Regional Operational Plan SF.1J.2013.06

Assessment of Coho Salmon in Cowee Creek Using Coded Wire Tagging, 2013

by

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and

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June 2013

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

Symbols and Abbreviations

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

Weights and measures (metric)	
centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm
Weights and measures (English)	
cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd
Time and temperature	
day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s
Physics and chemistry	
all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

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

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

REGIONAL OPERATIONAL PLAN SF.1J.2013.06

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PURPOSE

The purpose of this project is to estimate marine harvest and determine where and when, and by what gear type adult coho salmon (*Oncorhynchus kisutch*) from Cowee Creek are intercepted in marine fisheries. Cowee Creek, located on the Juneau road system, is believed to have one of the largest runs of coho salmon within this area, and is one of the most heavily fished streams in the Juneau roadside fishery. Currently, only limited information exists on the Cowee Creek coho population. Capturing and tagging emigrating juvenile coho salmon with coded wire tags (CWTS), and subsequent recovery of tagged fish by marine and inriver adult sampling programs will provide a means for identifying where, when, and how many of these fish are caught in marine fisheries. This information will allow managers to determine the extent of commercial harvest related to this important roadside fishery, in addition to providing the basis for a more robust stock assessment.

BACKGROUND

The core mission of the Alaska Department of Fish and Game, Division of Sport Fish (ADF&G-SF) is to protect and improve the state's recreational fisheries resources. A number of goals and supporting objectives have been identified to ensure the mission is achieved. To successfully manage these resources, it is important for managers to: 1) identify data needs or gaps that exist; 2) prioritize stock assessment and research projects based on existing needs or gaps; and 3) determine if any management concerns exist, based on data gathered through ADF&G-SF projects (ADF&G 2012b). Occasionally, concerns raised by the public or proposals submitted through the Board of Fisheries process may warrant the attention of managers to issues not otherwise prioritized or considered. This may be especially true if potentially significant shifts in sport or commercial harvest patterns and effort occur.

Coho salmon are an important resource to numerous sport, commercial, and subsistence users in Southeast Alaska (SEAK) (Elliott and Kuntz 1988; Schmidt 1988; Halupka et al. 2000; Shaul et al. 2011; McCurdy 2012). The principle management objective, acted on jointly by the ADF&G-SF and ADF&G Division of Commercial Fisheries (ADF&G-CF), for coho salmon in SEAK fisheries is to achieve maximum sustained yield (MSY) from wild stocks. A secondary management objective, that may have varying significance for specific coho stocks, is to maintain long-term commercial gear-type allocations that were established by the Alaska Board of Fisheries in 1989. In the early 1980s, ADF&G implemented an improved stock assessment program to better understand and manage coho salmon stocks; new assessment projects were implemented for indicator stocks, which formed the basis for improved management of the species (Shaul et al. 2011). Despite the additional effort, stock-specific information is not available for over 90% of the coho salmon stocks in SEAK. Managing coho populations across SEAK is further clouded by the fact that the majority of commercial harvest occurs in temporally and geographically dispersed mixed stock fisheries where individual coho stocks intermingle (Shaul et al. 2011). The fact that coho have an extensive distribution in SEAK and return to fresh water during times of inclement weather and high stream flow further contribute to the complexity and cost of obtaining data once adults return to their natal streams. As a result, most data are derived from a small and limited subset of stocks throughout SEAK. Lack of sufficient information is the most pervasive risk factor threatening sustainable management of coho salmon stocks in the region (Halupka et al. 2000).

Coho salmon typically return to the marine waters of SEAK in July and August and enter fresh water in September and October. The direction of the return migration generally moves from northwest to southeast along the coast; however, relatively little is known about the migration routes used by specific coho salmon stocks (Schmidt 1988; Halupka et al. 2000). Commercial fisheries targeting other salmonid species often harvest a substantial incidental catch of coho salmon, which makes run timing an important biological trait influencing vulnerability. In general, stocks that pass through the most fisheries during their spawning migrations experience the highest exploitation rates. Stocks located in Lynn Canal, stocks in the Taku River region with normal run timing, and stocks in southern southeast Alaska have the highest exploitation rates; stocks on the outer coast generally have the lowest exploitation rates (Halupka et al. 2000). Small stocks are particularly vulnerable to high exploitation rates, which may or may not be sustainable (Hilborn 1985; Elliott and Kuntz 1988; Halupka et al. 2000). Considering the above, those coho stocks associated with small or moderately sized systems and located in inside waters of SEAK may be particularly vulnerable to unsustainable exploitation.

Recreational fisheries occur in both fresh and saltwater areas and have constituted an increasing component of the total coho salmon catch in recent years (Shaul et al. 2011). Based on ADF&G Statewide Harvest Survey (SWHS) results, one of the largest runs of coho salmon and one of the most heavily fished streams in the Juneau roadside fishery is Cowee Creek, located at the northern extent of the Juneau road system (ADF&G 2012aa; Figure 1; Appendix A). There is very little additional information available on the Cowee Creek coho population; fish populations in this system have never been assessed in detail, either through juvenile fish studies or adult escapement surveys. The semi-glacial water conditions in the Cowee Creek mainstem is one of the primary reasons for the lack of information on fish populations in the system (Bethers et al. 1995), at least with respect to visual counts of adult coho salmon obtained by foot or air.

The primary focus of the project described in this operational plan is to gain information about where and when adult coho salmon, originating in Cowee Creek, are harvested in marine fisheries. This will be realized by tagging juvenile coho salmon emigrating from Cowee Creek, followed by the evaluation of returning adults intercepted in marine waters. Tags recovered in marine sport and commercial fisheries will yield information on where (statistical area, district, etc.), when (statistical week), and how (type of fishery) coho smolt tagged in 2013 were harvested. This information will be useful to managers who are responsible for protecting this important and productive Juneau roadside fishery. Funding for the work outlined in this operational plan is provided through the Dingell-Johnson (DJ) Fund with a 25% match provided by the Fish and Game Fund.

DESCRIPTION OF PROJECT AREA

Cowee Creek is located approximately 64 km north of Juneau in the temperate coastal rainforest of SEAK (Figure 1). Cowee Creek is a popular sport fishing location due to its productive fisheries, road system access, and the presence of a trail that allows public access to fishing holes in the lower portion of the watershed (Figure 2). Cowee Creek has populations of coho, pink (*O. gorbuscha*), and chum salmon (*O. keta*), Dolly Varden (*Salvelinus malma*), and cutthroat trout (*O. clarkii*), and is reported to have small runs of spring and fall steelhead (*O. mykiss*) (Bethers et al. 1995). The Cowee Creek watershed has a drainage area of approximately 119 km^2 and empties into salt water at the south end of Berners Bay. The watershed is bordered by snow and

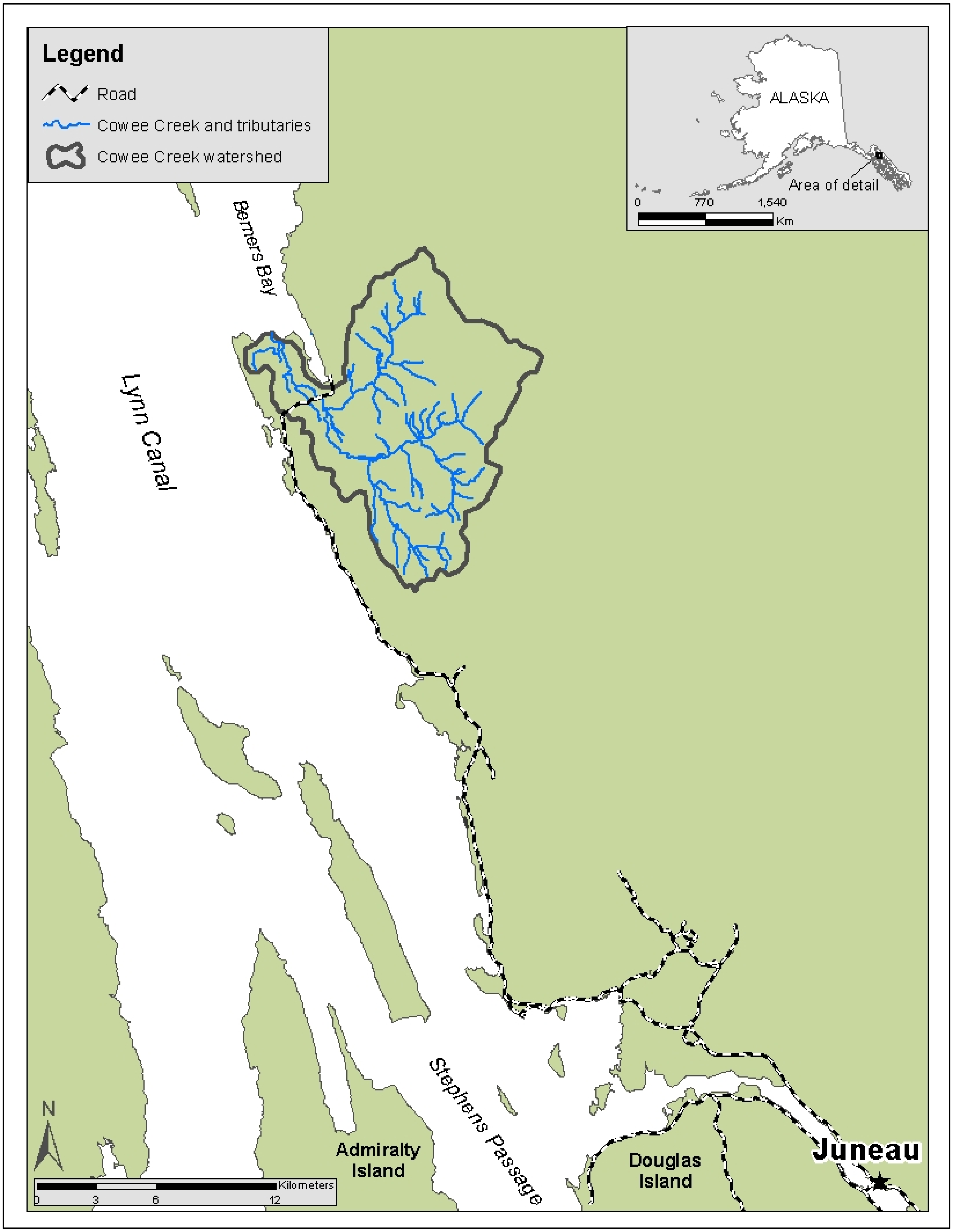

Figure 1.–Location of Cowee Creek watershed in Southeast Alaska.

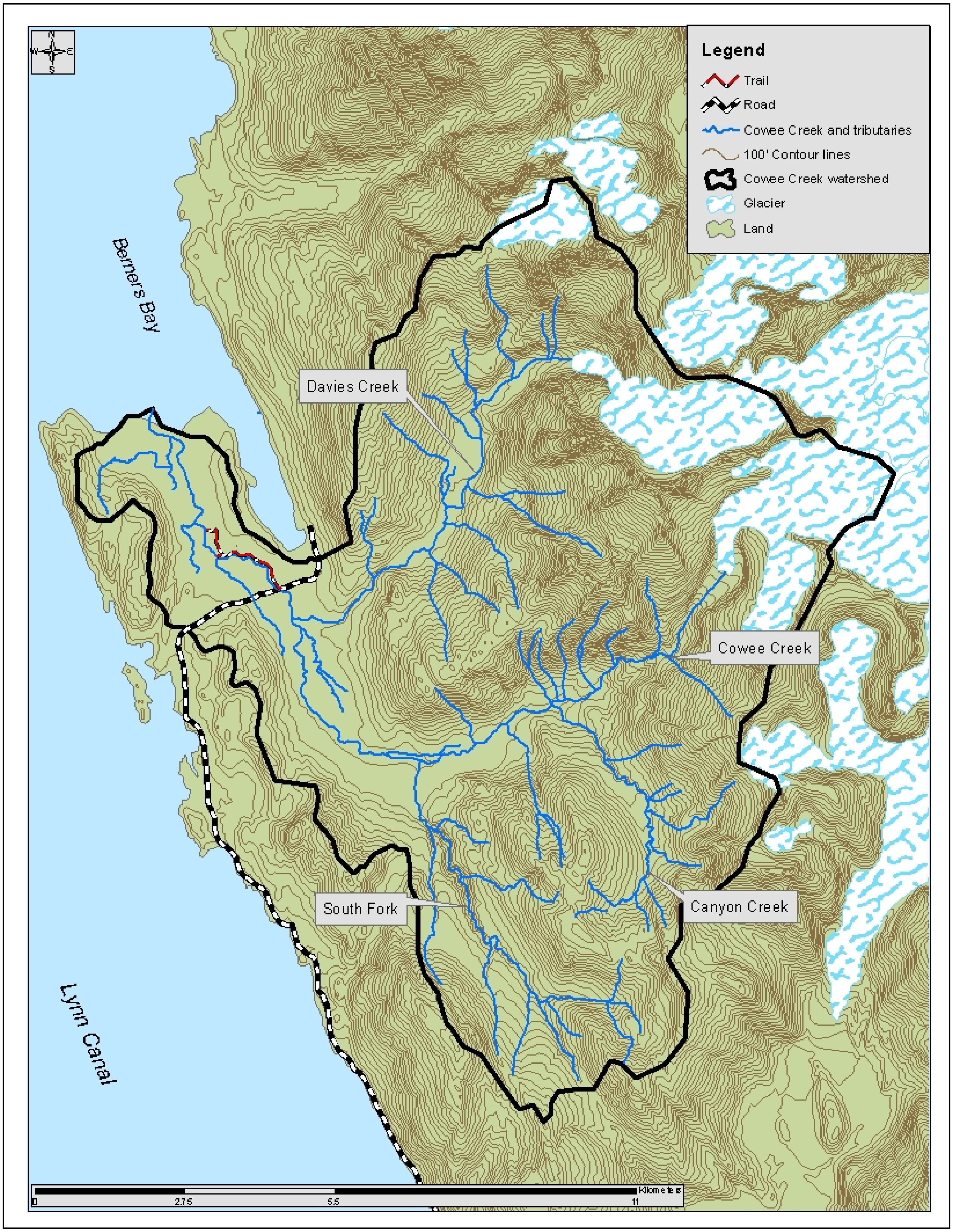

Figure 2.–Map showing road and trail access to Cowee Creek and significant tributaries, Southeast Alaska.

glacier covered mountains and includes numerous tributary streams, of which Davies Creek, South Fork, and Canyon Creek are the largest (Figure 2). Both Cowee and Davies creeks have hanging glaciers that drain into their respective valleys (USFS 2009), resulting in semi-glacial stream conditions from spring through fall (Bethers et al. 1995). Cowee Creek is believed to contain the largest amount of low gradient, floodplain stream habitat on the Juneau road system (CBJ 2012), and these habitats are often considered the most productive for salmon.

Nearly 88% of the land within the watershed boundary is owned and managed by the United States Forest Service (USFS), most of which is designated as the Héen Latinee Experimental Forest (USFS 2009). Other landowners within the watershed include: 1) the State of Alaska (including Point Bridget State Park); 2) Goldbelt, Incorporated; and 3) private owners (including Echo Ranch Bible Camp (ERBC)). Land owned by the USFS is primarily in the upper portion of the watershed, while other entities own land in the lower portion of the watershed (Figure 3).

OBJECTIVES

1. Estimate the marine harvest in sampled salmon fisheries in 2014 of adult coho salmon that originated from Cowee Creek via recovery of CWTs applied in 2013, such that the half-width of the calculated 95% confidence interval is 45% of the estimate ($738/3{,}415 \times 1.96 \leq 0.45$, see Appendix B1).

2. Estimate the number of coho salmon smolt ($\geq$75 mm FL) leaving Cowee Creek in 2013, such that the estimated number is within ±30% of the true value 80% of the time based on projections of total smolt abundance of 100,000; a marine survival of 10% for returning fish; and an estimated 3,400 harvested in marine fisheries (Appendix B1), leaving a remaining run size of 6,600.

    a. Sample size: if 3,000 smolt are tagged in 2013, or a 3% tagging rate, we would anticipate approximately 198 of the returning 6,600 fish to be tagged (6,600 x 0.03). With $N = 6{,}600$, 198 = tagged in the first event, $\alpha = 0.20$, and $d = 0.30$, 531 adults would need to be inspected for the presence of tags to meet the identified precision criteria (Thompson 2002). If 5,000 smolt are tagged, then using the same methodology, the number of returning tagged fish is projected to be 330 and we would need to inspect 322 returning adults for tags. These projections are based on projected data presented in Appendix B1.

3. Estimate the age composition of coho salmon smolt ($\geq$75 mm FL) captured in 2013 such that all age classes are estimated within ±10 percentage points of their true values 95% of the time, based on 100,000 smolt, a 50 % occurrence for each of the two age classes (1 and 2), and being unable to age 20% of the scales.

    a. Sample size is 120 per size class.

During the first year of this project, efforts will focus on the capture, marking, and tagging of juvenile coho salmon in Cowee Creek, during emigration, in order to establish a means of identifying marine exploitation patterns of adults returning to the system a year later. The

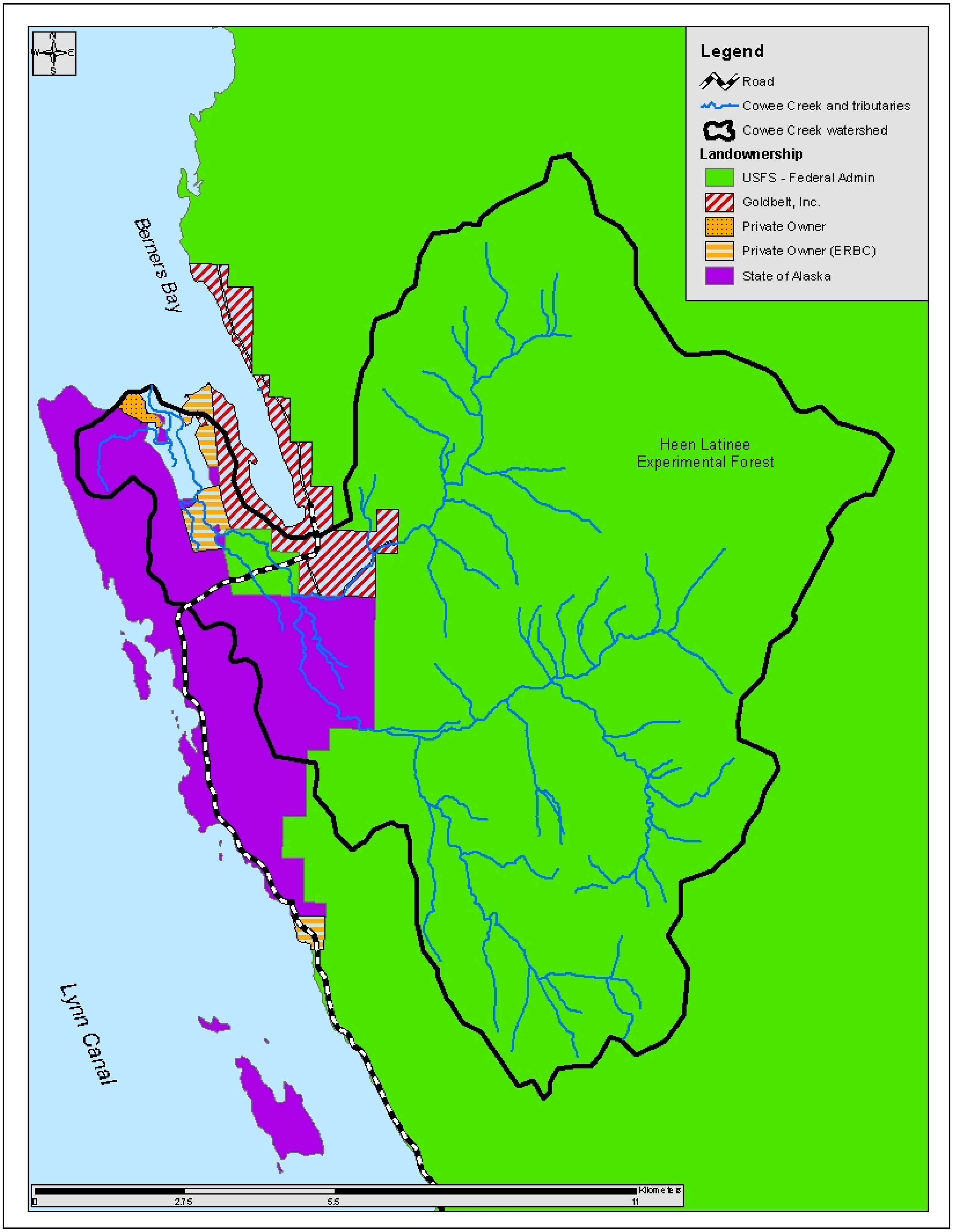

Figure 3.–Map identifying landownership in Cowee Creek watershed, Southeast Alaska.

groundwork is being laid in order to estimate marine harvest in sampled salmon fisheries, however this will be reliant on several important factors, including: 1) an adequate number of juvenile coho are tagged in year 1 (2013); 2) sufficient future (FY14, FY15) funding; and 3) an adequate number of adult coho are inspected inriver during year 2 (2014).

SECONDARY OBJECTIVES

This project will address the following secondary objectives:

1. Estimate the mean length of coho salmon smolt (≥75 mm FL) in 2013.
2. Estimate the mean weight of coho salmon smolt (≥75 mm FL) in 2013.
3. Test the hypothesis that smaller coho salmon smolt (75–85 mm FL) survive at the same rate as larger smolt (>85 mm).
4. Record numbers of coho smolt captured by location for each trap or gear type with the use of hand-held Global Positioning System (GPS) units.
5. Measure stream water levels at the Cowee Creek bridge to the nearest tenth of a foot during each day of operations by inspecting the staff crest gage.

METHODS

Smolt Abundance and Tagging Ratio

Mark-recapture experiments will be used to estimate the abundance of coho salmon smolt emigrating from Cowee Creek in 2013. Smolt will be tagged with CWTs and marked with adipose fin clips as part of Event I of a two-event closed population mark-recapture experiment. As part of Event II, returning adult coho salmon will be inspected for a missing adipose fin in 2014.

A minimum of a 2-person crew will be dedicated to capturing and tagging juvenile coho salmon with CWTs between approximately April 15 and June 7, 2013. Additional crew members may be used as available.

Juvenile coho salmon will be captured primarily in the central portion of Cowee Creek watershed using the following sampling methods:

- Baited minnow traps and hoop traps will be used to capture emigrating coho smolt on the mainstem and tributaries located in close proximity to the Juneau road system. Methods used for smolt trapping will closely follow those described in Magnus et al. (2006).
- Shallow, wadeable areas along the mainstem stream bank that are in close proximity to the Juneau road system will be sampled with a pole seine. The seine (7.5 m long x 2 m deep) consists of 13 mm stretch mesh, with small buoys attached to the top of the net and weights attached to the bottom of the net. A pole is attached to each end of the net and will be fished by holding the net upright and pulling it into the current, parallel to the stream bank.

Approximately 50–75 baited minnow traps will be set on days of operation when there are more than two people. Trapping and seining effort may be adjusted based on additional staff availability or smolt timing, distribution, and abundance patterns.

It is recognized that tagging lower in the Cowee Creek watershed brings along with it the possibility that juvenile coho salmon from nearby streams may have entered Cowee Creek for rearing. Therefore the majority of effort will be higher in the system, reducing this concern. However, if smolt capture is inadequate higher in the system, trapping and tagging operations will be expanded accordingly. If trapping and tagging operations are extended to downstream reaches, all juvenile coho captured within 1 river km from salt water will be given different tag codes, which will provide the ability to distinguish between those areas where nomad or straying rates may be higher. If smolt from other systems are tagged in Cowee Creek and return as adults to their nearby natal streams to spawn, one of the assumptions will be violated and the calculations may be suspect. However, without considerable effort to look for marked and tagged fish in nearby watersheds, this possibility cannot be eliminated. Smolt trapping and seining will not occur in tidally influenced reaches, recognizing that smolt in these transition habitats between fresh and salt water may be particularly vulnerable to additional stress.

All healthy coho smolt (≥75 mm FL) captured each day will be transported by foot to a central location on the mainstem, near the bridge, for sampling and tagging. Fish will be transported in buckets using aerators to help maintain adequate oxygen levels and water will be added as needed to maintain a near constant temperature similar to stream temperatures. Juvenile coho salmon that are ≥75 mm FL will be tranquilized with a buffered MS 222 solution, will have their adipose fin removed, and will be injected with a CWT. Each CWT is formed and inserted in the smolt by using a Mark IV tagging machine that cuts a 1.1 mm section of wire from a spool stamped with a unique numeric code. Four 2,500-tag spools of wire will be used for 2 size classes of coho salmon smolt: those 75–85 mm FL (small), and those >85 mm FL (large) (Table 1).

Table 1.–Coded wire tag codes that will be used for tagging small and large juvenile coho salmon on Cowee Creek, 2013.

Size class	Spool size	Tag code
Small (75–85 mm)	2.5K	04-32-93
Large (>85 mm)	2.5K	04-32-94
TBD[a]	2.5K	TBD
TBD[a]	2.5K	TBD

[a]Additionally, tag codes will be available for use by the project leaders discretion to either tag more of the above size classes or to distinguish between smolt tagged lower in the system.

Prior to release, all tagged fish will recover for 24 hours in a holding pen and will be checked for tag retention and post-tagging mortality to ensure ≥98% retention rate. The subsample of tagged fish to check for tag retention will consist of 100 fish, if the total number of tagged fish is ≥100; otherwise, every tagged fish will be evaluated for tag retention. Following these actions, all fish will be released in pocket waters of the mainstem, near the sampling location.

Event II of the mark-recapture will occur between the end of July and the end of October in 2014, when adult coho salmon returning to Cowee Creek are sampled and inspected for missing adipose fins. It should be noted that there will be no observation of coho jacks that may return in the fall of 2013. Because jacks tend to be larger smolt of the year (McCurdy 2012) it may give a biased low estimate for smolt survival, especially large (>85 mm) smolt, for the initial year of this project. However, the cost and effort associated with finding a few possible jacks that are tagged is not prudent. This limitation is accepted with the idea that the resulting bias should be low.

Adult salmon will be captured weekly in the river using beach seines. If adult returns are low, hook-and-line (i.e., sport fishing) gear and/or surveys of carcasses will be used to increase sample size. Care will be taken in handling fish captured in the lower river due to sensitivity to handling stress observed in transition zones in other systems. In addition to looking for adipose fin clips, adults will also be sampled for age, sex, length, and scales. These data will be recorded on standard adult sampling forms. Each sampled fish will be marked with an opercle punch on their upper right operculum to prevent double sampling. The marked fraction (fish missing adipose fins) of coho salmon captured will be used to estimate smolt abundance in 2013 and marine harvest in 2014. All fish observed with a missing adipose fin will be sacrificed and its head taken. Each head will be assigned an individual head tag number and will be sent to the ADF&G-CF Mark, Tag, and Age Laboratory (Tag Lab) for further dissection and tag decoding.

MODEL ASSUMPTIONS FOR ESTIMATION OF SMOLT ABUNDANCE

This two-event closed population mark-recapture experiments are designed so that a Petersen-type estimator may be used to estimate smolt abundance. For the estimate of abundance to be unbiased, certain assumptions must be met (Seber 1982). These assumptions, expressed in the circumstances of this study, along with their respective design considerations and test procedures, are:

Assumption I: There is no recruitment to the population between years

Considering the life histories of coho salmon, there should be no recruitment between sampling events. Because almost all surviving smolt return to their natal stream as adults to spawn, there will be no meaningful recruitment added to the population while they are at sea (i.e., low incidence of straying).

Assumption II: There is no trap-induced behavior, including mortality

There is no explicit test for this assumption because the behavior of unhandled fish cannot be observed. Trap-induced behavior is unlikely because different sampling gears will be used to capture smolt and adults. Results from other studies (Elliott and Sterritt 1990; Vincent-Lang 1993) indicate that clipping adipose fins and implanting CWTs does not affect the mortality of tagged salmon smolts.

Assumption III: Tagged fish will not lose their marks between sampling events and all marks are recognizable

The use of properly applied adipose fin clips will ensure that marks are not lost and that all marked fish are recognizable during second event sampling. Adipose fins will not regenerate like other fins if excised at the base. Naturally missing adipose fins on wild stocks of coho salmon are very rare (Magnus et al. 2006).

Assumption IV: One of the following 3 sets of conditions on mortality and sampling will be met

S1) All fish have an equal probability of being captured and marked during the first event, or

S2) All fish have the same probability of surviving between events whether marked or unmarked and across all tagging groups and complete mixing of marked and unmarked fish occurs prior to the second event; or

S3) All fish have the same probability of surviving between events whether marked or unmarked and across all tagging groups and all fish have an equal probability of being captured and inspected for marks during the second event.

Assumption V: All fish marked as juveniles are smolt emigrating to sea during the same year they were marked and will not return to another stream

One might have support that this assumption has been violated if a tag code comes back a year later than expected, or if a tag code is recovered escaping to a different system. If there are fish that do not smolt in a given tagging year, or return to a different system, then it may appear that there is a higher mark-to-unmarked ratio. If the smaller juveniles are less likely to smolt, it will appear that smaller fish survived at a lower rate.

Minnow traps will be operated continuously, Monday to Thursday, during smolt emigrations, and potentially 7 days a week during peak periods of emigration in 2013. Although minnow traps can be size selective, pole seines will also be used to reduce any bias this may induce. Pole seines will be used when smolt are migrating, on a similar schedule as identified for minnow traps. In 2014, adult coho salmon immigrations will be sampled throughout the Cowee Creek watershed, Monday through Friday, and potentially also on weekends during peak escapement.

It is noted that migration during both events may vary from day to day due to short-term changes in water conditions and fish behavior. Nonconstant sampling and daily variations may reduce equal probabilities of capture throughout migrations, although the vast majority of fish will be eligible for capture. However, S2 of assumption IV is expected to be met. Recall that this assumption does not rely on equal probability of capture. Due to the extended time period between the marking and recovery events and the difference in behavior of salmon between these events, it is likely that complete mixing of marked and unmarked fish will effectively occur prior to the adult recovery events.

A contingency table analysis (Agresti 2007) will be conducted to test the null hypothesis that the probability that an adult missing an adipose fin is independent of when the fish was inspected for marks during the second event. Failure to reject the null hypothesis will indicate that S1 and/or S2 of assumption IV are satisfied.

Coho salmon smolt likely represent at least 2 age groups and cover a range of sizes. In the Taku River, there has been size-selective sampling during the first event and size-differential mortality rates detected for coho salmon emigrating from the Taku River (Jones III et al. 2006), resulting in failure of all three sets of conditions.

Equal survival between the coho smolt tagging groups (2 sizes) will be evaluated using contingency table analysis (Agresti 2007) to test for lack of independence between tagging group and probability of recovery during adult sampling (Secondary Objective 3). If no lack of independence between tagging group and adult tag recovery is detected, at least S2 is satisfied and Chapman 's (1951) modification to the Petersen estimator will be used to estimate abundance after pooling the tag codes. If lack of independence is detected between adult tag recovery rate and tagging group, then equal probability of capture during the tagging event will need to be evaluated. The weighted variant of Chapman's modification to the Petersen estimator (equation 4 below) must be calculated in order to estimate the ratio of the catchability coefficient for larger to smaller smolt A (equation 6 below) and the sampling variance of the ratio. If the estimate of A is not significantly different from 1.0, Chapman's (1951) formula will be used to estimate abundance as noted above. Otherwise, the modified estimator (equation 4) will be used to provide an unbiased estimate (see Data Analysis; Appendix D1). Past use of this estimator on the Taku River has increased the coefficient of variation of the estimate modestly (about 2.5 percentage points) (Williams et al. 2013).

AGE COMPOSITION OF COHO SALMON SMOLT

A systematically drawn sample of at least 120 coho salmon smolt for each of the size classes (75–85 mm FL and ≥85 mm FL) will be collected, exceeding minimum sample sizes needed to meet criteria for objectives that relate to age composition. Only coho salmon smolt ≥75 mm FL will be considered for sampling, as smaller fish are more difficult to handle and have a higher probability of remaining in the river for subsequent years.

Based on an expected catch of about 3,000 coho salmon smolt, scale samples need to be taken from every 10th coho salmon smolt to achieve a systematic sample of 300, with the hopes that at least 120 will be from each of the size classes. We will take scales from every 10th coho salmon smolt.

MEAN LENGTH AND WEIGHT OF COHO SALMON SMOLT

No precision criteria were given for Secondary Objectives 1 and 2 relating to mean length and weight of coho smolt, as these data are considered ancillary. The sample size for estimating ages should be large enough to get a reasonably precise estimate on mean length and weight. We will take weight and length from every 10th coho salmon smolt, in other words every smolt that scales are taken from.

GLOBAL POSITIONING SYSTEM (GPS) AND TEMPORAL AND SPATIAL DATA COLLECTION

The GPS is a worldwide radio-navigation system formed from a constellation of at least 24 satellites. Positions on earth are determined by receiving the radio signals being emitted, and measuring the very precise distances and time to the available satellite(s). Handheld GPS units will be used to capture smolt observation data by identifying latitude/longitude for specific areas trapped or seined and the numbers of fish collected over time (Secondary Objective 4).

DETECTION AND HARVEST OF ADULT COHO IN FISHERIES

After considering reductions due to marine survival, most coho salmon smolt tagged in 2013 will emigrate to sea, mature, and return to the Cowee Creek watershed to spawn in 2014. Some returning adults will be harvested in marine sport and commercial fisheries in 2014, which are sampled by ADF&G port and creel sampling programs. Heads will be collected from fish carrying CWTs, as identified by a missing adipose fin. The CWTs will be decoded by the Tag Lab. Recovery of Cowee Creek CWTs intercepted in marine fisheries will provide important information to managers about where and when Cowee Creek coho salmon are being harvested, which is currently not known. Additionally, with the inriver adult work, a mark to unmarked ratio will be estimated, which will allow us to expand the number of tags recovered in fisheries to the number of Cowee Creek coho harvested in those fisheries. If an escapement estimate is pursued, which is currently not a part of this project, and not funded, then an exploitation rate estimate can be developed.

To meet the criteria in Primary Objective 1 (95% relative precision (RP) = ±42%), approximately 3,000 coho salmon smolt need to be tagged in 2013 according to procedures in Bernard et al. (1998). This is based on inspecting about 30% of the anticipated harvest in the various commercial fisheries and 10–20% in sport fisheries (Glen Oliver, Fishery Scientist, ADF&G-CF, Douglas, personal communication; Mike Jaenicke, Fishery Biologist, ADF&G-SF, Douglas, personal communication).

The marine fisheries evaluation used in this simulation, where Cowee Creek coho salmon are expected to be recovered, was modified from a list of fisheries where Taku River coho salmon are commonly recovered. The reason for using the Taku River stock as a surrogate for expected marine harvest, instead of Berners River, was due to the similar run timing between the Taku and Cowee stocks, compared to the later run timing exhibited by Berners River coho salmon.

Assuming 100,000 coho salmon smolt outmigrate in 2013 and 3,000 of them are tagged, 15 random fishery recoveries of CWTs are anticipated in 2014. Methodology in Bernard et al. (1998) was used to estimate the chance of missing harvest in fisheries. In the commercial troll fishery, the anticipated probability of recovering at least 1 CWT in all troll strata is 0.52 and the anticipated troll fishery harvest is 46% of the total harvest. In the sport fishery the probability of recovering at least 1 CWT in all strata is 0.13 and the anticipated sport fishery harvest is 18% of the total harvest. The seine and gillnet fisheries have 0.25 and 0.19 probabilities, respectively, of recovering at least 1 CWT in all strata and it is anticipated these fisheries will harvest 15% (seine) and 22% (gillnet) of the total harvest. Overall, for the strata producing 90% of the anticipated harvest, there is a 0.02 probability of not recovering a CWT. Thus, there is confidence that a nearly unbiased estimate of harvest will occur if 3,000 or more coho salmon smolt are coded-wire-tagged in 2013 and assumptions related to the mark-recapture and simulated data are met.

Beginning in 2014, adult coho salmon returning to Cowee Creek will be sampled and inspected for missing adipose fins between the end of July and the end of October. The marked fraction (fish missing adipose fins) of coho salmon captured will be used to estimate smolt abundance in 2013 and the harvest in the marine environment during 2014. See the "Smolt Abundance and Tagging Ratio" section earlier in this methods section.

MONITORING OF STREAM WATER LEVEL USING STAFF CREST GAGE

A crest staff gage currently exists on the mainstem of Cowee Creek near the bridge. This gage will be checked each morning and the water level recorded to the nearest tenth of a foot (Secondary Objective 5).

DATA COLLECTION

Tag codes used will be recorded on a Tagging and Release Information Form obtained from the Tag Lab; a short section of the spool of coded wire will be taped to the form the first day of tagging to identify which code is used for each of the two size classes. All tag and recapture data will be recorded daily on the form entitled Salmon Smolt CWT Daily Log and Tagging and Release Information Form (Appendix C1). The data on the Daily Log will be used to record daily environmental data, catch, tagging, release, and recapture data. A new daily log will be filled out for each day of operation. Magnus et al. (2006) describes in detail the methods that will be used for tagging coho smolt.

Daily procedures will be as follows:

1. Record water temperature to nearest 1°C and stream water level to the nearest tenth of a foot. Climatological data should be collected at the same time each day and recorded on the daily log.
2. Remove fish from traps, sort coho from other species and transport coho only to the tagging station. Record coho trap catches on the Salmon Smolt Capture and GPS Location form (Appendix C3).
3. Inspect each live coho smolt > 75 mm and count the number with adipose clips. Test all recaptures for tag retention, measure for length to the nearest mm, and release. Record number caught with and without CWTs on the daily log form and record length of all recaptures on the Salmon Smolt Length, Weight, and Scale Samples form (Appendix C2).
4. Inject all live fish with a CWT and pass each through the tag detector. If rejected by the detector, retag and tally all retags on a hand counter. Write the beginning and ending machine numbers on the daily log and record retags, mistags (goofs, misses, etc.), and practice tags. Show your calculations for the number of tags used.
5. Select every 10th coho salmon for sampling as described below.
6. Count the number of mortalities and record on the daily log form.
7. At 0900–1000 hrs the following day, check all fish for any overnight mortality and randomly select 100 representative fish (or all fish if < 100 were captured) to check for tag retention and record results on the CWT Daily Log. If tag retention is 98% or greater, count and record mortalities, record results, then transport fish to the release site and release all fish. Retag all fish that test negative. If tag retention is less than 98%, reprocess the entire batch as above and retag any that test negative.

Every 10th coho salmon smolt tagged will be measured from snout to fork of tail (FL) to the nearest 1 mm, weighed to the nearest 0.1 g, and sampled for scales. Twelve to 15 scales will be removed from the preferred area on the left side of the coho salmon smolt (Scarnecchia 1979). Scales will be sandwiched between two 1 x 3-in microscope slides and numbered consecutively for each sampled fish. Slides will be taped together and the unique number and length of each fish will be written on the frosted portion of the bottom slide according to scale position on the slide. Fish/slide number, length, location, date, and sampler's initials will be included on the scale sample form (Appendix C2). Ages will be estimated postseason.

Instructions to improve our ability to read scales, as determined by staff experience, are:

1. Clean the scales, spread them out so they do not touch,
2. Do not tape over any scales, and
3. Make sure slides and slide covers are accurately labeled.

DATA REDUCTION

The leader of the field crew will ensure that data forms are kept up to date at all times and will check all data for errors. Data will be sent to the office at regular intervals and inspected for accuracy and compliance with sampling procedures. Data will be transferred from forms to EXCEL®[1] files. When input is complete, data lists will be obtained and checked against the original field data. Electronic data files will be used to check tagging totals on data forms, to identify lengths less than prescribed guidelines, sampling rates for age, weight, and length, and for data on the tagging and release forms.

Completed tagging and release form will be sent to the Tag Lab. The Tag Lab is the clearinghouse for all information on CWTs. All CWT data (sampled fish, decoded tags, location, data type, samplers, etc.) are archived and accessible on a permanent ADF&G statewide database and once per year are provided to the permanent coastwide database at the Pacific States Marine Fisheries Commission.

Accumulated data from smolt capture and tagging in 2013 will be stored in Juneau at the following location: Y:\DJ_ReportingPlanning\CoweeCreek_FreshwaterAssessment_2012\Data. A final, edited copy of the data, along with a data map, will be sent to Research and Technical Services (RTS) in Anchorage electronically for archiving.

DATA ANALYSIS

ESTIMATES OF MEAN LENGTH AND WEIGHT

Standard sample summary statistics will be used to estimate mean length- and weight-at-age and variances (Thompson 2002).

HARVEST

The contribution r_{ij} of a release group j to a fishery stratum i is estimated:

$$\hat{r}_{ij} = \hat{N}_i \left[\frac{m_{ij}}{\lambda_i n_i} \right] \hat{\theta}_j^{-1} \tag{1}$$

where

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

N_i = total harvest in fishery stratum i,
n_i = number of fish inspected in fishery stratum i (the sample),
$\lambda_i = (a_i' t_i')/(a_i t_i)$ is the decoding rate for CWTs from recovered salmon,
a_i = number of fish which were missing an adipose fin,
a_i' = number of heads that arrived at the lab,
t_i = number of heads with CWTs detected,
t_i' = number of CWTs that were dissected from heads and decoded,
m_{ij} = number of CWTs with code(s) of interest, and
θ_j = fraction of the cohort tagged with code(s) of interest.

Note: j represents the different tagging codes. If no statistical difference in survivability or capture is found between the tagging codes, then j = 1 and the equations may be simplified. See Bernard and Clark (1996) for further details.

Because N_i is estimated with error in sport fisheries, unbiased estimates of the variance of $\hat{r}_{ij}$ will be obtained using the appropriate large-sample equations in Table 2 of Bernard and Clark (1996), including the covariance between estimated harvests of cohorts within strata.

The total harvest for a cohort was calculated as the sum of strata estimates:

$$\hat{H} = \sum_i \sum_j \hat{r}_{ij} \tag{2}$$

$$Var\left[\hat{H}\right] = \sum_i \sum_j v\left[\hat{r}_{ij}\right] \tag{3}$$

Commercial catch data for the analysis will be summarized by ADF&G statistical week and district (for gillnet and seine fisheries) or by period and quadrant for troll fisheries (e.g., see Clark et al. 1985). Sport harvest estimates from ADF&G Statewide Harvest Survey reports (e.g., Jennings et al. 2011) will be apportioned using information from sampled marine sport fisheries to obtain estimates of total harvest by biweek and fishery. Sport fish CWT recovery data will be obtained from Tag Lab reports and summarized by biweek and fishery (e.g., biweek 16 during the Sitka Marine Creel Survey) to estimate contribution. In most cases, CWTs of interest may be recovered in only a few of the sport fish sampling strata that defined the fishery biweek. Assuming that the harvests of fish with CWTs of interest are independent of sampling strata within fishery biweeks, harvests and sampling information will be totaled over the fishery biweek to estimate contributions.

SMOLT ABUNDANCE

The mark-recapture experiment based on coho salmon smolts and returning adults will use Chapman's modification of the Petersen Method (Seber 1982) to estimate abundance of smolts and its variance:

$$\hat{S} = \frac{(M+1)(C+1)}{(R+1)} - 1 \tag{4}$$

$$V[\hat{S}] = \frac{\hat{S}(M - R)(C - R)}{(R+1)(R+2)} \qquad (5)$$

where $\hat{S}$ is estimated abundance of smolts this year, M is the number of marked smolt (all tag codes) released alive into the population this year, C is the number of adults inspected for marks in the following year, and R is the number of adults with missing adipose fins in samples taken in the following year.

Several conditions must be met for this estimator to be unbiased for this experiment as noted earlier in this plan.

Equal survival between tagging groups will be evaluated using contingency table analysis (Agresti 2007) to test for lack of independence between tagging group and probability of recovery during adult sampling. If the null hypothesis of independence is not rejected, at least S2 (from assumptions listed earlier in this plan) is assumed to be satisfied and equations (4) and (5) will be used to estimate abundance after pooling the tag codes. If lack of independence is detected between the adult tag recovery rate, a weighted variant of Chapman's modification to the Petersen estimator will be used to estimate abundance of Cowee Creek smolt:

$$\hat{S}'' = \frac{(\hat{A}M_1 + M_2 + 1)(\hat{C}' + 1)}{\hat{A}(R_1 + \hat{\pi}_1 R_3) + (R_2 + \hat{\pi}_2 R_3) + 1} - 1 \qquad (9)$$

where A is the ratio of the catchability coefficients for larger (>85 mm FL) to smaller (≤85 mm FL) Cowee Creek smolt during the marking event and π_i is the fraction of adults that were smaller or larger Cowee Creek smolts during the marking event.

The estimate of A is used to adjust for differences in catchability during the marking event such that A>1 when larger smolt are more catchable, and <1 when larger smolt are less catchable. Because some recaptured fish are not sacrificed to find tags or some marked adults do not contain tags, π_I's are used to assign recaptured fish of unknown pedigree to the appropriate smolt size group. The estimate of π is calculated:

$$\hat{\pi}_i = \frac{T_i}{T_1 + T_2} \qquad (10)$$

where T_i is the number of all tags representing a smolt size group (i = 1, 2) recovered or recaptured from adult salmon regardless of how or where recovered or recaptured.

Evidence for smolts not having equal probability of being marked regardless of size can be found through calculations based on estimates of relative freshwater age composition of smolts and adults. If $\hat{p}$ is the estimated fraction of all <u>adults</u> that are of age-1., if $\hat{\phi}_1$ is the estimated fraction of <u>smolts</u> in the smaller-size group that were age-1., and if $\hat{\phi}_2$ is the estimated fraction of <u>smolts</u> in the larger-size group that were age-1., an estimate of the ratio of catchability coefficients for larger to smaller smolt is (see Appendix D1 for derivation):

$$\hat{A} = \frac{T_2(\hat{\phi}_2 - \hat{p})}{T_1(\hat{p} - \hat{\phi}_1)} \qquad (11)$$

Simulation results (see below) will be used to evaluate if this estimated rate is statistically different than 1.

Variance and 95% credibility interval for $\hat{S}'$ or $\hat{S}''$ and $\hat{A}$ will be estimated using empirical Bayesian methods (Carlin and Louis 2000). Using Markov Chain Monte-Carlo techniques, posterior distributions for the estimated parameters will be generated by collecting 100,000 simulated values of the parameter components and parameters which are calculated using equations described from simulated data. Simulated values are modeled from observed data using the appropriate binomial or multinomial distributions.

AGE COMPOSITION

Proportions by age will be estimated by:

$$\hat{p}_j = \frac{n_j}{n} \tag{14}$$

$$\text{var}[\hat{p}_j] = \frac{\hat{p}_j(1-\hat{p}_j)}{n-1} \tag{15}$$

where p_j is the proportion in the population in group *j*, *n* is sample size, and n_j *is* the subset of *n* that belong to group *j*. The systematic selection of samples implies proportional sampling and reduces bias from any inseason changes in age composition.

SCHEDULE AND DELIVERABLES

Dates for 2013 field and office activities associated with this project are included in Table 2.

Table 2.–Schedule for all office and field related activities for Cowee Creek, 2013.

Date	Activity
March 7–April 12, 2013	Field preparations for juvenile sampling
April 15–June 7, 2013	Smolt trapping and tagging
June 10–14, 2013	Field clean-up
June 17–21, 2013	Data entry
September, 2013	Federal aid performance report due
July 21–25, 2014	Field preparations for adult sampling
July 28–October 31, 2014	Adult inriver recapture
November 3–7, 2014	Field clean-up
November 10–14, 2014	Data entry
December 31, 2015	Fishery Data Series report due

A federal aid performance report will be prepared in September 2013 detailing all CWT-tagging activities occurring in the first year of this project. A future federal aid performance and Fisheries Data Series report will be prepared that will detail initial 2013 tagging operations, information obtained from CWT recovery, as well as evaluation of marine harvest of Cowee Creek originated coho stock.

RESPONSIBILITIES

Kercia Schroeder, Fishery Biologist II (Douglas).

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

Jeff Nichols, Habitat Biologist III (Douglas).

Oversees and reviews the following aspects of the project including study design; planning, budgeting, equipment acquisition, training, and supervision of project personnel. Assists with field work and data collection.

Roger Harding, Fishery Biologist III (Douglas).

Provides input and expertise related to the field component of the project and will assist with installation and removal of field equipment. Assists with field work and data collection.

David Love, Fishery Biologist II (Douglas).

Provides input and expertise related to the field component of the project and will assist with installation and removal of field equipment. Assists with field work and data collection.

Carol Coyle, Fishery Biologist II (Douglas).

Provides input and expertise related to the field component of the project and will assist with installation and removal of field equipment. Assists with field work and data collection.

John DerHovanisian, Regional Research Coordinator (Douglas).

Will review all operational plans and reporting documents.

Sarah Power, Biometrician II (Douglas).

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

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APPENDIX A. STATEWIDE HARVEST SURVEY RESULTS FOR JUNEAU ROADSIDE FISHERIES

Appendix A1.–Statewide Harvest Survey results for number of coho salmon harvested in Juneau roadside fisheries from 1996 to 2011.

	Number of coho salmon harvested (by survey year)																
Juneau roadside stream name	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average
Cowee Creek	361	271	735	393	575	312	644	989	456	588	498	230	468	1,270	505	458	547.1
Montana Creek	353	218	274	230	324	301	658	361	90	264	349	264	245	438	285	571	326.6
Peterson Creek and Salt Chuck	0	131	6	11	63	19	178	158	0	0	98	101	38	250	60	ND	74.2
Other Juneau road system	85	10	58	262	0	68	114	101	13	24	9	0	0	118	15	30	56.7
Fish Creek (Douglas Island)	30	0	30	0	111	73	111	35	0	197	0	110	24	0	376	35	70.8

Appendix A2.–Statewide Harvest Survey results for number of anglers fishing Juneau roadside fisheries from 1996 to 2011.

	Number of anglers that fished (by survey year)																
Juneau roadside stream name	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average
Cowee Creek	665	836	1,146	589	938	875	852	1,195	880	1,044	1,143	1,221	917	1,221	845	743	944.4
Montana Creek	805	810	806	686	669	973	707	892	564	820	780	785	819	814	781	785	781.0
Peterson Creek and Salt Chuck	393	441	482	336	367	387	462	440	333	459	288	520	805	550	427	ND	446.0
Other Juneau road system	845	405	550	433	493	719	742	760	699	623	824	708	407	683	629	954	654.6
Fish Creek (Douglas Island)	924	795	580	808	981	1,192	787	972	1,032	1,196	695	1,018	1,099	908	594	743	895.3

Appendix A3.–Statewide Harvest Survey results for number of days fished in Juneau roadside fisheries from 1996 to 2011.

	Number of days fished (by survey year)																
Juneau roadside stream name	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average
Cowee Creek	1,639	1,555	2,135	1,522	2,594	3,087	1,845	2,989	2,250	2,489	2,507	1,703	2,222	4,252	2,803	1,861	2,340.8
Montana Creek	2,241	2,448	2,221	2,069	2,763	3,993	3,015	2,229	1,570	1,782	1,654	2,072	2,796	4,887	2,890	2,474	2,569.0
Peterson Creek and Salt Chuck	1,076	1,090	1,334	906	1,249	1,613	1,469	1,275	803	1,134	800	946	1,475	1,030	1,431	ND	1,175.4
Other Juneau road system	1,718	704	1,379	842	1,375	1,840	2,503	1,703	1,194	1,893	1,647	2,212	1,289	1,791	1,369	1,822	1,580.1
Fish Creek (Douglas Island)	1,432	1,690	918	1,627	2,068	2,359	2,234	1,533	3,022	3,926	1,819	1,981	2,215	2,119	1,945	1,695	2,036.4

APPENDIX B. RESULTS FROM A SIMULATION PERFORMED TO ESTIMATE MARINE HARVEST FOR ADULT COHO RETURNING TO COWEE CREEK IN 2014

Appendix B1.–Statistics used to link the number of coho salmon smolt to tag in 2013 with the ultimate relative precision of the estimated marine harvest from adults returning to Cowee Creek in 2014.

ϕ = 0.30 (average all fisheries); θ = 0.03 (x 100,000 smolt corresponds to 3,000 smolt tagged)

Stratum	N_i or $\hat{N}_i$	$V[\hat{N}_i]$	n_i	m_i	λ_i	$\hat{r}_{ij}$	ϕ_i	$G(\hat{p}_i)$	$G(\hat{N}_i)$	$SE[\hat{r}_{ij}]$	Prob(m_{ij} >0)
Troll NW	464,526		136,722	5	0.9680	585	29%	0.198		260	0.171
Troll NW	342,310		107,596	3	0.9775	325	31%	0.330		187	0.267
Troll NE	116,205		32,082	2	0.9850	245	28%	0.496		173	0.338
Troll NW	2,473		274	1	0.7143	421	11%	0.998		421	0.462
Seine 112	66,452		11,548	1	1.0000	192	17%	0.995		191	0.518
Seine 114	17,511		3,675	1	1.0000	159	21%	0.994		158	0.564
Seine 109	9,874		2,341	1	1.0000	141	24%	0.993		140	0.606
Sport	3,389	418,542	3,389	3	0.9863	101	100%	0.323	0.0364	60	0.635
Sp738ort[SP1]	908	112,138	499	2	1.0000	121	55%	0.492	0.1360	91	0.671
Sport	5,720	706,420	2,328	1	0.8750	94	41%	0.989	0.0216	93	0.698
Sport	702		685	1	1.0000	34	98%	0.971		34	0.708
Sport	996	123,006	194	1	0.8333	205	19%	0.995	0.1240	205	0.768
Sport	316		302	1	0.6667	52	96%	0.981		52	0.784
Drift GN	17,759		6,692	2	0.9765	181	38%	0.494		127	0.837
Drift GN	2,740		577	2	1.0000	317	21%	0.497		223	0.929
Drift GN	9,101		3,811	1	1.0000	80	42%	0.987		79	0.953
Drift GN	723		584	1	0.9167	45	81%	0.978		45	0.966
Drift GN	2,228		637	1	1.0000	117	29%	0.991		116	1.000
	1,063,933	1,360,106	313,936	15		3,415	30%			738	

APPENDIX C. SALMON SMOLT DATA FORM USED FOR DAILY CODED WIRE TAG AND ENVIRONMENTAL CONDITIONS DATA RECORDING

Appendix C1.–Data form to record daily environmental conditions and coded wire tagging results.

SALMON SMOLT CWT DAILY LOG
SPORT FISH DIVISION

Tagging Site: Cowee Creek (above bridge) **Species:** coho salmon **Date**_______________

Air Temp: **Min.** __________° C **Max.** __________° C

Water Temp ________° C **Staff Gage Level** ________ft

Comments____

---

1. TAG RETENTION (The # released today alive that were tagged yesterday) __________________

TODAY'S TAGGING

2. TRAP MORTS: Fish found dead in trap or box______ / # of marked (ad clipped) dead fish______

3. RECAPTURES:

a. Total with CWTs ________ (Release immediately)

b. Number without CWTs ________ (Release next day after retention)

4. NEW CWTS APPLIED:

a. Ending Number ________ (Machine No.)

b. Beginning Number ________ (Machine No.)

c. Retags ________ (Hand counter)

d. Subtotal (a-b-c) ________ (Total CWTs Applied)

5. POST TAGGING MORTS: ________ (Morts)

6. NUMBER FISH HELD FOR TAG RETENTION ________ (Hold till next day)

7. TOTAL DAILY RELEASE (1+4d-5-6) ________

Notes:

---

1. TAG RETENTION TESTS (those fish held from the previous day):

a. From 24hr Hold : # of fish w/CWTs________ # of fish w/o CWTs________

b. Morts: _________

c. Retention Release: _________ (Carry over to next day)

Appendix C2.–A representative portion of the data form for recording salmon smolt length, weight, and scale samples.

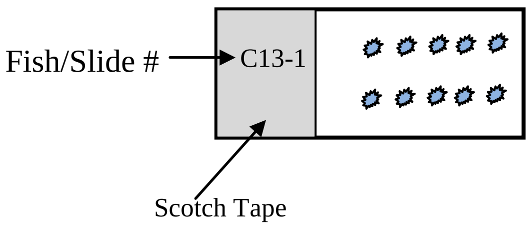
SALMON SMOLT LENGTH, WEIGHT, AND SCALE SAMPLES

Location: Cowee Creek **Year:** 2013 **Samplers:**______________________________

Page ____ **of** ____ (restart page count each day)

Page ____ **of** ____

Scale Slide



Scale Envelope

Fish/Slide #:________ Date:____________

Stream/Location:_____________Observers:____________

Length:_______ Scale determined Age:_______

Date	Fish/Slide #	Length (mm)	Weight (g)	Age	Comments
	C13-1				
	C13-2				
	C13-3				
	C13-4				
	C13-5				
	C13-6				
	C13-7				
	C13-8				
	C13-9				
	C13-10				
	C13-11				
	C13-12				
	C13-13				
	C13-14				
	C13-15				
	C13-16				
	C13-17				
	C13-18				
	C13-19				
	C13-20				
	C13-21				
	C13-22				
	C13-23				
	C13-24				

Appendix C3.–Data form used to record GPS and juvenile capture data.

SALMON SMOLT CAPTURE and GPS LOCATIONS

Year: 2013 **GPS Unit #:**__________ **Location:** Cowee Creek **Observers:**____

Comments:____

Date	Wpt # & Error (m)	# of traps checked	# of traps removed	Total # of traps	# of coho	# of DV	# of CT	Comments

*** a waypoint should only be associated with traps that are <5 m away from the place where the waypoint was captured; if you take a waypoint and place several traps that are <5 m away from that location, then place 1 additional trap and realize it’s ~7 m away, then take a new waypoint for the 1 additional trap.

APPENDIX D. ESTIMATION OF THE RATIO OF CATCHABILITIES

Appendix D1.–Estimation of the ratio of catchabilities.

The fraction p of adults with 1-freshwater age can be expressed as:

$$p = \frac{N_1\phi_1 S_1 + N_2\phi_2 S_2}{N_1 S_1 + N_2 S_2} = \frac{N_1\phi_1 S_1 + N_2\phi_2 B S_1}{N_1 S_1 + N_2 B S_1} = \frac{N_1\phi_1 + N_2\phi_2 B}{N_1 + N_2 B}$$

where N_i is smolt number by smolt size group i , S_i their survival rate, ϕ_i the fraction of the smolt group comprised of smolt age 1-freshwater, and B is the ratio of survival rates S_2/S_1. This relationship simplifies to:

$$\frac{N_1}{N_2} = \frac{B(\phi_2 - p)}{(p - \phi_1)}$$

If α_i is the capture rate of smolts, then $M_i = \alpha_i N_i$ is the number of smolts marked for groups i, and:

$$\frac{N_1}{N_2} = \frac{M_1}{M_2}\frac{\alpha_2}{\alpha_1} = \frac{B(\phi_2 - p)}{(p - \phi_1)}$$

If A is the ratio of catchability for the two groups of smolts, then $A = \alpha_2 / \alpha_1$ since fishing effort by definition is equal for both groups. Substitution creates:

$$A = \frac{M_2 B(\phi_2 - p)}{M_1 (p - \phi_1)}$$

A naïve estimate of A is therefore:

$$\hat{A} = \frac{M_2 \hat{B}(\hat{\phi}_2 - \hat{p})}{M_1 (\hat{p} - \hat{\phi}_1)}$$

Noting that the estimate for the ratio of survival rates is:

$$\hat{B} = \frac{T_2}{M_2}\frac{M_1}{T_1} \text{ since } B = \frac{S_2}{S_1} \propto \frac{\frac{T_2}{M_2}}{\frac{T_1}{M_1}}$$ where T_i is the number tags recovered from group i

A simpler estimate for A is:

$$\hat{A} = \frac{T_2 (\hat{\phi}_2 - \hat{p})}{T_1 (\hat{p} - \hat{\phi}_1)}$$