8%	2.5%	0.1%		2.5%	1.9%			0.2%			
	Sample Size		2				97	76	1		287	70			1			534
1997	Number by Age Class		18				249	404			10,793	664	20	35				12,182
	SE of Number		18				68	83			144	101	19	24				
	Proportion by Age Class		0.1%				2.0%	3.3%			88.6%	5.5%	0.2%	0.3%				
	SE of Proportion		0.1%				0.6%	0.7%			1.2%	0.8%	0.2%	0.2%				
	Sample Size		1				13	22			580	37	1	2				656
1998	Number by Age Class		27	9		3	75	49			576	332		66				1,138
	SE of Number		18	3		2	26	19			54	50		30				
	Proportion by Age Class		2.4%	0.8%		0.3%	6.6%	4.3%			50.6%	29.2%		5.8%				
	SE of Proportion		1.5%	0.3%		0.2%	2.3%	1.6%			4.7%	4.4%		2.7%				
	Sample Size		2	3		1	9	7			81	32		5				140
1999	Number by Age Class			29			1,658	538			573	363		6	7			3,174
	SE of Number			14			67	52			53	43		5	6			
	Proportion by Age Class			0.9%			52.2%	17.0%			18.1%	11.4%		0.2%	0.2%			
	SE of Proportion			0.4%			2.1%	1.6%			1.7%	1.4%		0.2%	0.2%			
	Sample Size			4			245	77			81	53		1	1			462
2000	Number by Age Class		14		13		918	302			2,251	769	14					4,281
	SE of Number		13		12		86	52			103	82	13					
	Proportion by Age Class		0.3%		0.3%		21.4%	7.1%			52.6%	18.0%	0.3%					
	SE of Proportion		0.3%		0.3%		2.0%	1.2%			2.4%	1.9%	0.3%					
	Sample Size		1		1		94	33			257	70	1					457

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Return Year		Age Class																
		0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	1.5	2.5	Total
2001	Number by Age Class	7	60			6	162	71			2,908	598		7	6			3,825
	SE of Number	6	18			6	34	18			60	49		6	6			
	Proportion by Age Class	0.2%	1.6%			0.2%	4.2%	1.9%			76.0%	15.6%		0.2%	0.2%			
	SE of Proportion	0.2%	0.5%			0.1%	0.9%	0.5%			1.6%	1.3%		0.2%	0.1%			
	Sample Size	1	9			1	25	14			591	120		1	1			763
2002	Number by Age Class		6	21			3,981	564			1,318	263		13				6,166
	SE of Number		6	11			89	58			76	41		9				
	Proportion by Age Class		0.1%	0.3%			64.6%	9.2%			21.4%	4.3%		0.2%				
	SE of Proportion		0.1%	0.2%			1.4%	0.9%			1.2%	0.7%		0.1%				
	Sample Size		1	3			582	77			197	36		2				898
2003	Number by Age Class		42	67		14	10,028	840	18	136	7,385	1,059						19,588
	SE of Number		23	28		13	287	121	17	44	276	129						
	Proportion by Age Class		0.2%	0.3%		0.1%	51.2%	4.3%	0.1%	0.7%	37.7%	5.4%						
	SE of Proportion		0.1%	0.1%		0.1%	1.5%	0.6%	0.1%	0.2%	1.4%	0.7%						
	Sample Size		3	5		1	622	50	1	9	437	65						1,193
2004	Number by Age Class		523	36			8,623	1,695			8,362	690						19,930
	SE of Number		102	25			339	196			341	113						
	Proportion by Age Class		2.6%	0.2%			43.3%	8.5%			42.0%	3.5%						
	SE of Proportion		0.5%	0.1%			1.7%	1.0%			1.7%	0.6%						
	Sample Size		25	2			385	84			387	39						922
2005	Number by Age Class			26			6,696	1,566		18	14,264	1,537						24,108
	SE of Number			18			267	152		18	296	150						
	Proportion by Age Class			0.1%			27.8%	6.5%		0.1%	59.2%	6.4%						
	SE of Proportion			0.1%			1.1%	0.6%		0.1%	1.2%	0.6%						
	Sample Size			2			440	98		1	900	97						1,538
2006	Number by Age Class						20,815	3,467			16,642	1,604						42,529
	SE of Number						1,029	488			1,000	303						
	Proportion by Age Class						48.9%	8.2%			39.1%	3.8%						
	SE of Proportion						2.4%	1.1%			2.4%	0.7%						
	Sample Size						314	102			357	46						819
2007	Number by Age Class						2,266	592			25,915	5,304						34,077
	SE of Number						383	188			655	555						
	Proportion by Age Class						6.6%	1.7%			76.0%	15.6%						
	SE of Proportion						1.1%	0.6%			1.9%	1.6%						
	Sample Size						34	11			494	96						635

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Return Year		Age Class																
		0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	1.5	2.5	Total
2008	Number by Age Class						1,437	855			708	445		129	16			3,590
	SE of Number						90	77			77	60		35	16			
	Proportion by Age Class						40.0%	23.8%			19.7%	12.4%		3.6%	0.4%			
	SE of Proportion						2.5%	2.1%			2.1%	1.7%		1.0%	0.4%			
	Sample Size						140	90			67	44		13	1			355
2009	Number by Age Class						2,407	1,588			4,397	1,091						9,483
	SE of Number						151	135			174	118						
	Proportion by Age Class						25.4%	16.7%			46.4%	11.5%						
	SE of Proportion						1.6%	1.4%			1.8%	1.2%						
	Sample Size						186	106			342	75						709
2010	Number by Age Class						3,020	2,762	17		7,987	1,728	120	12				15,646
	SE of Number						199	188	17		247	158	48	11				
	Proportion by Age Class						19.3%	17.7%	0.1%		51.0%	11.0%	0.8%	0.1%				
	SE of Proportion						1.3%	1.2%	0.1%		1.6%	1.0%	0.3%	0.1%				
	Sample Size						184	144	1		499	107	6	1				942
2011	Number by Age Class						796	9,019	11		7,898	4,261		43				22,029
	SE of Number						118	313	11		285	261		26				
	Proportion by Age Class						3.6%	40.9%	0.1%		35.9%	19.3%		0.2%				
	SE of Proportion						0.5%	1.4%	0.0%		1.3%	1.2%		0.1%				
	Sample Size						47	447	1		496	215		3				1,209
2012	Number by Age Class						313	1,370	43		3,927	7,629		50	22			13,353
	SE of Number						84	163	30		241	266		34	0			
	Proportion by Age Class						2.3%	10.3%	0.3%		29.4%	57.1%		0.4%	0.2%			
	SE of Proportion						0.6%	1.2%	0.2%		1.8%	2.0%		0.3%				
	Sample Size						13	59	2		175	335		2	1			587