

**Size Estimation and Long-term Coded Wire Tag
Retention of Hatchery Chinook Salmon Released into
Cook Inlet, 2015–2017**

by

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and

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April 2015

Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries



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Weights and measures (metric)		General		Mathematics, statistics	
centimeter	cm	Alaska Administrative Code	AAC	<i>all standard mathematical signs, symbols and abbreviations</i>	
deciliter	dL	all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.	alternate hypothesis	H_A
gram	g	all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.	base of natural logarithm	e
hectare	ha	at	@	catch per unit effort	CPUE
kilogram	kg	compass directions:		coefficient of variation	CV
kilometer	km	east	E	common test statistics	(F, t, χ^2 , etc.)
liter	L	north	N	confidence interval	CI
meter	m	south	S	correlation coefficient	
milliliter	mL	west	W	(multiple)	R
millimeter	mm	copyright	©	correlation coefficient	
		corporate suffixes:		(simple)	r
Weights and measures (English)		Company	Co.	covariance	cov
cubic feet per second	ft ³ /s	Corporation	Corp.	degree (angular)	°
foot	ft	Incorporated	Inc.	degrees of freedom	df
gallon	gal	Limited	Ltd.	expected value	E
inch	in	District of Columbia	D.C.	greater than	>
mile	mi	et alii (and others)	et al.	greater than or equal to	≥
nautical mile	nmi	et cetera (and so forth)	etc.	harvest per unit effort	HPUE
ounce	oz	exempli gratia	e.g.	less than	<
pound	lb	(for example)		less than or equal to	≤
quart	qt	Federal Information Code	FIC	logarithm (natural)	ln
yard	yd	id est (that is)	i.e.	logarithm (base 10)	log
		latitude or longitude	lat or long	logarithm (specify base)	log ₂ , etc.
Time and temperature		monetary symbols		minute (angular)	'
day	d	(U.S.)	\$, ¢	not significant	NS
degrees Celsius	°C	months (tables and figures): first three letters	Jan,...,Dec	null hypothesis	H_0
degrees Fahrenheit	°F	registered trademark	®	percent	%
degrees kelvin	K	trademark	™	probability	P
hour	h	United States	U.S.	probability of a type I error	
minute	min	(adjective)		(rejection of the null hypothesis when true)	α
second	s	United States of America (noun)	USA	probability of a type II error	
		U.S.C.	United States Code	(acceptance of the null hypothesis when false)	β
Physics and chemistry		U.S. state	use two-letter abbreviations (e.g., AK, WA)	second (angular)	"
all atomic symbols				standard deviation	SD
alternating current	AC			standard error	SE
ampere	A			variance	
calorie	cal			population	Var
direct current	DC			sample	var
hertz	Hz				
horsepower	hp				
hydrogen ion activity	pH				
(negative log of)					
parts per million	ppm				
parts per thousand	ppt, ‰				
volts	V				
watts	W				

REGIONAL OPERATIONAL PLAN SF.2A.2015.04

**SIZE ESTIMATION AND LONG-TERM CODED WIRE TAG
RETENTION OF HATCHERY CHINOOK SALMON RELEASED INTO
COOK INLET**

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April 2015

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SIGNATURE PAGE

Project Title: Size estimation and long-term coded wire tag retention of hatchery Chinook salmon released into Cook Inlet

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Division, Region, and Area: Division of Sport Fish, Region 0, Anchorage

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Approval

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ABSTRACT

The Alaska Department of Fish and Game (ADF&G) stocks hatchery-reared Chinook and coho salmon smolt in numerous locations throughout Southcentral Alaska to improve or create terminal sport fisheries in order to meet the demand on sport fishery resources. This project estimates long-term coded wire tag retention and weight composition for Chinook and coho salmon smolt release groups. The success of stocking hatchery smolt depends on numerous variables, many associated with the hatchery program. Marking, data collection, and reporting are monitored and standardized for each release group so that meaningful comparisons can be made among hatchery releases. Meaningful comparisons may in turn allow project managers to better understand factors critical to the success of smolt stocking projects and to improve existing programs.

Key words: adipose finclip, coded wire tag, Chinook salmon, coho salmon, stocking, smolt release.

PURPOSE

Smolt marking with an adipose finclip and coded wire tag (CWT) is a critical element in 3 anadromous salmon hatchery smolt stocking projects in Cook Inlet where hatchery-produced Chinook salmon return alongside naturally-produced Chinook salmon (Table 1). Anglers can use the adipose finclip to identify hatchery Chinook salmon from naturally-produced Chinook salmon in freshwater fisheries that target hatchery Chinook salmon. ADF&G personnel use the adipose finclip to identify hatchery Chinook salmon during brood collection. In addition to the adipose finclip and CWT, each release group is 100% thermally marked. All coho salmon and Chinook salmon release groups are reared at William Jack Hernandez Sport Fish Hatchery (WJHSFH).

A second critical element of smolt stocking programs is having a precise and accurate estimate of the number of tagged and untagged smolt released. At WJHSFH, for release groups that are not tagged, smolt abundance is estimated in 1 of 2 ways:

- 1) Electronic inventory—used when all the fish in the rearing unit belong to the same release group.
- 2) Volumetric estimate—used when the fish in the rearing unit belong to more than one release group.

For tagged release groups, abundance is estimated during the tagging process using the number of fish tagged as determined by the Northwest Marine Technology¹ Mark IV tag injector. Tagged abundance at release is the number of fish tagged adjusted for mortality and tag loss.

A third important element of hatchery smolt stocking programs is fish size. Weight and length of smolt at release are indicators of quality (Peltz and Starkey 1993). If smolt are too small at release, then ocean survival will be poor; and if smolt are too large at release, then ocean residence will be reduced, thus shifting age composition of returns to younger, smaller fish (Sweet and Peltz 1994). To maximize ocean survival of hatchery smolt and maintain the age composition of the existing population, we recommend that 80% of released hatchery coho smolt weigh between 15.1 and 25.0 g and released hatchery Chinook salmon weigh between 8.1 and 20.0 g.

¹ Product names used in this publication are included for completeness but do not constitute product endorsement.

Table 1.—Planned total release of fish into various systems in Cook Inlet, Prince William Sound, and Resurrection Bay as well as the number of fish marked with coded wire tags stocked into various systems in Cook Inlet.

Salmon species	Release site	Area	Broodstock	Planned number of fish in release group	Inventory method reported	Mark type ^a	Tagged
Chinook							
	Deception Creek	Cook Inlet	Deception Creek	212,000	tagging	thermal mark+CWT	212,000
	Ship Creek	Cook Inlet	Ship Creek	365,000	electronic	thermal mark	
	Crooked Creek	Cook Inlet	Crooked Creek	140,500	tagging	thermal mark+CWT	140,500
	Eklutna Tailrace	Cook Inlet	Deception Creek and Ship Creek	424,000	electronic	thermal mark	
	Halibut Cove	Cook Inlet	Ninilchik River and/or Crooked Creek	105,000	volumetric	thermal mark	
	Homer Spit	Cook Inlet	Ninilchik River and/or Crooked Creek	210,000	electronic	thermal mark	
	Seldovia	Cook Inlet	Ninilchik River and/or Crooked Creek	105,000	volumetric	thermal mark	
	Ninilchik River	Cook Inlet	Ninilchik River	150,000	tagging	thermal mark+CWT	150,000
	Fleming Spit	Prince William	Ship Creek	105,000	volumetric	thermal mark	
	Whittier	Prince William	Ship Creek	105,000	volumetric	thermal mark	
	Seward Lagoon	Resurrection Bay	Crooked Creek	315,000	electronic	thermal mark	
Coho							
	Bird Creek	Cook Inlet	Ship Cr (Little Susitna River)	125,000	volumetric	thermal mark	
	Campbell Creek	Cook Inlet	Ship Cr (Little Susitna River)	50,000	volumetric	thermal mark	
	Eklutna Tailrace	Cook Inlet	Ship Cr (Little Susitna River)	120,000	volumetric	thermal mark	
	Homer Spit	Cook Inlet	Ship Cr (Little Susitna River)	120,000	volumetric	thermal mark	
	Ship Creek	Cook Inlet	Ship Cr (Little Susitna River)	240,000	electronic	thermal mark	
	Lowell Creek	Resurrection Bay	Bear Lake	120,000	volumetric	thermal mark	
	Seward Lagoon	Resurrection Bay	Bear Lake	120,000	volumetric	thermal mark	
Total				3,131,500			

^a All release groups are 100%.

OBJECTIVES

PRIMARY OBJECTIVES

The goals of this project are to estimate long-term coded wire tag retention as well as estimate the size distribution of fish as an index of smolt quality at WJHSFH (Table 2). The specific objectives for FY15–17 will be as follows:

- 1) Estimate long-term CWT retention for all release groups of Chinook salmon smolt containing adipose finclipped fish at WJHSFH such that the estimate is within 2.5 percentage points of the true value 97.5% of the time.
- 2) Estimate the weight composition of each Chinook salmon release group containing tagged fish such that the estimates are within 5 percentage points of the true distribution 95% of the time.
- 3) Estimate the weight composition of at least 1 release group of coho salmon from the Ship Creek broodstock such that the estimates are within 5 percentage points of the true distribution 95% of the time.

Table 2.–Definitions of smolt quality for weight categories (in grams) of Chinook and coho salmon smolt.

Smolt size			Smolt quality
Chinook salmon	Coho salmon		
<8.1	<15.1	Smaller than preferred	
8.1–20.0	15.1–25	Preferred	
>20.1	>25	Larger than preferred	

SECONDARY OBJECTIVES

- 1) Obtain the electronic inventory and volumetric population estimates from hatchery staff for the Ninilchik River, Deception Creek, and Crooked Creek Chinook salmon release groups, and compare these estimates to the tagging inventory for each of these release groups.
- 2) Obtain a length for each fish weighed for estimating weight composition of smolt release groups.

Smolt marking will be performed according to the procedures presented in the Regional Operational Plan “Marking of Hatchery Chinook and Coho salmon Released into Cook Inlet, Prince William Sound, and Resurrection Bay, 2015–2017.”²

² Loopstra, D.P. and P.A. Hansen. *In prep.* Marking of hatchery Chinook and coho salmon smolt released into Cook Inlet, Prince William Sound, and Resurrection Bay, 2015–2017. Alaska Department of Fish and Game, Division of Sport Fish, Regional Operational Plan, Anchorage.

METHODS

STUDY DESIGN

Long-term Retention

Blankenship (1990) found that CWT loss was not significant after 29 days in Chinook and coho salmon held for up to 293 days after tagging (average weight at tagging ranged from 0.9 to 7.6 g). Consequently, all long-term tag retention measurements will occur more than 30 days after tagging is completed. To obtain a random sample, a plunger will be used repeatedly to create “popping” sounds in the rearing unit. Fish move away from the popping sounds so its application alleviates the tendency for undisturbed fish to sort themselves by size. Fish will be crowded together and several (minimum 5) dipnet samples will be taken from the rearing unit to obtain a minimum of 750 adipose finclipped fish (Cochran 1977). Each of the 750 marked fish will be passed in front of the wand detector and counted as either having a tag or lacking a tag. Counts will be kept on 2 manual counters. All fish lacking a tag will be passed in front of the wand detector again to assure the absence of a tag.

If the actual retention rate is at least 90%, this level of sampling provides an estimate that will be within 2.5 percentage points of the true retention rate 97.5% of the time. If long-term tag retention is less than 90%, additional marked fish will be sampled. The additional number of sampled fish will be based on the estimated long-term tag retention from the original sample of 750 fish and the required sample size to obtain the objective criteria (Table 3).

Table 3.–Level of additional sampling required to meet the objectives criteria if the long-term tag retention rate is less than 90%.

Retention rate of sample	Number of additional marked fish to sample
≥90%	0
85–89%	280
80–84%	540
75–79%	760
70–74%	940
65–79%	1,080
60–74%	1,180
55–69%	1,240
50–54%	1,260

Weight Composition

A sample of at least 510 fish (Thompson 1987) will be obtained from each rearing unit of Chinook salmon containing tagged fish and 1 randomly chosen rearing unit of coho salmon from Ship Creek broodstock within 7 days prior to the stocking date to estimate weight composition of each group such that the estimates are within 5% of the true distribution 95% of the time. A plunger will be used in each rearing unit to crowd the fish, and a sample will be netted and put into a small holding pen. All fish in the holding pen will be weighed. If a sample size of at least 510 is not achieved, the fish will be crowded a second time, and a second sample will be netted. All fish removed for sampling will be weighed.

Smolt Enumeration

Hatchery personnel will estimate the number of smolt in each release group using a volumetric technique as well as electronic inventory technique when available. Electronic inventory estimates will be made from an electronic count of fish obtained when fingerlings are transferred from the shared tank area to the smolt rearing area (see Electronic Inventory Estimates below). Volumetric estimates are based on the number (or weight) of fish that displace a volume of water in the tank sight gauge. These estimates for Ninilchik River, Deception Creek, and Crooked Creek release groups will be compared to the tagging inventory of fish in those release groups. Some circular rearing units contain fish for more than one release group. Electronic inventory estimates are not available for release groups that share a rearing unit with another release group. Volumetric estimates will be reported for such release groups.

Tagging Inventory

Tagging inventories (TI) for Chinook salmon release groups are established during tagging, in which 100% of the fish are marked with an adipose finclip and CWT. The Mark IV CWT injector counts the number of fish injected. Mortalities are monitored on a daily basis and subtracted from the original tagging inventory to yield a final tagging inventory for each release group. Hatchery personnel monitor the rearing units for mortalities on a daily basis and subtract mortalities from the original clipping inventory to yield a final clipping inventory for each release group.

Electronic Inventory Estimates

Electronic inventories (EI) for Chinook and coho salmon in the smolt production tanks are established when the fingerlings are moved from the 10-foot tanks in the Shared Tank Area to the 26-foot tanks in the Smolt Production Area. The fingerlings in the 10-foot tank are crowded and pumped using an Aqualife® fish pump to a Vaki® fish counter where they are electronically counted into the 26-foot tanks. The accuracy of the Vaki® counter is verified by passing 1 group of approximately 100 fish through the counter prior to the fingering transfer.

Volumetric Estimates

Volumetric estimates are determined when the fish are loaded into the stocking tanks for transport to the release sites. This estimate is a function of the tank volume (gallons), the estimated ratio of the volume of water displaced in the tank sight gauge to the volume of water placed in the tank (mm/gallon), and the estimated ratio of the number (or weight) of fish which displace a volume of water in the tank sight gauge (fish/mm or kg/mm).

At the time of transport, each tank is filled with water to the normal level for fish transport, and the water level on the tank sight gauge is recorded to the nearest millimeter. Fish are then pumped from the rearing unit into each of the transport tanks. The water level on each of the tank sight gauges is recorded again after the fish are loaded. The millimeters of water displaced is determined for each tank sight gauge, and using a known displacement value of kilograms of fish per millimeter of water displaced in the tank sight gauge, total weight of fish in the tank is calculated. Total number of fish is estimated by dividing the total weight by the estimated mean weight of a fish. Three to 5 samples (nets of fish) are obtained from crowded fish prior to loading. Each net of fish is split in half several times until the desired sample size (approximately 50 fish, visually estimated) is achieved. The fish are poured into a preweighed bucket of water, weighed to the nearest gram, and counted out of the bucket. Mean weight is calculated for each

sample, and an overall mean weight is estimated by summing the sample mean weights and dividing by the number of samples.

Comparison of Enumeration Techniques

For each release group where all fish were inventoried during tagging (Ninilchik River, Deception Creek, and Crooked Creek release groups), the number of fish obtained from that inventory (Tagging Inventory) is the official release number. The estimates obtained from the electronic inventory (EI) method and the volumetric displacement (WV) method will be compared to the tagging inventory for each of these 3 rearing units, and the more accurate of the 2 methods (EI or WV) will be determined.

In rearing units that contain a single release group and where a tagging inventory (TI) was not conducted, if the electronic inventory and volumetric displacement point estimates differ by less than 10%, the electronic inventory estimates will be used. If the point estimates differ by more than 10%, the estimate from the technique determined to be more accurate when compared to the tagging inventory will be used.

DATA COLLECTION

Long-term Retention

Long-term retention data for each release group will include the number of fish examined for the presence of a tag and the number of fish in which the tag is still present.

Weight Composition

A minimum of 510 fish will be individually measured for length and weight for each rearing unit containing marked Chinook salmon smolt as well as 1 rearing unit of coho salmon. Each fish will be measured to the nearest millimeter using a Bioscribe electronic fish measuring board, and weighed to the nearest 0.1 g on an electronic digital scale. Scale accuracy will be tested with a calibration weight, and the scale will be calibrated if necessary prior to sampling. Date, release group, and fish length and weight will be recorded on an Excel spreadsheet.

Smolt Enumeration

Tagging Inventory

The tagging inventory data for Ninilchik River, Deception Creek, and Crooked Creek releases include the following:

- 1) number of fish tagged in each release group
- 2) number of mortalities from the time the clipping inventory is established until the fish are released

Electronic Inventory Estimates

The electronic inventory data for each smolt rearing unit include the following:

- 1) electronic count of fish transferred into each smolt rearing unit
- 2) number of mortalities from the time the clipping inventory is established until the fish are released

Volumetric Estimates

The volumetric data include the following:

- 1) initial sight gauge reading in millimeters
- 2) final sight gauge reading in millimeters
- 3) weight and number of fish in each sample
- 4) known displacement value of fish (kg)/ water (mm) water displaced

DATA REDUCTION

Long term Retention

All data associated with long-term retentions will be kept on an Excel spread sheet and stored on a disk and the project leader's computer hard drive. The data will be examined for obvious errors and outliers by the project leader. All suspect data points will be double checked to determine if it was a data entry error or a data recording error or an outlier (which could be considered in the analysis).

Weight Composition

The individual measurements from each release group of fish will be recorded directly from the electronic measuring board into an Excel spreadsheet. The file will contain date, release group, fork length (mm), and weight (g). Any measurement (length or weight) considered to be an outlier (more than 2 standard deviations from the mean) will be brought to the project biologist's attention to determine inclusion in the estimates. Any exclusion of data points will be fully documented in the final report. All data associated with size estimation will be stored on the network server.

Smolt Enumeration

All data associated with tagging inventories, electronic inventory estimates, or volumetric estimates, will be kept on an Excel spreadsheet and stored on the network server.

A final, edited copy of all data along with a data map describing the data files will be sent to RTS on a CD or DVD for archiving in ASCII (Excel CSV) format on the Division of Sport Fish intranet site ("Docushare") at <http://docushare.sf.adfg.state.ak.us/>.

DATA ANALYSIS

Long-term Retention

For each release group, the long term tag retention rate (D_i) of smolt that were finclipped, tagged, and survived and its variance will be estimated as a binomial proportion:

$$\hat{D}_i = \frac{n_i}{n_{ii}} \quad (1)$$

and

$$Var(\hat{D}_i) = \frac{\hat{D}_i(1 - \hat{D}_i)}{n_{ii} - 1} \quad (2)$$

where

n_i = number of tagged smolt in the sample that retained the tag, and

n_{ti} = total number of tagged smolt in the sample.

Weight Composition

The proportion of smolt in weight class j and its variance will be estimated for each release group as a binomial proportion (Cochran 1977) as follows:

$$\hat{p}_j = \frac{n_j}{n} \quad (3)$$

and

$$Var(\hat{p}_j) = \frac{\hat{p}_j(1 - \hat{p}_j)}{n - 1}, \quad (4)$$

where

n_j = the number of smolt in weight class j , and

n = the total number of smolt measured for weight.

SCHEDULE AND DELIVERABLES

Activity	Time frame
1. Smolt enumeration	within 7 days of release
2. Smolt release	10 May–20 June
3. All data analysis completed.	1 August
4. First draft of report submitted.	1 October

The results of smolt marking, release, and production project components will be included in an annual report produced by each hatchery as well as in an Alaska Department of Fish and Game Division of Sport Fish, Fishery Data Series Report.

RESPONSIBILITIES

Fishery Biologist II (Diane Loopstra)	Project Leader: Coordinates marking activities at WJHSFH and insures that the marking plan described in the operational plan is followed. Direct supervision of smolt enumeration and size estimation. Assimilates all data from the fish culturists. Enters all marking data into ADF&G Mark, Tag, and Age Lab's Online Release Entry system. Primary author of annual report. Coordinates writing of operational plan with the Project Biometrician.
Biometrician III (Pat Hansen)	Project Biometrician: Provides statistical supervision

	and shares design and writing of the operational plan with the Project Leader. Assists with data analysis and reviews the annual report.
Fish Culturist III (Andrea Tesch)	Hatchery Manager–WJHSFH: Directs supervision of coho and Chinook salmon smolt rearing.
Fisheries Technicians/Culturists	Determine hatchery inventory and water volume population estimates. Assist with the collection of other data. Routine data entry and simple analysis.

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