Regional Operational Plan SF.1J.2018.01

Operational Plan: Neck Lake Cutthroat Trout Assessment

by

Craig J. Schwanke

and

Adam Reimer

March 2018

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 SF.1J.2018.01

OPERATIONAL PLAN: NECK LAKE CUTTHROAT TROUT ASSESSMENT

by
Craig J. Schwanke
Alaska Department of Fish and Game, Division of Sport Fish, Craig
and
Adam Reimer
Alaska Department of Fish and Game, Division of Sport Fish, Soldotna

Alaska Department of Fish and Game
Division of Sport Fish
PO Box 110024
Juneau, AK 99811

March 2018

Craig J. Schwanke,
Alaska Department of Fish and Game, Division of Sport Fish,
PO Box 682, Craig, AK 99921

and

Adam Reimer
Alaska Department of Fish and Game, Division of Sport Fish,
514 Funny River Road, Soldotna, AK 99669

This document should be cited as follows:
Schwanke, C. J., and A. Reimer. 2018. Operational Plan: Neck Lake cutthroat trout Assessment. Alaska Department of Fish and Game, Division, Regional Operational Plan ROP. SF.1J.2018.01, Anchorage.

SIGNATURE PAGE

Project Title:	Neck Lake Cutthroat Trout Assessment
Project leader(s):	Craig Schwanke, Fishery Biologist III
Division, Region, Area:	Sport Fish, Region I, Prince of Wales
Project Nomenclature:	F-10-33, F-10-34 C-1-3
Period Covered:	2018
Field Dates:	May and July 2018
Plan Type:	Category II

Approval

Title	Name	Signature	Date
Project leader	Craig Schwanke		3/1/2018
Biometrician	Adam Reimer		3-1-2018
Research Coordinator	Jeff Nichols		3-13-18

TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

The population status of cutthroat trout *Oncorhynchus clarki* at Neck Lake in Southeast Alaska which was last examined from 1996 through 1998 will be reexamined in 2018. Similar to the previous study, mark-recapture will be used to estimate abundance, catch per unit effort and length composition from fish captured in baited hoop traps and hook and line. An additional gear type of baited funnel traps will also be used. A comparison of the two studies will assess changes to the cutthroat population since 1996, when hatchery coho salmon fry commenced rearing in the lake and provide information to assess current sport fishing regulations. The data will also be used to examine the utility of using catch and length data collected over a three day period for a rapid assessment of the stock which could be useful for monitoring cutthroat populations in lakes throughout Southeast Alaska.

Key words: Southeast Alaska, Prince of Wales Island, Neck Lake, cutthroat trout, *Oncorhynchus clarki,* abundance, mark-recapture, length composition, coho salmon, *Oncorhynchus kisutch,* stocking.

PURPOSE

The purpose of this project is to evaluate the abundance and length composition of the cutthroat trout population in Neck Lake on Prince of Wales Island in Southeast Alaska. The rearing of enhanced coho salmon fry in net pens for the past 21 years may have affected the abundance and length composition of the resident cutthroat trout population. Data collected during this study will be compared to studies conducted shortly after coho salmon rearing was implemented to assess changes in cutthroat trout abundance and length composition. Catch and length data from this study will also be analyzed to assess whether a truncated data set collected during a shorter time frame can be effectively used as an abundance index for rapid assessments of cutthroat populations in other lake systems in Southeast Alaska. In addition, results from this study will help managers evaluate the status of the cutthroat trout population in Neck Lake and if current regulations are appropriate.

BACKGROUND

Cutthroat trout *Oncorhynchus clarki* are distributed throughout Southeast Alaska and provide an important resource for sport anglers. Since 1994, trout populations throughout Southeast Alaska have been managed conservatively with a region wide bag limit of two, minimum size and bait-use restrictions. Minimum size limits for the region are currently 11 inches, with some exceptions provided as special regulations. The minimum size limits were identified by past research on cutthroat maturity (Harding 2013) and intended to allow cutthroat trout to spawn at least once before they are susceptible to harvest.

There are numerous lakes on Prince of Wales Island (POW) that support cutthroat trout, including Neck Lake which is a relatively large (373 hectare) roadside lake (Figure 1). Located on northern POW, road access, a boat ramp and proximity to the community of Whale Pass make Neck Lake a popular destination for trout anglers. A barrier falls on Neck Creek prevents anadromous fish from entering Neck Lake, so the cutthroat trout population is only comprised of potanadromous fish. Other species present are kokanee *O. nerka* and Dolly Varden *Salvelinus malma*. Currently, the region-wide trout regulations apply to Neck Lake cutthroat trout sport angling.

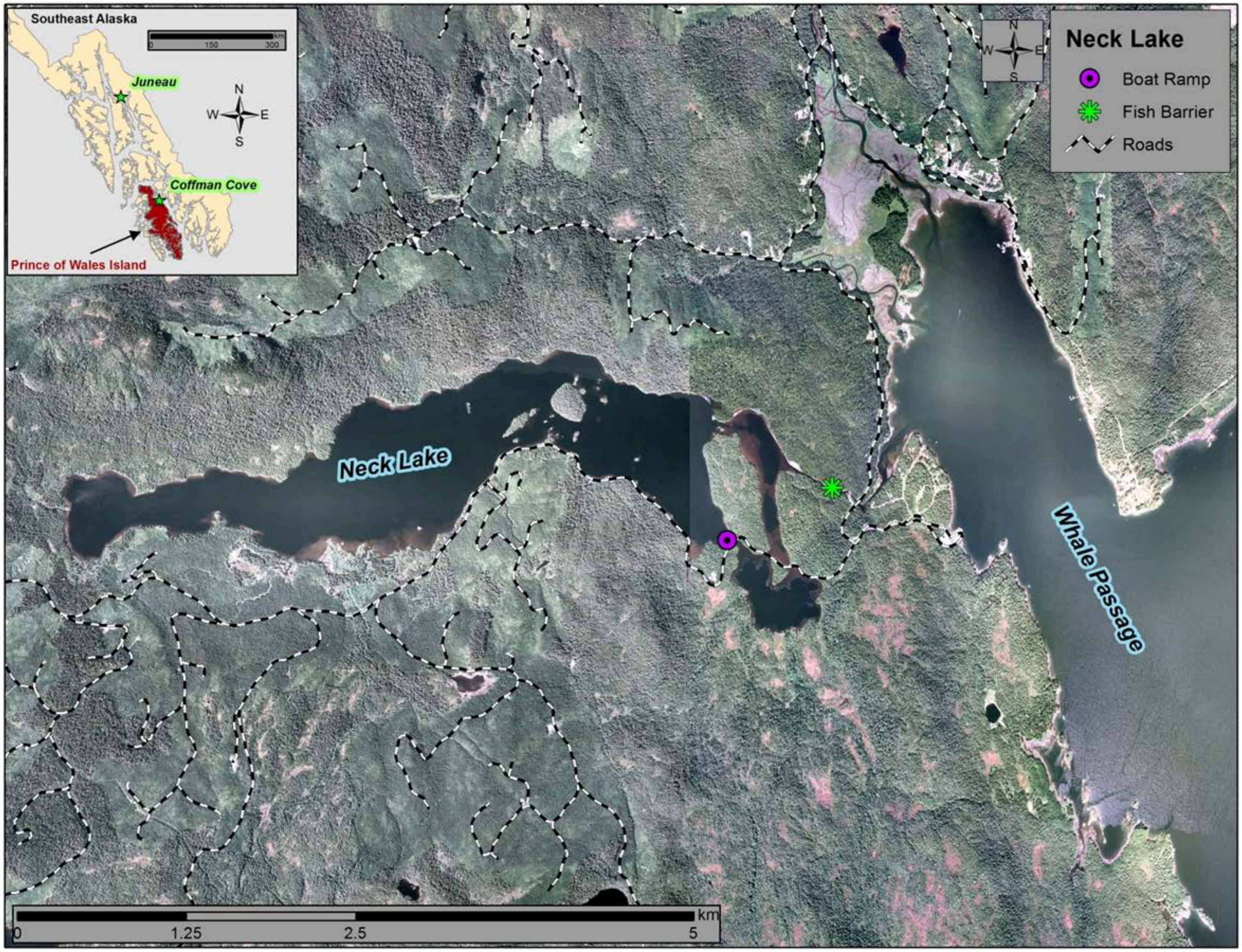


Figure 1.–Location of Neck Lake on Prince of Wales Island in southern Southeast Alaska.

The Neck Lake Hatchery has produced summer run coho salmon which have been reared in Neck Lake since 1996. The facility is operated by Southern Southeast Regional Aquaculture Association (SSRAA) and until 2017 was permitted to rear up to 2.2 million summer coho salmon fry in net pens located in Neck Lake. In 2017, the facility was permitted to rear an additional 2.2 million fall run coho salmon in Neck Lake. Until 2005, a portion of the coho salmon fry were released directly from net pens into Neck Lake during the fall to rear until they would leave the drainage as smolt in the spring (JR Parsley, Neck Lake Hatchery Manager, SSRAA, Whale Pass, personal communication). Currently, the fry are raised in the lake net pens for 12 months with a May release date as smolts into Neck Lake. During 2016/2017, 1.8 million coho salmon fry were raised by the facility with a release of 1.7 million. Adult coho salmon do not return to Neck Lake due to the barrier falls in Neck Creek.

When the rearing of coho salmon fry in Neck Lake commenced in 1996 there were concerns regarding the potential impacts of rearing coho salmon on cutthroat trout. Concerns included coho fry competition with juvenile cutthroat trout and the potential for adult trout predation on juvenile coho. In addition, restrictive trout sport harvest limits were implemented in 1994 throughout Southeast Alaska. In response to both issues, the Alaska Department of Fish and Game (ADF&G) conducted a cutthroat population study from 1996–1998. Results of the project include estimates of abundance in 1997 and 1998 and length distributions of cutthroat trout ≥180 mm fork length (FL) from 1996 through 1998.

A combination of baited hoop traps (BHT) and hook and line (H&L) was used to capture cutthroat trout throughout Neck Lake. Estimates indicated an abundance of approximately 3,000 cutthroat trout ≥180 mm FL in Neck Lake during 1997 and 1998 (Harding et al. 1999a). The majority of fish (76%) sampled during the study were <240 mm FL and only 6% of the cutthroat trout sampled were longer than the 12-inch (287 mm FL) minimum size limit established at that time (Harding et al. 1999a). The region wide minimum size limit was changed in 2000 to 11 inches.

It has been approximately 20 years since the last study and there is evidence that the size structure of cutthroat trout has changed. Reports from the public and H&L sampling by staff indicate that the length frequency of cutthroat trout in the lake has shifted towards larger fish. Coho salmon fry are reared in net pens and released as smolt into Neck Lake and may be prey to cutthroat trout for a short period of time in May. Cutthroat trout appear to concentrate at the net pens, likely feeding on commercial pellet food that filters through the net pens. This supplemental source of high quality food may have increased the growth rates of cutthroat trout in Neck Lake and affected population size.

The results of this study will provide ADF&G with two deliverables: 1) The 2018 study will duplicate the previous studies capture techniques and sampling design to document and compare cutthroat trout abundance and length structure 20 years after restrictive regulations and coho salmon rearing was implemented in the lake; and 2) The data collected from this study will be analyzed to assess effective gear types and reductions in sampling effort that can be effectively used as an abundance and length-composition index for rapid assessments of cutthroat populations in lakes. It is anticipated that catch per unit effort (CPUE) and length data collected over a few day period by a combination of gear types, including baited funnel traps (BFT), will provide for efficient monitoring of cutthroat trout populations in lakes throughout Southeast Alaska.

OBJECTIVES

1. Estimate abundance of cutthroat trout ≥180 mm FL in Neck Lake during 2018 within ± 15% of the true value 95% of the time using a closed population estimator;
2. Estimate length composition of the cutthroat trout ≥180 mm FL in Neck Lake in 20 mm increments during 2018 such that each multinomial proportion is within ±5 percentage points of the true value 90% of the time;

TASKS

1. Estimate catch per unit effort of cutthroat trout captured in BHTs, BFTs, and H&L from Neck Lake.
2. Calculate cutthroat trout length distribution and CPUE from reduced datasets to assess whether CPUE and length composition estimates collected over shorter time periods can be used to monitor the Neck Lake cutthroat trout population.
3. Compare cutthroat trout length distribution and CPUE between gear types.

METHODS

A two-event closed population (Petersen) model will be used to estimate abundance in 2018. Sampling dates were selected similar to the previous study to avoid sampling during spawning when cutthroat trout are likely to be in tributary streams.

This study will also duplicate the sampling methods and effort conducted in 1998 (Harding et al. 1999a) while adding an additional gear type of BFT. We plan to maintain similar levels of effort with BHTs and H&L capture techniques while adding BFTs in smaller numbers than BHTs. This design should minimize compensatory effects on the catch rate between the two gear types while providing length and catch per unit effort (CPUE) data from both gear types for comparison.

FIELD SAMPLING

A three-person crew will conduct two 10-day trips to Neck Lake to capture and mark cutthroat trout ≥180 mm FL with uniquely numbered anchor T-bar tags. The first sampling period (marking) will begin May 22 to May 31; a second 10-day sampling period (recapture) will begin July 2 and conclude July 11.

Cutthroat trout will be captured with BHTs (Appendix 2), BFTs (Appendix 3), and H&L. BHTs are 1.4 m long and consist of four 0.6-m-diameter steel hoops with 9-cm throats attached to the first and third hoops. BFTs are 0.9 m long, 0.6 m wide with 6.35 cm entrance. Knotless nylon netting with a mesh size of 1 cm will cover the BHT and BFTs. Bait for the funnel and hoop traps will consist of whole/crushed salmon eggs, which have been disinfected in betadine solution. H&L will be conducted by casting and trolling small spoons, spinners, and other lures in a manner such that all shoreline areas will be fished with similar effort.

The lake will be divided into three areas (A, B, C) to aid in evaluation of assumptions during data analysis (Figure 2). The three sampling areas (A, B, and C) are each further subdivided into three subareas (numbered 1 through 9, see Figure 2), so that daily sampling can proceed systematically from one end of the lake to the other. Area A will consist of subareas 1-3, Area B will consist of subareas 4-5 and Area C will consist of subareas 7-9. Prior to the first event each set of coordinates delineating these areas will be marked so that field crews can easily identify which area sampling gear is deployed. As done in the previous study, during each event sampling effort will be uniformly distributed across each of the nine sections of the lake in direct proportion to the amount of lake surface area present ≤40 m which will give an effort of 130 BHT days, 34 BFT days and 27 rod hours during each of the two 9-day sampling events (Table 1). Based on section area up to 24 trap days for BHTs, 6 trap days for BFTs and four hours 57 minutes of hook and line sampling will occur per section. Trap placement will be determined by randomly selecting a uniform distribution of a specified number of sampling points on enlarged maps of each of the nine areas prior to sampling. Traps will be set on the lake bottom at depths ≤40 m overnight, and depths will be determined with a fathometer. H&L will also be uniformly distributed along the shoreline of each section.

In the previous study, CPUE declined as depth increased to almost 0 fish/trap at 35 m (Harding et al. 1999a). Setting traps to ≤40 m will insure all cutthroat trout in the lake will have an equal probability of being sampled.

During each 10-day sampling trip, traps will be systematically moved throughout the nine sampling areas so that the total amount of gear is uniformly distributed across those parts of the lake. The order in which the traps are set during the first 10-day trip for each lake section will be recorded. During the second (or next) 10-day sampling trip, the geographic order in which traps are set across the lake will be the same as during the previous trip. This insures a relatively constant hiatus between sampling events by area of the lake.

Capture data for each trap will be recorded on field sampling forms (Appendices A4, A5) so that sampling locations (lake area) and depths can be associated with the data recorded for each fish captured.

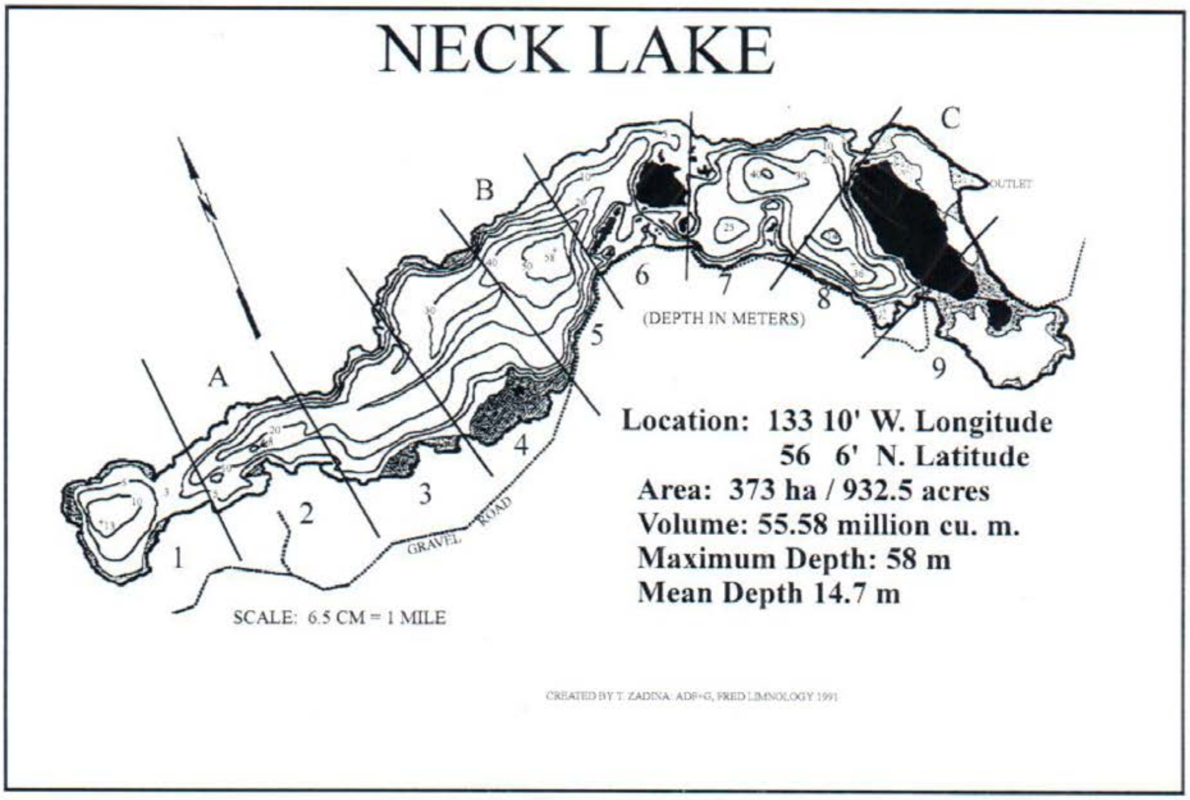


Figure 2.–Bathymetric map of Neck Lake study site on Prince of Wales Island in Southeast Alaska, with sampling area and subarea divisions.

Note: Area A is divided into subareas 1-3, area B into subareas 4-6 and area C into subareas 7-9.

Table 1.–Distribution of effort for sampling gear per area of Neck Lake for 2018.

Section	Area[a] (km^2)	Prop[a]	H&L Hrs[b] per event	Number BHTs per event	Number BFTs per event
Area 1	3.18	0.099	2:42	13	3
Area 2	2.73	0.085	2:15	11	3
Area 3	3.98	0.124	3:18	16	4
Area 4	5.94	0.185	4:57	24	6
Area 5	2.32	0.072	1:57	9	3
Area 6	3.5	0.109	3:00	14	4
Area 7	4.87	0.152	4:03	20	5
Area 8	3.87	0.120	3:18	16	4
Area 9	1.73	0.054	1:30	7	2
Totals	32.12	1.000	27:00	130	34

Note: Baited Hoop Trap = BHT, Baited Funnel Trap = BFT, Hook & Line= H&L

[a] Tabulated area and proportions are estimates for 0-40 m.

[b] Hrs:Min. Based on 3 rod hrs/day (1 hr at 3 persons).

SAMPLE SIZES

Abundance

Sampling expectations are based on the closed population study conducted in 1998 which included a total catch of approximately 1,800 fish and abundance estimate of 3,150 cutthroat trout ≥180 mm FL in Neck Lake (Harding et al. 1999a). Mean CPUE of cutthroat trout in Neck Lake in 1998 was approximately 6.6 cutthroat trout ≥180 mm per BHT day and approximately 3.5 per rod hour (Harding et al. 1999a).

With a population size of 3,000 fish, a sample size of approximately 600 cutthroat trout in each event will produce an estimate with relative precision of 15%, 95% of the time using a two-event Petersen closed population model (Robson and Regier 1964). This sample size is considerably less than were captured in 1998 using similar methods but affords some uncertainty for unknown changes in population size and sampling efficiently that are bound to occur. If sampling efficiency is similar to 1998 we would expect to meet precision objectives on populations as small as 1,000 cutthroat trout.

Length Composition

Using the method described by Thompson (1987), length measurements need to be taken on a sample of 403 cutthroat trout ≥180 mm to meet the objective criteria for length composition. Since the expected sample sizes far exceed the required sample sizes, statistical criteria for estimating length composition should achieved.

DATA COLLECTION

Abundance and length composition

During each event cutthroat trout ≥180 mm FL will be examined for marks, measured from tip of the snout to the fork of the tail (nearest mm FL), tagged (if untagged) with a uniquely numbered T-bar anchor tag and given a secondary mark. Tags will be inserted on the left side of the fish below the dorsal fin. Secondary marks will be the tip of the right pectoral fin during the first event and the tip of the left pectoral fin during the second event to control for tag loss. All fish ≥180 mm captured will be allowed to recover, and released in the area of capture. Lengths, tag numbers (or presence of a secondary mark), gear types, trap number (and depths of sets) for tagged, and newly captured (untagged) fish will be recorded by date and species. Mortality status and select comments (old or new tag or other scars, physical condition, etc.) will also be recorded. Catch and the number of gear units (trap-days, etc.) for each gear type will be recorded for each sampling day. Cutthroat trout <180 mm FL and other species captured will be counted and released.

All data collected will be recorded on custom field data sheets (Appendices 4 –5) and entered into a computer in the Craig ADF&G office.

DATA REDUCTION

The leader of the field crew will record and check all data forms for errors and omissions. Errors may consist of incorrect dates, transposed, or nonsensical lengths, and transposed or nonsensical tag numbers. Data will be sent to the Craig office at regular intervals and inspected for accuracy and compliance with sampling procedures. Data will be transferred from data sheet books or forms to Excel®[1] database (spreadsheet) files. When input is complete, data lists will be obtained and checked against the original field data.

ABUNDANCE

After thorough inspection of the data to ensure obvious errors are removed, a R script (R Core Team, 2017) will be used to check for errors in the Soldotna ADF&G Sport Fish Division office. The program will check for acceptable dates, species, gear type, location in the lake, mortality status, lengths, and correct (acceptable) tag numbers on newly marked and recaptured fish. The program also calculates growth of recaptured fish and "flags" cases where unusual (≥ ±2 SE) growth rates and total growth occur.

Length Composition

Length data will be checked for accuracy by comparing individual computer line entries to the original field data form entries. Also, paired lengths of marked and recaptured fish will be compared for obvious recording/data entry errors, and growth outside of an "acceptable" range (± 3 SD) will be culled from length analyses.

Archiving

A final, edited copy of the data, along with a data map, will be electronically sent to Sport Fish Division Research and Technical Services (RTS) for archiving. The data map will include a description of all electronic files contained in the data archive, all data fields, and details of where hard copies of any associated data are to be archived, if not in RTS. The data archive will include all R scripts and R input data files, Excel workbooks (presently in Excel 2010), and any other data summaries. Data fields for the tagging file will include (for each fish) lake, area location and depth, gear, species, date, time, fork length, Floy tag number, adipose clip and all other secondary marks, sex, ASL form #, mortality, and comments. The original hard copies and electronic files of all tagging and recovery forms and scales will be logged and stored in the Craig office.

The research coordinators and project leaders, in consultation with RTS staff, will develop an archive tree to keep track of all data archived with RTS and on Docushare® in Region 1, to facilitate accuracy of data archiving and retrieval, and then deposit data archives in the appropriate location.

DATA ANALYSIS

Abundance

Lincoln-Petersen or Darroch closed population (CP) models (Seber 1982: pages 59,431) will be used for estimating abundance in 2018. The assumptions necessary for accurate estimation of abundance with a two-event CP models are as follows:

1) the population will be closed; i.e., recruitment (or immigration) and death (or emigration) will not both occur between sampling events;
2) every fish has an equal probability of being marked during the first event, *or* every fish has an equal probability of being sampled during the second event, *or* marked and unmarked fish mixed completely between events;

[1] This and subsequent product names are included for a complete description of the process and do not constitute product endorsement.

3) marking will not affect the catchability of a fish; and
4) fish will not lose marks between events, *and* marks will be recognized in the recovery sample and reported.

The closure assumption (assumption 1) is addressed by the sample design given the natural barrier on Neck Creek, the relatively short time (30 days) between the two sampling events, and our expectation that significant natural mortality and growth recruitment is not expected at this time of the year.

The probability of capture/mixing assumption (assumption 2) has a good chance of being satisfied geographically because sampling effort will be distributed in proportion to available habitat throughout the lake during each event and because approximately 35 days will pass between events. Contingency table tests of equal recovery rates for fish marked during the first event in each stratum and equal marked fractions during the second event in each stratum (Arnason et al. 1996) will be used to verify this assumption using the three lake sections as geographic strata. Significant results on both tests indicate geographic stratification is necessary for an unbiased estimate of abundance in which case the Darroch CP model will be used. We do not anticipate that the cutthroat trout population in Neck Lake will be geographically stratified during the 2018 experiment considering the population was not geographically stratified during the 1998 experiment and amount of time between marking and recapture will be greater in 2018.

The probability of capture assumptions (assumption 2) with respect to size-selective sampling will be evaluated with a Kolmogorov-Smirnov (KS) and chi-square tests as described in Appendix 1. If size selectivity is indicated, the experiment will be stratified by fish size as described in Appendix 1.

We cannot test for effects of marking on catchability (assumption 3) with only two sampling events. However, Harding et al. (1999b) provides some evidence that capture with baited hoop traps and tagging does not lead to a significant short-term trap avoidance reaction.

Assumption 4 should be robust in this experiment, because all fish will be double-marked and technicians will be instructed to rigorously examine all captured fish for marks. Evidence of tag loss or tagging stress will be recorded for every fish handled. Because all tagged fish will be given a permanent secondary mark (a fin clip), tag loss can be estimated.

If geographic stratification is not indicated (see above) then the modified Chapman-Petersen CP model estimator (Seber 1982) will be used to estimate abundance in Neck Lake in 2018:

$$\hat{N} = \frac{(n_1+1)(n_2+1)}{(m_2+1)} - 1 \tag{1}$$

$$V[\hat{N}] = \frac{(n_1+1)(n_2+1)(n_1-m_2)(n_2-m_2)}{(m_2+1)^2(m_2+2)} \tag{2}$$

where:

$\hat{N}$ = abundance of cutthroat trout ≥180 mm FL;

n_1 = number of cutthroat trout ≥180 mm FL marked in event 1;

n_2 = number of cutthroat trout ≥180 mm FL examined in event 2;

m_2 = number of marked cutthroat trout recaptured in event 2.

Catch Per Unit Effort

For Task 1, mean CPUE by sampling period and gear type will be calculated using standard statistical methods. For Task 2, resampling 3 days per event from our full dataset will provide estimates of bias and loss of precision that can be anticipated if reduced sampling effort was used in future population monitoring efforts.

Length Composition

The sample for length composition will be obtained from all lengths collected from newly captured fish and from systematic samples collected from recaptured fish (see Sampling Design and Data Collection for details). Inseason size selectivity in sampling will be investigated according to the protocols in Appendix 1. In the absence of size selective sampling, length composition will be estimated using equations (3-4) where the subscript *i* is ignored; otherwise, equations (3-4) will be used to estimate composition within each length stratum and equations (1-2) in Appendix 1 will be used to estimate composition of the stratified estimates. The fraction p_{ik} of the fish in length group *k* (20 mm increments) in length stratum *i* will be calculated as:

$$\hat{p}_{ik} = \frac{n_{ik}}{n_i} \tag{3}$$

where n_i = the number of fish in length stratum *i* and n_{ik} = the number from n_i that belong to length group *k*. Note that $\sum_k p_{ik}$ = 1. The variance for $\hat{p}_{ik}$ is

$$\text{var}[\hat{p}_{ik}] = \frac{\hat{p}_{ik}(1-\hat{p}_{ik})}{n_i - 1} \tag{4}$$

Abundance of length group *k* in the population ($\hat{N}_k$) is estimated as

$$\hat{N}_k = \sum_i \hat{p}_{ik} \hat{N}_i \tag{5}$$

where = $\hat{N}_i$ the estimated abundance in length stratum *i* of the mark-recapture experiment. From Goodman (1960), the variance of $\hat{N}_k$ is:

$$\text{var}[\hat{N}_k] = \sum_i \left[\text{var}(\hat{p}_{ik})\hat{N}_i^2 + \text{var}(\hat{N}_i)\hat{p}_{ik}^2 - \text{var}(\hat{p}_{ik})\,\text{var}(\hat{N}_i) \right] \tag{6}$$

For Task 2, the cumulative length distribution of fish captured by each gear during a three day span will be compared to the cumulative length distribution of fish captured by each gear during each sampling event.

SCHEDULE AND DELIVERABLES

The timeline for field and office activities associated with this project are included in Table 2.

Table 2.–Schedule for office and field related activities for this project, 2017-2019.

Month	Years	Activity
November-April	2017/2018	Acquire traps, sampling supplies and housing logistics.
April	2018	Preparations for field sampling.
May 22-31	2018	First event field sampling.
July 2-11	2018	Second event field sampling.
September-December	2018	Data entry/analysis.
April	2019	Completion of draft Fisheries Data Series report.

RESPONSIBILITIES

Craig Schwanke, Fishery Biologist III, ADF&G; Principle Investigator and Project Leader; Duties: Oversight of project, review operational plan, edit, analyze, and report data.

Adam Reimer, Biometrician II, ADF&G;

Duties: Assist with sampling design and operational planning; assist with data analysis and report writing.

Vacant, Fishery Technician III, ADF&G; Crew Leader

Duties: Responsible for field logistics, data collection, gear preparation and assist with fieldwork.

Vacant, Fishery Technician II, ADF&G; Field Crew;

Duties: Assist with field logistics, data collection, gear preparation and fieldwork.

Vacant, Fishery Technician II, ADF&G; Field Crew;

Duties: Assist with field logistics, data collection, gear preparation and fieldwork.

REFERENCES CITED

Arnason, A. N., C. W. Kirby, C. J. Schwarz, and J. R. Irvine. 1996. Computer analysis of data from stratified mark-recovery experiments for estimation of salmon escapements and other populations. Can. Tech. Rep. Fish. Aquat. Sci. 2106: vi+37 p.

Darroch, J.N. 1961. The two-sample capture-recapture census when tagging and sampling are stratified. Biometrika 48:241-60.

Goodman, L. A. 1960. On exact variance of products. Journal of the American Statistical Association 55: 708-713.

Harding, R. D. 2013. Coastal cutthroat trout maturity studies in Southeast Alaska, 1997–1998. Alaska Department of Fish and Game, Fishery Data Series No. 13-32, Anchorage.

Harding, R. D., R. E. Chadwick, and G. M. Freeman. 1999a. Abundance, length composition, and annual mortality of cutthroat trout at Neck Lake, Southeast Alaska, 1996 through 1998. Alaska Department of Fish and Game, Fishery Data Series No. 99-42, Anchorage.

Harding, R. D., M. Laker, and R. P. Marshall, 1999b. Abundance and length, trap avoidance, and short-term spatial movement of cutthroat trout at McKinney Lake, Southeast Alaska, 1996. Alaska Department of Fish and Game, Fishery Data Series No. 99-20, Anchorage.

R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Robson, D. S., and H. A. Regier. 1964. Sample size in Petersen mark-recapture experiments. Transactions of the American Fisheries Society 93:215-226.

Seber, G.A.F. 1982. The estimation of animal abundance, second edition. Charles Griffin and Company, London, Great Britain.

Thompson, S.K. 1987. Sample size for estimating multinomial proportions. American Statistician 41: 42-46.

APPENDICES

Appendix A.–Detection and mitigation of selective sampling during a two-event mark recapture experiment.

Size- and sex-selective sampling may cause bias in two-event mark-recapture estimates of abundance and size and sex composition. Kolmogorov-Smirnov (KS) two sample tests are used to detect size-selective sampling and contingency table analyses (Chi-square tests of independence) are used to detect evidence of sex-selective sampling.

Results of the KS and Chi-square tests will dictate whether the data needs to be stratified to obtain an unbiased estimate of abundance. The nature of the detected selectivity will also determine whether the first, second, or both event samples are used for estimating size and sex compositions.

DEFINITIONS

M = Lengths or sex of fish marked in the first event

C = Lengths or sex of fish inspected for marks in the second event

R = Lengths or sex of fish marked in the first event and recaptured in the second event

SIZE-SELECTIVE SAMPLING: KS TESTS

Three KS tests are used to test for size-selective sampling.

KS Test 1 C vs R Used to detect size selectivity during the 1st sampling event.
H_o: Length distributions of populations associated with C and R are equal

KS Test 2 M vs R Used to detect size selectivity during the 2nd sampling event.
H_o: Length distributions of populations associated with M and R are equal

KS Test 3 M vs C Used to corroborate the results of the first two tests.
H_o: Length distributions of populations associated with M and C are equal

SEX-SELECTIVE SAMPLING: CHI-SQUARE TESTS

Three contingency table analyses (χ^2-tests on 2x2 tables) are used to test for sex-selective sampling.

χ^2 Test 1 C vs R Used to detect sex selectivity during the 1st sampling event.
H_o: Sex is independent of the C - R classification

χ^2 Test 2 M vs R Used to detect sex selectivity during the 2nd sampling event.
H_o: Sex is independent of the M - R classification

χ^2 Test 3 M vs C Used to corroborate the results of the first two tests.
H_o: Sex is independent of the M - C classification

Table A1 presents possible results of selectivity testing, their interpretation, and prescribed action.

Table A1.–Possible results of selectivity testing, interpretation and action.

	KS or χ^2 Test			
Case	M vs. R (2nd event test)	C vs. R (1st event test)	M vs. C (1st vs 2nd event)	Interpretation and Action
I	Fail to reject H_o	Fail to reject H_o	Fail to reject H_o	**Interpretation**: No selectivity during either sampling event. **Action**: Abundance: Use a Petersen-type model without stratification. Composition: Use all data from both sampling events.
II	Reject H_o	Fail to reject H_o	Reject H_o	**Interpretation:** No selectivity during the 1st event but there is selectivity during the 2nd event. **Action**: Abundance: Use a Petersen-type model without stratification. Composition: Use data from the 1st sampling event without stratification. 2nd event data only used if stratification of the abundance estimate is performed, with weighting according to Equations 1-3 below.
III	Fail to reject H_o	Reject H_o	Reject H_o	**Interpretation:** No selectivity during the 2nd event but there is selectivity during the 1st event. **Action**: Abundance: Use a Petersen-type model without stratification. Composition: Use data from the 2nd sampling event without stratification. 1st event data may be incorporated into composition estimation only after stratification of the abundance estimate and appropriate weighting according to Equations 1-3 below.
IV	Reject H_o	Reject H_o	Either result	**Interpretation:** Selectivity during both 1st and 2nd events. **Action**: Abundance: Use a stratified Petersen-type model, with estimates calculated separately for each stratum. Sum stratum estimates for overall abundance. Composition: Combine stratum estimates according to Equations 1-3 below.
V	Fail to reject H_o	Fail to reject H_o	Reject H_o	**Interpretation:** The results of the 3 tests are inconsistent. **Action:** Need to determine which of Cases I-IV best fits the data. Inconsistency can arise from high power of the M vs. C test or low power of the tests involving R. Examine sample sizes (generally M or C from <100 fish and R from <30 are considered small), magnitude of the test statistics (D_{max}), and the *P*-values of the three tests to determine which of which of Cases I-IV best fits the data.

COMPOSITION ESTIMATION FOR STRATIFIED ESTIMATES

An estimate of the proportion of the population in the k^{th} size or sex category for stratified data with I strata is calculated as follows:

$$\hat{p}_k = \sum_{i=1}^{I} \frac{\hat{N}_i}{\hat{N}} \hat{p}_{ik}, \quad (1)$$

with variance estimated as

$$\text{var}\left[\hat{p}_k\right] \approx \frac{1}{\hat{N}^2} \sum_{i=1}^{I} \left(\hat{N}_i^2 \, \text{var}\left[\hat{p}_{ik}\right] + \left(\hat{p}_{ik} - \hat{p}_k\right)^2 \text{var}\left[\hat{N}_i\right] \right), \quad (2)$$

where

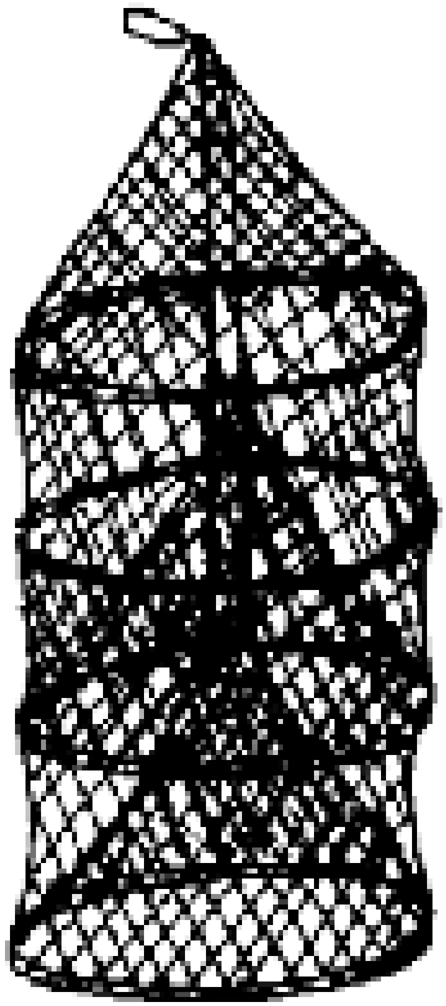
$\hat{p}_{ik}$ = estimated proportion of fish belonging to category k in stratum i;

$\hat{N}_i$ = estimated abundance in stratum i; and

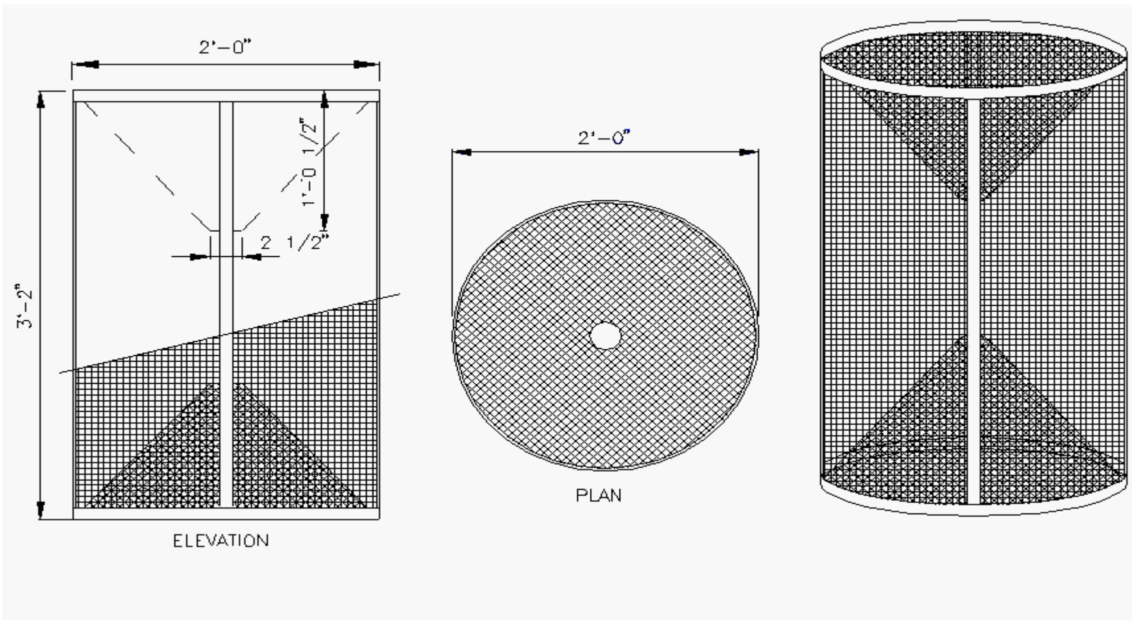
$\hat{N}$ = estimated total abundance

$$= \sum_{i=1}^{I} \hat{N}_i \, . \quad (3)$$

Appendix B.–Hoop trap design.



Appendix C.–Large funnel trap design.



Appendix D.–2018 Neck Lake sampling fish capture field form.

2018 Neck Lake Sampling AWL Form

Date_____/_____/_____ Collectors ______________________ Page_____of ______

						Marks Administered to Fish		Tags and / or Marks on Recaptured Fish			
	Trap #	Location	Gear	Depth	Fork Length	Floy Tag Number	Fin Clip	Color	Floy Tag Number	Old Fin Clips	Comment
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

Hoop Trap = HT; Funnel Trap = FT; Hook & Line =HL; Right Pectoral = RP; Left Pectoral = LP

Appendix E.–2018 Neck Lake sampling trap catch field form.

2018 Neck Lake Trap Catch Form

Date Set _____/_____/_____

Date Pulled_____/_____/_____ Collectors ____ Page_____of ______

	Trap #	Location	Gear	Time Set	Time Pulled	Trap Depth	Number of Fish Captured Cutthroat Trout ≥ 180 mm	 ≥ 180 mm	Comments
1				:	:				
2				:	:				
3				:	:				
4				:	:				
5				:	:				
6				:	:				
7				:	:				
8				:	:				
9				:	:				
10				:	:				
11				:	:				
12				:	:				
13				:	:				
14				:	:				
15				:	:				
16				:	:				
17				:	:				
18				:	:				
19				:	:				
20				:	:				

Hoop Trap = HT; Funnel Trap = FT; Hook & Line =HL.