Regional Operational Plan SF.XX.2019.XX

Operational Plan: Interior Lake Evaluations

2019-2023

by

Kelly Mansfield



April 2019

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

Symbols and Abbreviations

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**Weights and measures (metric)**

centimeter cm

deciliter dL

gram g

hectare ha

kilogram kg

kilometer km

liter L

meter m

milliliter mL

millimeter mm

**Weights and measures (English)**

cubic feet per second ft3/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 pH

(negative log of)

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 HA

base of natural logarithm *e*

catch per unit effort CPUE

coefficient of variation CV

common test statistics (F, t, χ2, 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) log2, etc.

minute (angular) '

not significant NS

null hypothesis HO

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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Kelly Mansfield

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Alaska Department of Fish and Game  
Sport Fish Division

April 2019

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Signature Page

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# Abstract

The Alaska Department of Fish and Game (ADF&G) Division of Sport Fish conducts lake evaluations on both stocked and wild systems throughout Region III. Evaluations fall into two categories: *Stocked Fishery Evaluations* and *New Lake Evaluations*. The study design and methods used to evaluate fish populations and lakes in each of these categories are similar and therefore summarized in one Operational Plan. Types of information collected during a lake evaluation include fish population status, water quality, and lake morphometry.

*Stocked Fishery Evaluations* are needed to evaluate and adjust current stocking strategies and fish hatchery production, update informational handouts, and provide the public with up to date information regarding fishing opportunities.

*New Lake Evaluations* are needed to identify new sport fishing opportunities and to collect baseline information on water bodies with limited or no existing information. Managers need baseline information to develop management plans, assess the impacts of current or proposed development, issue permits, and monitor changes in aquatic systems over time.

Results from these projects will be summarized in a memo at the end of each field season and made available to the public. The department disseminates this information through publications such as the *Guide to Stocked Fisheries*, through the Fish and Game internet website, the Alaska Lake Database (ALDAT), and in informational handouts.

Key words: fish population status, rainbow trout, *Oncorhynchus mykiss*, population structure, stocking evaluation, stock assessment, stocking method, stocking strategy, length-at-age, regional management objective.

# Purpose

This project is an ongoing, annual effort to evaluate stocked and wild lakes throughout Region III. Information collected during this project includes the status of fish populations and lake water quality and morphometry.

*Stocked Lake Evaluations* are conducted to determine if stocked fish are meeting management expectations, to document whether fish survived winter, to assess and compare the performance of different stocking products, and to identify physical and chemical lake properties possibly affecting stocked fish populations.

*New Lake Evaluations* are conducted to provide fishery managers and anglers with current information about fish species present (their size range and overall health) and to describe select physical and chemical properties possibly influencing fish species.

# Background

## Stocked Fishery Evaluations

In 2009, Alaska Department of Fish and Game (ADF&G) Division of Sport Fish Region III developed a management plan for stocked fisheries (Swanton and Taube 2009) and the plan was adopted by the Alaska Board of Fisheries (BOF) for each of the six management areas within Region III[[1]](#footnote-1). Management plans are similar for all areas and all use three approaches (regional, conservative, and special) to meet public demand for diverse fishing opportunities (e.g., *Tanana River Area Stocked Waters Management Plan*; Appendix A). Each management approach lists general objectives for numbers and sizes of fish that anglers should have a reasonable expectation to catch and harvest, but they do not have quantifiable standards.

Because management plan objectives cannot be assessed directly, Skaugstad (2016) developed a general model for evaluating stocked fish populations. This model provides a framework to calculate fishery specific minimum population length-frequency distributions (*m*LFD) that are needed to provide the types of fisheries intended by the BOF and subsequent minimum length standards (*m*LS) that stocked fish populations must meet or exceed to meet management objectives. Collected data can be compared to fishery specific *m*LFDs and *m*LSs to quantitatively and visually (graphically) assess stocked fisheries. For a fishery to be considered a success, the observed mean must equal or exceed the *m*LS.

### Information Needs

#### Fish Populations

Fishery managers have identified two levels of sampling to obtain fish population information needed to evaluate stocked fisheries.

The first level requires unbiased length information to determine if stocking strategies have resulted in fish populations that would meet BOF management objectives. This information is obtained using sampling methods that are described in the *Population Length Frequency Distribution* section of this plan.

The second level requires only basic information about the presence, size range, and general health of fish populations to determine if objectives are met. This information is collected using a less rigorous sampling regime that allows multiple lakes to be sampled each year while providing sufficient data to determine if fish survived winter and to make a general assessment of a population’s overall status. Sampling methods used to acquire this information are described in the section *Basic Population Information*.

Fishery managers will use the information from both levels of sampling to either adjust stocking methods and fish hatchery production or maintain status quo. After examining the information, managers may decide that more accurate and detailed research on fish populations or habitat is warranted.

#### Water Quality

Water quality data are needed to help biologists and managers determine stocking strategies and interpret results from fish population sampling.

Environmental factors such as temperature and dissolved oxygen are used to select suitable species for stocking and to determine the size and number of fish to stock. Because different species have different thermal tolerances and habitat niches, the data we collect helps us identify available habitat and then select the species that is best suited for that environment.

Water quality data also helps us interpret why a population’s LFD does not conform to our expectation. Water quality parameters can influence fish growth, health, and abundance of prey, consequently influencing survival and the population’s LFD. By examining a population LFD and using ancillary information about water quality, we can often identify likely explanations for differences between the actual and desired *m*LFD. Managers and biologists can then make informed and suitable adjustments to the stocking scheme. Occasionally, we may discover that for some lakes the desired population LFD is not realistic due to the natural limitations of the system.

#### Morphometry and Other Lake Characteristics

Depth data are needed to make bathymetric maps and to describe a lake’s physical characteristics. Bathymetric maps are used to calculate several morphometric characteristics such as surface area, mean depth, maximum depth, shoreline length, shoreline development, and volume that are crucial to understanding how a lake system functions. The shape and structure of a lake basin strongly influences the lake’s biotic and abiotic characteristics. We use a lake’s morphometric features, in combination with other limnology features such as prevalence and type of aquatic vegetation, to predict seasonal thermal and dissolved oxygen profiles and the likelihood of winter-kill events. We use this information to select suitable species and methods for stocking fish.

### Lake Selection

Stocked lakes fall within the Tanana River Management Area (TRMA) and Upper Copper Upper Susitna Management Area (UCUSMA) and are stocked with fish raised in the Ruth Burnett Sport Fish Hatchery (RBSFH) in Fairbanks. Currently, there are 118 lakes in the Stocked Fisheries Program (SFP) in Interior Alaska. This number fluctuates annually as lakes are added to or removed from the program.

The criteria for selecting lakes for studyinclude: 1) the importance of the information for management needs; 2) the number of public inquiries or requests for development of a fishery, or for information about the lake or species present in the lake; and, 3) the desire to visit most stocked lakes at least once every 5–10 years to assess fish populations and lake habitat. Because research and management resources are limited, approximately 10 to 15 lakes can be examined each year.

Fish populations in 8 stocked lakes in the TRMA and UCUSMA will be examined during the 2019 field season (Table 1, Figure 1– 3); all lakes are in the Regional Management category. A preliminary list of lakes that may be sampled in 2020-2023 are listed in Appendix B. This list will be reviewed annually and final lake selection will follow the criteria mentioned above based on current management priorities and resources.

Basic population information is needed for fish populations in 3 lakes and LFD information is needed for populations in 5 lakes (Table 1). Desired population *m*LFDs used to perform length analysis are shown in Appendix C. Water quality data will be collected on all 8 lakes (Table 1). Lake locations are shown in Figure 1–Figure 3 and recent stocking histories for each lake are listed in Appendix D.

## New Lake Evaluations

These projects are designed to collect baseline information about the current status of aquatic communities and habitat throughout Alaska over time. Information needed for new lake evaluations is nearly identical to that which is collected during *Stocked Fish Population Assessments*. We will collect data to determine fish species present, evaluate water quality, and create bathymetric maps.

For many lakes in Interior Alaska species and habitats have not been investigated, documented, or, in some cases, sampled in over 50 years. Some of these aquatic systems are in areas that are or will be impacted by current or proposed resource exploration and development. Exploration and development activities include the extension of the Alaska railroad, proposed roads, land sales, resource extraction, and more extensive and intensive use of military training areas. Resource managers need a better understanding of the distribution and habitat use of freshwater fishes within Interior Alaska in order to maintain healthy aquatic resources that will sustain responsible use and development.

Fish information, water quality data, and bathymetric maps are used by state and federal agencies when developing management plans, assessing the impacts of current or proposed development, issuing permits, and monitoring changes in aquatic systems over time. From these observations managers can judge if natural or human activity is resulting in changes to fish distribution, size, abundance, and community structure. In addition to documenting species and habitat, these sampling actives will also help ADF&G Sport Fish area managers identify new angling opportunities.

### Information Needs

#### Fish Populations

Basic population information is needed to document native species present, their size range, and their overall health. Resulting data helps biologists and managers identify critical habitats, fish distributions, the current status of fish communities, and fish populations that require more detailed investigation. Fish presence information is also needed to address public stocking requests and inquiries about wild systems and angling opportunities. Sampling methods used to acquire this information are described in the section *Basic Population Information*.

#### Water Quality

Water quality data is needed to identify the types and limits of habitat used by different fish species, to document baseline levels, to monitor habitat changes over time, and to plan more detailed fish or habitat research. Water quality information such as dissolved oxygen and temperature is useful when evaluating fish species presence or absence and is used to establish fish sampling protocol such as appropriate capture gear and sample locations.

#### Morphometry and Other Lake Characteristics

Bathymetric maps are used to calculate several morphometric characteristics such as surface area, mean depth, maximum depth, shoreline length, shoreline development, and volume. These characteristics are also useful when identifying habitat needs, usage, and limitations. Documentation of the physical attributes of a lake (e.g., surface hectares) can be used to monitor environmental changes, such as lake succession, declining water level, and identifying attributes (e.g., deep vs. shallow) that may limit fish presence or habitat. Additionally, volumetric calculations from bathymetric data are often required before permits for resource use and extraction are issued.

### Lake Selection

New lake evaluations are conducted on lakes within the 6 management areas in Region III and are conducted at area managers’ request. Sample lakes are prioritized based on 1) the importance of the data for management needs (i.e., proposed development or to issue permits); 2) input from the public; and, 3) the available budget and associated project costs.

In 2019, 5 lakes will be examined in the TRMA and UCUSMA (Table 1, Figure 1-Figure 3). Fish presence and water quality information will be collected at 3 locations and morphometric information will be collected at 5 locations. Appendix B lists additional lakes that managers have requested to be sampled. This list, along with any new lakes, will be reviewed annually and 2020-2023 sample locations will be selected based on current management priorities and resources.

Table 1.–Lake descriptions and data requirements for 2019 lake evaluations.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Lake | | Management Category | | | Hectare (Acre) | Fish Analysis | | | Native Species | | Stocked Species | | Water Quality | Map | Stocked? |
| ***Tanana River Management Area*** | | | | | | | | | | | | | | | |
| Chitanana Lake | | - | | | 39.8 (98.3) | basic | | | unknown | | - | | yes | yes | No |
| Coal Mine #5 | | Regional | | | 3.7 (9.1) | LFD | | | SSC | | RT, AC, KS, LTa | | yes | no | Yes |
| Craig Lake | | Regional | | | 8.4 (20.8) | LFD | | | LC | | RT, LTa | | yes | no | Yes |
| Cushman Lake | | Regional | | | 46.3 (114.4) | basic | | | NP, LNS | | RT, KS, GR | | yes | no | Yes |
| Fish Lake (Mt. Hayes) | | - | | | 206.4 (510.0) | - | | | GR, SSC, DV, LT | | - | | yes | yes | No |
| Glacier Lake | | - | | | 178.0 (439.8) | - | | | - | | - | | no | yes | No |
| Little Lost Lake | | Regional | | | 30.1 (74.4) | basic | | | none | | RT | | yes | no | Yes |
| Monte Lake | | Regional | | | 60.0 (148.3) | LFD | | | SSC | | RT | | yes | no | Yes |
| Olnes Pond | | Regional | | | 6.4 (15.8) | basic | | | BB, LNS, LCI, RWF, HWF, LC | | RT, GR | | yes | no | Yes |
| Quartz Lake | | Regional | | | 590 (1,457.9) | LFD | | | LC | | RT, SS, KS, AC | | yes | no | Yes |
| Rapids Lake | | Regional | | | 2.3 (5.7) | LFD | | | none | | RT, LTb | | yes | no | Yes |
| Unknown N of Monte Lake | | - | | | 3.0 (7.4) | basic | | | unknown | | - | | yes | yes | No |
| ***Upper Copper Upper Susitna Management Area*** | | | | | | | | | | | | | | | |
| Lake Louise | | - | | | 6,516.2 (16,101.9) | - | | | - | | - | | no | yes | No |
| Snodgrass Lake | | - | | | 83.2 (205.6) | basic | | | BB, LT | | - | | yes | yes | No |
| a Lake trout last stocked in 1991. | | |
| b Lake trout last stocked in 2000. | | |
| ABF=Alaska blackfish | | | *Dallia pectoralis* | | | |  |  | | LCI=least cisco | | *Coregonus sardinella* | | | |
| AC=Arctic char | | | *Salvelinus alpinus* | | | |  |  | | LNS=longnose sucker | | *Catostomus catostomus* | | | |
| BB=burbot | | | *Lota lota* | | | |  |  | | LT=lake trout | | *Salvelinus namaycush* | | | |
| DV=Dolly Varden | | | *Salvelinus malma* | | | |  |  | | NP=northern pike | | *Esox lucius linnaeus* | | | |
| GR=Arctic grayling | | | *Thymallus arcticus* | | | |  |  | | RT=rainbow trout | | *Oncorhynchus mykiss* | | | |
| HWF=humpback whitefish | | | *Coregonus pidschian* | | | |  |  | | RWF=round whitefish | | *Prosopium cylindraceum* | | | |
| KS=Chinook salmon | | | *Oncorhynchus tshawytscha* | | | |  |  | | SSC=slimy sculpin | | *Cottus cognatus* | | | |
| LC=lake chub | | | *Couesius plumbeus* | | | |  |  | | WF=whitefish unspecified | | *Coregonus* sp.*, Prosopium* sp. | | | |

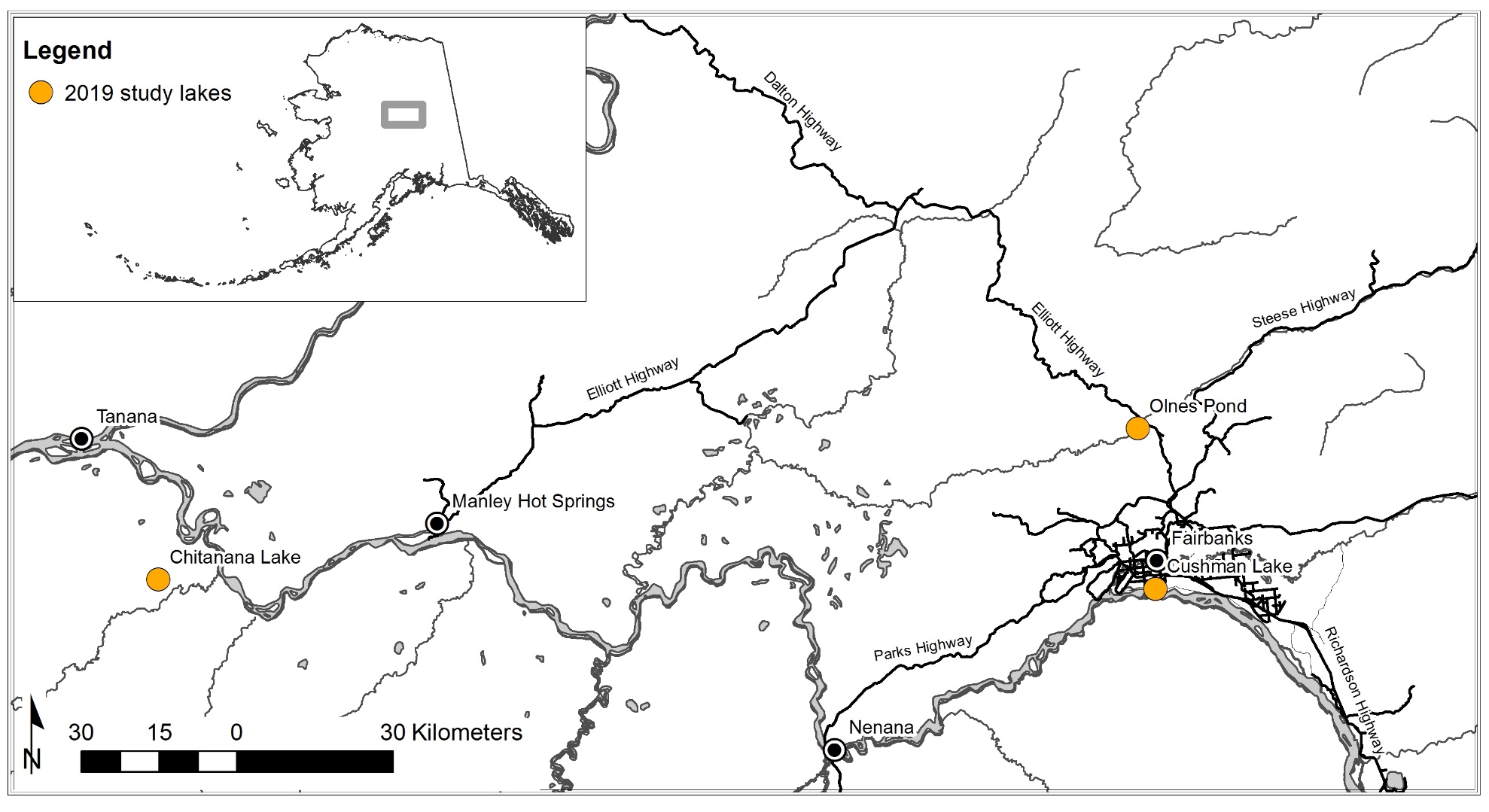


Figure 1.–Location of Lower Tanana River Management Area lakes (near Fairbanks) to be sampled in 2019.

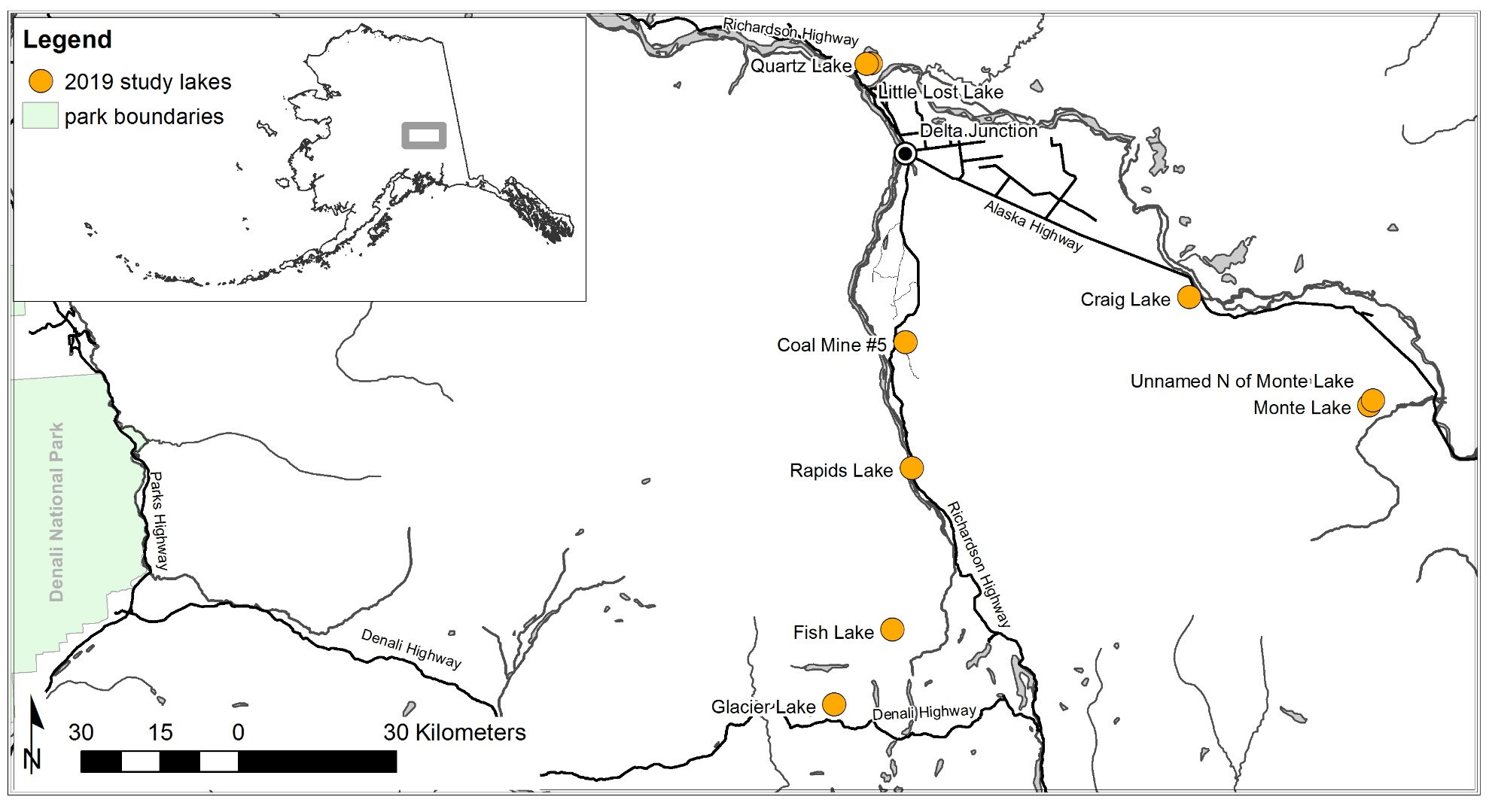


Figure 2.–Location of Upper Tanana River Management Area lakes (near Delta) to be sampled in 2019.

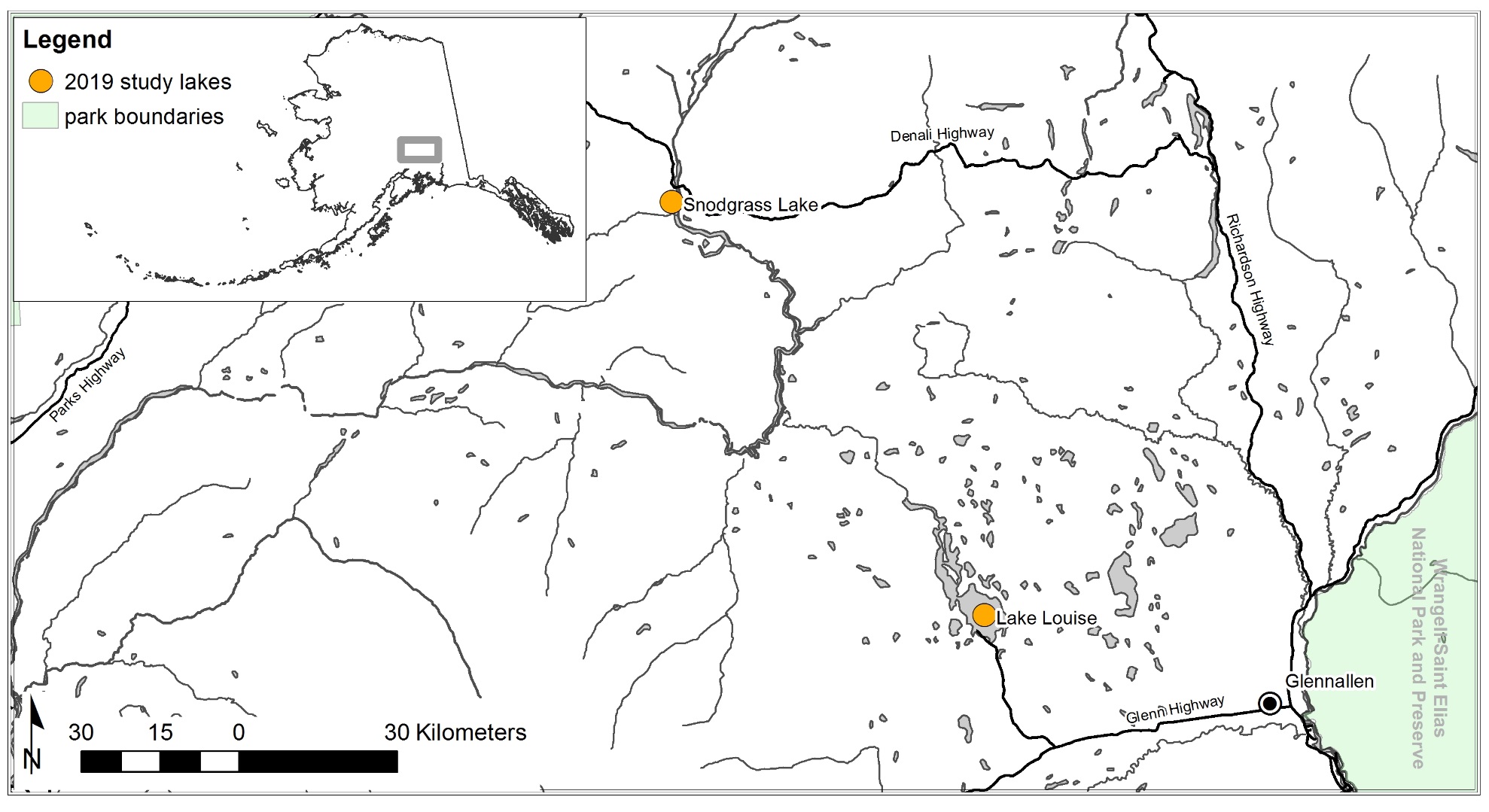


Figure 3.–Location of Upper Copper Upper Susitna River Management Area lakes (near Glennallen) to be sampled in 2019.

# Objectives

## Population Length Frequency Distributions

Management Objective 1: Determine if rainbow trout populations are achieving length standards for lakes listed in Appendix C.

Research Objective 1: Test the hypothesis that rainbow trout mean lengths are at least the model length standards (*m*LS) for defined length groups, such that a difference of at least 10% of the *m*LS will be detected 90% of the time at α = 10%.

## Basic Population Information

Management Objective 2: Provide fishery managers and anglers with current information about fish species present, size range, overall health, and document whether fish survived winter.

Research Objective 2: Survey selected lakes to determine fish species presence, document the size range of captured fish, and examine all captured fish for body and fin condition, external parasites and indications of disease.

## Water Quality

Management Objective 3: Document select physical and chemical properties during fish sampling (May, June, August, or September).

Research Objective 3: Measure water clarity, temperature, dissolved oxygen, pH, total dissolved solids, specific conductivity, and alkalinity.

## Morphometry and Other Lake Characteristics

Management Objective 4: Create bathymetric maps and document physical features for select lakes.

Research Objective 4: Survey lake bottom to obtain depth, longitude, and latitude data for producing bathymetric maps;

Research Objective 5: Describe the lake watershed and the immediate surroundings, such as tree/shrub cover, and inlets and outlets; and,

Research Objective 6: Photograph the lake and surrounding area from north and south locations and, if flown into a lake, take aerial photographs of the lake and surrounding area.

# Methods

## Population Length Frequency Distribution and Mean Length

### Study Design

We will use single-sample capture events to generate population LFDs for rainbow trout and to estimate mean lengths within defined length groups (200mm < L ≤ 350 mm or L > 350 mm). This sampling procedure will collect minimal but sufficient data to determine if stocked rainbow trout populations[[2]](#footnote-2) are meeting *m*LS for the appropriate management approach. All sampling will be conducted when water temperature 1 m below the surface is <18°C.

#### Sampling Methods

##### Capture Gear

Fyke nets will be set near shore on the lake bottom in 1 m to 2 m of water. Location and spacing of the nets will be left to the crew leader’s judgment. Fyke nets have square openings that are either 0.9 m or 1.2 m per side, body length from opening to cod end is about 5 m, hoop size is 0.9 m in diameter, and mesh size is 9 mm2. Wings measuring 7.5 m long by 1.2 m deep are attached to each side of the frame at the open end. The net body will be positioned parallel to shore and the wings will be set to form a “V”. Each fyke net will be pulled taut from the cod end and held in position with a weight. Center-leads attached to the opening of some fyke nets will be used at the discretion of the area manager or project leader.

Tangle nets will be set perpendicular to shore in water deeper than 2 m and will only be used when the crew is on site to reduce injury to fish. Tangle nets measure 45 m long by 5.4 m deep and are made of 13 mm bar fine thread monofilament. Mesh size is small to ensure that fish will be captured by entanglement around the mouth and not by the gill covers. One of two types of tangle nets will be used. One net is a “floater” (the float line buoyancy is greater than the weight of the lead line); the other net is a “sinker” (the lead line is weighted to overcome buoyancy of the float line). The floater has a triple float line and 13.6 kg lead line. The sinker has a double float line and a 31.75 kg lead line. Tangle nets will be checked every 30 minutes. The crew leader will adjust the time interval after visually assessing the physical condition of captured fish.

##### Sampling Schedule

The amount of capture gear and the duration of sampling projects will be based on lake size (Table 2).

Table 2.–Sampling effort according to lake size.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Hectare (Acre) | Nights | Fyke Nets | Tangle Nets | Minnow Trapsa | Hoop Trapsa |
| 0 to 20 (50) | 1 | 4 | 1 | 4 | 4 |
| >20 to 40 (100) | 2 | 4 | 1 | 4 | 4 |
| >40 to 200 (500) | 3 | 4 | 2 | 4 | 4 |
| >200 to 400 (1,000) | 3 | 6 | 2 | 6 | 6 |
| >400 (1,000) | 3 | 8 | 2 | 6 | 8 |

aMinnow and hoop traps are not used to sample stocked lakes; however, they are used during new lake evaluations and are referenced later in this plan.

##### Marking

If nets are fished for more than one night, fish captured for the first time regardless of gear type will be marked by an upper caudal fin clip. This marking method is desired because the mark is easily recognized, the amount of removed tissue is small, and the mark usually regenerates within a year. Other marking methods that use total fin removal or Floy™ tags are permanent and diminish the appearance that anglers desire for fish when they reach larger size.

##### Sample Size: Hypothesis Test of Mean Lengths (Research Objective 1)

Minimum sample sizes to satisfy precision criteria of Objective 1 were determined for each population by first calculating the *m*LS and variance for the appropriate length category (> 200 mm and  350 mm; or > 350 mm) and management approach using modeling methods described by Skaugstad (2016). Minimum sample sizes for each population (Table 3) were then calculated using (Zar 1984):

(1)

where:

*n* is the minimum sample size;

*t* are critical values from Student’s t-distribution for a one-tailed test;

α is the probability of Type I error (0.10);

β is the probability of Type II error (0.10);

*υ* is the degrees of freedom;

*δ* is the minimum detectable difference between observed mean length and *m*LS (10% of *m*LS, from Skaugstad 2016); and,

*σ2* is the variance calculated from modeled length data grouped by 10 mm length intervals using

(2)

where:

*f* is the number of fish within 10 mm length intervals within the appropriate length category;

*N* is the total number of fish within the appropriate length category;

*m* is the midpoint of a 10 mm length interval; and,

*µ* is *m*LS (mean length) for all fish within the appropriate length category.

Table 3.–Minimum sample size required to estimate mean length in a defined length group of rainbow trout in study lakes.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Lake | Predicted Abundance | | Sample Size (n) | |
| ***Tanana River Management Area*** | | | | |
| Coal Mine #5 | | 116 | | 6 |
| Craig Lake | | 116 | | 6 |
| Monte Lake | | 872 | | 5 |
| Quartz Lake | | 31,904 | | 13 |
| Rapids Lake | | 93 | | 6 |

The predicted abundance for each lake (Table 3) is based on current stocking schemes (Appendix D) and estimates of survival from age-1 through age-5 (Appendix C) as described in Skaugstad (2016). Typically, less than 10% of a population is handled during single-sample capture events. Proportionally more sampling effort will be directed towards smaller populations where minimum sample size exceeds 10% of the population.

### Data Collection

All data will be recorded in field notebooks or on pre-made forms (Appendix E). Prior to field work, the crew leader will obtain a lake map from files or generate a map from a computer mapping application. Bathymetric markings are preferred if available. The crew leader will provide one copy for each day of field work plus two extra copies.

Every day, capture gear type (e.g., fyke nets, tangle nets), capture gear locations (waypoint: WGS 84 ddd.ddddd), set depths (m or ft), set and pull dates (MM/DD) and times (military), and temperature (to the nearest 0.10°C) will be recorded on a data form (Appendix E). Also, a new lake map will be used each day to record capture gear type and locations.

Fish length (nearest mm FL), visual inspection of fish body appearance (thin vs. normal), and external signs of disease and parasites along with any tagging data (recapture) will be recorded on the field form as described in Appendix E.

The crew leader will also keep a detailed, daily field journal in a “Rite-in-the-Rain®” notebook. An important goal is to identify conditions that may substantially affect the probability of capture during a sampling event. Information collected should include:

1. Major weather events (rain, hail, high wind) and water conditions (waves, clarity); and,
2. Any other relevant details or observations, such as fish behavior (spawning, feeding), fish health, and note the type of aquatic invertebrates present (identify to order if possible).

### Data Reduction

Data will be transferred from notebooks and field data forms to Microsoft Excel worksheets for analysis and archival. The worksheets will provide a complete history of capture and biological data for each fish. All data and descriptive information in notebooks and field data forms will be examined for obvious errors, corrected, and entered into a Microsoft Excel spreadsheet immediately following the field collection period. After entering the data into the spreadsheet, a battery of data summaries will be performed to identify obvious transcription errors (i.e., lengths smaller or larger than what was observed in the field or GPS coordinates that lie outside the lake perimeter). Errors will be corrected when possible or the data will be excluded from further analysis. Additional columns may be added for clarity and a glossary of all column headings will be provided in a text box along with a brief project description. Final copies of worksheet files will be provided with the completed memo when it is submitted for printing to be archived in the Sport Fish Division Docushare repository. At that time, a file name and directory will be assigned, which will be included as an appendix in the memo. All fish data will also be stored in the Alaska Lake Database (ALDAT) accessible at:

<http://www.adfg.alaska.gov/index.cfm?adfg=fishingSportStockingHatcheries.lakesdatabase>.

### Data Analysis

#### Length Frequency Distributions

The *histogram* function in Excel will be used to enumerate rainbow trout that fall within 10 mm length categories. Length categories will start at 0 mm and increase by 10 mm intervals (e.g., 0 to <10 mm, 10 to <20 mm, etc.) The last length category for a data set will include the largest fish. This information will be used to create a column chart to illustrate the population LFD.

The histograms also will be used to enumerate fish that fall within one of two defined length categories: either 200 mm < L ≤ 350 mm or L > 350 mm (depending on lake management category). Additionally, the LFD chart will be used to visually identify age cohorts within the population and to help determine the length mode for each age cohort. For fisheries stocked on alternate years, age cohort LFDs have more pronounced separations allowing us to more accurately assign ages. However, when the fishery is stocked every year, it is more difficult to accurately assign age because faster growing fish in a younger cohort can be larger than the slower growing fish in an older cohort. As a result, due to greater overlap of age cohort LFDs it is more difficult to distinguish age cohort LFDs.

#### Estimates of Mean Lengths

Mean lengths () of fish captured and corresponding sampling variances within length categories described in Appendix C will be calculated using standard sample summary statistics (Cochran 1977).

#### Hypothesis Test of Mean Lengths

Observed mean lengths () from collected data will be compared to *m*LS for appropriate length categories (Appendix C) using bootstrap procedures described by Skaugstad (2016).

#### Assumptions and Bias

One potential concern with using data from this single-sample study design is that inadequate data are collected to evaluate size bias during sampling. This topic is addressed in Appendix F.

#### Other Biological Data

Numbers of fish classified as having external signs of disease, parasites, or a thin body will be summarized as a binomial proportion:

(3)

where:

*xi* is the number of fish classified with the condition in lake *i*, and

*ni* is the sample size in lake *i.*

The variance of the proportion will be estimated by (Cochran 1977):

(4)

## Basic Population Information

### Study Design

This sampling procedure is designed to collect minimal but sufficient data to answer basic questions posed by fishery managers. This approach is appropriate because costs are minimized, which allows a large number of fisheries to be sampled during the year.

We will use single-sample capture events to identify fish species present and to describe population LFDs and overall health of captured fish. Fyke nets and tangle nets will be used to capture fish species in stocked lakes. Fyke nets, tangle nets, and minnow traps will be used to sample fish populations in lakes that are not stocked.

#### Sampling Methods

##### Capture Gear

General descriptions and methods for using fyke nets and tangle nets are described in the preceding section *Population Length Frequency Distribution and Mean Length – Sampling Methods*.

Minnow traps will be used in both near shore and offshore areas. Lake depth at each set location will be recorded. Set and pull times will be noted so that sampling effort is available. Minnow traps are 22 cm diameter and 42 cm long with an inward pointing funnel at each end. Traps are made of 6 mm wire mesh and will be attached to a vertical line that has a float on one end and a weight on the other, positioned horizontally in the water column, and baited with unsalted salmon roe or raw shrimp.

Hoop traps will be used in water deeper than 2 m. Lake depth at each set location will be recorded. Set and pull times will be noted so that sampling effort is available. Hoop traps are 0.5 m diameter and 1.6 m long with an inward pointing conical funnel at one end. Netting is 6.4 mm Delta weave. Each hoop trap will be attached to a vertical line with a float on the other end, set on the lake bottom, and baited with herring. Hoop traps will not be set where dissolved oxygen levels are less than 2 ppm.

##### Sampling Schedule

Amount of capture gear and duration of sampling projects will be based on lake size as outlined in the preceding section *Population Length Frequency Distribution and Mean Length-Sampling Schedule* of this plan (Table 2). The amount of capture gear may be adjusted to accommodate logistical constraints and reduce transportation costs when sampling in remote areas accessible only by aircraft.

### Data Collection

The procedures described in the preceding section *Population Length Frequency Distribution and Mean Length–Data Collection* will be followed.

### Data Reduction

The procedures described in the preceding section *Population Length Frequency Distribution and Mean Length–Data Reduction* will be followed.

### Data Analysis

Sampling data will be summarized to show species present and size range (smallest and largest fish by species). Population LFD plots will be generated when 10 or more fish of the same species are captured.

## Water Quality

### Study Design

Water sampling will be conducted at each study lake during fish sampling (May, June, August, or September) and during midsummer (July) and late winter (March) if time permits. These times were selected because environmental conditions often approach critical biological limits and fish are physically stressed. Summer water temperatures normally peak in most Alaska lakes during July (LaPerriere et al. 2003a) and dissolved oxygen levels can fluctuate dramatically within the course of a single day. High temperatures and low dissolved oxygen levels approach and may possibly exceed critical limits for some game fish species.

In northern latitude lakes, increasing length of time of ice and snow cover can reduce the contribution of oxygen by photosynthetic organisms and prolong the depletion of the oxygen reservoir by decomposers (LaPerriere et al. 2003b; Horne and Goldman 1994; Wetzel 1975; Danylchuk and Tonn 2003). These conditions increase the likelihood of winterkill where fish die due to low levels of dissolved oxygen.

#### Sampling Methods

Physical and chemical properties will be measured at a minimum of two stations in each lake. One station will be situated at the maximum depth of each major basin present in the lake. If there is only one basin, the second station will be located equal distance between the maximum depth and nearest shore (along the long axis of the lake; Koenings et al. 1987). A *YSI ProDSS Sonde* will be used to measure temperature, pH, dissolved oxygen, percent dissolved oxygen, specific conductivity, and total dissolved solids. Methods for operating the instruments will follow procedures described in the appropriate instruction manual. A 1-L sample of lake water will be taken over the deepest basin from a depth of 0.3 m (1 ft) and later titrated at room temperature to determine total alkalinity. Water transparency will be measured as the average of the depths that a Secchi disk disappears and reappears as it is lowered and raised in the water (Koenings et al. 1987).

### Data Collection

Lake name (location), GPS coordinates, date, time, and weather conditions (e.g., cloud cover, air temperature) will be noted on a field data sheet (Appendix E). Water temperature, dissolved oxygen, percent dissolved oxygen, specific conductivity, pH, total dissolved solids, and oxidation reduction potential (ORP) readings will be recorded at 0.5 m intervals from the surface down to 5 m, and then at 1 m intervals until lake bottom is reached. The depths where a Secchi disk disappears and reappears in the water will be recorded. Lake water color will be visually assessed in the field as clear, ferric, glacial-high turbidity, glacial-low turbidity, humic, or muddy (Table 4).

Table 4.–Descriptions of water color.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Code | Description | | Definition | |
| CLR | | Clear | | Transparent water, or nearly so. |
| FER | | Ferric | | Rust (orange) - stained. |
| GHT | | Glacial, High Turbidity | | High turbidity waters (visibility ≤ 30 cm (12 in) typical of streams originating directly from glaciers (e.g., Matanuska River). |
| GLT | | Glacial, Low Turbidity | | Low turbidity waters (visibility > 30 cm) typical of systems with large lakes (settling basins) below glacial discharge (e.g., Kenai River). These waters are frequently turquoise-colored. |
| HUM | | Humic | | Tea-colored water (tannic) |
| MUD | | Muddy | | Dark water with high suspended particulate load. |

A 1-L water sample for total alkalinity will be collected near the middle of the lake about 0.3 m beneath the surface immediately before leaving the lake and stored in a dark bottle and kept cool. Alkalinity samples will be refrigerated until they are analyzed in a laboratory. Prior to titration, samples will be brought to room temperature. A 100 mL sample will be titrated with sulfuric acid (0.02N) to an endpoint of pH 4.5 and the amount of titrant will be recorded (Koening et al. 1987). Each sample will be analyzed three times and the average will be the total alkalinity.

### Data Reduction and Analysis

Data collected in the field and laboratory will be transferred from field data sheets and laboratory notes into computer spreadsheets for reduction, analysis, and archiving.

Graphic profiles of temperature and dissolved oxygen will be generated using Microsoft Excel. Profiles will be inspected for readings that approach or exceed the upper and lower biological limits for stocked game fish species.

Total alkalinity (mg/L as CaCO3) will be calculated using the following equation (Koening et al. 1987):

(3)

where:

*TA* is the total alkalinity (mg/L as CaCO3);

*B* is the mL of titrant (0.02N H2SO4);

*N* is the normality of the titrant; and,

*V* is the sample volume.

The Secchi disk transparency (SD) is the average of the two recorded depth readings.

Reduced data from water quality sampling will be stored at the ADF&G Region III Sport Fish office and distributed to the public upon request.

## Morphometry and other Lake Characteristics

### Study Design

Selected lakes will be surveyed for morphometric information and peripheral watershed features, such as inlets and outlets, and the main terrestrial vegetation type surrounding the lake (tree, grass, shrub). For lakes that have bathymetry data already available, perimeter mapping may be conducted to update existing files.

#### Sampling Methods

Position and depth data for bathymetry mapping will be collected with a *Lowrance HDS-5 Lake Insight* sonar and GPS unit. Location data will be recorded in Lowrance Mercator Meter format. Latitude and longitude will be recorded in degrees to the fifth decimal.

### Data Collection

Data will be collected by first following the shoreline in a small skiff within 5 m off shore where adequate depth (>0.5 m) allows. When shallow water (<0.5 m) is encountered, we will move the skiff further away from shore until there is adequate depth (>0.5 m) and mark the section on the map. Where the 0.5 m contour deviates substantially from the shore, a GPS will be used to track these sections along the lake perimeter (by either walking the shore or near shore) and depth measurements will be documented where the fathometer is unable to take readings. After surveying the shoreline the rest of the lake will be surveyed along multiple concentric transects, spaced equidistantly, paralleling the shoreline and decreasing in size until the middle of the lake is reached (Figure 4).

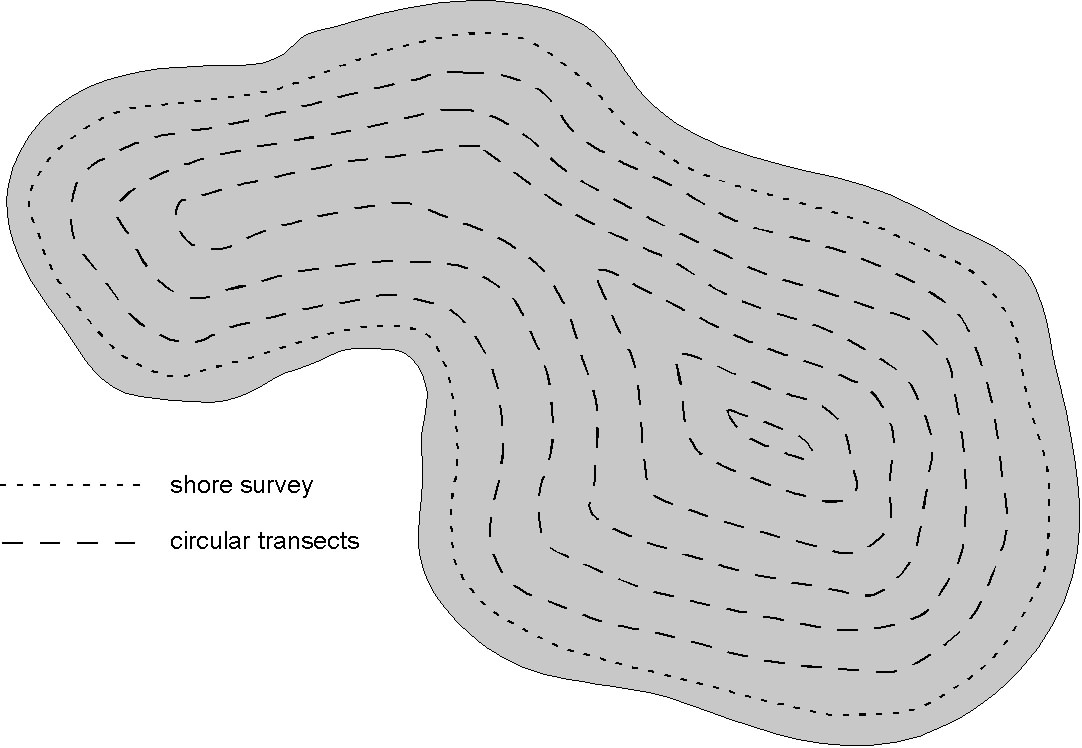


Figure 4.–Shore and circular transect pattern used to collect depth data in study lakes.

The number of transects will be determined by these guidelines: Lakes that are less than 40 ha will have a minimum of six transects; lakes between 40 and 200 ha will have a minimum of 10 transects; and, lakes that are 200 to 800 ha will a have a minimum of 15 transects. If the lake bottom appears to be highly variable or “interesting,” more transects will be added after the initial transects are complete. Position and depth data are recorded every 2 seconds. This is a general design and it will be modified to conform to different lakes.

The immediate surroundings (up to 5 m from shore) of the lake will be described through visual observations. This will include documenting inlets and outlets and noting the general vegetation cover as tundra, shrub (willow), deciduous, coniferous, or a combination of these types.

At each lake, a minimum of two digital photographs will be taken: One photograph taken from the south shore looking north, and one photograph taken from the north shore looking south. Additional photographs may be taken of notable habitat features or other subjects of interest at the lake. Aerial photographs (when possible) will be taken from an altitude of 300 m above the lake and cover the entire shoreline.

### Data Reduction and Map Generation

Lake maps will be generated using *ArcMap 10.3* and *3D Spatial Analyst*. Position data will be converted from Lowrance Mercator Meter to WGS84 (decimal degrees to the fifth decimal place) using methods provided by Lowrance:

Longitude=RadDeg(X/r) (4)

and

Latitude=RadDeg(2arctan(e^(Y/r))-п/2). (5)

where:

X is the X position recorded in Mercator Meters from the Lowrance unit;

Y is the Y position recorded in Mercator Meters from the Lowrance unit;

RadDeg is the number of degrees in 1 radian (57.2957795132°); and,

r is the assumed radius of the earth (6356752.3142 m).

Conversions assume the earth is a sphere with a fixed radius (r) and does not account for the actual ellipsoid shape of the earth.

Surface area, mean depth, max depth, volume, max length, and shoreline length will also be calculated using *ArcMap 10.3*.

Bathymetric maps will be added to the Alaska Lake Database (ALDAT) (http://www.adfg. alaska.gov/index.cfm?adfg=fishingSportStockingHatcheries.lakesdatabase), used to update the Division of Sport Fish’s Lake Fishing Information webpage ([http://www.adfg.alaska.gov/index. cfm?adfg=fishingSport.region](http://www.adfg.alaska.gov/index.%20cfm?adfg=fishingSport.region)), and made available to the public at ADF&G offices.

# Schedule and Deliverables

Preliminary dates for sampling, data reduction and analysis, and reporting are summarized below. Results from lake evaluations will be summarized in a memo with 2019 data. Water quality data and bathymetric maps resulting from lake surveys will be summarized and filed by lake at the Fairbanks Regional Office.

**Stocked Fishery Population Assessments (SFP)**

Dates Activity

1 Mar–30 April 2019 Critical period for conducting dissolved oxygen surveys (as time permits). These data will be summarized and archived in a regional database.

15 May–30 June 2019 Spring lake sampling. Actual stop time will depend on water temperature and flight availability. Fisheries to sample: Craig Lake, Coal Mine #5, and Rapids Lake.

1 Aug–31 Aug 2019 Fall lake sampling. Actual start time will depend on water temperature. Fisheries to sample: Cushman Lake, Little Lost Lake, Monte Lake, Olnes Pond, and Quartz Lake.

15 Nov 2019 Fish, water quality, and morphometric information summary and analysis complete. Resulting data, maps, and photos uploaded to ADF&G websites and databases.

1 March 2020 Memo summarizing stocked fishery evaluations submitted to Research Supervisor.

**New Lake Evaluations (ILA)**

Dates Activity

1 Mar–30 April 2019 Critical period for conducting dissolved oxygen surveys (as time permits). These data will be summarized and archived in a regional database.

1 June–15 July 2019 Lake sampling. Actual sample times will depend on ice out and water temperature. Lakes to sample: Chitanana Lake, Lake Louise, and Fish Lake (Mt. Hayes).

1 Aug–31 Aug 2019 Fall lake sampling. Actual start time will depend on water temperature. Fisheries to sample: Glacier Lake, and Unnamed N of Monte Lake.

15 Nov 2019 Fish, water quality, and morphometric information summary and analysis complete. Resulting data, maps, and photos uploaded to ADF&G websites and databases.

1 March 2020 Memo summarizing lake evaluations submitted to Research Supervisor.

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# Responsibilities

**Kelly Mansfield:** Fishery Biologist II, Stocked Fisheries Program Project Biologist

**Duties:** Project Leader. Supervision of all aspects of Interior lake evaluations on stocked and wild lakes. Supervise, coordinate, and lead lake sampling projects. Assign and supervise field crews, coordinate and supervise field data collection, conduct data analysis for fish population sampling, summarize water quality data, generate bathymetric maps, assist in field work, and author an annual memo summarizing study results (Management Objectives 1–4, Research Objectives 1–6). Coordinate with area management biologists to adjust and develop stocking plans for Region III fisheries based on sample results.

**Benjamin Buzzee:** Biometrician II.

**Duties:** Project Biometrician. Provide biometric support for operational plans, data analysis, and FDS report review.

**Virgil Davis:** Technician III.

**Duties:** Field crew leader. Assist with field and laboratory work and data entry.

**Elizabeth Rowe:** Technician II.

**Duties:** Crew member. Assist with field and laboratory work and data entry.

**Nancy Sisinyak:** Information Officer II.

**Duties:** Disseminate information to the public through handouts, booklets, and the ADF&G web page.

# Reference Cited

Behr, A. E., J. T. Fish, and C. Skaugstad. 2005. Evaluation of rainbow trout in Lisa Lake during 2001, and fish population monitoring in stocked waters in the Tanana River and Copper River drainages, 1999-2003. Alaska Department of Fish and Game, Fishery Data Series No. 05-19, Anchorage.

Behr, A. and C, Skaugstad. 2006. Evaluation of Rainbow Trout in Koole Lake and Rainbow Lake, 2004. Alaska Department of Fish and Game, Fishery Data Series No. 06-39, Fairbanks.

Behr, A. and C. Skaugstad. 2007. Evaluation of stocked rainbow trout populations in Interior Alaska, 2005. Alaska Department of Fish and Game, Fishery Data Series No. 07-49, Anchorage.

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

Conover, W. J. 1980. Practical nonparametric statistics 2nd ed. John Wiley & Sons, New York.

Danylchuk, A. J. and W. M. Tonn. 2003. Natural disturbances and fish: local and regional influences on winterkill of fathead minnows in boreal lakes. Transactions of the American Fisheries Society 132:289-298

Doxey, M. 1989. Evaluation of stocked waters in the Tanana drainage, 1988. Alaska Department of Fish and Game, Fishery Data Series No. 106, Juneau.

Doxey, M. 1992. Abundance of rainbow trout in Birch and Quartz lakes, 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-10, Anchorage.

Fish, J. T., C. Skaugstad. 2004. Evaluation of Rainbow Trout in Quartz Lake, 2001 & 2002. Alaska Department of Fish and Game, Fishery Data Series No. 04-02, Anchorage.

Havens, A. C., M. Alexandersdottir, and S. Sonnichsen. 1992. Evaluation of rainbow trout populations in Big Lake, Alaska, 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-18, Anchorage.

Horak, D. L. and H. A. Tanner. 1964. The use of vertical gill nets in studying fish depth distribution, Horsetooth Reservoir, Colorado. Transactions of the American Fisheries Society 93:137-145.

Horne, A. J. and C. R. Goldman. 1994. Limnology, 2nd Edition. McGraw-Hill, Inc., New York.

Koenings, J. P., J. A. Edmundson, G. B. Kyle, and J. M. Edmundson. 1987. Limnology field and laboratory manual: methods for assessing aquatic production. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development, No. 71.

Kwain, W. and R. W. McCauley. 1978. Effects of age and overhead illumination on temperatures preferred by underyearling rainbow trout, *Salmo gairdneri*, in a vertical temperature gradient. Journal of the Fisheries Research Board of Canada 35:1430-1433.

LaPerriere, J. D., T. D. Simpson and J. R. Jones. 2003a. Comparative limnology of lakes in Interior Alaska. Lake and Reserv. Manage. 19(2):122-132.

LaPerriere, J. D, J. R. Jones and D. K. Swanson. 2003b. Limnology of lakes in Gates of the Arctic National Park and Preserve, Alaska. Lake and Reserv. Manage. 19(2):108-121.

Overholtz, W. J., A. W. Fast, R. A. Tubb, and R. Miller. 1977. Hypolimnion oxygenation and its effects on the depth distribution of rainbow trout and gizzard shad. Transactions of the American Fisheries Society 106:371-375.

Rowe, D. K. 1984. Factors affecting the foods and feeding patterns of lake-dwelling rainbow trout in the North Island of New Zealand. New Zealand Journal of Marine and Freshwater Research 18:129-141.

Rowe, D. K. and B. L. Chisnall. 1995. Effects of oxygen, temperature and light gradients on the vertical distribution of rainbow trout, Oncorhynchus mykiss, in two North Island, New Zealand, lakes differing in trophic status. New Zealand Journal of Marine and Freshwater Research 29:421-434.

Seber, G. A. F. 1982. Estimation of animal abundance and related parameters. -2nd edition. Charles Griffin & Co Ltd.

Skaugstad, C. 2016. Fish Stocking Model to Create and Maintain Stocked Fisheries in Interior Alaska. Alaska Department of Fish and Game, Fishery Data Series No. 16-22, Anchorage.

Skaugstad, C. and J. Fish. 2002. Evaluation of stocked game fish in the Tanana Valley, 2000. Alaska Department of Fish and Game, Fishery Data Series No. 02-11, Anchorage.

Warner, E. J. and T. P. Quinn. 1995. Horizontal and vertical movements of telemetered rainbow trout (*Oncorhynchus mykiss*) in Lake Washington. Canadian Journal of Zoology 73:146-153.

Wetzel, R. G. 1975. Limnology. Saunders, Philadelphia.

Zar, J. H. 1984. Biostatistical Analysis, 2nd ed. Prentice-Hall Inc. Englewood Cliffs, NJ.

Swanton, C. O. and T. T. Taube. 2009. A Management Plan for Stocked Waters Fisheries within Sport Fish Region III. Alaska Department of Fish and Game, Fishery Management Report No. 09-03, Anchorage.

Appendix A

**Example of Board of FISHERIES Management Plan For Stocked Waters**

Appendix A.‑Example of Board of Fisheries Management Plan for Stocked Waters. Page 1 of 2.

5 AAC 74.065. Tanana River Area Stocked Waters Management Plan

(a) The department shall manage stocked waters in the Tanana River Area in order to meet public demand for diverse fishing opportunities. The department may manage fisheries to provide or maintain qualities that are desired by sport anglers. The department shall manage the stocked waters according to one of three management approaches. The management approaches are the

(1) regional management approach;

(2) conservative management approach; and,

(3) special management approach.

(b) The board's regulations that govern stocked waters in the Tanana River Area shall be consistent with the applicable management approach specified in (a) of this section.

(c) When a water body in the Tanana River Area is first stocked, it shall be placed under the regional management approach category. After receiving a proposal from the public, the department, or from the board to reclassify a water body, and when the proposal meets the criteria for a different classification, the board may reclassify the water body. The board will act on a proposal to reclassify a water body or to designate a water body for special management only if the proposal has been submitted according to the procedures set out in [5 AAC 96.610](http://www.legis.state.ak.us/basis/aac.asp#5.96.610) and is consistent with the board's regular meeting cycle schedule.

(d) Regional management approach. Under the regional management approach, stocked waters will be managed so that there will be a reasonable expectation of high catch rates and harvesting a daily bag limit. The bag and possession limit is 10 fish in combination of all stocked species, and only one of those fish may be 18 inches or greater in length. The fishing season is open year round and bait may be used.

(e) Conservative management approach. Under the conservative management approach, stocked waters will be managed so that there will be a reasonable expectation to catch a daily bag limit with a reasonable chance of catching fish 18 inches or greater in length. The bag and possession limit is five fish in combination of all stocked species, and only one of those fish may be 18 inches or greater in length. The fishing season is open year round and bait may be used.

(f) Special management approach. Under the special management approach, stocked waters will be managed so that there will be a high probability of an angler catching more than one fish a day that is 18 inches or greater in length. When considering a proposal regarding this management approach, the board should consider taking the following actions:

(1) limit fishing to

(A) catch-and-release fishing;

(B) fly fishing;

(C) trophy fishing, which means that a fish retained must be 18 inches or greater in length;

(2) establish seasonal periods when fishing is closed or is restricted to catch-and-release fishing; or,

(3) establish a bag limit of one fish, 18 inches or greater in length, or another appropriate bag and size limit.

(g) Water bodies managed under the special management approach include Harding Lake.

-continued-

Appendix A.‑Page 2 of 2.

(h) Water bodies managed under the conservative management approach include

(1) Dune Lake;

(2) Koole Lake; and

(3) Rainbow Lake.

(i) During times of low hatchery output, the commissioner may, by emergency order, modify methods and means, reduce bag limits, or institute a catch-and-release fishing only fishery.

Appendix B

**Candidate Lakes to be sampled in 2020-2023**

Appendix B.–Candidate lakes to be sampled in 2020-2023. Page 1 of 4.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Lake** | **Latitude (WGS84)** | **Longitude (WGS84)** | **Management Category** | **Area (ha)** | **Fish Analysis** | **Water Quality** | **Map** | **Year to Sample** |
|  | | | | | | | | |
| **Stocked Lakes** | | | | | | | | |
| ***Tanana River Management Area*** | | | | | | | | |
| Backdown Lake | 63.71486 | -145.82391 | Regional | 2.1 | Yes | Yes | No | 2020 |
| Bluff Cabin Lake | 64.16678 | -145.66504 | Regional | 15.5 | Yes | Yes | No | 2020 |
| Four Mile Lake | 63.36110 | -142.57192 | Regional | 49.9 | Yes | Yes | No | 2020 |
| Hidden Lake (EAFB) | 64.68721 | -147.13696 | Regional | 6.7 | Yes | Yes | No | 2020 |
| Hidden Lake (Tok) | 62.78909 | -141.31306 | Regional | 11.4 | Yes | Yes | No | 2020 |
| Nordale #2 | 64.85338 | -147.44574 | Regional | 4.9 | Yes | Yes | No | 2020 |
| North Pole Pond | 64.75328 | -147.33231 | Regional | 5.7 | Yes | Yes | No | 2020 |
| North Twin Lake | 63.86430 | -145.83965 | Regional | 6.4 | Yes | Yes | No | 2020 |
| South Twin Lake | 63.86333 | -145.83851 | Regional | 5.4 | Yes | Yes | No | 2020 |
| Weasel Lake | 63.75922 | -145.85368 | Regional | 4.5 | Yes | Yes | No | 2020 |
| Big "D" Pond | 64.13700 | -145.82786 | Regional | 4.0 | Yes | Yes | No | 2021 |
| Brodie Lake | 63.71232 | -145.83409 | Regional | 2.1 | Yes | Yes | No | 2021 |
| Chena Hot Springs Rd #56.0 | 65.05364 | -146.05817 | Regional | 1.0 | Yes | Yes | No | 2021 |
| Dune Lake | 64.42324 | -149.90426 | Regional | 85.6 | Yes | Yes | No | 2021 |
| J Lake | 63.83345 | -145.83582 | Regional | 6.8 | Yes | Yes | No | 2021 |
| Last Lake | 63.71657 | -145.83474 | Regional | 1.2 | Yes | Yes | No | 2021 |
| Parks Hwy 261 | 64.01124 | -149.14122 | Regional | 0.4 | Yes | Yes | No | 2021 |
| Paul's Pond | 63.70651 | -145.82966 | Regional | 2.2 | Yes | Yes | No | 2021 |
| Rangeview Lake | 63.70576 | -145.82924 | Regional | 1.8 | Yes | Yes | No | 2021 |
| Z Pit | 64.72762 | -147.24341 | Regional | 4.6 | Yes | Yes | No | 2021 |
| Bullwinkle Lake | 63.90700 | -145.82309 | Regional | 2.0 | Yes | Yes | No | 2022 |
| Cather's Lake | 64.71036 | -147.12113 | Regional | 11.0 | Yes | Yes | No | 2022 |
| Chena Lake | 64.76917 | -147.22286 | Regional | 93.1 | Yes | Yes | No | 2022 |
| Chet Lake | 63.83059 | -145.83734 | Regional | 3.6 | Yes | Yes | No | 2022 |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Lake** | **Latitude (WGS84)** | **Longitude (WGS84)** | **Management Category** | **Area (ha)** | **Fish Analysis** | **Water Quality** | **Map** | **Year to Sample** |
| ***Tanana River Management Area*** | | | | | | | | |
| Dicks Pond | 63.68955 | -145.82665 | Regional | 2.6 | Yes | Yes | No | 2022 |
| Forrest Lake | 63.47449 | -144.02746 | Regional | 13.6 | Yes | Yes | No | 2022 |
| Kens Pond | 63.68144 | -145.82423 | Regional | 2.5 | Yes | Yes | No | 2022 |
| Koole Lake | 64.19888 | -146.60049 | Regional | 85.6 | Yes | Yes | No | 2022 |
| Manchu Lake | 64.70151 | -147.03376 | Regional | 15.6 | Yes | Yes | No | 2022 |
| Mark Lake | 63.87163 | -145.86523 | Regional | 5.2 | Yes | Yes | No | 2022 |
| Monterey Lake | 64.82154 | -147.62312 | Regional | 3.0 | Yes | Yes | No | 2022 |
| Nickel Lake | 63.82820 | -145.83434 | Regional | 2.7 | Yes | Yes | No | 2022 |
| Polaris Lake | 64.68868 | -147.07280 | Regional | 19.3 | Yes | Yes | No | 2022 |
| Rich 28 | 64.60934 | -147.06096 | Regional | 2.9 | Yes | Yes | No | 2022 |
| Sheefish Lake | 63.91124 | -145.81336 | Regional | 2.9 | Yes | Yes | No | 2022 |
| Bathing Beauty | 64.71442 | -147.19345 | Regional | 5.0 | Yes | Yes | No | 2023 |
| Donnelly Lake | 63.75350 | -145.80576 | Regional | 12.3 | Yes | Yes | No | 2023 |
| Fourteen Mile Lake | 63.07195 | -145.80594 | Regional | 39.0 | Yes | Yes | No | 2023 |
| Jan Lake | 63.56665 | -143.91706 | Regional | 10.1 | Yes | Yes | No | 2023 |
| Lisa Lake | 63.70995 | -144.67461 | Regional | 18.7 | Yes | Yes | No | 2023 |
| Lost Lake | 64.30083 | -146.67855 | Regional | 42.2 | Yes | Yes | No | 2023 |
| Parks Hwy 285 | 64.31050 | -149.08131 | Regional | 2.1 | Yes | Yes | No | 2023 |
| Pyrite Pond | 64.77879 | -147.25820 | Regional | 1.0 | Yes | Yes | No | 2023 |
| ***Upper Copper – Upper Susitina Management Area*** | | | | | | | | |
| Junction Lake | 62.08955 | -146.35207 | Regional | 4.9 | Yes | Yes | No | 2020 |
| Sculpin Lake | 61.52339 | -144.14605 | Regional | 48.4 | Yes | Yes | No | 2020 |
| North Jans Lake | 62.29013 | -146.38554 | Regional | 25.3 | Yes | Yes | No | 2021 |
| South Jans Lake | 62.28666 | -146.36555 | Regional | 34.6 | Yes | Yes | No | 2021 |
| Two Mile Lake | 61.55416 | -144.44628 | Regional | 5.2 | Yes | Yes | Yes | 2021 |

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Appendix B.– Page 3 of 4.

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| **Lake** | **Latitude (WGS84)** | **Longitude (WGS84)** | **Management Category** | **Area (ha)** | **Fish Analysis** | **Water Quality** | **Map** | **Year to Sample** |
| ***Upper Copper – Upper Susitina Management Area*** | | | | | | | | |
| Three Mile Lake | 61.56538 | -144.44483 | Regional | 9.7 | Yes | Yes | No | 2022 |
| Buffalo Lake | 62.06514 | -146.45070 | Regional | 2.9 | Yes | Yes | No | 2023 |
| Gergie Lake | 62.04463 | -146.47429 | Regional | 31.1 | Yes | Yes | No | 2023 |
| Tex Smith Lake | 62.09207 | -146.29144 | Regional | 6.3 | Yes | Yes | No | 2023 |
| Tolsona Mtn Lake | 62.14636 | -146.20669 | Regional | 23.2 | Yes | Yes | No | 2023 |
|  |  |  |  |  |  |  |  |  |
| **Wild Lakes** | | | | | | | | |
| ***Kuskokiwm-Goodnews Drainages*** | | | | | | | | |
| Aniak Lake | 60.46815 | -159.18242 | - | unknown | Yes | Yes | Yes | TBD |
| Eek Lake | 60.22462 | -160.32305 | - | unknown | Yes | Yes | Yes | TBD |
| Heart Lake | 60.09903 | -159.66001 | - | unknown | Yes | Yes | Yes | TBD |
| Pegati Lake | 59.86643 | -160.09253 | - | unknown | Yes | Yes | Yes | TBD |
| ***North Slope Drainage*** | | | | | | | | |
| Lake Peters | 69.32291 | -145.04738 | - | unknown | Yes | Yes | Yes | TBD |
| Lake Schrader | 69.37954 | -145.00258 | - | 1,077.3 | Yes | Yes | Yes | TBD |
| ***Tanana River Drainage*** | | | | | | | | |
| American Wellesley Lake #2 | 62.50951 | -141.24906 | - | unknown | Yes | Yes | Yes | TBD |
| Big Grayling Lake | 62.53204 | -143.07936 | - | unknown | Yes | Yes | Yes | TBD |
| Deadman Lake | 64.84375 | -149.95941 | - | 207.2 | Yes | Yes | Yes | 2020 |
| Deadman Lake (AK Hwy) | 62.88376 | -141.54979 | - | 132.8 | Yes | Yes | No | TBD |
| Engineer Lake | 64.81984 | -147.60158 | - | 5 | No | No | Yes | TBD |
| Grizzly Lake | 62.22356 | -143.36677 | - | unknown | Yes | Yes | Yes | TBD |
| Iksgiza Lake | 64.75313 | -150.23854 | - | 78.5 | Yes | Yes | Yes | TBD |
| Jatahmund Lake | 62.62185 | -142.02902 | - | unknown | Yes | Yes | Yes | 2020 |
| Lower Tangle Lake | 63.13506 | -145.96094 | - | unknown | Yes | Yes | Yes | TBD |

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Appendix B.– Page 4 of 4.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Lake** | **Latitude (WGS84)** | **Longitude (WGS84)** | **Management Category** | **Area (ha)** | **Fish Populations** | **Water Quality** | **Map** | **Year to Sample** |
| ***Tanana River Drainage*** | | | | | | | | |
| Mineral Lake | 62.94205 | -143.36716 | - | 40.5 | No | No | Yes | TBD |
| Peggy Lake | 62.56021 | -143.29992 | - | unknown | Yes | Yes | Yes | TBD |
| Rock Island Lake | 65.09204 | -149.49634 | - | 348 | Yes | Yes | Yes | TBD |
| Wellesley Lake #1 | 62.47010 | -141.32238 | - | unknown | Yes | Yes | Yes | TBD |
| Wien Lake | 64.34976 | -151.29739 | - | 1,416.4 | Yes | Yes | Yes | TBD |
| ***Upper Copper-Upper Susitna Drainages*** | | | | | | | | |
| Indian Pass Lake | 62.82222 | -143.94528 | - | 32.4 | Yes | Yes | Yes | TBD |
| Little Swede Lake | 63.01698 | -145.89305 | - | unknown | Yes | Yes | Yes | 2020 |
| ***Yukon River Drainage*** | | | | | | | | |
| Agiak Lake | 68.07416 | -152.95399 | - | unknown | Yes | Yes | Yes | TBD |
| Burman Lake | 66.05157 | -145.95643 | - | 323.7 | Yes | Yes | Yes | TBD |
| Helpmejack Lake | 66.93192 | -153.54150 | - | 242.8 | Yes | Yes | Yes | TBD |
| Wild Lake | 67.50274 | -151.57378 | - | 951 | Yes | Yes | Yes | TBD |

Appendix C

**Fish population structures**

**based on Management stocking schemes**

Appendix C.–Fish population *m*LFDs and *m*LS based on management stocking schemes. Page 1 of 5.

Coal Mine #5 – Spring Sampling

Surface Area: 3.7 hectares

Management Category: Regional

Sub-Category: Rural

Stocking Frequency: Alternate years

*m*LS for observed mean length () by defined length group for 2019 based on a spring sampling date of 21 May 2019.

|  |  |
| --- | --- |
|  | 200 mm < L ≤ 350 mm |
| *m*LS (mm) | 304 |
| variance | 669 |

**Coal Mine #5.** Modeled length distribution of rainbow trout by age cohort for 2019 using the management stocking scheme of 2,000 fingerlings released on alternate years. Actual stockings are listed in Appendix D. Vertical lines indicate the length category between 200 mm and 350 mm fish for Regional Management.

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Appendix C.–Page 2 of 5.

Craig Lake – Spring Sampling

Surface Area: 8.4 hectares

Management Category: Regional

Sub-Category: Rural

Stocking Frequency: Alternate years

*m*LS for observed mean length () by defined length group for 2019 based on a spring sampling date of 23 May 2019.

|  |  |
| --- | --- |
|  | 200 mm < L ≤ 350 mm |
| *m*LS (mm) | 304 |
| variance | 664 |

**Craig Lake.** Modeled length distribution of rainbow trout by age cohort for 2019 using the management stocking scheme of 2,000 fingerlings released on alternate years. Actual stockings are listed in Appendix D. Vertical lines indicate the length category between 200 mm and 350 mm fish for Regional Management.

Appendix C.–Page 3 of 5.

Monte Lake – Fall Sampling

Surface Area: 85.6 hectares

Management Category: Regional Management

Sub-Category: Remote

Stocking Frequency: Alternate years

*m*LS for observed mean length () by defined length group for 2019 based on a fall sampling date of 26 August 2019.

|  |  |
| --- | --- |
|  | 200 mm < L ≤ 350 mm |
| *m*LS (mm) | 319 |
| variance | 554 |

**Monte Lake.** Modeled length distribution of rainbow trout by age cohort for 2019 using the management stocking scheme of 15,000 fingerlings released on alternate years. Actual stockings are listed in Appendix D. Vertical lines indicate the length category between 200 mm and 350 mm fish for Regional Management.

-continued-

Appendix C.–Page 4 of 5.

Quartz Lake – Spring Sampling

Surface Area: 590.0 hectares

Management Category: Regional Management

Sub-Category: Large

Stocking Frequency: Annual

*m*LS for observed mean length () by defined length group for 2019 based on a spring sampling date of 20 August 2019.

|  |  |
| --- | --- |
|  | 200 mm < L ≤ 350 mm |
| *m*LS (mm) | 273 |
| variance | 1,257 |

**Quartz Lake.** Modeled length distribution of rainbow trout by age cohort for 2019 using the management stocking scheme of 20,000 catchables released annually. Actual stockings are listed in Appendix D. Vertical lines indicate the length category between 200 mm and 350 mm fish for Regional Management.

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Appendix C.–Page 5 of 5.

Rapids Lake – Spring Sampling

Surface Area: 2.3 hectares

Management Category: Regional Management

Sub-Category: Rural

Stocking Frequency: Alternate years

*m*LS for observed mean length () by defined length group for 2019 based on a spring sampling date of 17 June 2019.

|  |  |
| --- | --- |
|  | 200 mm < L ≤ 350 mm |
| *m*LS (mm) | 309 |
| variance | 600 |

**Rapids Lake.** Modeled length distribution of rainbow trout by age cohort for 2019 using the management stocking scheme of 1,600 fingerlings released on alternate years. Actual stockings are listed in Appendix D. Vertical lines indicate the length category between 200 mm and 350 mm fish for Regional Management.

Appendix d

**Stocking History (2013–2018) for 2019 Study Lakes**

Appendix D.–Stocking history (2013–2018) for lakes to be sampled in 2019. Page 1 of 4.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Lake | Date | Species | Average Length (mm) | Number |
| Coal Mine 5 | 8/26/2013 | Arctic char | 113 | 200 |
| Coal Mine 5 | 5/22/2014 | rainbow trout | 65 | 2,008 |
| Coal Mine 5 | 9/2/2015 | Arctic char | 122 | 200 |
| Coal Mine 5 | 5/26/2016 | rainbow trout | 63 | 2,070 |
| Coal Mine 5 | 8/29/2017 | Arctic char | 110 | 200 |
| Coal Mine 5 | 9/21/2017 | Chinook salmon | 221 | 202 |
| Coal Mine 5 | 6/11/2018 | rainbow trout | 66 | 2,000 |
| Coal Mine 5 | 9/19/2018 | Chinook salmon | 215 | 200 |
| Craig Lake | 6/3/2014 | rainbow trout | 70 | 2,000 |
| Craig Lake | 6/11/2016 | rainbow trout | 68 | 1,279 |
| Craig Lake | 6/1/2018 | rainbow trout | 63 | 2,000 |
| Cushman Lake | 6/23/2014 | Arctic grayling | 192 | 1,317 |
| Cushman Lake | 5/29/2015 | Arctic grayling | 200 | 1,519 |
| Cushman Lake | 9/28/2015 | Chinook salmon | 219 | 2,290 |
| Cushman Lake | 9/28/2015 | Chinook salmon | 219 | 2,259 |
| Cushman Lake | 5/9/2016 | rainbow trout | 210 | 2,812 |
| Cushman Lake | 9/22/2016 | Chinook salmon | 229 | 4,379 |
| Cushman Lake | 9/23/2016 | Chinook salmon | 219 | 1,121 |
| Cushman Lake | 5/18/2017 | rainbow trout | 240 | 1,707 |
| Cushman Lake | 5/18/2017 | rainbow trout | 238 | 2,234 |
| Cushman Lake | 5/18/2017 | rainbow trout | 238 | 1,685 |
| Cushman Lake | 5/19/2017 | rainbow trout | 241 | 769 |
| Cushman Lake | 6/13/2017 | rainbow trout | 247 | 1,372 |
| Cushman Lake | 6/13/2017 | rainbow trout | 247 | 3,587 |
| Cushman Lake | 8/24/2017 | rainbow trout | 241 | 1,509 |
| Cushman Lake | 8/25/2017 | rainbow trout | 254 | 3,157 |
| Cushman Lake | 9/21/2017 | Chinook salmon | 221 | 1,916 |
| Cushman Lake | 9/22/2017 | Chinook salmon | 219 | 2,060 |
| Cushman Lake | 9/26/2017 | Chinook salmon | 210 | 600 |
| Cushman Lake | 12/14/2017 | Chinook salmon | 238 | 3,341 |
| Cushman Lake | 5/21/2018 | rainbow trout | 239 | 2,999 |
| Cushman Lake | 6/6/2018 | rainbow trout | 245 | 1,528 |
| Cushman Lake | 6/14/2018 | Arctic grayling | 199 | 1,000 |
| Cushman Lake | 8/23/2018 | rainbow trout | 266 | 1,500 |
| Cushman Lake | 10/2/2018 | Chinook salmon | 225 | 3,953 |
| Cushman Lake | 10/5/2018 | Arctic grayling | 81 | 4,911 |
| Cushman Lake | 11/13/2018 | Chinook salmon | 218 | 5,481 |
| Cushman Lake | 11/13/2018 | Chinook salmon | 218 | 1,245 |

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Appendix D.– Page 2 of 4.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Lake | Date | Species | Average Length (mm) | Number |
| Little Lost Lake | 6/10/2013 | rainbow trout | 221 | 1,582 |
| Little Lost Lake | 6/13/2013 | rainbow trout | 323 | 140 |
| Little Lost Lake | 5/12/2014 | rainbow trout | 217 | 1,350 |
| Little Lost Lake | 5/11/2015 | rainbow trout | 242 | 1,090 |
| Little Lost Lake | 5/9/2016 | rainbow trout | 212 | 1,360 |
| Little Lost Lake | 5/10/2017 | rainbow trout | 240 | 1,389 |
| Little Lost Lake | 5/23/2018 | rainbow trout | 246 | 1,348 |
| Monte Lake | 6/1/2018 | rainbow trout | 63 | 15,000 |
| Monte Lake | 6/11/2016 | rainbow trout | 68 | 7,759 |
| Monte Lake | 6/3/2014 | rainbow trout | 70 | 15,000 |
| Olnes Pond | 6/8/2013 | rainbow trout | 215 | 830 |
| Olnes Pond | 6/15/2013 | rainbow trout | 217 | 717 |
| Olnes Pond | 6/15/2013 | Arctic grayling | 233 | 250 |
| Olnes Pond | 5/14/2014 | rainbow trout | 216 | 1,415 |
| Olnes Pond | 6/9/2014 | Arctic grayling | 205 | 250 |
| Olnes Pond | 5/18/2015 | rainbow trout | 241 | 1,396 |
| Olnes Pond | 5/21/2015 | Arctic grayling | 201 | 467 |
| Olnes Pond | 5/13/2016 | rainbow trout | 206 | 1,604 |
| Olnes Pond | 5/19/2017 | rainbow trout | 241 | 502 |
| Olnes Pond | 6/13/2017 | rainbow trout | 247 | 512 |
| Olnes Pond | 8/24/2017 | rainbow trout | 247 | 500 |
| Olnes Pond | 5/24/2018 | rainbow trout | 249 | 500 |
| Olnes Pond | 6/20/2018 | Arctic grayling | 196 | 507 |
| Olnes Pond | 8/22/2018 | rainbow trout | 261 | 502 |
| Quartz Lake | 6/4/2013 | rainbow trout | 221 | 4,973 |
| Quartz Lake | 6/10/2013 | rainbow trout | 221 | 1,526 |
| Quartz Lake | 6/11/2013 | rainbow trout | 229 | 4,487 |
| Quartz Lake | 6/13/2013 | rainbow trout | 323 | 325 |
| Quartz Lake | 6/18/2013 | rainbow trout | 211 | 2,078 |
| Quartz Lake | 6/21/2013 | coho salmon | 78 | 22,030 |
| Quartz Lake | 8/26/2013 | Arctic char | 113 | 6,800 |
| Quartz Lake | 8/27/2013 | rainbow trout | 214 | 3,837 |
| Quartz Lake | 8/29/2013 | rainbow trout | 210 | 4,070 |
| Quartz Lake | 9/12/2013 | rainbow trout | 222 | 3,113 |
| Quartz Lake | 9/25/2013 | Chinook salmon | 211 | 3,069 |
| Quartz Lake | 5/12/2014 | rainbow trout | 217 | 5,730 |
| Quartz Lake | 5/20/2014 | rainbow trout | 212 | 2,403 |
| Quartz Lake | 5/27/2014 | rainbow trout | 216 | 4,983 |

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|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Lake | Date | Species | Average Length (mm) | Number |
| Quartz Lake | 6/11/2014 | coho salmon | 79 | 29,193 |
| Quartz Lake | 6/11/2014 | coho salmon | 75 | 18,311 |
| Quartz Lake | 6/16/2014 | rainbow trout | 214 | 2,007 |
| Quartz Lake | 8/25/2014 | rainbow trout | 226 | 4,212 |
| Quartz Lake | 8/26/2014 | rainbow trout | 228 | 4,604 |
| Quartz Lake | 9/2/2014 | rainbow trout | 239 | 1,029 |
| Quartz Lake | 9/23/2014 | Chinook salmon | 227 | 1,631 |
| Quartz Lake | 10/1/2014 | Chinook salmon | 220 | 1,807 |
| Quartz Lake | 10/1/2014 | Chinook salmon | 220 | 3,254 |
| Quartz Lake | 5/11/2015 | rainbow trout | 242 | 3,612 |
| Quartz Lake | 5/12/2015 | rainbow trout | 238 | 1,896 |
| Quartz Lake | 5/29/2015 | coho salmon | 77 | 45,554 |
| Quartz Lake | 6/3/2015 | coho salmon | 74 | 53,171 |
| Quartz Lake | 8/26/2015 | rainbow trout | 240 | 1,497 |
| Quartz Lake | 8/26/2015 | rainbow trout | 240 | 3,224 |
| Quartz Lake | 8/27/2015 | rainbow trout | 244 | 3,118 |
| Quartz Lake | 8/28/2015 | rainbow trout | 247 | 2,531 |
| Quartz Lake | 9/3/2015 | Arctic char | 119 | 7,576 |
| Quartz Lake | 9/15/2015 | Arctic char | 129 | 2,005 |
| Quartz Lake | 9/22/2015 | Chinook salmon | 217 | 4,153 |
| Quartz Lake | 9/23/2015 | Chinook salmon | 223 | 3,828 |
| Quartz Lake | 5/3/2016 | rainbow trout | 217 | 4,806 |
| Quartz Lake | 5/9/2016 | rainbow trout | 212 | 907 |
| Quartz Lake | 5/12/2016 | coho salmon | 72 | 34,819 |
| Quartz Lake | 5/17/2016 | rainbow trout | 225 | 2,378 |
| Quartz Lake | 5/19/2016 | rainbow trout | 221 | 2,290 |
| Quartz Lake | 5/23/2016 | rainbow trout | 222 | 762 |
| Quartz Lake | 5/23/2016 | rainbow trout | 225 | 1,500 |
| Quartz Lake | 5/24/2016 | rainbow trout | 219 | 4,830 |
| Quartz Lake | 5/25/2016 | rainbow trout | 219 | 438 |
| Quartz Lake | 9/19/2016 | Chinook salmon | 242 | 3,465 |
| Quartz Lake | 9/21/2016 | Chinook salmon | 236 | 4,062 |
| Quartz Lake | 9/26/2016 | Chinook salmon | 218 | 1,277 |
| Quartz Lake | 9/28/2016 | Chinook salmon | 225 | 634 |
| Quartz Lake | 5/8/2017 | rainbow trout | 244 | 611 |
| Quartz Lake | 5/9/2017 | rainbow trout | 242 | 1,894 |
| Quartz Lake | 5/10/2017 | rainbow trout | 238 | 596 |
| Quartz Lake | 5/15/2017 | rainbow trout | 236 | 2,020 |

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Appendix D.– Page 4 of 4.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Lake | Date | Species | Average Length (mm) | Number |
| Quartz Lake | 5/25/2017 | rainbow trout | 241 | 624 |
| Quartz Lake | 5/26/2017 | rainbow trout | 248 | 1,806 |
| Quartz Lake | 5/30/2017 | rainbow trout | 241 | 3,912 |
| Quartz Lake | 5/31/2017 | rainbow trout | 243 | 3,704 |
| Quartz Lake | 6/1/2017 | coho salmon | 71 | 52,254 |
| Quartz Lake | 6/1/2017 | coho salmon | 69 | 23,745 |
| Quartz Lake | 6/6/2017 | rainbow trout | 248 | 3,945 |
| Quartz Lake | 6/13/2017 | coho salmon | 71 | 12,426 |
| Quartz Lake | 6/13/2017 | rainbow trout | 245 | 1,010 |
| Quartz Lake | 9/7/2017 | Arctic char | 124 | 10,514 |
| Quartz Lake | 9/20/2017 | Chinook salmon | 217 | 4,107 |
| Quartz Lake | 9/25/2017 | Chinook salmon | 222 | 4,602 |
| Quartz Lake | 9/26/2017 | Chinook salmon | 210 | 1,000 |
| Quartz Lake | 5/21/2018 | rainbow trout | 244 | 3,875 |
| Quartz Lake | 5/23/2018 | rainbow trout | 246 | 3,458 |
| Quartz Lake | 5/31/2018 | rainbow trout | 241 | 2,413 |
| Quartz Lake | 6/1/2018 | coho salmon | 73 | 40,665 |
| Quartz Lake | 6/1/2018 | coho salmon | 73 | 14,480 |
| Quartz Lake | 6/1/2018 | rainbow trout | 244 | 3,392 |
| Quartz Lake | 6/4/2018 | rainbow trout | 250 | 3,290 |
| Quartz Lake | 6/5/2018 | rainbow trout | 247 | 2,930 |
| Quartz Lake | 6/6/2018 | rainbow trout | 245 | 649 |
| Quartz Lake | 6/25/2018 | rainbow trout | 246 | 294 |
| Quartz Lake | 6/25/2018 | coho salmon | 81 | 8,792 |
| Quartz Lake | 10/2/2018 | Chinook salmon | 218 | 2,415 |
| Quartz Lake | 10/2/2018 | Chinook salmon | 218 | 4,476 |
| Rapids Lake | 5/22/2014 | rainbow trout | 65 | 1,606 |
| Rapids Lake | 5/26/2016 | rainbow trout | 63 | 1,600 |
| Rapids Lake | 6/5/2018 | rainbow trout | 66 | 1,504 |

Appendix E

**Field Data Forms**

Appendix E.–Field data forms.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Gear - Field Data Sheet** | | | | |  | | |
| *Alaska Department of Fish and Game* | | | | |
| *Division of Sport Fish – Stocked Fisheries Program* | | | | |
|  | | | | | | | |
| **Lake Name:** | |  | | | | | |
| **Date:** |  | | | | | | |
| **Personnel:** | |  | | | | | |
|  | | | | | | | |
| **Gear** | | **Waypoint** | **Depth** | **Set**  **Day & Time** | | **Pull**  **Day & Time** | **Water Temp (°C)** |
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**Gear Codes**

FNn fyke net n net number cl = center lead (for fyke nets)

TNn/s tangle net\* s set number

MTn minnow trap

HTn hoop trap

SG sport gear

\*distinguish between floating (F) and sinking (S) nets

**Waypoints**

Save waypoints marking daily gear set locations in WGS 84 GPS datum (decimal degrees to the fifth decimal). Mark waypoints on a new bathymetric map each day.

**Depth**

Measure the water depth (m or ft) at each set location using a hand held depth instrument.

**Set and Pull Time**

Record date (MM/DD) and time (military time) for each gear set and pull.

**Temperature**

When each net is SET record water temperature (to the nearest 0.10°C) 1 m below the surface at each set location.

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| **Fish - Field Data Sheet** | | | | | | | | | | | | | | | | | | | | | |
| ***Alaska Department of Fish and Game*** | | | | | | | | | | | | | | | | | | | | | |
| ***Division of Sport Fish – Stocked Fisheries Program*** | | | | | | | | | | | | | | | | | | | | | |
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| **Lake Name:** | | |  | | | | | | | | | | | | | | | | | | |
| **Date:** | | |  | | | | | | | | | | | | | | | | | | |
| **Personnel:** | | |  | | | | | | | | | | | | | | | | | | |
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| **Gear** | **WP** | **Species** | | **Length** | **M** | **T** | **D** | **P** |  | | **Gear** | | | **WP** | **Species** | **Length** | | **M** | **T** | **D** | **P** |
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| **Gear Codes** | | | | | | | | | | | |  | **Species Codes** | | | | | | | | |
| FNn fyke net\* | | | | \*mark **cl** for center lead (cl) if one used | | | | | | | |  | RT rainbow trout | | | | KS king salmon | | | | |
| HNn hoop net | | | | n net number | | | | | | | | SS silver salmon | | | | BB burbot | | | | |
| TNn/s tangle net \*\* s set number | | | | | | | | | | | |  | AC Arctic char | | | | GR Arctic grayling | | | | |
| HTn hoop trap | | | |  | | | | | | | |  | Species not given a code will be written out. | | | | | | | | |
| MTn minnow trap | | | |  | | | | | | | |  |  | | | | | | | | |
| SG sport gear | | | |  | | | | | | | |  |  | | | | | | | | |
| \*\*distinguish between floating (F) and sinking (S) nets | | | | | | | | | | | |  |  | | | | | | | | |
| **WP**=way point in WGS 84 GPS datum (ddd.ddddd)  **Length=** measured FL to nearest millimeter | | | | | | | | | | **M**=Recapture (marked); **T**=thin; **D**=disease; **P**=parasite: Leave blank if no signs exist. For D or P provide brief description. | | | | | | | | | | | |

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| **Water Quality - Field Data Sheet** | | | | | | | | | | | | | | | | | |
| *Alaska Department of Fish and Game* | | | | | | | | | | | | | | | | | |
| *Division of Sport Fish – Stocked Fisheries Program* | | | | | | | | | | | | | | | | | |
|  | | | | | | | | | | | | | | | | | |
| **Location:** | | |  | | | | | **Station #:** | |  | | | **Way Point:** | | | |  |
| **Date:** |  | | | | | | | **Time:** | |  | | | | | | | |
| **Personnel:** | | |  | | | | | | | | | | | | | | |
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| **Weather/Cloud Cover:** | | | | |  | | | | | | | | | | | | |
| **Air Temperature (°C):** | | | | |  | | | **Secchi Depth:** | | | | **Disappear (m):** | | |  | | |
| **Snow Cover (cm):** | | | | |  | | |  | | | | **Reappear (m):** | | |  | | |
| **Ice Thickness (cm):** | | | | |  | | | **Alkalinity Sample Time:** | | | | | | |  | | |
|  | | | | | | | | | | | | | | | | | |
| **Depth (M)** | | **Temp (˚C)** | | **Bar Pres (mmHg)** | | **%D.O.** | **D.O. (mg/L)** | | **SP Cond (µS/cm)** | | **pH** | | | **TDS (g/L)** | | **ORP** | |
| 0 | |  | |  | |  |  | |  | |  | | |  | |  | |
| 0.5 | |  | |  | |  |  | |  | |  | | |  | |  | |
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| 14 | |  | |  | |  |  | |  | |  | | |  | |  | |
| 15 | |  | |  | |  |  | |  | |  | | |  | |  | |
| **Max Depth** | |  | |  | |  |  | |  | |  | | |  | |  | |

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| **Water Color** | | |  | **Pictures** (at least 2) | |
|  | CLR | Clear |  | From south shore |
|  | FER | Ferric |  | From north shore |
|  | GHT | Glacial, High Turbidity |  | Trails (if any) |
|  | GLT | Glacial, Low Turbidity |  |  |
|  | HUM | Humic |  |  |
|  | MUD | Muddy |  |  |

Appendix F

**assumptions and bias**

Appendix F.–Assumptions and bias.

An accurate estimate of a population length frequency distribution requires that all fish in a population have the same probability of capture. In practice this likely does not happen and this assumption cannot be evaluated with a single-sample capture-event. However, a review of the literature and previous mark recapture studies conducted by ADF&G indicates that potential bias may be minimized by avoiding sampling activities when water temperatures are high, by sampling different habitat areas, and by using gear that is not size selective.

Researchers have found that water temperature influences rainbow trout distribution in lake systems, and have documented movement of rainbow trout from nearshore to offshore habitats when water temperature exceeds 20°C (Horak and Tanner 1964; Overholtz et al. 1977; Rowe and Chisnall 1995; Rowe 1984). Doxey (1989, 1992; M. Doxey, Sport Fish Biologist, Retired, ADF&G, Fairbanks; personnel communication) noted an influx of rainbow trout to shallow, nearshore areas as water temperature dropped during fall sampling activities conducted at Birch Lake, Alaska. Researchers have also noted that rainbow trout preferred depths of 0-4 m in the spring, and avoided shallow water as temperature increased throughout the summer (Overholtz et al. 1977). Additionally, a study conducted by Kwain and McCauley (1978) found that older rainbow trout have a lower temperature preference than do younger fish. Based on these findings, we conclude that larger fish will likely be the first to seek thermal refuge offshore as water temperature in littoral areas increases. To minimize the potential for size bias sampling due to this phenomenon, all sampling during our study will be conducted when water temperature 1 m beneath the surface is <18°C.

Although we expect rainbow trout populations to be distributed nearshore when water temperature is <18°C, we will sample both nearshore and offshore habitats to verify the presence or absence of fish in both areas. Previous studies conducted by ADF&G (under similar thermal conditions) found that capture rates for rainbow trout in offshore tangle nets, fyke nets, and hoop traps were lower than those for nearshore fyke nets (Fish and Skaugstad 2004; Havens et al. 1992; Behr and Skaugstad 2007). Warner and Quinn (1995) found that radio-tagged rainbow trout in Lake Washington were predominantly found in nearshore areas and resided in the top 3 m of the water column 90% of the time during sampling conducted in June, August, September, and October. Similarly, approximately 88% of all rainbow trout caught during sampling activities in 2005 were captured in nearshore fyke nets (Behr and Skaugstad 2007).

To minimize the potential for size bias due to capture gear we will use fyke nets and 13 mm bar, fine thread, monofilament tangle nets during our study. Fyke nets are typically fished in shallow waters and have proven effective at catching rainbow trout 50 mm to 600 mm (Behr and Skaugstad 2006; Fish and Skaugstad 2004). The length of fish captured in tangle nets is variable and depends on mesh size; however, a 13 mm mesh should be sufficient to capture age-1 and older fish in stocked lakes.

The sampling methods used in this study are similar to those used in previous two-sample mark-recapture experiments conducted by ADF&G in which size bias was examined using either Kolmogorov-Smirnov (K-S) tests (Conover 1980) or chi-square contingency table analysis (Seber 1982). Robust and objective evaluation of size biased sampling is problematic, at best, when fish grow between sampling events. In Interior Alaska, average growth rates of nearly 1 mm per day have been observed for rainbow trout during summer (Doxey 1989).

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We reviewed several previous experiments to evaluate the relation between detected size bias during rainbow trout sampling and water temperature. In two-sample experiments where a hiatus of more than two weeks occurred between sampling events (allowing for substantial growth), we reanalyzed experimental data using methods described in Behr and Skaugstad (2006), where unambiguous testing for size bias could only be conducted for first event sampling. In other experiments, where necessary, data were reanalyzed to test for size bias during both sampling events using methods described in Behr et al. (2005). These results may differ from published results in some cases, as we analyzed size data from all rainbow trout captured during these experiments, not just the target age classes.

In 2004, two mark-recapture experiments were conducted at Koole Lake and Rainbow Lake to estimate the abundance of rainbow trout. Sampling procedures for both experiments were similar to those for this study, except that hook-and-line gear was used to supplement catches at both lakes and hoop nets were used at Rainbow Lake. K-S test results indicated that no significant size bias occurred during the first sampling event at Koole Lake, where the maximum water temperature recorded was 14°C at a depth of 0.3m during June 7–11. Similarly, no significant size bias was detected for the first sampling event at Rainbow Lake where the highest water temperature recorded was 17.7°C at a depth of 0.5m on August 25 (Behr and Skaugstad 2006). During Events 1 and 2, 97% and 99% of samples, respectively, were caught in fyke traps. Age-0 rainbow trout that were stocked in Rainbow Lake prior to sampling and subsequently captured in fyke nets were not used in the mark-recapture experiment. Usually the smallest age-0 fish can escape through the fyke net mesh and they are subject to predation by larger fish in the fyke nets. This situation will likely result in an observed probability of capture that is significantly different from that for the other age cohorts. Consequently, age-0 fish are enumerated and measured during population sampling but the data are not used to generate information about population structure.

Only near shore fyke nets were used during a two-sample mark-recapture experiment conducted in mid-June and mid-August of 2001 at Lisa Lake. K-S test results indicated that size bias for rainbow trout captured during the first event was not significant (Behr et al. 2005). Water temperature during mid-June was 17.5°C 1 m beneath the surface. In September and October of 2006 a second mark-recapture experiment was performed at Lisa Lake. Offshore tangle nets and nearshore fyke nets were used during both events, and K-S test results indicated that no significant size bias occurred (Behr and Skaugstad 2007). Water temperatures at 1 m beneath the surface were 11.1°C during Event 1 and 5.5° during Event 2.

In 2000, four two-sample mark-recapture experiments were conducted at Dune, Bluff Cabin, Donna, and Little Donna lakes (Skaugstad and Fish 2002). Fyke nets, tangle nets, and hook-and-line gear were used. Sampling was conducted in June and August. Reanalysis of rainbow trout mark-recapture data for Dune Lake provided no significant evidence of size bias sampling during Event 1 (p = 0.972) where the water temperature was 16.3°C at a depth of 1.0 m on June 15 (the last day of sampling). Reanalysis of Donna Lake data provided no significant evidence of size bias sampling during either Event 1 (p = 0.196) or Event 2 (p = 0.772). Water temperature was

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about 10.5°C at a depth of 1 m on August 31 (first day of Event 2 sampling). Similar results were obtained from data from Little Donna Lake for both Event 1 (p = 0.425) and Event 2 (p = 0.978). While sampling at Little Donna Lake occurred during the same time frame as at Donna Lake, no water temperature data were available. In contrast, reanalysis of Bluff Cabin Lake data indicated significant size bias sampling during both Event 1 (p < 0.001) and Event 2 (p = 0.001) where the water temperature was 17.2°C at a depth of 1.0 m and 18.6°C at a depth of 0.5 m on 6 June (the first day of sampling).

Two-sample mark-recapture experiments were performed at Quartz Lake in 2001 to estimate the abundance of age-1 rainbow trout and in 2002 to estimate the abundance of age-2 and older rainbow trout (Fish and Skaugstad 2004). Nearshore and offshore fyke nets, hoop nets, and tangle nets were used in 2001 and sampling was conducted May 29 to June 1 (Event 1) and June 18 to 22 (Event 2). Reanalysis of these data indicated significant size bias sampling during both Event 1 (p < 0.001) and Event 2 (p < 0.001) where the water temperature was 11°C at a depth of 1 m on May 31 and 20°C at a depth of 1 m on June 22. Less than 1% of the rainbow trout were caught in floating fyke nets, hoop nets, and tangle nets deployed in water >1 m in depth. In 2002, fyke nets and tangle nets were used and sampling was conducted in September. Re-analysis provided no significant evidence of size bias sampling during either Event 1 (p = 0.384) or Event 2 (p = 0.493). Water temperature was not recorded during sampling but typically lake temperatures have cooled to <14°C by September. Rainbow Lake (16 km from Quartz Lake) was <12°C 1 m below the surface in mid-September. During Event 1 no rainbow trout were caught in tangle nets in deep water and during Event 2 sixteen percent of the fish sampled were caught in tangle nets. The size distributions of fish captured with all gear types during Event 1 and Event 2 were not statistically different (p = 0.734).

Of the studies reviewed, only one result was inconsistent with our prescription to restrict sampling to when water temperature is <18°C in order to minimize potential for size biased sampling of rainbow trout. Significant size bias sampling was detected during Event 1 sampling at Quartz Lake in 2001, when water temperatures was 11°C. Probability of capture of rainbow trout 170 mm and larger (age 2 and older) was greater than that of smaller rainbow trout (age-1). During Event 1 the larger rainbow trout were concentrated in a few nearshore areas for spawning and later, during the hiatus and Event 2, dispersed throughout the lake (Fish and Skaugstad 2004). Researchers realized that spawning behavior in spring would likely affect the capture probability of age-2 and older rainbow trout during the course of the study; however, they were interested only in estimating the abundance of age-1 rainbow trout. Future studies of the Quartz Lake rainbow trout population using single-sample methods to estimate relative abundance should be conducted in fall to avoid capture heterogeneity between different size/age cohorts.

Detecting capture heterogeneity when sampling small populations (< 2,000 fish) is very difficult. The K-S test is typically used during two-sample mark-recapture experiments to detect size bias sampling during either sampling event and to guide model selection for estimating abundance and composition. To estimate the power of the K-S test to detect size bias sampling in small populations, we constructed artificial populations of two age classes (age-1 and 2) of rainbow trout based on length-at-age data from previous experiments (ADF&G spreadsheet available from the authors). Population size varied from 500 to 2,000 fish, and within each population the

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proportion of age-2 fish was varied from 20% to 66%. We then simulated two-event mark-recapture sampling on these populations with sufficient sampling intensity to estimate abundance within 20% of the true value 95% of the time (assuming no size bias during sampling). We simulated probability of capture for age-2 fish to be 50% of the probability of capture of age-1 fish during both sampling events, and also simulated this size bias sampling during only Event 1 with no size bias during Event 2. We conducted K-S tests to detect capture heterogeneity and estimated power by evaluating the frequency when size bias sampling was concluded. The results from capture heterogeneity during both events and during Event 1 are reported in Table 5 and Table 6, respectively. When capture heterogeneity was simulated during both sampling events, the power of the K-S tests was poor (<1% to 30%) when the segment of the population with lower capture probability comprised 50% or less of the population when using  as the rejection criteria for the test. When  was used as the rejection criteria, power was still poor (<1% to 26%) when the segment of the population with lower capture probability comprised 33% or less of the population. In simulations where capture heterogeneity occurred only during Event 1, the power of the K-S test was poor (<1% to 29%) when the segment of the population with lower capture probability comprised 33% or less of the population when using  as the rejection criteria. When  was used as the rejection criteria, power was still poor (<9% to 23%) when the segment of the population with lower capture probability comprised 20% or less of the population.

The levels of capture heterogeneity sufficient to cause concern when interpreting composition proportions (detecting large fish 50% as often as smaller fish) are not likely to be detected during reasonably well designed two-sample experiments on small populations with age structures similar to what are usually encountered. The fairly poor power of widely used diagnostics tests under these conditions emphasizes the need to identify the field conditions where the chances of size bias sampling occurring can be minimized.

For our studies, the bias introduced by unequal capture probabilities for the different length-age cohorts has different effects on estimating length frequency mode location and mode amplitude. Mode location is important for determining the mean length of length-age cohorts while mode amplitude is important for determining the relative abundance of the length-age cohorts in the population. The bias caused by unequal capture probabilities when estimating mode location will be minimal when individuals in each length-age cohort have the same capture probability (i.e., capture probabilities are the same within cohorts but may be different between cohorts).

Bias will likely have a greater influence on estimating mode amplitude and, thus, on estimating proportions of fish in different length-age categories (i.e., relative abundance). As such, analysis of relative abundance is no longer performed; however, this bias could still affect mean values within specified length categories because multiple age cohorts are often present in a specified length category. Different capture probabilities between length-age cohorts will result in catches that are not representative of cohort abundance in the population. Increasing the sample size will make the modes more prominent but it will not improve the accuracy of the estimate. However, our review of other studies has shown that the likelihood of size bias is low when sampling is restricted to periods when water temperature is <18°C. It is anticipated that two-sample mark-

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recapture studies will be conducted periodically for the larger lakes that are stocked on an annual basis and support a number of age cohorts. We will continue to use information from these studies to evaluate potential size bias associated with single-capture sampling.

Table 5.–Power of Kolmogorov-Smirnov (K-S) test to detect capture heterogeneity in small populations during two-sample mark-recapture studies designed to estimate true abundance within 20% of the true value 95% of the time, where ***x***% of the population has 50% of the capture probability of the remainder of the population during both sampling events. Results based on 10,000 simulations of two age classes of fish with adjacent but non-overlapping bell shaped length distributions and ***x***% represents one entire age class.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Mean** | |  | **Power of RvC & MvC K-S tests** | | |
| **N** | ***x*%** | **M & C** | **R** |  |  |  |  |
| 500 | 0.20 | 157 | 52 |  | <0.01 | <0.01 | 0.02 |
| 750 | 0.20 | 204 | 58 |  | <0.01 | <0.01 | 0.03 |
| 1,000 | 0.20 | 245 | 63 |  | <0.01 | 0.01 | 0.04 |
| 1,500 | 0.20 | 313 | 69 |  | <0.01 | 0.02 | 0.05 |
| 2,000 | 0.20 | 372 | 73 |  | <0.01 | 0.02 | 0.06 |
| 500 | 0.33 | 158 | 54 |  | <0.01 | 0.03 | 0.08 |
| 750 | 0.33 | 205 | 60 |  | 0.02 | 0.05 | 0.13 |
| 1,000 | 0.33 | 244 | 64 |  | 0.02 | 0.06 | 0.16 |
| 1,500 | 0.33 | 313 | 71 |  | 0.03 | 0.09 | 0.21 |
| 2,000 | 0.33 | 373 | 75 |  | 0.05 | 0.12 | 0.26 |
| 500 | 0.50 | 157 | 55 |  | 0.08 | 0.19 | 0.37 |
| 750 | 0.50 | 204 | 62 |  | 0.14 | 0.27 | 0.46 |
| 1,000 | 0.50 | 244 | 66 |  | 0.19 | 0.33 | 0.53 |
| 1,500 | 0.50 | 313 | 73 |  | 0.26 | 0.42 | 0.61 |
| 2,000 | 0.50 | 371 | 76 |  | 0.30 | 0.46 | 0.65 |
| 500 | 0.66 | 157 | 56 |  | 0.26 | 0.43 | 0.61 |
| 750 | 0.66 | 205 | 63 |  | 0.36 | 0.53 | 0.70 |
| 1,000 | 0.66 | 245 | 67 |  | 0.44 | 0.61 | 0.76 |
| 1,500 | 0.66 | 314 | 74 |  | 0.54 | 0.69 | 0.81 |
| 2,000 | 0.66 | 372 | 78 |  | 0.59 | 0.73 | 0.84 |

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Table 6.–Power of Kolmogorov-Smirnov (K-S) test to detect capture heterogeneity in small populations during two-sample mark-recapture studies designed to estimate true abundance within 20% of the true value 95% of the time, where ***x***% of the population has 50% of the capture probability of the remainder of the population during first event sampling and no capture heterogeneity occurs during second event sampling. Results based on 10,000 simulations of two age classes of fish with adjacent but non-overlapping bell shaped length distributions and *x*% represents one entire age class.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Mean** | |  | **Power of RvC K-S test** | | |
| **N** | ***x*%** | **M & C** | **R** |  |  |  |  |
| 500 | 0.20 | 157 | 49 |  | <0.01 | 0.03 | 0.09 |
| 750 | 0.20 | 204 | 56 |  | 0.01 | 0.04 | 0.13 |
| 1,000 | 0.20 | 245 | 60 |  | 0.02 | 0.06 | 0.16 |
| 1,500 | 0.20 | 313 | 65 |  | 0.03 | 0.09 | 0.21 |
| 2,000 | 0.20 | 373 | 69 |  | 0.04 | 0.11 | 0.23 |
| 500 | 0.33 | 158 | 50 |  | 0.08 | 0.18 | 0.35 |
| 750 | 0.33 | 205 | 56 |  | 0.12 | 0.25 | 0.43 |
| 1,000 | 0.33 | 244 | 59 |  | 0.17 | 0.32 | 0.49 |
| 1,500 | 0.33 | 313 | 65 |  | 0.24 | 0.39 | 0.57 |
| 2,000 | 0.33 | 373 | 70 |  | 0.29 | 0.44 | 0.61 |
| 500 | 0.50 | 157 | 49 |  | 0.24 | 0.39 | 0.57 |
| 750 | 0.50 | 204 | 55 |  | 0.34 | 0.49 | 0.67 |
| 1,000 | 0.50 | 244 | 60 |  | 0.40 | 0.55 | 0.71 |
| 1,500 | 0.50 | 313 | 65 |  | 0.48 | 0.63 | 0.77 |
| 2,000 | 0.50 | 371 | 69 |  | 0.53 | 0.67 | 0.80 |
| 500 | 0.66 | 158 | 50 |  | 0.24 | 0.39 | 0.57 |
| 750 | 0.66 | 204 | 56 |  | 0.34 | 0.50 | 0.66 |
| 1,000 | 0.66 | 244 | 60 |  | 0.39 | 0.55 | 0.70 |
| 1,500 | 0.66 | 314 | 65 |  | 0.48 | 0.63 | 0.77 |
| 2,000 | 0.66 | 372 | 69 |  | 0.53 | 0.67 | 0.80 |

1. 5 ACC 52.065. *Upper Copper River and Upper Susitna River Area Stocked Waters Management Plan.*

   5 ACC 69.165. *North Slope Area Stocked Waters Management Plan*.

   5 ACC 70.065. *Northwestern Area Stocked Waters Management Plan*.

   5 ACC 71.065. *Kuskokwim Goodnews Area Stocked Waters Management Plan*.

   5 ACC 73.065. *Yukon River Area Stocked Waters Management Plan*.

   5 ACC 74.065. *Tanana River Area Stocked Waters Management Plan*. [↑](#footnote-ref-1)
2. A fish population is defined as a species confined to a specific lake. [↑](#footnote-ref-2)