Fishery Data Series No. 15-38

Distribution and Run Timing of Stocked McDonald Lake Sockeye Salmon, 2011–2014

by

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and

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November 2015

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)

Measures (fisheries)

fork length	FL
mideye to fork	MEF
mideye to tail fork	METF
standard length	SL
total length	TL

Mathematics, statistics

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

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ABSTRACT

Due to a persistent decline in escapement, the McDonald Lake sockeye salmon run was classified a stock of management concern in 2009, and an action plan was developed to rebuild the stock. Measures to reduce commercial harvest and improve stock assessment were established, and a new program to evaluate information from a recent stocking program was developed. Southern Southeast Regional Aquaculture Association collected eggs from McDonald Lake (2007–2009), thermal marked and reared the fry at Burnett Inlet Hatchery then released them as full-term smolt in McDonald Lake (2009–2011). To obtain potentially improved information on the timing and distribution of McDonald Lake sockeye salmon in commercial fisheries affected by the action plan, we analyzed otoliths from sockeye salmon harvested in southern Southeast Alaska purse seine and drift gillnet fisheries (2011–2014). Although few thermal marked McDonald Lake sockeye salmon were recovered in most fisheries, peak harvests occurred in the District 106 drift gillnet and District 101-outside purse seine fisheries during and immediately after the weeks of action plan fishery closures, which corroborated results from a recent genetic stock identification analysis and previous tagging studies. Migratory timing of thermal marked fish indicated shifting the action plan later by 1 statistical week could improve its efficacy. Otoliths from the McDonald Lake escapement were also analyzed (2011–2014). Annual contributions of stocked fish ranged from 0.5% (2014) to 19% (2012) of the escapement. Estimated smolt-to-adult survival was highest for the 2007 brood year (7.5%) and very poor for the 2008 brood year (<0.5%).

Key words: sockeye salmon, *Oncorhynchus nerka,* McDonald Lake, otolith, stock of concern, lake stocking, thermal mark.

INTRODUCTION

Located on the mainland, approximately 70 km north of Ketchikan (Figure 1), McDonald Lake has historically been considered the largest sockeye salmon (*Oncorhynchus nerka*) producing system in southern Southeast Alaska. This stock contributes substantially to several mixed stock, commercial net fisheries (Johnson et al. 2005; Gilk-Baumer et al. 2013) and supports a personal use fishery in Yes Bay, near the mouth of Wolverine Creek (outlet stream of McDonald Lake). The personal use harvest averaged 4,290 sockeye salmon from 1985 to 2014, including a harvest of more than 10,000 sockeye salmon in 1994 (Johnson et al. 2005). Because of its size, McDonald Lake is the only wild Alaska sockeye stock that is specifically identified in the sockeye salmon run reconstruction model currently used by the Northern Boundary Technical Committee of the Pacific Salmon Commission to allocate sockeye salmon harvests in the boundary area (Gazey and English 2000; English et al. 2004).

Between 1980 and 2000, escapement goals for McDonald Lake sockeye salmon were met or exceeded in most years, and annual sockeye salmon escapements averaged over 100,000 fish (Appendix A). Over the next decade, however, sockeye salmon escapements declined to an average 51,000 fish, and 6 escapements between 2002 and 2010 were below the sustainable escapement goal range of 55,000–120,000 spawners. Consequently, in 2009 the McDonald Lake sockeye salmon run was formally classified a stock of management concern by the Board of Fisheries under the State of Alaska’s Policy for the Management of Sustainable Salmon Fisheries (5 AAC 39.222 (f) (21)). A stock of management concern is defined as “a concern arising from a chronic inability, despite use of specific management measures” to maintain escapements for a salmon stock within the bounds of an escapement goal. The Alaska Department of Fish and Game (ADF&G) developed an action plan that outlined steps to rebuild the run, which included management actions intended to reduce harvests of McDonald Lake sockeye salmon in southern Southeast Alaska commercial net fisheries (Bergmann et al. 2009). Following 3 years of improved escapements, the stock of concern designation was lifted at the 2012 Board of Fisheries meeting, which made the fishery restrictions in the action plan no longer mandatory.

McDonald Lake sockeye salmon have primarily been harvested in distant, mixed stock fisheries that do not target McDonald Lake sockeye salmon, so comprehensive harvest information for this stock is limited (Johnson et al. 2005). Joint U.S.–Canada mark–recapture studies conducted in the Boundary Area in 1982 and 1983 (Hoffman et al. 1983 and 1984) and coded-wire tagging studies conducted by ADF&G in the mid-1980s showed that McDonald Lake sockeye salmon migrated around Prince of Wales Island through Sumner and Clarence straits to the north, and Dixon Entrance to the south, and were harvested from early July to early September in all of the Alaska commercial net fisheries from Districts 101 through 107, as well as in British Columbia Areas 1 and 3 (Geiger et al. 2004). Commercial fisheries in British Columbia were not sampled for coded-wire tagged sockeye salmon so estimates of the distribution and contribution of McDonald Lake sockeye salmon to Canadian fisheries are not available. In southern Southeast Alaska, coded-wire tagged McDonald Lake sockeye salmon were recovered primarily in the District 106 drift gillnet fishery, followed by the District 101, 102, and 104 purse seine fisheries (Johnson et al. 2005). Time and area restrictions in the action plan were, therefore, focused on the weeks when McDonald Lake sockeye salmon were known to be most abundant in the District 106 drift gillnet fishery and adjacent purse seine fisheries in Districts 101, 102, 105, 106, and 107 (Figure 1; Bergmann et al. 2009). It was recognized that, while the management actions would likely reduce harvests of McDonald Lake sockeye salmon, those actions would also result in significant foregone harvest of other healthy stocks, because the migratory timing of McDonald Lake sockeye salmon broadly overlaps the timing of other sockeye, pink (*O. gorbuscha*) and chum (*O. keta*) salmon runs (Bergmann et al. 2009).

Two projects designed to provide current harvest information for McDonald Lake sockeye salmon were recently implemented. The first was a multi-year genetic stock identification (GSI) project conducted by ADF&G to estimate the proportions of McDonald Lake sockeye salmon in fisheries affected by the action plan and determine if the timing of management restrictions was appropriate (Gilk-Baumer et al. 2013). From 2007 through 2009, sockeye salmon tissue samples were collected and analyzed from commercial harvests in 4 local subdistricts: the 106-30 (Clarence Strait) and 106-41 (Sumner Strait) drift gillnet fisheries and the 101-29 (Gravina shoreline) and 107-10 (Ernest Sound) purse seine fisheries. Harvest proportions of McDonald Lake sockeye salmon generally peaked during and slightly after the action plan weeks in Subdistricts 106-30 and 106-41, which suggested fishery restrictions could be extended later into the season in those areas to further reduce harvest on this stock (Gilk-Baumer et al. 2013). Results were less conclusive for Subdistricts 101-29 and 107-10 due to limited data; however, proportions of McDonald Lake sockeye salmon were relatively high in those areas (7–31% in Subdistrict 101-29 and 31–61% in Subdistrict 107-10), which indicated the action plan likely was effective at reducing harvest.

In addition to the GSI (Genetic Stock Identification) study, Southern Southeast Regional Aquaculture Association (SSRAA) conducted a project to stock thermal marked McDonald Lake sockeye smolt in the lake so they could be tracked through the fisheries when they returned as adults. SSRAA was permitted to take up to 450,000 eggs annually from Hatchery Creek (the primary sockeye salmon spawning tributary at McDonald Lake) for 3 years, 2007–2009. Fish were thermal marked and reared at SSRAA’s Burnett Inlet Hatchery then returned to the lake as full-term smolt in the springs of 2009–2011 (Table 1). Thermal marked smolt were held in net pens for 24 hours to imprint at the mouth of Hatchery Creek prior to release and were expected to immediately migrate to saltwater with wild fish.

From 2011 to 2014, we sampled harvests in southern Southeast Alaska commercial net fisheries for stocked, thermal marked McDonald Lake sockeye salmon. We estimated the contribution and time and area distribution of stocked McDonald Lake sockeye salmon in weekly harvests through Bayesian hierarchical modeling (Geiger 1994; Gelman et al. 2004). Our intent was to relate information about stocked fish to the McDonald Lake sockeye salmon run as a whole, assuming that stocked fish would be representative of wild fish (i.e., stocked fish would be harvested in the same places, at the same time, and in the same relative abundance as wild fish). Results from the fisheries sampling portion of this study could potentially provide up-to-date, area-specific harvest information that would augment the recent GSI study. We also analyzed otoliths collected at McDonald Lake to estimate the contribution of stocked fish to the escapement. This information, along with data from the fisheries sampling program, was used to calculate survival and harvest rates on stocked fish, which could be used as a proxy for wild fish if their run timing and distribution on the spawning grounds were similar.

Table 1.–Number, size at release, and adult return years of thermal marked sockeye salmon smolt released in McDonald Lake, 2009–2011.

Brood Year	Release Date	Mean Weight (g)	Mean Length (mm)	Total Released	Return Years	
					Ocean Age-2	Ocean Age-3
2007	4-May-2009	6.8	86	276,083	2011	2012
2008	27-Apr-2010	6.0	89	160,350	2012	2013
2009	6-May-2011	5.2	83	322,700	2013	2014

OBJECTIVES

1. Estimate the weekly proportions of stocked McDonald Lake sockeye salmon in the Subdistrict 101-11, Districts 106 and 108 commercial drift gillnet fisheries and relate these proportions to the temporal and spatial characteristics of the harvest.
2. Estimate the weekly proportions of stocked McDonald Lake sockeye salmon in the Districts 101, 102, 104, 105, and 107 commercial purse seine fisheries and relate these proportions to the temporal and spatial characteristics of the harvest.
3. Estimate the proportion and number of wild and stocked adult sockeye salmon on the spawning grounds at Hatchery Creek so that we are 95% confident that the point estimate of the number of hatchery fish in the escapement will be in error by less than 5%.

STUDY SITE

McDonald Lake is located in the Tongass National Forest, approximately 70 km north of Ketchikan, on the Cleveland peninsula in Southeast Alaska (Figure 1; 55^{o} 58’ N, 131^{o} 50’ W; Orth 1967). The lake is situated within a heavily forested watershed of 118 km^2 (Olson 1989), and has a surface area of 420 ha, a mean depth of 45.6 m, and a maximum depth of 110 m (Zadina and Heinl 1999). The lake is organically stained with a volume of 197 x 10^6 m^3 and a residence time of approximately 0.67 years (Zadina and Heinl 1999; Olson 1989). The primary inlet stream and spawning grounds is Hatchery Creek (ADF&G stream number 101-80-10680-2030; also known as Walker Creek, Orth 1967). Movement of salmon upstream into Hatchery Creek is blocked by a barrier falls approximately 1.5 km upstream of the lake. The outlet stream, Wolverine Creek (ADF&G stream number 101-80-10680), flows south 2.4 km to Yes Bay in West Behm Canal.

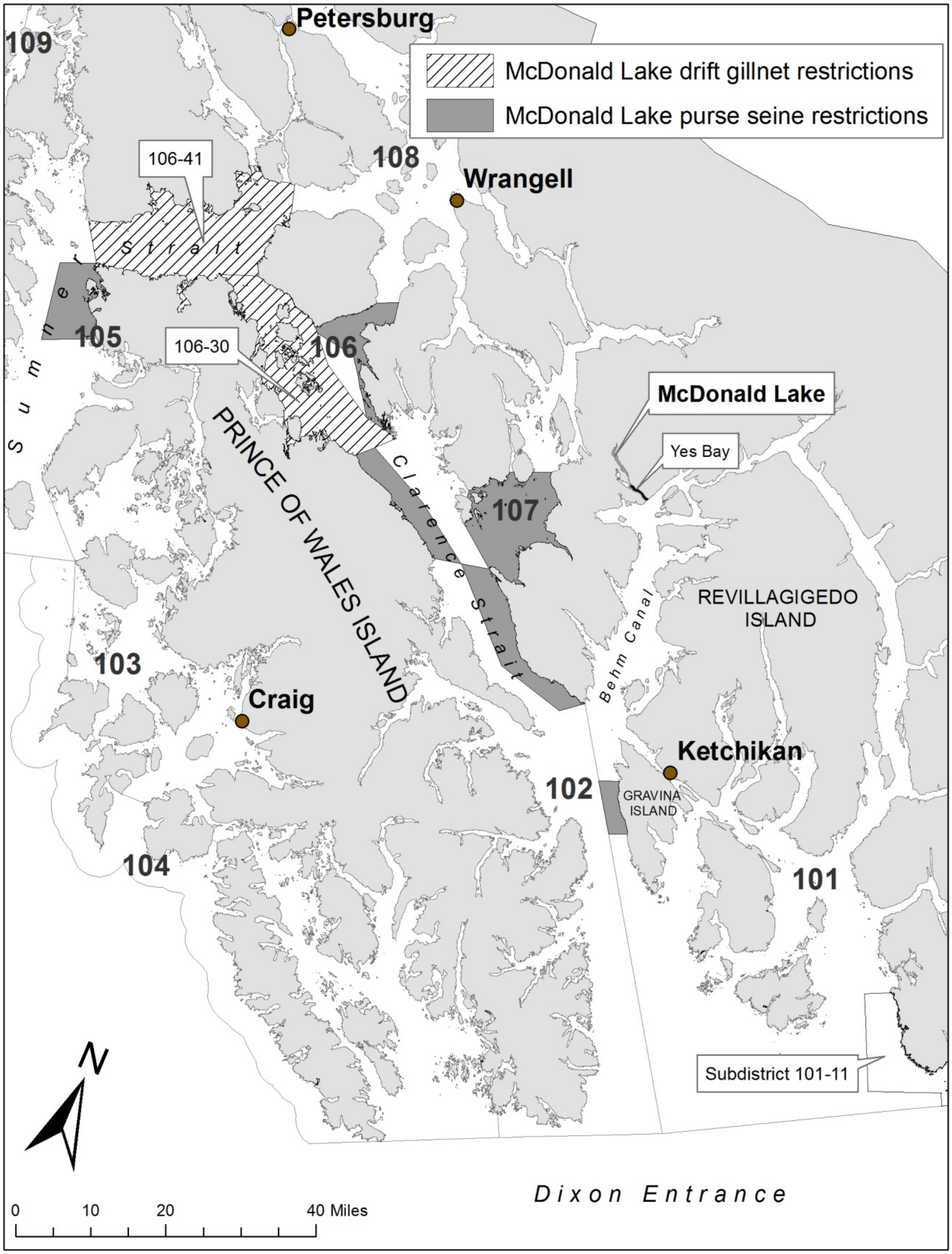

Figure 1.–The location of McDonald Lake in southern Southeast Alaska and commercial fishing areas affected by the action plan.

DESCRIPTION OF FISHERIES CLOSURES

ADF&G statistical weeks run from Sunday through Saturday and are numbered sequentially through the year (Appendix B). Management actions outlined in the McDonald Lake sockeye salmon action plan included the following time and area restrictions:

1. District 101 purse seine—from statistical weeks 29 through 31, the purse seine fishery on the western shore of Gravina Island was closed north of the latitude of Cone Point.
2. District 102 purse seine—from statistical weeks 29 through 32, the purse seine fishery on the western shore of the Cleveland Peninsula (within 3 nautical miles of the shoreline) was closed.
3. District 105 purse seine—from statistical weeks 29 through 31, the District 105 purse seine fishery along the northwest corner of Prince of Wales Island between Point Baker and the Barrier Islands was closed.
4. District 106 purse seine—from statistical weeks 29 through 31, the District 106 purse seine fishery along the west side of Etolin Island between Point Stanhope and the latitude of Round Point was closed, and the purse seine fishery along the east side of Prince of Wales Island between Luck Point and Narrow Point was closed.
5. District 107 purse seine—from statistical weeks 29 through 31, the District 107 purse seine fishery in Section 7-B was closed. If pink salmon runs were extremely strong, the northern portion of section 7-B, north of Union Point may have been opened during statistical week 31. If that occurred, restrictions may have occurred in that area south of Union Point into statistical week 32 to reduce the overall interception of sockeye salmon.
6. District 106 drift gillnet—from statistical weeks 29 through 31, the District 106 drift gillnet fishery was open for a maximum of 2 days.

METHODS

SAMPLING THE COMMERCIAL FISHERIES

Data collection and analysis closely followed methods outlined for a very similar project conducted from 2004 to 2007 to sample District 101 fishery harvests for thermal marked Hugh Smith Lake sockeye salmon (Heinl et al. 2007). Fishery harvests were partitioned into weekly units, or sampling "domains," to emphasize that the primary estimates of interest were estimates of the proportion of thermal marked fish present in each ADF&G statistical week. Total weekly harvest was obtained from the ADF&G fish ticket database. We focused sampling efforts on statistical weeks 25 through 35 (approximately mid-June to late August) when 99% of the sockeye salmon harvest (2001–2010 average) occurred in southern Southeast Alaska traditional net fisheries (Districts 101–108).

Commercial fisheries sampling was implemented through the existing ADF&G Port Sampling program, which collects biological and fishery performance data at the major fish processing ports in Southeast Alaska to facilitate commercial fisheries management and support the Pacific Salmon Treaty process. Our weekly otolith sampling goals matched, as much as possible, annual Port Sampling goals for sockeye salmon tissue and scale sampling in Districts 101–108 to minimize handling additional fish. The only exception was the District 101 purse seine fishery, which was split into 2 sample areas (see section describing Purse Seine Fisheries below). Although annual sample goals totaled over 30,000 otoliths (Table 2), adequate numbers of sockeye salmon were not always available to meet weekly goals and the actual seasonal sample size averaged 15,000 otoliths (Appendices C and D).

In 2011 and 2014, the entire head from each sampled sockeye salmon was shipped to the ADF&G Commercial Fisheries Mark, Tag, and Age Laboratory, in Juneau, where the otoliths were removed and decoded as outlined by Scott et al. (2001). In 2012 and 2013, otolith samples were extracted from whole fish at processing facilities and sent to the ADF&G Mark, Tag, and Age Lab for analysis. A dorsal-ventral cut was made through the rear of the fish's head, approximately 1"–1½" anterior of where the cartilage of the head meets the fleshy meat of the body and perpendicular to the axis of the fish's body. This cut exposed the brain cavity and sagittal wells that hold the otoliths without completely removing the head from the fish. The left and right sagittal otoliths were removed from each fish and placed into a single cell of a labeled, 96-cell plastic tray (trays were 8.5 cm x 12.5 cm, with 96 small individual cells arranged in 8 rows x 12 columns into which the otolith pairs were deposited). Otoliths were cleaned using a treatment described by Hagen et al. (1995): we soaked them in a 0.5% chlorine solution for up to 8 minutes, followed by a dechlorinating solution rinse, and a final rinse in tap water.

Table 2.–Weekly and seasonal sockeye salmon otolith sampling goals for the Districts 101–108 net fisheries in southern Southeast Alaska, 2011–2013.

Fishery	Weekly Sampling Goal	Statistical Weeks	Seasonal Sample Goal
101-inside Purse Seine	96	28–35	768
101-outside Purse Seine	260	29–35	1,820
102 Purse Seine	260	26–35	2,600
104 Purse Seine	260	28–35	2,080
105 Purse Seine	260	32–35	1,040
107 Purse Seine	260	28–35	2,080
101-11 Drift Gillnet	260	26–35	2,600
106-30 Drift Gillnet	520 [a]	25–35	5,720
106-41 Drift Gillnet	520 [a]	25–35	5,720
108 Drift Gillnet (Subdistricts 108-30 and 108-40)	260	25–34	2,600
108 Drift Gillnet (Subdistricts 108-50 and 108-60)	260	25–34	2,600
Grand Total	3,216		30,148

[a] Weekly sampling goals for the District 106 drift gillnet fishery were reduced from 520 per statistical week to 300 per statistical week in 2013–2014.

Purse Seine Fisheries

Purse seine harvests were sampled from early July to late August (approximately statistical week 27 to 35). District 101 purse seine harvests were sampled at fish processing plants in Ketchikan. In order to obtain better information about the distribution of stocked McDonald Lake sockeye salmon within the District 101 purse seine fishery, we divided the district into 2 areas: what we called the District 101 "inside" area (Revillagigedo Channel; Subdistricts 101-23 and 101-41 combined) and the District 101 "outside" area (Clarence Strait; Subdistricts 101-25 and 101-29 combined). A portion of the District 101-outside area, in Subdistrict 101-29, had been identified as an area of high McDonald Lake sockeye salmon abundance and was included in the action plan fishery restrictions. Additionally, the sockeye salmon harvest is typically much larger and the stock composition more highly mixed in the outside areas of Clarence Strait (2005–2014 average harvest 25,000) than in the inside areas of Revillagigedo Channel (2005–2014 average harvest 14,000). To compensate for differences in harvest magnitude and stock composition complexity, the weekly sampling goal for District 101-outside subdistricts was larger (260 otoliths per statistical week) than the sampling goal for District 101-inside subdistricts (96 otoliths per statistical week; Table 2).

Otolith sampling goals for all other purse seine fisheries in Districts 102–107 matched annual Port Sampling goals for sockeye salmon (Table 2). Samples from Districts 101–103 were collected in Ketchikan and samples from Districts 105 and 107 were collected in Petersburg. The weekly District 104 sampling goal was split between Ketchikan and Petersburg since both ports received regular deliveries from this area.

Established ADF&G Port Sampling procedures ensured that weekly samples were as representative of a specific district harvest as possible. Only deliveries originating from a single fishing district and gear type were sampled. No more than 40 otolith samples (both left and right sagittal otoliths were collected per sample) were collected from each individual seine boat delivery and no more than 80 otolith samples were collected from each tender sampled. When individual seine boats delivered fewer than 40 total sockeye salmon, otoliths were collected from every sockeye salmon in the delivery. When possible, samples from a single delivery were collected from the entire hold as it was offloaded in order to best represent all sockeye salmon in that delivery. In addition, sampling effort was distributed over the entire statistical week, and samples were collected from multiple deliveries from each fishing district as much as possible. Additional information, including the sample date, subdistricts fished, and statistical week in which fish were harvested, was also recorded.

Drift Gillnet Fisheries

Subdistrict 101-11

The weekly goal for the Subdistrict 101-11 drift gillnet fishery was 260 otolith samples from approximately mid-June to late August (statistical weeks 26 to 35; Table 2). Virtually all of the sockeye salmon harvested in the Subdistrict 101-11 drift gillnet fishery passed through 2 processing plants in Ketchikan. Each processor deployed 2 to 3 tenders to the fishing grounds and tenders delivered fish to the processors twice per week, depending upon fishing conditions (i.e., about 4 deliveries a week to each processor and as many as 8 deliveries total).

District 106 and 108

Otolith samples from the Subdistrict 106-30 drift gillnet fishery were collected by an ADF&G tender rider from approximately mid-June to late August (statistical weeks 25 to 35). Sequentially numbered otolith coordination tags were used to identify fish that had been sampled for tissues and scales so the heads could be recovered after processing and sent to the Mark, Tag, and Age Lab in Juneau for otolith removal and analysis. As was done with purse seine samples, no more than 40 otolith samples were collected from individual boat deliveries and no more than 80 otolith samples were collected from tender deliveries in town. Samples were collected in Petersburg from the drift gillnet fisheries in Subdistrict 106-41, and Subdistricts 108-50 and 108-60 combined. Samples were collected in Wrangell from Subdistricts 108-30 and 108-40 combined. Weekly Port Sampling goals for District 106 drift gillnet fisheries were reduced midway through our study, thus otolith sample goals were also reduced from 520 fish in 2011–2012 to 300 fish in 2013–2014 (Table 2).

ESCAPEMENT SAMPLING

Otolith samples were collected from carcasses throughout the spawning season at Hatchery Creek. Samples were collected throughout the length of the stream, which was divided into 2 sampling areas to test if stocked fish were evenly distributed throughout the length of the creek. The lower stream section extended from the mouth of Hatchery Creek to a point approximately 0.5 km upstream. The remainder of the stream was considered the upper stream section.

We wanted to estimate the proportion of hatchery fish in the escapement at Hatchery Creek so that we were 95% confident that the point estimate of the proportion of hatchery fish in the escapement was in error by less than 5%. Sample size (n_0) for each of the 2 sampling regions was calculated using methods described in Thompson (1992; pg. 41–42) for determining the sample size for estimating a proportion:

$$n_0 = \frac{z^2 p(1-p)}{d^2}. \tag{1}$$

The value of z is 1.96, which is the upper 0.025 point of the normal distribution and d is our maximum error tolerance of 5%. Since the proportion of hatchery fish in the escapement was unknown, we used a value of 0.5 for p to estimate the sample size that would meet our precision threshold for any proportion of hatchery fish. Using this formula we obtained a sampling goal of 385 fish per sampling area and 770 otolith samples total. We rounded the total goal to 800 otolith samples (400 per area) to ensure we met our goal if a number of samples were unreadable. Since results from 2011 and 2012 indicated no significant differences in the proportions of hatchery fish in the lower and upper stream sections, we combined strata into a stream-wide total goal of 400 otolith samples in 2013 and 2014.

Otolith samples were collected approximately every ten days from the second week of September through the second week of October. We used historic foot survey counts of live sockeye salmon to weight samples by sampling date (Figure 2). From 1979 to 2007, standardized foot surveys of Hatchery Creek were conducted on or near the same dates each year to count live sockeye salmon over the entire spawning season. The otolith sampling goal by date was calculated by multiplying total sample size by the historic average proportion of fish counted by sampling date. Because the weighting of samples was based on counts of live fish, we shifted the otolith sampling goals later by 1 survey date to ensure the availability of dead fish to sample. Sampling goals for each sampling area were as follows: 45 samples on 10 September; 130 samples on 20 September; 160 samples on 28 September; 135 samples on 10 October; and 30 samples on 20 October.

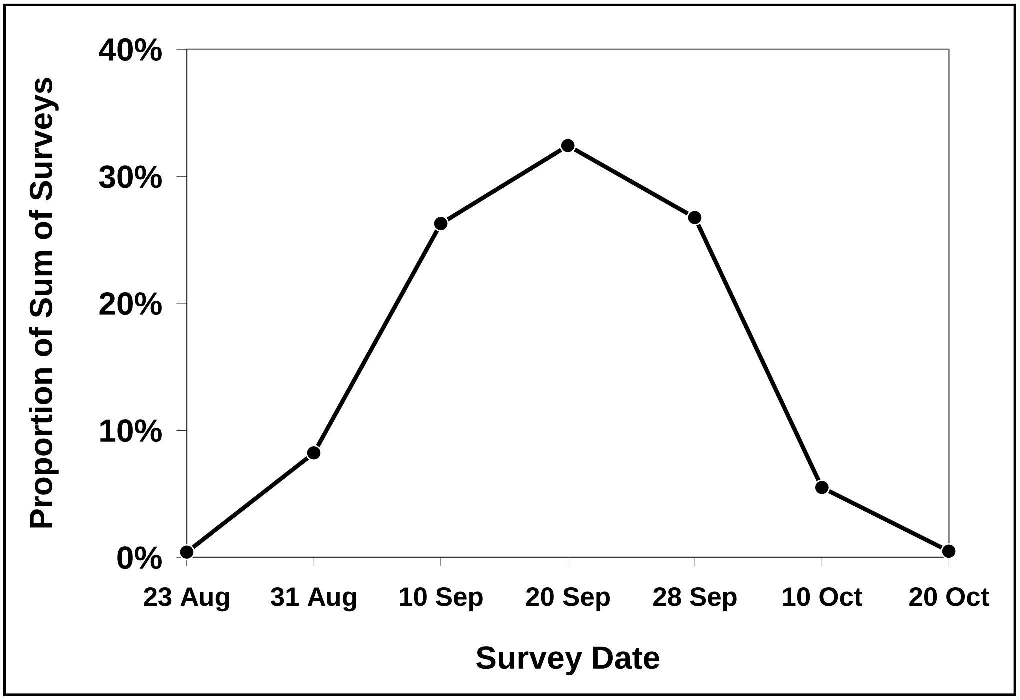

Figure 2.–Run timing of McDonald Lake sockeye salmon spawning based on historic foot survey estimates, 1979–2007.

DATA ANALYSIS

FISHERIES SAMPLING

Data analysis was very similar to that outlined in Heinl et al. (2007). Let π_i denote the proportion of thermal marks in one of the sampling domains (i.e., statistical weeks), and suppose there are D total domains (i = 1, 2, 3 ... D). Let n_i denote the number of otoliths decoded in statistical week i, and let x_i denote the number of thermal marks observed from statistical week i. We assumed independent binomial models for the number of thermal marks, x_i:

$$x_i \sim \text{Bin}(n_i, \pi_i),\ i = 1, \ldots D,$$

with the number of sampled otoliths decoded, n_i , known. The parameters π_i are assumed to be independent samples from a beta distribution:

$$\pi_i \sim \text{Beta}(\alpha, \beta),\ i = 1, \ldots D.$$

The beta distribution was a prior distribution for π_i.

To estimate the prior parameters, α and β, we used all the data, $\{\pi_i\} = \{x_i / n_i\}$, from total domains ($i$ = 1 ... D). Since $\pi_i \sim$ Beta (α, β), we have

$$E(\pi_i) = \frac{\alpha}{\alpha + \beta}, \text{var}(\pi_i) = \frac{\alpha\beta}{(\alpha + \beta)^2(\alpha + \beta + 1)};$$

Then we have

$$\alpha + \beta = \frac{E(\pi_i)(1 - E(\pi_i))}{\text{var}(\pi_i)} - 1,$$

$$\alpha = (\alpha + \beta)E(\pi_i), \text{ and}$$

$$\beta = (\alpha + \beta)(1 - E(\pi_i)).$$

$E(\pi_i)$ and $\text{var}(\pi_i)$ were estimated as the sample mean, $\bar{\pi} = \frac{1}{D}\sum_{i=1}^{D}\pi_i$, and sample variance, $s^2 = \frac{1}{D-1}\sum_{i=1}^{D}(\pi_i - \bar{\pi})^2$, respectively. The analysis using the data to estimate the prior parameters is called empirical Bayes (Gelman et al. 2004).

The beta distribution is a conjugate prior for binomial likelihood; that is, the posterior distributions are also beta distributions with new parameters, $(\alpha + x_i)$ and $(\beta + n_i - x_i)$:

$$\pi_i \,|(x_i \text{ and } n_i) \sim \text{Beta}(\alpha + x_i, \beta + n_i - x_i),\ i = 1, 2, 3, \ldots D.$$

The posterior mean of π_i, given x_i and n_i, which can be interpreted as the proportion of thermal marks from the population in statistical week i, is now

$$E(\pi_i) = \frac{\alpha + x_i}{\alpha + \beta + n_i}, \tag{2}$$

which always lies between the sample proportion, x_i / n_i, and the prior mean, $\alpha / (\alpha + \beta)$. The posterior variance is

$$\text{var}(\pi_i) = \frac{(\alpha + x_i)(\beta + n_i - x_i)}{(\alpha + \beta + n_i)^2(\alpha + \beta + n_i + 1)}. \tag{3}$$

Inference about the proportions of thermal marked sockeye salmon in each domain was calculated through this posterior distribution. We then reported the posterior mean and a measure of precision (credible interval) for each sampling domain.

In order to calculate the total annual contribution of stocked fish we had to account for weekly harvests that were not sampled. This usually occurred when weekly harvests were small (<600 fish), generally late in the season, on or after statistical week 35 (the last designated sample week). We compensated for missing data by using Bayesian analysis to generate a predicted proportion of stocked fish (posterior mean) when no sampling occurred. These values were applied to harvests that were not sampled and are labeled "imputed" (Appendices C and D). Since 99% of the sockeye salmon harvest occurs before week 35, using predicted proportions for harvests after statistical week 35 had minimal effect on the total contribution estimates.

ESCAPEMENT SAMPLING

We determined the proportion of stocked, thermal marked sockeye salmon in the escapement at Hatchery Creek from our sample goal of 800 otolith samples (2011–2012) and 400 otolith samples (2013–2014) taken from carcasses over the entire duration of the run. In 2011 and 2012, we first calculated the proportion of hatchery fish in the upper and lower sampling sections to test if stocked fish were distributed throughout the length of the stream, then combined both samples to calculate the proportion and number of hatchery fish in the escapement using the total sample. For calculating the number of stocked and wild fish in the escapement we used the total escapement estimate provided by our expanded peak foot survey count (Heinl et al. 2009).

Let m denote the number of fish sampled that were thermal marked, and let n denote the number of fish sampled. The estimated proportion, $\hat{p}_E$, of thermal marked fish in the escapement E was calculated from our weighted samples as

$$\hat{p}_E = m_E / n_E \ . \tag{3}$$

Let N_E equal the total escapement of adult sockeye salmon at McDonald Lake as estimated from our expanded peak foot survey. The estimate of the number of thermal marked fish in the escapement, $\hat{M}_E$, was calculated as

$$\hat{M}_E = \hat{p}_E N_E \, . \tag{4}$$

The variance of the estimated number of thermal marked fish in the escapement was calculated as (Cochran 1977, pg. 52)

$$v\left(\hat{M}_E\right) = \left[\frac{N_E\left(N_E - n_E\right)}{n_E - 1}\right]\left[\hat{p}_E\left(1 - \hat{p}_E\right)\right], \tag{5}$$

and the standard error was calculated as the square root of the variance.

To test if stocked fish were distributed throughout the stream, we used the null hypothesis (H_0) that the proportion of stocked fish in the lower sampling section equals the proportion of stocked fish in the upper sampling region, and the alternate hypothesis (H_1) that the proportion of stocked fish in the upper sampling region was less than the proportion in the lower sampling region. We used a left-tailed test at a 0.05 level of significance and calculated a z value as

$$z = \left[\frac{\hat{p}_1 - \hat{p}_2}{\sqrt{\left(\frac{\hat{p}\hat{q}}{n_1} + \frac{\hat{p}\hat{q}}{n_2}\right)}}\right], \tag{6}$$

where $\hat{p}_1$ is the proportion of stocked fish in the lower sampling region, $\hat{p}_2$ is the proportion of hatchery fish in the upper sampling region, n_1 is the number of samples in the lower sampling region, n_2 is the number of samples in the upper sampling region, $\hat{q}$ is equal to 1- $\hat{p}$, and $\hat{p}$ is the pooled estimate of proportion

$$\hat{p} = \frac{r_1 + r_2}{n_1 + n_2} \, . \tag{7}$$

In Equation 7, r_1 is the number of thermal marked fish in the lower spawning region and r_2 is the number of thermal marked fish in the upper spawning region (Weiss 2002, pg.623).

If the calculated *z* value was less than the critical value at the 0.05 level of significance (-1.645), we rejected the null hypothesis that the proportions of stocked fish are the same in the upper and lower regions of Hatchery Creek and accepted the alternate hypothesis that the proportion of stocked fish is lower in the upper sampling region.

RESULTS

FISHERIES SAMPLING

Drift Gillnet Fisheries

Subdistrict 101-11

Stocked McDonald Lake sockeye salmon accounted for 0.3% or less of the total annual sockeye salmon harvest in the Subdistrict 101-11 drift gillnet fishery, and annual contribution estimates ranged from 15 to 165 fish (Table 3, Appendix C). Estimated proportions of stocked McDonald Lake sockeye salmon in weekly harvests were also very low (<1.0%), and, when estimated proportions were applied to weekly harvests, peak harvests of stocked McDonald Lake sockeye salmon occurred in statistical weeks 28 (2012), 31 (2011), and 32 (2013; Appendix C). The precision of our estimates for this fishery was very poor (mean coefficient of variation = 64%; Table 3) due to the low number of recoveries.

Subdistrict 106-30

Stocked McDonald Lake sockeye salmon accounted for 3.5% or less of the total annual sockeye salmon harvest in the Subdistrict 106-30 drift gillnet fishery, and annual contribution estimates ranged from 75 to 671 fish (Table 3, Appendix C). Estimated proportions of stocked McDonald Lake sockeye salmon in weekly harvests were generally very low, with peak weekly contributions of 6.1% (2012), 2.4% (2011), 1.0% (2013), and 0.5% (2014; Appendix C). When estimated proportions were applied to weekly harvests, peak harvests of stocked McDonald Lake sockeye salmon occurred in statistical weeks 29 (2013), 30 (2012; Figure 3), 32 (2014), and 33 (2011; Figure 4, Appendix C). The coefficient of variation of our annual harvest estimates ranged from 10% to 34% and averaged 21% from 2011 to 2014, which was the most precise of all areas sampled (Table 3).

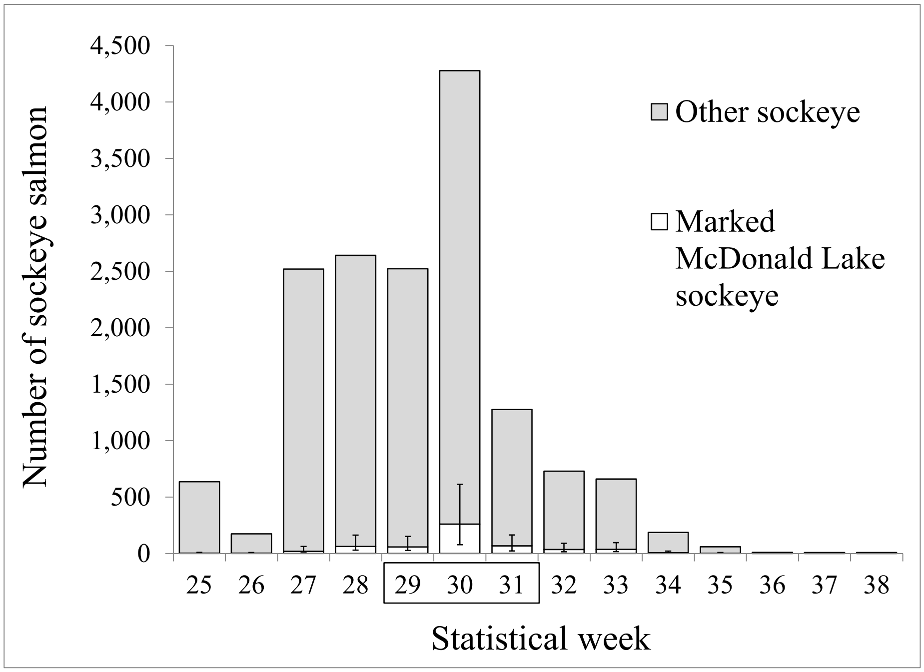

Figure 3.–Total weekly harvest of sockeye salmon and estimated weekly harvest of stocked McDonald Lake sockeye salmon in the Subdistrict 106-30 drift gillnet fishery, 2012. Error bars represent the 95% credible intervals. Box surrounding statistical weeks 29–31 indicates the weeks outlined in the action plan.

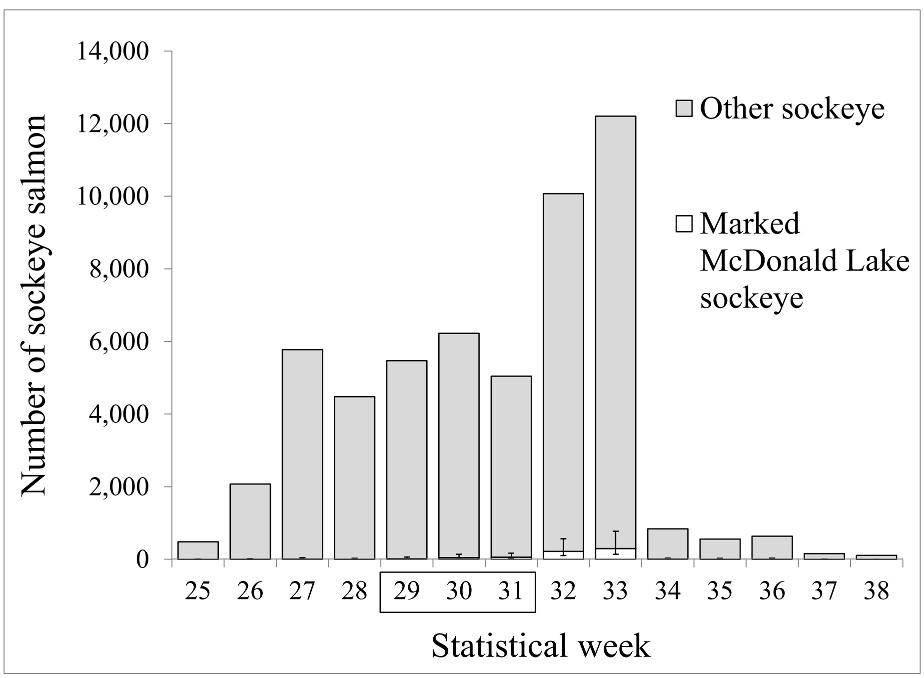

Figure 4.–Total weekly harvest of sockeye salmon and estimated weekly harvest of stocked McDonald Lake sockeye salmon in the Subdistrict 106-30 drift gillnet fishery, 2011. Error bars represent the 95% credible intervals. Box surrounding statistical weeks 29–31 indicates the weeks outlined in the action plan.

Subdistrict 106-41

Stocked McDonald Lake sockeye salmon accounted for 2.8% or less of the total annual sockeye salmon harvest in the Subdistrict 106-41 drift gillnet fishery. Annual contribution estimates ranged from 0 to 821 fish, and the contribution of 821 fish in 2012 was the largest total contribution to any fishery in all years of this study (Table 3, Appendix C). Estimated proportions of stocked McDonald Lake sockeye salmon in weekly harvests were generally very low, and peak weekly contributions ranged from 25 (2014) to 330 fish (2012; Appendix C). When estimated proportions were applied to total weekly harvests, peak harvests of stocked fish occurred in statistical week 28 (2014), 29 (2012; Figure 5), and 32 (2011; Appendix C). No thermal marked McDonald Lake sockeye salmon were recovered in Subdistrict 106-41 in 2013. The coefficient of variation of our annual harvest estimates ranged from 12% to 34% and averaged 24% from 2011 to 2014 (Table 3).

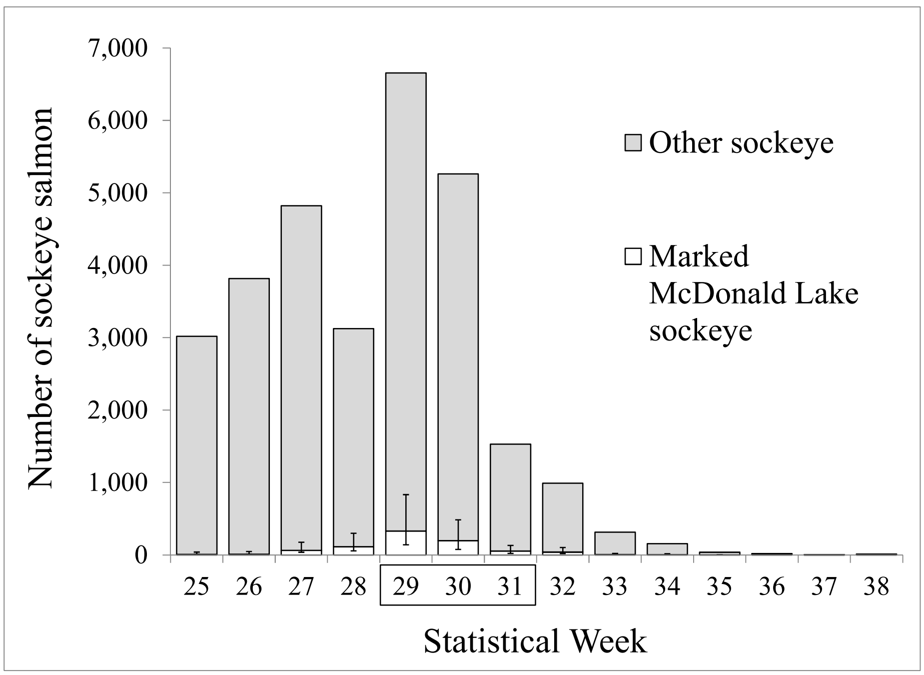

Figure 5.–Total weekly harvest of sockeye salmon and estimated weekly harvest of stocked McDonald Lake sockeye salmon in the Subdistrict 106-41 drift gillnet fishery, 2012. Error bars represent the 95% credible intervals. Box surrounding statistical weeks 29–31 indicates the weeks outlined in the action plan.

District 108

Stocked McDonald Lake sockeye salmon accounted for 0.3% or less of the total annual sockeye salmon harvest in the District 108 drift gillnet fishery, and annual contribution estimates ranged from 6 to 25 fish (Table 3, Appendix C). Estimated proportions of stocked McDonald Lake sockeye salmon in weekly harvests were also very low (<1.0%). When estimated proportions were applied to weekly harvests, peak harvests of stocked fish occurred in statistical weeks 27 (2011 and 2014), 29 (2012), and 30 (2013; Appendix C). The average coefficient of variation of our harvest estimates was 82% from 2011 to 2014 (Table 3).

Purse Seine Fishery

District 101-inside

Stocked McDonald Lake sockeye salmon accounted for 3.5% or less of the total annual sockeye salmon harvest in the District 101-inside purse seine fishery, and annual contribution estimates ranged from 32 to 317 fish (Table 3, Appendix D). Estimated proportions of stocked McDonald Lake sockeye salmon in weekly harvests were generally very low (<4.5%; Appendix D). When estimated proportions were applied to weekly harvests, peak harvests of stocked fish occurred in statistical weeks 28 (2013) and 30 (2011 and 2012; Appendix D). The average coefficient of variation of our harvest estimates was 44% from 2011 to 2013 (Table 3).

District 101-outside

Stocked McDonald Lake sockeye salmon accounted for 5.3% or less of the total annual sockeye salmon harvest in the District 101-outside purse seine fishery, and annual contribution estimates ranged from 75 to 483 fish (Table 3, Appendix D). Estimated proportions of stocked McDonald Lake sockeye salmon in weekly harvests were very low in 2011 and 2013 (≤1.5%), and higher in 2012 (maximum 8.6%; Appendix D). When estimated proportions were applied to weekly harvests, peak harvests of stocked fish occurred in statistical week 30 (2013), 31 (2012), and 32 (2011; Appendix D). The coefficient of variation of our annual harvest estimates ranged from 17% to 38% and averaged 29% from 2011 to 2013 (Table 3).

District 102

Stocked McDonald Lake sockeye salmon accounted for 0.9% or less of the total annual sockeye salmon harvest in the District 102 purse seine fishery, and contribution estimates ranged from 30 to 400 fish (Table 3, Appendix D). Estimated proportions of stocked McDonald Lake sockeye salmon in weekly harvests were very low in 2011 and 2013 (≤0.5%), and slightly higher in 2012 (maximum 3.3%; Appendix D). When estimated proportions were applied to weekly harvests, the peak annual weekly harvest of stocked fish occurred in statistical week 28 (2013), 30 (2012), and week 32 (2011; Appendix D). The average coefficient of variation of our harvest estimates was 45% from 2011 to 2013 (Table 3).

Districts 103 and 105

No McDonald Lake sockeye salmon were identified in any of our samples from District 103 or 105 purse seine fisheries. Sockeye salmon harvested in these 2 districts were often combined with fish caught in other adjacent districts before arriving in port, which made it difficult to obtain a “pure” (district specific) sample. Small samples were collected from District 103 in 2012 and 2013, and from District 105 in 2013; however, no thermal marked McDonald Lake sockeye salmon were identified in these samples (Appendix D).

District 104

Stocked McDonald Lake sockeye salmon accounted for 0.7% or less of the total sockeye salmon harvest in the District 104 purse seine fishery, and contribution estimates ranged from 54 to 505 fish (Table 3, Appendix D). Estimated proportions of stocked fish in weekly harvests were generally low in all years (maximum 3.4%; Appendix D). When estimated proportions were applied to the total weekly sockeye salmon harvest, peak weekly harvests of stocked fish occurred in statistical week 28 (2013), week 29 (2012), and week 30 (2011; Appendix D). The average coefficient of variation of our harvest estimates was 69% from 2011 to 2013 (Table 3).

District 107

Stocked McDonald Lake sockeye salmon accounted for less than 1.0% of the total annual sockeye salmon harvest in the District 107 purse seine fishery, and contribution estimates ranged from 11 to 43 fish (Table 3, Appendix D). No samples were obtained in 2011. Estimated proportions of stocked McDonald Lake sockeye salmon in weekly harvests were very low in 2012 and 2013 (maximum 1.4%; Appendix D). When estimated proportions were applied to total weekly harvests of sockeye salmon, peak harvests of stocked McDonald Lake fish occurred in statistical weeks 28–31 (2012) and week 29 (2013; Appendix D). The average coefficient of variation of our harvest estimates was 65% for 2012 and 2013 (Table 3).

Table 3.–Estimated distribution and harvest of stocked McDonald Lake sockeye salmon in southern Southeast Alaska net fisheries sampled in 2011–2014.

		Drift Gillnet Fisheries				Purse Seine Fisheries					
Year		101-11	106-30	106-41	108	101-inside [a]	101-outside [b]	102	104	107	Total
2011	Estimated Harvest	63	671	448	11	32	124	86	209	–	1,644
	Estimated Proportion	0.1%	1.2%	0.5%	0.0%	0.4%	1.0%	0.2%	0.1%	–	
	95% Credible Interval	0–143	462–880	230–667	0–38	0–74	31–218	17–156	0–543	–	
	Coefficient of Variation	64%	16%	25%	125%	68%	38%	41%	82%	–	
2012	Estimated Harvest	165	557	821	13	317	483	400	505	43	3,304
	Estimated Proportion	0.3%	3.5%	2.8%	0.1%	3.5%	5.3%	0.9%	0.7%	0.8%	
	95% Credible Interval	50–279	451–663	624–1,018	0–27	160–473	324–643	237–564	58–951	0–92	
	Coefficient of Variation	35%	10%	12%	60%	25%	17%	21%	45%	59%	
2013	Estimated Harvest	15	94	0	6	140	75	30	54	11	425
	Estimated Proportion	0.0%	0.5%	0.0%	0.0%	0.7%	1.2%	0.1%	0.1%	0.2%	
	95% Credible Interval	0–41	47–141	N/A	0–15	28–252	29–120	0–71	0–136	0–25	
	Coefficient of Variation	92%	25%	N/A	85%	41%	31%	72%	79%	71%	
2014	Estimated Harvest	–	75	65	25[c]	–	–	–	–	–	165
	Estimated Proportion	–	0.2%	0.2%	0.3%	–	–	–	–	–	
	95% Credible Interval	–	24–125	21–108	0–52	–	–	–	–	–	
	Coefficient of Variation	–	34%	34%	57%	–	–	–	–	–	
	Total	243	1,397	1,334	55	489	682	516	768	54	5,538

[a] The District 101-inside area includes Subdistricts 101-23 and 101-41 combined.
[b] The District 101-outside area includes Subdistricts 101-29 and 101-25 combined.
[c] Contribution estimates for Subdistricts 108-30 and 108-40 only.

ESCAPEMENT SAMPLING

2011

The total McDonald Lake sockeye salmon escapement was estimated to be 113,000 fish, based on the expanded peak foot survey count at Hatchery Creek. A total of 997 usable otolith samples were collected from Hatchery Creek: 500 from the lower stream section and 497 from the upper stream section (Table 4). A test for the difference in proportions of stocked fish between the upper and lower stream sections indicated that stocked fish were well distributed throughout the creek (z = -0.173; Critical Value = -1.645); therefore, we pooled samples from both sections. We estimated that 4.5% of the sockeye salmon escapement, or 5,100 fish (SE = 740), were stocked fish (Table 4).

Table 4.–Number of otoliths sampled by date and stream section, and estimated number of stocked, thermal marked sockeye salmon in the 2011 McDonald Lake sockeye salmon escapement.

Stream Section	Sample Date	*n*	Unmarked	Thermal Marked	Percent Marked
Lower	9/12/2011	45	45	0	0%
Upper	9/12/2011	45	41	4	9%
Lower	9/25/2011	160	153	7	4%
Upper	9/25/2011	160	158	2	1%
Lower	9/28/2011	130	126	4	3%
Upper	9/28/2011	128	127	1	1%
Lower	10/10/2011	135	126	9	7%
Upper	10/10/2011	135	122	12[a]	9%
Lower	10/20/2011	30	28	2	7%
Upper	10/20/2011	29	25	4	14%
Total Upper Section		497	473	23[a]	5%
Total Lower Section		500	478	22	4%
Both Sections Combined		997	951	45[a]	5%
Total Escapement					113,000
Number Thermal Marked					5,100
Standard Error					740
95% Confidence Interval Lower Bound					3,650
95% Confidence Interval Upper Bound					6,551

[a] Does not include 1 additional fish with an "unknown mark" found in the upper section on 10/10/2011.

2012

The total sockeye salmon escapement was estimated to be 57,000 fish based on an expanded peak foot survey estimate at Hatchery Creek. The peak foot survey count occurred on 10 September; very few fish remained in the creek by the end of the month (1,250 on 28 September), which made it impossible to achieve our overall sampling goal. A total of 554 usable otolith samples were collected from Hatchery Creek: 298 from the lower stream section and 256 from the upper stream section (Table 5). A test for difference in proportions of stocked fish between the upper and lower stream section indicated that stocked fish were well distributed throughout the creek (z = -0.424; Critical Value = -1.645), which allowed us to pool samples from both sections to estimate the overall number of stocked fish in the escapement. We estimated that 18.8% of the sockeye salmon escapement, or 10,700 fish (SE=942), were thermal marked stocked fish (Table 5).

Table 5.–Number of otoliths sampled by date and stream section, and estimated number of stocked, thermal marked sockeye salmon in the 2012 McDonald Lake sockeye salmon escapement

Stream Section	Sample Date	*n*	Unmarked	Thermal Marked	Percent Marked
Lower	9/10/2012	36	36	0	0%
Upper	9/10/2012	7	7	0	0%
Lower	9/18/2012	134	119	15	11%
Upper	9/20/2012	121	106	15	12%
Lower	9/28/2011	128	89	39	30%
Upper	9/28/2011	128	93	35	27%
Total Upper Section		256	206	50	20%
Total Lower Section		298	244	54	18%
Both Sections Combined		554	450	104	19%
Total Escapement					57,000
Number Thermal Marked					10,700
Standard Error					942
95% Confidence Interval Lower Bound					8,854
95% Confidence Interval Upper Bound					12,546

2013

The total sockeye salmon escapement was estimated to be 15,400 fish based on an expanded peak foot survey estimate at Hatchery Creek. A total of 282 usable otolith samples were collected from Hatchery Creek (Table 6). We did not separate samples between the upper and lower sections of the creek due to low fish abundance, and because results from the prior 2 years indicated that stocked fish were evenly distributed throughout the creek. We estimated that 5.3% of the sockeye salmon escapement, or 817 fish (SE=204), were thermal marked stocked fish (Table 6).

Table 6.–Number of otoliths sampled by date and stream section, and estimated number of stocked, thermal marked sockeye salmon in the 2013 McDonald Lake sockeye salmon escapement.

Sample Date	*n*	Unmarked	Thermal Marked	Percent Marked
9/10/2013	36	36	0	0%
9/18/2013	82	82	0	0%
10/2/2013	164	149	15	9%
Combined	282	267	15	5.3%
Total Escapement				15,400
Number Thermal Marked				817
Standard Error				204
95% Confidence Interval Lower Bound				418
95% Confidence Interval Upper Bound				1,216

2014

The total sockeye salmon escapement was estimated to be 43,400 fish based on an expanded peak foot survey estimate at Hatchery Creek. A total of 401 usable otolith samples were collected from Hatchery Creek in 2014; however, samples were not weighted by historic run timing or collected throughout the entire spawning season, therefore results are only representative of the early portion of the run (Table 7). Results from previous years indicated stocked fish were more abundant on the spawning grounds later in the season so our contribution estimate for 2014 likely underrepresents the total contribution of stocked fish. As in 2013, we did not separate samples between the upper and lower sections of the creek. We estimated that 0.5% of the sockeye salmon escapement, or 217 fish (SE=152), present during the early portion of the run were thermal marked stocked fish (Table 7).

Table 7.–Number of otoliths sampled by date and stream section, and estimated number of stocked, thermal marked sockeye salmon in the 2014 McDonald Lake sockeye salmon escapement.

Sample Dates	*n*	Unmarked	Thermal Marked	Percent Marked
9/4–9/6/2014	92	N/A	N/A	N/A
9/7–9/13/2014	250	N/A	N/A	N/A
9/14–9/15/2014	59	N/A	N/A	N/A
Combined	401	399	2	0.5%
Total Escapement				43,400
Number Thermal Marked				217
Standard Error				152
95% Confidence Interval Lower Bound				0
95% Confidence Interval Upper Bound				515

DISCUSSION

The distribution and run timing of stocked McDonald Lake sockeye salmon in southern Southeast Alaska net fisheries corroborated results from older coded wire tagging studies (Johnson et al. 2005) and the recent GSI study (Gilk-Baumer et al. 2013). Although we recovered some stocked fish in most of the fisheries that were sampled, a substantial proportion (49–81%; Appendices C and D) were harvested annually in the fisheries identified in the action plan and they were most abundant in the District 106 drift gillnet and District 101 purse seine fisheries. Within those areas, most fish were harvested during the action plan weeks in 2012 and 2013, but they were harvested a little later in 2011. If the action plan were to have been extended by 1 week in 2011, the proportion of stocked McDonald Lake sockeye salmon caught during the action plan weeks in the District 106 drift gillnet and District 101-outside purse seine fisheries would have increased from 23% to 73% (Appendices C and D). Results from the GSI study also indicated that it would be beneficial to include statistical week 32 if action plan closures should become necessary to reduce harvest on this stock in the future (Gilk-Baumer et al. 2013).

The precision of our estimates was poor due to the low number of stocked McDonald Lake sockeye salmon recovered in our samples, and the coefficient of variation of our estimates for most fisheries exceeded 30% (Table 3). Annual contribution estimates for the District 106 drift gillnet and District 101-outside purse seine fisheries were the most precise, yet the coefficient of variation of estimates for those fisheries still exceeded 15% in most years. Very few marked fish were recovered and, in most fisheries, no marked fish were found in the majority of statistical weeks. It would have been impossible, however, to collect enough samples to improve the precision of our estimates given the scarcity of marked fish and our limited resources. With such a high degree of uncertainty around our estimates, their utility should be limited, in most cases, to general spatial distribution indicators.

The average exploitation rate for stocked McDonald Lake fish returning from brood year (BY) 2007 and 2008 was 35%. Fish from BY 2007 experienced the lowest exploitation rate (24%) and highest smolt-to-adult survival rate (7.5%), and made the largest contribution to adult escapements (Appendix E). Adult returns from the BY 2008 release group were not as numerous; they experienced a higher exploitation rate (47%) and considerably lower smolt-to-adult survival rates (0.2%, Appendix E). The estimated survival rate of 3-ocean adults from the BY 2009 release group was biased low due to the lack of comprehensive commercial fisheries sampling and possibly incomplete escapement sampling in 2014 (Appendix E). The average size at release of fish in the BY 2008 and BY 2009 release groups was slightly smaller than the BY 2007 release group (Table 1), which may have contributed to their reduced survival (Henderson and Cass 1991; Koenings et al. 1993).

Harvest estimates from a comparable study conducted on Hugh Smith Lake sockeye salmon (Heinl et al. 2007) were more precise than we were able to achieve for thermal marked McDonald Lake sockeye salmon. Eggs were taken at Hugh Smith Lake, fish were thermal marked at the hatchery, then reared in net pens in the lake and released as pre smolt. Marked Hugh Smith Lake sockeye salmon were tracked through the fisheries from 2004 to 2006 when they returned as adults, and contribution estimates were developed using essentially the same methods and analysis as this study. Heinl et al (2007), however, consistently achieved a coefficient of variation averaging 10% or less in fisheries with the largest estimated harvests of stocked Hugh Smith Lake fish. This high precision was partially due to the remarkably high survival rate (range=13–27%) of the thermal marked pre-smolts released at Hugh Smith Lake, which returned in greater numbers than stocked McDonald Lake fish. In comparison, our estimates of smolt-to-adult survival of stocked McDonald fish were 7.5% for BY 2007 and less than 1% for BY 2008 and BY 2009 (Appendix E).

Though similar in concept, the stocking programs at McDonald Lake and Hugh Smith Lake had markedly different release strategies. At Hugh Smith Lake, pre-smolt were reared in nets pens near the lake outlet for 2 to 3 months before they were released in mid-summer; fish overwintered in the lake prior to smolting. Consequently, juvenile sockeye salmon imprinted on the rearing location, far from the primary spawning tributaries, and many returning adults homed to the net pen site where there was no suitable spawning habitat (Piston et al. 2007). As a result, SSRAA changed the release strategy at McDonald Lake to ensure fish homed to the primary spawning area. At McDonald Lake, fish were reared in a hatchery to full-term smolt before being released into the lake next to the inlet stream in spring; they were expected to immediately imprint and emigrate to saltwater with wild smolt. Reasons for the markedly lower survival of stocked fish released at McDonald Lake compared to Hugh Smith Lake are unknown, but could be related to differences in hatchery rearing strategies, release timing, size at release, and early marine migration corridors, or to changes in freshwater and marine environments encountered in the different years these projects were conducted.

In this study, we were only able to estimate harvest of the stocked portion of the run. Since stocked fish represented a relatively minor component of escapements from 2011 to 2014, harvest estimates for stocked fish greatly under estimate the total harvest of wild McDonald Lake sockeye salmon and may not reflect accurate run timing. By systematically sampling the escapement at an adult counting weir, Heinl et al. (2007) observed later run timing for stocked fish than for wild fish at Hugh Smith Lake (2004 and 2005). We were unable to directly compare run timing of wild and stocked sockeye salmon at McDonald Lake; however, proportions of stocked fish in our escapement samples were higher later in the season than earlier in the season (Tables 4–6), potentially pointing to later run timing for stocked fish at McDonald Lake as well.

Theoretically, using proxy fish to determine migration routes, timing, and harvest rates has potentially useful applications. However, this project was expensive to implement and better information is now available through existing region-wide GSI programs. The combined expense of collecting broodstock, feeding and transporting fish, and decoding otoliths from the commercial harvest and escapement exceeded $400,000. If updated information is desired in the future, funding additional tissue sample collection and genetic analysis would be far less costly and labor intensive than implementing a stocking and fishery sampling program and would eliminate uncertainty regarding differences in timing or movement between stocked and wild fish.

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REFERENCES CITED

Bergmann, W. R, S. N. Forbes, S. C. Heinl, B. L. Meredith, A. W. Piston, and S. B. Walker. 2009. McDonald Lake sockeye salmon action plan, 2009. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 1J09-03, Douglas.

Cochran, W.G. 1977. Sampling techniques, 3rd Ed. John Wiley and Sons, New York.

English, K. K., W. J. Gazey, D. Peacock, and G. Oliver. 2004. Assessment of the Canadian and Alaskan sockeye stocks harvested in the northern boundary fisheries using run reconstruction techniques, 1982–2001. Pacific Salmon Commission, Technical Report No. 13, Vancouver.

Gazey, W. J., and K. K. English. 2000. Assessment of sockeye and pink salmon stocks in the northern boundary area using run reconstruction techniques, 1982–1995. Canadian Technical Report of Fisheries and Aquatic Sciences No. 2320, Vancouver.

Geiger, H. J. 1994. A Bayesian approach to estimating hatchery contribution in a series of salmon fisheries. Alaska Fishery Research Bulletin 1:66–75.

Geiger, H. J., M. A. Cartwright, J. H. Clark, J. Conitz, S. C. Heinl, K. Jensen, B. Lewis, A. J. McGregor, R. Riffe, G. Woods, and T. P. Zadina. 2004. Sockeye salmon stock status and escapement goals in Southeast Alaska [*in*] Stock status and escapement goals for salmon stocks in Southeast Alaska. H. J. Geiger and S. McPherson, editors. Alaska Department of Fish and Game, Divisions of Sport and Commercial Fisheries, Special Publication 04-02, Anchorage.

Gelman, A., J. B. Carlin, H. S. Stern, and D. B. Rubin. 2004. Bayesian data analysis, Second Edition. Chapman & Hall, New York.

Gilk-Baumer, S., S. M. Turner, C. Habicht, and S. C. Heinl. 2013. Genetic stock identification of McDonald Lake sockeye salmon in selected Southeast Alaska fisheries, 2007–2009. Alaska Department of Fish and Game, Fishery Manuscript Series No. 13-04, Anchorage.

Hagen, P, K. Munk, B. Van Alen, and B. White. 1995. Thermal mark technology for inseason fisheries management: a case study. Alaska Fishery Research Bulletin 2:143–155.

Heinl, S. C., X. Zhang, and H. J. Geiger. 2007. Distribution and run-timing of Hugh Smith Lake sockeye salmon in the District 101 commercial net fisheries of southern Southeast Alaska, 2004–2006. Alaska Department of Fish and Game, Fishery Manuscript No. 07-03, Anchorage.

Heinl, S. C., D. M. Eggers, and A. W. Piston. 2009. Sockeye salmon mark-recapture and radio-telemetry studies at McDonald Lake in 2007. Alaska Department of Fish and Game, Fishery Data Series No. 09-42, Anchorage.

Henderson, M. A., and A. J. Cass. 1991. Effect of smolt size on smolt-to adult survival for Chilko Lake sockeye salmon (*Oncorhynchus nerka*). Canadian Journal of Fisheries and Aquatic Sciences 48:988–994.

Hoffman, S. H., L. Talley, and M. C. Seibel. 1983. 1982 U.S./Canada research pink and sockeye salmon tagging, interception rates, migration patterns, run timing, and stock intermingling in southern Southeast Alaska and Northern British Columbia. [*In*]: Final Report 1982 salmon research conducted in Southeast Alaska by the Alaska Department of Fish and Game in conjunction with joint U.S.-Canada Interception investigations. Contract No. NASO-82-00134.

Hoffman, Stephen H., Larry Talley, and M. C. Seibel. 1984. 1983 sockeye and chum salmon tagging, notional contribution rates, migration patterns, run timing, and stock intermingling research in southern Southeast Alaska and northern British Columbia. [*In*] Final Report. 1983 salmon research conducted in Southeast Alaska by the Alaska Department of Fish and Game in conjunction with National Marine Fisheries Service Auke Bay Laboratory for joint U.S.-Canada Interception Studies. Contract No. WASC-83-ABC-00157.

Johnson, T., S. C. Heinl, and H. J. Geiger. 2005. McDonald Lake: stock status report and escapement goal recommendations. Alaska Department of Fish and Game, Fishery Manuscript No. 05-07, Anchorage.

Koenings, J. P., H. J. Geiger, and J. J. Hasbrouck. 1993. Smolt-to-adult survival patterns of sockeye salmon (*Oncorhynchus nerka*): effects of smolt length and geographic latitude when entering the sea. Canadian Journal of Fisheries and Aquatic Sciences 50:600–611.

References Cited (Continued)

Olson, R. P. 1989. Effects of lake fertilization on growth of juvenile sockeye salmon (*Oncorhynchus nerka*) in Lake McDonald, Tongass National Forest, Alaska. Masters Thesis. Humboldt State University, Arcata.

Orth, D.J. 1967. Dictionary of Alaska place names. U.S. Government Printing Office, U.S. Geological Survey, Professional Paper 567, Washington D. C.

Piston, A. W., S. C. Heinl, and H. J. Geiger. 2007. Hugh Smith Lake sockeye salmon adult and juvenile studies, 2006. Alaska Department of Fish and Game, Fishery Data Series No. 07-58, Anchorage.

Scott, R. J, R. P. Josephson, P. T. Hagen, B. A. Agler, and J. W. Cashen. 2001. Alaska Department of Fish and Game otolith marking and recovery program. North Pacific Anadromous Fisheries Commission Technical Report No. 3:45–46.

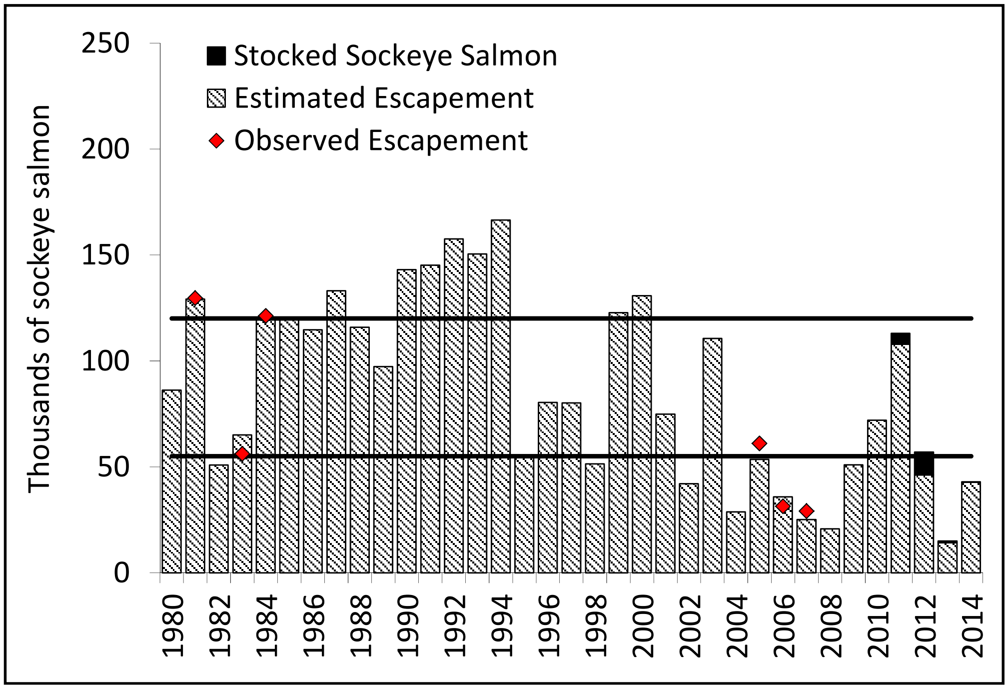
Thompson, S. K. 1992. Sampling. Wiley. New York.

Weiss, N.A. 2002. Introductory Statistics. Sixth Edition. Addison-Wesley, USA.

Zadina, T. P., and S. C. Heinl. 1999. Limnological and fisheries investigations at McDonald Lake, Southeast Alaska, 1998. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 1J99-15, Juneau.

APPENDICES

Appendix A.–Estimated McDonald Lake sockeye salmon spawning escapement, 1980–2014, with the stocked portion of the 2011–2014 escapement shown as black bars. Bold black lines represent the current sustainable escapement goal range of 55,000 to 120,000 spawners.



Appendix B.–ADF&G statistical week calendar start and end dates, 2011–2014.

Statistical Week	2011		2012		2013		2014	
	Start	End	Start	End	Start	End	Start	End
25	12-Jun	18-Jun	17-Jun	23-Jun	16-Jun	22-Jun	15-Jun	21-Jun
26	19-Jun	25-Jun	24-Jun	30-Jun	23-Jun	29-Jun	22-Jun	28-Jun
27	26-Jun	2-Jul	1-Jul	7-Jul	30-Jun	6-Jul	29-Jun	5-Jul
28	3-Jul	9-Jul	8-Jul	14-Jul	7-Jul	13-Jul	6-Jul	12-Jul
29	10-Jul	16-Jul	15-Jul	21-Jul	14-Jul	20-Jul	13-Jul	19-Jul
30	17-Jul	23-Jul	22-Jul	28-Jul	21-Jul	27-Jul	20-Jul	26-Jul
31	24-Jul	30-Jul	29-Jul	4-Aug	28-Jul	3-Aug	27-Jul	2-Aug
32	31-Jul	6-Aug	5-Aug	11-Aug	4-Aug	10-Aug	3-Aug	9-Aug
33	7-Aug	13-Aug	12-Aug	18-Aug	11-Aug	17-Aug	10-Aug	16-Aug
34	14-Aug	20-Aug	19-Aug	25-Aug	18-Aug	24-Aug	17-Aug	23-Aug
35	21-Aug	27-Aug	26-Aug	1-Sep	25-Aug	31-Aug	24-Aug	30-Aug
36	28-Aug	3-Sep	2-Sep	8-Sep	1-Sep	7-Sep	31-Aug	6-Sep
37	4-Sep	10-Sep	9-Sep	15-Sep	8-Sep	14-Sep	7-Sep	13-Sep
38	11-Sep	17-Sep	16-Sep	22-Sep	15-Sep	21-Sep	14-Sep	20-Sep
39	18-Sep	24-Sep	23-Sep	29-Sep	22-Sep	28-Sep	21-Sep	27-Sep
40	25-Sep	1-Oct	30-Sep	6-Oct	29-Sep	5-Oct	28-Sep	4-Oct

Appendix C.–Weekly sockeye salmon harvest, otolith sample size (*n*), estimated proportion, 95% credible interval, and contribution of thermal marked McDonald Lake sockeye salmon in the commercial drift gillnet fisheries, 2011–2014. Boldfaced values were imputed.

Year	Subdistrict	Statistical Week	Total Harvest	*n*	Thermal Marked McDonald Lake Sockeye salmon	Estimated Proportion	95% CI Lower	95% CI Upper	Estimated Contribution
2011	101-11	26	8,853	257	0	0.0%	0.0%	0.3%	4
2011	101-11	27	21,319	252	0	0.0%	0.0%	0.4%	10
2011	101-11	28	10,013	246	0	0.0%	0.0%	0.4%	5
2011	101-11	29	9,290	245	0	0.0%	0.0%	0.4%	4
2011	101-11	30	8,686	219	0	0.0%	0.0%	0.4%	4
2011	101-11	31	8,564	290	1	0.3%	0.0%	0.9%	23
2011	101-11	32	16,143	250	0	0.0%	0.0%	0.4%	7
2011	101-11	33	3,821	238	0	0.0%	0.0%	0.4%	2
2011	101-11	34	671	239	2	0.6%	0.1%	1.5%	4
2011	101-11	35	384	179	0	0.1%	0.0%	0.4%	0
2011	101-11	36–39	874	0	–	**0.1%**	**0.0%**	**0.9%**	**1**
2011	101-11	Total	88,618	2,415	3	0.1%	0.0%	0.2%	63
2012	101-11	25	21,695	260	0	0.1%	0.0%	0.6%	32
2012	101-11	26	13,083	253	0	0.1%	0.0%	0.7%	20
2012	101-11	27	9,305	258	0	0.1%	0.0%	0.7%	14
2012	101-11	28	7,553	260	2	0.6%	0.1%	1.5%	45
2012	101-11	29	2,475	257	2	0.6%	0.1%	1.5%	15
2012	101-11	30	2,643	261	3	0.8%	0.2%	1.8%	21
2012	101-11	31	2,826	255	1	0.4%	0.0%	1.1%	11
2012	101-11	32	1,517	260	1	0.4%	0.0%	1.1%	6
2012	101-11	33	642	253	0	0.1%	0.0%	0.7%	1
2012	101-11	34	262	168	0	0.2%	0.0%	0.8%	0
2012	101-11	35–38	341	0	–	**0.3%**	**0.0%**	**1.5%**	**1**
2012	101-11	Total	62,342	2,485	9	0.3%	0.1%	0.4%	165
2013	101-11	25	9,082	256	0	0.0%	0.0%	0.2%	2
2013	101-11	26	12,186	258	0	0.0%	0.0%	0.2%	2
2013	101-11	27	7,267	298	0	0.0%	0.0%	0.2%	1
2013	101-11	28	5,507	263	0	0.0%	0.0%	0.2%	1
2013	101-11	29	6,559	261	0	0.0%	0.0%	0.2%	1
2013	101-11	30	5,790	260	0	0.0%	0.0%	0.2%	1
2013	101-11	31	5,130	262	0	0.0%	0.0%	0.2%	1
2013	101-11	32	1,684	237	1	0.2%	0.0%	0.8%	4
2013	101-11	33	662	186	0	0.0%	0.0%	0.2%	0

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Year	Subdistrict	Statistical Week	Total Harvest	*n*	Thermal Marked McDonald Lake Sockeye salmon	Estimated Proportion	95% CI Lower	95% CI Upper	Contribution
2013	101-11	34	477	96	0	0.0%	0.0%	0.3%	0
2013	101-11	35–39	234	0	–	**0.0%**	**0.0%**	**0.4%**	**0**
2013	101-11	Total	54,578	2,377	1	0.0%	0.0%	0.1%	15
2011	106-30	25	481	172	0	0.3%	0.0%	1.2%	1
2011	106-30	26	2,072	410	0	0.1%	0.0%	0.6%	3
2011	106-30	27	5,775	417	0	0.1%	0.0%	0.6%	8
2011	106-30	28	4,482	507	0	0.1%	0.0%	0.5%	5
2011	106-30	29	5,471	505	1	0.3%	0.0%	0.9%	16
2011	106-30	30	6,227	457	3	0.7%	0.2%	1.5%	43
2011	106-30	31	5,041	499	6	1.2%	0.5%	2.2%	58
2011	106-30	32	10,071	508	12	2.2%	1.1%	3.5%	217
2011	106-30	33	12,205	481	13	2.4%	1.3%	3.9%	298
2011	106-30	34	836	382	5	1.2%	0.4%	2.4%	10
2011	106-30	35–38	1,452	0	**–**	**0.8%**	**0.0%**	**3.7%**	**12**
2011	106-30	Total	54,113	4,338	40	1.2%	0.9%	1.6%	671
2012	106-30	25	636	336	0	0.4%	0.0%	1.2%	3
2012	106-30	26	174	73	0	1.3%	0.1%	3.9%	2
2012	106-30	27	2,520	512	3	0.8%	0.2%	1.7%	20
2012	106-30	28	2,643	488	11	2.3%	1.2%	3.8%	62
2012	106-30	29	2,522	498	11	2.3%	1.2%	3.7%	58
2012	106-30	30	4,278	503	32	6.1%	4.3%	8.2%	261
2012	106-30	31	1,276	500	28	5.4%	3.7%	7.4%	69
2012	106-30	32	729	232	12	4.8%	2.7%	7.7%	35
2012	106-30	33	659	174	11	5.7%	3.0%	9.1%	37
2012	106-30	34	186	77	3	3.6%	1.1%	7.6%	7
2012	106-30	35–38	88	0	**–**	**3.2%**	**0.2%**	**9.8%**	**3**
2012	106-30	Total	15,711	3,393	111	3.5%	2.9%	4.2%	557
2013	106-30	25	240	237	0	0.2%	0.0%	0.8%	1
2013	106-30	26	1,047	287	0	0.2%	0.0%	0.7%	2
2013	106-30	27	2,759	284	1	0.4%	0.0%	1.1%	11
2013	106-30	28	2,425	289	1	0.4%	0.0%	1.1%	10
2013	106-30	29	4,911	288	2	0.6%	0.1%	1.4%	30
2013	106-30	30	2,804	280	2	0.6%	0.1%	1.5%	17
2013	106-30	31	1,765	281	4	1.0%	0.3%	2.1%	18

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Appendix C.–Page 3 of 6.

Year	Subdistrict	Statistical Week	Total Harvest	*n*	Thermal Marked McDonald Lake Sockeye salmon	Estimated Proportion	95% CI Lower	95% CI Upper	Contribution
2013	106-30	32	638	138	1	0.6%	0.1%	1.6%	4
2013	106-30	33	244	19	0	0.4%	0.0%	1.6%	1
2013	106-30	34–38	290	0	–	**0.5%**	**0.0%**	**1.7%**	**1**
2013	106-30	Total	17,123	2,103	11	0.5%	0.3%	0.8%	94
2014	106-30	25	535	117	0	0.2%	0.0%	0.8%	1
2014	106-30	26	897	191	0	0.1%	0.0%	0.6%	1
2014	106-30	27	2,029	292	0	0.1%	0.0%	0.5%	2
2014	106-30	28	5,600	290	0	0.1%	0.0%	0.5%	6
2014	106-30	29	3,681	295	2	0.5%	0.1%	1.3%	18
2014	106-30	30	5,083	293	0	0.1%	0.0%	0.5%	5
2014	106-30	31	1,099	287	0	0.1%	0.0%	0.5%	1
2014	106-30	32	7,744	296	1	0.3%	0.0%	0.9%	23
2014	106-30	33	1,018	260	2	0.5%	0.1%	1.4%	5
2014	106-30	34	1,894	294	2	0.5%	0.1%	1.3%	9
2014	106-30	35–39	807	0	–	**0.2%**	**0.0%**	**1.2%**	**3**
2014	106-30	Total	30,387	2,615	7	0.2%	0.1%	0.4%	75
2011	106-41	25	1,549	300	0	0.1%	0.0%	0.5%	1
2011	106-41	26	10,617	456	0	0.1%	0.0%	0.4%	6
2011	106-41	27	26,345	510	0	0.1%	0.0%	0.3%	14
2011	106-41	28	13,983	239	0	0.1%	0.0%	0.6%	14
2011	106-41	29	8,365	375	0	0.1%	0.0%	0.4%	6
2011	106-41	30	5,617	198	0	0.1%	0.0%	0.7%	6
2011	106-41	31	8,249	79	1	1.0%	0.1%	3.2%	81
2011	106-41	32	8,384	418	12	2.6%	1.4%	4.2%	219
2011	106-41	33	5,544	210	4	1.6%	0.5%	3.5%	91
2011	106-41	34	1,225	62	0	0.3%	0.0%	1.6%	3
2011	106-41	35	798	199	0	0.1%	0.0%	0.7%	1
2011	106-41	36–40	1,280	0	–	**0.5%**	**0.0%**	**3.5%**	**8**
2011	106-41	Total	91,956	3,046	17	0.5%	0.2%	0.7%	448

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Year	Subdistrict	Statistical Week	Total Harvest	*n*	Thermal Marked McDonald Lake Sockeye salmon	Estimated Proportion	95% CI Lower	95% CI Upper	Contribution
2012	106-41	25	3,019	380	0	0.3%	0.0%	1.0%	9
2012	106-41	26	3,815	398	0	0.3%	0.0%	0.9%	11
2012	106-41	27	4,821	516	6	1.3%	0.5%	2.4%	62
2012	106-41	28	3,124	260	10	3.6%	1.8%	6.0%	113
2012	106-41	29	6,656	277	15	5.0%	2.9%	7.5%	330
2012	106-41	30	5,261	517	20	3.7%	2.3%	5.4%	197
2012	106-41	31	1,529	488	17	3.4%	2.0%	5.1%	52
2012	106-41	32	989	238	10	3.9%	2.0%	6.4%	38
2012	106-41	33	314	27	0	1.6%	0.1%	5.3%	5
2012	106-41	34–39	227	0	–	**2.4%**	**0.1%**	**8.0%**	**6**
2012	106-41	Total	29,755	3,101	78	2.8%	2.1%	3.4%	821
2013	106-41	25	3,971	0	–	**0.0%**	**0.0%**	**0.0%**	**0**
2013	106-41	26	4,966	298	0	0.0%	0.0%	0.0%	0
2013	106-41	27	6,414	299	0	0.0%	0.0%	0.0%	0
2013	106-41	28	6,089	299	0	0.0%	0.0%	0.0%	0
2013	106-41	29	4,449	80	0	0.0%	0.0%	0.0%	0
2013	106-41	30	2,382	300	0	0.0%	0.0%	0.0%	0
2013	106-41	31	2,111	49	0	0.0%	0.0%	0.0%	0
2013	106-41	32	794	299	0	0.0%	0.0%	0.0%	0
2013	106-41	33	564	72	0	0.0%	0.0%	0.0%	0
2013	106-41	34–40	360	0	–	**0.0%**	**0.0%**	**0.0%**	**0**
2013	106-41	Total	32,100	1,696	0	0.0%	0.0%	0.0%	0
2014	106-41	25	2,683	275	0	0.1%	0.0%	0.5%	2
2014	106-41	26	1,729	28	0	0.2%	0.0%	1.0%	3
2014	106-41	27	3,189	289	0	0.1%	0.0%	0.5%	3
2014	106-41	28	5,064	300	2	0.5%	0.1%	1.3%	25
2014	106-41	29	4,477	298	0	0.1%	0.0%	0.4%	4
2014	106-41	30	4,213	298	0	0.1%	0.0%	0.4%	3
2014	106-41	31	2,446	299	2	0.5%	0.1%	1.3%	12
2014	106-41	32	3,664	300	0	0.1%	0.0%	0.4%	3
2014	106-41	33	1,124	299	2	0.5%	0.1%	1.3%	5
2014	106-41	34	2,986	240	0	0.1%	0.0%	0.5%	3
2014	106-41	35–39	1,303	0	–	**0.2%**	**0.0%**	**1.1%**	**3**
2014	106-41	Total	32,878	2,626	6	0.2%	0.1%	0.3%	65

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Year	District	Statistical Week	Total Harvest	*n*	Thermal Marked McDonald Lake Sockeye salmon	Estimated Proportion	95% CI Lower	95% CI Upper	Contribution
2011	108	26	5,300	500	0	0.0%	0.0%	0.2%	1
2011	108	27	19,809	519	0	0.0%	0.0%	0.2%	4
2011	108	28	10,625	519	0	0.0%	0.0%	0.2%	2
2011	108	29	4,620	448	0	0.0%	0.0%	0.2%	1
2011	108	30	3,585	409	0	0.0%	0.0%	0.2%	1
2011	108	31	2,401	516	0	0.0%	0.0%	0.2%	0
2011	108	32	808	258	0	0.0%	0.0%	0.3%	0
2011	108	33	526	113	0	0.1%	0.0%	0.6%	0
2011	108	34	136	62	1	0.9%	0.0%	3.2%	1
2011	108	35–39	160	0	–	**0.2%**	**0.0%**	**1.7%**	**0**
2011	108	Total	47,970	3,344	1	0.0%	0.0%	0.1%	11
2012	108	21	3	0	–	**0.1%**	**0.0%**	**0.5%**	**0**
2012	108	25	3,146	419	0	0.0%	0.0%	0.2%	1
2012	108	26	2,545	419	0	0.0%	0.0%	0.2%	0
2012	108	27	3,913	446	0	0.0%	0.0%	0.2%	1
2012	108	28	3,469	338	0	0.0%	0.0%	0.2%	1
2012	108	29	2,721	417	2	0.3%	0.0%	0.9%	9
2012	108	30	2,488	299	0	0.0%	0.0%	0.2%	1
2012	108	31	684	77	0	0.0%	0.0%	0.4%	0
2012	108	32	232	73	0	0.0%	0.0%	0.4%	0
2012	108	33	89	36	0	0.0%	0.0%	0.4%	0
2012	108	34–37	44	0	–	**0.1%**	**0.0%**	**0.5%**	**0**
2012	108	Total	19,334	2,524	2	0.1%	0.0%	0.1%	13
2013	108	25	1,721	298	0	0.0%	0.0%	0.2%	0
2013	108	26	4,990	520	0	0.0%	0.0%	0.1%	1
2013	108	27	4,438	203	0	0.0%	0.0%	0.2%	1
2013	108	28	2,124	344	0	0.0%	0.0%	0.2%	0
2013	108	29	2,637	375	0	0.0%	0.0%	0.2%	0
2013	108	30	1,266	298	1	0.2%	0.0%	0.7%	2
2013	108	31	731	295	0	0.0%	0.0%	0.2%	0
2013	108	32	445	134	0	0.0%	0.0%	0.2%	0
2013	108	33	249	95	0	0.0%	0.0%	0.3%	0
2013	108	34–36	137	0	–	**0.0%**	**0.0%**	**0.4%**	**0**
2013	108	Total	18,738	2,562	1	0.0%	0.0%	0.1%	6

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Year	District	Statistical Week	Total Harvest	*n*	Thermal Marked McDonald Lake Sockeye salmon	Estimated Proportion	95% CI Lower	95% CI Upper	Contribution
2014	108[a]	25	857	118	0	0.1%	0.0%	0.6%	1
2014	108	26	1,587	179	0	0.1%	0.0%	0.5%	1
2014	108	27	2,990	197	2	0.7%	0.1%	1.8%	20
2014	108	28	886	88	0	0.1%	0.0%	0.7%	1
2014	108	29	433	209	0	0.1%	0.0%	0.4%	0
2014	108	30	397	254	1	0.3%	0.0%	1.1%	1
2014	108	31	59	12	0	0.1%	0.0%	1.1%	0
2014	108	32	198	38	0	0.1%	0.0%	0.9%	0
2014	108	33	9	0	–	**0.2%**	**0.0%**	**1.2%**	**0**
2014	108	34	2	8	0	0.1%	0.0%	1.1%	0
2014	108	35–36	16	0	–	**0.2%**	**0.0%**	**1.2%**	**0**
2014	108	Total	7,434	1,103	3	0.3%	0.0%	0.7%	25

[a] Sockeye salmon harvest and contribution estimates for Subdistricts 108-30 and 108-40 only.

Appendix D.–Weekly sockeye salmon harvest, otolith sample size (*n*), estimated proportion, 95% credible interval, and contribution of thermal marked McDonald Lake sockeye salmon in the commercial purse seine fisheries, 2011–2013. Boldfaced values were imputed.

Year	Subdistrict	Statistical Week	Total Harvest	*n*	Thermal Marked McDonald Lake Sockeye salmon	Estimated Proportion	95% CI Lower	95% CI Upper	Contribution
2011	101-23/41	28	2,869	89	0	0.2%	0.0%	1.1%	5
2011	101-23/41	29	435	0	–	**0.3%**	**0.0%**	**2.0%**	**1**
2011	101-23/41	30	3,293	99	1	0.7%	0.0%	2.2%	22
2011	101-23/41	31	336	0	–	**0.3%**	**0.0%**	**2.0%**	**1**
2011	101-23/41	32	718	95	0	0.2%	0.0%	1.0%	1
2011	101-23/41	33	129	0	–	**0.3%**	**0.0%**	**2.0%**	**0**
2011	101-23/41	Total	7,780	283	1	0.4%	-0.1%	0.9%	32
2012	101-23/41	27	1,627	78	0	1.0%	0.0%	3.6%	16
2012	101-23/41	28	24	0	–	**4.1%**	**0.1%**	**14.3%**	**1**
2012	101-23/41	29	1,047	149	3	2.3%	0.6%	5.0%	24
2012	101-23/41	30	4,345	178	8	4.4%	2.1%	7.7%	193
2012	101-23/41	31	1,697	28	1	3.8%	0.5%	10.3%	65
2012	101-23/41	32	297	0	–	**4.1%**	**0.1%**	**14.3%**	**12**
2012	101-23/41	33–34	83	39	0	7.8%	2.6%	15.5%	5
2012	101-23/41	Total	9,120	472	16	3.5%	1.8%	5.2%	317
2013	101-23/41	28	3,100	96	2	1.7%	0.3%	4.4%	54
2013	101-23/41	29	5,963	95	0	0.4%	0.0%	1.9%	24
2013	101-23/41	30	5,282	96	0	0.4%	0.0%	1.9%	21
2013	101-23/41	31	3,744	97	0	0.4%	0.0%	1.8%	15
2013	101-23/41	32	1,192	140	0	0.3%	0.0%	1.4%	4
2013	101-23/41	33	570	103	3	2.3%	0.6%	5.2%	13
2013	101-23/41	34	451	35	1	1.8%	0.2%	5.4%	8
2013	101-23/41	35–36	73	0	–	**1.1%**	**0.0%**	**5.1%**	**1**
2013	101-23/41	Total	20,375	662	6	0.7%	0.1%	1.2%	140
2011	101-25/29	28	298	0	–	**0.7%**	**0.0%**	**3.0%**	**2**
2011	101-25/29	29	189	39	0	0.5%	0.0%	2.2%	1
2011	101-25/29	30	2,798	195	1	0.6%	0.1%	1.7%	16
2011	101-25/29	31	3,236	0	–	**0.7%**	**0.0%**	**3.0%**	**23**
2011	101-25/29	32	6,154	250	4	1.3%	0.4%	2.8%	82
2011	101-25/29	Total	12,675	484	5	1.0%	0.2%	1.7%	124

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Year	District / Subdistrict	Statistical Week	Total Harvest	*n*	Thermal Marked McDonald Lake Sockeye salmon	Estimated Proportion	95% CI Lower	95% CI Upper	Contribution
2012	101-25/29	28	378	80	0	0.9%	0.0%	3.4%	3
2012	101-25/29	29	12	0	–	**4.0%**	**0.1%**	**14.7%**	**0**
2012	101-25/29	30	1,323	80	0	0.9%	0.0%	3.4%	12
2012	101-25/29	31	3,271	151	14	8.6%	4.9%	13.1%	280
2012	101-25/29	32	2,452	200	11	5.3%	2.8%	8.6%	131
2012	101-25/29	33	1,293	209	4	2.1%	0.7%	4.3%	28
2012	101-25/29	34	437	40	3	6.2%	1.7%	13.3%	27
2012	101-25/29	35	35	0	–	**4.0%**	**0.1%**	**14.7%**	**1**
2012	101-25/29	Total	9,201	760	32	5.3%	3.5%	7.0%	483
2013	101-25/29	25–29	553	0	–	**0.8%**	**0.0%**	**3.6%**	**5**
2013	101-25/29	30	2,716	235	4	1.5%	0.5%	3.0%	40
2013	101-25/29	31	1,597	118	2	1.3%	0.3%	3.3%	21
2013	101-25/29	32	177	20	0	0.7%	0.0%	2.9%	1
2013	101-25/29	33	229	70	0	0.5%	0.0%	2.0%	1
2013	101-25/29	34–36	737	0	–	**0.8%**	**0.0%**	**3.6%**	**7**
2013	101-25/29	Total	6,009	443	6	1.2%	0.5%	2.0%	75
2011	102	26	164	40	0	0.2%	0.0%	0.9%	0
2011	102	27	3,860	251	0	0.1%	0.0%	0.5%	3
2011	102	28	3,751	248	0	0.1%	0.0%	0.5%	3
2011	102	29	11,535	256	0	0.1%	0.0%	0.5%	10
2011	102	30	7,417	235	1	0.3%	0.0%	1.0%	23
2011	102	31	2,201	235	1	0.3%	0.0%	1.0%	7
2011	102	32	7,007	257	2	0.5%	0.1%	1.3%	36
2011	102	33	23	0	–	**0.2%**	**0.0%**	**1.0%**	**0**
2011	102	34	178	72	0	0.1%	0.0%	0.8%	0
2011	102	35	708	190	0	0.1%	0.0%	0.5%	1
2011	102	36–40	2,132	0	–	**0.2%**	**0.0%**	**1.0%**	**4**
2011	102	Total	38,976	1,784	4	0.2%	0.0%	0.4%	86
2012	102	25	2,320	80	0	0.5%	0.0%	2.0%	10
2012	102	26	1,191	234	0	0.2%	0.0%	1.0%	3
2012	102	27	7,548	259	1	0.5%	0.0%	1.5%	38
2012	102	28	5,512	214	1	0.6%	0.1%	1.8%	33
2012	102	29	4,821	259	0	0.2%	0.0%	0.9%	10
2012	102	30	3,888	259	10	3.3%	1.6%	5.4%	127

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Year	District	Statistical Week	Total Harvest	*n*	Thermal Marked McDonald Lake Sockeye salmon	Estimated Proportion	95% CI Lower	95% CI Upper	Contribution
2012	102	31	9,678	258	2	0.8%	0.1%	2.0%	79
2012	102	32	6,272	279	3	1.1%	0.3%	2.4%	66
2012	102	33	1,726	236	4	1.5%	0.5%	3.2%	27
2012	102	34	527	64	1	1.3%	0.1%	3.7%	7
2012	102	35–38	79	0	–	**1.0%**	**0.0%**	**4.3%**	**1**
2012	102	Total	43,562	2,142	22	0.9%	0.5%	1.3%	400
2013	102	25–26	3,693	0	–	**0.0%**	**0.0%**	**0.4%**	**2**
2013	102	27	7,633	260	0	0.0%	0.0%	0.2%	2
2013	102	28	9,108	255	1	0.2%	0.0%	0.8%	20
2013	102	29	2,385	80	0	0.0%	0.0%	0.3%	1
2013	102	30	4,795	264	0	0.0%	0.0%	0.2%	1
2013	102	31	6,798	259	0	0.0%	0.0%	0.2%	2
2013	102	32	2,970	93	0	0.0%	0.0%	0.3%	1
2013	102	33	1,204	104	0	0.0%	0.0%	0.3%	0
2013	102	34	1,076	166	0	0.0%	0.0%	0.3%	0
2013	102	35–37	922	0	–	**0.0%**	**0.0%**	**0.4%**	**0**
2013	102	Total	40,584	1,481	1	0.1%	0.0%	0.2%	30
2012	103	31–32	1,621	0	–	**0.0%**	**0.0%**	**0.0%**	**0**
2012	103	33	1,341	50	0	0.0%	0.0%	0.0%	0
2012	103	34	355	75	0	0.0%	0.0%	0.0%	0
2012	103	Total	3,317	125	0	0.0%	0.0%	0.0%	0
2013	103	30–32	4,160	0	–	**0.0%**	**0.0%**	**0.0%**	**0**
2013	103	33	1,684	18	0	0.0%	0.0%	0.0%	0
2013	103	34	1,356	49	0	0.0%	0.0%	0.0%	0
2013	103	35–36	892	0	–	**0.0%**	**0.0%**	**0.0%**	**0**
2013	103	Total	8,092	67	0	0.0%	0.0%	0.0%	0
2011	104	28	2,130	0	–	**0.2%**	**0.0%**	**1.6%**	**4**
2011	104	29	9,287	37	0	0.1%	0.0%	1.1%	11
2011	104	30	13,863	80	1	0.7%	0.0%	2.5%	100
2011	104	31	37,917	119	0	0.1%	0.0%	0.6%	27
2011	104	32	109,375	290	0	0.0%	0.0%	0.3%	42
2011	104	33	23,091	126	0	0.1%	0.0%	0.6%	16
2011	104	34	2,403	40	0	0.1%	0.0%	1.0%	3
2011	104	35	2,480	40	0	0.1%	0.0%	1.0%	3

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Year	District	Statistical Week	Total Harvest	*n*	Thermal Marked McDonald Lake Sockeye salmon	Estimated Proportion	95% CI Lower	95% CI Upper	Contribution
2011	104	36–37	1,958	0	–	**0.2%**	**0.0%**	**1.6%**	**3**
2011	104	Total	202,504	732	1	0.1%	-0.1%	0.3%	209
2012	104	27	372	0	–	**0.9%**	**0.0%**	**6.5%**	**3**
2012	104	28	1,504	78	0	0.2%	0.0%	1.6%	3
2012	104	29	8,488	40	2	3.4%	0.5%	9.0%	291
2012	104	30	7,936	129	2	1.5%	0.2%	3.8%	115
2012	104	31	8,184	115	0	0.2%	0.0%	1.2%	14
2012	104	32	26,728	130	0	0.2%	0.0%	1.1%	41
2012	104	33	13,946	226	0	0.1%	0.0%	0.7%	13
2012	104	34	4,636	34	0	0.4%	0.0%	2.8%	18
2012	104	35	599	0	–	**0.9%**	**0.0%**	**6.5%**	**6**
2012	104	Total	72,393	752	4	0.7%	0.1%	1.3%	505
2013	104	28	5,152	159	1	0.4%	0.0%	1.3%	19
2013	104	29	3,250	122	0	0.1%	0.0%	0.4%	2
2013	104	30	4,700	179	0	0.0%	0.0%	0.4%	2
2013	104	31	11,408	180	0	0.0%	0.0%	0.4%	5
2013	104	32	15,995	171	0	0.0%	0.0%	0.4%	7
2013	104	33	25,454	227	0	0.0%	0.0%	0.3%	9
2013	104	34	10,873	163	0	0.0%	0.0%	0.4%	5
2013	104	35–36	6,050	0	–	**0.1%**	**0.0%**	**0.8%**	**6**
2013	104	Total	82,882	1,201	1	0.1%	0.0%	0.2%	54
2013	105	30	32	10	0	0.0%	0.0%	0.0%	0
2013	105	31	193	0	–	**0.0%**	**0.0%**	**0.0%**	**0**
2013	105	32	33	15	0	0.0%	0.0%	0.0%	0
2013	105	33	5	0	–	**0.0%**	**0.0%**	**0.0%**	**0**
2013	105	34	144	14	0	0.0%	0.0%	0.0%	0
2013	105	35–36	13	0	–	**0.0%**	**0.0%**	**0.0%**	**0**
2013	105	Total	420	39	0	0.0%	0.0%	0.0%	0
2012	107	27	91	96	0	0.3%	0.0%	1.6%	0
2012	107	28–31	4,026	0	–	**0.8%**	**0.0%**	**4.0%**	**32**
2012	107	32	575	191	3	1.4%	0.3%	3.1%	8
2012	107	33–35	345	0	–	**0.8%**	**0.0%**	**4.0%**	**3**
2012	107	Total	5,037	287	3	0.8%	0.0%	1.8%	43

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Year	District	Statistical Week	Total Harvest	*n*	Thermal Marked McDonald Lake Sockeye salmon	Estimated Proportion	95% CI Lower	95% CI Upper	Contribution
2013	107	28	556	107	0	0.1%	0.0%	0.6%	0
2013	107	29	1,306	129	1	0.5%	0.0%	1.6%	6
2013	107	30	1,694	256	0	0.1%	0.0%	0.4%	1
2013	107	31	1,246	0	–	**0.2%**	**0.0%**	**1.2%**	**2**
2013	107	32	478	67	0	0.1%	0.0%	0.8%	0
2013	107	33	232	88	0	0.1%	0.0%	0.7%	0
2013	107	34	341	0	–	**0.2%**	**0.0%**	**1.2%**	**1**
2013	107	Total	5,853	647	1	0.2%	0.0%	0.4%	11

Appendix E.–Description of methods used to allocate harvest and escapement contributions to release groups.

Rough estimates of the total return of each hatchery release group were developed to provide information about the effectiveness of the McDonald Lake stocking program. In order to allocate harvest and escapement contribution estimates to individual release groups and calculate survival estimates, some basic assumptions regarding stocked fish were made:

1. The number of stocked smolt leaving McDonald Lake was equal to the reported number of smolt released (no pre-emigration mortality), and
2. The proportion of marks recovered from each release group was representative of the proportion of adults that returned from each release group.

The total harvest contribution by brood year was calculated by multiplying the estimated and imputed weekly contributions of stocked fish (Appendices C and D) by the proportion of each release group identified in the weekly sample (obtained from the ADF&G Mark, Tag, and Age Lab website (http://mtalab.adfg.alaska.gov/OTO/reports/MarkSummary.aspx), then adding the brood year (BY) contributions across all weeks. Only 1 adult age class returned in 2011 (age-1.2) so all stocked fish that year were attributed to BY 07. For 2012–2014, we expanded the estimated and imputed weekly harvest of stocked fish as described above. For example, in 2012 the estimated contribution of stocked fish in the District 101-outside purse seine fishery in statistical week 31 was 280 fish (Appendix D). The estimated contribution of 280 fish in statistical week 31 was proportioned by brood year contribution (93% from BY07 [260 fish]; 7% from BY08 [20 fish]; 0% from BY09 [0 fish]).

In some cases data were imputed when no marked McDonald Lake fish were recovered and the posterior mean from the Bayesian analysis predicted an estimated harvest of stocked fish. When this occurred, the total annual proportion of recoveries from each release group in that fishery was used to allocate weekly contribution estimates to each release group. For example, in 2012, the estimated contribution of stocked fish to the District 101-outside purse seine fishery in statistical week 30 was 12 fish. Detailed BY contribution information was not available for this week, because no marked fish were recovered in the sample; therefore, annual BY contributions from the District 101-outside purse seine fishery, from a summation of all available statistical weeks (31–34), was used as a proxy for the BY contributions in statistical week 30 (84% BY 2007 [10 fish]; 16% BY 2008 [2 fish]; 0% BY 2009 [0 fish]; Appendix Table E1). BY contributions for statistical weeks 28, 29, and 35 for this fishery were also calculated using this method in 2012 due to the lack of samples or marked fish. Adding across statistical weeks and by BY contribution, 416 fish from District 101-outside purse seine fishery in 2012 were from the BY 2007 release group, 67 fish were from the BY 2008 release group, and 0 fish were from the BY 2009 release group (Appendix Table E1).

After calculating the annual contribution for each fishery and each BY in 2012, the total run was calculated by summing each BY across all fisheries. For example, of the total estimated 3,303 stocked fish harvested in 2012, we estimate 3,215 were from BY 2007 and 88 were from BY 2008 (Appendix Tables E1 and E2). Annual BY contributions of marked McDonald Lake sockeye salmon to the annual escapement and to the commercial harvest in return years 2011, 2013, and 2014 were calculated using similar methods (Appendix Table E2).

The smolt-age at return survival rate was calculated by summing the total estimated commercial harvest and escapement contribution for that year, then dividing the sum by the number of smolt released (Appendix Table E2). For example, the Smolt-Age 1.3 survival for BY 2008 was calculated as (56+164)/160,350=0.1%. Confidence intervals for these survival estimates were not developed due to the scarcity of marks in our samples and large degree of uncertainty around the contribution estimates.

Appendix Table E1.–Example of the annual contribution for each fishery and each release group in 2012. The total return was calculated by summing each BY across all fisheries.

	Percentage			Total Fish				
	BY 2007	BY 2008	BY 2009	BY 2007	BY 2008	BY 2009		% of Total Annual
Fishery	Age 1.3	Age 1.2	Age 1.1	Age 1.3	Age 1.2	Age 1.1	Total	McDonald Lake Harvest
Subdistrict 101-11 Drift Gillnet	100%	0%	0%	165	0	0	165	5%
Subdistrict 106-30 Drift Gillnet	99%	1%	0%	550	6	0	557	17%
Subdistrict 106-41 Drift Gillnet	100%	0%	0%	821	0	0	821	25%
District 108 Drift Gillnet	100%	0%	0%	13	0	0	13	0%
District 101-inside Purse Seine	100%	0%	0%	317	0	0	317	10%
District 101-outside Purse Seine	84%	16%	0%	416	67	0	483	15%
District 102 Purse Seine	97%	3%	0%	387	14	0	400	12%
District 104 Purse Seine	100%	0%	0%	505	0	0	505	15%
District 105 Purse Seine	0%	0%	0%	0	0	0	0	0
District 107 Purse Seine	100%	0%	0%	43	0	0	43	1%
Total	97%	3%	0%	3,215	88	0	3,303	100%

Appendix Table E2.–Estimated total return, survival, and exploitation rates of stocked McDonald Lake sockeye salmon by brood year.

	Brood Year		
	2007	2008	2009
Smolt Released	276,083	160,350	322,700
Commercial Harvest 2011	1,644	0	0
Commercial Harvest 2012	3,215	88	0
Commercial Harvest 2013	15	56	348
Commercial Harvest 2014[a]	0	0	149
Escapement 2011	5,100	0	0
Escapement 2012	10,700	0	0
Escapement 2013	55	164	601
Escapement 2014	0	0	216
Total Return[b]	20,729	307	1,314
Smolt to Age 1.2 Survival Rate	2.4%	0.1%	0.3%
Smolt to Age 1.3 Survival Rate	5.0%	0.1%	0.1%
Smolt to Total Return Survival Rate[b]	7.5%	0.2%	0.4%
Exploitation Rate[b]	23.5%	46.7%	37.8%

[a] Harvest estimates provided for 2014 represent results from District 106 and 108 drift gillnet fisheries exclusively. No other fisheries were sampled in 2014.

[b] Estimated totals are minimums and do not include jacks (ocean age 1.1).