Regional Operational Plan CF.1J.2014.07

Operational Plan: McDonald Lake Sockeye Salmon Escapement and Juvenile Abundance, 2014–2016

by

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and

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September 2014

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

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by

Malika T. Brunette and Andrew W. Piston

Alaska Department of Fish and Game, Division of Commercial Fisheries, Ketchikan

Alaska Department of Fish and Game
Division of Commercial Fisheries

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SIGNATURE PAGE

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PURPOSE

The primary purpose of this project is to provide inseason and total estimates of the sockeye salmon escapement at McDonald Lake by operating a combination video camera and net weir at the outlet. We will also verify the weir count with a concurrent mark-recapture study. During the peak spawning period, foot surveys will be conducted on the spawning grounds at Hatchery Creek so visual estimates may be calibrated to weir counts. We will also estimate the adult age composition of the escapement, and the proportion of stocked, otolith-marked fish on the spawning grounds to evaluate Southern Southeast Regional Aquaculture Association's (SSRAA) sentinel fish stocking program. This project also includes a fall hydroacoustic survey to estimate rearing juvenile sockeye salmon abundance.

Key words: Hatchery Creek, hydroacoustic survey, lake stocking, McDonald Lake, *Oncorhynchus nerka*, otolith, sockeye salmon, video camera.

OBJECTIVES

1. Enumerate the adult salmon escapement through the McDonald Lake net weir, by species.
2. Provide a back-up mark-recapture estimate of the total spawning population of adult (non-jack) sockeye salmon in McDonald Lake with a 0.95 probability that the population estimate will not differ from the true population size by more than 10%. Provide a mark-recapture estimate of the total spawning population of jack sockeye salmon in McDonald Lake.
3. Estimate the age, length, and sex composition of adult sockeye salmon in McDonald Lake with a 0.95 probability that the estimated proportions will not differ from the true proportions by more than 5%.
4. Estimate the sockeye salmon spawning escapement at McDonald Lake using a calibrated peak foot survey estimate.
5. Estimate the proportion of wild and stocked adult sockeye salmon on the spawning grounds in Hatchery Creek with a 0.95 probability that the estimate will not differ from the true population size by more than 5%.
6. Estimate the rearing fall fry population at McDonald Lake through a species-apportioned hydroacoustic estimate of fish abundance such that the estimated coefficient of variation of estimated total fish targets in the lake is no greater than 15%.

BACKGROUND

The McDonald Lake sockeye salmon (*Oncorhynchus nerka*) run is one of the largest in southern Southeast Alaska. This stock contributes substantially to commercial net fisheries in Sumner Strait, Clarence Strait, and West Behm Canal, and is harvested in the Yes Bay personal-use fishery near the outlet stream (Wolverine Creek), and in the fresh water sport fishery (Johnson et al. 2005). Annual sockeye salmon escapements to McDonald Lake have been estimated from weir counts (1981–1984) and through a foot-survey method (1985–2007) based on calibrations from two years of weir counts (1983 and 1984; Johnson et al. 2005). Using information from a recent three-year project aimed at improving the escapement estimation (2005–2007; Heinl et al. 2008, 2009) the Alaska Department of Fish and Game (ADF&G) re-cast estimated historical escapements and updated the escapement goal using spawner-recruit methods in 2009 (Eggers et

al. 2009). The current sustainable escapement goal for McDonald Lake is 55,000–120,000 sockeye salmon.

From 1980 to 2001, estimated sockeye salmon escapements to McDonald Lake were above or within the current escapement goal range in all but two years, however; the run declined after 2001 and estimated escapements were below the sustainable escapement goal range in six of eight years (2001–2008). In 2009, the Alaska Board of Fisheries classified McDonald Lake sockeye salmon a stock of management concern based on recommendations by ADF&G (Eggers et al. 2009), and an action plan intended to reduce commercial harvests of McDonald Lake sockeye salmon through time and area closures in nearby mixed-stock fisheries was implemented (Bergmann et al. 2009). The action plan also outlined potential research projects to improve stock assessment. Over the next three years (2009–2011), McDonald Lake sockeye salmon escapement estimates were within the escapement goal range (Heinl et al. 2011) and the run was de-listed as a stock of management concern at the following Alaska Board of Fisheries meeting in 2012.

Prior to stock of concern designation, Southern Southeast Regional Aquaculture Association (SSRAA) initiated a stocking program intended to supplement future adult escapements and provide current harvest information for McDonald Lake sockeye salmon in mixed-stock commercial fisheries. SSRAA collected eggs from the McDonald Lake sockeye salmon run from 2007 to 2009. These fish were reared to full-term smolt at SSRAA's Burnett Inlet Hatchery and returned to McDonald Lake each spring from 2009 to 2011. Fish were briefly held in net pens located at the mouth of the inlet stream (Hatchery Creek) and were expected to immediately smolt after imprinting on the main spawning channel. All stocked fish were thermal marked so their migration through the commercial fisheries could be tracked when they returned as adults from 2011 through 2014; thus 2014 will be the final year that marked fish will return to the lake. (Sampling commercial fisheries for otolith-marked McDonald Lake sockeye salmon was conducted through a separate study).

Beginning in 2014, we will improve our estimates of the McDonald Lake sockeye salmon escapement by counting fish through a combination video camera and net weir installed at the outlet of the lake. This project will provide more accurate and precise escapement estimates than those currently generated through expanded peak foot survey counts (which have fairly broad 80% confident intervals), and will potentially provide improved inseason information on run size useful for managing fisheries. McDonald Lake is a major contributor to southern Southeast Alaska commercial net fisheries, but the magnitude of the escapement is unknown until foot surveys are conducted on the spawning grounds in mid- to late September, well after the commercial net fisheries have closed. Video-camera weirs, which have been operated successfully elsewhere in Southeast Alaska, allow fish to move unimpeded (sockeye salmon often migrate at night), fish handling is much reduced compared to operation of a traditional picket weir, and net weirs can be used in situations where it would be difficult to operate a traditional picket weir (Van Alen and Mahara 2011; Vinzant et al. 2013).

Here we outline our methods to estimate the magnitude and age, sex, and length (ASL) composition of the sockeye salmon escapement, estimate the proportion of stocked fish in the escapement, and estimate the fall sockeye salmon fry population at McDonald Lake.

STUDY SITE

McDonald Lake (55° 58’ N, 131° 50’ W; Orth 1967) is located on mainland Southeast Alaska, on the northeast side of Cleveland Peninsula, 70 km north of Ketchikan (Figure 1). The lake is organically stained with a surface area of 420 ha, mean depth of 45.6 m, maximum depth of 110 m, and volume of 197 × 10^6 m^3. The primary spawning stream, Hatchery Creek (ADF&G Anadromous Waters Catalog number 101-80-10680-2030), flows southwest 9.6 km to the head of the lake. Movement of salmon into Hatchery Creek is blocked by a barrier falls approximately 1.5 km upstream of the lake. The outlet stream, Wolverine Creek (ADF&G Anadromous Waters Catalog number 101-80-10680), flows south 2.4 km to Yes Bay, in West Behm Canal.

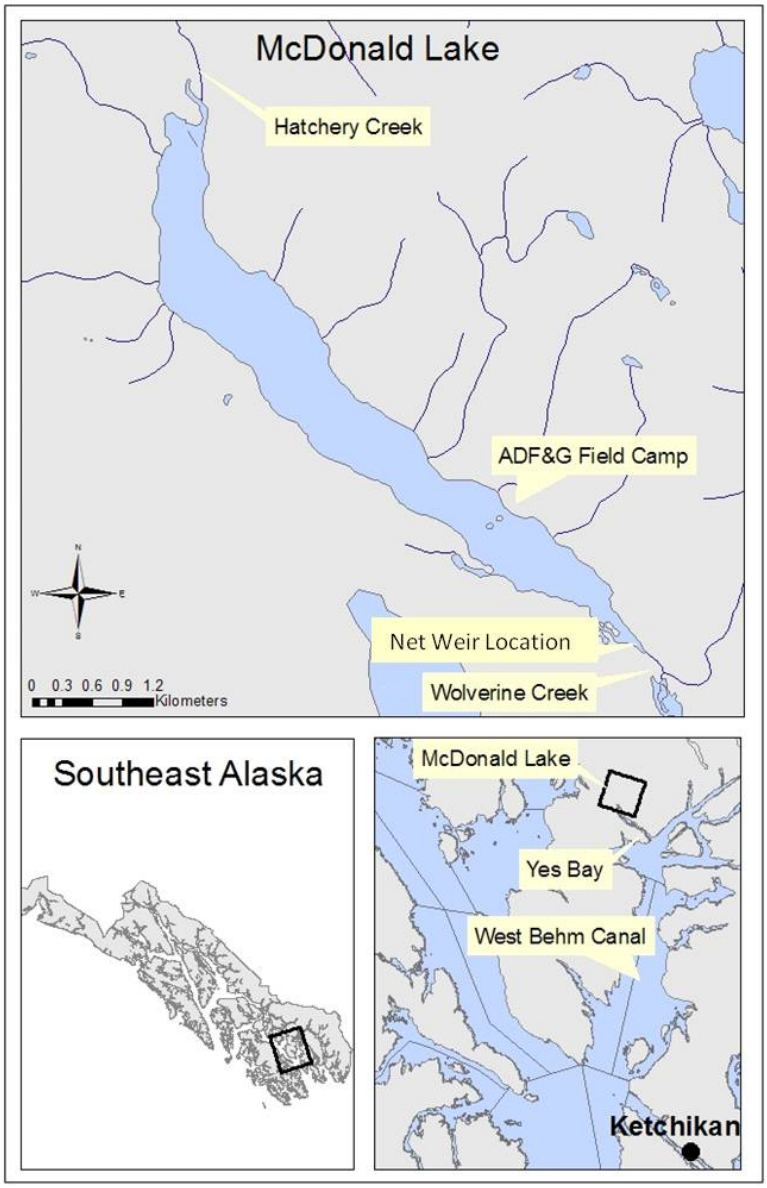

Figure 1.–Map of McDonald Lake, its location in Southeast Alaska with respect to Ketchikan, and the location of the net weir.

METHODS

ESCAPEMENT

Weir Counts

A net weir will be installed at the upper end of Wolverine Creek (outlet stream), approximately 0.16 km downstream of the southernmost end of McDonald Lake and 1.9 km upstream from saltwater. It will span 55 m across Wolverine Creek and will be secured along the streambed with 5/8 anchor chain to a maximum depth of 6 m. The net is constructed with 210/48 × 1.625" stretch black knotless nylon hung on the square with braided black polyester float line and floats along the surface edge. Aqua line runs along the middle of the net as tension line which intersects the upper and lower midlines constructed with floating green weed line and lead line, respectively (Figure 2). The weir will be operated from mid-July to mid-September. Integrity of the weir will be verified by periodic underwater inspections and a secondary mark-recapture study.

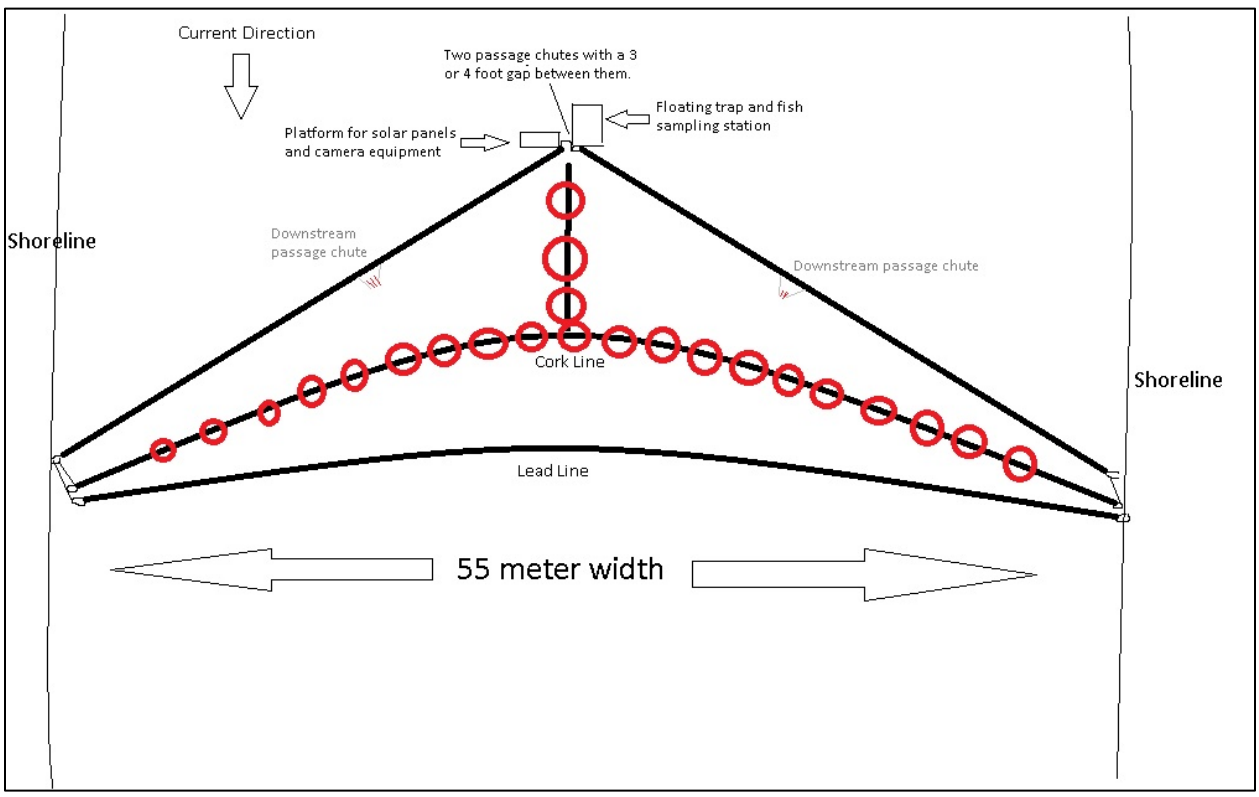

Figure 2.–Basic aerial view diagram of the net weir. Top of figure is facing upstream.

In order to reduce the incidence of fish holding behind the weir and handling-induced stress, nearly all fish will be counted and passed through the weir as they swim freely through a dual-camera chute. Two underwater 3.6 mm color video cameras will be installed on the left and right sides of the video chute to record passing fish (Figure 3). Video cables will transfer data from the cameras to mini-Digital Video Recorders (DVRs) that record motion-detected video files at a rate of 30 frames/sec, and video files will be stored on Secure Digital (SD) memory cards. Each

camera/DVR pair will be wired independently so that if one set fails, the count will not be compromised. The video chute will be lighted continuously by two bright white 25.4 cm, 14-bulb LED light strips. Video systems will be powered by two 140-W solar panels that trickle charge two 100ah Absorption Glass Mat (AGM) 12V DC batteries through a metered 30A charge controller. Solar panels will be positioned to face the midday sun, as best as possible. Mini-DVRs and a 17.8 cm color monitor will be housed in a waterproof Pelican case. Voltage converters will be used to regulate 12V power from the battery to 5V power for the mini-DVRs.

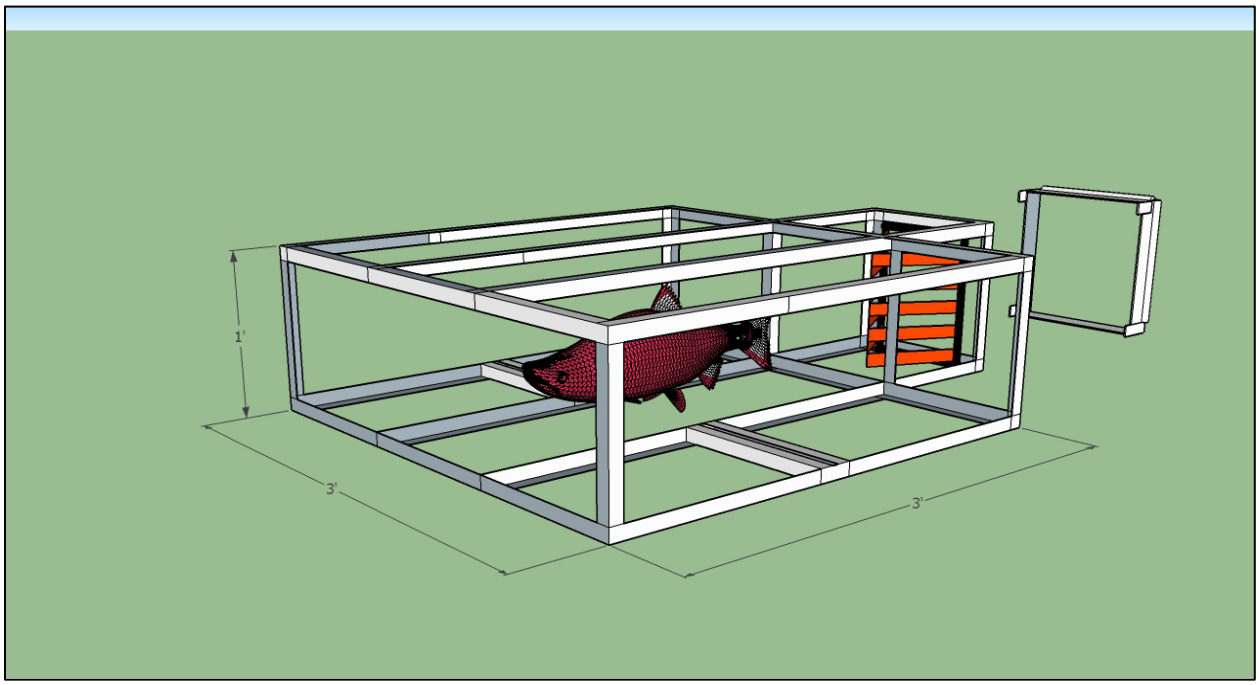

Figure 3.–Aluminum frame of the underwater dual-camera chute. Crab fingers will allow only one or two fish to pass through the chute at a time.

A pair of SD cards (for left and right cameras) will be swapped back and forth daily so the crew can review video data recorded on the SD cards on a laptop computer in camp. Separate counts will be recorded for all fish species recorded by the cameras. Counts by hour by both cameras and any other observations will be recorded on daily data files. At the end of the field season, video files may be reviewed to corroborate inseason counts.

In addition to species enumeration, all sockeye and coho salmon will be counted as either jacks or adults based on size. Sockeye and coho salmon with a mideye to tail fork (MEF) length <400 mm will be considered jacks. There is almost no overlap in size between jack and adult salmon; however, the average size of jacks and adults varies from year to year. The net weir will be operated from mid- July to mid- September when 99% of all sockeye salmon were observed to enter the lake in years when the weir (1981–1984) and fyke nets (2005–2007) were operated.

Mark-Recapture Studies

Two separate and concurrent sockeye salmon mark-recapture studies will be conducted to estimate the total spawning population at McDonald Lake: one for adults and one for jacks. These studies will help determine if sockeye salmon entered the lake before the weir was installed or if they passed through the weir uncounted. Fish will be anesthetized in a clove oil

solution (Woolsey et al. 2004), fin-clipped, scale-sampled, and released upstream into an open net pen to recover. Fish that do not appear healthy will not be marked.

Adults

We will begin marking adult fish at a rate of 1 in 20 (5%) with a readily identifiable fin clip at the weir. Marking will be stratified through time on the following schedule: right ventral fin clip 1 July–8 August, left ventral fin clip 9 August–25 August, and partial dorsal fin clip 26 August–15 September. These dates were chosen to represent the historical average thirds of the run using daily fish passage data in years when the weir and fyke nets were operated.

Jacks

We will mark all (100%) jacks (males ≤ 400 mm) not passed through the camera chute with a readily identifiable partial dorsal fin clip throughout the duration of the field season.

Sample Size

Daily stream surveys will be conducted on the spawning grounds to sample carcasses for marks starting in early September when sockeye salmon begin spawning and dying in significant numbers. All carcasses found on stream surveys, floating in the lake, or that wash up on the weir will also be examined for fin clips. Each previously unexamined fish will be recorded as: 1) an adult or jack; 2) unmarked (no fin clip) or marked; and 3) by the type of fin clip: right ventral, left ventral, or dorsal fin clip. A secondary mark will be applied to fish that have been sampled to prevent re-sampling the same fish on subsequent sampling events: live fish will receive a left operculum hole punch and carcasses will have their tails removed. Our objective is to examine as many sockeye salmon as possible throughout the entire spawning season. Between 2005 and 2007, as many as 12,074 carcasses and as few as 3,905 carcasses were inspected on the spawning grounds for mark-recapture studies (Heinl et al. 2008, 2009). The 2006 and 2007 estimated escapements were only 36,000 and 25,000 fish, respectively, and based on the low escapements in those years, inspecting enough fish to meet our precision goals should be achieved even when the escapement is low. When a population of 69,300 (recent 20-year average wild escapement) is marked at a rate of 5%, a sample size of 6,725 would need to be examined to provide a population estimate with a 0.95 probability that the estimate will not differ from the true population size by more than 10% (Robson and Regier 1964).

Foot Surveys

In addition to weir counts and mark-recapture estimates, the McDonald Lake sockeye salmon escapement will also be estimated by expanding a peak survey estimate by a factor of 4.85. The expansion factor was derived from comparison of the peak foot survey estimate to total escapement estimates for the six years when weir counts or mark-recapture estimates were obtained (Heinl et al. 2009; Model P1). The peak survey count will be determined from three foot surveys of the spawning grounds conducted on approximately the 10th, 20th, and 28th of September. Additional foot surveys will be conducted on sampling trips to collect otoliths. The spawning area is defined as 1.5 km of Hatchery Creek from just upstream of the mouth (GPS coordinates: 55.992° N, 131.844° W) to a location just downstream of the barrier falls (GPS coordinates: 56.002° N, 131.840° W) and includes the old hatchery side channel on the lower section of the creek. Two or three experienced observers will conduct the surveys simultaneously and estimate the number of live and dead fish (of all species) in the study area. The number of live sockeye salmon present will be estimated as the average of the counts of all experienced

surveyors. Survey data will be entered into the ADF&G Southeast Integrated Fisheries database at the end of the field season.

AGE, SEX, AND LENGTH SAMPLING

The age composition of adult sockeye salmon at McDonald Lake will be 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 (1987, 2002) for calculating a sample size to estimate several proportions simultaneously. A sample size of 510 fish is needed to ensure the estimated proportion of each adult sockeye salmon age class will be within 5% of the true value 95% of the time. This sample size is adequate if there are at least three age classes. We increased our scale sample size from 510 to 600 samples to guarantee the sampling goal would be met, even if 15% of the samples were unreadable. A weekly scale sampling schedule was developed, based on historical run timing information from the 1981–1984 weir and 2005–2007 fyke net operations (Table 1). Within each statistical week, scale samples will be collected throughout the week as much as possible. Length, from mideye to tail fork (MEF), and sex information will be recorded for each adult fish sampled. Fish shorter than 400 mm will be counted as jacks and not included in the adult sockeye salmon age composition sample. Three scales will be collected from the preferred area from each fish (INPFC 1963), placed on a gum card, and prepared for analysis as described by Clutter and Whitesel (1956). Scale samples will be analyzed at the ADF&G salmon-aging laboratory in Douglas, Alaska.

Table 1.–Adult sockeye salmon weekly scale sampling schedule.

Statistical Week	2014 Effective Dates	Weekly ASL Goal	Cumulative
27	July 1–5	0	0
28	July 6–12	0	0
29	July 13–19	3	3
30	July 20–26	5	8
31	July 27–August 2	52	60
32	August 3–9	165	224
33	August 10–16	77	302
34	August 17–23	80	381
35	August 24–30	112	493
36	August 31–September 6	81	574
37	September 7–13	15	589
38	September 14–20	11	600
39	September 21–27	0	600
40	September 28–30	0	600

CONTRIBUTION OF STOCKED FISH

We will estimate the proportion of stocked fish in the escapement at Hatchery Creek, the primary spawning tributary at McDonald Lake. Otolith samples will be collected from carcasses throughout the spawning season and the length of the stream. The left and right sagittal otoliths will be removed from each fish and placed into a single cell of a labeled, plastic, 96-cell tray. Otoliths will later be cleaned by soaking in a 0.5% chlorine solution for no more than eight

minutes, followed by a rinse in dechlorinating solution, and a rinse in tap water (Hagen et al. 1995). Otolith samples will be processed and decoded by personnel of the ADF&G Commercial Fisheries Mark Laboratory, Juneau.

Sample Size

To estimate the proportion of hatchery fish in the escapement at Hatchery Creek, the otolith sample size (n) will be calculated using methods described in Thompson (2002). Ignoring the finite population correction factor, because the sample size is small relative to population size, the sample size estimate will be,

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

To obtain an estimator $\hat{p}$ having the probability at least 0.95 of being no farther than d=0.05 from the population proportion, the value of z will be 1.96, which is the upper 0.025 (or $\alpha/2$) limit of the normal distribution. The proportion of hatchery fish in the escapement is unknown, so we will use p = 0.5, which will ensure a sample size sufficient to meet our criteria no matter what the true proportion of hatchery fish is. Using eq. #1, we obtained a sample size of 385 fish. We rounded the sampling goal to 400 otoliths, which will ensure we meet our goal even if a small number of samples are unreadable.

Samples will be 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 apportion the samples by sampling date (Figure 4, Table 2). From 1979 to 2007, standardized foot surveys of Hatchery Creek were conducted to count live sockeye salmon over the entire spawning season, with surveys conducted on or near the same dates each year. The weekly otolith sample size was calculated by multiplying total sample size by the historic average proportion of fish counted for the sampling date. Because the weighting of samples was based on counts of live fish, we then shifted the otolith sampling goals later by one survey date to ensure the availability of dead fish to sample. Sampling goals on each sampling date are as follows: 36 samples on 10 September; 104 samples on 20 September; 128 samples on 28 September; 108 samples on 10 October; and 24 samples on 20 October.

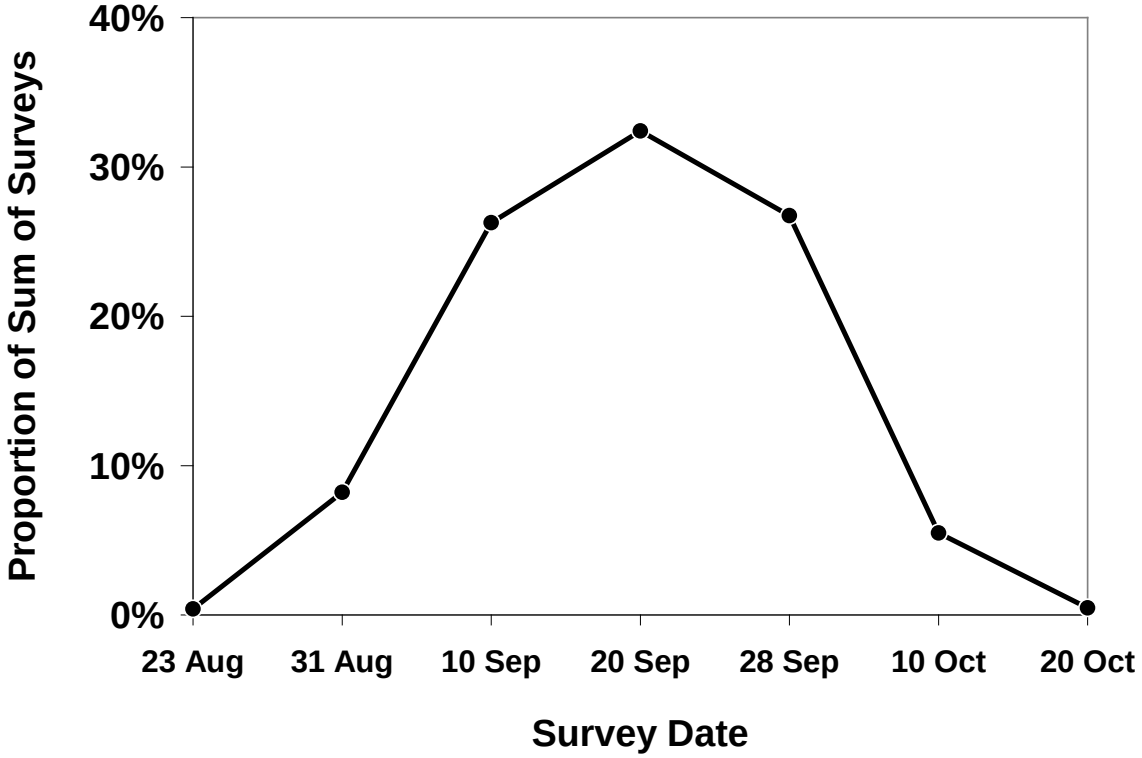

Figure 4.–Mean timing of McDonald Lake sockeye salmon spawning based on historic foot survey estimates, 1979–2007.

Table 2.–Annual foot survey counts of sockeye salmon at McDonald Lake, 1979–2013.

	Survey Date and Number							
Year	23-Aug 1	31-Aug 2	10-Sep 3	20-Sep 4	28-Sep 5	10-Oct 6	20-Oct 7	Sum of Surveys
1979	2	**1,191**[a]	5,010	6,600	**6,732**	**2,395**	**286**	22,215
1980	1,363	**4,714**	19,500	14,775	13,378	**2,119**	**185**	56,034
1981	1,370	2,825	**19,550**	23,050	11,000	1,025	**195**	59,016
1982	0	9,000	13,200	6,100	**7,444**	**1,410**	**123**	37,277
1983	500	3,200	11,500	15,000	8,000	2,500	**531**	41,231
1984	0	12,000	21,600	27,100	24,800	7,100	200	92,800
1985	35	1,425	15,600	27,300	23,890	6,250	**971**	75,471
1986	1,500	9,000	9,200	24,900	25,400	600	**317**	70,917
1987	2	5,000	16,100	**46,030**	**42,530**	27,880	2,800	140,342
1988	20	5,780	25,000	12,500	6,600	700	1	50,601
1989	150	165	13,000	**18,617**	24,000	100	**730**	56,763
1990	3	2,950	23,000	22,780	33,600	2,100	275	84,708
1991	304	30,000	27,770	34,300	27,000	**4,714**	579	124,667
1992	5	5,500	28,300	20,600	**14,948**	5,250	**248**	74,851
1993	4	57	3,950	14,100	37,000	4,300	370	59,781
1994	0	250	11,000	28,600	32,700	6,100	49	78,699
1995	0	918	12,975	16,130	2,260	600	**147**	33,030
1996	315	**2,489**	7,372	16,865	16,300	3,055	41	46,437
1997	0	9,533	11,775	**14,144**	13,900	1,853	128	51,333
1998	225	5,762	11,520	12,793	7,625	5,108	81	43,114
1999	355	5,202	20,557	22,540	15,940	**2,540**	54	67,188
2000	**109**	9,761	17,610	25,605	7,458	**7,325**	84	67,952
2001	213	4,910	11,275	11,656	3,700	207	**106**	32,067
2002	**40**	**1,253**	5,568	8,000	4,405	61	**0**	19,327
2003	40	9,455	15,780	20,353	16,052	5,095	139	66,914
2004	0	44	4,420	**5,434**	5,920	134	3	15,955
2005	42	205	10,200	10,375	**9,839**	3,455	**348**	34,464
2006	2	618	2,853	5,153	3,200	729	15	12,570
2007	21	1,250	6,700	7,100	6,100	630	69	21,870
2008	–[b]	–	3,430	5,430	4,990	–	–	13,850
2009	–	1,500	7,770	–	4,620	–	–	13,890
2010	–	–	13,900	8,320	10,200	–	–	32,420
2011	–	4,000	23,250	–	17,500	2,380	–	47,130
2012	–	–	11,760	9,705	1,250	–	–	22,715
2013	–	–	1,894	3,170	1,330	–	–	6,394
Average Proportion 1979–2007	0.004	0.082	0.263	0.324	0.267	0.055	0.005	1.00

[a] Bold data for 1979–2007 were interpolated for missed surveys (Johnson et al. 2005).
[b] An n-dash (–) means no survey was conducted.

JUVENILE SOCKEYE ABUNDANCE

A hydroacoustic survey will be conducted at McDonald Lake in late fall (early October) to estimate the abundance of rearing sockeye salmon fry. In 2004, McDonald Lake was divided into 10 sampling areas based on surface area, and two replicate, orthogonal transects were randomly

selected from each sampling area. These 20 transects will remain fixed in order to compare annual changes in target density. Hydroacoustic sampling of each transect will be conducted during post-sunset darkness in one night. A Biosonics DT-X™ scientific echosounder (430 kHz, 7.3° split-beam transducer) with Biosonics Visual Acquisition © version 5.0 software will be used to collect data. Ping rate will be set at 5 pings per second and pulse width at 0.2 ms. Surveys will be conducted at a constant boat speed of about 2.0 m per second. A target strength of –40 dB to –70 dB will be used to represent fish within the size range of juvenile sockeye salmon and other small pelagic fish.

A 2 m × 2 m elongated trawl net will be used for pelagic fish sampling. We will conduct at least two trawls at four different depths, ranging from near surface to 15 m, for a total of eight trawls at depth. The trawl depths and duration will be determined from observations of fish densities and distributions throughout the lake during the hydroacoustic survey. Fish will be counted by species and released.

DATA ANALYSIS

ESCAPEMENT

Mark-Recapture Population Estimate

We will use Stratified Population Analysis System (SPAS) software (Arnason et al. 1996) to generate separate mark-recapture estimates of adult sockeye salmon and jack sockeye salmon. The program SPAS was designed for analysis of two-sample mark-recapture data where marks and recoveries take place over a number of strata. Based on work by Chapman and Junge (1956), Darroch (1961), Seber (1982), Schaefer (1951), and Plante (1990), this program calculates: 1) a maximum likelihood (ML) Darroch estimate, a least squares estimate, the Schaefer estimate, and the pooled-Petersen estimate, and along with standard errors on the estimates (if available); 2) χ^2 tests for goodness-of-fit to assess the adequacy of the stratified model for lack of fit; and 3) two χ^2 tests of the validity of using fully pooled data. One of two conditions must be satisfied in order for the pooled-Petersen estimate to be unbiased and the preferred model. The first condition, 'complete mixing,' states that the recovery probabilities are constant across strata. The second condition, 'equal probability,' states that the expected ratio of marked and unmarked individuals is constant across all recovery strata due to similar migration patterns. If either of these conditions are satisfied ($P > 0.05$), the pooled-Petersen estimator is considered to be the appropriate model (Arnason et al. 1996). Our goal is to estimate the escapement such that the coefficient of variation is no greater than 10% of the point estimate. The manipulation of release and recovery strata in calculating estimates (the method used in SPAS) is presented and discussed at length by Schwarz and Taylor (1998).

Weir Count

The adult weir count will be used as the official escapement estimate if it falls within the 95% confidence interval of the adult sockeye salmon mark-recapture estimate. If the weir count is also within the current escapement goal range, the McDonald Lake escapement goal will have been met. The escapement goal will *not* have been met if both the weir count and the mark-recapture estimate are below the lower bound of the escapement goal range. In the case where either the weir count or the mark-recapture estimate falls within the escapement goal range, the weir count will be used as the official escapement estimate, *unless* it falls below the lower bound of the 95% confidence interval of the mark-recapture estimate. The mark-recapture "point" estimate will be

used, rather than either end of the 95% confidence interval, for the purpose of achieving the escapement objective.

Foot Survey Escapement Estimate

The McDonald Lake escapement will be estimated using a simple peak survey model that is based on calibrating peak foot survey counts to six years of observed escapement (weir counts in 1981, 1983, and 1984; mark-recapture estimates 2005–2007; Heinl et al. 2009). The conversion factor from peak survey count to total escapement based on these years was approximately 4.85. We will calculate 80% confidence intervals for the estimated escapement as the estimated escapement plus or minus the square root of the variance times the appropriate *t*-value (Zar 2010).

ESCAPEMENT SIZE AND AGE COMPOSITION

Scale samples will be analyzed at the ADF&G salmon-aging laboratory in Douglas, Alaska. The weekly age distribution, the seasonal age distribution weighted by week, and the mean length by age and sex weighted by week will be calculated using equations from Cochran (1977; Appendix A).

STOCKED CONTRIBUTION ESTIMATE

We will determine the proportion of stocked, otolith-marked sockeye salmon in the escapement at Hatchery Creek from our sample of 400 otoliths taken from carcasses over the entire duration of the run.

Letting m_E denote the number of fish sampled that had otolith marks, and n_E denoting the number of fish sampled for otolith marks, the proportion, $\hat{p}_E$, of otolith-marked fish in the escapement *E* will be estimated from our weighted samples as

$$\hat{p}_E = m_E / n_E \,. \tag{2}$$

Let $\hat{N}_E$ denote the total escapement of adult sockeye salmon at McDonald Lake as estimated from our expanded peak foot survey count. The estimate of the number of otolith-marked fish in the escapement, $\hat{M}_E$, will be calculated as

$$\hat{M}_E = \hat{p}_E \hat{N}_E \,. \tag{3}$$

The variances of the estimated proportion and number of otolith-marked fish in the escapement will be calculated using standard methods (Cochran 1977). An unbiased estimate of the variance of the proportion is,

$$\hat{v}(\hat{p}_E) = \frac{\hat{p}_E(1-\hat{p}_E)}{n_E - 1} \,. \tag{4}$$

The estimated variance for the estimated *number* of otolith marked fish in the escapement requires incorporating our calibrated foot survey estimate (which has a relatively large 80% confidence interval range) using the Delta method,

$$\hat{v}(\hat{M}_E) = \hat{v}(\hat{p}_E \hat{N}_E) \approx \hat{N}_E \hat{v}(\hat{p}_E) + \hat{p}_E \hat{v}(\hat{N}_E) - \hat{v}(\hat{N}_E \hat{p}_E) \tag{5}$$

(Goodman 1960). The standard errors will be calculated as the square root of the variance.

JUVENILE SOCKEYE POPULATION ESTIMATE

Fish-target density will be estimated using Biosonics Visual Analyzer © version 4.1 software, using the echo integration technique to generate a target density (targets per m^2; MacLennand and Simmonds 1992). Note that target density will be expressed as average targets per unit of lake surface area, not per unit of volume. McDonald Lake was divided into 10 lake sections, with two replicate transects within each section. Mean target density for each section will be calculated as the average of the two replicate transects. A total-target estimate for each of the sample sections will be calculated as the product of the mean target density and the surface area of each of the sample sections. Summing the section estimates of total targets will result in an estimate of total targets for the entire lake. The variance of the total-target estimate within a section will be calculated based on 1-degree-of-freedom estimates for each pair of transects. Because the estimate of total targets in each section is essentially independent (neglecting any movement of fry from one section to the other during data collection), a 10-degrees-of-freedom variance in the estimate of the total targets in the entire lake will be formed by summing variances across sections. Sampling error for the estimate of total targets for the whole lake will be measured and reported with the coefficient of variation (Sokal and Rohlf 1995). The estimates of total targets will be partitioned into species categories based on the proportion of each species captured in the mid-water trawls.

SCHEDULE AND DELIVERABLES

The net weir and camera trap will be operated from early July through late September. Escapement surveys and scale and otolith sampling on the spawning grounds will take place from early September through late October. The hydroacoustic survey will take place between late September and late October. A final report in the ADF&G Fisheries Data Series will be completed by the principle investigator annually. Information derived from this project will also be used in a stock status report on sockeye salmon in the form of an ADF&G Special Publication that will be produced at 3-year intervals (next due in fall 2014). These reports will be co-authored by Brunette, Piston, and Heinl, and; other co-authors may be added.

RESPONSIBILITIES

Malika T. Brunette, Fishery Biologist II, Project Leader. Oversight of all aspects of project, including planning, budgeting, sample design, permits, equipment, personnel, and training. Analyzes data and reports project results. Assists with fieldwork.

Andrew W. Piston, Fishery Biologist IV. Assists with all aspects of project, including planning, budgeting, sample design, permits, equipment, personnel, and training. Analyzes data and reports project results. Assists with fieldwork.

Steven C. Heinl, Regional Research Coordinator. Assists with project operational planning, field work, and review of project report.

Sara Miller, Biometrician II. Provides biometric review for the project.

Kimberly A. Vicchy, Fish and Game Program Technician. Provides administrative support to the project and assists with field work.

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APPENDIX A

Appendix A.–Escapement sampling data analysis.

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, will be 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:

$$\hat{p}_{hj} = n_{hj} / n_h \ . \tag{1}$$

If N_h equals the number of fish in the escapement in week h, standard errors of the weekly age class proportions will be calculated in the usual manner (Cochran 1977, page 52, equation 3.8),

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

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

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

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),

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

The mean length, by sex and age class (weighted by week of escapement), and the variance of the weighted mean length, will be 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,

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

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