Regional Operational Plan SF.4A.2014.06

Anadromous Cataloging and Fish Inventory in Select Bristol Bay Drainages

by

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and

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August 2014

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.4A.2014.06

ANADROMOUS CATALOGING AND FISH INVENTORY IN SELECT BRISTOL BAY DRAINAGES

by

James Bales and Joseph Giefer

Alaska Department of Fish and Game, Division of Sport Fish, Anchorage

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Division of Sport Fish

August 2014

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Signature/Title Page

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Plan Type:	Category III

Approval

Title	Name	Signature	Date
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Biometrician	Adam Craig	[signature]	7/10/2014
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ABSTRACT

From July 28 to August 19, 2014, the Alaska Department of Fish and Game, Division of Sport Fish will conduct an inventory of stream-fish assemblages and associated aquatic and riparian habitats in a 35,436 square kilometer study area spanning much the Nushagak, Wood, and Kvichak river drainages (excluding conservation units). We defined three stream size classes based on upstream drainage area: Headwaters (50-sq.km), Intermediate (200-sq.km), and Mainstem (1500 -sq.km) streams. We identified 172 potential study sites, made up of 156 Headwaters locations that will be sampled with a backpack electrofisher, and 11 Intermediate and 5 Mainstem locations that will sampled with a cataraft-mounted electrofisher. Prior to conducting fish surveys at each stream study site, we will collect data describing location, water quality, channel morphology, streamflow, aquatic habitat, and riparian vegetation. Anadromous fish-assemblage information collected will be used to nominate rivers and streams to the State of Alaska's *Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes*, or to update fish life stage information for waters already in the catalog.

Key words: fish inventory, stream survey, anadromous, Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes, Anadromous Waters Catalog, electrofishing, Nushagak River drainage, Wood River drainage, Kvichak River drainage.

INTRODUCTION

The State of Alaska is committed to conserving fish habitat. Alaska is the only state with a constitutional mandate[1] to maintain sustained yields of fish stocks (ADCCED 2009), and the Alaska Department of Fish and Game (ADF&G) has a statutory responsibility to manage the use of wild fish stocks for sustained yield (AS 16.05.730(a)). Along with proper management of harvests, protection of fully-functioning and connected aquatic habitats is necessary to sustain fish stocks supporting Alaska's commercial, subsistence, and recreational fishing economies.

The state has multiple administrative tools to protect fish habitat. Alaska Statute (AS) 16.05.871 (the Anadromous Fish Act), along with the Fishway Act (AS 16.05.841, which requires that fish passage be maintained in any stream "frequented by salmon or other fish"), constitute Alaska's strongest and most comprehensive instream fish habitat protection standards. Several other Alaska statutes specifically reference fish habitat, including multiple sections in AS 41.17 (Forest Resources and Practices Act) and AS 46.15 (Water Use Act), both administered by the Department of Natural Resources, and AS 46.03.758 (Civil penalties for discharges of oil), administered by the Department of Environmental Conservation.

The Anadromous Fish Act requires ADF&G to "specify the various rivers, lakes, and streams or parts of them" of the state that are important to the spawning, rearing, or migration of anadromous fish. The *Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes* (Anadromous Waters Catalog, AWC) and its associated atlas are the media used to accomplish this specification, and are adopted as regulation under 5 AAC 95.011. Activities and uses conducted in, or otherwise affecting, either any AWC-listed water bodies (under the Anadromous Fish Act), or fish passage in any fish-bearing waters (under the Fishway Act) statewide, require prior approval from the ADF&G Division of Habitat, which is responsible for reviewing project plans and specifications submitted by permit applicants. Permitting biologists work closely with project applicants to ensure that project plans provide for the proper protection of fish habitat. If so, a Fish Habitat Permit is issued authorizing the activity. Permit applications may be denied if impacts to fish habitat cannot be adequately avoided, minimized, or mitigated.

[1] The Constitution of the State of Alaska; Article 8, Section 4 – Sustained Yield states "Fish, forests, wildlife, grasslands, and all other replenishable resources belonging to the State shall be utilized, developed, and maintained on the sustained yield principle, subject to preferences among beneficial uses."

Many other federal, state, and local government policies specify additional protections for anadromous fish habitat in Alaska. Like the Anadromous Fish Act, these only apply to those waters where anadromous fish use is explicitly documented, typically by reference to the AWC. For example, the National Marine Fisheries Service (NMFS) identifies Essential Fish Habitat (EFH) for Alaska stocks of Pacific Salmon in freshwater by reference to the AWC. Three of the U.S. Army Corps of Engineers' regional conditions for nationwide permits in Alaska specify additional requirements and restrictions for proposed projects located in or near AWC-listed water bodies. Other policies that protect AWC-listed water bodies are found in: area plans for state lands; state forest management plans; resource management plans for Bureau of Land Management (BLM) lands; federal and state regulations specifying waters closed to commercial and subsistence fishing; and city and borough ordinances.

Comprehensive fish distribution information is required for effective land use, conservation, and restoration planning to identify sensitive and important habitats. State land management plans, such as the *Susitna Area Plan* and the *Bristol Bay Area Plan*, and more specific plans such as the *Kenai Peninsula Brown Bear Conservation Strategy*, identify management guidelines or specify geographic areas of concern based in large part on the known distribution of fish. Watershed and conservation planning efforts also rely heavily on knowledge of fish distributions and aquatic habitat characteristics and their spatial and temporal relationship to other resources and activities. Planning for habitat restoration programs, such as fish passage enhancement, is also better informed with access to comprehensive fish distribution information.

Resource developments, such as transportation and utility corridors, are most effectively informed if complete fish distribution data is available at project onset. If comprehensive fish distribution information is provided during project scoping, projects can be designed to avoid habitat impacts; however, absence of comprehensive fish distribution information can lead to unintended fish habitat impacts.

All these fish habitat conservation authorities and planning processes are limited, however, by the extent of current knowledge of fish habitats and their distribution. The Anadromous Fish Act, along with other federal, state, and local government policies that refer to the AWC, provides protection only to those waters listed in the AWC. Listing new water bodies requires site specific, direct, and unambiguous observations of anadromous fish followed by a biological and public review process. Habitat modeling, speculation, or professional judgment is not sufficient to add water bodies to the AWC.

Previous field inventories have demonstrated significant data gaps in the understanding of Alaskan freshwater fish distribution and habitat characteristics. For example, recent (2003–2008) anadromous cataloging work resulted in a 75% increase in the sum of the lengths of AWC-listed streams, and a 72% increase in the number of cataloged water bodies, in the Nushagak River drainage. The state has limited authority to protect undocumented fish habitat.

To refine fish habitat management in specific waters, resource agencies also need knowledge of local aquatic and riparian habitat characteristics. Since aquatic and riparian habitats vary in their sensitivity to human activities, these habitat characteristics should be well understood when planning or permitting general or specific activities. Physical and biological characteristics of riparian and aquatic habitats are important factors in determining appropriate best management practices and mitigation strategies. Documenting habitat characteristics at fish collection reaches also provides baseline information for comparison with future studies, and may contribute to improved understanding of fish habitat associations.

In response to the above needs, in the summer of 2014, we will complete a rapid, baseline inventory of fish assemblages and associated aquatic and riparian habitat characteristics in select Bristol Bay drainages in conjunction with a lake focused fish sampling project (operational plan in prep.). So far, since 2002, we have conducted similar baseline fish inventories in 36 (Table 1.) of Alaska's 139 subbasins.

Table 1.–Completed AFFI projects since 2002.

HUC	Name	Year
19020301	Lower Kenai Peninsula	2012
19020302	Upper Kenai Peninsula	2012
19020401	Anchorage	2012
19020402	Matanuska	2011
19020501	Upper Susitna River	2003, 2011
19020502	Chulitna River	2003, 2011
19020503	Talkeetna River	2003, 2011
19020504	Yentna River	2003, 2011
19020505	Lower Susitna River	2003, 2011
19020601	Redoubt-Trading Bays	2002, 2012, 2013
19020602	Tuxedni-Kamishak Bays	2012, 2013
19030205	Lake Clark	2012
19030206	Lake Iliamna	2012
19030301	Upper Nushagak River	2003, 2005, 2006
19030302	Mulchatna River	2003
19030303	Lower Nushagak River	2003, 2005, 2006

HUC	Name	Year
19030402	Farewell Lake	2007
19030403	Takotna River	2007
19030404	Holitna River	2009
19030405	Stony River	2007
19030501	Aniak	2009
19040301	MF-NF Chandalar Rivers	2010
19040404	Ramparts	2004
19040507	Tanana Flats	2004
19040508	Nenana River	2004
19040511	Lower Tanana River	2004
19040601	Upper Koyukuk River	2010
19040602	South Fork Koyukuk River	2010
19040701	Tozitna River	2004
19040801	Anvik River	2008
19040802	Upper Innoko River	2008
19040803	Lower Innoko River	2008
19040804	Anvik to Pilot Station	2008
19050102	Unalakleet	2009
19050103	Norton Bay	2004
19050105	Imuruk Basin	2004
19050201	Shishmaref	2004
19050202	Goodhope-Spafarief Bay	2004
19050203	Buckland River	2004

OBJECTIVES

The overall goal of the AFFI program is to provide information needed for management of the habitats that support Alaska's freshwater fish. This project will contribute to that goal by achieving the following objectives:

Objective 1: To maximize the spatial increase of mapped anadromous fish habitat depicted in the AWC by completing a baseline inventory of fish (with emphasis on anadromous fish) assemblages in select Bristol Bay drainages.

Task 1: Locate fish-collection reaches to maximize the spatial increase in length of AWC-listed streams while minimizing the number of reaches sampled per stream.

Task 2: Sample each reach using standardized fish-collection techniques and with sufficient sampling effort such that, in at least 90% of the reaches sampled, the number of species detected is within 1 species of the true species richness.

Task 3: For each water body in which anadromous fish are observed, submit a nomination to the AWC, providing sufficient information to achieve the intended result (i.e., addition, deletion, correction, or backup information).

Objective 2: To record, at each fish collection reach, characteristics of aquatic and riparian habitats such that sufficient information is documented to: (a) identify well supported and adequate habitat protection stipulations for permitting of local low level disturbances; or (b) identify further sampling needs necessary to design adequate habitat protection stipulations or mitigation for permitting greater level disturbances.

Task 1: Establish a habitat transect at each fish-collection reach and record a suite of standard aquatic and riparian habitat parameters.

Objective 3: For nonwadeable streams, to collect data to test the hypothesis that sampling a reach having a length equal to 120 wetted channel widths is sufficient to detect within 1 species of the true species richness 85% of the time.

Task 1: At each nonwadeable target-stream reach, record fish observations separately for a minimum of 12 spatially-sequential subreaches (or as many as can be sampled in 1 day), each equivalent in length to 10 wetted channel widths. If time allows, sample additional subreaches as necessary until no new fish species are recorded from 6 consecutive subreaches.

STUDY DESIGN

CIAP 4-YEAR STUDY AREA

In the past, AFFI study area boundaries were delineated on a year to year basis to coincide with watershed boundaries such that the spatial expanse of a single years study area could be sampled with sufficient effort to achieve our objectives as well as those of our various funding sources and project partners while staying within the logistical sideboards of the project. In contrast to these prior yearly study areas, we have, due to funding source stipulations, selected a relatively expansive 4-year study area (bound as before by drainage areas) to be iteratively visited over 4 field seasons (2012-2015). This 98,750 square-km (sq. km) study area (Figure 1) spans east to west from Anchorage to Dillingham and north to south from the Susitna River drainage to Cold Bay, excluding conservation units. Due to the vastness of this 4-year study area, and the distances between suitable field bases (those able to provide adequate resources to address project logistics), we have divided our study area into smaller geographic areas that are most closely associated (spatially) with suitable field bases though not necessarily directly associated with drainage area boundaries as before. The result was the identification of 9 field bases (Kodiak, Moose Pass, Nikiski, Drift River, Port Alsworth, Koliganek, Dillingham, King Salmon, and Port Heiden) each to be assigned its own suite of target streams. A set of adjacent field bases and their associated target streams will be selected for investigation each field season.

This 4-year study area was selected for fish inventory fieldwork based upon: expected gaps in AWC coverage; human activities and infrastructure potentially affecting fish habitat; land conservation status; and stipulations related to funding source objectives.

2014 STUDY AREA

For investigation in 2014, a 35,436 sq. km study area was delineated around the Dillingham and Koliganek field bases (Figure 2) excluding all areas in conservation unit status. For logistical reasons, the Koliganek field base was later changed to the Alagnak Lodge located near King Salmon. Following the methods outlined in the Target Streams section of this document, a set of target streams (156 *Headwaters*, 11 *Intermediate*, and 5 *Mainstem*) were identified within the vicinities of these bases. An associated AFFI lake sampling study will also be conducted in the same study area concurrently with this project.

As was mentioned above, the study area was, for logistical purposes, delineated primarily based upon proximity to the most accommodating field bases identified in the area. Using GIS applications, the following steps were taken to delineate a discreet 2014 Study Area: From the 4-year Study Area, several HUC8s (4^{th} level Hydrologic Unit Codes; subbasins) (19030206, 19030301, 19030302, 19030303, 19030304, 19030305, and 19030306) were identified to most closely encapsulate the 2014 field bases and all of their associated target streams. For the most part this 2014 study area does in fact follow watershed boundaries, however Hydrologic Unit 19030206 (Lake Iliamna) was split such that target streams could be associated with the most appropriate (nearest) field camp (in 2012 and 2015).

FIELDWORK DATES AND BASES

See Table 5. The 23-day field trip with the full crew and helicopter support is planned for July 28–August 19, 2014. All teams will be based out of the Alagnak Lodge near King Salmon from July 28–August 8 while working in the eastern half of our study area. We will then be based out of Dillingham at the Northern Lights Bed and Breakfast from August 9-August 18 while working in the western half of our study area, before returning to Anchorage on August 19.

By conducting fieldwork in July and August, we believe we will maximize our chances of observing a variety of anadromous fishes, especially stream rearing species and life stages, at the upstream limits of their range, in order to achieve Objective 1. Anadromous fishes rearing in headwater streams (i.e., mainly age-0 and age-1 coho and Chinook salmon) are presumed to be at or near their maximum upstream distribution in the study area during July–August, after they emerge and disperse from their natal habitats, but prior to the onset of rapidly cooling waters in the fall, when they likely begin moving to their winter habitats.

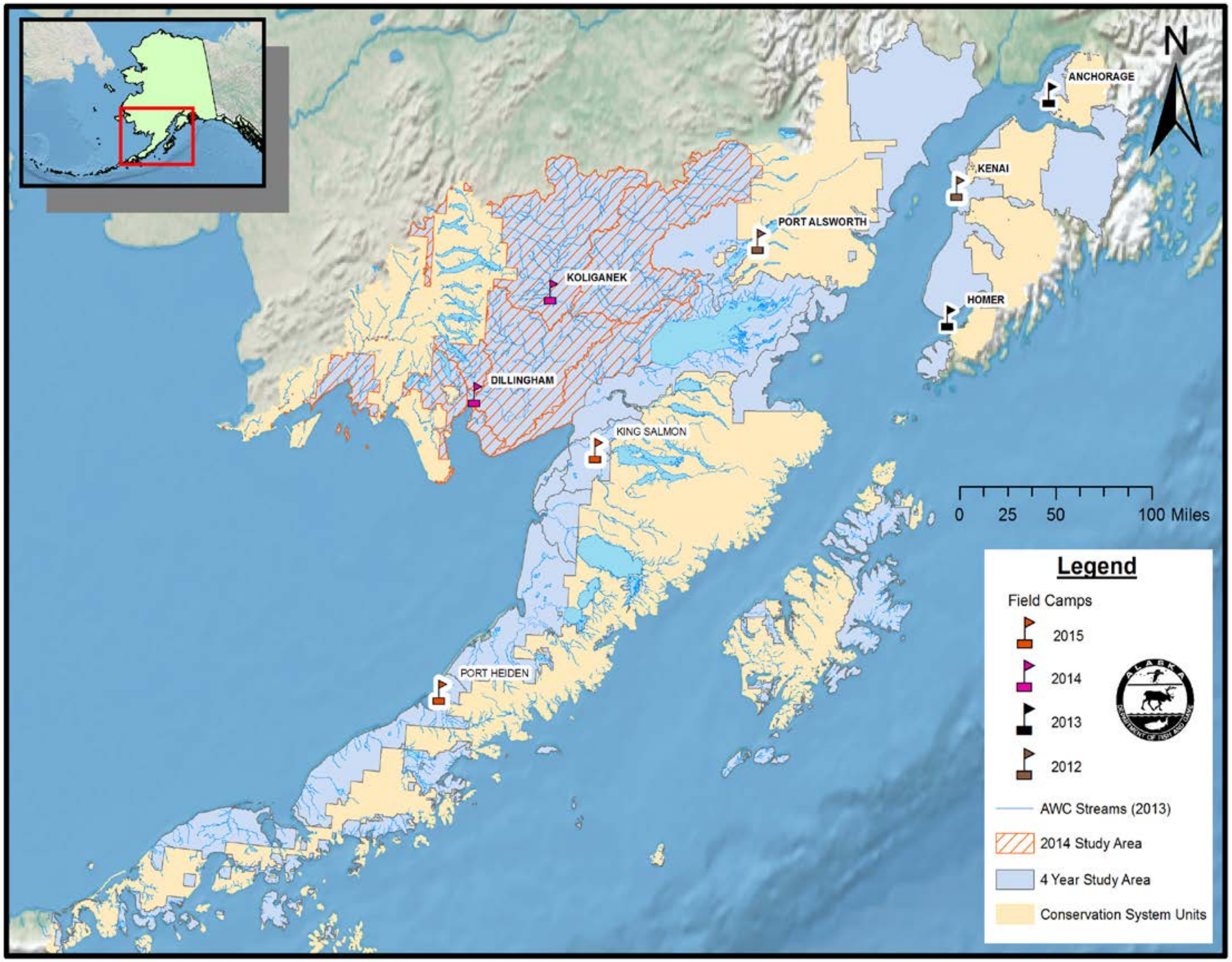

Figure 1.–CIAP 4-year study area map.

TARGET STREAMS

We defined 3 stream size classes based on upstream drainage (catchment) area. *Headwaters* drain 50 sq. km, *Intermediate Streams* drain 200 sq. km, and *Mainstems* drain at least 1500 sq. km. From these 3 classes, we selected a prioritized set of target streams, as described below.

Headwaters target streams

One headwaters team (Team C) transported by a dedicated Robinson R-44 helicopter will visit *Headwaters* throughout the study area for a total of 20 field days in July and August. We identified 95 candidate *Headwaters* in the study area, excluding streams that are: 1) already listed in the AWC; 2) those we surveyed previously; and 3) located upstream of known fish migration barriers (e.g., waterfalls and glaciers). From previous experience, we anticipate Team C will have time to sample up to 6 target streams per day, so we expect they will visit up to 120 target streams. Some of the 95 candidate *Headwaters* will likely be deemed unsuitable by the crew leader, either due to the lack of a suitable helicopter landing zone, the lack of suitable fish habitat, or the presence of an obvious fish passage barrier downstream.

To maximize the length of previously uncataloged anadromous fish habitat documented by Team C, we ranked each *Headwaters* target stream by the length of stream located between the upstream terminus of AWC coverage, and the point along the stream where the upstream watershed area first reached 50-sq km (referred to hereafter as the 50-sq km pour point). We do not understand enough about the ecological factors that may limit anadromous fish distribution in the study area to include additional calculable criteria (e.g., valley gradient) in our target stream selection process.

95 qualifying *Headwaters* target streams were selected and ranked using a GIS based protocol as follows:

1. All 50-sq km pour points within the study area were plotted[2].
2. Any already listed in the AWC were deleted.
3. Any that we already surveyed were deleted.
4. Any located upstream of known fish-migration barriers were deleted or shifted downstream of the barrier.
5. The length of stream from each 50-sq km pour point downstream to the upper terminus of AWC coverage was measured and recorded using an ESRI ArcInfo script. Where more than one 50-sq km pour point draining to the same AWC terminus was identified, we determined which pour point had the longest flowpath downstream to the AWC terminus, and recorded the length of that flowpath. Then we recorded the length of the next-longest flowpath measured only to the confluence with the longest flowpath determined in the previous iteration. This step was repeated until a flowpath length was recorded for each 50-sq km pour point that shared a common downstream AWC upper terminus.
6. To rank the 95 pour points, we sorted them in descending order by their recorded flowpath length, and sequentially numbered them from 1 to *n*.

[2] The source GIS layer for identifying target streams in the study area was the National Elevation Dataset (NED), which is a digital elevation model (DEM) with a 60-m cell size throughout our study area. We clipped the NED to the extent of our study area, then reconditioned it by "burning-in" NHD flowlines using Arc Hydro Tools version 1.2 for ArcGIS 10 (available at http://support.esri.com/index.cfm?fa=downloads.dataModels.gateway). Then we used GIS hydrology tools (bundled with the Spatial Analyst extension for ESRI ArcGIS 10.0) to generate a flow accumulation grid from the reconditioned NED. Finally, we created a pour point overlaying each flow-accumulation grid cell where the accumulated number of upstream cells first equaled or exceeded 13,889, which corresponded to the 50-sq km threshold identified for *Headwaters* streams. In Step 5 above, stream distances were measured along flowpath lines derived from the flow accumulation grid.

A set of 95 *Headwaters* target streams was identified for Team C comprising the streams flowing through the 95 pour points selected above. In an effort to more fully inventory species presence in areas of elevated environmental concern, a set of 61 additional target sites were selected from: 1) previously surveyed sites that, based on survey notes and professional judgment, were deemed to have high potential to be anadromous fish habitat; 2) unsubstantiated AWC streams in the study area; and 3) streams draining less than 50 sq km (therefore not included in our original suite of target streams) based upon the input of regional habitat biologists.

Intermediate and Mainstem target streams

A cataraft team (Team A) transported by a Bell 206BIII helicopter will visit *Intermediate* and *Mainstem* target streams throughout the study area for a total of 20 field days. For logistical reasons, Team A will sample 1 reach per field day, for a total of up to 20 reaches in *Intermediate* and *Mainstem* target streams.

Using the same methods described above for selecting and ranking *Headwaters* target streams, we ranked 11 candidate *Intermediate* target streams (i.e., uncataloged (with the exception of unsubstantiated AWC streams), potentially anadromous fish accessible stream segments in the study area having an upstream catchment area of 200 sq km).

We also identified an additional 5 candidate reaches in *Mainstem* target streams (draining 1500 sq. km) in the study area: Kokwok, Koktuli, Nushagak, Chilikadrotna, and Mulchatna rivers. Team A will spend 1 day sampling each of the 5 *Mainstem* target streams in the vicinity of the 1500-sq km pour point.

Thus, we identified a total of 16 candidate reaches in *Intermediate* and *Mainstem* streams, and we anticipate having sufficient time to sample each of them. Some of our candidate reaches will likely be deemed unsuitable for sampling by the crew leader in the field, including those that are not safely raftable, or where we find fish-passage barriers downstream. To fill our four remaining field days and to provide potential back up cataraft sites, we have prepared a list of eight potential cataraft sites on uncataloged streams draining less that 200 sq km, based on notes and photos from previous AFFI surveys in the study area. The suitability of these streams as cataraft sites will be evaluated in season. In the event that there are remaining field days and no remaining viable cataraft sites, Team A will switch to a backpack electrofisher and sample *Headwaters* streams during the remaining time in the field.

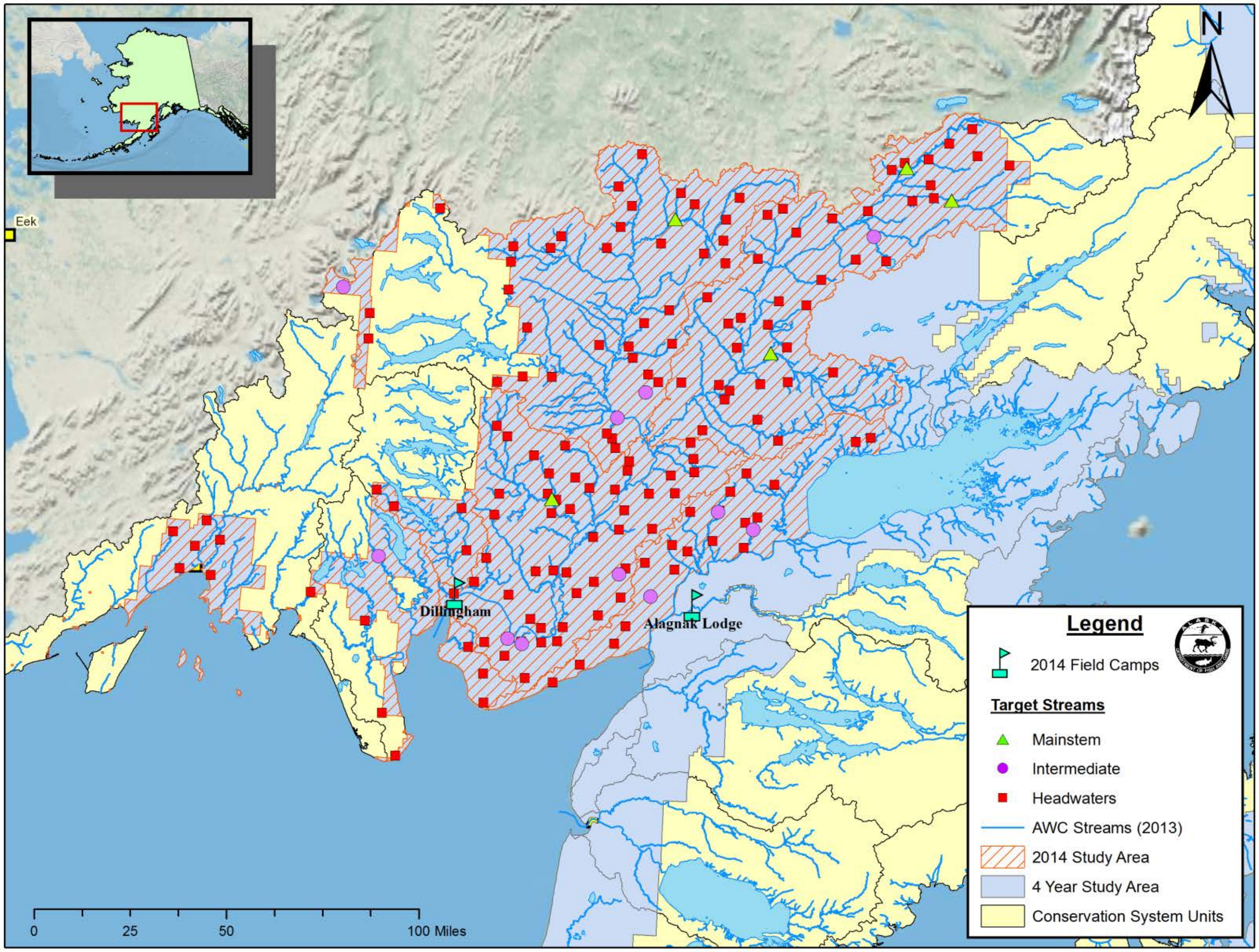

Figure 2.–2014 study area and target stream map.

FISH-COLLECTION REACHES

Sampling sufficiency

Since collecting all common species of the local fish assemblage is the primary task; we will be essentially sampling for fish species richness. According to Temple and Pearsons (2007), when species richness is the primary variable of interest, linear sampling distances should be based on multiples of wetted channel width (CW). Several recent studies have estimated the amount of stream length that should be sampled to capture most (typically 90–95%) of the species present in a given stream reach (see Table 2). Based on studies (i.e., Patton et al. 2000, Reynolds et al. 2003, Temple and Pearsons 2007) from regions with similarly low species richness as in Alaska, we have previously selected a standard minimum reach length of 40 CW for *Headwaters* streams, a standard which has been in place during prior AFFI projects since the 2003 field season. From a fish-inventory we conducted during August 2009 in western Alaska (middle Kuskokwim and eastern Norton Sound drainages) using the same standard fish sampling protocols and equipment, it appears that sampling a reach having a length of 40 CW is sufficient to detect within 1 species of the true species richness 90% of the time in Alaskan *Headwaters* streams (unpublished data, Daniel Reed, ADF&G biometrician, July 2010, Nome Alaska). Therefore, for single-pass backpack electrofishing in *Headwaters* streams, we will continue to sample 40 CW long reaches.

Table 2.–Recommended number of stream widths that should be sampled to capture common species present.

No. of stream widths	Region	Reference
	Small streams	
5–49	southern Wisconsin	Lyons 1992
22–67	Virginia	Angermeier and Smogor 1995
13–83	South Carolina	Paller 1995
12–50	Wyoming	Patton et al. 2000
86	Arkansas	Dauwalter and Pert 2003
40	western Oregon	Reynolds et al. 2003
27–31	Yakima basin, WA	Temple and Pearsons 2007
	Nonwadeable rivers	
85	Oregon	Hughes et al. 2002
30–40	Idaho	Maret and Ott 2003

Recent analysis of prior (2007–2010) AFFI fish collections indicated that single-pass electrofishing in a standard 40 CW reach typically underestimates true species richness in *Intermediate* and *Mainstem* streams of Western and Interior Alaska (Buckwalter et al. 2012). Therefore, to better ensure that all common species of the extant fish assemblage in *Intermediate* and *Mainstem* streams are detected, we will sample a minimum reach length of 120 CW (or as much as we can sample in one day), and we will continue to collect data (as described under Objective 3 Task 1) to develop and assess regional sampling-sufficiency recommendations for *Intermediate* and *Mainstem* streams in Alaska.

Fish-collection reaches in *Headwaters* target streams

To ensure adequate sampling effort occurs in the smallest *Headwaters*, and to avoid spending an excessive amount of time in the largest *Headwaters*, 40 CW fish collection reaches in *Headwaters* will be limited to a length of 150–300 m. This range of reach lengths is consistent with the National Water Quality Assessment Program (NAWQA) protocols for sampling fish communities (Fitzpatrick et al. 1998) and with recommendations developed for small Wyoming streams (Patton et al. 2000). Thus, in *Headwaters* reaches having a wetted-width < 3.75 m, actual reach length will exceed 40 CW; and in *Headwaters* reaches having a wetted-width > 7.5 m, reach length will be less than 40 CW.

Individual fish collection reaches in *Headwaters* will be selected in the field by the Team-C crew leader during slow, low-level helicopter reconnaissance. Target stream reconnaissance will generally begin at the 50-sq km pour point (Appendix C3) and proceed up the mainstem. As the helicopter flies upstream at altitudes and speeds sufficiently low to allow adequate visual inspection, the crew leader will evaluate the stream, paying particular attention to water flow, gradient, and barriers to fish passage.

The crew leader will select a fish collection reach meeting the following criteria:

1. a reach at or near the apparent upstream limit of anadromous fish distribution;
2. a reach where the crew leader anticipates anadromous fish could be present, based on observable characteristics including: fish observed from the air; stream substrate; velocity; juxtaposition of aquatic habitat types; known seasonal variation in instream flow; and accumulated experience in evaluating the presence of anadromous fish in adjacent and similar water bodies;
3. a safe helicopter landing site within a 5 minute walk of the selected reach, and;
4. where prior approval to access private, native, military, or municipal lands has been provided.

In some cases, the crew leader may judge that the target stream is not likely to provide anadromous fish habitat, and that the objective of maximizing the increase in length of AWC-listed anadromous fish habitats would be better served by devoting effort to another stream. In such cases, the crew leader will take an aerial photograph(s) of the target stream, and then direct the pilot to the next target stream.

If anadromous fish are collected from a reach, and in the absence of migratory barriers upstream, additional upstream sampling may be conducted at the discretion of the crew leader. Likewise, if no anadromous fish were collected from a reach, the crew leader may select another fish-collection reach further downstream. These options will be weighed against the need to visit other higher-priority target streams.

Fish-collection reaches in *Intermediate* and *Mainstem* target streams

Prior to landing at an *Intermediate* target stream, the cataraft team will generally travel by helicopter to the downstream waypoint associated with each target stream (Appendix C2) then proceed slowly and at low-level upstream from there. As the helicopter travels along the target stream, the crew leader will evaluate the channel's aquatic habitat, paying particular attention to water flow, gradient, barriers to fish passage, and any potential rafting hazards (e.g., rapids, sweepers, falls). The crew leader will select a segment of the target stream for the day's float meeting the following criteria:

1. a segment that can be safely floated in a day;
2. a segment where the crew leader anticipates anadromous fish may be present, based on observable characteristics including: fish observed from the air; stream substrate; velocity; juxtaposition of aquatic habitat types; known seasonal variation in instream flow; and accumulated experience in evaluating the presence of anadromous fish in adjacent and similar water bodies;
3. a safe helicopter landing zone within a 5 minute walk of the stream at both the upstream (put-in) and anticipated downstream (take-out) ends of the segment;
4. where prior approval to access private, native, military, or municipal lands has been provided (unless both landing zones and the reach are accessible within the bounds of the ordinary high water level, in which case no access permission is needed, except for sites located within restricted military land or airspace).

Each day, the cataraft team will sample 1 reach within the target stream segment identified for the day's float. At each fish collection reach, they will record fish observations separately for each of a minimum of 12 (or as many as can be sampled in 1 day) spatially-sequential subreaches (each equivalent in length to 10 CW). Additional subreaches will be sampled as necessary until no new fish species are recorded from 6 consecutive subreaches.

In *Mainstems,* the crew leader will select a reach location according to the methods described above for *Intermediate* streams, except they will navigate directly to the vicinity of the 1500-sq. km waypoint (Appendix C1).

WAYPOINTS AND STATIONS

At each study site, we will mark a waypoint[3] at the habitat transect using a handheld, consumer-grade GPS receiver (Garmin GPSMAP 60CSx). We will refer to this point location as the Station. If fish sampling is attempted, we will also mark additional GPS waypoints at the upstream and downstream ends of the fish collection reach. If a fish collection reach is established in the absence of a habitat transect (e.g., when we aerially observe an aggregation of adult fish spread throughout a stream segment), we refer to the upstream terminus of the fish collection reach as the Station. We may also establish a Station at sites with no habitat transect and no fish-collection reach—such as: target streams lacking a suitable landing zone; target streams deemed unlikely to support anadromous fish use; target streams deemed to be inaccessible or nonwadeable or unraftable; waterfalls or other definite migratory barriers (Appendix B3); or other features of interest.

We will assign a unique 5-character alphanumeric identifier (Station ID) to each Station. Any observations recorded in the project database must be associated with a Station ID. The structure of the Station ID will be:

1. the first 2 characters will represent the sequential survey day (e.g., 01, 02…)
2. the third character will represent the team making the observation (e.g., A, B, …). For this project, the cataraft team will be designated Team "A", the associated lake team will be designated as Team "B", and the headwaters team will be designated as Team "C."

[3] To minimize GPS error when marking waypoints, we used the waypoint-averaging mode (10 s).

3. the fourth and fifth characters (e.g., 01, 02, …) will represent the sequential Station number visited on a given survey day. Note that the Station number (4^{th} and 5^{th} characters of the Station ID) will begin at 01 at the start of each survey day.

For example, Station 04A01 will be the 1^{st} Station visited by Team A on the 4^{th} field day.

Data pertaining to this project will be housed in an AFFI programs master database under a unique project code (CIA14) for all sampling completed in 2014. The combination of Project Code and Station ID therefore will ensure a universally-unique identifier for each Station.

See Table 4 for a list of geographic information variables to be recorded at each study site.

FISH-COLLECTION METHODS

Our objective is to sample the entire fish assemblage at each study site. In general, it is usually best to use multiple gear types to get a more representative sample of the fish assemblage. However, study objectives, logistical constraints, and project budgets affect gear selection choices. Since our main objective entails sampling fish assemblages in a large number of remote streams in a short amount of time, we decided to rely primarily on a single fish collection gear type, single-pass electrofishing, for this project because: 1) electrofishing is considered to be the single most effective (Barbour et al. 1999, Simon and Sanders 1999, Flotemersch and Blocksom 2005) and widely applicable (Hughes et al. 2002) method in streams and rivers; 2) electrofishing typically captures more species with less size selectivity than other gear types (Hendricks et al. 1980); 3) electrofishing is a relatively safe method for biologists, and captures fishes with minimal mortality or injury to the fishes (Curry et al. 2009); 4) long reaches can be sampled relatively quickly using electrofishing (Curry et al. 2009); 5) electrofishing equipment is compact and portable; and 6) electrofishing is recommended as a standard fish sampling method for coldwater fishes in streams and rivers (Bonar et al. 2009). We will standardize our electrofishing effort by adopting: a systematic protocol to identify study site locations; electrofishing reach length as a multiple of wetted channel width; and standardized electrofisher power output (Appendix A3—backpack electrofishing, Appendix A2—boat electrofishing).

Since electrofishing tends to be size selective, with larger fish being more vulnerable to capture (reviewed by Reynolds [1996]), smaller fish species and life stages are likely to be underrepresented in our catch. Furthermore, large fish are more likely to be seen and counted than small or cryptic species. Small or cryptic fish are only likely to be observed if mobilized toward the anode; however, large fish and their carcasses are typically easier to observe and count, even if they remain beyond the electrical field. Therefore, our results should not be used to infer absolute or relative abundance of fishes.

Larger fish, and species with high vertebral counts and fine scales, such as trout, salmon, and char, are more likely to be injured by electrofishing (reviewed by Reynolds [1996]). However, in order to collect all the common fish species present, we need to electrofish with sufficient power to capture even the smallest fish, and those having low vertebral counts or large scales. Therefore, we acknowledge that some fish may be injured or killed as a direct or indirect result of our selecting electrofishing power output settings necessary to capture members of the entire fish assemblage. Since our sampling efforts will be restricted to single-pass electrofishing in 1–2 fish collection reaches (representing a very small fraction of a given target stream's length) per target stream, this project is not expected to significantly affect fish populations. For example, Kocovsky et al. (1997) found no population level effects in salmonids after 8 years of repeat electrofishing in 3 Colorado streams. Furthermore, we will carefully choose electrofisher output settings to minimize trauma to fish, and will generally cease electrofishing in the vicinity of any observed large (> 300 mm) salmonids, except to collect individuals if necessary to confirm the species identification.

Single-pass electrofishing will be the principal fish collection method, supplemented on a limited basis by other gear types (i.e., angling, dip net, minnow trapping, or visual observations) if electrofishing is not feasible. Reach length will be determined as specified below as a multiple of the wetted CW measured across a straight, non-pool (typically a glide) channel unit. To determine where to end each electrofishing reach, crewmembers will use a handheld, consumer-grade GPS unit (Garmin GPSMap 60CSx or 76S) in trip-computer mode to measure the distance traveled from the starting point. The GPS unit will be setup to record a track point every 5 seconds and the track log saved daily. Crews will follow standard electrofishing protocols (

Appendix A) to minimize stress to fish, for operators' safety, and in an attempt to standardize sampling efforts between locations and operators so results are comparable between locations and across time. Team C will use a Smith-Root model LR-24 battery-powered backpack electrofisher, and the cataraft team will use a Smith-Root model GPP 2.5 generator-powered electrofisher.

All collected fish will be identified to species, and fish fork lengths [measured from tip of snout to fork of tail (or to tip of tail, if no fork)] will be measured to the nearest mm. Field reference books (e.g., Pollard et al. 1997), or copies of appropriate pages from desk references (e.g., Mecklenburg et al. 2002; Morrow 1980) and other materials containing species descriptions, ranges, and identification keys will be available and consulted as necessary. If a species cannot be confidently identified in the field, crews will photograph the specimen, record the observations under a higher taxonomic level (e.g., genus or family name) in the database, and retain a voucher specimen(s) fixed in a 10% formalin solution. Entries for unknown/uncertain species will be annotated in the appropriate comment field with the best guess at identification. At the first opportunity, the voucher specimens and photographs will be examined and identified to species, and the corresponding records in the database updated.

Up to approximately 30 fish of each species and life stage will be measured from each reach—any additional fish captured or seen will be identified and tallied. Where more than 30 fish of a given species and life stage are collected, in order to avoid biased sampling of fish to be measured, we will measure every *n*th fish removed from the bucket, where the value of *n* is the estimated number of fish of a given species and life stage collected, divided by 30. For each fish, we will record species (Appendix B5), life stage (Appendix B1), life history (anadromous, resident, unknown), and anomalies in fish appearance or condition (Appendix B2, *sensu* McCormick and Hughes 1998). Where life stage cannot be determined by external features, we will use fork length thresholds identified in Appendix B1 to classify fish into life stage categories. Injuries due to sampling will be noted in the comments field. Bruising (blackening, usually following the myomeres) may result from electrofishing, and may be accompanied by spinal injury that may not be visible externally. We will minimize voltage and pulses-per-second when electrofishing to avoid unnecessary stress and injury to fish. If fish die due to the effects of sampling or processing, we will note the mortality in the comments field.

If spawning by a given species is not directly observed, but the crew leader suspects (based on indirect evidence such as external morphological characteristics, behavior, condition, expression of gametes when handled, or presence of newly emerged young) the species likely spawns within or near the study reach, "suspected spawning" will be recorded in the database for the given species. In addition to recording fish that are collected, we also will record counts (by species and life stage—estimates OK) of additional fish detected, but not collected. We will document any definite barriers to fish passage (Appendix B3).

After being identified, measured, and allowed a period of recuperation, all fish (except specimens to be retained for further study) will be released. Specimens to be retained include:

- Those needed to confirm species identification.
- From Wood River sub-basin sites where they are collected, Dolly Varden pelvic fin clips will be retained in vials with silica beads and delivered to Penelope Crane (USFWS Conservation Genetics Laboratory, Anchorage, Alaska) for genetic analysis. For this task, all fin clips collected from within the same reach may be placed together in the same vial labeled with the Station ID.
- Up to 12 large (> 300 mm) individuals of each of the following optionally-anadromous fishes will be retained (whole, frozen) from each study site where they are collected for an otolith-chemistry study for evidence of anadromy: Dolly Varden; humpback whitefish; and Bering cisco. These retained specimens will be killed by a blow to the head or an overdose of CO_2 and retained (frozen) for further study to detect evidence of anadromy using otolith trace elements to indicate periods of saltwater residency. In the lab following fieldwork, we will extract the pair of sagittal otoliths and record standard meristic data from each retained fish.
- On behalf of Andres Lopez (Curator of Fishes, University of Alaska Museum, Fairbanks), we will retain (in 10% formalin solution) up to 10 (from the entire study area or each major drainage) voucher specimens (<300 mm-long specimens only) representing each fish species collected. Before storing these specimens in formalin, we will take from each specimen a right-side pectoral fin clip and store it in a uniquely-numbered vial with 95% ethanol—one clip per vial. We will label each whole retained specimen with a pre-numbered tag attached to the right operculum with a zip tie. Each individual fin clip retained for this task will be placed in a separate pre-numbered vial. Tag numbers and vial numbers will be recorded on a datasheet for each individual fish. For specimens >200 mm, we will make an incision through the belly wall before placing in formalin. In addition, we will collect up to a total of 40 fin clips from Pike, Alaska blackfish, Arctic lamprey, grayling and least cisco.
- On behalf of Robert Gerlach (ADEC Veterinarian), we will retain (whole, frozen) up to 6 resident fish of any species (with a priority placed on sculpin or stickleback) from mainstem and intermediate sites. All retained fish from the same reach may be placed in a ziplock bag labeled with the Station ID.
- On behalf of Michael Young (Research Fisheries Biologist with the U.S. Forest Service), we will collect sculpin fin clips to support a regional sculpin genetic study. We will collect a pelvic fin clip from each sculpin captured. Fin clips will be preserved using chromatography paper and we will record the Station ID of the collection reach.

See Table 4 for a list of variables associated with fish-collection events and fish catch that will be recorded at each study site.

Fish-collection protocols for *Headwaters*

See Appendix A1 for detailed fish-collection protocols for *Headwaters* streams.

After establishing a habitat-transect location (Station) and determining the location of the fish-collection reach relative to the Station (i.e., up- or down-stream), Team C will multiply the wetted CW by 40 to calculate the reach length to be sampled. A minimum reach length of 150 m will be sampled in target streams having a wetted CW < 3.75 m, and a maximum reach length of 300 m will be sampled in target streams having a wetted CW > 7.5 m.

The backpack electrofishing system to be used in *Headwaters* streams is a Smith-Root LR-24 fitted with a standard Smith-Root rattail cathode (a 10-ft length of braided, 3/16-in stainless steel cable with the connected end insulated with a 6-ft length of neoprene) and a single anode pole having a standard (3/8-in diameter stock) Smith-Root 28-cm (11-in) diameter stainless steel anode ring.

By default, Team C will begin electrofishing with an unpulsed direct current (DC) waveform, but may switch to pulsed DC if necessary to extend battery life or improve electrofishing efficiency. To avoid exposing fish to more harmful higher pulse frequencies, if pulsed DC is used, pulse frequency may not exceed 50 pulses per second (pps). A ***minimum*** electrofisher on-time of 300 s per reach will be required to ensure an adequate minimum level of electrofishing effort.

While collecting fish, the electrofisher operator should move in an upstream direction, zigzagging between the banks, sampling all accessible habitat types, with an emphasis on cover (e.g., large substrate elements, large wood, debris piles, undercut banks, aquatic macrophyte beds, overhanging vegetation). A second crewmember will follow closely, collecting fish with a fiberglass handled dip net. While walking back downstream to the start of the reach, we will electrofish the thalweg and pools as described in Appendix A1.

At the end of the reach, fish will be processed according to the protocol detailed in Appendix A4, and electrofisher settings and fish observations will be recorded in the database.

Fish-collection protocols for *Intermediate* and *Mainstem* streams

After arriving at the upstream terminus of each fish-collection reach, Team A will measure the wetted CW of the channel in a straight, representative glide channel unit and multiply by 10 to calculate the subreach length. The reach will comprise a minimum of 12 consecutive subreaches (with observations recorded separately for each subreach), with additional subreaches added as necessary until no new species are detected in 6 consecutive subreaches (or as many subreaches as can be completed in 1 day).

In *Intermediate* and *Mainstem* streams, Team A will use a cataraft (Outcast model PAC 1200, or similar) measuring 13-ft long and 65-in wide, with a load capacity of at least 750 pounds and with a break down aluminum rowing frame equipped with (from stern toward bow): a rear cargo deck (on which the generator and control box are mounted); a tractor seat for the rower; a cooler tray (on which a live box/cooler is mounted); a forward platform (on which the netter stands during operation); and a lean bar in the bow.

The following electrofishing system will be set up on the cataraft (Figure 3): a Smith-Root GPP 2.5 generator powered electrofisher and control box; an anode system comprised of 2 Smith-Root SAA-6 adjustable spider array electrodes, each having 6 stainless steel dropper cables (38-in long, 3/16-in diameter), suspended from 2 booms [Smith-Root light-duty fiberglass booms (p/n 06248) or modified 12-ft fiberglass pole-vault poles] extending out over the bow; and a cathode system consisting of 18 braided stainless steel dropper cables (38-in long; 3/16-in diameter) bolted directly to the forward platform. While electrofishing, a rower seated near the stern will maneuver the cataraft laterally (across the current) with oars, and a second operator will stand on the forward platform and control the electrofisher foot switch while collecting fish with a fiberglass handled dip net.

The GPP 2.5 cannot produce smooth DC, so a pulsed-DC waveform will be selected. By default, Team A will begin electrofishing using a pulse frequency of 30 pps. To avoid exposing fish to more harmful higher pulse frequencies, pulse frequency may not exceed 60 pps. At the end of the reach, fish will be processed according to the protocol detailed in Appendix A4, and electrofisher settings and fish observations will be recorded in the database.

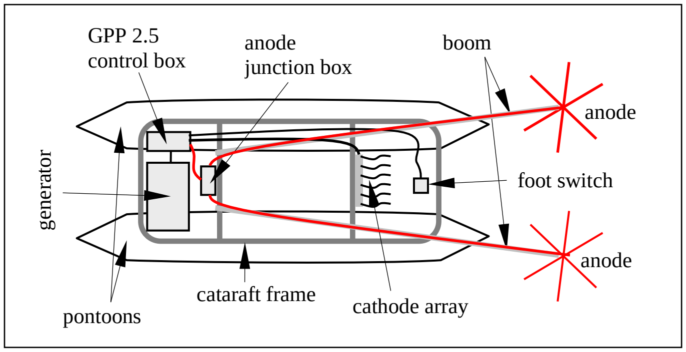

Figure 3.– Cataraft electrofishing system schematic.

AQUATIC AND RIPARIAN HABITAT ASSESSMENT

At each site where fish collection is attempted, we will also measure a standard suite of habitat variables describing water quality, channel morphology, stream flow, and riparian vegetation. See Table 4 for a list of habitat variables, along with information about instruments used, units and domains, and precision of measures.

Habitat transect

We will establish the habitat transect perpendicular to the direction of flow across a representative (of the fish collection reach), non-pool channel unit. In selecting the habitat transect location, we will look for:

1. A straight section, ideally a glide or run, where streamflow lines are parallel to each other, where
2. The streambed is relatively uniform and free of numerous boulders and heavy aquatic growth, and
3. Flow is relatively uniform and free of eddies, slack water, and excessive turbulence.

In pool-riffle stream reaches, the habitat transect will typically be located in the transition between a pool and riffle. Most habitat variables will be assessed at the habitat transect (Station); however, some variables (i.e., stream gradient, substrate composition and embeddedness, and riparian vegetation) will be assessed over a short (e.g., 5-CW) stream section spanning the habitat transect.

Site photos

For each station recorded in the database, we will take ground and aerial photographs with a digital camera. After marking the Station GPS waypoint, the first photo taken at each station will be of the GPS screen showing the GPS date and time. This will provide the information needed to accurately associate photos with the correct Station and also to geotag each photo with GPS data. We will take at least 4 additional photos at each site, including 2 photos from the streambank at the Station, one upstream and one downstream, and at least 2 aerial photos of the drainage with the fish collection reach in the foreground, one upstream and one downstream. Additional photographs should be taken of notable habitat features, fish, or other subjects of interest throughout the reach. After returning to the office, we will link photos with Stations, geotag photos, and use GIS to derive the elevation of each station from the National Elevation Dataset digital elevation model, along with other attributes (legal description of Station locations, USGS quad name, HUC) to be reported.

Water quality

We will measure 4 water quality variables (temperature, pH, dissolved oxygen, conductivity) with a YSI 556 multiprobe meter with a built in barometer (used in calibrating dissolved oxygen). The pH, dissolved oxygen, and conductivity sensors will be calibrated[4] weekly (or more frequently if readings are suspect). To measure these variables, we will place the probe in flowing water as near to the thalweg[5] as practical, and wait for the readings to stabilize before recording them. We will measure turbidity with a LaMotte 2020e turbidimeter, which we will calibrate daily using 0- and 1-, 10-, or 100-NTU standards (depending on the estimated turbidity of the sample). We will collect a water sample for turbidity analysis from flowing water as near to the thalweg as practical. We also will visually assess water color (Appendix B4).

Channel morphology

To measure stream gradient, we will select a relatively straight stream segment in the vicinity of the habitat transect, which spans at least 2 consistent channel features (e.g., top of riffle to top of riffle). Then we will use a clinometer to measure the water surface angle (%) between consistent channel features. If no single suitable segment is found, multiple gradient measures can be averaged as follows, where *y* is water-surface angle (%) and *x* is segment length:

$$\bar{y} = \frac{y_1 x_1 + y_2 x_2 + \cdots y_n x_n}{x_1 + x_2 + \cdots + x_n} \tag{1}$$

To characterize substrate composition, we will visually (or, in turbid water, by feel under-foot, or with a pole) assess the 3 most dominant substrate classes (Appendix B4) within the perimeter of the scoured stream bed in a 5-CW (up to 100 m maximum) stream section centered on the habitat transect. Within the same stream section, we will also visually estimate substrate embeddedness (Appendix B4) in (or as close as possible to) the thalweg.

In wadeable channels <30-m wide, we will measure channel width, both at the bankfull (BF) level[6] (BF width) and at the wetted edges (wetted width), using a fiberglass tape stretched horizontally across the stream perpendicular to the direction of flow. We will also measure thalweg depths as the vertical distance from the stream bed in the thalweg to both the water surface (wetted depth) and BF level (BF depth). In nonwadeable streams, or where channel width exceeds 30 m, we will measure channel widths using a laser range finder, and wetted depth

[4] The pH sensor will be calibrated with pH 4, 7, and 10 standards. The dissolved-oxygen sensor will be calibrated in water-saturated air. The conductivity sensor will be calibrated with a 1 mS/cm conductivity standard.

[5] Path of a stream that consistently follows the deepest part of the channel (Armantrout 1998).

[6] BFW is the width of the water surface perpendicular to the direction of flow at bankfull discharge. Bankfull discharge is defined as the flow at which a stream begins to flow onto the floodplain. However, since the floodplain may be narrow or undetectable in entrenched streams, and because downcutting or channelization may result in the channel being disconnected from its former floodplain, observers should always look for additional indicators when identifying bankfull level. Other than the presence of an active floodplain, the principal indicators of bankfull level (Leopold 1994) are: top of point bar; change in vegetation (e.g., bare gravel to herbs; alders above bankfull level); topographic break (vertical stream bank to horizontal floodplain; horizontal bar surface to vertical bank); change in substrate size; or flood-deposition debris.

with a handheld sonar. To calculate BF depth in nonwadeable streams, we will add the wetted depth to the estimated distance from the water surface to the BF level. We will use a clinometer to aid in estimating the BF level by sighting along the habitat transect to BF indicators on both banks and moving the clinometer up or down to achieve a level sighting. We will estimate the entrenchment ratio[7] category in the vicinity of the habitat transect.

In the office following fieldwork, we will assign both a level-II Rosgen (1994) channel type code and a level-II Rosgen (1994) valley type code to each fish collection reach such that general ecological characteristics are described for each sample reach located in a lotic habitat. We will use site specific field observations, aerial and ground based photos, and digital imagery to determine valley type. To determine channel type, we will use site photos, measured stream gradient, calculated width-to-depth ratio, estimated entrenchment class, dominant substrate, and estimated sinuosity (calculated using GPS tracks, site photos, or NHD hydrography) values collected during fieldwork. For lentic habitats, we added 5 more channel-type classes, including: Lake/Pond; Slough; Beaver pond complex; Wetland; and No defined channel.

Streamflow

We will assess stream stage visually (Appendix B4). We will note recent (within approximately the past 48 hours) precipitation (None/Trace, Moderate, Heavy). At sites where the thalweg is wadeable at the habitat transect, and the wetted depth is <0.9 m, all teams will measure thalweg head depth using a transparent velocity head rod (TVHR), then convert head depth to mean water-column velocity (Fonstad et al. 2005). If use of a TVHR is not feasible, we will estimate thalweg velocity by timing the passage of a whole orange during a 6-meter long float in the thalweg beginning at the habitat transect. In nonwadeable streams where neither a TVHR nor an orange can be used, Team B will estimate thalweg (surface) velocity as the maximum sustained GPS ground speed of the boat drifting in the thalweg with minimal wind effects.

Riparian vegetation

In a reach 5 channel widths long (up to 100 m maximum) centered on the habitat transect, we will visually assess the dominant riparian vegetation community (*sensu* Viereck et al. 1992; Appendix B6) and measure its canopy height and identify any disturbance (Appendix B7) in each of the following 8 zones (4 zones on each bank): 0-5 m (from the bankfull level); 5-10 m; 10-20 m; and 20-30 m. We will estimate canopy heights <1.5 m with a graduated rod, and canopy heights >1.5 m with a clinometer and range finder[8].

PERMISSION FOR ACCESS TO STUDY SITES

ADF&G is responsible for the sustainability of all fish and wildlife throughout Alaska, regardless of land ownership. No prior permission is needed for ADF&G to access study sites located on State of Alaska (54% of the 4-year study area and 68% of the 2014 study area; see Table 3) or BLM (9% of the 4-year study area and 11% of 2014 study area) lands. A Master Memoranda of Understanding (MOUs) between ADF&G and BLM recognizes the right of ADF&G to enter onto their lands at any time to conduct routine management activities. Under the MOU, ADF&G informs BLM of the project and estimated dates but does not need formal permission for these activities. However, on other lands (e.g., private, native, municipal, or

[7] Entrenchment ratio is defined (Rosgen 1994) as flood-prone width divided by bankfull width. Flood-prone width is the width of the floodplain measured at a water level (i.e., depth) of twice the maximum (i.e., thalweg) depth at bankfull discharge.

[8] Canopy height can be estimated by: 1) multiplying the horizontal distance (*d*) to a representative tree (measured with a range finder) by the angle (%; measured with a clinometer) from eye level to the top of the tree, 2) multiplying the angle (%) from eye level to the base of the tree by *d*, then 3) taking the sum of the 2 heights (eye level to tree top + base of tree to eye level).

Department of Defense), prior permission is needed to access study sites where a helicopter cannot land within the ordinary high water (OHW) zone, which is often the case in Small and Medium streams. At Large streams, we can typically access and conduct activities within the OHW level. To identify any study sites where prior approval may be needed for access, target stream locations were plotted on land status maps in GIS (Appendix D). From inspection of this map it was determined that 2014 target streams are located on: Bristol Bay Regional Native Corporation lands; villages of Clarks Point, Dillingham, Ekuk, Ekwok, Koliganek, Levellock, Manokotak, Naknek, New Stuyahok, Olsonville, Portage Creek, Togiak and Twin Hills lands; and Lake and Peninsula Borough lands. Prior to visiting these sites, we will apply for permission to access them. We will not access any sites on private land above the OHW level without prior permission from the land owner.

Table 3.–General land status within 4-year and 2014 study areas.

Land ownership	4-Year study area		2014 study area	
	sq km	%	sq km	%
State	53,211	54	24,157	68
Native Corp.	23,020	24	6,282	18
BLM	9,213	9	4,016	11
USFWS	2,950	3	475	1
USFS	4,037	4	0	0
Municipal	1,656	2	179	<1
Private	2,560	3	5	<1
Native Allotments	676	1	319	1
DOD	209	<1	1.5	<1
Total	97,530	100	35,436	100

Source: Alaska Department of Natural Resources, Land Records Information Section. Alaska General Land Status GIS layer. Published October 2013. Available online at: http://www.asgdc.state.ak.us/

Table 4.–List of variables to be collected during fieldwork.

Variable name	Equipment	Units/Domain	Precision	Comment
Geographic information				
Project Code & Station ID	-	text	-	5-digit alphanumeric—see Waypoints and Visits heading in text.
Station location Upper end of reach Lower end of reach	consumer-grade GPS unit (e.g. Garmin GPSmap 60CSx or 76S)	decimal degrees: latitude (DD.DDDDD); longitude (-DDD.DDDDD)	0.00001 degrees	
Geodetic datum		Text	-	Default is NAD83.
Water-body name	Water-body name from USGS topo map	text	-	
Geographic comments	-	text	-	Describes location of study site in relation to adjacent long-term or permanent geographic features
Observers	-	list of field staff	-	
Date/time	field notebook computer	mm/dd/yyyy hh:mm:ss	1 s	Value input automatically from computer's clock when data entry is begun
Camera counter	-	sequential integers	-	List of photo filenames (last 3 digits only) associated with each station
Visit comments	-	text	-	Physical and biological conditions at the station during the visit—focus on ephemeral conditions, such as weather or stream conditions, or the dynamics of riparian conditions, that may help explain other recorded observations
Wildlife comments	-	text	-	Anecdotal wildlife observations, particularly those that relate to fish.
Water quality				
Water temperature	YSI 556 meter	°C	0.01 °C	Sample thalweg
pH		pH units	0.01 pH units	Sample thalweg
Dissolved oxygen		mg/L	0.01 mg/L	Sample thalweg
Conductivity		µS/cm	1 µS/cm	Ambient conductivity (not temperature corrected). Sample thalweg
Turbidity	LaMotte 2020e turbidimeter	NTU	1 NTU	Sample thalweg
Water color	-	see Appendix B4	-	

-continued-

Table 4.–Page 2 of 4.

Variable name	Equipment	Units/Domain	Precision	Comment
Channel morphology				
Channel width (wetted and BF)	30-m fiberglass tape	m	0.1 m	In wadeable channels < 30 m wide
	laser range finder (Bushnell Yardage Pro)	m	1 m	In nonwadeable channels, or where width > 30 m
Thalweg depth (wetted and BF)	handheld sonar (HawkEye Digital Sonar) and clinometer (to find the BF level)	m	0.1 m	For nonwadeable channels
	graduated rod	m	0.01 m	All teams—wadeable channels
Stream gradient	clinometer (Sokkia 5x magnifying abney level with clinometer, or Suunto PM-5)	%	0.1%	Water surface angle between consistent channel features near habitat transect.
Substrate composition	-	see Appendix B4	-	3 most dominant substrate classes within scoured portion of streambed in a 5-CW (<100 m) section centered on habitat transect.
Embeddedness category		see Appendix B4	-	Estimated embeddedness of gravel, cobble, and boulder particles in, or as near to as possible, the thalweg in a 5-CW (<100 m) section centered on the habitat transect.
Entrenchment ratio category	Visual estimate or laser range finder (floodprone width), and see channel width (BF)	1.0–1.4=entrenched; 1.41–2.2=moderately-entrenched; >2.2=slightly-entrenched	-	Entrenchment ratio (Rosgen 1994) = flood-prone width ÷ BF width. Flood-prone width is the width of the floodplain measured at a water level of twice the thalweg BF depth.
Channel type	see Channel width, Thalweg depth and Stream gradient	Rosgen (1994) level-II channel types, plus the following: Lake/Pond; Slough; Beaver pond complex; Wetland; or No defined channel	-	To be determined in the office following fieldwork based on BF width and BF depth (width-to-depth ratio), gradient, entrenchment ratio, dominant substrate, and estimated sinuosity values.
Valley type	Visual estimate	Rosgen (1994) level-II valley types.		To be determined in the office following field work based upon site observations, photos and Imagery.
Stream flow				
Stream stage	-	See Appendix B4	-	Water level relative to BF stage.
48-hour precipitation	-	none/trace, moderate, heavy	-	

-continued-

Table 4.–Page 3 of 4.

Variable name	Equipment	Units/Domain	Precision	Comment
Stream flow (continued)				
Thalweg velocity	Transparent velocity-head rod (TVHR)	Head depth (mm)→mean water column velocity (m/s)	1 mm (0.1 m/s)	Wadeable streams, depth <0.9 m
	Whole orange, fiberglass tape, stopwatch	m/s	0.1 m/s	Wadeable streams (alternate). Timed orange float through a 6-m length.
	consumer-grade GPS unit (Garmin GPSmap 60CSx or 76S)	m/s	0.1 m/s	Nonwadeable streams—maximum sustained GPS velocity of boat drifting in thalweg.
Meter type	-	TVHR, orange, or GPS	-	
Riparian vegetation communities				
Riparian vegetation composition	-	Viereck et al. (1992) vegetation communities	-	Dominant vegetation community recorded in 8 zones (4 zones on each bank): 0-5 m (from OHW); 5-10 m; 10-20 m; 20-30 m
Canopy height	graduated rod (< 1.5 m); clinometer & range finder (> 1.5 m)	m	0.1 m (< 1.5 m); 0.5 m (>1.5 m)	Recorded for each of the 8 zones described above
Disturbance	-	Disturbance classes (Appendix B6)	-	
Fish-collection events				
Channel	-	main-, side-, or off-channel	-	Channel type of fish-collection event
Fish-collection method	-	backpack electrofisher, boat electrofisher, visual observations (ground, boat, or helicopter), dipnet, angling, none	-	
Waveform	electrofisher setting	DC-pulsed; DC-unpulsed	-	
Voltage		V	1 V	(LR-24 only)
Range		Low or High	-	(GPP 2.5 only)
Percent of range		0–100 %	Continuous	(GPP 2.5 only)
Frequency		pulses per second (pps)	1 pps	
Duty cycle		%	1%	(LR-24 only)
Current	electrofisher output meter	A	0.01 A (LR-24); 0.1 A (GPP 2.5)	Peak current (LR-24); average current (GPP 2.5)
Power	electrofisher output meter	W	1 W	Peak power (LR-24 only)
Electrofisher on-time	electrofisher timer	s	1 s	
Efficiency	-	excellent, good, fair, poor	-	Perceived electrofishing efficiency, relative to optimal conditions.

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Table 4.–Page 4 of 4.

Variable name	Equipment	Units/Domain	Precision	Comment
Catch				
Reach length	GPS (trip computer mode, or track)	m	1 m	Indicate actual length of fish-collection reach, measured by GPS.
Species	-	list of Alaskan freshwater fish species	-	
Life stage	-	see Appendix B1	-	
Life history	-	anadromous, freshwater-resident, marine, unknown, N/A	-	
Suspect spawning	-	yes, no	-	
Barrier	-	see Appendix B3	-	
Fork length	fish measuring board	mm	1 mm	
Sex	-	male, female, blank (if sex was not determined)	-	
Anomalies	-	see Appendix B2	-	
Retained	-	Checkbox (Y/N)	-	Indicate each individual fish retained.
Tag No.	-	10-digit alphanumeric text	-	For retained specimens, indicate the tag number affixed to each fish.
Vial No.	-	10-digit alphanumeric text	-	If a tissue sample was taken, indicate the vial number.
Photo No.	Digital camera	3-digit positive integer	1	For each fish photographed, indicate the photo number (last 3 digits of the photo filename) for each photo taken. May use comma or hyphen to separate non-sequential photo numbers or indicate a range of photo numbers.
Individual fish comments	-	text	-	Comments pertaining to an individual fish (e.g., sampling injuries or mortalities, unusual features or behavior)
Additional counts	-	integer--no. of fish	1 fish	
Estimated	-	yes, no	-	Indicates whether the no. of additional fish recorded above was an estimate or a direct count
Species-life-stage comments	-	text	-	Comments pertaining to an entire group of fish of the same species and life stage

DATA COLLECTION AND REDUCTION

Other than derived values to be computed later, we will directly enter all measured or observed values in the field (while at the Station) into a Microsoft Access relational database (MDB) using a ruggedized notebook computer (Itronix GO Book Max, Itronix GO Book III, or xplore iX104C4). Wherever appropriate, the MDB will use drop down lists or validation rules (e.g., for continuous data within an acceptable range of values, such as pH values restricted to 0–14).

In base camp, at the end of each field day, crew leaders will error check all data recorded that day. Each team's MDB file, GPS unit files (waypoints and tracks), and digital photographs will be backed up each day onto an external hard drive and then transferred to a laptop computer, which will be securely stored and transported separately from the field computers.

After the field season, all the teams' MDBs will be aggregated and checked for nonsensical values. Using ESRI ArcGIS software and GIS layers, we will derive additional station location information (i.e., USGS quadrangle name, HUC, meridian, township, range, section, AWC Region, NED elevation) for each station. We will also update fish life stage assignments based on Appendix B1. These values will then be appended into the compiled MDB.

Data from the compiled MDB will then be replicated to the AFFI database (AFFID), a Microsoft SQL Server database, for long term usage. Accessing AFFID data for staff review, editing, and reporting is primarily achieved through a Microsoft Access Data Project (ADP). SQL Server is also used to provide raw data and web based reports for the Internet using ESRI ArcIMS, Adobe ColdFusion, and related GIS applications, along with other appropriate and available map layers (e.g., topographic maps, hydrography, land ownership coverage).

DATA ANALYSIS

For each water body where we observe anadromous fish, we will prepare and submit a nomination package to the AWC. The nomination package will include all the information required by the AWC program (see Appendix H1 for an example) and will include a summary of all fish species observed (anadromous or not), from every sampling event on that water body (regardless if anadromous fish were observed during each sampling event).

To pursue Objective 3, true species richness (*TSR*) will be estimated for each site where sampling-sufficiency data were collected, and compared to observed species richness (*SR*), the total number of species observed at a site. For a site *i*, where data are collected over a series of n_i subreaches, *TSR* and *SR* will be compared at the conclusion of each subreach beginning with the 4th subreach and continuing to the n_ith subreach.

A Horvitz-Thompson estimator (Cochran 1977) will be used to estimate *TSR*. For each observed species *s* in *SR* in the sample of n_i subreaches for site *i*, the probability that this species was detected in one subreach is estimated:

$$\hat{p}_{s,i} = \frac{n_{s,i}}{n_i} \tag{2}$$

where $n_{s,i}$ is the number of subreaches n_i where species *s* was detected. We then calculate the probability that the species would not have been detected by sampling n_i subreaches:

$$1 - \hat{p}_s = \left(1 - \hat{p}_{s,i}\right)^{n_i} \tag{3}$$

from which we can directly calculate $\hat{p}_s$, and estimate the probability that the species can be detected at site i with n_i sampled subreaches. The Horvitz-Thompson estimate of *TSR* is calculated as a sum across all detected species:

$$TSR_{H-T} = \sum_{j=1}^{SR} \frac{1}{\hat{p}_s}. \tag{4}$$

The analytical formulae presented in Cochran (1977) for estimating the sampling variance of the Horvitz-Thompson estimator when p_s is estimated (not known with certainty) are not stable for small sample sizes. We are in the process of evaluating a bootstrap approach (Efron and Tibshirani 1993) for estimating variance using the type of data collected in this project.

Fixed stopping rules will be evaluated for stream sampling where data are recorded after completion of sampling of the entire reach. Stopping rules of 80, 100, 120,and 140 wetted widths (8, 10, 12, and 14 subreach lengths) will be considered.

The estimate $TSR_{H\text{-}T}$ rounded to the nearest integer will be used to indicate total species richness for each reach sampled. Observed *SR* at each stopping point is subtracted from the estimate of species richness for the entire reach to estimate the number of species undetected. The proportion of reaches where an estimated 0, 1, 2, …5 species are missed will be calculated and cumulative proportions will be calculated. Only those reaches where 9 or more subreaches were sampled will be used to estimate the number of undetected species per reach when evaluating stopping sampling at 8 subreaches. Those reaches where 11 or more subreaches were sampled will be used to estimate undetected species when evaluating stopping at 10 subreaches, and to provide an additional evaluation for stopping at 8. Reaches with 13 or more subreaches sampled will be used to evaluate stopping at 12 subreaches, and to provide additional evaluations for stopping at 10 and 8 subreaches. Reaches with 15 or more subreaches sampled will be used to evaluate stopping at 14 subreaches, and to provide additional evaluations for stopping a 12, 10 and 8 subreaches.

Adaptive stopping rules will be evaluated for stream sampling where data are recorded after completion of sampling of each subreach (10 wetted widths) and the series of data recorded for all subreaches are used to determine if additional sampling is necessary at that reach after sampling a minimum number of subreaches. Adaptive stopping rules have two criteria. First, a minimum number of subreaches are required to be sampled before sampling can be terminated. Minimums evaluated will be 6, 8, 10, 12, and 14 subreaches. Second, sampling would be continued unless no new species were detected in the last 4 or 6 subreaches sampled. Adaptive stopping rules will be evaluated using methods similar to those described above for fixed stopping rules. Observed species richness at a stopping point will be subtracted from estimated species richness for the entire reach to estimate the number of species undetected.

SCHEDULES AND REPORTS

SAMPLING DATES

See Table 5 (schedule of project activities) and Table 6 (field-crew schedule) below:

Table 5.–Schedule of project activities.

Year	Dates	Activity
2014	July 1	Complete operational plan.
	July 11	Shotgun and bear-safety training.
	July 28	Deploy full crew to Alagnak Lodge; set up day; helicopters arriving.
	July 29	Day 1 of sampling Alagnak Lodge area.
	August 8	Full crew moves to Dillingham base camp.
	August 19	All teams return home.
	August 25	Begin data reduction and validation.
	September 30	Submit AWC nominations.
	November 30	Post data summaries online.
	December	Analyze sampling-sufficiency data.
	October–December	Extract otoliths from retained specimens.
2015	January–March	Otolith chemistry analysis.
	April 30	Draft FDS report submitted to Regional Supervisor.

Table 6.–Field-crew schedule, including the associated lake sampling team.

Cataraft Team		
Team	Alagnak Lodge (July 28–August 8)	Dillingham (Aug 8–19)
A (Mainstem and Intermediate streams)	James Bales	Joe Giefer
	Ryan Snow	Bob Powers

Lake Team		
Team	Alagnak Lodge (July 28–August 8)	Dillingham (Aug 8–19)
B (Lakes)	Joe Giefer	James Bales
	Holly Zafian	Josh Brekken

Headwater Team		
Team	Alagnak Lodge (July 28–August 8)	Dillingham (Aug 8–19)
C (Headwaters streams)	Raye Ann Neustel	Raye Ann Neustel
	Joe Buckwalter	Marla Carter

RESPONSIBILITIES

Table 7.–List of personnel and duties.

Name	Duties
James Bales	Principle investigator, field-crew supervisor, Team-A and -B leader. Prepare and manage project budget and funding proposals. Prepare operational plan. During fieldwork, perform daily data quality-control procedures and data backups. Complete post-season data reduction, review, and analysis. (Co)author publications, reports, and papers for scientific journals.
Josh Brekken	Team-B member
Joe Buckwalter	Team-C member.
Marla Carter	Team-C member.
Adam Craig	Provide guidance on inventory design. Assist with post-season data analysis. Review project operational plan and reports. (Co)author on papers for scientific journals.
Joe Giefer	Team-A and -B leader. Prepare operational plan. During fieldwork, perform daily data quality-control procedures and data backups. Complete post-season data reduction, review, and analysis. Prepare and submit nominations of appropriate waters to the AWC. Conduct specimen dissections and otolith extractions. (Co)author publications, reports and papers for scientific journals.
Jason Graham	Prepare land-status maps with target streams.
Raye Ann Neustel	Team-C leader. Assist with all aspects of project. Coordinate fieldwork logistics. Coordinate field crew trainings. Inventory, procure, maintain, and package field equipment and supplies. Prepare and submit nominations of appropriate waters to the AWC. Conduct specimen dissections and otolith extractions.
Bob Powers	Team-A member
Skip Repetto	GIS analyses of target stream locations. Post summarized results to project web site. Maintain and develop online mapper.
Thalassa Smith	Prepare field maps and maps for FDS report.
Ryan Snow	Team-A member. Design project database. Compile field data files in Anchorage network. Assist data retrieval and database reporting. Provide technical support for software and hardware development operations and maintenance. Develop software tools to integrate GIS and database functions. Develop software tools to display spatial, tabular, and graphic data via the Web.
Holly Zafian	Team-B member.

BUDGET

Table 8.–Budget summary.

Cost category	Allocation ($K)
100 Personnel	293.4
200 Travel	8.9
300 Contractual	171.7
400 Supplies	29.5
500 Equipment	0.0
Total	503.5

Table 9.–Summary of personnel expenses.

Name	PCN	Job class	Months	OT (hr)	Haz (hr)	Salary & benefits
James Bales	11-4153	Habitat Biologist III	12.0	0	175	104.7
Joe Giefer	11-6140	Habitat Biologist II	12.0	0	150	104.4
Ryan Snow	11-6087	Analyst/Programmer IV	1.0	0	0	10.3
Vacant	11-6118	GIS Analyst II	1.0	0	0	10.2
Raye Ann Neustel	11-4335	F&W Tech III	7.0	100	200	44.5
Vacant	11-L403	Habitat Biologist II	1.0	0	200	6.9
Vacant	11-L405	Habitat Biologist IV	1.2	0	200	12.4
Total						293.4

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APPENDIX A. FIELD PROTOCOLS

Appendix A1.–Electrofishing protocol for wadeable streams.

The procedure to collect fish with a backpack electrofisher (Smith-Root LR-24) is presented below. The objective is to detect all the common fish species found in the reach. Fish collection should be completed within 30 minutes with a cumulative electrofishing time of *at least* 300 s.

Procedures to collect fish at wadeable sites. (adapted from McCormick and Hughes 1998).

1. Establish the habitat transect (Station) in a straight, representative, non-pool (preferably glide or run) channel unit, mark the first GPS waypoint at the Station, and complete habitat characterization and data entry.
2. Measure wetted channel width (CW, to the nearest 0.1 m) at the station. The minimum fish collection reach length is 40 CW, or 150 m, whichever is greater. The maximum reach length for wadeable streams is 300 m.
3. Both crewmembers must wear leak-free chest waders with wading belt snugly fastened, wading shoes that fit properly, electrically-insulated gloves, and polarized sunglasses (preferably with amber lenses). A hat with a brim may also be helpful in reducing glare.
4. Make sure the electrofisher battery is securely fastened. Check electrical connections (battery, anode, cathode). Replace the battery cover securely.
5. Try on the backpack unit, and make any adjustments to the suspension system to achieve a comfortable fit, with the unit snug against the operator's back and resting above the hip bones. If necessary, untangle and route the cathode (rat tail) and anode cables.
6. With both electrodes out of the water and clear of each other and both operators, turn the unit on and confirm the system is ready. Reset the timer to zero.
7. The two person electrofishing team will typically begin electrofishing at the station and work their way upstream the predetermined reach length while collecting fish. If the downstream end of the reach does not coincide with the Station, the team will mark a second GPS waypoint at the downstream end of the reach. A handheld, consumer-grade GPS unit in trip computer mode, a hip chain, or other similarly accurate method, will be used to measure the reach length as they work their way upstream. At the upstream end of the reach, the team will mark a third GPS waypoint. While walking back downstream to the start of the reach, continue electrofishing in the thalweg (see Step 14 below).
8. To use a smooth-DC waveform (preferred):
    a. Set the waveform to smooth DC, and select the initial voltage setting according to the ambient water conductivity (***not*** specific conductance, which is temperature compensated) —see Appendix A3.
    b. Ensure that all non-target organisms are clear of the water, and begin fishing when both crewmembers are ready.
    c. Closely observe the fishes' response and attempt to maximize capture-prone responses (i.e, taxis or forced swimming) and minimize responses associated with elevated trauma (i.e., immobilization, branding, spinal deformities, or recovery period exceeding 15 seconds). Try to capture fish before they approach near to the electrodes, and remove fish quickly from the electric field.

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   d. If fish are unresponsive, increase the voltage by 50 V, press the Enter key and try again. If fish exhibit symptoms of trauma, decrease the voltage by 50 V, press the Enter key, and try again.

   e. If fish are still not showing capture-prone responses, or if it is necessary to extend battery life, switch to a pulsed-DC waveform.

9. To use a pulsed-DC waveform:

   a. Select initial voltage setting according to the ambient (not temperature compensated) water conductivity—see Appendix A3.

   b. Set initial pulse frequency to 30 pulses-per-second (pps).

   c. Set duty cycle to achieve a pulse width of 2 ms, according to the following table:

Frequency	Duty cycle (%)	
(pps)	2 ms	4 ms
30	6	12
35	7	14
40	8	16
45	9	18
50	10	20
60	12	24

   d. If electrofishing is unsuccessful:

      i. Increase the voltage by 50 V, press the enter key and try again. Stop increasing voltage when fish exhibit a forced response (twitch).

      ii. If fish twitch, but are not showing taxis (induced movement of the fish toward the anode), increase the duty cycle to achieve a pulse width of 4 ms, according to the table in Step 9.c. Press the Enter key and try again. If necessary, repeat this step, increasing duty cycle by 10% until fish show taxis. If the duty cycle is increased to maximum, and taxis is still not achieved, proceed to Step iii.

      iii. Increase the frequency by 10 pps, and press the Enter key. Adjust the duty cycle to achieve a pulse width of 2 ms for the new frequency setting (see Step 9.c), and try again. Repeat Step ii after each frequency increase. Avoid frequencies >60 pps.

10. Beginning at the downstream end of the sampling reach, the electrofishing team will fish in an upstream direction, zigzagging across the channel from bank to bank in order to sample all habitat types. On the upstream pass, the emphasis is on sampling cover and channel margins. The thalweg is more effectively sampled during the downstream pass. Depress the switch and sweep the anode slowly from side to side in the water. Electrofish intermittently to avoid herding fish, especially in glides or long pools. After electrofishing continuously for a duration of up to 5 s, quietly advance upstream approximately 2–4 m before resuming electrofishing.

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11. Attempt to sample the variety of habitats (deep and shallow, fast and slow, complex and simple, warmer and colder) present throughout the reach. Be sure to sample available cover (e.g., large substrate elements, large wood, debris piles, undercut banks, aquatic macrophyte beds, overhanging vegetation). Move the anode into confined cover with the power off, then depress the switch and sweep the anode away from the cover to draw fish out into open. Do not attempt to sample in or near pools greater than waist deep, or where velocity is too fast to safely wade. Always move slowly and carefully to avoid startling fish and to minimize risk of falling.

12. The netter follows downstream of the electrofisher operator, collecting fish with a dip net with a non-conductive handle (e.g. fiberglass or wood) and placing them into a 5 gallon bucket with stream water for later processing. Try to net all fish seen. When this is not feasible (e.g., in highly productive systems), try to collect a representative sample of the fish assemblage (e.g., not just large game fish). Pay special attention to netting small and benthic fish, as well as fish that respond differently to the electric field—not just the big fish that move to the surface. Particularly when visibility is obscured by turbidity, debris, or vegetation, the netter should keep the dip net in the water downstream of the anode. The dip net opening should be near vertical, perpendicular to the current, with the dip net frame in contact with the substrate. The distance between the anode and the dip net is related to the current velocity: the faster the current, the greater the distance between the anode and dip net. In fast water, the net should remain several meters downstream of the anode.

13. Refresh the water in the bucket periodically to minimize physiological stress prior to measuring fish.

14. At the upstream end of the reach, mark a GPS waypoint. Then, while walking back downstream to the start of the reach, electrofish the thalweg while trying to walk the same speed as the water. Try to herd fish out of deep pools towards the pool tailout. When approaching the tailout, to avoid herding fish further downstream into the riffle, briefly (e.g., 2-s pause) cease electrofishing to allow fish to turn and attempt to re-enter the pool, then resume electrofishing as they swim past the anode. For the downstream pass, the netter should stay even with the electrofisher operator as they both walk downstream.

15. Record in the database the final, or most successful, electrofisher output settings (voltage, frequency, waveform, electrofisher on-time, duty cycle and typical peak current and power), sampling efficiency (poor, fair, good, excellent), and distance sampled, along with fish observations, including fish collected while electrofishing, as well as any additional fish observed within the reach, but not collected[1]. If conditions prevent safe or effective electrofishing within a reach, the conditions, and their effect on sampling efficiency, should be noted in the Sampling Event tab in the database, and the length of stream that was actually sampled should be noted in Sampling Event comments.

[1] In the database, only those fish captured while electrofishing should be associated with an electrofishing sampling event. Fish observed, but not captured should be recorded under a separate sampling event (e.g., Visual observations-ground). Fish collected from off-channel habitats (e.g., tributaries, side channels, floodplain habitats, adjacent beaver ponds) should be recorded under a distinct sampling event.

Appendix A2.–Electrofishing protocol for nonwadeable streams.

The objective is to detect all the common fish species found in the reach. The procedure to sample with a generator powered boat electrofisher unit (Smith-Root GPP 2.5) is presented below.

Procedures to collect fish by boat electrofishing. (adapted from McCormick and Hughes 2000)

Onshore at launch site

1. Check generator oil and fill tank with gas (wipe up any spillage).
2. Attach electrodes to boat, and connect their cables to the corresponding outlet on the control box. If the fishing site is distant, keep electrodes and anode poles in boat.
3. Connect generator and pulsator (control box).
4. Confirm that all gear for the day is in the boat.
5. Put on a life jacket. Wear polarized sunglasses to aid vision.

At sample reach

1. Establish the habitat transect (Station) in a straight, representative, non-pool (preferably glide or run) channel unit, mark the first GPS waypoint at the Station, and complete habitat characterization and data entry.
2. Measure wetted channel width (CW, in meters) at the station—multiply by 10—this is the length of a single subreach. The minimum fish collection reach length is 10 subreaches, plus any additional subreaches necessary until no new species are detected in the last 6 consecutive subreaches (or as much as can be sampled in a day). Record fish observations and electrofisher settings separately for each subreach under a unique sampling-event code.
3. Check all electrical connections and suspend the electrodes in the water. The wetted surface area of the cathode(s) should be greater than that of the anode(s). Fill live well and put on electrically insulated gloves. Verify that all electrical switches are off, that all non-target organisms are clear of the water or 2 boat lengths away, and that both crewmembers are clear of the water and electrodes and ready to begin electrofishing. Reset the timer on the electrofisher control box to zero at the start of each subreach.
4. If ambient conductivity is <300 µS/cm, set the Range dial to High. If ambient conductivity is >300 µS/cm, set the Range dial to Low. Switch the Mode dial to DC (**Caution! The position of this switch should not be changed when the foot switch is engaged!**) and select an initial frequency of 30 pulses-per-second (pps) and an initial Percent of Range (POR) setting of 10%.
5. Start the generator and depress the foot pedal to begin electrofishing. Increase POR as needed to elicit a capture-prone response [i.e, taxis (induced movement of the fish toward the anode) or forced swimming] from fish, while minimizing responses associated with elevated trauma (i.e., immobilization, branding, spinal deformities, or recovery period exceeding 15 seconds).

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Note: Where water conductivity is high (>300 µS/cm), avoid using POR settings in excess of 60%, which will simply increase duty cycle, but not peak voltage, and may overload the generator (Martinez and Kolz 2009). If the generator sounds labored, decrease POR and/or switch from High to Low range.

6. If fish taxis cannot be achieved, increase frequency to 60 pps, return the POR dial to 10%, and repeat Step 5.
7. Select the riverbank for fishing (river left for odd-numbered target streams, river right for even), and stay along the selected bank through the entire reach, to the degree it is safely navigable. Position the boat so the bow is angled downstream and toward the bank. While drifting downstream, maneuver laterally in the channel to avoid obstacles and position the anode(s) into habitats providing cover for fish. Most effort should occur near the bank, where most fish are expected to occur, and at depths less than 3 m wherever possible. However, all habitat types should be sampled, so zigzag between the thalweg and the bank to allocate some sampling effort to a variety of habitats throughout the channel.

   With electrical current off, maneuver the boat so the anode(s) approach near to fish cover elements (e.g., large substrate elements, large wood, debris piles, undercut banks, aquatic macrophyte beds, overhanging vegetation), then begin electrofishing as the boat is backed away from the cover. Electrofish intermittently to avoid herding fish, especially in glides or long pools. After electrofishing continuously for a duration of up to 10 s, drift quietly for 5–10 m before resuming electrofishing. Do not place the boat in danger in order to fish particular habitats. Cut the generator and stow the gear before negotiating hazards.
8. The netter uses a dip net with non-conductive (e.g. fiberglass) handle to retrieve fish, which are then deposited into a livewell for later processing. Try to capture fish before they approach near to the electrodes, and remove fish quickly from the electric field. Try to net all fish seen. When this is not feasible (e.g., in highly productive systems), try to collect a representative sample of the fish assemblage (e.g., not just large game fish). Pay special attention to netting small and benthic fish, as well as fish that respond differently to the electric field—not just the big fish that move to the surface. If benthic fish are being missed, hold the net behind the anode just above the bottom so some are collected.
9. Change the water in the livewell periodically to minimize stress prior to processing.
10. Using a GPS unit in trip computer mode to monitor distance traveled, continue sampling downstream to the end of the subreach. At the end of the subreach, process the fish according to Appendix A4. Be sure to release them upriver, or preferably near the opposite bank, to reduce the likelihood of recapturing them.

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11. Record in the database the final, or most successful, electrofisher output settings (mode, range, POR, pulse frequency, current, electrofisher on-time, duty cycle and power, if known), sampling efficiency (poor, fair, good, excellent), and distance sampled, along with fish observations, including fish collected while electrofishing, as well as any additional fish observed within the reach, but not collected[1]. If conditions prevent safe or effective electrofishing within a reach, the conditions, and their effect on sampling efficiency, should be noted in the Sampling Event tab in the database, and the length of stream that was actually sampled should be noted.

12. Be sure the station visit information is completely entered before leaving the site.

[1] In the database, only those fish captured while electrofishing should be associated with an electrofishing sampling event. Fish observed, but not captured should be recorded under a separate sampling event (e.g., Visual observations-boat). Fish collected from off-channel habitats (e.g., tributaries, side channels, floodplain habitats, adjacent beaver ponds) should be recorded under a distinct sampling event.

Appendix A3.–Recommended target voltage for standardized backpack electrofishing (constant power transfer) for predominantly juvenile salmonids in cold waters at various ambient water conductivities.

Ambient conductivity (µS/cm)	Target voltage		Ambient conductivity (µS/cm)	Target voltage	
	pulsed DC[a]	Smooth DC		pulsed DC	Smooth DC
20	1155	490	170	306	130
30	834	354	180	299	127
40	674	286	190	294	125
50	577	245	200	289	123
60	513	218	210	284	121
70	467	199	220	280	119
80	433	184	230	276	117
90	406	173	240	273	116
100	385	163	250	269	115
110	367	156	260	266	113
120	353	150	270	264	112
130	340	145	280	261	111
140	330	140	290	259	110
150	321	136	300	257	109
160	313	133			

Note: Target voltage values were calculated for a Smith-Root LR-24 backpack electrofisher fitted with a standard Smith-Root rat-tail cathode (a 10-ft length of braided, 3/16-in stainless-steel cable with the connected end insulated with a 6-ft length of neoprene) and a single anode pole having a standard Smith-Root 11-inch-diameter stainless-steel anode ring, and are optimized for capturing juvenile salmonids in cold, wadeable flowing waters with predominantly rocky substrates. These target voltages may not be optimal for electrofishing systems having a different internal resistance (i.e., different electrofishing system, electrode type, or if electrodes are heavily corroded), if targeting different fish species/life stages, or when electrofishing in nonwadeable waters or over predominantly fine substrates.

We prepared this power-standardization table based on the power-transfer theory for electrofishing (Kolz 1989), using water ambient conductivity measurements and metered electrofisher output values (peak voltage and current) selected while electrofishing to maximize capture-prone responses (taxis and forced swimming) and minimize responses associated with elevated trauma (immobilization, branding, spinal deformities, or recovery period exceeding 15 seconds) in target fish. We assumed fish conductivity = 100 (µS/cm).

This table provides a starting voltage setting for standardized backpack electrofishing. While electrofishing, always monitor the response of target and non-target organisms, and fine-tune electrofisher operations and settings as recommended in the user's manual to achieve the desired response.

[a] 30 pulses per second, 12% duty cycle (4 mS pulse width)

Appendix A4.–Procedure to process collected fish.

1. Anesthetize collected fish with AQUI-S 20E according to instructions.
2. Remove 1 fish at a time from the sedation bucket and place on a length measuring tube (FL ≤ 250 mm) or board (FL ≥ 250 mm).
3. Identify all collected fish to species (Appendix B5), life stage (Appendix B1), and life history (anadromous, resident, marine/estuarine, unknown) and measure fork length to the nearest mm. Refer primarily to Pollard et al. 1997 to identify unknown salmoninae (salmon, trout, or char) and to Mecklenburg et al. 2002 for all other species. Also refer to photos of known specimens for confirmation. Check each fish for external anomalies (Appendix B2). Document any definite fish passage barriers (Appendix B3) found in or adjacent to the reach. Immediately after identification and measurement, place fish in a second bucket of fresh stream water for recovery.
4. Take a representative photo of each anadromous species and life stage, as well as any rare or unusual fish, fish with anomalies, or fish where ID was uncertain. Record the photo number(s) associated with each fish in the database.
5. Take a fin clip from each Dolly Varden to be retained (see below), from additional species requested by UAF, and from sculpin requested by U.S. Forest Service. Follow the appropriate instructions for taking fin clips (USFWS instructions for Dolly Varden, UAF instructions for other species, U.S. Forest Service instructions for sculpin). Record the fin clip vial number in the database.
6. Retain the following specimens:
    - Species unknown: In 10% formalin—up to 5 (from each site) individual fish of each species and life stage that cannot be confidently identified in the field;
    - UAF Museum: In 10% formalin—voucher specimens of each species (see UAF instructions);
    - Optionally-anadromous fishes for otolith study: Frozen—up to 12 large (> 300 mm, individuals from each study site where they are collected of each optionally-anadromous species, such as: Dolly Varden; humpback whitefish; least cisco, and Bering cisco.
    - ADEC Veterinarian: Frozen—up to 6 individual resident fish from each study site where they are collected (See DEC instructions).

    Euthanize (by a blow to the head, or an overdose of AQUI-S 20E) all specimens to be retained. Tag any retained fish with a unique tag number, and record the tag number in the database. For UAF, each fish must be individually tagged. For all other retained specimens, fish of the same species and life stage that were all collected from the same reach may be retained as a group with a single unique tag for the group. Any specimens retained for the

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otolith study must be frozen. All other specimens should be stored in 10% formalin solution. For specimens >200 mm, make an incision through the belly wall before placing in formalin. Keep specimens cool (e.g., in fresh stream water) until they can be put in formalin or frozen. ***CAUTION! MINIMIZE THE CHANCE OF ATTRACTING WILDLIFE BY KEEPING RETAINED FISH INSIDE A COVERED COOLER OR HEAVY DUTY PLASTIC BAG. NEVER LEAVE SPECIMENS UNATTENDED IN THE FIELD.***

7. While 1 crewmember processes fish, the other will enter fish observations into the appropriate fields in the database.
8. When fish have recovered, release them to slow water. When additional subreaches will be sampled downstream (nonwadeable streams), be sure to release the fish upriver, or preferably near the opposite bank, to avoid recapturing them.
9. Record the species, life stage, life history, and count, along with any comments indicating average size, behavior, anomalies, etc., of any additional fish that were observed, but not collected (e.g., visually observed adults).

APPENDIX B. LOOKUP TABLES

Appendix B1.–Fish life-stage classes and threshold fork-length values.

Descriptions of fish life-stage classes.

Code	Name	Description
FXE	fixed egg	Eggs adhering to or buried within a substrate.
PLE	planktonic egg	Non-adherent, buoyant or nearly so, eggs drifting with currents.
FXA	alevin	Pre-emergent sac-fry within the interstices of the substrate.
PLL	planktonic larvae	Hatched juveniles drifting with currents and with no, or poorly, developed volitional swimming capabilities.
JUV	juvenile	Sexually immature free-swimming fish.
SMT	smolt	Juvenile anadromous fish on first emigration from fresh to marine water.
JOA	juvenile/adult	Free swimming fish whose sexual maturity is not determined.
ADT	adult	Fish at, or approaching sexual maturity.
ASP	adult spawning	Adults observed in the act of spawning.
KLT	kelt	Post-spawning iteroparous anadromous fish in freshwater prior to return to marine water.
CAR	carcass	Post-spawning adult carcass.
NAP	not applicable	No fish observed or general information record only.
NRD	not recorded	Life stage not recorded.

Fork-length threshold values (mm) used to assign fish to selected life-stage classes.

	Life stage		
Species	Juvenile	Juvenile-or-adult	Adult
lamprey-unspecified	-	-	-
longnose sucker	<188	188–348	>348
northern pike	<330	330–448	>448
Alaska blackfish	<42	42–113	>113
broad whitefish	<343	343–448	>448
humpback whitefish	<280	280–363	>363
least cisco	<199	199–318	>318
round whitefish	<199	199–318	>318
inconnu (sheefish)	<586	586–648	>648
Arctic grayling	<190	190–328	>328
pink salmon	-	-	-
chum salmon	-	-	-
coho salmon	-	-	-
sockeye salmon	-	-	-
Chinook salmon	-	-	-
Dolly Varden	<83	83–	-
burbot	<280	280–498	>498
slimy sculpin	<51	51–68	>68

Note: A hyphen or missing value indicates that we assigned individual fish to the indicated life stage based only on examination of morphological indicators of sexual maturity, not based on fork-length threshold values.

Appendix B2.–Fish-anomaly classes.

Code	Name	Description
AB	Absent	Absent eye, fin, tail.
BK	Blackening	Tail or whole body with darkened pigmentation.
BL	Blisters	In mouth, just under skin.
BS	Extensive black spot	Small black cysts (dots) all over the fins and body.
CO	Copepod	A parasitic infection characterized by a worm-like copepod embedded in the flesh of the fish; body extends out and leaves a sore/discoloration at base, may be in mouth gills, fins, or anywhere on body.
CY	Cysts	Fluid-filled swellings; may be either small or large dots.
DE	Deformities	Skeletal anomalies of the head, spine, and body shape; amphibians may have extra tails, limbs, toes.
EF	Eroded fins	Appear as reductions or substantial fraying of fin surface area.
EG	Eroded gills	Gill filaments eroded from tip.
EX	Exophthalmia	Bulging of the eye.
FA	Fin anomalies	Abnormal thickenings or irregularities of rays
FU	Fungus	May appear as filamentous or "fuzzy" growth on the fins, eyes, or body.
GR	Grubs	White or yellow worms embedded in muscle or fins.
HM	Hemorrhaging	Red spots on mouth, body, fins, fin bases, eyes, and gills.
IC	Ich	White spots on the fins, skin or gills.
LE	Lesions	Open sores or exposed tissue; raised, granular, or warty outgrowths.
LI	Lice	Scale-like, mobile arthropods.
MU	Mucus	Thick and excessive on skin or gill, or as long cast from vent.
NO	None	No anomalies present.
OT	Other	Anomalies or parasites not specified.
SA	Scale anomalies	Missing patches, abnormal thickenings, granular skin
SO	Shortened operculum	Leaves a portion of the gill chamber uncovered
TU	Tumors	Areas of irregular cell growth which are firm and cannot be easily broken open when pinched. (Masses caused by parasites can usually be opened easily.)
WR	Leeches	Annelid worms which have anterior and posterior suckers. They may attach anywhere on the body.

Source: McCormick and Hughes 1998.

Appendix B3.–Fish-passage barrier classes.

Code	Name	Description
EBD	Ephemerally Fixed, Beaver Dam	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a beaver dam. Used where the location of the barrier to movement is known within 100 m.
EDJ	Ephemerally Fixed, Debris Jam	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a debris jam. This category is restricted to small scale (?10 m) features that do not dramatically alter the overall channel type. Larger mass-wasting created barriers fall in the EGD category. Used where the location of the ultimate barrier to movement is known within 100 m.
EGD	Ephemerally Fixed, Hydro-Geomorphically Dynamic	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by current hydrological or geomorphic conditions but where evidence indicates that these landscape-scale conditions are in flux over brief (decades) geologic time. Used in areas of recent or ongoing geomorphic alteration (e.g., glacial advance or retreat, mass wasting, tectonic movements, dynamic channel formation). Used where the location of the barrier to movement is within 100 m.
ELF	Ephemerally Fixed, Low Flow	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by low stream flow, but where evidence indicates that at higher stream flow, fish could ascend further up the channel. Used where the location of the barrier to movement is known within 100 m.
EOT	Ephemerally Fixed, Other	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a non-permanent barrier other than those listed immediately above. Used where the location of the ultimate barrier to movement is known within 100 m.
ESS	Ephemerally Fixed, Spring Source	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling or on-site analysis, to be blocked by the emergence of ground water from an unconfined substrate. Compare to GSL. Used where the location of the barrier to movement is known within 100 m.
GLK	Geologically Fixed, Lake Shore	Where the upstream movements of a given species appear, based on sufficient sampling or on-site analysis, to be limited by the perimeter of a geologically-stable lake shore. Used where the location of the barrier to movement is known within 100 m.
GOT	Geologically Fixed, Other	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling or on site analysis, to be blocked by a geologically fixed barrier other than those listed immediately above. Used where the location of the ultimate barrier to movement is known within 100 m.
GSL	Geologically Fixed, Stream Limit	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling or on-site analysis, to be limited to the presence of surface water, and where that presence of surface water appears to be fixed in space and stable in time (compare to ELF). Spring-fed headwall pools are examples. Used where the location of the barrier to movement is known within 100 m.

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Appendix B3.–Page 2 of 2.

Code	Name	Description
GWG	Geologically Fixed, Waterfall/High Gradient	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling or on-site analysis, to be blocked by a waterfall, cascade, or other similar geologically fixed barrier. Used where the location of the barrier to movement is known within 100 m.
HCU	Human, Culvert	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a culvert through a road bed, a railroad bed, a runway, or through any other type of fill. This code includes culverts of all materials (e.g., metal, plastic, wood) and shapes (e.g., round, arched, bottomless) Used where the location of the barrier to movement is known within 100 m.
HDB	Human, Debris	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by debris placed or deposited in the stream as the direct result of human activities but where that material was not intentionally placed to impound, filter, or divert stream flow. Examples include woody debris from logging activities, and debris flows from failed road prisms. Used where the location of the barrier to movement is known within 100 m.
HDM	Human, Dam	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a dam, weir, head gate, or other cross channel structure that impounds, filters, or diverts stream flow. This code includes structures of all materials (e.g., earth, concrete, rip rap, metal, wood). Used where the location of the barrier to movement is known within 100 m.
HOT	Human, Other	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a human-created structure other than those listed immediately above. Used where the location of the barrier to movement is known within 100 m.
NAP	Not applicable	No fish observed. See downstream stations.
NON	None	No barrier exists at survey station.
SBU	Specific Barrier Unknown	Where a given species is collected at a downstream station and not at an upstream station but where no specific barrier is known between the 2 stations. Used where the distributional limits are not known within 100 m.
UNK	Unknown	No information exists upstream of a sample station. Often where a species is collected at a station and no additional sampling or survey occurs upstream.

Appendix B4.–Water color, substrate, and stream-stage classes.

Water-color classes.

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.

Substrate classes.

Code	Name	Intermediate-axis dimensions
BED	Bedrock	> 4,096 mm. Solid rock—few or no discrete particles
BLD	Boulder	256–4,096 mm
CBL	Cobble	64–256 mm
GRV	Gravel	2–64 mm
SND	Sand	0.0625–2 mm
SCL	Silt/Clay	≤ 0.0625 mm
ORG	Organic	Incompletely-decomposed organic material

Source: adapted (Bedrock and Organic classes added) from Cummins (1962), which is based on the Wentworth (1922) scale.

Stream-stage classes.

Code	Description
DNC	Dry, no defined channel
DDC	Dry, defined channel
LDF	Low, intermittent surface flow
LCF	Low, continuous surface flow
MED	Medium
HIH	High
WNC	Wet, no defined channel

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Embeddedness classes.

Code	Level of embeddedness[a]	Description
NEG	Negligible	Gravel, cobble, and boulder particles have <5% of their height covered by fine sediment[b].
LOW	Low	Gravel, cobble, and boulder particles have 5-25% of their height covered by fine sediment.
MOD	Moderate	Gravel, cobble, and boulder particles have 25-50% of their height covered by fine sediment.
HIH	High	Gravel, cobble, and boulder particles have 50-75% of their height covered by fine sediment.
VHI	Very high	Gravel, cobble, and boulder particles have >75% of their height covered by fine sediment.

[a] Embeddedness (*sensu* Armantrout 1998): Degree that gravel and larger sizes of particles (boulders, cobble, or rubble) are surrounded or covered by fine sediment (e.g., less than 2 mm).

[b] <2 mm, i.e., sand, silt, or clay.

Note: If the dominant substrate type is sand, silt, or clay, the level of embeddedness will be rated as Very high. If the dominant substrate type is bedrock, the level of embeddedness will be rated as Negligible.

Source: modified from Bain (1999), which was adapted from Platts et al. 1983.

Appendix B5.–Fish species codes.

Code	Common name	Scientific name
ACI	sturgeon-unspecified	*Acipenser* sp.
ATG	green sturgeon	*Acipenser medirostris*
ATW	white sturgeon	*Acipenser transmontanus*
CAC	Arctic char	*Salvelinus alpinus*
CBT	brook trout	*Salvelinus fontinalis*
CDV	Dolly Varden	*Salvelinus malma*
CHR	char-unspecified	*Salvelinus* sp.
CLK	lake trout	*Salvelinus namaycush*
DAL	Alaska blackfish	*Dallia pectoralis*
ERC	trout-perch	*Percopsis omiscomaycus*
FAR	Arctic flounder	*Pleuronectes glacialis*
FLN	righteye flounders-unspecified	Pleuronectidae
FST	starry flounder	*Platichthys stellatus*
GAD	cod-unspecified	Gadidae
GAR	Arctic cod	*Boreogadus saida*
GBR	burbot	*Lota lota*
GPA	Pacific cod	*Gadus macrocephalus*
GRA	Arctic grayling	*Thymallus arcticus*
GSA	saffron cod	*Eleginus gracilis*
HAM	American shad	*Alosa sapidissima*
HER	herrings-unspecified	Clupeidae
HPA	Pacific herring	*Clupea pallasii*
IDA	salmonid, unspecified	Salmonidae
KNS	ninespine stickleback	*Pungitius pungitius*
KSB	stickleback-unspecified	Gasterosteidae
KTS	threespine stickleback	*Gasterosteus aculeatus*
LAC	Arctic-Alaskan brook lamprey paired species	*L. camtschatica / L. alaskense*
LAK	Alaskan brook lamprey	*Lampetra alaskense*
LAR	Arctic lamprey	*Lampetra camtschatica*
LMO	Atlantic salmon	*Salmo salar*
LMP	lamprey-unspecified	*Lampetra* sp.
LPC	Pacific lamprey	*Lampetra tridentata*
LRV	American river lamprey	*Lampetra ayresii*
LWB	western brook lamprey	*Lampetra richardsoni*
MIN	lake chub	*Couesius plumbeus*
NOS	longnose sucker	*Catostomus catostomus*
OEU	eulachon	*Thaleichthys pacificus*
OLS	longfin smelt	*Spirinchus thaleichthys*
OPS	pond smelt	*Hypomesus olidus*
ORM	rainbow smelt	*Osmerus mordax*
OSM	smelt-unspecified	Osmeridae
OSS	surf smelt	*Hypomesus pretiosus*
PIK	northern pike	*Esox lucius*
SAM	Pacific salmon-unspecified	semelparous *Oncorhynchus sp.*
SCK	Chinook salmon	*Oncorhynchus tshawytscha*
SCM	chum salmon	*Oncorhynchus keta*

Code	Common name	Scientific name
SCO	coho salmon	*Oncorhynchus kisutch*
SPI	pink salmon	*Oncorhynchus gorbuscha*
SSE	sockeye salmon	*Oncorhynchus nerka*
TCT	cutthroat trout	*Oncorhynchus clarkii*
TRB	rainbow trout	*Oncorhynchus mykiss*
TRT	trout-unspecified	iteroparous *Oncorhynchus sp.*
UCR	coastrange sculpin	*Cottus aleuticus*
UFH	fourhorn sculpin	*Myoxocephalus quadricornis*
ULP	sculpin-unspecified	Cottidae
UPR	prickly sculpin	*Cottus asper*
UPS	Pacific staghorn sculpin	*Leptocottus armatus*
USH	sharpnose sculpin	*Clinocottus acuticeps*
USL	slimy sculpin	*Cottus cognatus*
WAK	Alaska whitefish	*Coregonus nelsonii*
WAR	Arctic cisco	*Coregonus autumnalis*
WBC	Bering cisco	*Coregonus laurettae*
WBD	broad whitefish	*Coregonus nasus*
WHB	humpback whitefish	*Coregonus pidschian*
WHC	humpback whitefish complex	*C. clupeaformis / C. nelsonii / C. pidschian*
WHF	whitefish-unspecified	Coregoninae
WIN	inconnu (sheefish)	*Stenodus leucichthys*
WLC	least cisco	*Coregonus sardinella*
WLK	lake whitefish	*Coregonus clupeaformis*
WPG	pygmy whitefish	*Prosopium coulteri*
WRN	round whitefish	*Prosopium cylindraceum*
YMA	shiner perch	*Cymatogaster aggregata*
YYP	yellow perch	*Perca flavescens*
QQQ	other species not listed	-
VVV	no collection effort	-
XXX	no fish collected or observed	-
ZZZ	general fish observation, no species information	-

Appendix B6.–Riparian vegetation communities (Viereck et al. 1992).

Code	Key	Class	Description
I	Trees > 3 m tall with canopy cover of ≥ 10%. If not, go to II.	Forest	Single stemmed woody plants at least 3 m tall at maturity and at least 10% cover.
IA	> 75% of tree cover contributed by coniferous species. If not, go to IB.	Coniferous Forest	Dominated by coniferous (needleleaf) tree species (Sitka, White, and Black Spruce; Western and Mountain Hemlock; Western Redcedar; Alaska-Cedar, Silver and Subalpine Fir, Pacific Yew, Lodgepole Pine, and Tamarack.
IA1	Tree canopy of 60 - 100% cover. If not, go to IA2.	Closed Coniferous Forest	Forest community has a 60 - 100% total tree canopy coverage.
IA1a	Sitka Spruce dominates overstory and regeneration.	Closed Sitka Spruce Forest	Occupies wet sites in SE Alaska, primarily in alluvial flood plains, and in narrow coastal band in SC Alaska to Kodiak.
IA1b	Western Hemlock dominates overstory; other species < 25% of overstory.	Closed Western Hemlock Forest	Widespread in SE Alaska, often with a Sitka Spruce component.
IA1c	Sitka Spruce and Western Hemlock each contribute > 30% cover. Sitka Spruce constitutes most of overstory, Western Hemlock usually provides most of understory.	Closed Sitka Spruce-Western Hemlock Forest	Occurs on moist sites throughout SE Alaska and in coastal band in SC Alaska.
IA1d	Western Hemlock dominates. Sitka Spruce > 25% cover but < Western Hemlock.	Closed Western Hemlock-Sitka Spruce-(Western Redcedar) Forest	Widespread in SE Alaska and in coastal band in SC Alaska (Redcedar may be present S of 57º N).
IA1e	Western Hemlock and Alaska-Cedar dominate (each contributes 25 - 75% of canopy cover).	Closed Western Hemlock-Alaska-cedar	Occurs on a variety of upland sites from sea level to subalpine throughout SE Alaska.
IA1f	Mountain Hemlock dominates canopy cover.	Closed Mountain Hemlock Forest	Occurs near tree line, normally on saturated soil, throughout SE Alaska and in narrow subalpine band in SC Alaska.
IA1g	Western Hemlock and Western Redcedar dominate (each contributes 25 - 75% of canopy cover). Alaska-cedar and Mountain Hemlock may also be significant.	Closed Western Hemlock-Western Redcedar Forest	Occurs on low-producing, poorly drained sites in southern SE Alaska.
IA1h	Silver Fir and Western Hemlock dominate (each contributes 25 - 75% of canopy cover). Sitka Spruce and Western Redcedar may also be important.	Closed Silver Fir-Western Hemlock Forest	Limited distribution in southernmost SE Alaska.

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Code	Key	Class	Description
IA1i	Subalpine Fir dominates canopy cover. Other important species include Sitka Spruce, Mountain Hemlock, and Alaska-cedar.	Closed Subalpine Fir Forest	Occurs in scattered locations near tree line in SE Alaska.
IA1j	White Spruce dominates canopy cover. May include scattered Paper Birch or Balsam Poplar.	Closed White Spruce Forest	Widespread in SC and Interior Alaska, generally on well-drained, permafrost-free soils.
IA1k	Black Spruce dominates canopy cover. White Spruce and Paper Birch may be present.	Closed Black Spruce Forest	Widespread in SC and Interior Alaska, generally on poorly-drained organic soils, often over permafrost-free soils.
IA1l	Black Spruce and White Spruce codominate (each contributes 25 - 75% of canopy cover).	Closed Black Spruce-White Spruce Forest	Occurs in Interior Alaska near the northern and western limits of trees. Also on terraces and bases of south-facing slopes.
IA2	Tree canopy of 25 - 60% cover. If not, go to IA3.	Open Coniferous Forest	Forest community has a 25 - 60% total tree canopy coverage.
IA2a	Sitka Spruce dominate overstory. Other species < 25% of canopy cover.	Open Sitka Spruce Forest	Often occurs in alluvial deposits and glacial moraines and outwash in SE Alaska and in narrow coastal band in SC Alaska to Kodiak.
IA2b	Western Hemlock and Sitka Spruce dominate overstory (each contributes 25 - 75% of canopy cover).	Open Western Hemlock-Sitka Spruce Forest	Occurs from low to mid-elevations in SE Alaska.
IA2c	Mountain Hemlock dominates overstory. Other trees < 25% of canopy cover.	Open Mountain Hemlock Forest	Primarily on high mountain slopes in SC and SE Alaska.
IA2d	Dominated by various combinations of Alaska-cedar, Western Hemlock, Mountain Hemlock, Sitka Spruce, Lodgepole Pine, Western Redcedar, and Pacific Yew.	Open Mixed Conifer Forest	Stands with 3 - 5 overstory conifer species common on level or gently sloping wet sites in SE Alaska.
IA2e	White Spruce dominates overstory. Other species < 25% of canopy cover.	Open White Spruce Forest	On well-drained sites and near tree line in Interior, SW, NW, and SC Alaska.
IA2f	Black Spruce dominates overstory. Other species < 25% of canopy cover.	Open Black Spruce Forest	Extremely common on poorly drained, cold sites in Interior and SC Alaska.
IA2g	Black Spruce and White Spruce codominate (each contributes 25 - 75% of canopy cover).	Open Black Spruce-White Spruce Forest	Occurs mostly near tree line in Interior Alaska.
IA2h	Black Spruce and Tamarack codominate (each contributes 25 - 75% of canopy cover).	Open Black Spruce-Tamarack Forest	On wet lowland sites with permafrost in Interior Alaska.

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Code	Key	Class	Description
IA3	Tree canopy of 10 - 25% cover.	Coniferous Woodland	Forest community has a 10 - 25% total tree canopy coverage.
IA3a	Lodgepole Pine dominates overstory. Other species < 25% of canopy cover.	Lodgepole Pine Woodland	Generally on boggy, poorly-drained sites in SE Alaska.
IA3b	Sitka Spruce dominates overstory. Other species < 25% of canopy cover.	Sitka Spruce Woodland	On poorly-drained sedge peat in SE and coastal SC Alaska.
IA3c	White Spruce dominates overstory. Other species < 25% of canopy cover.	White Spruce Woodland	Common and northern and elevational treelines.
IA3d	Black Spruce dominates overstory. Other species < 25% of canopy cover.	Black Spruce Woodland	In Interior, SC, SW, and NW Alaska on wet, boggy sites, often with sphagnum mosses, and on dry upland sites frequently with lichens.
IA3e	Black Spruce and White Spruce codominate (each contributes 25 - 75% of canopy cover).	Black Spruce-White Spruce Woodland	In Interior, SC, SW, and NW Alaska, often near the northern, western, and elevational limit of trees.
IB	> 75% of tree cover contributed by broadleaf species. If not, go to IC.	Broadleaf Forest	Dominated by broadleaf (all deciduous trees except for tamarack) tree species (Red Alder, Black Cottonwood, Balsam Poplar, Quaking Aspen, Paper Birch).
IB1	Tree canopy of 60 - 100% cover. If not, go to IB2.	Closed Broadleaf Forest	Forest community has a 60 - 100% total tree canopy coverage.
IB1a	Red Alder dominates overstory. Other species < 25% of canopy cover.	Closed Red Alder Forest	Occupies moist sites and disturbed areas in SE Alaska.
IB1b	Black Cottonwood dominates overstory. Other species < 25% of canopy cover.	Closed Black Cottonwood Forest	Generally along streams in SE and SC Alaska.
IB1c	Balsam Poplar dominates overstory. Other species < 25% of canopy cover.	Closed Balsam Poplar Forest	Occurs most frequently on floodplains in Interior, SC, and SW Alaska and in isolated stands on the northern slope of the Brooks Range.
IB1d	Paper Birch dominates overstory. Other species < 25% of canopy cover.	Closed Paper Birch Forest	Occurs on many upland sites, both with and without permafrost, in Interior and SC Alaska.
IB1e	Quaking Aspen dominates overstory. Other species < 25% of canopy cover.	Closed Quaking Aspen Forest	Occurs on warm, well-drained upland soils in Interior and SC Alaska.

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Code	Key	Class	Description
IB1f	Paper Birch and Quaking Aspen codominate (each contributes 25 - 75% of canopy cover).	Closed Paper Birch-Quaking Aspen Forest	Found on moderately warm sites in Interior and SC Alaska.
IB1g	Quaking Aspen and Balsam Poplar codominate (each contributes 25 - 75% of canopy cover).	Closed Quaking Aspen-Balsam Poplar Forest	Occurs on floodplains in Interior Alaska.
IB2	Tree canopy of 25 - 60% cover. If not, go to IB3.	Open Broadleaf Forest	Forest community has a 25 - 60% total tree canopy coverage.
IB2a	Paper Birch dominates overstory. Other species < 25% of canopy cover.	Open Paper Birch Forest	Occurs on dry to moist sites in Interior, SC, and W Alaska. On dry sites lichens are important in understory; on moist sites, shrubs are dominant.
IB2b	Quaking Aspen dominates overstory. Other species < 25% of canopy cover.	Open Quaking Aspen Forest	Primarily on extremely dry sites on steep south-facing slopes in Interior and SC Alaska.
IB2c	Balsam Poplar or Black Cottonwood dominate overstory. Other species < 25% of canopy cover.	Open Balsam Poplar (Black Cottonwood) Forest	Occurs as open clumps near tree line in Interior, SC, SW, and NW Alaska and in isolated groves on north slope of Brooks Range (Black Cottonwood restricted to SC and SE Alaska).
IB3	Tree canopy of 10 - 25% cover.	Broadleaf Woodland	Forest community has a 10 - 25% total tree canopy coverage.
IB3a	Paper Birch (may be multistemmed) dominates overstory. Other species < 25% of canopy cover.	Paper Birch Woodland	On dry sites, such as old sand dunes and coarse gravel deposits, in NW and northern Interior Alaska.
IB3b	Balsam Poplar dominates overstory. Other species < 25% of canopy cover.	Balsam Poplar Woodland	Reported from the Susitna R. floodplain. May occur on slopes near tree line.
IB3c	Paper Birch and Quaking Aspen codominate (each contributes 25 - 75% of canopy cover).	Paper Birch-Balsam Poplar Woodland	Reported from the Susitna Valley.
IC	Broadleaf or coniferous species both contribute 25 - 75% of tree cover.	Mixed Forest	Broadleaf or coniferous species contribute 25 - 75% of tree cover.
IC1	Tree canopy of 60 - 100% cover. If not, go to IC2.	Closed Mixed Forest	Forest community has a 60 - 100% total tree canopy coverage.

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Code	Key	Class	Description
IC1a	Paper Birch and White and/or Black Spruce dominate overstory.	Closed Spruce-Paper Birch Forest	Primarily in Interior and SC Alaska where it tends to occur on cool wet sites when black spruce is included in mixture
IC1b	White Spruce, Paper Birch, and Balsam Poplar/Black Cottonwood dominate overstory.	Closed White Spruce-Paper Birch-Balsam Poplar (Black Cottonwood Forest)	Reported from the Susitna Valley.
IC1c	White and/or Black Spruce, Paper Birch, and Quaking Aspen dominate overstory.	Closed Spruce-Paper Birch-Quaking Aspen Forest	Reported from Interior Alaska.
IC1d	Quaking Aspen and White and/or Black Spruce dominate overstory.	Closed Quaking Aspen-Spruce Forest	Most common in Interior and SC Alaska on warm, well-drained sites--an intermediate successional phase.
IC1e	Balsam Poplar and White Spruce dominate overstory.	Closed Balsam Poplar-White Spruce Forest	On floodplains In Interior, SC, SW, and NW Alaska where it is an intermediate successional stage.
IC2	Tree canopy of 25 - 60% cover. If not, go to IC3.	Open Mixed Forest	Forest community has a 25 - 60% total tree canopy coverage.
IC2a	Paper Birch and White and/or Black Spruce dominate overstory.	Open Spruce-Paper Birch Forest	On a variety of upland sites in Interior, SC, SW, and NW Alaska.
IC2b	Quaking Aspen and White and/or Black Spruce dominate overstory.	Open Quaking Aspen-Spruce Forest	Reported from the Porcupine River area in Interior Alaska.
IC2c	White Spruce, Paper Birch, and Balsam Poplar dominate overstory.	Open Paper Birch-Balsam Poplar-Spruce Forest	Reported from Susitna Valley.
IC2d	White Spruce and Balsam Poplar dominate overstory.	Open Spruce-Balsam Poplar	Reported from Susitna Valley.
IC3	Tree canopy of 10 - 25% cover.	Mixed Woodland	Forest community has a 10 - 25% total tree canopy coverage.
IC3a	Paper Birch and White and/or Black Spruce dominate overstory.	Spruce-Paper Birch Woodland	Reported from Susitna Valley.
II	Erect to decumbent woody shrubs with cover ≥ 25% OR dwarf trees (< 3 m tall) with cover ≥ 10% cover. If not, go to III.	Scrub	Scrub communities are composed of combinations of dwarf trees, and tall, low, and dwarf shrubs.

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Code	Key	Class	Description
IIA	Dwarf trees (< 3 m tall) with cover ≥ 10% cover. If not, go to IIB.	Dwarf Tree Scrub	Community dominated by dwarf trees (< 3 m tall), usually shrublike. Shrubs may be absent or abundant.
IIA1	Dwarf tree canopy of 60 - 100% cover. If not, go to IIA2.	Closed Dwarf Tree Scrub	Dwarf tree canopy of 60 - 100% cover.
IIA1a	Mountain Hemlock dominates overstory. Sitka Spruce may be present.	Closed Mountain Hemlock Dwarf Tree Scrub	Occurs at tree line in SE Alaska. On wind-exposed sites may form mat 0.3 m tall.
IIA1b	Subalpine Fir dominates overstory. Mountain Hemlock and Sitka Spruce may be present.	Closed Subalpine Fir Dwarf Tree Scrub	Forms dense stands at elevational tree line in SE Alaska. On highly exposed sites may form prostrate mat 0.15 m tall.
IIA2	Dwarf tree canopy of 25 - 59% cover. If not, go to IIA3.	Open Dwarf Tree Scrub	Dwarf tree canopy of 25 - 59% cover. Shrubs may be absent or abundant, usually common.
IIA2a	Black Spruce dominates overstory. Dwarf tamarack and paper birch may also be present.	Open Black Spruce Dwarf Tree Scrub	Found on very cold and/or wet soils in Interior, SC, and W Alaska.
IIA2b	Mountain Hemlock dominates overstory. Sitka Mountain-ash may be present.	Open Mountain Hemlock Dwarf Tree Scrub	Common on peatlands and sometimes on exposed ridges in SE Alaska.
IIA3	Dwarf tree canopy of 10 - 25% cover.	Dwarf Tree Scrub Woodland	Dwarf tree canopy of 10 - 24% cover. If other vegetation types are lacking, dwarf tree cover can be as low as 2%.
IIA3a	Black Spruce dominates overstory. Other tree species usually not present.	Black Spruce Dwarf Tree Woodland	Common in Interior, SC, and W Alaska on very cold or wet sites.
IIB	Shrubs > 1.5 m tall and ≥ 25% cover dominate. If not, go to IIC.	Tall Scrub	Woody plants other than trees > 1.5 m tall and ≥ 25% cover dominate.
IIB1	Shrub canopy cover > 75%. If not, go to IIB2.	Closed Tall Scrub	Shrub canopy cover > 75%.
IIB1a	Willow species dominate overstory (< 25% other canopy species).	Closed Tall Willow Shrub	Characteristic of floodplains and common throughout Alaska except for Aleutian Is. and Arctic coast.
IIB1b	Alder species dominate overstory (< 25% other canopy species).	Closed Tall Alder Shrub	Common throughout most of state on steep slopes, floodplains, and stream banks.
IIB1c	Shrub Birch species or hybrids dominate overstory (< 25% other canopy species).	Closed Tall Shrub Birch Shrub	Generally found in taiga openings in Interior Alaska near tree line.
IIB1d	Alder and Willow species codominate (each contributes 25 - 75% of canopy cover).	Closed Tall Alder-Willow Shrub	Occurs on floodplain terraces and drainages on slopes throughout most of Alaska except Aleutian Is. and Arctic Coastal Plain.

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Code	Key	Class	Description
IIB1e	Shrub Birch and Willow species codominate (each contributes 25 - 75% of canopy cover).	Closed Tall Shrub Birch-Willow Shrub	Not common but present on Seward Peninsula.
IIB1f	Standing water present most or all of growing season. Alder (usually) and willow typically dominate.	Closed Tall Shrub Swamp	Common in Interior, SC, and SE Alaska on sites with poorly drained soil and hummocky microrelief with depressions containing standing water. Typically dominated by alder or willow.
IIB2	Shrub canopy cover 25 - 74% OR ≥ 2% IF little or no other vegetation cover present.	Open Tall Scrub	Shrub canopy cover 25 - 74% (or ≥ 2% if little or no other vegetation present).
IIB2a	Willow species dominate overstory (< 25% other canopy species).	Open Tall Willow Shrub	Occupies a variety of sites, from dunes to river banks. Most common in Interior, W, SC, and Arctic Alaska.
IIB2b	Alder species dominate overstory (< 25% other canopy species).	Open Tall Alder Shrub	Found throughout state, but not as abundant as closed alder communities.
IIB2c	Shrub Birch species or hybrids dominate overstory (< 25% other canopy species).	Open Tall Shrub Birch Shrub	Occurs at and above tree line, especially in Alaska Range.
IIB2d	Alder and Willow species codominate (each contributes 25 - 75% of canopy cover).	Open Tall Alder-Willow Shrub	On floodplain terraces and steep slopes near tree line in Interior and N Alaska.
IIB2e	Shrub Birch and Willow species codominate (each contributes 25 - 75% of canopy cover).	Open Tall Shrub Birch-Willow Shrub	Occurs near tree line especially in Alaska Range and W Alaska.
IIB2f	Standing water present most or all of growing season. Alder (usually) and Willow typically dominate.	Open Tall Shrub Swamp	Occurs on floodplains and drainages in Interior and SC Alaska.
IIC	Shrubs 0.2 - 1.5 m tall and ≥ 25% cover dominate. If not, go to IID	Low Scrub	Woody plants other than trees 0.2 - 1.5 m tall and ≥ 25% cover dominate.
IIC1	Shrub canopy cover > 75%. If not, go to IIC2.	Closed Low Scrub	Shrub canopy cover > 75%.
IIC1a	Shrub Birch species or hybrids dominate overstory (< 25% other canopy species).	Closed Low Shrub Birch	Thickets not common but do occur on Seward Peninsula and Interior Alaska.
IIC1b	Willow species dominate overstory (< 25% other canopy species).	Closed Low Willow Shrub	Common in Interior, W and N Alaska along streams and lakes.
IIC1c	Shrub Birch and Willow species codominate (each contributes 25 - 75% of canopy cover).	Closed Low Shrub Birch-Willow Shrub	Occupies alluvial deposits in N and W Alaska.
IIC1d	Ericaceous (e.g., Copperbush Cladothamnus pyrolaeflorus) species dominate.	Closed Low Ericaceous Shrub	Near tree line in SE Alaska (Copperbush Cladothamnus pyrolaeflorus).

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Code	Key	Class	Description
IIC1e	Alder and Willow species codominate (each contributes 25 - 75% of canopy cover).	Closed Low Alder-Willow Shrub	Reported from SE Alaska on poorly drained soils.
IIC2	Shrub canopy cover 25 - 74% OR ≥ 2% IF little or no other vegetation cover present.	Open Low Scrub	Shrub canopy cover 25 - 74% (or ≥ 2% if little or no other vegetation present).
IIC2a	Mixed shrubs and tussock-forming sedges dominate (in arctic and alpine regions beyond tree line).	Open Low Mixed Shrub-Sedge Tussock Tundra	One of the most extensive tundra units in Alaska; centered in N and W Alaska.
IIC2b	Mixed shrubs and tussock-forming sedges dominate (in subarctic and subalpine regions within tree limit).	Open Low Mixed Shrub-Sedge Tussock Bog	Occurs in lowland areas of Interior and SC Alaska.
IIC2c	Shrub Birch and Ericaceous species codominate (each contributes 25 - 75% of canopy cover) on wet non-peat soils. Hydrophytic sedges and Sphagnum are absent.	Open Low Mesic Shrub Birch-Ericaceous Shrub	Mesic slopes and alpine areas in Interior and SC Alaska and in N and W Alaska. Hydrophytic sedges and Sphagnum mosses generally absent.
IIC2d	Shrub Birch and Ericaceous species codominate (each contributes 25 - 75% of canopy cover) on wet peat soils. Peat-forming sedges and/or mosses are present.	Open Low Shrub Birch-Ericaceous Shrub Bog	Common on peat mounds and ridges of poorly drained lowlands in all Alaska except SE Alaska and Aleutian Is. Hydrophytic sedges and Sphagnum mosses generally present.
IIC2e	Ericaceous species dominate (< 25% other canopy species). Wet peat soils.	Open Low Ericaceous Shrub Bog	Common in maritime climates of SE and SC Alaska and Aleutian Is. Hydrophytic sedges and Sphagnum mosses generally present.
IIC2f	Shrub Birch and Willow species codominate (each contributes 25 - 75% of canopy cover).	Open Low Shrub Birch-Willow Shrub	Occurs in poorly drained lowlands and on moist slopes in N, Interior, SC, and SW Alaska
IIC2g	Willow species dominate overstory (< 25% other canopy species).	Open Low Willow Shrub	Occurs on moist uplands in N, Interior, and SC Alaska
IIC2h	Willow species dominate overstory (< 25% other canopy species); sedges dominate understory (in arctic and alpine regions beyond tree line).	Open Low Willow-Sedge Shrub Tundra	Occurs on poorly drained lowlands of Arctic and W Alaska.
IIC2i	Willow species dominate overstory (< 25% other canopy species); graminoids dominate understory on peat soils (in subarctic and subalpine regions within tree line).	Open Low Willow-Graminoid Shrub Bog	Occurs in wet stream bottoms and depressions in Interior, SW, SC, and SE Alaska.

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Code	Key	Class	Description
IIC2j	Sweetgale and graminoids dominate on extremely wet (often standing water) on peat soils.	Open Low Sweetgale-Graminoid Bog	Occupies poorly drained lowlands and pond margins in SE, SC, and SW Alaska.
IIC2k	Alder and Willow species codominate (each contributes 25 - 75% of canopy cover).	Open Low Alder-Willow Shrub	Occurs near tree line in interior Alaska and on river terraces in Arctic Alaska.
IIC2l	Alder species dominate overstory (< 25% other canopy species).	Open Low Alder Shrub	Occupies moist areas, especially drainages, in most of Alaska, except SE and Aleutian Is.
IIC2m	Sagebrush and Juniper dominate.	Sagebrush-Juniper	Exists on steep south-facing bluffs in Interior and SC Alaska.
IIC2n	Sagebrush and grasses dominate.	Sagebrush-Grass	Occurs on south-facing bluffs in Interior and SC Alaska.
IID	Shrubs < 0.2 m tall and ≥ 25% cover OR ≥ 2% IF little or no other vegetation cover present.	Dwarf Scrub	Woody plants other than trees < 0.2 m tall and ≥ 25% cover dominate.
IID1	Dryas species dominate. If not, go to IID2.	Dryas Dwarf Scrub	Dryas species dominant in dwarf shrub layer.
IID1a	Dryas species dominate.	Dryas Dwarf Shrub Tundra	Very wide-spread throughout the northern two-thirds of Alaska.
IID1b	Dryas species and sedges dominate.	Dryas-Sedge Dwarf Shrub Tundra	Common on alpine sites throughout the northern two-thirds of Alaska.
IID1c	Dryas species and fruticose lichens dominate.	Dryas-Lichen Dwarf Shrub Tundra	Occurs on windswept alpine sites, especially on the Seward Peninsula.
IID2	Ericaceous species dominate. If not, go to IID3.	Ericaceous Dwarf Scrub	Ericaceous species dominant in dwarf shrub layer.
IID2a	Bearberry Arctostaphylos species dominate.	Bearberry Dwarf Shrub Tundra	Occurs in alpine areas in Interior and Arctic Alaska, but most common in W Alaska.
IID2b	Vaccinium cranberry species dominate.	Vaccinium Dwarf Shrub Tundra	Common in alpine areas of Interior, N, and W Alaska.
IID2c	Crowberry Empetrum nigrum dominates.	Crowberry Dwarf Shrub Tundra	Characteristic of S. Alaska and Aleutian Is.
IID2d	Mountain-Heath Phyllodoce aleutica dominates.	Mountain Heath Dwarf Shrub Tundra	Common on alpine slopes in SC and SE Alaska.
IID2e	Cassiope species dominate.	Cassiope Dwarf Shrub Tundra	Widespread on moist alpine sites throughout Alaska.
IID3	Willow species dominate.	Willow Dwarf Scrub	Willow species dominant in dwarf shrub layer.

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Code	Key	Class	Description
IID3a	Willow species dominate.	Willow Dwarf Shrub Tundra	Common in alpine areas throughout Alaska except for SE Alaska.
III	Herbaceous (non-woody) vegetation dominates with < 25% scrub and < 10% forest cover. If not, go to IV.	Herbaceous	Herbaceous (non-woody) vegetation with ≤25% shrub cover and <10% forest cover.
IIIA	Grasses and Sedges dominate (Rushes and Horsetails are treated as forbs). If not, go to IIIB.	Graminoid Herbaceous	Grasses, sedges, or rushes dominant.
IIIA1	Graminoids dominate on well- to excessively-drained sites. If not, go to IIIA2	Dry Graminoid Herbaceous	Grasslands of well-drained, dry sites, such as south facing bluffs, old beaches, and sand dunes.
IIIA1a	Elymus species dominate.	Elymus	Occurs on beaches, dunes, gravel outwash flats, and dry slopes mostly in coastal areas, but occasionally in Alaska and Brooks Ranges and Interior Alaska.
IIIA1b	Fescue species dominate.	Dry Fescue	Occupies dry slopes in Interior, SC, and W Alaska.
IIIA1c	Medium height grasses dominate with conspicuous shrubs providing < 25% cover.	Midgrass-Shrub	Locally common on steep, south-facing slopes in Interior and SC Alaska.
IIIA1d	Medium height grasses and broad-leaved herbs dominate.	Midgrass-Herb	Occupies various sites in SC, SE, and Interior Alaska and Aleutian Is. from alpine meadows to stream banks.
IIIA1e	Hair-grasses Deschampsia species dominate.	Hair-Grass	Common in Aleutian Is. and along southern coast of Alaska. Often diverse stands with small numbers of a great many species.
IIIA2	Graminoids dominate or codominate on mesic sites.	Mesic Graminoid Herbaceous	Grasslands on moist sites, but usually not with standing water (tussocks often present).
IIIA2a	Bluejoint Calamagrostis dominates (includes lawns).	Bluejoint Meadow	Found throughout Alaska except for SE and Arctic Alaska. Occupies large areas in SC and SW Alaska. Includes installed and maintained lawns.
IIIA2b	Bluejoint Calamagrostis and herbs codominate.	Bluejoint-Herb	Widely distributed in southern half of state.
IIIA2c	Bluejoint Calamagrostis dominates with conspicuous shrubs providing < 25% cover.	Bluejoint-Shrub	Extensive in SW Alaska and probably also common in SC and Interior Alaska.
IIIA2d	Sedges in tussock growth form dominate (in arctic and alpine regions beyond tree line).	Tussock Tundra	Widely distributed throughout W, N, and Interior Alaska.
IIIA2e	Sedges and Grasses dominate in various combinations (in arctic and alpine regions beyond tree line).	Mesic Sedge-Grass Meadow Tundra	Usually of minor extent in arctic and alpine settings.

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Code	Key	Class	Description
IIIA2f	Sedges and broad-leaved herbs codominate (in arctic and alpine regions beyond tree line).	Mesic Sedge-Herb Meadow Tundra	Usually of minor extent in arctic and alpine settings.
IIIA2g	Grasses and broad-leaved herbs codominate (in arctic and alpine regions beyond tree line).	Mesic Grass-Herb Meadow Tundra	Occurs in small, limited areas. Reported from Arctic Slope but probably more widespread.
IIIA2h	Sedges dominate with conspicuous willow component providing < 25% cover (in arctic and alpine regions beyond tree line).	Sedge-Willow Tundra	Widely distributed in tundra areas throughout Alaska except SC and SE; probably most abundant from Brooks Range north.
IIIA2i	Sedges dominate with conspicuous shrub birch component providing < 25% cover (in arctic and alpine regions beyond tree line).	Sedge-Birch Tundra	Known from northern Alaska.
IIIA2j	Sedges dominate with conspicuous dryas component providing < 25% cover (in arctic and alpine regions beyond tree line).	Sedge-Dryas Tundra	Widely distributed in tundra areas throughout Alaska except SE.
IIIA3	Graminoids dominate or codominate on wet (saturated or flooded most or all of growing season) sites.	Wet Graminoid Herbaceous (emergent)	Grasslands on wet sites, standing water present for part of year; dominated by sedges or grasses; includes wet tundra, bogs, marshes, and fens.
IIIA3a	Sedges dominate (in arctic and alpine regions beyond tree line).	Wet Sedge Meadow Tundra	Found in very wet areas, generally underlain by permafrost, in every part of Alaska except SE and Aleutian Is.
IIIA3b	Sedges and Grasses dominate in various combinations (in arctic and alpine regions beyond tree line).	Wet Sedge-Grass Meadow Tundra	Largely confined to the Arctic Coastal Plain in very wet areas underlain by shallow permafrost.
IIIA3c	Sedges and broad-leaved herbs codominate (in arctic and alpine regions beyond tree line).	Wet Sedge-Herb Meadow Tundra	Found on very wet, poorly drained sites with standing water, such as oxbow lakes and alpine bogs. Apparently widely distributed throughout Alaska.
IIIA3d	Tall Sedges emerging from standing water (> 0.15 m deep) dominate.	Fresh Sedge Marsh	Found in SC and SE Alaska; may be found in Interior.
IIIA3e	Grasses emerging from standing water (> 0.15 m deep) dominate.	Fresh Grass Marsh	Common in ponds, slow-flowing streams, lake margins, and thermokarst pits in N and W Alaska. Depth of water ranges from seasonally flooded to 2 m.

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Code	Key	Class	Description
IIIA3f	Coarse, relatively tall Sedges in saturated or shallow flooded (≤ 0.15 m deep) soils dominate (in subarctic and subalpine regions within tree limit).	Subarctic Lowland Sedge Wet Meadow	Common in very wet areas on floodplains, margins of ponds, lakes, and sloughs and in depressions in upland areas. Reported from W, SC, SE, Interior Alaska and Aleutian Is.
IIIA3g	Sedges in saturated or shallow flooded (≤ 0.15 m deep) soils dominate with conspicuous shrub component providing < 25% cover (in subarctic and subalpine regions within tree limit).	Subarctic Lowland Sedge-Shrub Wet Meadow	Occupies upper parts of coastal marshes in SC and SE Alaska.
IIIA3h	Salt-tolerant Grasses (e.g., Puccinellia) dominate.	Halophytic Grass Wet Meadow	Commonly occupies tidal mud flats along entire Alaska coast.
IIIA3i	Salt-tolerant Sedges (e.g., Carex) dominate.	Halophytic Sedge Wet Meadow	Commonly occupies tidal mud flats along entire Alaska coast.
IIIA3j	Delicate, low Sedges on bog peats dominate (in subarctic and subalpine regions within tree limit).	Subarctic Lowland Sedge-Bog Meadow	Develops on peat deposits, sometimes forming quaking sedge mats, in filled lakes, ponds, and depressions throughout the southern two-thirds of Alaska.
IIIA3k	Mosses (e.g., Sphagnum) dominate with delicate, low sedges present and usually codominant on peat soils (in subarctic and subalpine regions within tree limit).	Subarctic Lowland Sedge-Moss Bog Meadow	Occurs on peat soils, including seepage slopes, raised bogs, slope bogs, early stages of flat bogs, and floating bogs in SE and SC Alaska and Aleutian Is.
IIIB	Forbs (broad-leaved herbs), Rushes (Juncaceae), Horsetails (Equisetaceae), and Ferns dominate. If not, go to IIIC.	Forb Herbaceous	Vegetation dominated by forbs (broadleaf herbs, ferns, rushes, or horsetails).
IIIB1	Forbs dominate on dry sites (often sparsely vegetated pioneer communities). If not, go to IIIB2.	Dry Forb Herbaceous	On dry sites, usually rocky and well-drained; mostly tundra sites.
IIIB1a	Open Herb communities colonizing previously unvegetated non-alpine sites.	Seral Herbs	Found throughout Alaska on floodplains, river banks, and eroding bluffs.
IIIB1b	Wide variety of herbs and sedges dominate on sites covered by late melting snow beds.	Alpine Herb-Sedge (Snowbed)	Includes a wide-variety of types below late-lying snowbanks in mountainous areas throughout Alaska.
IIIB1c	Sparse herb communities on alpine rock outcrops, talus and blockfields.	Alpine Herbs	Occur as sparse vegetation on talus and blockfields, and in some well-vegetated herbaceous meadows in alpine valleys throughout Alaska.
IIIB2	Forbs dominate on mesic soils.	Mesic Forb Herbaceous	On moist sites but without standing water, mostly within forested areas.

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Code	Key	Class	Description
IIIB2a	Mixture of herbs dominate.	Mixed Herbs	Occur on mesic slopes and streambanks throughout most of Alaska.
IIIB2b	Fireweed Epilobium angustifolium dominates.	Fireweed	Occurs on disturbed areas in SC and Interior Alaska.
IIIB2c	Tall (0.5 - 1.5 m) Umbilliferae (e.g., Heracleum and Angelica) dominate.	Large Umbel	Occurs on moist to wet areas, often along drainages, in SE and SC Alaska and Aleutian Is.
IIIB2d	Ferns (e.g., Athyrium and Dryopteris) dominate.	Ferns	Restricted to localized areas in SE and SC Alaska and Aleutian Is.
IIIB3	Forbs dominate on wet (saturated or flooded most or all of growing season) sites.	Wet Forb Herbaceous (emergent)	On wet sites, usually with standing water for part of year.
IIIB3a	Herbs (e.g., Equisetum, Menyanthes trifoliata, and Potentilla palustris) emerging from standing water (> 0.15 m deep) dominate.	Fresh Herb Marsh	Found in ponds, sloughs, and oxbow lakes in SC, SW, SE and Interior Alaska.
IIIB3b	Herbs on saturated or shallow flooded (≤ 0.15 m deep) non-peat soils dominate (in subarctic and subalpine regions within tree limit).	Subarctic Lowland Herb Wet Meadow	Found in seepage areas, ephemeral pools, pond margins and upper edges of coastal marshes on Aleutian Is. and in W, SC, and SE Alaska.
IIIB3c	Broad-leaved Herbs on saturated or shallow flooded (≤ 0.15 m deep) peat soils (often floating mat) dominate (in subarctic and subalpine regions within tree limit).	Subarctic Lowland Herb Bog Meadow	Commonly forms floating mats or occurs along margins of bog ponds in Interior, SC, and SE Alaska. Also occurs in wet areas above streams in Aleutian Is.
IIIB3d	Halophytic Herbs dominate on tidal areas inundated ≥ a few times/month by salt water.	Halophytic Herb Wet Meadow	Occurs on a variety of wet substrates on beaches and seaward parts of coastal marshes along entire Alaska coastline.
IIIC	Bryophytes (mosses and liverworts) and/or Lichens dominate. If not, go to IIID.	Bryoid herbaceous	Vegetation dominated by mosses or lichens.
IIIC1	Bryophytes (mosses and liverworts) dominate. If not, go to IIIC2.	Bryophyte	Vegetation cover dominated by mosses.
IIIC1a	Bryophytes (e.g., Gymnocolea, Scapania, and Nardia) dominate on wet sites. Vascular plants are virtually absent.	Wet Bryophyte	Occurs on a wide variety of small and localized, mostly wet sites in the southern part of Alaska.
IIIC1b	Bryophytes (e.g., Rhacomitrium, Grimmia, and Andreaea) dominate on non-wet sites. Vascular plants are virtually absent.	Dry Bryophyte	Occurs on gravelly slopes, sand dunes, and mounds. Cover usually is sparse.
IIIC2	Lichens dominate.	Lichen	Vegetation cover dominated by lichens.

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Code	Key	Class	Description
IIIC2a	Crustose Lichen species dominate.	Crustose Lichen	Occurs on extremely harsh, dry, windblown rocky sites with little or no soil development primarily in alpine regions throughout Alaska.
IIIC2b	Foliose and Fruticose Lichen species dominate. Other plant types are absent or nearly so.	Foliose and Fruticose Lichen	Occurs on dry fellfields and exposed ridges.
IIID	Plants with floating or submerged leaves dominate. Plants may also have emergent leaves and flowers.	Aquatic (nonemergent) Herbaceous	Dominant vegetation growing submerged in water or floating on water surface. Emergent (often specialized) leaves may occur.
IIID1	Aquatic communities in fresh water.	Freshwater Aquatic Herbaceous	Vegetation submerged or floating in fresh water.
IIID1a	Pondlilies Nuphar and Nymphaea dominate.	Pondlily	In fairly large ponds with mineral substrates. Widely distributed throughout SE, SC, W, and Interior Alaska.
IIID1b	Common Marestail Hippuris vulgaris dominates. Standing water may dry up for several weeks during growing season. Emergents are absent or nearly so.	Common Marestail	Found in oxbows, tundra ponds, and sluggish sloughs in SE, SC, W, and N Alaska.
IIID1c	Aquatic Buttercup Ranunculus species dominate or codominate.	Aquatic Buttercup	Occurs in shallow ponds and flooded gravel pits in SC, W, and N Alaska.
IIID1d	Burreed Sparganium species dominate.	Burreed	Occurs in shallow ponds and lakes in SE, SC, W, and N Alaska.
IIID1e	Water Milfoil Myriophyllum spicatum dominates.	Water Milfoil	Found in shallow ponds in SC, W, and Interior Alaska.
IIID1f	Pondweeds Potamogeton species dominate.	Fresh Pondweed	Present in small ponds and pools throughout Alaska.
IIID1g	Water Star-Wort Callitriche species dominate.	Water Star-Wort	Reported from shallow seasonal pools with rock bottoms on Amchika Is.
IIID1h	Aquatic Cryptogams (e.g., mosses Fontinalis, liverwort Scapania, lichen Siphula, and quillwort Isoetes) dominate.	Aquatic Cryptogam	Poorly described but probably widely distributed in shallow lakes and ponds throughout Alaska.
IIID2	Aquatic communities in brackish water.	Brackish Water Aquatic Herbaceous	Vegetation submerged or floating in brackish water.
IIID2a	Four-Leaf Marestail Hippuris tetraphylla dominates.	Four-Leaf Marestail	Occurs on deltas, tidal flats, and bays along the Alaska coastline.
IIID2b	Brackish water-tolerent Pondweed Potamogeton, Wigeongrass Ruppia spiralis, or Horned Pondweed Zannichellia palustris dominate.	Brackish Pondweed	Occurs in permanent shallow (0.10 - 0.15 m deep) brackish ponds in SE, SC, and SW Alaska.

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Code	Key	Class	Description
IIID3	Aquatic communities in marine water.	Marine Aquatic Herbaceous	Vegetation submerged or floating in salt water.
IIID3a	Eelgrass Zostera marina dominates.	Eelgrass	Occupies subtidal and low intertidal sites with clear water in bays, inlets, and lagoons from SE Alaska to the Seward Peninsula.
IIID3b	Marine Algae dominates.	Marine Algae	Found on subtidal and intertidal sites, often in exposed rocky areas on the SC, SE, and Aleutian coasts.
IV	< 2% vegetative cover.	Unvegetated	Less than 2% vegetative cover; either natural or anthropogenic.

Appendix B7.–Vegetation disturbance classes.

Code	Description
A	Anthropogenic Disturbance
AA	Unique
AA1	Timber Harvest
AA1a	0-1 year post-harvest
AA1b	1-5 year post-harvest
AA1c	10-20 year post-harvest
AA1d	20+ year post-harvest
AA2	Construction
AA2a	0-1 year post-construction
AA2b	1-5 year post-construction
AA2c	10-20 year post-construction
AA2d	20+ year post-construction
AA3	Enhancement/Restoration
AA3a	Bank Stabilization
AA3b	Riparian Thinning
AA3c	Fisheries Related
AA3d	Rip-Rap
AB	Repeated Seasonal
AB1	Foot Traffic
AB1a	Anglers
AB1b	Non-anglers
AB2	Vehicle Traffic
AB2a	Non-Recreational (road vehicle)
AB2b	Recreational (ATV, snowmachine)
AC	Permanent
AC1	Pervious Surfaces
AC1a	Urban/Commercial Landscaping
AC1b	Agricultural
AC1c	Gravel
AC1d	Other
AC2	Impervious Surfaces
AC2a	Parking Area
AC2b	Paved Trail/Walkway
AC2c	Concrete Wall/Abutment
N	Natural Disturbance
NA	Water/Flood
NA1	Slumping/Undercutting
NA1a	Wood Inputs
NA1b	Sediment Inputs
NA2	Sediment deposition from tributary
NB	Windthrow
NC	Glacial Retreat
ND	Fire
NE	Mass Wasting
NE1	Avalanche
NE2	Landslide
NE3	Debris Torrent
NE4	Natural Tree Mortality

APPENDIX C. TARGET STREAM LOCATIONS

Appendix C1.–*Mainstem* target-stream location information (NAD83 datum).

Base camp	Reach ID	Stream name	Latitude	Longitude	Distance from base (miles)[a]
Alagnak Lodge (7/28–8/8)	MA02	Koktuli River	59.997	-156.217	67
	MA03	Nushagak River	60.485	-156.980	101
	MA04	Chilikadrotna River	60.586	-154.870	125
	MA05	Mulchatna River	60.706	-155.219	127
Dillingham (8/8–8/19)	MD01	Kokwok River	59.415	-157.800	35

[a] Straight-line distance from the base camp to the upstream terminus of the target stream segment.

Appendix C2.–*Intermediate* target-stream location information, (NAD83 datum).

Area	Stream ID	Distance to AWC (km) [a]	Upstream terminus Latitude	Upstream terminus Longitude	Downstream terminus Latitude	Downstream terminus Longitude	Distance from base (miles) [b]
Alagnak Lodge (7/28-8/8)	IA04	29	59.831	-157.144	59.712	-157.169	57
	IA06	0	60.444	-155.460	60.444	-155.460	107
	IA09	0	59.333	-156.302	59.333	-156.302	25
	IA11	0	59.395	-156.566	59.395	-156.566	25
Dillingham (8/8-8/19)	ID01	67	60.153	-159.466	60.080	-158.609	85
	ID02	52	59.146	-157.275	59.206	-157.632	43
	ID03	32	59.068	-157.038	59.006	-156.902	51
	ID05	3	58.8822	-158.063	58.887	-158.033	18
	ID07	0	58.866	-157.958	58.866	-157.958	22
	ID08	0	59.731	-157.345	59.731	-157.345	62
	ID10	0	59.158	-159.046	59.158	-159.046	22

[a] Stream distance between the 200–sq km pour point and the upper extent of AWC coverage.
[b] Straight-line distance from the base camp to the upstream terminus of the target stream segment.

Appendix C3.–*Headwaters* target stream location information (NAD83 datum).

Area	Stream ID	Distance to AWC (km)[a]	Latitude	Longitude	Distance from base (miles)
Alagnak Lodge	HA04	45	59.898241	-157.132354	61
(7/28-8/8)	HA06	41	59.872109	-157.055076	59
	HA14	19	59.698634	-156.709416	46
	HA15	19	59.379313	-156.274456	28
	HA17	16	59.458963	-156.893064	29
	HA22	14	59.873603	-156.879777	58
	HA23	14	59.171547	-156.870591	10
	HA24	13	60.326879	-156.585871	89
	HA27	12	59.321929	-157.049622	23
	HA34	10	59.649367	-156.793065	42
	HA35	10	60.539651	-156.161432	106
	HA38	9	60.750981	-154.675346	138
	HA39	9	60.411056	-156.605678	95
	HA41	8	59.999972	-157.512155	72
	HA43	8	60.125659	-156.451315	76
	HA44	8	60.390338	-157.080139	94
	HA47	7	60.012465	-156.475857	68
	HA53	5	59.999200	-157.289441	69
	HA54	5	60.718173	-154.430810	141
	HA55	5	60.179359	-155.960181	83
	HA56	4	60.574201	-156.494574	107
	HA57	4	59.957659	-157.252925	66
	HA58	4	60.514679	-156.277155	103
	HA61	4	60.489986	-156.591173	101
	HA64	4	59.851400	-156.518664	57
	HA66	4	60.191985	-156.168940	82
	HA68	4	60.103462	-156.247603	76
	HA69	4	60.525981	-157.317572	105
	HA71	4	59.539801	-156.755151	35
	HA74	3	60.736265	-155.051524	131
	HA75	3	59.241697	-156.781509	14
	HA79	2	60.721294	-155.237548	127
	HA82	2	60.364744	-157.491872	96
	HA84	2	60.451708	-156.052674	101
	HA85	2	59.590063	-156.765698	38
	HA86	2	60.356465	-155.593695	99
	HA87	2	59.390620	-156.774742	24
	HA88	1	59.879980	-156.288930	60
	HA91	<1	59.399325	-156.557973	25
	HA93	<1	59.931166	-155.744513	71
	HA94	<1	59.263776	-156.370200	20

-continued-

[a] Stream distance between the 50–sq km pour point and the upper extent of AWC coverage.

Area	Stream ID	Distance to AWC (km)[a]	Latitude	Longitude	Distance from base (miles)
Alagnak Lodge	HA97	0	59.871089	-156.597630	58
(continued)	HA98	0	59.817463	-156.552611	54
	HA99	0	59.523706	-156.928481	34
	HA103	0	60.640103	-155.032988	125
	HA105	0	60.102429	-156.545471	74
	HA106	0	60.853228	-154.718491	144
	HA108	0	60.276169	-155.851101	91
	HA109	0	60.090465	-157.180455	74
	HA111	0	59.504768	-156.157956	38
	HA112	0	59.689958	-155.451644	63
	HA114	0	60.360408	-156.750165	92
	HA115	0	60.020305	-156.096057	71
	HA117	0	60.196626	-156.711435	80
	HA119	0	60.542738	-156.839210	104
	HA120	0	59.669855	-156.141378	48
	HA122	0	60.017008	-156.964725	68
	HA125	0	59.357609	-156.363037	25
	HA126	0	60.508130	-155.782069	107
	HA127	0	60.348262	-156.340862	92
	HA128	0	59.472707	-156.483836	31
	HA129	0	59.286243	-156.600673	17
	HA130	0	60.694625	-155.334672	124
	HA133	0	60.444814	-157.395839	100
	HA134	0	60.796392	-154.895307	137
	HA135	0	59.745019	-156.301074	51
	HA136	0	60.592270	-155.008380	123
	HA137	0	60.721019	-157.259189	118
	HA139	0	60.538786	-155.511000	112
	HA140	0	60.579699	-155.171159	120
	HA145	0	59.263883	-156.897470	17
	HA146	0	59.890349	-156.082448	63
	HA147	0	60.352543	-155.363792	103
	HA148	0	59.542488	-156.368637	37
	HA149	0	60.583918	-156.947852	107
	HA152	0	60.142013	-156.994455	77
	HA153	0	59.673659	-155.563185	60
	HA155	0	60.595804	-157.425981	111
Dillingham	HD01	74	59.058796	-157.255009	43
(8/8-8/19)	HD02	66	59.192858	-157.089658	50
	HD03	56	59.167944	-157.230727	45
	HD05	42	58.986944	-157.415898	37

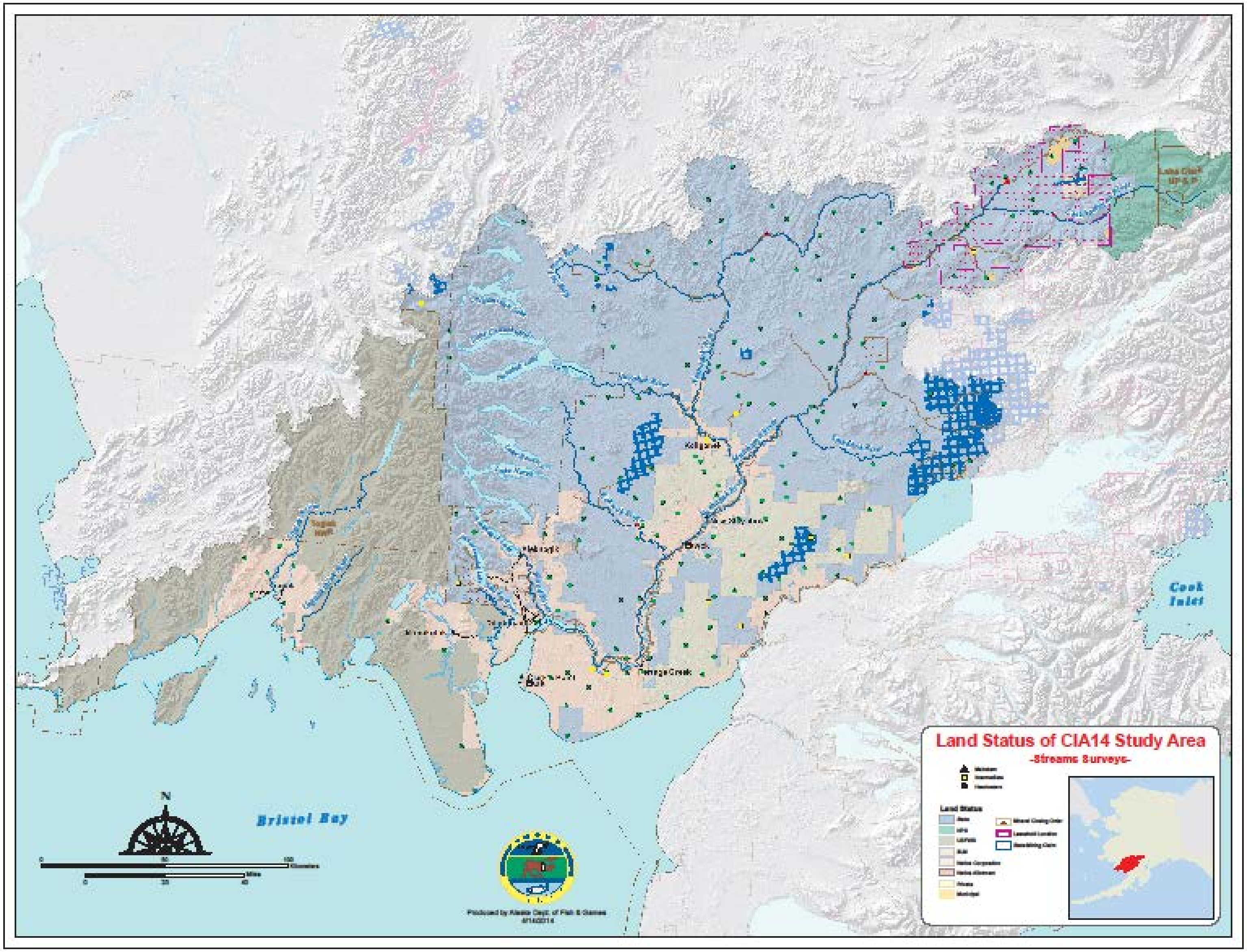
-continued-

[a] Stream distance between the 50–sq km pour point and the upper extent of AWC coverage.

Area	Stream ID	Distance to AWC (km)[a]	Latitude	Longitude	Distance from base (miles)
Dillingham	HD77	3	59.182348	-160.564550	75
(continued)	HD78	3	59.675059	-158.240187	45
	HD80	2	59.572780	-157.950165	41
	HD81	2	60.291481	-158.212698	87
	HD83	2	58.415342	-158.818545	45
	HD89	1	58.936550	-157.666349	29
	HD90	1	59.312018	-157.292184	45
	HD92	<1	58.727556	-157.717890	34
	HD95	<1	59.003003	-159.521445	38
	HD96	0	59.508569	-157.831258	39
	HD100	0	59.451950	-157.083232	56
	HD101	0	59.617016	-157.722949	48
	HD102	0	59.461776	-157.525425	44
	HD104	0	59.421740	-158.192227	28
	HD107	0	59.870493	-157.851603	62
	HD110	0	59.637874	-158.158433	43
	HD113	0	59.535466	-157.251298	55
	HD116	0	58.875478	-157.816603	26
	HD118	0	58.873994	-157.963859	21
	HD121	0	59.341876	-158.217795	23
	HD123	0	59.405195	-159.098898	34
	HD124	0	60.352496	-157.918352	93
	HD131	0	60.350434	-158.201183	91
	HD132	0	60.050037	-158.058869	72
	HD138	0	59.047480	-160.490443	72
	HD141	0	59.357448	-158.461658	22
	HD142	0	59.346968	-158.961628	28
	HD143	0	59.146242	-157.758616	26
	HD144	0	59.177650	-158.257449	12
	HD150	0	58.840648	-158.347600	15
	HD151	0	60.398699	-157.844018	97
	HD154	0	59.037152	-158.476830	1
	HD156	0	60.186591	-158.218533	80

[a] Stream distance between the 50–sq km pour point and the upper extent of AWC coverage.

APPENDIX D. LAND STATUS MAP



Appendix D1.–Study area land status map.

APPENDIX E. SAFETY PROTOCOLS

Appendix E1.–Flight safety.

Introduction:
This appendix was adapted from material provided by Coastal Helicopters and Greens Creek Mine, and is used by permission. The purpose of this information is to provide employees with safe practices in and around helicopters.

Pre-Flight Briefing

1. The aircraft pilot is in charge of all passengers. The pilot is responsible and accountable for all aspects regarding the safe operation and performance of the aircraft in flight or on the ground.
2. Transport of Cargo: Field Gear is controlled by and at the discretion of the pilot. Always inform the pilot about any weapons or other potentially hazardous items to be taken on board the aircraft, especially aerosol deterrents such as "Bear Pepper Spray". Items such as these should be isolated and transported in sealed containers.
3. Passengers riding in the front seat should never ride with items larger than a map board in their hand. Bulkier items should be stowed in the cargo bay or on the rear seats.
4. Have daily supplies and equipment needs planned ahead of time, so loads can be properly stowed prior to boarding the aircraft.
5. Know the location and operation of seat belts, harnesses, doors and hatches that may have to be operated during an emergency.
6. Know and understand the use of the intercom system.
7. Know the location and operation of all emergency and survival equipment on board appropriate for the type of flight operation conducted. This includes the fire extinguisher, emergency fuel shut-off, and the ELT (emergency locator transmitter) and emergency floatation devices.
8. Smoking and open flames are not permitted within 100 feet of the aircraft, fuel tanks or landing sites containing either.

Personal Protection for Flight

1. Hearing protection is mandatory.
2. Natural fiber clothing (wool, cotton, etc) offer better protection than synthetics in case of fire.
3. PFDs should be worn for extended overwater flights.

Approaching and Departing the Helicopter

Always keep your eyes on the ship during landings and takeoffs. When performing these critical tasks, your observations and awareness will protect you and others from unnecessary risk while the helicopter is in operation.

NEVER TURN YOUR BACK TOWARD THE AIRCRAFT!

- Always wait for the pilot's acknowledgement, command or signal before approaching or departing the aircraft.
- Always approach and depart the aircraft the within the pilot's field of view.
- Crouch low when approaching or departing under the main rotor.

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- In side-hill situations always approach and depart from the aircraft from the DOWNHILL SIDE.
- NEVER approach or depart the aircraft from the rear.
- Always stay alert when near the aircraft, but DON'T RUSH! Be deliberate and think your actions through (don't let the noise and air blast make you hasty!).
- Ensure that no loose objects can be sucked, blown, or thrown into the rotor system; ensure that loose personal items such as hats (including hard hats), jackets, clipboards, folders, maps, etc. are secure.
- Always check and then double check for loose exterior items or loads.
- To avoid contact with the main rotor blades, long pieces of equipment or tools (e.g., electrofishing poles, dip net handles) should be carried horizontally at or below waist level. Equipment or tools of this type should never be carried upright and/or over the shoulder.
- NEVER THROW OR TOSS anything from or toward the aircraft.
- Eye protection must be worn at all times near the aircraft. If suddenly blinded by dust, stop and crouch down or, better yet, sit down and wait for help.

Entering the Helicopter

1. When entering the aircraft, confirm the pilot acknowledges your approach, use caution, the doors are fragile (and expensive pieces of equipment). Do not put your weight on the doors and do not use the doors as handles for hoisting or lowering yourself into or from the aircraft. Close doors snugly so that all latches are engaged and check to ensure that interior loads will not damage the doors when shut.
2. Once in the aircraft, fasten your seatbelt and (if present) shoulder harness. Put on and secure the headset. Rear seat passengers should notify the pilot when they are secured that they are ready.
3. The pilot and passengers must ensure that all equipment on board in the cockpit is securely stowed before taking off.

Exiting the Helicopter

1. Wait until the pilot has giving you permission to exit the aircraft. Follow any special instructions that the pilot gives you.
2. When landed, remove the headset and seat/shoulder belts.
3. Retrieve any equipment stored in the cockpit or cargo hold, being cautious of the main rotor at all times. Carry equipment and loads horizontally. Secure loose clothing, equipment etc.
4. Depart downhill if the landing site is on a hill and always walk around the front of the aircraft to avoid the area of lowest rotor clearance.
5. Enter or Exit on the Downhill Side
6. NEVER ATTEMPT TO WALK AROUND THE REAR OF THE AIRCRAFT TO AVOID LOW MAIN ROTOR CLEARANCE ON A HILL!
7. Use caution if the landing surface is slippery or wet.
8. Move as far away as possible from the helicopter to offer the maximum amount of take-off room possible. If it is a tight remote landing zone, the pilot may command you to crouch down next to the aircraft/skids as the take-off is performed.

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9. If the helicopter departs the sampling site for fuel or other reasons, reconfirm the time and place for the next pick-up; have a contingency plan and alternate-landing zone in case the weather is down or the helicopter fails to show for a pick-up.

In-flight

1. Be extra eyes and ears for pilot. Observe your surroundings and airspace at all times. Watch for hazards while landing and taking off. Warn the pilot of any unusual circumstances regarding the safety of the aircraft.
2. Wear your seatbelt and shoulder harness at all times during the flight.
3. Ensure to keep communication over the intercom to a minimum so as not to distract the pilot.

Remote Landing Zone Sites & Operations

1. Each LANDING ZONE selected by the crew leader will be inspected and approved by the pilot before landing.
2. All landing sites are at the complete discretion of the pilot
3. Exit or enter a hovering aircraft one at a time in one smooth, unhurried motion.

Finding and Preparing Suitable Landing Zones:

Do……

a. Select a spot that is relatively flat and open. The clearing needs to be wide enough to allow safe approach and departure angles for the aircraft at all times.

b. The pilot has absolute final say on the appropriateness of the landing site. If the pilot cannot land there, search for an alternative suitable Landing Zones.

c. Position yourself in such a way that you are not in the direct path of the aircraft and so that you have an accessible escape route should something go wrong.

Do Not……

d. Do not select a Landing Zones with abundant small trees or other hazards that could inadvertently obstruct the tail rotor.

e. Do not select a Landing Zones with abundant loose material on the ground.

f. Do not select a Landing Zones where the placement of the tail rotor will endanger other individuals or strike other objects.

g. Do not demand the pilot to land at a site that is not desirable or presents unacceptable risks, give only suggestions and trust the judgment of the pilot.

Refueling Operations

1. No smoking or open flames are allowed within 100 feet of the aircraft or fuel storage tanks.
2. The aircraft and fueling tanks should be grounded to dissipate static electricity.
3. If a spill occurs, the helicopter company will follow its emergency spill response plan.

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4. Ground power units should not be connected or disconnected during refueling.
5. Fuel servicing personnel should not carry lighters or matches when refueling.
6. At the first sight of lightning in the area, refueling operations should be suspended.
7. Refueling should not be conducted with passengers on board.

Slinging Equipment

1. Slinging will be an unusual event most often used to transport fuel drums to and from remote fuel stashes.
2. The pilot shall ensure that all persons are briefed before takeoff on all pertinent procedures to be followed (including normal, abnormal, and emergency procedures) and equipment to be used during the external-load operation.
3. Have all loads and pick-ups planned out ahead of time so that the operation can proceed smoothly.
4. The pilot will determine the sites and both ends of the operations and of all loads being transported (must be well within the aircraft's lifting ability). All slings must be furnished by the aircraft company.
5. All verbal commands and hand signals will be reviewed and confirmed before operations take place.
6. The slinging of loads must be pre-planned so the load flies in the intended manner, and ensures that nothing will cause the load to hang up, get caught, or have articles come loose during flying. When an inbound load is spinning on the sling the pilot should set it down near the destination to stop the spinning, then bring it to the unload point. Do not attempt to grab a spinning load.
7. Helicopter slung loads will often build up static electricity that will give a shock to the individual unhooking the sling. Use either insulated gloves and/or have the pilot discharge the line first by touching the ground.
8. Never go underneath a slung load.
9. Do not reach for a load as you may over reach and lose balance. Let the pilot bring the load to you.
10. Always have an escape route in the event of sudden and unexpected movement of the load so that you can quickly get away from the area.

Flight Following Procedures

1. Pilots will abide by their company's procedures for flight following.

Flight Plan and Overdue Aircraft Procedures

1. Each morning at base camp, each team leader will fill out a daily flight plan, which will include the date, aircraft type, tail number, color, company name, pilot and crewmembers' names, destinations (target stream IDs) listed in the order to be visited, and time due back.
2. During the day, the team leader will check in with the base camp by radio or satellite phone, if any deviation from the flight plan occurs.

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3. If a helicopter is overdue, base camp staff will initiate the following overdue aircraft procedures:
    a. 10 minutes past due: Base camp personnel will begin a communications search. Attempt contact with the helicopter via radio and/or Iridium phone.
    b. 30 minutes past due: Base camp personnel will continue attempting contact with the overdue helicopter. If the 2nd project helicopter and/or other teams are still out, also attempt contact with them to notify them of the overdue helicopter and obtain its last-known location. If airborne, the 2nd helicopter pilot will also attempt radio contact with the overdue helicopter.
    c. 60 minutes past due:
        i. Check in with helicopter company (Coastal Helicopters **800-789-5610** or **907-789-5600**; Quicksilver Air **907-457-1941)** to notify them of the overdue helicopter and see if they have been in contact with the pilot. Obtain last-known location from helicopter company (Coastal has automatic flight following; Quicksilver uses a spot indicator activated by the pilot).
        ii. Aircraft is declared "Missing". Notify State Troopers in King Salmon (**907-246-3307**) or Dillingham (**907-842-5641**) to activate Search and Rescue. Continue attempting to contact the helicopter. State Troopers will coordinate all search and rescue activities, including any search flights to be made by the second project helicopter.

Emergency Procedures

1. Respond and obey to all instructions or commands given by the pilot.
2. Passenger Position: The passenger's body position is an important factor in a survivable accident. The "brace-for-impact" position is used to reduce secondary impact and flailing around. If contact with the aircraft interior is likely, the passenger should place his/her body against what the passenger will hit before the impact occurs. If a passenger is resting against the surrounding structure, he/she can "ride the structure down" during the crash, thus avoiding a secondary impact. In addition, this position will reduce the forces acting on the body and can help reduce the severity of injuries. If a passenger is in a seat equipped with a shoulder harness and a safety belt, the harness should be snug, not slack.
3. After a forced landing, follow the pilot's instructions. Exit the aircraft immediately, unless there is danger from the rotor blades or directed not to do so by the pilot.
4. Emergency Water Landing. Passengers should follow the instructions of the pilot in the event of a forced landing in water. Use life vests when clear of the aircraft. If the life raft lanyard is dangling loose the pilot and passengers should exercise extreme caution not to accidentally pull the lanyard or allow it to become entangled with the aircraft.
5. If practical, retrieve the emergency and survival gear, and ensure that the ELT is transmitting.
6. If practical, and the pilot is incapacitated, activate the emergency fuel shutoff valve.
7. If available, activate a personal locator beacon.
8. Administer first aid to those in need.
9. Assess the situation: determine the need to evacuate the injured individuals, determine the nearest landing zone and the easiest route to safety.).

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Evacuation Procedures

1. On an Iridium satellite phone, dial "**911**" and press "OK". The call will be routed to the nearest public safety location. You may also contact the State Troopers in King Salmon (**907-246-3307**) or Dillingham (**907-842-5641**) for medical assistance, to request an air ambulance, or any other special medivac needs. If an Iridium phone is not available, attempt to contact anyone by VHF radio:

   Emergency Channels
   Red Button labeled "**121.5**" – This is an emergency frequency monitored by all. Press and **hold button** until display shows the entire frequency.

   **The following are Air Traffic Control frequencies that overhead/line-of-sight aircraft may be listening too. If ATC is talking to them on these frequencies, you would not hear the ATC transmission, but you may hear responses from aircraft. If the aircraft is listening to a transmission from ATC, they would not hear you at the same time, so wait for a break in the communications & keep trying.*
   Chan 4. = Bethel ATC – 125.2 MHz
   Chan 5. = Cap Newenham ATC – 124.2 MHz
   Chan 6. = Dillingham ATC – 132.75 MHz

2. Be prepared to provide the following information:
   a. Nature of the emergency and evacuation urgency (e.g., urgent evacuation—life or limb threat);
   b. Number of victims and basic diagnosis of injuries (e.g., "internal bleeding and loss of consciousness");
   c. GPS coordinates for the injured person's location;
   d. Injured person's full name, date of birth, and weight;
   e. Name and weight of escort (if any) who will ride along in the medivac;

3. As an alternative to waiting for a medivac to arrive, if the accident occurred during daylight hours and an aircraft is available, ***coordinate with State Troopers*** to fly the victim to the nearest or most appropriate hospital (likely Dillingham or Anchorage). Contact the hospital emergency room at the contact number advised by the trooper ASAP to provide the ETA and to request an accepting physician.

4. Contact base camp personnel. Base camp personnel will contact the Field Supervisor. The Field Supervisor (or base camp personnel, if Field Supervisor cannot be reached) will contact victim's emergency contact(s) listed on the project contact sheet.

This guidance is commensurate with material contained in the following aviation safety documents:

• Federal Aviation Administration – AC 61-13B - Helicopter Handbook.

• Federal Aviation Administration – AC 91-32B – Safety In and Around Helicopters

• United States Government – Interagency Helicopter Operations Guide

Appendix E2.–Bear safety.

The following outline, used by permission, accompanies the video *Staying safe in bear country*, which will be mandatory viewing for all field crew members.

Main Messages of the Video

STAYING SAFE IN BEAR COUNTRY

Safety in Bear Country Society, 2001

BEAR'S CHARACTERISTICS, BEHAVIOR AND SOCIETY

MIND OF BEARS

- ☐Bears are intelligent.
- ☐Curious
- ☐Individuals
- ☐More predictable than most people think.

PHYSICAL TRAITS

- ☐Amazing noses and ears and eyes are good.
- ☐Strong and fast, good swimmers.
- ☐Black bears are great at tree climbing, but grizzlies are not bad.

BLACK VS GRIZZLY BEARS

- ☐Grizzly distribution more limited but locally can be the most abundant.
- ☐Grizzlies more likely to attack when threatened.
- ☐Black bears rarely attack defensively.
- ☐Grizzlies more dangerous than blacks, but risks from either much less than people tend to fear.
- ☐Humans are more tolerant of black bears.

BEAR SOCIETY

- ☐Flexible social structure that allows bears to function at low densities or at concentrated food sources with reduced chance of injury.
- ☐Bears do fight but more often use avoidance, restraint, and posturing to prevent injury.

THREE MAJOR ASPECTS OF BEAR SOCIETY

- ☐Body language and vocalizations to communicate with each other
- ☐Dominance hierarchy or pecking order
- ☐Personal space

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BEARS' MOTIVATIONS

Bears have varying motivations for what they do.

- Food and the search for it dominate a bear's life
- Mating and raising offspring
- Investigating novel stimuli; curiosity
- Establishing and asserting dominance

From a safety standpoint it's important to understand the difference between "defensive" and other motivations, especially ones that might lead to "predatory" attack. It is also important to understand the psychology of bears as they grow up. There's a big difference in the mentality of a recently weaned 2 to 4 year old bear versus an adult female with cubs or an adult male.

BEAR-HUMAN INTERACTIONS

Most bears have previous experience around people and learn from each interaction. Humans usually don't even know they came close to a bear, BEARS USUALLY AVOID PEOPLE. Two major categories of bear-human interactions where bears don't avoid or even approach people: Defensive and Non-defensive.

DEFENSIVE INTERACTIONS

- Bear thinks you are a threat to itself, its cubs or its food.
- Usually you approached it and entered into its personal space, surprising or crowding it.
- Most likely will appear agitated and stressed.
- Closer you are to it before it becomes aware of you, more likely it is to react defensively.
- Almost always stop short of contact, fight/flight is triggered.
- Defensive response that results in an attack (physical contact) almost always involve grizzly bears surprised at close range, on a carcass or protecting young. The few defensive attacks by black bears have been females protecting cubs (but these are very rare).

NON-DEFENSIVE INTERACTIONS

A number of different non-defensive motivations that may appear similar to each other:

- Curious bear
- Human-habituated bear
- Food-conditioned bear
- Dominance-testing bear
- Predatory bear

AVOIDING BEAR ENCOUNTERS OR REACTING DURING ONE

AVOID BEARS WHENEVER POSSIBLE

LET BEAR YOU CANNOT AVOID KNOW YOU ARE HUMAN by talking and slowly waving your arms. Try to give the bear your scent

AVOID BEARS THAT ARE AWARE OF YOU AND UNCONCERNED

NEVER APPROACH A BEAR

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LEAVE AREA YOU ENCOUNTERED A BEAR

IF YOU HEAR VOCALIZATIONS OR SEE UNATTENDED CUBS…be extremely cautious and leave the area silently the way you came.

Review of your response during bear encounters:

- ☐Identify yourself as human to bears you cannot avoid by talking and slowly waving your arms. Try to give the bear your scent.
- ☐Increase your distance from the bear, even if it appears unconcerned.
- ☐Do not run, it could invite pursuit.

If a bear approaches you:

- ☐Stand your ground!
- ☐Quickly assess the situation. Is the bear behaving defensively or in some other way?
- ☐Remain calm, attacks are rare.
- ☐Do not run unless you're absolutely sure of reaching safety.
- ☐Group together. Prepare your deterrent

If the bear is approaching in a defensive manner:

- ☐Stand your ground. Try to appear non-threatening.
- ☐Don't shout at the bear. Talk to the bear in a calm voice.
- ☐If the bear stops its approach, increase your distance.
- ☐If the bear resumes its approach, stand your ground, keep talking calmly, and prepare to use your deterrent.
- ☐If the bear cannot be deterred and is intent on attack, fall to the ground as close to contact as possible and play dead.
- ☐When the attack stops, remain still and wait for the bear to leave. If an attack is prolonged or the bear starts eating you, it is no longer being defensive.

If the bear approaches in a non-defensive manner:

- ☐Talk to the bear in a firm voice.
- ☐Try to move away from the bear's travel path; that may be all it wants you to do.
- ☐If the bear follows you with its attention directed at you. Stop! Stand your ground and prepare to use your deterrent.
- ☐Act aggressively toward the bear. Let the bear know you will fight if attacked. Shout! Make yourself look as big as possible. Stamp your feet as you take a step or two toward the bear. Threaten the bear with whatever is at hand. A bear that is initially curious or testing you may become predatory if you do not stand up to it. The more the bear persists, the more aggressive your response should be.
- ☐If the bear attacks, use your deterrent and fight for your life. Kick, punch, or hit the bear with whatever weapon is available. Concentrate your attack on the face, eyes, and nose. Fight any bear that attacks you in your building or tent.

Remember:

- ☐If an attack (that is, physical contact is made) is defensive… Play dead. (Don't play dead before you have used all possible means, such as deterrents to prevent an attack).

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- ☐If the attack is predatory… Fight back.

HELPING SOMEONE BEING ATTACKED

You may be able to drive away an attacking bear from someone else, but if you do this you risk drawing the attack to yourself.

DETERRENTS AND PREVENTING PROBLEMS

DETERRENTS

BEAR SPRAY

- ☐Used to deter bears at close range.
- ☐It is not 100 percent effective or a substitute for avoiding an encounter.
- ☐Use only approved bear sprays.
- ☐Carry it ready to use and keep it handy in your tent at night.
- ☐Exercise caution

FIREARMS

- ☐Make sure it's adequate
- ☐Practice
- ☐Mentally rehearse the situations where you would use it.

DETERRENTS IN GENERAL

- ☐Know their capabilities and limitations.
- ☐Can be useful but should not give you a false sense of security.
- ☐Training and practice are essential.
- ☐Observe regulations governing their transport and use.
- ☐Consult with local authorities.

PREVENTING BEAR PROBLEMS

Most of bear safety is prevention.

LEARN ABOUT BEARS

AVOID ENCOUNTERS

- ☐Move away undetected from bears that are unaware of you or distant.

STAY ALERT

- ☐Be aware of your surroundings.

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☐Look for signs of recent bear activity.

DON'T SURPRISE BEARS

☐Warn bears of your presence.

TRAVEL IN A GROUP

☐Groups are noisier and easier to detect and several people are more intimidating to a bear.

KEEP CHILDREN CLOSE

DOGS

☐Keep it on a leash or leave it at home. The exception is a specially trained dog, but most dogs are not.

CHOOSE CAMPSITES CAREFULLY

☐Don’t camp on bear travel routes
☐Use local knowledge of bears and recommended camping practices.

DON'T ATTRACT BEARS OR REWARD THEM WITH FOOD

☐Keep a clean camp free of attractants.

OTHER DETECTION/DETERRENT OPTIONS

☐Trip wires, motion detectors and compact electric fences can be useful

FIRST AID

☐Be proficient in first aid.
☐Carry sufficient medical supplies.

COMMUNICATION

☐Inform others of your plans.
☐Communication can save lives.

Appendix E3.–Electrofishing safety.

All electrofishing crew leaders are required to have attended an approved electrofishing course. Other electrofishing crewmembers will receive an electrofishing orientation (see Appendix E4) and be directly supervised by the crew leader at all times while electrofishing. All crewmembers will be certified in 1st Aid and adult CPR.

The following was adapted from McCormick and Hughes, 1998:

Because fishes are collected using electrofishing units, safety procedures must be followed meticulously at all times. Primary responsibility for safety while electrofishing rests with the electrofishing team leader. Electrofishing units have a high voltage output and may deliver a dangerous electrical shock.

While electrofishing, avoid contact with the water unless sufficiently insulated against electrical shock. Use chest waders or hip boots with nonslip soles and watertight rubber (or electrician's) gloves. If they become wet inside, **stop fishing until they are thoroughly dry. Avoid contact with the anode and cathode at all times due to the potential shock hazard.** If you perspire heavily, wear polypropylene or some other wicking and insulating clothing instead of cotton.

While electrofishing, avoid reaching into the water. If it is necessary for a team member to reach into the water to pick up a fish or something that has been dropped, **do so only after the electrical current has been interrupted and the anode is removed from the water**. Do not resume electrofishing until all individuals are clear of the electroshock hazard.

Avoid operating electrofishing equipment near unprotected people, or non-target animals. Discontinue activity during thunderstorms or heavy rain.

Team members should keep each other in constant view or communication while electrofishing. Although the electrofishing team leader has authority, each team member has the responsibility to question and modify an operation or decline participation if it is unsafe.

Appendix E4.–Acknowledgment of electrofishing orientation.

Acknowledgment of Electrofishing Orientation

I have received instruction and orientation about Electrofishing from my employer. As a result, I understand and accept the following conditions:

1. Electrofishing (EF) is an inherently hazardous activity in which safety is the primary concern. The electrical energy used in EF is sufficient to cause death by electrocution.
2. During operations, it is critical to avoid contact with the electrodes and surrounding water. The EF field is most intense near the electrodes and can extend 5-10 m outward.
3. The electrodes are energized by the power source, a generator or battery, and controlled by safety switches; these switches must remain off until the signal is given to begin EF.
4. The power source has a main switch that must be turned off immediately if an emergency occurs.
5. The electrodes are usually metal probes suspended in the water. If direct current is issued from a boat, the anodes (+) are in front of the boat to catch fish and the cathodes (-) may be suspended from the sides; both can produce electroshock. When a metal boat is the cathode, the boat is safe as long as all metal surfaces inside it are connected to the hull.
6. Moveable anodes on a boat are dangerous, especially on metal boats. All electrodes on a conventional EF boat should be in fixed position during operation.
7. Dry skin and clothing are good protection against electroshock. The body should be fully clothed during EF. Rubber knee boots are minimal foot protection, as are rubber gloves for the hands. A personal flotation device must be worn when the water is considered swift, cold, or deep. Ear protection is necessary for those working near the generator.
8. At least 2 members of the EF crew must have knowledge of CPR and first aid. A first aid kit and, in an EF boat, a fire extinguisher must be within immediate reach during an operation. Electroshock can cause heart fibrillations or respiratory arrest; CPR can cure only the latter. The EF crew must know the location of the nearest defibrillation unit.
9. A communication system, particularly hand signals, must be available to all members of an EF crew. When multiple anodes are used in a portable EF operation, the buddy system must be used. Above all, NEVER OPERATE ALONE.
10. Stunned fish should be removed from the EF field as soon as possible and not subjected to continuous electroshock by being held in the dip net. Using the anode as a dip net is unhealthy for fish and people and should be avoided.
11. An EF operation should proceed slowly and carefully; avoid chasing fish and other sudden maneuvers. Night activities require bright, bow-mounted headlights. Operations should crease during lightning or thunderstorms; use discretion during rain. Avoid EF too close to bystanders and pets or livestock.
12. All EF crewmembers must know who their leader is and recognize his or her authority as final in operational decisions. However, every crewmember has the right to ask questions or express concern about any safety aspect of an EF operation. A crewmember has the right to decline participation in an EF operation, without fear of employer recrimination, if he or she feels unsafe in such participation.

____ __________

Signature of Employee Date

I have discussed the above-named conditions with the employee and am satisfied that he or she understands them.

____ __________

Signature of Supervisor Date

*Adapted from Reynolds (1996), with permission.

APPENDIX F. EQUIPMENT LISTS

Appendix F1.– Field equipment list.

Group	Item	Estimated wt (lb)	Team-A (cataraft) qty	Team-A (cataraft) Total wt (lb)	Team-C (headwaters) qty	Team-C (headwaters) Total wt (lb)	Spare qty	Spare Total wt (lb)
crew gear	bug dope: 30-40% DEET	0	1	0	1	0	4	0
crew gear	bug dope: 90% DEET	0	1	0	1	0	4	0
crew gear	clipboard – metal	0	1	0	1	0	0	0
crew gear	dry bag	0.5	1	0.5	1	0.5	1	0.5
crew gear	ear plugs	0	2	0	2	0	20	0
crew gear	field notebooks - Rite in the Rain	0	2	0	2	0	4	0
crew gear	field data sheets	0.5	40	0.5	0	0	10	1
crew gear	wader repair kit	0.25	1	0.25	1	0.25	2	0.50
crew gear	head nets; black	0	2	0	2	0	0	0
crew gear	marker - Sharpie fine, mixed colors	0	2	0	2	0	4	0
crew gear	marker - Sharpie ultra fine, mixed colors	0	2	0	2	0	4	0
crew gear	pencil (9-mm mechanical)	0	2	0	2	0	6	0
crew gear	PFD	2	2	4	0	0	1	2
crew gear	radio - battery for ICOM IC-A6	0.25	1	0.25	1	0.25	4	1
crew gear	radio – ICOM IC-A6	1	1	1	1	1	1	1
crew gear	rubber gloves	0.5	2	1	2	1	4	2
crew gear	sun block	1	1	1	1	1	0	0
crew gear	sunglasses, polarized	0	2	0	2	0	0	0
crew gear	survival knife	0	2	0	0	0	0	0
crew gear	whistle	0	2	0	2	0	0	0
electrofisher	1-gal gas can for GPP 2.5	1	1	1	0	0	0	0
electrofisher	anode ring, 11-inch	1	0	0	1	1	2	2
electrofisher	anode rod, LR-24; 6-ft	0	0	0	1	3	2	6
electrofisher	anode spider array for GPP 2.5	5	2	10	0	0	1	5
electrofisher	cathode for LR-24	0	0	0	1	0.5	2	1
electrofisher	dipnet with 6-ft fiberglass handle	5	1	5	1	5	2	10
electrofisher	electrofisher - Smith-Root GPP 2.5 (generator; control box; cables; foot switch, anode poles)	120	1	120	0	0	0	0
electrofisher	electrofisher - Smith-Root LR-24	0	0	0	1	18	2	36
electrofisher	electrofisher battery adapter cable	0	0	0	0	0	2	0
electrofisher	electrofisher battery, 24V, 7-aH	12.2	0	0	0	0	2	24.4
electrofisher	electrofisher battery, Lithium 24V, 9.6 aH	5.5	0	0	2	11	2	11
electrofisher	fire extinguisher	10	1	10	0	0	0	0

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			Team-A (cataraft)		Team-C (headwaters)		Spare	
Group	Item	Estimated wt (lb)	qty	Total wt (lb)	qty	Total wt (lb)	qty	Total wt (lb)
electronics	GPS unit (Garmin GPSmap 76S, or comp.), with data transfer cable	0.5	1	0.5	1	0.5	1	0.5
electronics	Itronix ultra-rugged notebook/tablet PC	10	1	10	1	10	1	10
fish gear	Bucket w/aquarium net -5 gal. (dark color)	1	2	2	2	2	2	2
fish gear	Smith-Root bucket tote	1	0	0	0	0	2	1
fish gear	live well (cooler)	10	1	10	0	0	0	0
fish gear	measuring board - large (30-in)	3	1	3	0	0	1	3
fish gear	measuring board - small (10-in)	0	1	0	1	0	4	0
fish gear	minnow traps with line	4	0	0	4	4	10	10
fish gear	net twine, for dipnet repair	0	1	0	1	0	1	0
fish gear	netting, ⅛-in mesh, for dipnet repair	0	1	0	1	0	1	0
fish gear	nylon stockings/bags for retaining voucher specimens	0	5	0	5	0	5	0
fish gear	AQUI-S 20E anesthetic and MSDS	0.5	2	1	2	1	1	0.5
fish gear	seine, 1/2-in mesh x 40-ft long x 6-ft high	7	0	0	0	0	1	7
fish gear	seine, 1/8-in mesh x 16-ft long x 6-ft high	2	0	0	0	0	1	2
fish gear	ZipLock bags (1 quart, 1 gal)	0	1	0	1	0	1	0
fish gear	cured salmon roe (100 sets)	5	0	0	0	0	1	5
flow	Transparent Velocity Boards	1	1	1	1	1	1	0
flow	orange	0.33	0	0	2	0.66	4	1.32
flow	stopwatch	0.1	1	0.1	1	0.1	1	0.1
habitat	Abney level; Sokkia 5x magnifying with clinometer	0.5	1	0.1	1	0.5	1	0.5
habitat	clinometer - Suunto PM-5/360 PC	0	1	0	1	0	1	0
habitat	tape measure - fiberglass 30-meter	3	1	3	1	3	1	3
habitat	tent stake	0	2	1	2	1	2	1
inflatable	battery, 12V for inflator (P/N 12/18 at Batteries Plus)	15	1	15	0	0	1	15
inflatable	Cataraft w/frame and oars (PAC1200)	150	1	150	0	0	0	0
inflatable	inflator – electric	3	1	3	0	0	0	0
inflatable	inflator – manual	2	1	2	0	0	1	2
inflatable	repair kit for inflatable boat	1	1	1	0	0	0	0
inflatable	rubber mallet	1	1	1	0	0	0	0
optics	digital camera (Fujifilm XP10), memory card (250 MB min.), card reader	2	1	2	1	2	1	2
optics	Pelican case (1200) for digital camera & GPS	0.25	1	0.25	1	0.25	0	0

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Appendix F1.–Page 3 of 3.

			Team-A (cataraft)		Team-C (headwaters)		Spare	
Group	Item	Estimated wt (lb)	qty	Total wt (lb)	qty	Total wt (lb)	qty	Total wt (lb)
optics	rangefinder - Bushnell Yardage Pro	1	1	1	1	1	0	0
power	AA batteries (NIMH) for GPS (2 ea)	0	2	0	2	0	6	0
reference	Pollard et al. 1997	0	1	0	1	0	0	0
reference	species list guide book	0.25	1	0.25	1	0.25	1	0.25
repair	20 zip ties	0	1	0	1	0	1	0
repair	duct tape	0.5	1	0.5	1	0.5	0	0
repair	electrical tape	0	1	0	1	0	1	0
repair	tool kit (Ratchet w/ ½ in. socket, crescent wrench; needle-nose pliers; screwdrivers)	5	1	5	1	5	1	5
storage	dry storage box (York)	6	1	6	1	6	0	0
survival	12-gauge slugs: (e.g. Brenneke), box of 5	1	1	1	1	1	2	2
survival	defibrillator	3	0	0	0	0	1	3
survival	medical kit (REI Adventure, or comp.)	3	1	3	1	3	1	3
survival	MRE/dehydrated meals	1	2	2	2	2	2	2
survival	bear spray	1	2	1	2	1	2	1
survival	satellite phone (with charger and antenna)	1	1	1	1	1	1	1
survival	shotgun (Rem. model 870 Marine Magnum)	10	1	10	1	10	0	0
survival	shotgun case - (e.g., Kolpin Gun Boot)	6	1	6	0	0	0	0
survival	survival kit (rations, signaling, fire starter, water purification, shelter)	2	1	2	1	2	1	2
survival	throw bag (75-ft, 3/8-in polypro)	2	2	4	0	0	0	0
survival	Z-drag kit (three 1-in webbing slings; two 2-in pulleys; 3 locking D karabiners; two 7-mm prussic slings; static line)	15	1	15	0	0	0	0
WQ	Lamotte 2020e turbidity meter	2	1	2	1	2	0	0
WQ	YSI 556 in Pelican case	8	1	8	1	8	0	0
Total estimated weight of field equipment = 690 lb				**428.2**		**111.26**		**188.57**

Appendix F2.–Office equipment for field trip.

Group	Item	qty	Estimated wt (lb)	Total wt (lb)
crew gear	radio - charger for ICOM IC-A6	3	3	9
crew gear	Aquaseal	5	0	0
electrofisher	case for LR-24 electrofisher	3	25	75
electrofisher	charger for electrofisher batteries	3	10	30
electrofisher	motor oil (quarts) for GPP 2.5 (SAE 10-30)	2	1	2
electrofisher	ScotchBrite pads	8	0	0
electronics	charger for Itronix notebook/tablet PCs	5	0.5	2.5
electronics	MapSource U.S. topo software	1	0	0
electronics	spare battery for Itronix notebook/tablet PCs	5	0.5	2.5
electronics	external hard drive	1	1	1
electronics	USB card reader	3	0	0
fish gear	formalin, 10% buffered, 4L	2	8	16
fish gear	bottle; 4 L plastic, wide mouth, with cap for voucher specimens	4	0	0
power	12 V charger for inflator battery	1	1	1
power	AA battery charger	2	1	2
power	AA Alkaline and NiMH batteries for GPS	2	0	0
power	extension cord	2	1	2
power	power strip	3	0.5	1.5
power	spare batteries (Alkaline C, 9V, 6V, CR2, AAA)	4	1	1
reference	reference books (op-plan; instrument manuals; field guides/keys)	1	20	20
repair	shotgun cleaning kit (bore brush; rod; patches; solvent; oil; rag)	1	2	2
repair	Tri-flow (for cleaning guns)	1	0.5	0.5
storage	Roughneck totes with lids	10	1	10
WQ	conductivity standard sol'n (1000 uS/cm, 500 ml)	8	1	8
WQ	pH 10 calibration standard sol'n, 500 ml	8	1	8
WQ	pH 4 calibration standard sol'n, 500 ml	15	5	15
WQ	pH 7 calibration standard sol'n, 500 ml	8	1	8
	Total estimated weight of office equipment			**217**

APPENDIX G. FISH SPECIES KNOWN TO OCCUR IN THE STUDY AREA

Appendix G1.–Fish species known to occur in the 2014 study area.

Species code	Common name	Scientific name
LAK	Alaskan brook lamprey	*Lampetra alaskense*
LAR	Arctic lamprey	*Lampetra camtschatica*
LPC	Pacific lamprey	*Lampetra tridentata*
NOS	longnose sucker	*Catostomus catostomus*
PIK	northern pike	*Esox lucius*
DAL	Alaska blackfish	*Dallia pectoralis*
OPS	pond smelt	*Hypomesus olidus*
ORM	rainbow smelt	*Osmerus mordax*
OEU	eulachon	*Thaleichthys pacificus*
WLC	least cisco	*Coregonus sardinella*
WHB	humpback whitefish	*Coregonus pidschian*
WBC	Bering cisco	*Coregonus laurettae*
WRN	round whitefish	*Prosopium cylindraceum*
WPG	pygmy whitefish	*Prosopium coulterii*
GRA	Arctic grayling	*Thymallus articus*
CLK	lake trout	*Salvelinus namaycush*
CAC	Arctic char	*Salvelinus alpinus*
CDV	Dolly Varden	*Salvelinus malma*
TRB	rainbow trout	*Oncorhynchus mykiss*
SPI	pink salmon	*Oncorhynchus gorbuscha*
SCO	coho salmon	*Oncorhynchus kisutch*
SCK	Chinook salmon	*Oncorhynchus tshawytscha*
SCM	chum salmon	*Oncorhynchus keta*
SSE	sockeye salmon	*Oncorhynchus nerka*
GBR	burbot	*Lota lota*
KTS	threespine stickleback	*Gasterosteus aculeatus*
KNS	ninespine stickleback	*Pungitius pungitius*
USL	slimy sculpin	*Cottus cognatus*
UCR	coastrange sculpin	*Cottus aleuticus*
FST	starry flounder	*Platichthys stellatus*

APPENDIX H. ANADROMOUS WATERS CATALOG NOMINATION FORM

State of Alaska
Department of Fish and Game
Division of Sport Fish

Nomination Form
Anadromous Waters Catalog

Region ____________ USGS Quad(s) ____________

Anadromous Waters Catalog Number of Waterway ____________

Name of Waterway ____________ ☐ USGS Name ☐ Local Name

☐ Addition ☐ Deletion ☐ Correction ☐ Backup Information

For Office Use

Nomination # ______	______ Fisheries Scientist ______ Date
Revision Year: ______	______ Habitat Operations Manager ______ Date
Revision to: Atlas ______ Catalog ______ Both ______	______ AWC Project Biologist ______ Date
Revision Code: ______	______ Cartographer ______ Date

OBSERVATION INFORMATION

Species	Date(s) Observed	Spawning	Rearing	Present	Anadromous
					☐
					☐
					☐
					☐
					☐

IMPORTANT: Provide all supporting documentation that this water body is important for the spawning, rearing or migration of anadromous fish, including: number of fish and life stages observed; sampling methods, sampling duration and area sampled; copies of field notes; etc. Attach a copy of a map showing location of mouth and observed upper extent of each species, as well as other information such as: specific stream reaches observed as spawning or rearing habitat; locations, types, and heights of any barriers; etc.

Comments:

Name of Observer (please print): ______

Signature: ______ Date: ______

Agency: ______

Address: ______

This certifies that in my best professional judgment and belief the above information is evidence that this waterbody should be included in or deleted from the Anadromous Waters Catalog.

Signature of Area Biologist: ______ Date: ______ Revision 02/08

Appendix H1.–Anadromous Waters Catalog nomination form.