Regional Operational Plan SF.3F.2017.05

Operational Plan: Interior Lake Evaluations

by

April Behr

May 2017

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

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

REGIONAL OPERATIONAL PLAN SF.3F.2017.05

OPERATIONAL PLAN: INTERIOR LAKE EVALUATIONS

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SIGNATURE PAGE

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Project leader(s):	*April Behr*
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Approval

Title	Name	Signature	Date
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Biometrician	Matt Tyers		
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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. Lakes to be sampled during the 2017 field season fall into two categories (with two separate funding sources): *Stocked Fishery Evaluations* (Federal Aid-FA) and *New Lake Evaluations* (State Wildlife Grant-SWG). 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 made available to managers and anglers in a Fishery Data Series (FDS) report containing 2017–2019 data. The department also 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 status of fish populations and lake water quality and morphometry.

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. 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.

Wild lakes are in the TRMA and Yukon Management Area (YMA). 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

Stocked Fisheries Management Plan

In 2009, Alaska Department of Fish and Game (ADF&G) Division of Sport Fish Region III developed a management plan for stocked waters 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]. Management plans are similar for all areas and all use three approaches

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

(regional, conservative, and special) to meet public demand for diverse fishing opportunities (e.g., *Tanana River Area Stocked Waters Management Plan*; Appendix A).

Stocked Fish Population Assessments

Each management approach lists general objectives for numbers and sizes of fish that anglers should have a reasonable expectation to catch and harvest. To meet these objectives we developed a general model (Skaugstad 2016) that describes the minimum population length-frequency distribution (*m*LFD)[2] that we determined was needed to provide the type of fishery intended by the BOF. We used this model to develop region-wide minimum length standards (*m*LS) that stocked fish populations should meet or exceed. By comparing stocked fish populations to *m*LFD and *m*LS for the appropriate management approach we can quantitatively and visually (graphically) assess each fishery to determine if management plan objectives were achieved. A fish population with statistics similar to the appropriate *m*LFD and *m*LS will provide a fishery that most anglers will consider minimally acceptable for fish size. We don't directly address standards for catch rate or number harvested because these factors are outside the scope of our current model and they may be evaluated with other methods such as the annual statewide mail survey conducted by ADF&G to estimate participation, effort, catch, and harvest of sport-caught fish[3].

Using methods described by Skaugstad (2016) we determined *m*LFD for each management approach and *m*LS by calculating the mean length for the portion of the modeled population structure (*m*LFD) within an appropriate size group (Appendix B). For a fishery to be considered a success, the observed mean must equal or exceed *m*LS.

Information Needs

Fish Populations

Fishery managers have identified two levels of sampling to obtain fish population information needed to periodically evaluate stocked fisheries and determine if reasonable opportunity is being provided. The first level requires unbiased length information to determine if stocking strategies have created desired population LFDs, which typically have been defined for most rainbow trout populations (*m*LFDs). 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 sampling methods to observe fish populations in several lakes each year, 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*.

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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*.

[2] Lower case *m* identifies a minimum population metric (i.e., length frequency distribution *m*LFD or length standard *m*LS) derived from our model.

[3] Summaries of sport fishing participation, catch, and harvest for 1996–2015 are displayed at: http://www.adfg.alaska.gov/sf/sportfishingsurvey/

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.

We also use important environmental factors such as temperature and dissolved oxygen 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.

We also use water quality data to help 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.

Bathymetric Maps

Bathymetric maps are used to describe a lake's physical characteristics. A bathymetric map is 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

Currently, there are 112 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 study include: 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, only 10 to 20 lakes can be examined each year.

Fish populations in 10 stocked lakes in the TRMA and UCUSMA will be examined during the 2017 field season (Table 1, Figure 1– 3); all lakes are in the Regional Management category.

Table 1.–Lake description and data requirements for 2017 Stocked Fisheries Program (SFP) and State Wildlife Grant (SWG) lake sampling.

Lake	Management Category	Hectare (Acre)	Fish Analysis	Native Species	Stocked Species	Water Quality	Map	Project
Tanana River Management Area								
14 Mile Lake	Regional	36.0 (89)	LFD	SSC	LT, RT	yes	no	SFP
Bear Lake	Regional	25.9 (64)	basic	LCI, LNS, NP, WF	RT, GR	yes	no	SFP
Cather's Lake	n/a	10.7 (26)	basic	unknown	n/a	yes	yes	SWG
Jack Lake	n/a	182.1 (450)	-	GR, BB, LT, WF	n/a	no	yes	SWG
Ken's Pond	Regional	2.5 (6)	LFD	SSC	AC, RT	yes	no	SFP
Lisa Lake	Regional	18.7 (46)	LFD	NP[a]	RT	yes	no	SFP
Lost Lake	Regional	42.2 (104)	LFD	LC, LNS, NP	AC, GR, LT, RT	yes	no	SFP
Mullins Pit	Regional	31.0 (77)	basic	NP	RT, GR, KS, AC	yes	no	SFP
Rich 81 Mile Pond	Regional	0.9 (2)	LFD	none	RT, GR	yes	no	SFP
Round Tangle	n/a	155.4 (384)	-	GR, BB, LT, LNS, RWF, SSC	n/a	no	yes	SWG
Triangle Lake	Regional	44.0 (109)	LFD	AKBF	RT	yes	no	SFP
Upper Copper Upper Susitna Management Area								
Crater Lake	Regional	5.0 (12)	LFD	SSC	RT, AC	yes	no	SFP
John Lake	Regional	56.6 (140)	basic	GR, BB, LNS, SSC	AC, RT	yes	no	SFP
Yukon Management Area								
Iniakuk Lake	n/a	1133.1 (2,800)	basic	BB, HBWF, LT, NP, RWF, SSC	n/a	yes	yes	SWG

[a] Angler report

AKBF=Alaska blackfish	*Dallia pectoralis*	LNS=longnose sucker	*Catostomus catostomus*
AC=Arctic char	*Salvelinus alpinus*	LT=lake trout	*Salvelinus namaycush*
BB=burbot	*Lota lota*	NP=northern pike	*Esox lucius linnaeus*
GR=Arctic grayling	*Thymallus arcticus*	RT=rainbow trout	*Oncorhynchus mykiss*
HBWF=humpback whitefish	*Coregonus oidschian*	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.
LCI=least cisco	*Couesius said*		

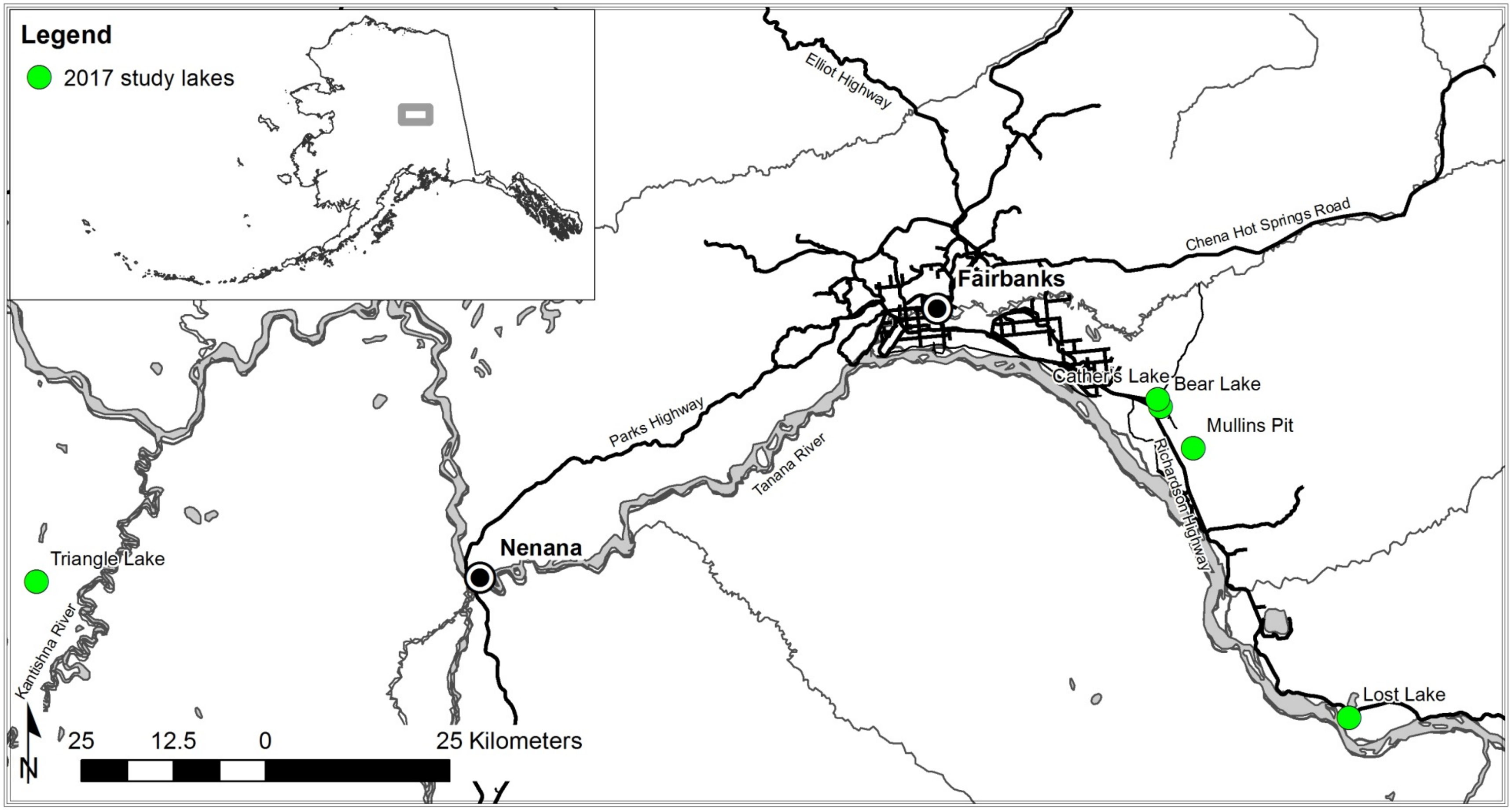

Figure 1.–Location of Lower Tanana River Management Area lakes (near Fairbanks) to be sampled in 2017.

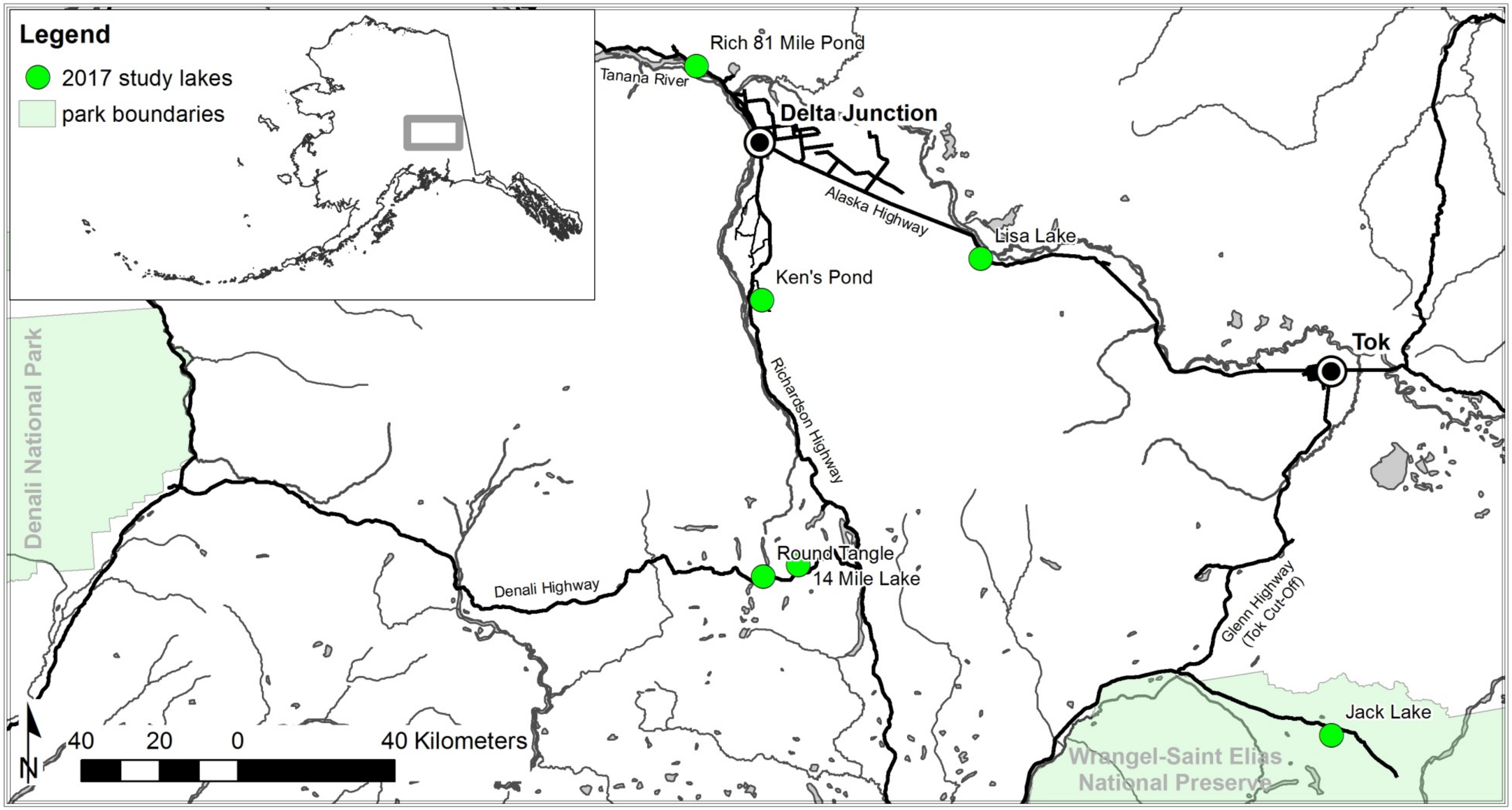

Figure 2.–Location of Upper Tanana River Management Area lakes (near Delta) to be sampled in 2017.

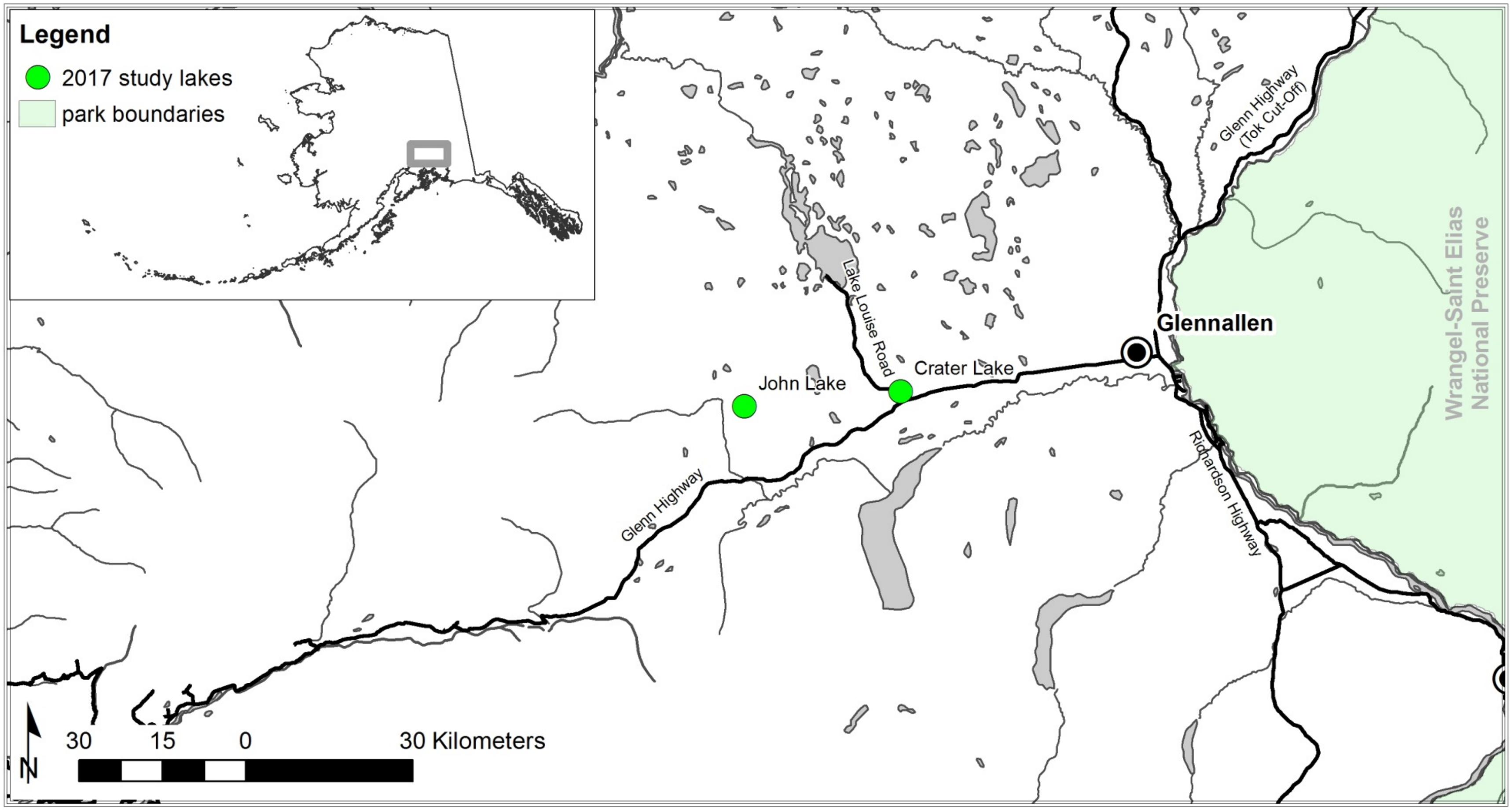

Figure 3.–Location of Upper Copper Upper Susitna River Management Area lakes (near Glennallen) to be sampled in 2017.

Basic population information is needed for fish populations in three lakes and LFD information is needed for populations in seven lakes (Table 1). Desired population *m*LFDs used to perform length analysis are shown in Appendix B. Water quality data will be collected on all 10 lakes (Table 1). Lake locations are shown in Figure 1–Figure 3 and recent stocking histories for each lake are listed in Appendix C.

NEW LAKE EVALUATIONS (SWG)

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, 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 bathometric 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.

Bathymetric Maps

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

Lakes are selected for sampling at an area manger's 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.

Three lakes have been selected for evaluation in the TRMA and YMA (Table 1, Figure 1-2 and Figure 4). Fish presence, water quality, and morphometric information will be collected at Cather's Lake near Fairbanks and at Iniakuk Lake northwest of Bettles. Morphometric information will be collected at Jack Lake south of Tok.

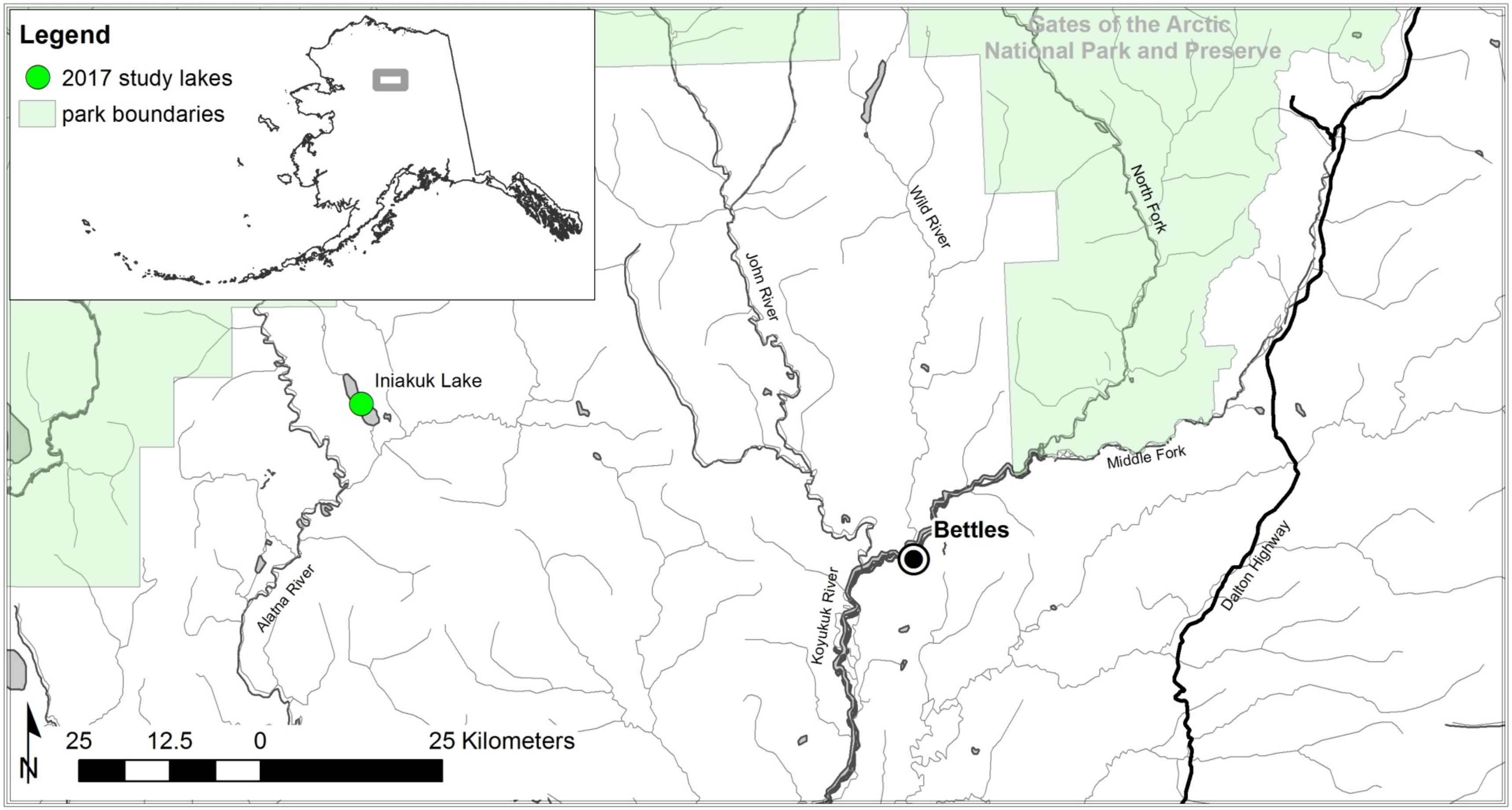

Figure 4.–Location of Yukon Management Area lakes to be sampled in 2017.

OBJECTIVES

POPULATION LENGTH FREQUENCY DISTRIBUTIONS

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

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 $\alpha = 10\%$.

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 (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[1] are meeting *m*LS for the appropriate management approach. All sampling will be conducted when water temperature 1 m below surface is <18°C.

Sampling Methods

Capture Gear

Fyke nets will be set near shore on 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 mm^2. 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.

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).

[1] A fish population is defined as a species confined to a specific lake.

Table 2.–Sampling effort according to lake size.

Hectare (Acre)	Nights	Fyke Nets	Tangle Nets	Minnow Traps[a]
0 to 20 (50)	1	4	1	4
>20 to 40 (100)	2	4	1	4
>40 to 200 (500)	3	4	2	4
>200 to 400 (1,000)	3	6	2	6
>400 (1,000)	3	8	2	6

[a] Minnow 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 removing a half circle of tissue from the trailing edge of the upper lobe of the caudal fin. The mark will be made with a paper punch that produces a 7 mm diameter circular hole. 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 will be determined for each population by first calculating mLS 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) will then be calculated using (Zar 1984):

$$n = \frac{\sigma^2}{\delta^2}\left(t_{\alpha,\nu} + t_{(1-\beta),\nu}\right)^2 \tag{1}$$

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 mLS (10% of mLS, from Skaugstad 2016); and,
- σ^2 is the variance calculated from modeled length data grouped by 10 mm length intervals using

$$\sigma^2 = \frac{\sum f(m-\mu)^2}{N} \tag{2}$$

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;

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		
14 Mile Lake	194	9
Ken's Pond	58	5
Lisa Lake	582	5
Lost Lake	4,762	6
Rich 81 Mile Pond	574	13
Triangle Lake	216	8
Upper Copper Upper Susitna Management Area		
Crater Lake	116	7

The predicted abundance for each lake (Table 3) is based on current stocking schemes (Appendix C) and estimates of survival from age-1 through age-5 (Appendix B) 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 D). 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 (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 D). 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 D.

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 report 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 final report. 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 $\leq$ L $<$ 350 mm or L $\geq$ 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 ($\hat{\bar{L}}$) of fish captured and corresponding sampling variances within length categories described in Appendix B will be calculated using standard sample summary statistics (Cochran 1977).

Hypothesis Test of Mean Lengths

Observed mean lengths ($\hat{\bar{L}}$) from collected data will be compared to *m*LS for appropriate length categories (Appendix B) 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 E.

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:

$$\hat{p}_i = \frac{x_i}{n_i} \tag{3}$$

where x_i denotes number of fish classified with the condition out of a sample size of n_i fish sampled in lake i.

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.

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 (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 Incorporated Environmental Monitoring System 600XLM Sonde, YSI ProDSS Sonde,* or *Hydrolab MS5 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 D). 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 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 $CaCO_3$) will be calculated using the following equation (Koening et al. 1987):

$$TA = \frac{B \times N \times 50{,}000}{V} \tag{3}$$

where:

TA is the total alkalinity (mg/L as $CaCO_3$);

B is the mL of titrant (0.02N H_2SO_4);

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 5).

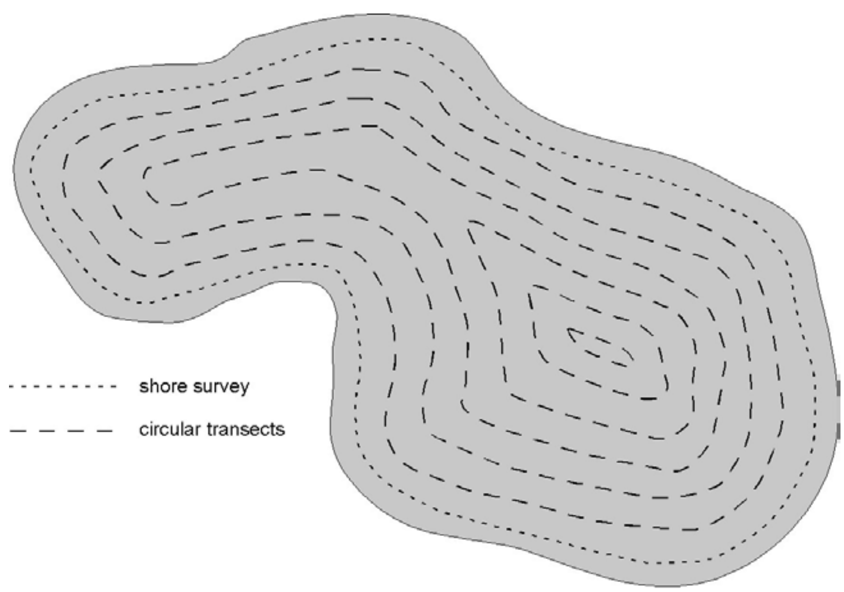

Figure 5.–Shore and circular transect pattern used to collect depth data in study lakes.

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 10.2.2* 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:

$$\text{Longitude}=\text{RadDeg}\times(X/r) \quad (4)$$

and

$$\text{Latitude}=\text{RadDeg}\times(2\times\arctan(e^{\wedge}(Y/r))-\pi/2). \quad (5)$$

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 10.2.2*.

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), and made available to the public at Fairbanks, Delta, and Glennallen 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 FDS report containing 2017–2019 data. A draft of this report will be submitted to the Research Supervisor by March 1, 2019. 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 2017	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 2017	Spring lake sampling. Actual stop time will depend on water temperature and flight availability. Fisheries to sample: Bear Lake, Mullins Pit, Crater Lake, Lost Lake, John Lake, and 14 Mile Lake.
1 Aug–31 Aug 2017	Fall lake sampling. Actual start time will depend on water temperature. Fisheries to sample: Ken's Pond, Lisa Lake, Rich 81 Mile Pond, and Triangle Lake.
15 Nov 2017	Fish, water quality, and morphometric information summary and analysis complete. Resulting data, maps, and photos uploaded to ADF&G websites and databases.
1 March 2019	Draft FDS report summarizing stocked fishery evaluations submitted to Research Supervisor.

New Lake Evaluations (SWG)

Dates	Activity
1 Mar–30 April 2017	Critical period for conducting dissolved oxygen surveys (as time permits). These data will be summarized and archived in a regional database.
1 June–30 June 2017	Lake sampling. Actual sample times will depend on ice out and water temperature. Lakes to sample: Cather's Lake, Round Tangle Lake, and Iniakuk Lake.
1 Aug–31 Aug 2017	Fall lake sampling. Actual start time will depend on water temperature. Fisheries to sample: Jack lake.
15 Nov 2017	Fish, water quality, and morphometric information summary and analysis complete. Resulting data, maps, and photos uploaded to ADF&G websites and databases.
1 March 2019	Draft FDS report summarizing lake evaluations submitted to Research Supervisor.

RESPONSIBILITIES

April Behr:	Fishery Biologist II, Stocked Fisheries Program Project Coordinator
Duties:	Supervision of all aspects of projects in the Stocked Fisheries Program. Develop stocking plans for Region III and coordinate sampling schedules, data analysis, and report writing with project personnel. 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 one FDS report (Management Objectives 1–4, Research Objectives 1–6).
Kelly Mansfield:	Fishery Biologist I.
Duties:	Supervise laboratory work. Assist with fish population data analysis, water quality data summaries, making bathymetric maps, and draft portions of one FDS report (Management Objectives 1–4, Research Objectives 1–6).
Matt Tyers:	Biometrician II.
Duties:	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.
Sarah Johnson:	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.

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APPENDIX A:
EXAMPLE OF BOARD OF FISHERIES MANAGEMENT PLAN FOR STOCKED WATERS

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 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-

(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.

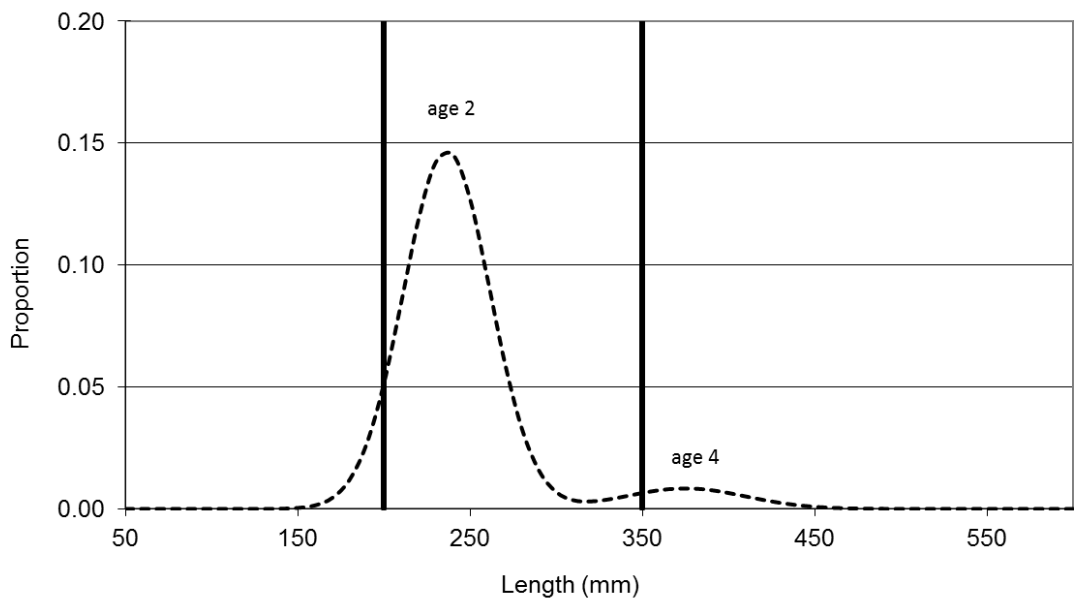
APPENDIX B:
FISH POPULATION STRUCTURES BASED ON MANAGEMENT STOCKING SCHEMES

14 MILE LAKE – SPRING SAMPLING

Surface Area:	36.0 hectares
Management Category:	Regional
Sub-Category:	Remote
Stocking Frequency:	Alternate years

*m*LS for observed mean length ($\hat{\bar{L}}$) by defined length group for 2017 based on a spring sampling date of 14 June 2017.

	200 mm ≤ L <350 mm
*m*LS (mm)	239



14 Mile Lake. Modeled length distribution of rainbow trout by age cohort for 2017 using the management stocking scheme of 9,000 fingerlings released on alternate years. Actual stockings are listed in Appendix C. Vertical lines indicate the length category between 200 mm and 350 mm fish for Regional Management.

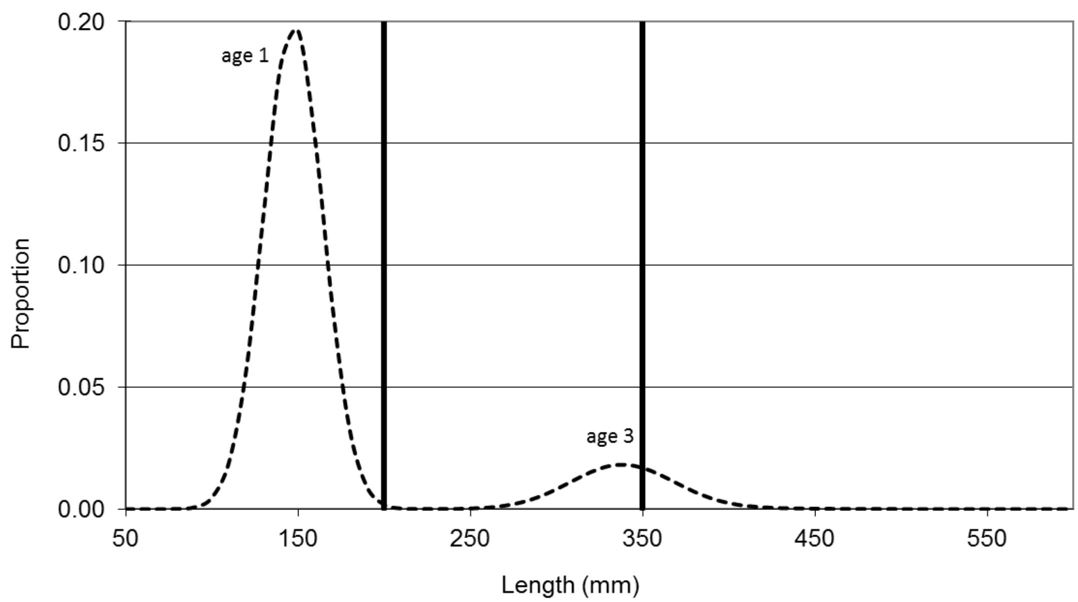
-continued-

KEN'S POND – FALL SAMPLING

Surface Area:	2.5 hectares
Management Category:	Regional Management
Sub-Category:	Rural
Stocking Frequency:	Alternate years

*m*LS for observed mean length ($\hat{\bar{L}}$) by defined length group for 2016 based on a fall sampling date of 14 August 2017.

	200 mm ≤ L <350 mm
*m*LS (mm)	319



Ken's Pond. Modeled length distribution of rainbow trout by age cohort for 2017 using the management stocking scheme of 1,000 fingerlings released on alternate years. Actual stockings are listed in Appendix C. Vertical lines indicate the length category between 200 mm and 350 mm fish for Regional Management.

-continued-

LISA LAKE – FALL SAMPLING

Surface Area: 18.7 hectares

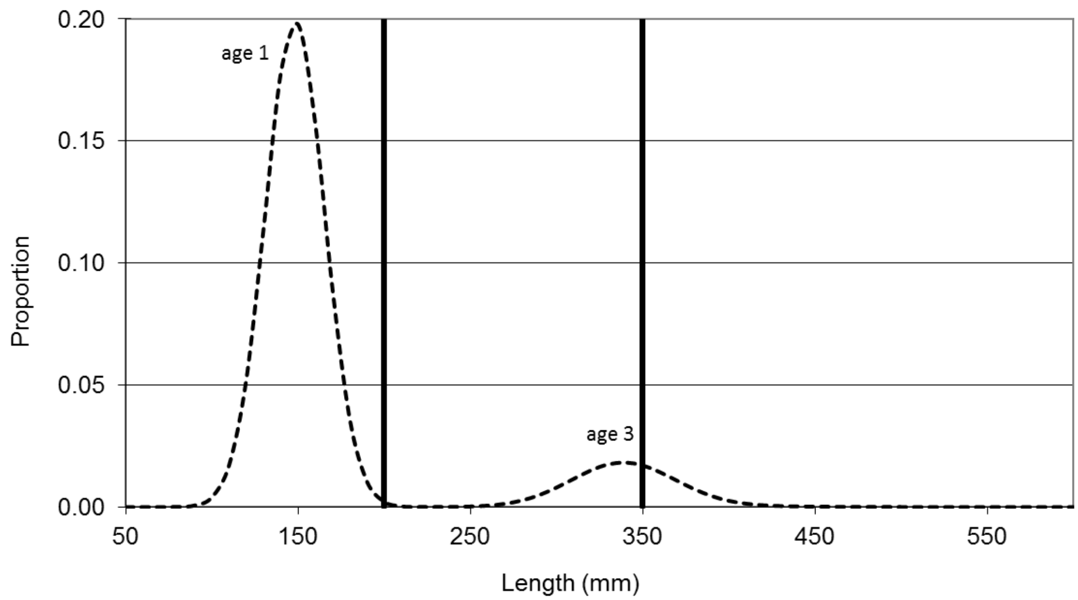
Management Category: Regional Management

Sub-Category: Rural

Stocking Frequency: Alternate years

*m*LS for observed mean length ($\hat{\bar{L}}$) by defined length group for 2017 based on a fall sampling date of 16 August 2017.

	200 mm ≤ L <350 mm
*m*LS (mm)	319



Lisa Lake. Modeled length distribution of rainbow trout by age cohort for 2017 using the management stocking scheme of 10,000 fingerlings released on alternate years. Actual stockings are listed in Appendix C. Vertical lines indicate the length category between 200 mm and 350 mm fish for Regional Management.

-continued-

LOST LAKE – SPRING SAMPLING

Surface Area: 42.2 hectares

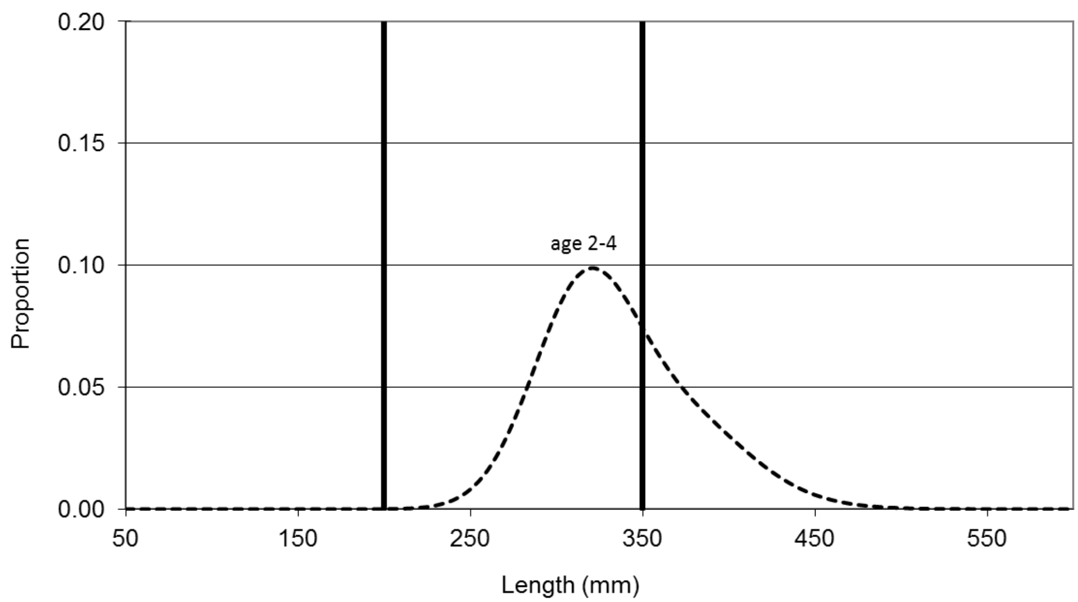
Management Category: Regional Management

Sub-Category: Rural

Stocking Frequency: Annual

*m*LS for observed mean length ($\hat{\bar{L}}$) by defined length group for 2017 based on a spring sampling date of 30 May 2017.

	200 mm ≤ L <350 mm
Length (mm)	308



Lost Lake. Modeled length distribution of rainbow trout by age cohort for 2016 using the management stocking scheme of 8,000 catchables released annually. Actual stockings are listed in Appendix C. Vertical lines indicate the length category between 200 mm and 350 mm fish for Regional Management.

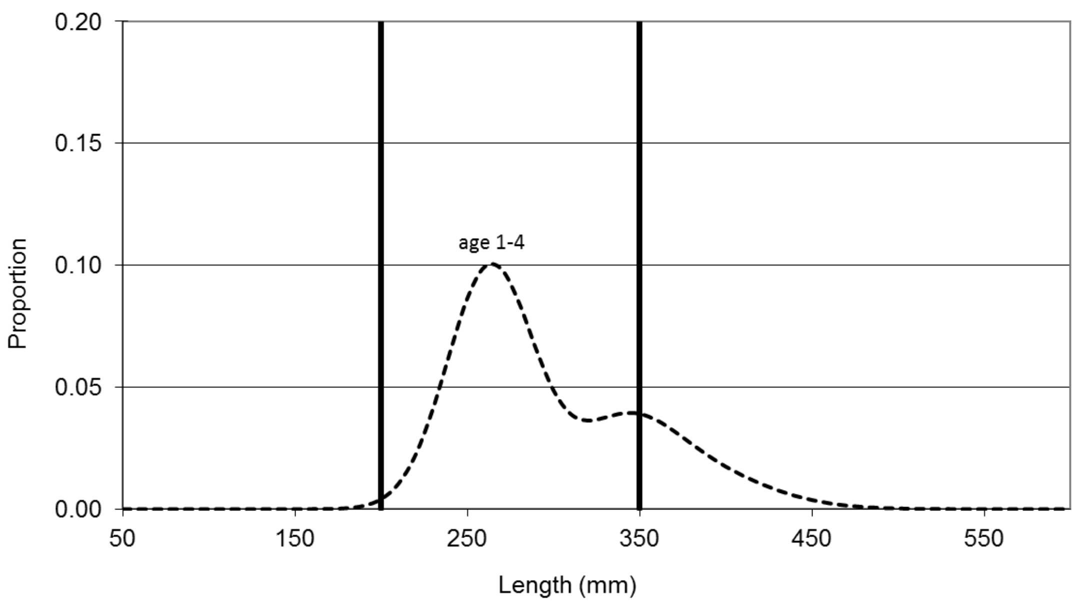
-continued-

RICH 81 MILE PIT – FALL SAMPLING

Surface Area:	0.9 hectares
Management Category:	Regional Management
Sub-Category:	Rural
Stocking Frequency:	Annual

*m*LS for observed mean length ($\hat{\hat{L}}$) by defined length group for 2017 based on a fall sampling date of 22 August 2017.

	200 mm ≤ L <350 mm
*m*LS (mm)	274



Rich 81 Mile Pond. Modeled length distribution of rainbow trout by age cohort for 2017 using the management stocking scheme of 360 catchables released annually. Actual stockings are listed in Appendix C. Vertical lines indicate the length category between 200 mm and 350 mm fish for Regional Management.

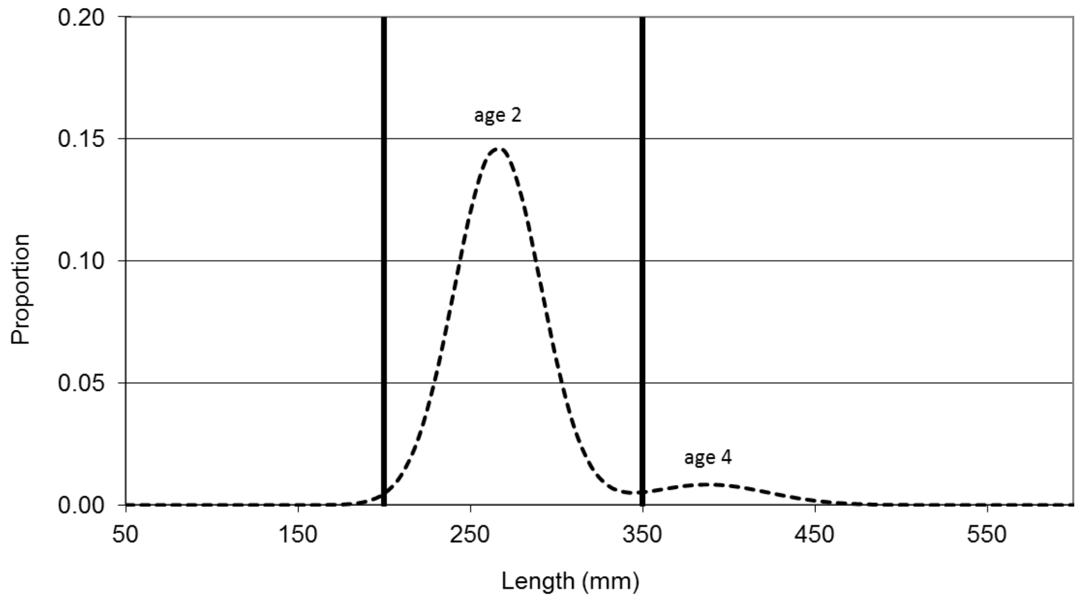
-continued-

TRIANGLE LAKE – FALL SAMPLING

Surface Area:	44.0 hectares
Management Category:	Regional Management
Sub-Category:	Remote
Stocking Frequency:	Alternate years

*m*LS for observed mean length ($\hat{\hat{L}}$) by defined length group for 2017 based on a fall sampling date of 28 August 2017.

	200 mm ≤ L <350 mm
*m*LS (mm)	262



Triangle Lake. Modeled length distribution of rainbow trout by age cohort for 2017 using the management stocking scheme of 10,000 fingerlings released on alternate years. Actual stockings are listed in Appendix C. Vertical lines indicate the length category between 200 mm and 350 mm fish for Regional Management.

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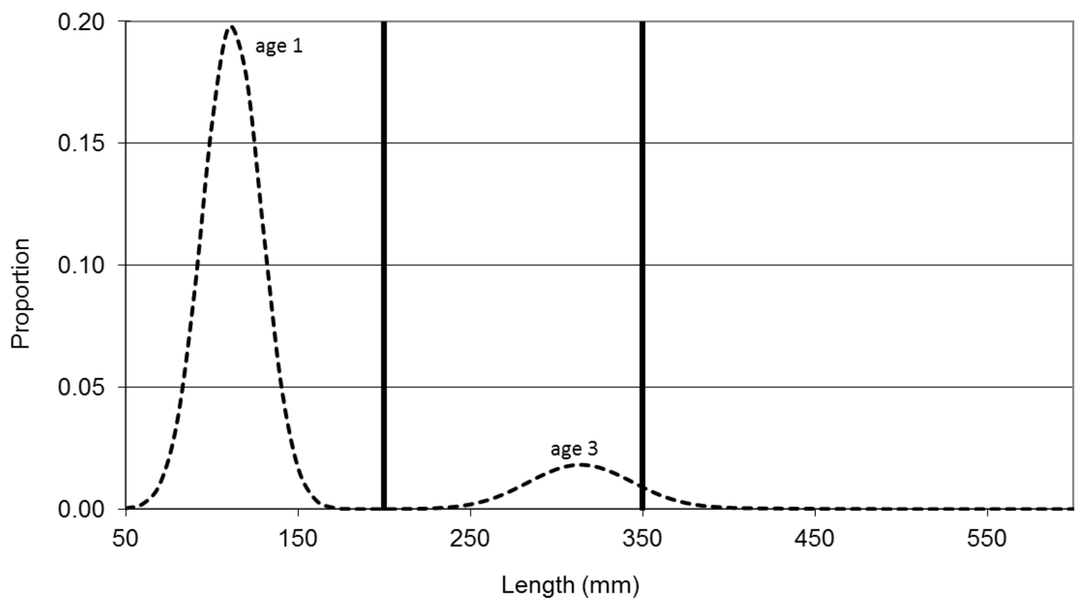
CRATER LAKE – SPRING SAMPLING

Surface Area:	5.0 hectares
Management Category:	Regional Management
Sub-Category:	Rural
Stocking Frequency:	Alternate years

*m*LS for observed mean length ($\hat{\bar{L}}$) by defined length group for 2017 based on a spring sampling date of 22 May 2017.

	200 mm ≤ L <350 mm
*m*LS (mm)	304



Crater Lake. Modeled length distribution of rainbow trout by age cohort for 2017 using the management stocking scheme of 2,000 fingerlings released on alternate years. Actual stockings are listed in Appendix C. Vertical lines indicate the length category between 200 mm and 350 mm fish for Regional Management.

APPENDIX C:
STOCKING HISTORY (2011–2016) FOR LAKES TO BE SAMPLED IN 2017

Appendix C.–Stocking history (2011–2016) for lakes to be sampled in 2017.

Lake	Date	Species	Average Length (mm)	Number
14 Mile Lake	6/16/2015	rainbow trout	72	9,000
14 Mile Lake	8/20/2013	rainbow trout	65	9,000
14 Mile Lake	6/3/2011	rainbow trout	86	4,126
Bear Lake	5/12/2016	rainbow trout	209	1,517
Bear Lake	5/26/2015	Arctic grayling	199	794
Bear Lake	5/15/2015	rainbow trout	238	1,501
Bear Lake	6/10/2014	Arctic grayling	203	394
Bear Lake	5/21/2014	rainbow trout	212	1,509
Bear Lake	6/19/2013	Arctic grayling	222	400
Bear Lake	6/11/2013	rainbow trout	229	1,500
Bear Lake	10/4/2012	rainbow trout	79	3,394
Bear Lake	6/14/2012	rainbow trout	183	1,312
Crater Lake	5/31/2016	rainbow trout	65	2,000
Crater Lake	6/11/2015	Arctic char	59	1,500
Crater Lake	6/12/2014	rainbow trout	73	2,000
Crater Lake	6/26/2012	rainbow trout	95	2,247
John Lake	6/11/2015	Arctic char	59	2,001
John Lake	6/20/2013	Arctic char	57	2,000
John Lake	6/2/2011	Arctic char	43	2,000
Ken's Pond	5/26/2016	rainbow trout	63	1,035
Ken's Pond	9/2/2015	Arctic char	122	375
Ken's Pond	5/22/2014	rainbow trout	65	1,010
Ken's Pond	8/26/2013	Arctic char	113	375
Ken's Pond	6/26/2012	rainbow trout	95	742
Ken's Pond	8/23/2011	Arctic char	100	191
Lisa Lake	6/11/2016	rainbow trout	68	6,400
Lisa Lake	6/3/2014	rainbow trout	70	10,000
Lisa Lake	8/30/2012	rainbow trout	63	10,000
Lost Lake	5/20/2016	rainbow trout	225	140
Lost Lake	5/20/2016	rainbow trout	223	280
Lost Lake	5/16/2016	rainbow trout	225	2,428
Lost Lake	5/16/2016	rainbow trout	220	2,397
Lost Lake	5/11/2016	rainbow trout	210	2,758
Lost Lake	5/2/2016	Arctic char	232	503
Lost Lake	5/22/2015	Arctic grayling	199	508
Lost Lake	5/14/2015	rainbow trout	238	3,289
Lost Lake	5/12/2015	rainbow trout	238	3,517
Lost Lake	6/6/2014	Arctic grayling	196	501

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Lake	Date	Species	Average Length (mm)	Number
Lost Lake	5/30/2014	rainbow trout	204	3,198
Lost Lake	5/20/2014	Arctic char	245	302
Lost Lake	5/19/2014	rainbow trout	217	5,166
Lost Lake	6/21/2013	rainbow trout	206	4,000
Lost Lake	6/20/2013	Arctic grayling	222	250
Lost Lake	6/8/2013	rainbow trout	215	4,235
Lost Lake	6/4/2013	Arctic char	261	303
Lost Lake	6/18/2012	rainbow trout	168	3,940
Lost Lake	6/7/2012	rainbow trout	195	3,765
Lost Lake	6/1/2012	Arctic char	263	200
Lost Lake	8/23/2011	Arctic char	178	2,085
Mullins Pit	5/10/2016	rainbow trout	205	3,024
Mullins Pit	5/26/2015	Arctic grayling	199	2,988
Mullins Pit	6/10/2014	Arctic grayling	203	801
Mullins Pit	6/24/2013	Arctic grayling	225	803
Mullins Pit	6/1/2011	Chinook salmon	62	2,000
Mullins Pit	6/1/2011	Arctic char	172	2,070
Richardson 81 Mile Pit	5/3/2016	rainbow trout	217	360
Richardson 81 Mile Pit	5/22/2015	Arctic grayling	199	160
Richardson 81 Mile Pit	5/19/2015	rainbow trout	240	355
Richardson 81 Mile Pit	6/18/2014	Arctic grayling	200	100
Richardson 81 Mile Pit	5/19/2014	rainbow trout	217	398
Richardson 81 Mile Pit	6/19/2013	Arctic grayling	222	100
Richardson 81 Mile Pit	6/5/2013	rainbow trout	222	361
Richardson 81 Mile Pit	6/7/2012	rainbow trout	195	360
Triangle Lake	6/11/2015	rainbow trout	60	10,000
Triangle Lake	9/9/2013	rainbow trout	74	8,500
Triangle Lake	6/14/2011	rainbow trout	85	3,640

APPENDIX D:
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	Pull	Water Temp (°C)

Gear Codes

FNn	fyke net	n	net number
TNn/s	tangle net*	s	set number
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

Lake Name: ____________________
Date: ____________________
Personnel: ____________________

Gear	WP	Species	Length	M	T	D	P

Gear	WP	Species	Length	M	T	D	P

Gear Codes

FNn	fyke net	n	net number
HNn	hoop net	s	set number
TNn/s	tangle net *		
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

Species Codes

RT	rainbow trout	KS	king salmon
SS	silver salmon	BB	burbot
AC	Arctic char	GR	Arctic grayling

Species not given a code will be written out.

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: ______________________

Weather/Cloud Cover: ______________________
Air Temperature (°C): ______________________ **Secchi Depth:** **Disappear (m)** ________
Snow Cover (cm): ______________________ **Reappear (m):** ________
Ice Thickness (cm): ______________________ **Alkalinity Sample Time:** ________

Depth (M)	Bar Pres	Temp C	D.O.	%D.O.	SP Cond	pH	TDS	ORP
0								
0.5								
1								
1.5								
2								
2.5								
3								
3.5								
4								
4.5								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
Max Depth								

Water Color

______	CLR	Clear
______	FER	Ferric
______	GHT	Glacial, High Turbidity
______	GLT	Glacial, Low Turbidity
______	HUM	Humic
______	MUD	Muddy

Pictures (at least 2)

______	From south shore
______	From north shore
______	Trails (if any)

APPENDIX E:
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 $\alpha = 0.05$ as the rejection criteria for the test. When $\alpha = 0.20$ 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 $\alpha = 0.05$ as the rejection criteria. When $\alpha = 0.20$ 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**	$\alpha = 0.05$	$\alpha = 0.10$	$\alpha = 0.20$
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

-continued-

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**	$\alpha = 0.05$	$\alpha = 0.10$	$\alpha = 0.20$
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