Regional Operational Plan No. CF.1J.2021.05

Operational Plan: McDonald Lake Sockeye Salmon Stock Assessment, 2021–2023

by

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And

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May 2021

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

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

REGIONAL OPERATIONAL PLAN NO. CF.1J.2021.05

OPERATIONAL PLAN: MCDONALD LAKE SOCKEYE SALMON STOCK ASSESSMENT, 2021–2023

by

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May 2021

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This document should be cited as follows:
Piston, A. W., and T. M. Fish. 2021. Operational plan: McDonald Lake sockeye salmon stock assessment, 2021–2023. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Operational Plan No. ROP.CF.1J.2021.05, Douglas.

SIGNATURE PAGE

Project Title:	*McDonald Lake Sockeye Salmon Stock Assessment, 2021–2023*
Project leader(s):	*Teresa M. Fish*
Division, Region, and Area:	*Division of Commercial Fisheries, Region 1, Ketchikan*
Project Nomenclature:	*FM-142 GF McDonald Lake Sockeye*
Period Covered:	*1 July 2021 to 30 June 2023*
Field Dates:	*Annually, 1 September–31 October*
Plan Type:	*Category II*

Approval

Title	Name	Signature	Date
Project Leader	Teresa M. Fish		3-25-2021
Biometrician	Sara Miller		3-25-2021
Research Coordinator	Steven C. Heinl		3-25-2021

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PURPOSE

The primary purpose of this project is to provide an estimate of the sockeye salmon escapement at McDonald Lake by conducting foot surveys on the spawning grounds at Hatchery Creek. We will also estimate the adult age composition of the escapement. Using results from a Pacific Salmon Treaty genetic stock identification project, we will estimate the contribution of McDonald Lake sockeye salmon to southern Southeast Alaska commercial net fisheries. This project also includes a fall hydroacoustic survey to estimate rearing juvenile sockeye salmon abundance.

Keywords: foot survey, genetic stock identification, Hatchery Creek, hydroacoustic survey, McDonald Lake, *Oncorhynchus nerka*, sockeye salmon, stock of concern

OBJECTIVES

1. Estimate the sockeye salmon spawning escapement at McDonald Lake using a calibrated peak foot survey estimate.
2. 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%.
3. 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 the estimate is no greater than 15%.
4. Estimate the contribution of McDonald Lake sockeye salmon to the southern Southeast Alaska commercial purse seine and drift gillnet fisheries such that the estimates are within 10% of the true value with at least 90% probability.

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 freshwater sport fishery (Johnson et al. 2005). Annual sockeye salmon escapements to McDonald Lake are estimated through a foot-survey method based on calibrations from three years of weir counts (1981, 1983, and 1984) and three years of mark-recapture studies (2005–2007; Heinl et al. 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 6 of 8 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 delisted as a stock of management concern at the Alaska Board of Fisheries meeting in 2012. Escapements fell below the sustainable escapement goal range in 4 out of 5 consecutive years from 2013 to 2017, and the stock was again classified as a stock of concern at the 2018 Alaska Board of Fisheries meeting. A revised action plan, similar to the 2009 plan, was implemented to reduce harvest on the McDonald Lake sockeye salmon stock (Walker et al. 2018). Escapements were below goal from 2018 to 2020 and estimated escapements in 2018 (11,000) and 2020 (8,200) were the lowest on record.

Here we outline methods to estimate the magnitude and age, sex, and length (ASL) composition of the sockeye salmon escapement, estimate the contribution of McDonald Lake sockeye salmon to southern Southeast Alaska commercial net fisheries, 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 (Figures 1 and 2). 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; also known as Walker Creek), 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.

METHODS

ESCAPEMENT

Foot Surveys

The McDonald Lake sockeye salmon escapement will be estimated by expanding a peak survey count by a factor of 4.85. The expansion factor was calculated based on six years of matched peak foot survey counts with total escapement estimates from weir counts and mark–recapture studies (Heinl et al. 2009; Model P1). Sockeye salmon spawn from late August to mid-October, and peak spawning activity typically occurs in mid-September. The peak survey count will be determined from three standardized foot surveys of the spawning grounds conducted on approximately the 10th, 20th, and 28th of September (Table 1). Additional foot surveys may be conducted on sampling trips to collect scale samples. 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 (Figure 2). Stream characteristics, including shallow depth over nearly the entire survey length, relatively narrow stream width, and contrasting pale granite substrate, provide excellent conditions for counting fish. 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 Region 1 Commercial Fisheries Database at the end of the field season.

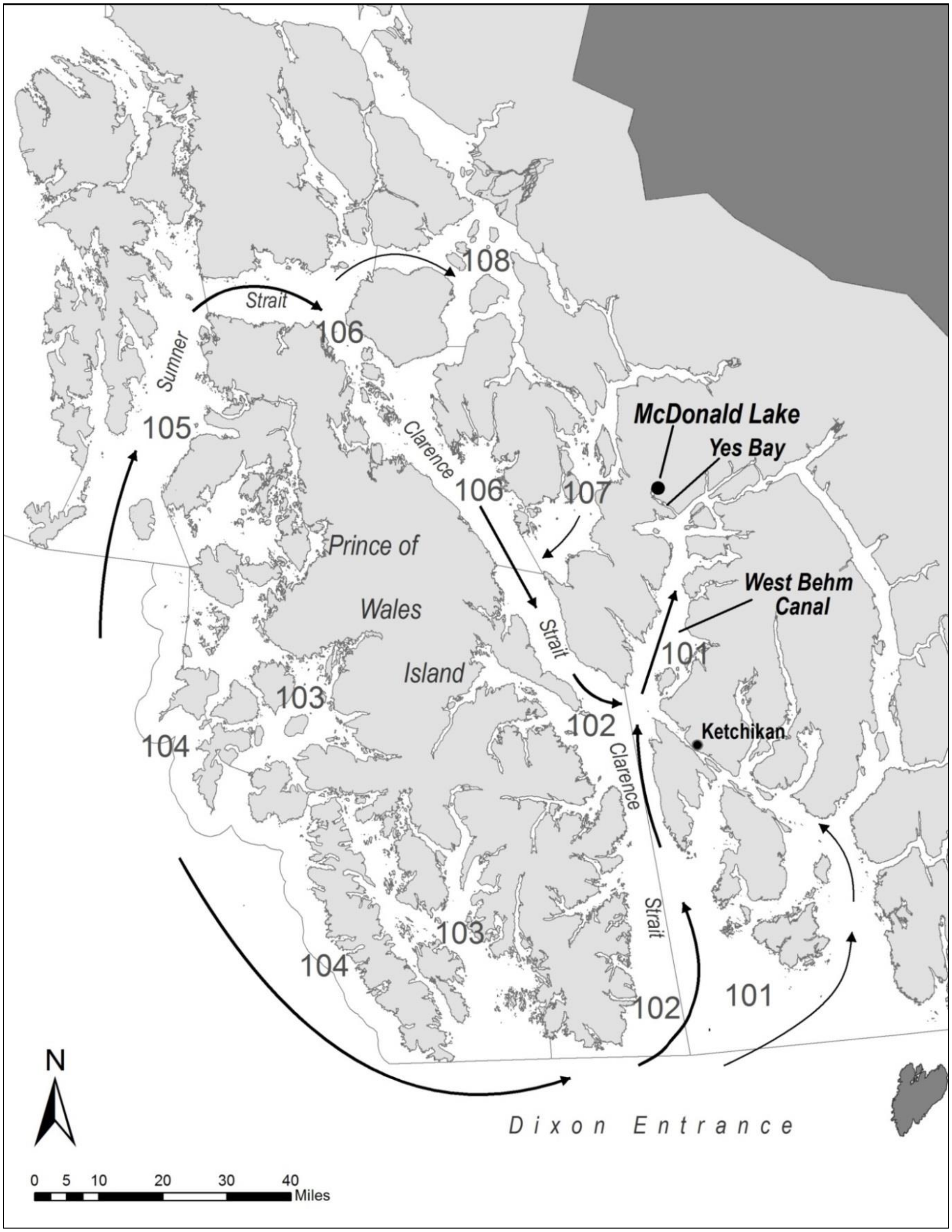

Figure 1.–Map of southern Southeast Alaska, the location of McDonald Lake, and major (thick arrows) and minor (thin arrows) migration routes of McDonald Lake sockeye salmon through management Districts 101–108. Migration routes were determined from marking (Hoffman et al. 1984a, 1984b), coded-wire tagging (Johnson et al. 2005), otolith (Brunette et al. 2015), and genetic stock identification (Gilk-Baumer et al. 2013, Walker et al. 2018) studies.

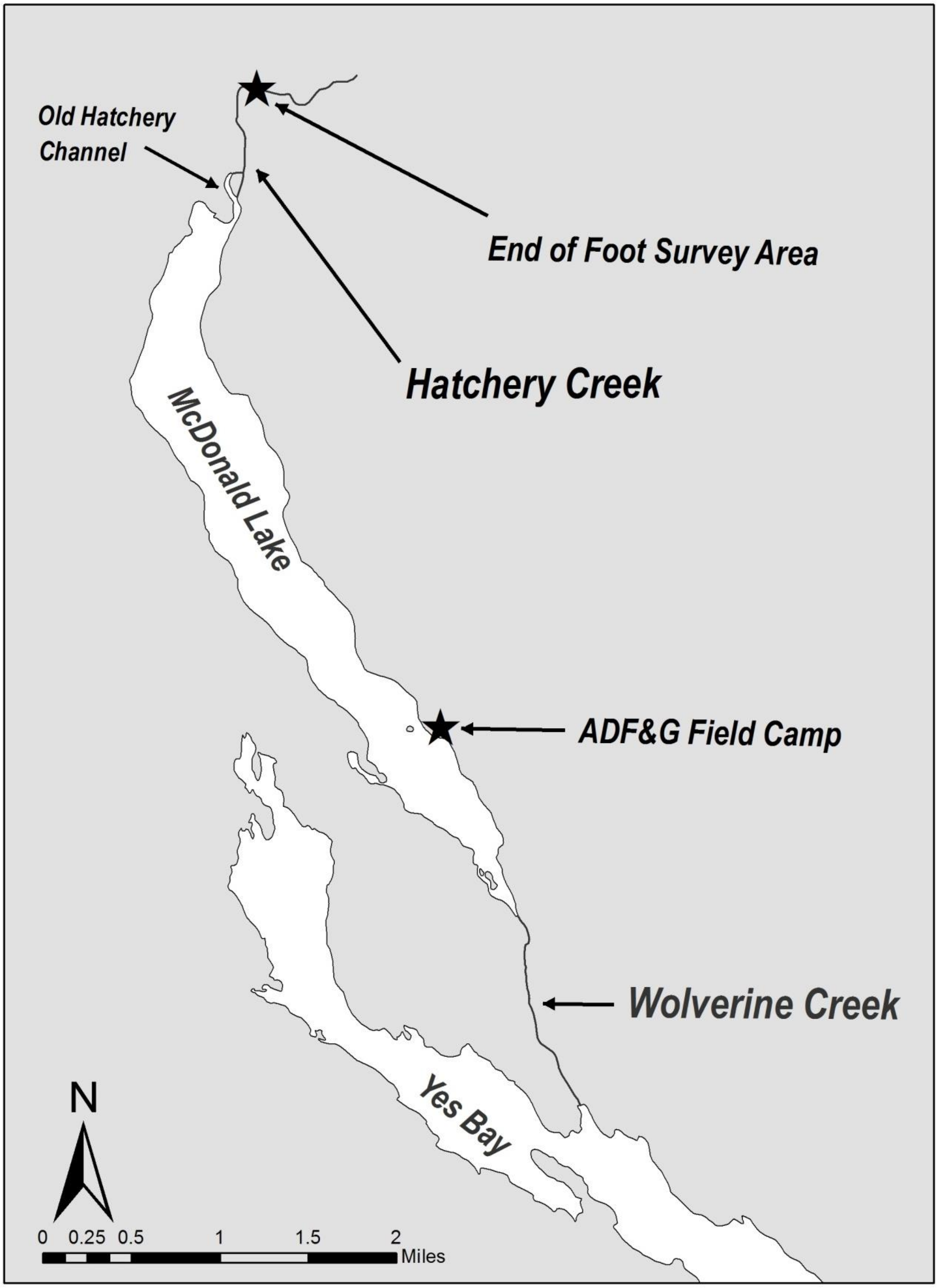

Figure 2.–Map of McDonald Lake showing the location of the primary inlet and outlet streams, the end point of the foot survey area, and other features of the lake system.

AGE, SEX, AND LENGTH SAMPLING

The McDonald Lake sockeye salmon adult age composition will be determined from scale samples collected from 810 live fish in Hatchery Creek (or carcasses if availability is high). This sample size was selected based on work by Thompson (1987, 2002) to estimate several proportions simultaneously. Since there are at least three major age classes, 510 readable scales are needed to ensure the estimated proportion of each age class will be within 5% of the true value with at least 95% probability. Annual proportions of unreadable scales collected from live fish on the spawning grounds ranged from 5% to 37% so we increased the total sample size by the maximum annual proportion of unreadable scales collected from live fish to increase the likelihood we will meet the sample goal even with a large proportion of unreadable samples.

In recent years (2015–2020), it has not been possible to estimate the age composition of adult McDonald Lake sockeye salmon using samples collected from carcasses due to the following factors:

1) growth after the third marine annulus was significantly reduced, thus, natural scale resorption obscured the third marine annulus on many scales, resulting in inaccurate age assignment;

2) spacing between the second and third marine annuli was inconsistent with previous years;

3) historical length-age frequencies did not fit contemporary scale collections and could not be used to accurately age scales; and

4) in years with very low escapements (2015, 2017–2020), carcass availability was severely limited.

From 1982–2014, 6,000 scale samples were collected from live fish captured by beach seine, 2,700 samples were collected from live fish captured by dip net, and 11,500 samples were collected from carcasses. During that time (and prior to recent changes observed in marine growth observed in 2015–2017), 14% of all scales collected from live fish captured by beach seine were unreadable, 11% of all scales collected from live fish captured by dip net were unreadable, and 36% of all scales collected from carcasses were unreadable. To potentially decrease the proportion of unreadable scales by half, we will collect scales from live fish at the mouth of Hatchery Creek when possible.

Lengths, from mid eye to tail fork and rounded to the nearest 5 mm, 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 age composition sample. Three scales will be collected from the preferred area on 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.–Annual foot survey counts of sockeye salmon at McDonald Lake, 1979–2020.

	Survey Date[a] and Number						
	23-Aug	31-Aug	10-Sep	20-Sep	28-Sep	10-Oct	20-Oct
Year	1	2	3	4	5	6	7
1979	2	–[b]	5,010	6,600	–	–	–
1980	1,363	–	19,500	14,775	13,378	–	–
1981	1,370	2,825	–	23,050	11,000	1,025	–
1982	0	9,000	13,200	6,100	–	–	–
1983	500	3,200	11,500	15,000	8,000	2,500	–
1984	0	12,000	21,600	27,100	24,800	7,100	200
1985	35	1,425	15,600	27,300	23,890	6,250	–
1986	1,500	9,000	9,200	24,900	25,400	600	–
1987	2	5,000	16,100	–	–	27,880	2,800
1988	20	5,780	25,000	12,500	6,600	700	1
1989	150	165	13,000	–	24,000	100	–
1990	3	2,950	23,000	22,780	33,600	2,100	275
1991	304	30,000	27,770	34,300	27,000	–	579
1992	5	5,500	28,300	20,600	–	5,250	–
1993	4	57	3,950	14,100	37,000	4,300	370
1994	0	250	11,000	28,600	32,700	6,100	49
1995	0	918	12,975	16,130	2,260	600	–
1996	315	–	7,372	16,865	16,300	3,055	41
1997	0	9,533	11,775	–	13,900	1,853	128
1998	225	5,762	11,520	12,793	7,625	5,108	81
1999	355	5,202	20,557	22,540	15,940	–	54
2000	–	9,761	17,610	25,605	7,458	–	84
2001	213	4,910	11,275	11,656	3,700	207	–
2002	–	–	5,568	8,000	4,405	61	–
2003	40	9,455	15,780	20,353	16,052	5,095	139
2004	0	44	4,420	–	5,920	134	3
2005	42	205	10,200	10,375	–	3,455	–
2006	2	618	2,853	5,153	3,200	729	15
2007	21	1,250	6,700	7,100	6,100	630	69
2008	–	–	3,430	5,430	4,990	–	–
2009	–	1,500	7,770	–	4,620	–	–
2010	–	–	13,900	8,320	10,200	–	–
2011	–	4,000	23,250	–	17,500	2,380	–
2012	–	–	11,760	9,705	1,250	–	–
2013	–	–	1,894	3,170	1,330	–	–
2014	–	–	8,965	6,270	8,000	–	–
2015	–	–	6,075	14,495	–	5,865	–
2016	–	–	3,220	–	570	–	–
2017	–	–	4,943	4,945	1,065	–	–
2018	–	–	270	816	2,260	–	–
2019	–	–	300	4,985	4,105	–	–
2020	–	–	1,700	1,510	1,315	–	–

[a] Surveys conducted on or within 3 days of dates shown.
[b] A dash indicates that no survey was conducted.

JUVENILE SOCKEYE SALMON 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.

To determine if the majority of pelagic fish targets are sockeye salmon, we will conduct at least three 20-minute trawls using a 2 m × 2 m elongated trawl net at different depths, ranging from near-surface to 15 m. Trawl net sampling is likely biased towards the capture of slow swimming stickleback (*Gasterosteus aculeatus*) and age-0 sockeye salmon fry, so we will use trawl catches primarily to determine if the assemblage of pelagic fish in the lake has dramatically changed from previous years. From 2012 to 2016, juvenile sockeye salmon averaged 87% of trawl catches. 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.

COMMERCIAL HARVEST

Tissue samples will be collected at the major commercial fish processing ports in Southeast Alaska by the ADF&G Port Sampling program to facilitate management of commercial fisheries and fulfill obligations under the Pacific Salmon Treaty (Reynolds-Manney 2020). Sample sizes were primarily designed to determine the harvest contribution by country of origin in the boundary area fisheries; specifically, the estimated contribution of British Columbia Nass and Skeena River sockeye salmon.

Sampling effort will span the historical peak weeks of sockeye salmon harvests in southern Southeast Alaska traditional net fisheries (Districts 101–108): statistical weeks 25 through 35 (approximately mid-June to late August; Table 2). On average, 99% of the sockeye salmon harvest in southern Southeast Alaska occurs during those weeks. Established ADF&G Port Sampling procedures will ensure that weekly samples are as representative of a specific district harvest as possible. Only harvests originating from a single fishing district and gear type will be sampled. No more than 40 tissue samples will be collected from each individual boat's harvest and no more than 200 tissue samples will be collected from each tender (Reynolds-Manney et al. 2020). When individual seine boats deliver fewer than 40 total sockeye salmon, every fish will be sampled. When possible, samples will be collected from the entire hold in order to best represent all sockeye salmon in that delivery. Additionally, multiple deliveries from each district will be sampled over the entire statistical week as much as possible. Total weekly harvest will be obtained from the ADF&G Region 1 Commercial Fisheries Database.

Table 2.–Weekly sockeye salmon tissue sample goals for southern Southeast Alaska net fisheries, 2021.

District and fishery	Weekly sample target	Statistical weeks	Annual sample goal
101 Purse Seine	260	29–35	1,820
102 Purse Seine	260	26–35	2,600
103 Purse Seine	–	28–35	390
104 Purse Seine	260	28–35	2,080
101-11 Drift Gillnet	260	26–35	2,600
106-30 Drift Gillnet	300	25–35	3,300
106-41 Drift Gillnet	300	25–35	3,300
108 Drift Gillnet (Subdistricts 30 and 40)	260	25–34	2,600
108 Drift Gillnet (Subdistricts 50 and 60)	260	25–34	2,600
Grand Total	2,160		21,290

DATA ANALYSIS

ESCAPEMENT

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 in these years was approximately 4.85. We will calculate 80% prediction 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).

JUVENILE SOCKEYE SALMON 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 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 sample section will be calculated as the product of the mean target density and the surface area of each section. Summing the total target estimates for each section will result in an estimate 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 another 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).

COMMERCIAL HARVEST

The commercial harvest of McDonald Lake sockeye salmon will be estimated through genetic stock identification methods. Laboratory analysis, including quality control, will be performed by the ADF&G Gene Conservation Laboratory in Anchorage, Alaska following methods outlined in Dann et al. (2012), or by the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service, Alaska Fishery Science Center, Auke Bay Laboratories, Ted Stevens Marine Research Institute using methods outlined in Guthrie et al. (2017). The current genetic baseline is used by ADF&G and NOAA and consists of 241 stocks which are representative of major sockeye salmon producing systems in Southeast Alaska, British Colombia, and the Pacific Northwest (Rogers Olive et al 2018; with additions in the Yakutat area). The ADF&G baseline is characterized for 96 genetic markers while the NOAA baseline is characterized for a subset of 48 genetic markers. Stock composition estimates for the District 101–103 purse seine fisheries will be computed by the ADF&G Gene Conservation Laboratory, using the R package *rubias* (Moran and Anderson 2019). Briefly, a single Markov Chain Monte Carlo chain with starting values equal among all populations will form the posterior distribution that describes the stock composition of each stratum. Summary statistics will be tabulated from these distributions to describe stock compositions. Estimates for the District 104 purse seine and District 101 drift gillnet fisheries will be computed by the NOAA Auke Bay Laboratory using the Bayesian mixed stock analysis approach in the program BAYES (Pella and Masuda 2001; Gilk-Baumer et al. 2015). Stock composition estimates for the District 106 and 108 drift gillnet fisheries will be computed by the ADF&G Gene Conservation Laboratory using a method that incorporates ages from matched scales and hatchery thermal marks on matched otoliths to help inform the genetic estimates. This method ("mark- and age-enhanced GSI") requires two sets of parameters: 1) a vector of stock compositions, summing to one, with a proportion for each of the wild and hatchery stocks weighted by harvest per stratum; and 2) a matrix of age composition, with a row for each of the wild and hatchery stocks (summing to one), and a column for each age class. This method utilizes all available information to assign individuals to stock of origin based on age, genotype, and/or otolith information.

We will report point estimates as well as standard deviations and credibility intervals as outputs of their respective models. Harvest estimates for all fisheries over a year will be calculated by multiplying the estimated proportion by the respective harvest for each stratum, then summing across all strata. Standard deviations across all strata in a year will be derived by calculating the sum of squares to estimate variance, and taking the square root of this value. The standard deviation was multiplied by 1.645 to calculate 90% confidence intervals over all fisheries. Commercial harvest rates will be calculated by dividing the total commercial harvest by the sum of commercial harvest and escapement.

SCHEDULE AND DELIVERABLES

Sampling of fisheries by Southeast Alaska Port Sampling staff will take place from June through September. Escapement surveys and scale 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. Results from this project will be reported at annual taskforce meetings with industry and escapement estimates will be published on a tri-annual basis in escapement goal review reports prepared in advance of Alaska Board of Fisheries meetings (Heinl et al. 2017).

RESPONSIBILITIES

Teresa M. Fish, 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.

Chase Jalbert, Fisheries Geneticist I. Genetics project leader responsible for analysis and reporting of stock composition.

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

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APPENDIX

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),

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

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

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

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),

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

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,

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

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