Regional Operational Plan SF.1J.2019.02

Juneau Area Rainbow Trout Post-stocking Assessment, 2019-2022

by

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and

Adam Reimer

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

REGIONAL OPERATIONAL PLAN SF.1J.2019.02

JUNEAU AREA RAINBOW TROUT POST-STOCKING ASSESSMENT, 2019-2022

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April 2019

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SIGNATURE PAGE

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Approval

Title	Name	Signature	Date
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Biometrician	Adam Reimer	Adam Reimer	4-22-19
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ABSTRACT

The Alaska Department of Fish and Game, Division of Sport Fish is scheduled to begin stocking 4 lakes (Crystal, Glacier, Moraine, and Twin lakes) along the Juneau roadside freshwater fishery with all-female triploid rainbow trout (*Oncorhynchus mykiss*) beginning in 2018. After these lakes get stocked with rainbow trout, post-release surveys will be conducted to assess biological and chemical conditions at selected lakes. These surveys will evaluate growth, survival, and movement out of or between the lakes where fish are stocked for the lakes sampled, as well as fishing effort and harvest at each stocked lake. Fish will be captured using hoop traps, a tangle net, and hook-and-line (i.e., sport fishing) gear. Water quality profiles will be performed in each lake sampled to measure water clarity, temperature, dissolved oxygen, pH, specific conductivity, salinity, and total dissolved solids. Results from these surveys will help managers determine the success of these stocking efforts and whether the stocking strategy needs to be modified.

Key words: triploid, rainbow trout, *Oncorhynchus mykiss*, stocking, Juneau roadside fishery, post-release surveys, lake assessment, water quality, survival, fishing effort, harvest, Crystal Lake, Glacier Lake, Moraine Lake, Twin Lakes

PURPOSE

The purpose of this project is to evaluate 4 lakes along the Juneau roadside freshwater fishery where all-female triploid rainbow trout are scheduled to be stocked, beginning in 2018. Post-release surveys, described in this operational plan, include evaluation of biological and chemical lake conditions, as well as monitoring growth, survival, movement, fishing effort, and harvest of stocked fish. Over time, results from these surveys will help managers determine the success of these stocking efforts and whether the stocking strategy needs to be modified.

BACKGROUND

One of the core functions of the Alaska Department of Fish and Game, Division of Sport Fish (ADF&G-SF) is to create and diversify sport fishing opportunities for anglers through fisheries enhancement (ADF&G 2015). The stocking of Alaska’s lakes with hatchery-reared fish was initiated in the 1950’s and continues to be an integral component of the ADF&G-SF management program (ADF&G 2013; ADF&G 2019b; Havens et al. 1995; Swanton and Taube 2009). Benefits of lake stocking programs include helping to divert pressure from natural stocks and providing diverse, year-round fishing opportunities for sport anglers (ADF&G 2019b; Havens et al. 1995).

Currently, ADF&G-SF owns and operates 2 hatcheries where fish are produced for stocking prioritized waters across the state. These 2 hatcheries are the William Jack Hernandez Sport Fish Hatchery (WJHSFH) in Anchorage and the Ruth Burnett Sport Fish Hatchery in Fairbanks. In addition to the state-owned hatcheries, there are several private non-profit hatcheries around the state that are also involved in the sport fish stocking program. The primary hatchery product used for lake stocking in Alaska is rainbow trout (*Oncorhynchus mykiss)*, currently produced from captive broodstock maintained at both ADF&G-SF hatcheries (ADF&G 2019b).

In general, stocking sites tend to be located near population centers to maximize the benefits to sport anglers (ADF&G 2019b). There are 4 lakes in the Juneau roadside freshwater fishery where fish have been stocked in recent years: Twin Lakes, located near downtown Juneau (Figures 1 and 2); and Crystal, Glacier, and Moraine lakes, located in the Mendenhall Glacier Recreation Area (MGRA; Figures 1 and 3). Fish stocking in Twin Lakes occurs annually, in support of a popular annual event known as Family Fishing Day. Stocking in the 3 MGRA lakes has happened a few times since 2010 (ADF&G 2019a) but has not occurred on an annual or consistent basis because of an insufficient number of fish available to stock all 4 lakes due to poor hatchery survival in certain years.

Past practices have been to stock these Juneau roadside lakes using the Chinook salmon (*O. tshawytscha*) stock that is already being raised at the local Macaulay Salmon Hatchery (MSH), operated by Douglas Island Pink and Chum, Inc. (DIPAC), for on-going local marine waters stocking programs. Recently, an alternative stocking product was proposed and approved for stocking the 4 Juneau area lakes; the new stocking product will be certified, all-female, triploid[1] rainbow trout that will come from the WJHSFH broodstock. The rainbow trout will be transported from the hatchery in Anchorage to be raised at MSH in Juneau for 2-3 years before being released in Crystal, Glacier, Moraine, and Twin lakes. The change in stocking product is scheduled to begin in 2018; after the stocking begins, the plan is for it to continue to occur on an annual basis at each of the 4 lakes (ADF&G 2019b). Catchable-sized (i.e., approximately >100 g and >200 mm) rainbow trout were chosen as the stocking product because they are considered non-anadromous and more suitable for the freshwater lakes stocking program. Rainbow trout are expected to have higher over-winter survival than the catchable-sized Chinook salmon used currently, which should improve stocking success and diversify opportunity for sport anglers (ADF&G 2019b).

In 2017, ADF&G-SF initiated pre-release surveys in anticipation of the change in stocking product. Pre-release surveys included evaluation of existing biological, chemical, and physical conditions at each lake scheduled to be stocked (Schroeder et al. 2017a), as well as sport fishing effort and harvest (Schroeder et al. 2017b). In addition to sampling the 4 lakes that will be stocked, there was one additional lake (Moose Lake) in the MGRA that was also sampled, due to the fact that the lake is located downstream from the 3 MGRA lakes that will be stocked (Figure 3). Moose Lake has been included as part of the overall project to help determine whether stocked fish are moving out of the lake where they were originally released.

The project described in this operational plan is a post-stocking evaluation of the 4 Juneau roadside lakes mentioned above, that are scheduled to be stocked with rainbow trout (Figure 1). Post-release surveys will include evaluation of biological and chemical conditions at selected lakes, as well as monitoring growth, survival, movement, fishing effort, and harvest of stocked fish. Preliminary results from pre-release surveys indicate that survival rates might be low for fish stocked in Twin Lakes; as a result, post -release surveys for Twin Lakes will be treated differently than the other 3 lakes that are scheduled to be stocked. The different sampling strategy is described in the Methods section, below. Over time, results from these surveys will help managers determine the success of these stocking efforts and whether the stocking strategy needs to be modified. Funding for the work outlined in this operational plan is by Federal Aid in Sport Fish Restoration, Dingell-Johnson (DJ) Fund (75%) with a 25% match provided by the Fish and Game Fund.

[1] The ADF&G certification rate for all-female triploid rainbow trout requires a 95% confidence level that the triploid rate is 90% or higher (ADF&G 2013).

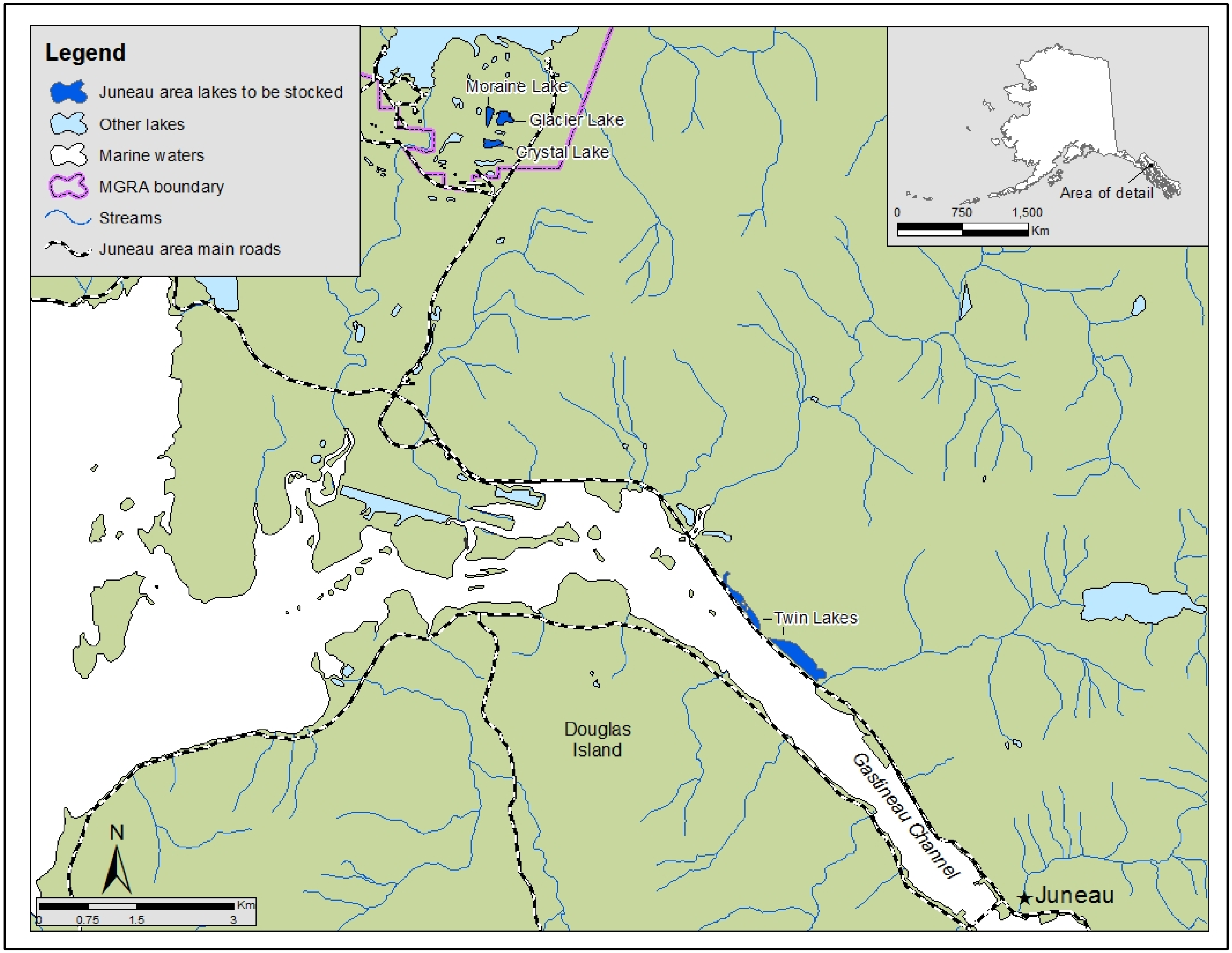

Figure 1.–Locations of the 4 lakes scheduled to be stocked with all-female triploid rainbow trout in the Juneau roadside fishery, Southeast Alaska.

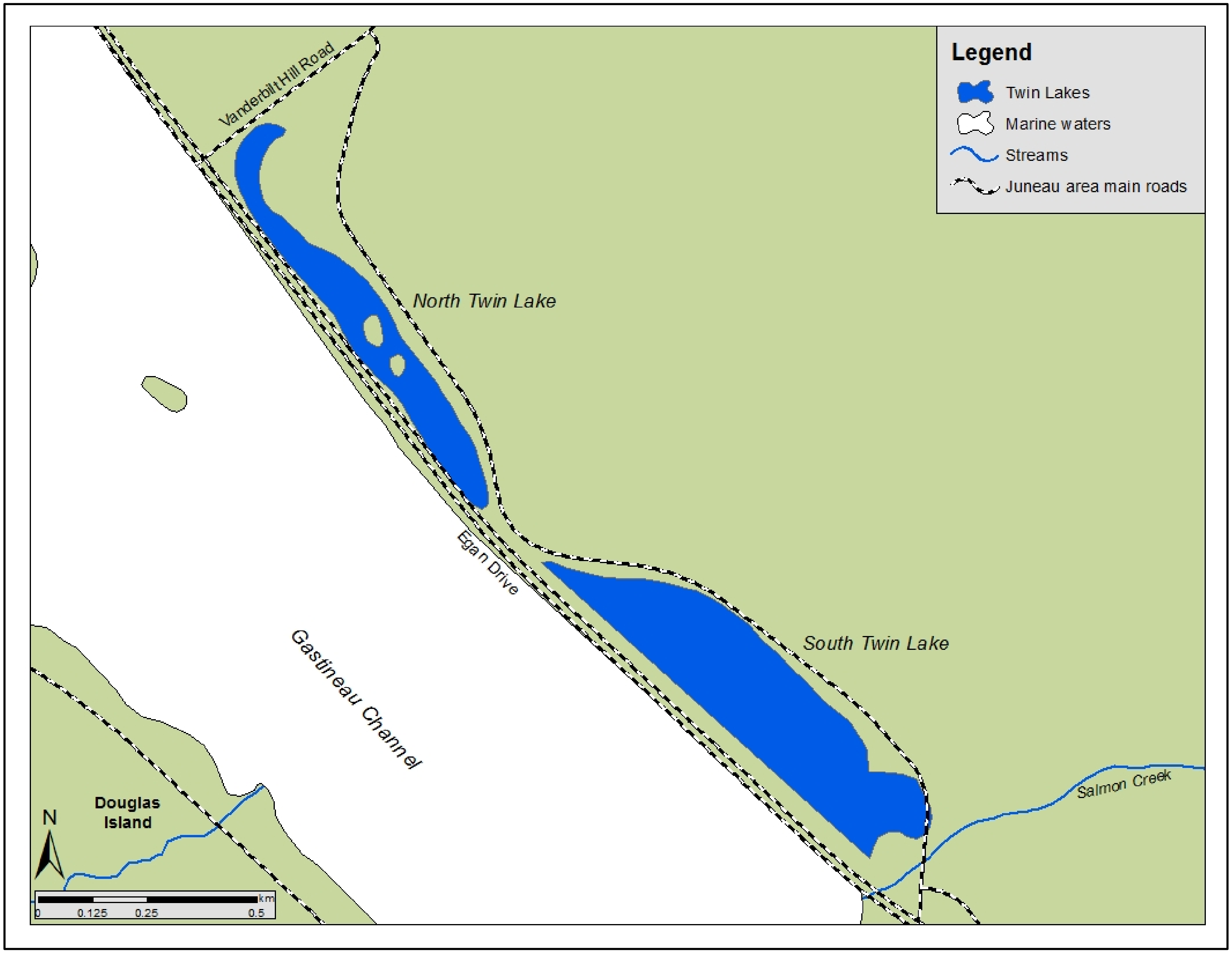

Figure 2.–Map of the Twin Lakes area, Juneau, Alaska.

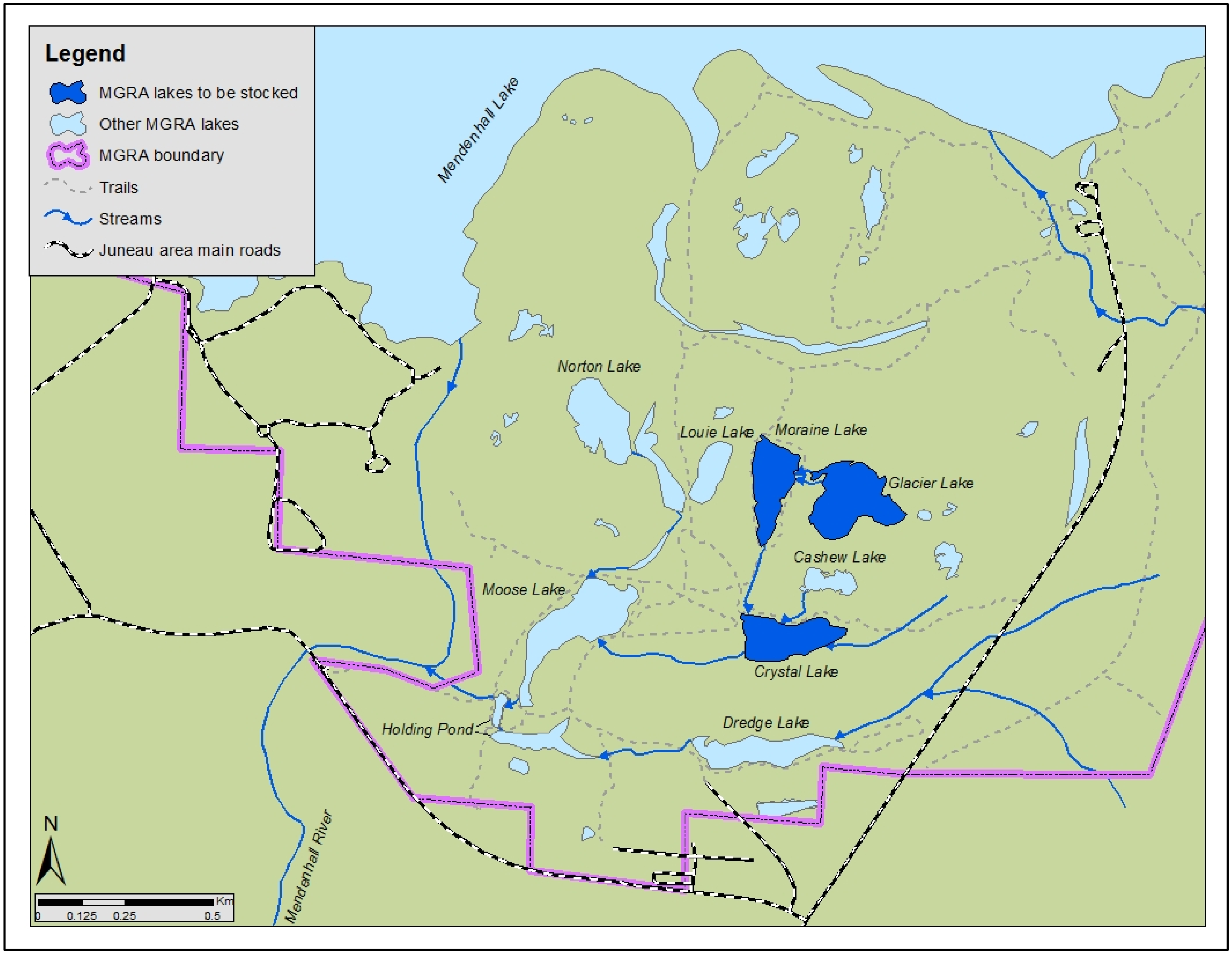

Figure 3.–Map of the Dredge Lakes area, located within the Mendenhall Glacier Recreation Area (MGRA), Juneau, Alaska.

DESCRIPTION OF PROJECT AREA

Twin Lakes

Twin Lakes are a pair of manmade lakes that were developed along the Juneau road system during the construction of Egan Drive, in the 1970's. The 2 lake basins (North Twin and South Twin lakes; Figure 2) were developed from tidal mud flats and marsh and are nearly separated by a small point of land that extends out from the mainland toward Egan Drive (Bethers et al. 1995). The lakes stretch approximately between mile 4 and mile 5.5 of Egan Drive (ADOT&PF 2019).

North Twin Lake is bounded on the northwest end by Vanderbilt Hill Road and is the smaller of the two basins, covering approximately 22 acres when full. South Twin Lake covers approximately 47 acres and is bounded on the southeast end by an earthen dike which separates the lake from Salmon Creek (Bethers et al. 1995). Both lakes have gate valves on culverts under Egan Drive, through which the lakes can be partially drained and flooded with salt water. Each lake also has screened outlet control structures, which are used to regulate lake levels. Both lakes receive fresh water inputs from small streams that drain into the lake (Bethers et al. 1995).

The City and Borough of Juneau has developed the southern part of South Twin Lake as an outdoor recreation area that includes a playground, picnic area, restrooms, a shallow swimming area, a fishing dock, and a small boat launch ramp. There is also a paved walking path that extends along the east side of both lakes, with a parking lot located at each end of the path. Over the past 40 years, Twin Lakes has been stocked with a variety of salmonid species (Appendix A1) and has provided a popular, easy access, year-round sport fishery on the Juneau road system (Bethers et al. 1995). Since 1989, the fish stockings in Twin Lakes have supported a popular annual event known as Family Fishing Day (ADF&G 2019b; Bethers et al. 1995), as well as providing opportunity to sport fish during the rest of the year.

Mendenhall Glacier Recreation Area

The USDA Forest Service (USFS) manages the federally protected land in the MGRA, which encompasses 5,815 acres at the head of the Mendenhall Valley. By the early 1950's, this area was set aside as a Special Interest Area that was divided into 5 management units, each having different management objectives (USFS 1996). Included in the MGRA Special Interest Area is the Dredge Lakes unit, which contains 9 main lakes ranging in size from approximately 2-10 acres (Bethers et al. 1995; Figure 3); this unit is also commonly referred to as "Dredge Lakes" or "Mendenhall Ponds". Five of the lakes in the Dredge Lakes area are natural kettle ponds (Cashew, Glacier, Louie, Moraine, and Norton lakes) and the other 4 were excavated (Crystal, Dredge, Holding Pond, and Moose lakes).

One of the management objectives established for the Dredge Lakes unit is to improve sport fishing opportunities for members of the public (USFS 1996), which has been realized through dedicated stocking efforts, as well as providing and maintaining an extensive trail system that allows the public easy access to the lakes in the area. There is a long history of fish stocking in the Dredge Lakes area (Appendix A2), which extends as far back as 1931 (Bethers et al. 1995). There are several man-made structures located throughout the Dredge Lakes area that were installed at lake inlet or outlet streams with the intent of diverting water flow or restricting fish movement between the lakes.

Motorized vehicles are not allowed in the Dredge Lakes unit; however, the public is able to gain access to the trail system though established entrance points. Beaver activity is high in the area, which frequently results in high water and flooded trails during periods of heavy rain and snow melt. The Dredge Lakes area can also flood during glacier outburst floods that occur as a result of water building up and getting released out of Suicide Basin, located adjacent to the Mendenhall Glacier at the head of Mendenhall Valley. When water gets released from Suicide Basin, it rapidly drains into Mendenhall Lake, which causes the lake and Mendenhall River to flood. The proximity of the Dredge Lakes area to Mendenhall Lake and Mendenhall River (Figure 3) make it possible for overflow from the glacial flood to inundate the area. The extent of flooding during each event is variable and depends on the amount of water built up in Suicide Basin, as well as lake and river levels at the time when flooding occurs.

OBJECTIVES

1) Estimate survival of stocked rainbow trout in the Dredge lakes area so that the estimate is within 15% of the true value 95% of the time.
2) Estimate movement into Moose Lake such that the estimate is within 7% of the true value 95% of the time.

SECONDARY OBJECTIVES

1) Survey selected lakes to determine fish species and life stages present, to characterize the size range of the fish captured, and the overall condition of the fish observed.
2) Survey selected lakes to assess the growth of stocked rainbow trout.
3) Describe physical and chemical properties of the selected lakes during fish sampling events. Measured parameters include: water clarity, temperature, dissolved oxygen, pH, specific conductivity, salinity, and total dissolved solids.
4) Collect fishing effort and harvest information for each lake scheduled to be stocked through the installation of trail cameras and volunteer survey drop boxes.

METHODS

FISH POPULATION INFORMATION

Study Design

Approximately 500 catchable/subcatchable size rainbow trout are scheduled to be released into Crystal, Glacier, and Moraine lakes each year, beginning in spring 2019. Released fish will be individually marked prior to their release, with recapture events planned each spring and fall through the spring of 2022. Recapture efforts will occur in Crystal, Glacier, and Moraine lakes, as well as Moose lake. The location and timing of recaptures will be analyzed using a multi-state mark-recapture model to estimate survival and movement of stocked fish.

Approximately 10,000 catchable/subcatchable rainbow trout are scheduled to be released into Twin Lakes each spring, prior to Family Fishing Day. If available, up to 2,500 subcatchable rainbow trout will be released into Twin Lakes in the fall to provide additional fish for the winter ice fishery. As previously mentioned, pre-release surveys indicate that survival rates might be low for fish stocked in Twin Lakes; as a result, a different sampling strategy will be used for post-release surveys. In 2019, post-release surveys will be conducted at Twin Lakes in the spring and fall. Results from the 2019 surveys will be used to determine whether post-release fish sampling will continue or if Twin Lakes will be considered a “put and take” fishery and will only be evaluated for fishing effort and harvest of stocked fish. Prior to being released, all fish will be marked with an adipose fin clip. Fin clipping will occur in DIPAC hatchery facilities where the rainbow trout are being raised. Fish will be tranquilized using a buffered tricaine methanesulfonate (MS-222) solution, then their adipose fins will be removed using methods described in Magnus et al. (2006). In addition to an adipose fin clip, fish that will be stocked in the Dredge Lakes area will receive an additional mark; each fish will be marked with a uniquely numbered T-bar anchor tag. The additional mark will allow investigators to create individual capture histories to assess growth, survival, and movement of stocked fish. Fish that will be released in Crystal, Glacier, and Moraine lakes will be clipped, tagged, measured, and released into one of the 3 rainbow trout holding tanks at the hatchery. Clipping and tagging prior to their release will allow recovery time in the hatchery before they undergo the stress of transport and release into the lakes. Fish will be held for at least 21 days prior to release, which is in accordance with the drug withdrawal period required by the U.S. Food and Drug Administration (FDA) when releasing fish that have been anaesthetized using MS-222 for potential human consumption (FDA 2018).

For lake surveys, a minimum of a 2-person crew will be dedicated to capturing and sampling fish in 5 Juneau roadside lakes. Fish sampling will occur in the 4 lakes scheduled to be stocked with triploid rainbow trout (i.e., Crystal, Glacier, Moraine, and Twin lakes; Figures 1-3) as well as Moose Lake which is located downstream from the 3 MGRA lakes scheduled to be stocked (Figure 3).

Moose Lake has been added to the study design to help assess movement of stocked fish in the Dredge Lakes area. Currently there are structures located at the outlet stream of Moraine Lake (flowing toward Crystal Lake), the outlet stream of Crystal Lake (flowing toward Moose Lake), and at an inlet stream of Moose Lake (flowing in from Crystal Lake) that were installed to restrict or prevent fish movement between the lakes. No structures have been installed for the streams that flow between Glacier and Moraine lakes, which are both natural lakes (P. Schneider, Staff Biologist, U.S. Forest Service, Juneau Ranger District, Juneau, Alaska; personal communication).

Each lake will be sampled in the spring, after lakes become ice free, and in the fall, prior to lakes freezing over. Fish sampling will be conducted primarily from an open skiff. In an effort to avoid stressing out newly stocked fish, lake sampling events will occur either prior to releasing fish or at least one week after fish are released (B. Meredith, Operations Manager, Douglas Island Pink and Chum, Inc., Juneau, Alaska; personal communication). Additionally, sampling will be conducted when surface water temperatures are <18°C, if possible. Fish will be captured using a combination of collapsible hoop traps, a tangle net, and hook-and-line (i.e., sport fishing) gear. For each sampling event, hoop traps will be set before setting the tangle net or using sport fishing gear.

Methods that will be used for operation of the traps will be similar to those described in Magnus et al. (2006). Hoop traps are approximately 1.25 m long, have a diameter of 50 cm, are covered with untreated 6 mm delta knotless mesh. Each trap has an inward pointing funnel at one end of the trap and a cod end to release fish at the other end. A total of 20 traps will be set in each lake. Hoop traps will be baited with a combination of frozen shrimp and treated salmon eggs; salmon eggs will be prepared following instructions provided in Magnus et al. (2006). Baited traps will be left to soak overnight. An effort will be made to achieve uniform coverage across the lake; however, trap locations and spacing will ultimately be left to the discretion of the crew. Set and pull times will be recorded for each trap, which will provide sampling effort information. Depths will be measured at each trap location using a Hawk Eye digital handheld sonar (for depths >1 m) or by using a weighted line with measurements marked on it (for depths <1 m). Each hoop trap has a bridle rope that will be attached to a buoy line. Most traps will be set on the lake bottom; however, traps will be suspended at locations where there is concern about critically low dissolved oxygen levels (i.e., < 7 mg/L; ADF&G 1983) at depth. Traps will be suspended by attaching the hoop trap bridle rope close to the buoy end of the buoy line; the buoy line has 2 foam bullet buoys tied to the end that provide enough buoyancy to float the hoop trap. A weight will be attached to the other end of the buoy line that will rest on the lake bottom to hold the suspended trap in place.

As time allows, the crew will set a floating tangle net and will use sport fishing gear to sample after traps have been set. The tangle net is approximately 50 m long, 3 m deep, and is made using fine thread monofilament in 13 mm square mesh. Sampling methods for the tangle net will follow those described in Behr (2017). Sport fishing will consist of crew members using a variety of spin casting lures to sample deeper water areas of each lake (approximately >0.5 m depth), where aquatic vegetation will be less likely to hinder sport fishing efforts. The tangle net will be checked every 30 minutes; sport fishing will occur while the tangle net is fishing. Start and stop times will be recorded for each net set and during periods of sport fishing.

All fish captured will be placed in an aerated tote. Salmonids will be identified to species and will be counted. Other species captured will be noted but will not be counted or identified to species level. For each stocked lake, every salmonid captured will be measured from the snout to the fork of the tail (FL), to the nearest 1 mm. Each rainbow trout captured will be inspected for an anchor tag and an adipose fin clip; tag numbers will be recorded, and marks observed will be noted. The sampling frequency will be similar for Moose Lake, except that every 5th coho salmon and every 5th Dolly Varden will be measured instead of each one being measured. Fish will be released after processing.

Data Collection

Prior to field activities, hardcopy color maps will be printed on weatherproof paper for each lake. Maps will include lake bathymetry contours and locations of inlet and outlet streams for the crew to reference while setting traps. Data forms associated with fish sampling (Appendix B1 and B2) will also be printed on weatherproof paper, prior to field activities.

The “ADF&G Gear” form (Appendix B1) will be used to record information about sampling location and effort. Information to be recorded includes: sampling dates, lake being sampled, sampling crew, GPS unit ID, general weather comments, GPS waypoint and associated error (for documenting trap locations, tangle net locations, and places where sport fishing occurs), gear type used at each waypoint, lake depth at the waypoint, and the date and time when fishing started and stopped at each sampling waypoint.

The “ADF&G Fish Sampling” form (Appendix B2) will be used to record fish capture data. Information will be recorded at each sampling waypoint, regardless of whether fish are captured or not. The following information will be recorded: sampling date, lake being sampled, sampling crew, GPS unit ID, GPS waypoint (corresponds with the waypoints recorded on the “ADF&G Gear” form described above), gear type used at the waypoint, species captured, lengths for fish measured (FL measurements; every salmonid captured will be measured, except for Moose Lake where only every 5th coho salmon and every 5th Dolly Varden will be measured), condition of the fish inspected, marks and tag numbers observed (for stocked rainbow trout), total counts for each salmonid species captured at a trap location, and any relevant comments the samplers might have.

At each lake, sampling location waypoints will be collected using a Garmin GPSMAP 60CSx. This model of GPS is WAAS-enabled for accuracy to within 3 m, 95% of the time (Garmin Ltd. 2017).

Data Reduction

At the end of each day of sampling, the field crew will check all data forms to ensure they were filled out completely and do not contain errors. After completion of each sampling event, datasheets will be taken to the office and the data will then be entered into Microsoft Excel files. After data has been entered into spreadsheets, they will be checked for accuracy against the original field data.

All data collected on electronic devices will be downloaded and saved in their respective folders for each lake. This includes waypoint files from GPS receivers (S:\RMIG\DJ_ReportingPlanning|Juneau_RBT_Enhancement\WaypointDownloads) and digital photograph files from cameras (S:\RMIG\DJ_ReportingPlanning|Juneau_RBT_Enhancement\Photos). Waypoints associated with sampling will be imported into ArcGIS for subsequent mapping and will be saved as shapefiles in NAD83, State Plane, AK1, FIPS5001 projection.

Accumulated data for this project will be stored in Juneau at the following folder location: S:\RMIG\DJ_ReportingPlanning\Juneau_RBT_Enhancement\Data\DataEntry. A final, edited electronic copy of the data and relevant files will be sent to Research and Technical Services (RTS) in Anchorage for archiving.

Data Analysis

Survival and Movement

Survival and movement of tagged rainbow trout will be estimated using a state-space parameterization for a multistate Cormack-Jolly-Seber model. In the mark-recapture framework state-space models separate process error (i.e., variability due to population dynamics) from observation error (i.e., variability due to imperfect observation). The list of possible states includes: A = "alive in stocking area", B = "alive outside stocking area", and "dead". The list of possible observations includes: A = "observed in stocking area", B = "observed outside stocking area", and "not observed".

Data from the "ADF&G Fish Sampling" form will be converted into a capture history matrix for analysis. The capture history matrix will have *I* rows and *T* columns, where *I* is the number of tagged individuals that are released, and *T* is the number of sampling occasions. The capture history matrix can take values of 0, A, and B, where 0 indicates the fish was not observed, A indicates the fish was observed in the stocking area, and B indicates the fish was observed below the stocking area.

The likelihood describing the state of fish *i* at time *t*+1 ($z_{i,t+1}$) given its state at time *t* ($z_{i,t}$) is:

$$z_{i,t+1} \,|z_{i,t} \sim \text{catagorical}\left(\Omega_{z_i,1:S,i,t}\right)$$

Where the state transition matrix (ignoring *i* and *t* subscripts):

$$\Omega = \begin{bmatrix} \phi_A(1-\psi_{AB}) & \phi_A\psi_{AB} & 1-\phi_A \\ \phi_B\psi_{BA} & \phi_B(1-\psi_{BA}) & 1-\phi_B \\ 0 & 0 & 1 \end{bmatrix}$$

describes the probability of changing states, where $\phi_X$is the probability of survival in state *x*, while ψ_{XY} is the probability of migration from state *x* to state *y*. The rows of the state transition matrix apply to the true state at time *t*, while the columns apply the true state at time *t*+1. A row of the state transition matrix ($\Omega_{z_i,1:s}$) forms the categorical probabilities in the state likelihood. For example, a fish in the stocking area at time t will remain in the stocking area with probability $\phi_A(1-\psi_{AB})$, will migrate outside the stocking area with probability $\phi_A\psi_{AB}$, and will die with probability $1-\phi_A$.

The likelihood of observing fish *i* at time *t* given the true state ($z_{i,t}$) is:

$$y_{i,t}\,|z_{i,t} \sim \text{catagorical}\left(\Theta_{z_i,1:s,i,t}\right)$$

Where *y* is the capture history matrix. The observation matrix (ignoring *i* and *t* subscripts):

$$\Theta = \begin{bmatrix} p_A & 0 & 1-p_A \\ 0 & p_B & 1-p_B \\ 0 & 0 & 1 \end{bmatrix}$$

contains recapture probabilities. The rows of the observation matrix apply to the true state at time *t*, while the columns apply to the observed state at time *t*. A row of the observation matrix ($\Theta_{z_i,1:s}$) forms the categorical probabilities in the observation likelihood. For example, a fish in the stocking area at time *t* will be observed in the stocking area with probability p_A, will be observed outside of the stocking area with probability 0, and will not be observed with probability $1-p_A$.

Objective #1 places precision criteria on the parameter ϕ_A, while Objective #2 places precision criteria on ψ_{AB}. To estimate expected precision, data were simulated with releases of 1,500 catchables in the spring of 2019, 2020, and 2021; which represents the stocking plan at the time of this publication. Survival within the stocking area was assumed to be 90% between each spring and fall and 75% between each fall and spring. These survivals are consistent with the expectations of WHJSFH staff (J. Milton, Fishery Biologist IV, ADF&G-SF, WHJSFH, Anchorage, Alaska; personal communication). Movement out of the stocking area was assumed to be 5% while migration back into the stocking area was assumed to be 1%. Two sets of simulations were run by varying the parameters that were likely to result in imprecise or biased estimates of ϕ_A or ψ_{AB}.

In one set of simulations, the probability of capture was varied within the stocking area between 10% and 30% in 10% increments. The probability of capture outside of the stocking area was set to ~73%[2] of the probability inside of the stocking area, reflecting the smaller surface areas of lakes within the stocking area. These simulations (Table 1) were intended to test the ability to estimate ϕ_A under various catch rates. Median 95% confidence intervals for $\phi_A$indicate precision objectives are achievable with probabilities of capture that exceed 10% and that at least 76% of all simulations had 95% confidence intervals that included the true values of ϕ_A (0.9, 0.75, 0.9, 0.75, 0.9, 0.75).

Table 1.–Median confidence interval width and coverage probability for survival parameters from 50 simulated datasets under 3 assumed probabilities of capture.

p_A	Median 95% CI width (ϕ_A)	Coverage Probability (ϕ_A)
0.1	0.266 – 0.315	76% – 98%
0.2	0.153 – 0.180	88% – 98%
0.3	0.108 – 0.131	88% – 100%

[2] Identical sampling effort will be expended in each of the 4 lakes, although the surface acreage (sa) of Crystal (6.7 sa), Glacier (9.4 sa), and Moraine (6.4 sa) lakes are smaller than the surface acreage of Moose Lake (10.4 sa).

In a second set of simulations, a 20% probability of capture was assumed and survival below the stocking area varied between 3 levels (equal to survival within the stocking area, half of the survival inside the stocking area, and one quarter of survival inside the stocking area). These simulations were intended to cover the situation where fish that make it into Moose Lake emigrate from the entire drainage, resulting in increased apparent mortality in Moose Lake. While project objectives do not include evaluating survival of stocked fish in Moose Lake, this situation could make it difficult to detect movement out of the study area because some migrants would be unavailable for recapture in Moose Lake. In these simulations (Table 2) median 95% confidence intervals for ψ_{AB} indicate the precision objectives are achievable when apparent survival in Moose Lake is only 25% of survival inside the stocking area and that 88% of all simulations had a 95% confidence interval that included the true value of ψ_{AB} (0.05).

Table 2.–Median confidence interval width and coverage probability for movement parameters from 50 simulated datasets under 3 assumed Moose Lake survival rates.

Survival	Median 95% CI width (ψ_{AB})	Coverage Probability (ψ_{AB})
$\phi_B = \phi_A$	0.033	100%
$\phi_B = \phi_A/2$	0.072	92%
$\phi_B = \phi_A/4$	0.145	88%

A third set of simulations was conducted to assess our ability to satisfy precision objectives when survival is only one-half or one-third of our expected survival rates (90% summer; 75% winter). Simulation results suggest both objectives would be satisfied in either scenario.

In the model description above, individual and temporal subscripts were omitted to simplify presentation, proposing the simplest possible model applicable for the study objectives. Multi-state Cormack-Jolly-Seber models are very flexible and more detailed models will be considered during data analysis. More detailed models that are possible include models that estimate migration between lakes within the stocking area and models that include individual, temporal, or group level covariates when estimating survival, movement, and/or capture probabilities.

Growth

Capture data collected for this project will also provide a robust dataset on age-length relationship for stocked rainbow trout, as the length and age of every released fish will be known and length will be measured during any subsequent recapture. This information will be summarized by fitting a Von Bertalanffy curve to length age data:

$$L_t = L_\infty\left[1 - e^{-\kappa(t-t_0)}\right]$$

Where L_t is the length at time t, L_∞ is the theoretical maximum length, κ controls how quickly the curve approaches L_∞ and t_0 is the theoretical time when length is equal to zero.

The size distribution of non-stocked fish will be summarized as medians and ranges when less than 10 lengths are recorded per species and as a histogram when 10 or more lengths are recorded per species.

WATER QUALITY

Study Design

Prior to fish sampling activities, physicochemical conditions will be assessed at each lake using methods similar to those described in Behr (2017) and USEPA (2011). A vertical water quality profile will be obtained at the maximum depth of each major basin present in the lake being sampled. Locations of water quality sampling stations were determined by using bathymetry data collected during pre-release surveys (Schroeder et al. 2017a). Lake bathymetry was used to identify the number of major lake basins in each lake and the deepest point of each basin. Each sampling station was given a unique station ID that identified the lake and specific sampling station (e.g., Glacier Lake had a total of 3 basins; the deepest basin was assigned a station ID of “G1” and the shallowest basin was assigned a station ID of “G3”).

At each sampling station, profile measurements will be collected in 0.5 m increments, between the surface and the lake bottom. A YSI Inc. Environmental Monitoring System ProDDS Sonde[3] will be used to measure temperature, dissolved oxygen, percent dissolved oxygen, pH, specific conductivity, salinity, and total dissolved solids. Methods for operating and maintaining this instrument will follow procedures described in the instruction manual (YSI Inc. 2014). Water transparency will also be measured at each water quality sampling station by averaging the depths at which a Secchi disk disappears when being lowered in the water and when it reappears as it gets raised back toward the surface (Koenings et al. 1987; USEPA 2011).

In addition to the profile data collected with the YSI sonde, an ONSET HOBO Pro V2 temperature data logger has been recording temperature data in the lakes that are scheduled to be stocked since they were deployed in spring 2017. The temperature data loggers will remain deployed for the duration of the project; the only exception will be if the crew is unable to successfully download data in the field and have to take the data logger to the office to download. If a data logger has to be taken to the office to download, it will be redeployed as soon as possible. Data will be downloaded in the field each spring (using the shuttle download cable), after lakes become ice free, and in the fall, prior to the lakes freezing over. Data loggers will be set up to record temperature data once every 15 minutes. To ensure data loggers stay in place and can easily be retrieved, they will be attached to a small buoy line on one end and will be attached to a weight on the other end. Data loggers will be placed in areas of relatively low foot traffic and will be submerged to a depth of approximately 1 m. Methods for setting up, operating, and maintaining the data loggers will follow procedures described in the instruction manual (ONSET 2010).

Data Collection

Prior to field activities, GPS waypoints for each sampling station will be uploaded to a Garmin GPSmap 60CSx. Observers will navigate to established sampling stations using the “Find” and “Go To” functions on the GPS (Garmin Ltd. 2007).

The YSI ProDDS Sonde has been programed with all station ID’s. Once the crew has navigated to a sampling station in the boat, a bow and stern anchor will get set to help the boat remain as stationary as possible. Prior to collecting data for the vertical water quality profile, the appropriate sampling station ID will get selected on the YSI meter and the profile data will get saved to that sampling station. Vertical water quality profiles will include measuring the following parameters:

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

temperature, dissolved oxygen, percent dissolved oxygen, pH, specific conductivity, salinity, and total dissolved solids.

The "ADF&G Gear" form will be used to record data associated with Secchi depth measurements (i.e., the depth it disappears when getting lowered, the depth it reappears when getting raised back to the surface, and the average of the 2 measurements).

A HOBO temperature data logger has been deployed in each of the 4 lakes scheduled to be stocked. A GPS waypoint has been recorded for the location of each data logger. Data will be downloaded in the field each spring (using the shuttle download cable) after lakes become ice free, and in the fall, prior to the lakes freezing over. If there are issues with downloading data in the field, the data loggers will be taken to the office to download and will be redeployed as soon as possible afterward.

Data Reduction

Data reduction for this section will follow the same procedures described in the Fish Population Information section.

At the end of each sampling event, the YSI ProDDS Sonde will be taken to the office and all water quality profile data will be downloaded using KorDSS (Version 1.4.0.24) software.

Each spring and fall, the shuttles containing downloaded HOBO temperature data will be taken to the office and will be downloaded using HOBOware Pro (Version 3.7.8) software.

Data Analysis

Graphic profiles of temperature and dissolved oxygen will be generated using Microsoft Excel and will be saved in the same file as the data was entered in.

The Secchi disk transparency will be calculated as the average of the 2 depth readings measured (i.e., the depth when the disk disappeared and when it reappeared).

Graphs will be produced using Microsoft Excel to summarize weekly average water temperatures recorded on the data loggers.

FISHING EFFORT AND HARVEST

To help document fishing effort, at least one game camera will be installed at each lake scheduled to be stocked. Cameras will be set up each spring, after ice out, and will be removed on or after November 1. Each camera will be placed in a location most likely to capture photos of people fishing at each lake and at a height and aspect to capture as much of the shoreline as possible in each photograph. Cameras will be programed to capture one photo every hour, during hours of daylight, and photos will be downloaded from the cameras approximately once a month. A similar system has been used to estimate angler effort successfully in 3 small to medium sized lakes stocked with rainbow trout in Alberta (Fitzsimmons et al. 2010). Provided this data is of sufficient quality to accurately count anglers throughout the season, sample days will be randomly selected and sample hours within each sample day will be systematically selected to calculate angler effort within the camera coverage area as described in Bernard et al. 1998 (section 2.2.1). Using the mapped shoreline of each lake, camera coverage areas will be determined to quantify the fishing area covered by the photos in each lake. Crews will also conduct ad-hoc angler counts both within and outside of the camera's coverage area during scheduled sampling events to quantify angler distribution relative to the camera coverage area.

Volunteer angler questionnaires will also be used to obtain fishing effort and harvest data at each lake scheduled to be stocked. A drop-box will be installed at trailheads and by Crystal and Moose lakes in the Dredge Lakes area and one will be installed next to the fishing dock at Twin Lakes. Drop-boxes will be installed each spring, after ice out, and will not be removed until after October 31. Anglers will be asked to record: the date fished; how many anglers fished; and for each lake fished they will be asked the name of the lake, how much time was spent fishing, how many fish were caught, and how many fish were harvested (Appendix C1). Volunteer angler surveys will also be distributed to participants during the annual Family Fishing Day held at Twin Lakes.

Data Reduction

Data reduction for this section will follow the same procedures described in the Fish Population Information.

Data Analysis

Survey responses will be entered into an Excel spreadsheet and will be summarized for each lake to show reported numbers of fish captured and released, as well as catch and harvest rates. Since survey responses are voluntary, unbiased estimates of catch and harvest will not be possible; however, annual changes in catch and harvest rates may help managers assess changes in angler success after stocking.

SCHEDULE AND DELIVERABLES

The timeline for field and office activities associated with this project are included in Table 1. The timeline does not include specific dates because actual sampling dates will depend on a variety of factors, including weather conditions (i.e., timing of lakes becoming ice-free in the spring and when they ice up in the fall), release dates, availability of people conducting the surveys, etc.

Table 3.–Schedule for all activities related to post-release sampling, 2019-2023.

Date	Years	Activity
April	2019-2022	Preparations for spring field sampling
		Marking fish at DIPAC (prior to spring release in all lakes, if applicable)
April-June	2019-2022	Spring field sampling at selected lakes (post-release surveys at Crystal, Glacier, and Moraine lakes and possibly Twin Lakes)
July-August	2019-2021	Data download, data entry, analysis, and preparing for fall field sampling
August-September	2019-2021	Fall field sampling at selected lakes (post-release surveys at Crystal, Glacier, and Moraine lakes and possibly Twin Lakes)
September-March	2019-2021	Marking fish at DIPAC (prior to fall release, if applicable)
		Data download, data entry, analysis, and preparing for spring field sampling
July-December	2022-2023	Data download, data entry, analysis, and final report preparation

Each year, a federal aid performance report will be prepared in September that will detail all activities performed and any results produced during the reporting period. A Fisheries Data Series report will be prepared by December 31, 2023 that will summarize results from the post-release surveys described in this operational plan.

RESPONSIBILITIES

Kercia Schroeder, Fishery Biologist II (Douglas).

Project leader. Oversees all aspects of the project, including study design, planning, budgeting, equipment acquisition, training, logistical matters, data collection, data entry, QA/QC, etc. Writes all required documents related to the project.

Jeff Nichols, Regional Research Coordinator (Douglas).

Oversees and reviews the following aspects of the project including study design; planning, budgeting, equipment acquisition, training, and supervision of project personnel. Will review all operational plans and reporting documents. Assists with field work and data collection.

Vacant, Fish and Wildlife Technician III (Douglas).

Assists with all aspects of field work and data collection, including preparation and cleanup from sampling events.

Adam Reimer, Biometrician II (Soldotna).

Responsible for biometric input including study design, writing of operational plan, analysis and coauthoring of all reporting documents.

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APPENDIX A. FISH STOCKING HISTORY FOR TWIN, CRYSTAL, GLACIER, AND MORAINE LAKES

Appendix A1.–Fish stocking history for Twin Lakes.

Date	Species	Number released
09/15/76	Rainbow trout	13,020
04/26/77	Rainbow trout	3,642
05/27/82	Coho salmon	7,999
08/06/83	Coho salmon	3,972
09/21/83	Coho salmon	5,285
06/22/84	Dolly Varden	1,894
09/05/84	Coho salmon	3,997
05/28/85	Coho salmon	3,062
02/07/86	Coho salmon	5,010
06/17/87	Coho salmon	10,000
10/21/87	Coho salmon	2,307
10/21/87	Coho salmon	4,100
05/19/88	Coho salmon	5,232
05/27/89	Coho salmon	2,885
05/27/89	Coho salmon	6,500
1989	Chinook salmon	10,000
05/05/90	Chinook salmon	9,200
1991	Chinook salmon	11,540
05/28/92	Chinook salmon	10,900
1992	Steelhead	1,445
1992	Steelhead	150
06/14/05	Coho salmon	1,700
10/22/92	Coho salmon	1,719
05/27/93	Chinook salmon	10,736
06/11/93	Coho salmon	4,796
1993	Steelhead	1,800
06/01/94	Chinook salmon	10,000
1994	Chinook salmon	3,400
05/14/95	Chinook salmon	6,216
08/19/95	Chinook salmon	4,730
08/19/95	Coho salmon	4,730

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Appendix A1.–Page 2 of 3.

Date	Species	Number released
04/15/96	Chinook salmon	3,249
05/30/96	Chinook salmon	734
10/08/96	Coho salmon	4,506
06/03/97	Coho salmon	8,265
10/09/97	Chinook salmon	1,521
05/14/98	Chinook salmon	10,574
06/10/98	Chinook salmon	4,029
03/17/99	Chinook salmon	10,153
07/18/99	Steelhead	12,278
10/29/99	Chinook salmon	2,520
04/05/00	Chinook salmon	10,680
01/24/01	Chinook salmon	2,947
04/05/01	Chinook salmon	5,972
05/22/01	Chinook salmon	5,765
10/22/01	Chinook salmon	3,941
04/16/02	Chinook salmon	4,928
05/29/02	Chinook salmon	5,408
10/23/02	Chinook salmon	3,890
03/27/03	Chinook salmon	5,561
05/07/03	Chinook salmon	4,628
10/23/03	Coho salmon	5,816
02/19/04	Coho salmon	4,034
05/19/04	Coho salmon	5,152
06/08/04	Coho salmon	50,039
09/23/04	Chinook salmon	3,019
06/02/05	Chinook salmon	7,811
10/05/05	Chinook salmon	4,002
06/01/06	Chinook salmon	8,799
10/20/06	Chinook salmon	3,498

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Date	Species	Number released
06/01/07	Chinook salmon	10,316
10/15/07	Chinook salmon	4,038
06/06/08	Chinook salmon	10,172
10/30/08	Chinook salmon	5,133
06/11/09	Chinook salmon	10,260
10/16/09	Chinook salmon	5,200
05/14/10	Chinook salmon	4,200
06/01/10	Chinook salmon	5,800
06/01/11	Chinook salmon	2,231
06/01/11	Chinook salmon	7,920
11/03/11	Chinook salmon	2,500
05/18/12	Chinook salmon	7,500
05/18/12	Chinook salmon	2,100
11/05/12	Chinook salmon	3,300
05/31/13	Chinook salmon	2,000
05/31/13	Chinook salmon	5,500
05/19/14	Chinook salmon	9,516
12/18/14	Chinook salmon	2,500
06/05/15	Chinook salmon	6,300
10/23/15	Chinook salmon	1,800
05/16/16	Chinook salmon	8,200
11/14/16	Chinook salmon	1,500
05/12/17	Chinook salmon	5,116

Appendix A2.–Fish stocking history for the 4 lakes in the Mendenhall Glacier Recreation Area that will be sampled for the project described in this operational plan (i.e., Crystal, Glacier, Moose, and Moraine lakes).

Date	Location	Species	Number released
1954	Glacier & Moraine lakes	Rainbow trout	8,000
08/08/1955	Glacier & Moraine lakes	Rainbow trout	2,500
1956	Glacier & Moraine lakes	Rainbow trout	10,600
1958	Glacier & Moraine lakes	Rainbow trout	9,000
1959	Glacier & Moraine lakes	Rainbow trout	8,000
1960	Glacier & Moraine lakes	Rainbow trout	8,000
1960	Glacier & Moraine lakes	Rainbow trout	5,000
1961	Glacier & Moraine lakes	Rainbow trout	10,000
1963	Glacier & Moraine lakes	Rainbow trout	10,000
1965	Glacier & Moraine lakes	Grayling	20,000
1965	Glacier & Moraine lakes	Rainbow trout	15,000
06/11/1968	Mendenhall ponds	Grayling	30,000
06/11/1968	Glacier & Moraine lakes	Grayling	50,000
09/25/1973	Mendenhall ponds	Coho salmon	156,165
09/25/1973	Moose Lake	Chinook salmon	155,078
10/13/1973	Mendenhall ponds	Chinook salmon	129,740
1974	Glacier & Moraine lakes	Rainbow trout	4,030
05/21/1974	Mendenhall ponds	Chinook salmon	82,184
05/28/1974	Glacier Lake	Not recorded	2,273
05/28/1974	Glacier Lake	Rainbow trout	2,273
05/28/1974	Moraine Lake	Rainbow trout	1,725
09/16/1974	Mendenhall ponds	Coho salmon	110,000
09/16/1974	Mendenhall ponds	Coho salmon	100,000
09/16/1974	Moose Lake	Coho salmon	209,485
05/19/1975	Mendenhall ponds	Coho salmon	45,045
05/23/1975	Mendenhall ponds	Coho salmon	60,475
06/23/1975	Mendenhall ponds	Coho salmon	150,000
06/24/1975	Moose Lake	Coho salmon	149,500
1976	Glacier & Moraine lakes	Cutthroat trout	349

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Date	Location	Species	Number released
06/07/1976	Moose Lake	Coho salmon	545,000
05/04/1977	Mendenhall ponds	Coho salmon	30,030
05/04/77	Mendenhall ponds	Coho salmon	20,020
05/1977	Moose Lake	Coho salmon	15,272
05/01/1978	Mendenhall ponds	Not recorded	10,565
1982	Glacier & Moraine lakes	Cutthroat trout	354
06/01/1984	Mendenhall ponds	Not recorded	199,893
11/01/1989	Moose Lake	Coho salmon	70,000
12/18/1989	Mendenhall ponds	Coho salmon	100,763
10/27/2010	Crystal Lake	Chinook salmon	500
10/27/2010	Glacier Lake	Chinook salmon	500
10/27/2010	Moraine Lake	Chinook salmon	500
05/18/2012	Crystal Lake	Chinook salmon	500
05/18/2012	Glacier Lake	Chinook salmon	500
05/18/2012	Moraine Lake	Chinook salmon	500
06/04/2013	Crystal Lake	Chinook salmon	850
06/04/2013	Moraine Lake	Chinook salmon	650
05/30/2014	Glacier Lake	Chinook salmon	700
05/30/2014	Moraine Lake	Chinook salmon	700

Note. The 9 lakes in the Dredge Lakes area are also collectively referred to as the “Mendenhall ponds”. Historical stocking records containing a location of “Mendenhall ponds” are for records that do not specify which lake the release occurred in.

APPENDIX B. FIELD DATA FORMS

Appendix B1.–Data form used to record secchi disk measurements, GPS location information for fish sampling, the gear type used at each waypoint, total lake depth at the location, and the sampling start and stop dates and times.

ADF&G Gear **Pg _____ of _____**

Date(s) _______________

Location ____ Personnel _______________________________

GPS ID _______________

Weather (cloud cover, precip, wind, etc.) ____

Secchi: Station ID _____ Disappear (m) _____ Station ID _____ Disappear (m) _____ Station ID _____ Disappear (m) _____

Reappear (m) _____ Reappear (m) _____ Reappear (m) _____

Average (m) _____ Average (m) _____ Average (m) _____

Waypoint	**Error** (m)	**Gear Type**	**Depth** (m)	**Date/Time SET**	**Date/Time PULL**

Gear Codes

hoop trap = HT tangle net = TN fishing rod = rod

Appendix B2.–Data form used to record fish capture data, including FL measurements, marks observed, anchor tag numbers, and species counts.

ADF&G Fish Sampling Pg _____ of _____

Date(s) ________________

Location ____ Personnel ____

GPS ID ________________

Waypoint (on gear sheet)	**Gear Type**	**Spp**	**Length** (mm FL)	**Cond**	**Marks/Tag #** (and color)	**Count**	**Comments**

<u>Gear Codes</u>
hoop trap = HT
tangle net = TN
fishing rod = rod

<u>Fish Spp. Codes</u>
Chinook salmon = KS
coho salmon = CS
cutthroat trout = CT
Dolly Varden = DV
pink salmon = PS
sockeye salmon = SS
rainbow trout = RT

<u>Marks Obs.</u>
ad clip = ad
tag = # and color

<u>Condition</u> (can use more than one; include details in the Comments section)
thin = T
fat = F
injured = I
parasite = P*
disease = D*
* - P/D if uncertain

APPENDIX C. VOLUNTEER FISHING SURVEY FORM

Appendix C1.–Volunteer fishing survey form.

ADF&G Volunteer Fishing Survey

Date ____________________ **# of people fishing ____________________**

Lake fished	Time spent fishing	# of *rainbow trout* ***caught***	# of *rainbow trout* ***kept***	# of *other fish* ***caught***	# of *other fish* ***kept***