Fishery Data Series No. 09-67

Auke Creek Weir Studies: 2007

by

Jesse D. Echave

December 2009

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

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

Alaska Department of Fish and Game	ADF&G
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)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

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

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ADF&G Fishery Data Series was established in 1987 for the publication of Division of Sport Fish technically oriented results for a single project or group of closely related projects, and in 2004 became a joint divisional series with the Division of Commercial Fisheries. Fishery Data Series reports are intended for fishery and other technical professionals and are available through the Alaska State Library and on the Internet: http://www.sf.adfg.state.ak.us/statewide/divreports/html/intersearch.cfm This publication has undergone editorial and peer review.

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ABSTRACT

A weir on Auke Creek was operated from March 10 through October 31, 2007 to count pink *Oncorhynchus gorbuscha*, chum *O. keta*, coho *O. kisutch*, and sockeye *O. nerka* salmon; steelhead *O. mykiss* and cutthroat trout *O. clarkii*; and Dolly Varden *Salvelinus malma* char. Age, weight and length data were collected from emigrant coho and sockeye salmon, and coded wire tagging was conducted on coho salmon. Length distributions were determined for emigrant cutthroat trout and Dolly Varden. Returning adult coho salmon were sampled for age, sex, and length data, and a length distribution was determined for immigrant cutthroat trout captured at the weir. A total of 4,056 coho smolts were successfully given a coded wire tag (CWT) and released downstream. An estimated 38% (SE = 2%) were age 1. and 62% (SE = 2%) were age 2. During the emigration, 162 cutthroat trout, 4,300 Dolly Varden, 13,716 sockeye smolt, 81,899 pink fry, 12,839 chum fry, and 6 steelhead juveniles were counted through the weir. Average fork length of emigrant Dolly Varden was 244 mm (SE = 3 mm). Fork lengths of emigrant cutthroat trout averaged 264 mm and had a SD of 50 mm. During the immigration period, 94 cutthroat trout, 1,202 Dolly Varden, 2,754 adult sockeye salmon, 3,123 pink salmon (2,944 wild and 179 hatchery), 719 chum salmon, 352 adult coho salmon, and 1 juvenile steelhead were passed through the weir. Fork lengths of captured immigrant cutthroat trout averaged 266 mm (SE = 6 mm). Auke Creek contributed an estimated 200 (SE = 27) adult coho salmon to marine fisheries in 2007, yielding an exploitation rate of 36% (SE = 2.2%). Smolt-to-adult survival for the 2006 coho smolt emigration was estimated at 15% (SE = 0.7%). Of all counts during both the emigration and immigration periods, only the chum salmon fry count was above its historical average.

Key words: Alaska, Auke Lake, Auke Creek, cutthroat trout, Dolly Varden, steelhead, coho salmon, sockeye salmon, pink salmon, chum salmon, smolt, sea-run, weir, length distribution, timing, PIT, CWT, tag retention, exploitation, survival.

INTRODUCTION

The Alaska Department of Fish and Game, Division of Sport Fish (ADF&G), the University of Alaska, Fairbanks (UAF), and the National Marine Fisheries Service (NMFS) cooperatively fund and operate the NMFS Auke Creek weir on the outlet of Auke Lake, near Juneau, Alaska (Figure 1). The weir is a permanent structure designed to capture all emigrant and immigrant fish at Auke Creek. It is operated from the beginning of March to the end of June to intercept all emigrating species, after which time it is converted and operated through the end of October to intercept all immigrating adult Pacific salmon species.

A weir has been operated at Auke Creek since 1963 and the present permanent structure was installed during spring 1980. In 1997 further modifications were made to capture, in addition to several other species, all immigrant Dolly Varden and cutthroat trout. Since installation of the permanent structure, Auke Creek weir has provided consistent, long-term information on all emigrating and immigrating species, and it provides the most complete database for several anadromous species in Southeast Alaska (Lum and Taylor 2004).

Researchers at ADF&G, UAF, and NMFS use information gathered at the Auke Creek weir in a variety of projects aimed at understanding long-term trends. Weir counts and coded wire tag (CWT) data provide indicators for local stocks and are used by fisheries managers to assess the exploitation by and contribution to various fisheries, e.g., Auke Creek coho salmon serve as a key stock in northern Southeast Alaska. Studies initiated at the weir have provided important insights into developmental processes, the genetic composition of runs, outbreeding depression, local adaptation, marine survival estimates, life history strategies, age composition, maturity, run timing, and growth of several species present in Auke Lake and Auke Creek (Gharrett and Smoker 1991; Gharrett et al. 1999; Gilk et al. 2004; Goddard 1995; Hebert et al. 1998; Hoover 2005, 2007, 2008; Lum et al. 1998-2002; Lum and Taylor 2004; Neimark 1984a-b; Taylor *Unpublished-a-c* 2005-2007; Taylor and Lum *Unpublished* a-g; Wang 2004). The Division of Sport Fish also uses data collected by this project to better understand sea-run life history forms of Dolly Varden and cutthroat trout, and this information has contributed to several Alaska Board of Fish management decisions.

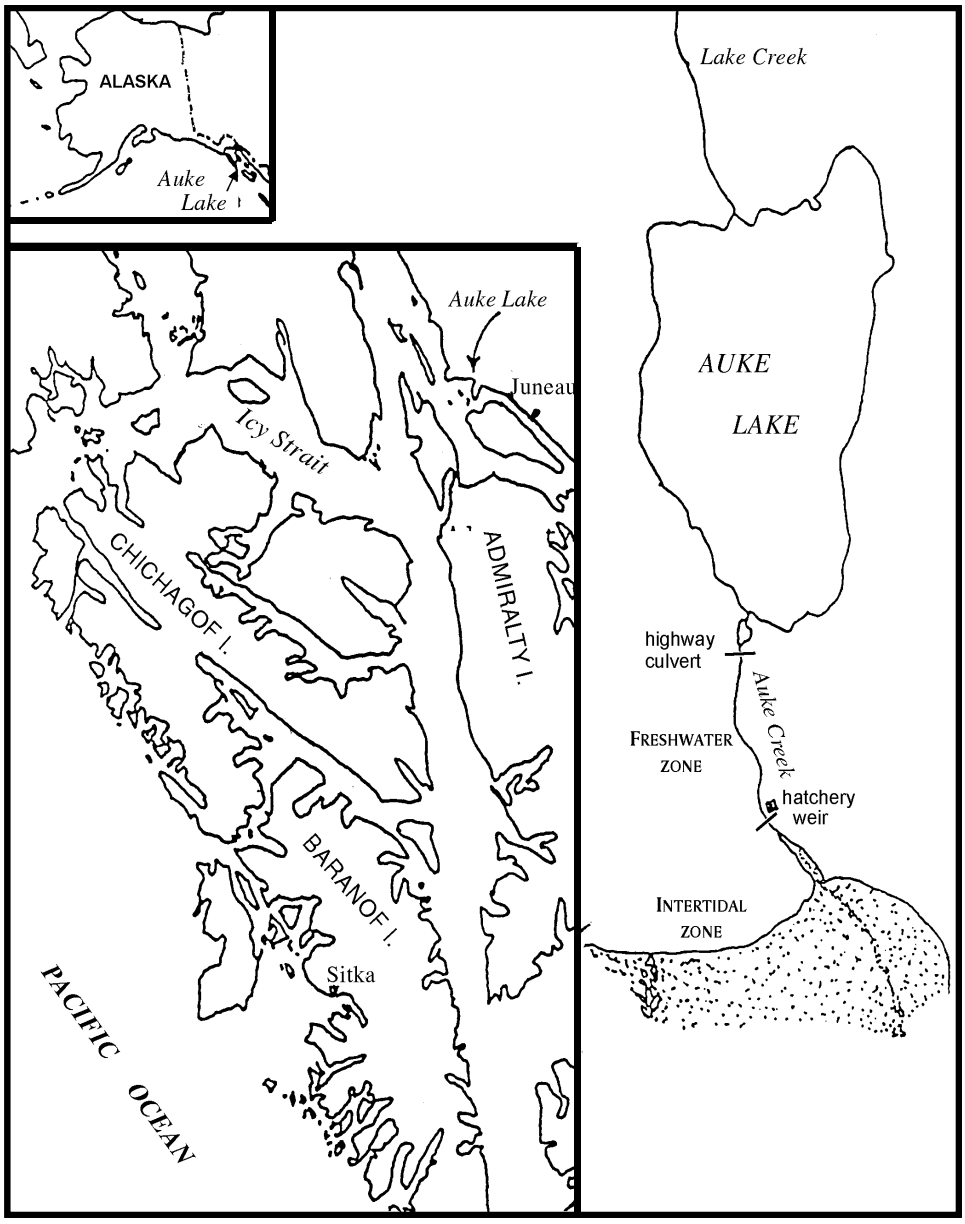

Figure 1.–The Auke Lake system in northern Southeast Alaska and location of the Auke Creek weir.

OBJECTIVES

There are two components of this project: the spring emigrant weir operated between March 10 and June 28, and the summer/fall immigrant weir operated between June 29 and October 31. The specific objectives, times and subsampling schemes by species are presented below. In an effort to reduce handling stress on smaller immigrant Dolly Varden and cutthroat trout, the upstream weir was not modified to capture all immigrants during 2007 as it has been in the past. However, cutthroat trout and Dolly Varden were still captured in the adult salmon trap, but it is assumed that fish about 200 to 250 mm FL could pass through the weir panels uncounted.

The objectives at the Auke Creek weir from March 10 through June 28, 2007 were to:

1. Determine the length distribution of emigrant sea-run cutthroat trout;
2. Estimate the length distribution of Dolly Varden;

3. Enumerate all emigrating cutthroat trout, Dolly Varden, juvenile steelhead, sockeye smolt, pink fry and chum fry, and enumerate and CWT all emigrating coho salmon smolt;
4. Estimate length and age composition of emigrating coho salmon smolt, and estimate the number of emigrants by freshwater age; and,
5. Estimate mean weight- and length-at-age of emigrating coho salmon smolt.

The objectives from June 29 through October 31, 2007 were to:

1. Determine the length distribution of immigrating sea-run cutthroat trout captured at the weir;
2. Enumerate any cutthroat trout, Dolly Varden, and steelhead juveniles captured at the weir, as well as all immigrating sockeye, pink, chum, and coho adults, and estimate sex composition of immigrant pink salmon;
3. Estimate length, age, and sex composition of immigrating coho salmon adults and jacks, and estimate the number of immigrants by age class; and,
4. Estimate the marine harvest, total abundance, smolt-to-adult marine survival, and exploitation rate of adult coho salmon bound for Auke Creek in 2007.

STUDY AREA

Auke Lake is located 19.2 km north of Juneau, Alaska (53°23′, 134°37′), on the Juneau road system (Figure 1). It is 1.6 km long and 1.2 km wide and has a surface area of approximately 67 ha. The lake is fed by five tributaries, drains a mainland watershed of approximately 1,072.5 ha, and its biggest tributary, Lake Creek, drains 647.5 ha. Auke Lake's depth is 31.4 m, and it has an elevation of approximately 19.1 m. The lake bottom is primarily mud with gravel areas off the inlet streams. The shoreline of the lake is bordered by forested terrain that varies from gentle slopes to steep-sided banks, and the shoreline zone consists of areas dominated by emergent vegetation of *Equisetum* spp. and *Nuphar* spp. Other areas of the lake are characterized by large numbers of submerged and floating conifers anchored to the lakeshore and bottom by root wads. At least 50% of the shoreline has been urbanized by residential development (Lum and Taylor 2004).

Auke Creek is the outlet of Auke Lake. The weir on Auke Creek is located above mean tide level and about 400 m downstream from the outlet of Auke Lake. On average, Auke Creek supports annual migrations of about 700 coho salmon adults, 6,000 coho smolts, 3,300 sockeye salmon adults, and 17,000 sockeye smolts (Table 1). The Auke Lake system also supports migrating populations of about 5,000 Dolly Varden and 225 cutthroat trout (Table 1). The lake is closed to retention of sport-caught Dolly Varden, but it supports a small sport fishery for cutthroat trout. Cutthroat trout are caught through the ice during the winter and from the beach or small boats during the remainder of the year. Anecdotal information suggests that the trout fishery in Auke Lake was once more productive than at present. The emigration of adult cutthroat from Auke Lake initially increased as enhancement efforts occurred in the lake (Lum and Taylor 2004), but migration numbers have been declining since 1996.

METHODS

EMIGRANT POPULATIONS

The Auke Creek weir was operated from March 10 through June 28, 2007 to intercept all emigrant salmonids. During this time fish could not move upstream through the weir. The weir is designed so that water spills through five inclined traps and vertical aluminum panels covered with 3 mm perforations that are effective at both high and low flows. Fish that exited the inclined traps were diverted through an aluminum trough to a fiberglass holding tank. Fish were sorted by species, counted, sampled, and released each day downstream of the weir. All emigrating cutthroat trout were counted, measured to the nearest mm FL, examined for external marks or tags, and checked for passive integrated transponder (PIT) tags. No new fish were PIT tagged in 2007. All emigrating Dolly Varden were counted, and length composition was estimated using a

Table 1.–Average number of migrating species counted at Auke Creek; fall and spring averages calculated from 1980–2006 immigrants and emigrants where applicable. Counts in italics represent smolt.

Migration period	Pink salmon	Coho salmon	Sockeye salmon	Chum salmon	Chinook salmon	Dolly Varden	Cutthroat trout	Juvenile steelhead
Spring	*106,280*	*5,992*	*17,245*	*4,572*	-	6,068	250	*12*[a]
Fall	11,041	716	3,341	1,443	224[b]	3,973[c]	207[c]	6[c]

[a] Average of 1990–2006 weir counts when this species was tallied.

[b] Average of 1987–2006 weir counts; these (presumed hatchery strays) are killed at the weir.

[c] Average of 1997–2006 weir counts when upstream weir was modified for small immigrants.

systematic sampling procedure where every 10th Dolly Varden passed downstream was measured to the nearest mm FL. The sample was taken by holding (placing in a basket) the 1st, 11th, 21st, etc. fish passed downstream; selected fish were measured after all fish were counted for the day. No conscious effort was made to select fish by size. Dolly Varden and cutthroat trout mortalities found in the traps or on the weir were noted separately and included in the daily total. Cutthroat mortalities were sampled for length, sex, and the PIT tag, if present, was removed. Emigrating steelhead juveniles were also counted and measured for FL to the nearest mm.

Salmon smolts emigrating from Auke Creek were counted daily. Each captured coho salmon smolt was anesthetized in a solution of MS-222, injected in the snout with a full-length (1 mm) CWT, and marked by excising the adipose fin. Each week, a sample of coho smolt captured on one or more days was re-anesthetized, weighed to the nearest 0.01 g, measured to the nearest mm FL, scale sampled, and released downstream below the weir the following morning after being tested for tag retention. Either every smolt captured in a given day was sampled or a systematic (1 in *x*) procedure was used. Overall goals were to maintain a proportional sample over the entire length of the run such that at least 300 fish or 10% of the emigrant population were sampled. Several scales were collected from the preferred area (Scarnecchia 1979) of each fish and sandwiched between two microscope slides that were taped together and labeled with location and sample date. Scales were then aged at a later time.

Sockeye salmon smolts were collected, anesthetized, weighed, measured, and sampled for scales in the same manner as coho smolt. There is no aging of sockeye scales at the current time, but they are collected for possible aging at a later date. Pink and chum salmon fry were also counted daily, and 50 pink salmon fry were collected every Monday, anesthetized with MS-222, weighed, measured to the nearest mm FL, and upon recovery, released downstream from the weir. Chum salmon fry were not measured or weighed.

IMMIGRANT POPULATIONS

The upstream weir was operated from June 29 through October 31, 2007 to intercept and count all immigrating adult pink, chum, sockeye, and coho salmon, as well as a portion of cutthroat and juvenile steelhead trout, and Dolly Varden. Adult Chinook salmon *O. tshawytscha* from releases of hatchery smolts in Auke Bay near the mouth of Auke Creek also returned during the immigration period. Because these are not indigenous to Auke Creek, they were counted by maturity (adult or jack, where jacks are defined as age-.0 fish) and killed at the weir.

The upstream weir was modified by installing vertical slotted aluminum panels (90 x 178 cm) into the structure to divert fish into the adult trap without restricting water flow. This allowed fish moving upstream to be captured while blocking any downstream movement. Trout screens (45 x 90 cm) made out of perforated aluminum (1.5 x 10 cm) have been used in the past to prevent the movement of smaller-sized fish, but were not installed in 2007. Many small fish migrating upstream, however, were caught not only in the adult trap but in two trout traps located on either side of the creek. These traps measured 1.5 x 2.4 x 0.8 m high and were attached to the upstream side of the weir. To better protect the smaller fish, pickets spaced 2.5 cm apart prevented larger salmonids from entering these traps. Plastic mesh

netting (6 x 6 mm) was used to cover the walls of the trout traps, as well as the adult trap, to retain smaller fish.

Cutthroat trout were counted, measured, and examined for external marks and the presence of a PIT tag and released upstream. All cutthroat mortalities were sampled for length, sex, and the PIT tag, if present, was removed. All captured steelhead trout and Dolly Varden were counted and examined for external marks or tags prior to release upstream. Steelhead trout were also measured to the nearest mm FL.

All adult (≥age-.1) and jack (age-.0) sockeye and coho salmon passing the weir were counted, examined for external marks, and released upstream. Coho are generally not allowed to enter the stream until roughly the second week of September. It has been observed that coho salmon that are allowed to enter Auke Creek before this time can experience high mortality. Since the weir is located just above the tidal area, it is thought that prior to the installation of the weir, coho salmon may have entered and exited the stream several times before they became fully osmocompetent in fresh water. The presence of the weir makes this impossible for immigrating coho and therefore may be the cause of this higher mortality. To correct for this, coho are turned back downstream until greater numbers begin to arrive, stream temperatures are cooler, and water levels are higher, which typically occurs toward the middle of September.

Length (nearest 5 mm MEF) and sex for coho and sockeye salmon were recorded, and scales were collected from a target 40 to 120 fish sampled on one or more days per week. Targets within sample days were to either sample every adult or adopt a systematic (1 in *x*) procedure. Overall sampling goals were to maintain an approximately proportional sample throughout the run such that about 250 or more fish of each species were sampled. Adult coho salmon were stunned in an electroshock basket prior to sampling. Scales from jacks and adults (4 per fish) were collected from the preferred area and placed on a gum card. Scales were pressed onto acetate cards and analyzed for age using a microfiche reader. Length, sex and heads were collected from adipose-clipped coho mortalities collected on the weir. All heads collected from adipose-clipped coho salmon were dissected and CWTs were removed and deciphered at the Auke Creek hatchery facility.

Adult pink and chum salmon returning to Auke Creek were counted, examined for marks and released upstream when appropriate. Marked pink salmon also returned in 2007 as part of a UAF research project. Each of these hatchery-produced fish had an adipose-pelvic fin mark combination. All hatchery fish were sorted into creek pens and retained for the continuation of the research project. No hatchery pink salmon were released upstream. The sex of all wild pink salmon adults was also determined. Hatchery returns from the same UAF research project are also expected in 2008.

MARINE FISHERIES SAMPLING

Adult coho salmon are harvested in various fisheries as they return to spawn. Recovery of tagged fish from troll, purse seine, and gillnet fisheries is done by ADF&G Division of Commercial Fisheries port samplers, and the Division of Sport Fish creel survey program recovers tagged fish from sport fisheries. Recoveries of CWTs from adult coho salmon (identified by missing adipose fins) in sampled sport and commercial fisheries in 2007 were used to estimate the contribution of Auke Lake fish to these fisheries using methods described in Bernard and Clark (1996).

Catch and harvest expansion data for commercial and sport fisheries were obtained using the ADF&G Mark, Tag and Age Laboratory online reporting system (2007 Agency Report, 2007 Southeast Sport Report, 2007 Commercial Expansion by Harvest Code Report, and Sport Expansion Report). Commercial catch data were summarized by ADF&G statistical week and district (for gillnet and seine fisheries), or by period and quadrant for troll fisheries. Sport fish CWT recovery data were summarized by biweek and fishery (e.g., biweek 16 during the Juneau Marine Creel Survey). Final harvest estimates were calculated according to Suchanek and Bingham (1992).

DATA ANALYSIS

Age, Length, and Sex Composition

Length composition of the emigrant Dolly Varden population passing the weir was estimated by:

$$\hat{p}_\ell = \frac{n_\ell}{n} \tag{1}$$

$$\text{var}(\hat{p}_\ell) = \left[1 - \frac{n_\ell}{N}\right] \frac{\hat{p}_\ell(1-\hat{p}_\ell)}{n_\ell - 1} \tag{2}$$

where $\hat{p}_\ell$ is the estimated proportion of the population in length group ℓ, n is the number of fish measured in the systematic (1 in 10) sampling, n_ℓ is the subset of n belonging to group ℓ, and N is the total weir count. A finite population correction factor (fpc) = (1 - n_ℓ / N) is included because the population total is known and the sampling rate is relatively high. As all cutthroat trout were measured, size composition of cutthroat emigrants was known and did not need to be estimated.

Abundance of Dolly Varden in each length group in the population ($\hat{N}_\ell$) was estimated:

$$\hat{N}_\ell = \hat{p}_\ell N \tag{3}$$

$$\text{var}(\hat{N}_\ell) = N^2 \text{var}(\hat{p}_\ell) \tag{4}$$

Age composition ($\hat{p}_a$) of the migrant coho salmon (smolt, adult, and jack) populations passing the weir were estimated using a temporally stratified sampling design:

$$\hat{p}_{a,h} = \frac{n_{a,h}}{n_h} \tag{5}$$

$$\text{var}(\hat{p}_{a,h}) = \left[1 - \frac{n_h}{N_h}\right] \frac{\hat{p}_{a,h}(1-\hat{p}_{a,h})}{n_h - 1} \tag{6}$$

$$\hat{p}_a = \frac{1}{N}\sum_h N_h \, \hat{p}_{a,h} \tag{7}$$

$$\text{var}(\hat{p}_a) = \sum_h W_h^2 \text{var}(\hat{p}_{a,h}) \tag{8}$$

where $\hat{p}_{a,h}$ is the estimated proportion of the population in age group *a* and temporal strata *h*, n_h is the number of fish successfully aged in strata *h*, $n_{a,h}$ is the subset of n_h belonging to group *a*, and N_h is the total count at the weir in stratum *h*. Sampling weights were defined as $W_h = N_h / N$, and $N = \sum N_h$. Strata were defined as weeks. Abundance at age $\hat{N}_a$ was estimated as in (3) and (4), using $\hat{p}_a$ rather than $\hat{p}_\ell$.

Sex composition in each age group was estimated using the same temporally stratified design:

$$\hat{p}_{a,sex,h} = \frac{n_{a,sex,h}}{n_{a,h}} \tag{9}$$

$$\text{var}(\hat{p}_{a,sex,h}) = \left[1 - \frac{n_{a,h}}{\hat{N}_{a,h}}\right] \frac{\hat{p}_{a,sex,h}\left(1-\hat{p}_{a,sex,h}\right)}{n_{a,h} - 1} \tag{10}$$

$$\hat{p}_{a,sex} = \frac{1}{\hat{N}_a}\sum_h \hat{N}_{a,h} \, \hat{p}_{a,sex,h} \tag{11}$$

$$\begin{aligned} \text{var}(\hat{p}_{a,sex}) \approx & \sum_h \hat{W}_{a,h}^2 \text{var}(\hat{p}_{a,sex,h}) \\ & + \frac{\sum_h \text{var}(\hat{N}_{a,h})\left(\hat{P}_{a,sex,h} - \hat{P}_{a,sex}\right)^2}{\hat{N}_a{}^2} \end{aligned} \tag{12}$$

where ($\hat{p}_{a,sex,h}$) is the estimated proportion being male or female at age *a* in strata *h*, $n_{a,h}$ is the number of age *a* fish successfully sexed in strata *h*, $n_{a,sex,h}$ is the subset of $n_{a,h}$ being male or female, and $\hat{N}_{a,h}$ is calculated as in (3), but by stratum using (5) and N_h. Because sampling weights are estimated, variance (12) was approximated using the delta method (Seber 1982; Zar 1999).

Abundance by age and sex was calculated

$$\hat{N}_{a,sex} = \hat{p}_a \, \hat{p}_{a,sex} \, N \tag{13}$$

$$\begin{aligned} \text{var}(\hat{N}_{a,sex}) \approx & N^2[\hat{p}_a^2 \, \text{var}(\hat{p}_{a,sex}) \\ & + \hat{p}_{a,sex}^2 \, \text{var}(\hat{p}_a) - \text{var}(\hat{p}_{a,sex}) \, \text{var}(\hat{p}_a)] \end{aligned} \tag{14}$$

Equivalently, the product $\hat{p}_a\,\hat{p}_{a,sex}$ in (13) could simply be defined as $\hat{p}_{a,sex}$ = the proportion at age and sex, and (14) would simplify accordingly (setting $\text{var}(\hat{p}_a) = 0$). Mean lengths and weights of coho migrants at age were also estimated using the temporally stratified design. For length at age (ℓ_a), where *i* denotes an individual fish,

$$\hat{\bar{l}}_{a,h} = \frac{1}{n_{a,h}} \sum_i l_{a,h,i} \tag{15}$$

$$\text{var}\left(\hat{\bar{l}}_{a,h}\right) = \left[1 - \frac{n_{a,h}}{\hat{N}_{a,h}}\right] \sum_i \frac{\left(l_{a,h,i} - \hat{\bar{l}}_{a,h}\right)^2}{n_{a,h}\left(n_{a,h} - 1\right)} \tag{16}$$

$$\hat{\bar{l}}_a = \frac{1}{\hat{N}_a} \sum_h \hat{N}_{a,h}\,\hat{\bar{l}}_{a,h} \tag{17}$$

$$\text{var}(\hat{\bar{l}}_a) \approx \sum_h \hat{W}^2_{a,h}\,\text{var}\left(\hat{\bar{l}}_{a,h}\right) + \frac{\sum_h \text{var}(\hat{N}_{a,h})\left(\hat{\bar{l}}_{a,h} - \hat{\bar{l}}_a\right)^2}{\hat{N}^2_a} \tag{18}$$

where $n_{a,h}$ is the number of age *a* fish successfully measured in strata *h*. Equations 15–18 above were modified for estimating mean lengths and weights at age by sex, by adding notation for sex (i.e., $\ell_{a,sex,h,i}$, $\hat{\bar{\ell}}_{a,sex,h}$, $\hat{\bar{\ell}}_{a,sex}$, $n_{a,sex,h}$, $\hat{N}_{a,sex,h}$, $\hat{N}_{a,sex}$, $\hat{W}^2{}_{a,sex,h}$). Mean lengths and weights without respect to age by sex were also computed. In this case notation for age (*a*) is dropped; N_h, *N*, and W_h are not estimates (as in equations 6-8); and the very rightmost term in (18) is dropped.

Marine Harvest, Adult Return, Survival, and Exploitation

Because all coho salmon smolt emigrating from Auke Creek were presumed marked with a CWT, we assumed all returning jacks and adults that originated from Auke Creek had been tagged (and marked with a adipose finclip) when estimating harvest. The fraction of jacks (from 2006) and adults (in 2007) passing the weir with an adipose finclip were used to evaluate this assumption. Any unmarked, mature coho salmon captured at the weir were treated as strays from nearby hatchery enhancement efforts and from streams with natural production.

Total abundance of adult coho salmon returning to Auke Creek was calculated by summing the estimated marine harvest and the escapement of adipose-clipped and CWT-marked fish counted through the weir,

$$\hat{N}_R = \hat{T} + N_e \tag{19}$$

$$\text{var}\left(\hat{N}_R\right) = \text{var}\left(\hat{T}\right) \tag{20}$$

where $\hat{N}_R$ is the estimated abundance of adult coho salmon returning to Auke Creek, N_e is the escapement count of adult coho returning to Auke Creek in 2007, and $\hat{T}$ is the estimated marine harvest of adult Auke Creek coho salmon in 2007.

Smolt-to-adult marine survival $\hat{S}$ was calculated by dividing the estimated total adult abundance by the number of coho salmon smolts that were counted, tagged, and released alive in 2006,

$$\hat{S} = \frac{\hat{N}_R}{C} \tag{21}$$

$$\text{var}\left(\hat{S}\right) = \left(\frac{1}{C}\right)^2 \text{var}\left(\hat{N}_R\right) \tag{22}$$

where *C* is the number of smolt counted, tagged, and released alive from Auke Creek in 2006.

The exploitation rate $\hat{E}$ for adult coho salmon was calculated by:

$$\hat{E} = \frac{\hat{T}}{\hat{N}_R} \tag{23}$$

$$\hat{\text{var}}\left(\hat{E}\right) = \frac{\hat{\text{var}}\left(\hat{T}\right) N_e^2}{\hat{N}_R^4} \tag{24}$$

RESULTS

MIGRANT CUTTHROAT TROUT

A total of 162 cutthroat trout emigrated in 2007 (Appendix A1, Table 2, Figure 2). This count was lower than the 27-year average of 250 (Table 1, Figure 3). The first emigrant was captured on April 30 and the last on June 18 (Appendix A1). The midpoint of emigration (date on which 50% of fish passed the weir) was May 20.

Table 2.–Length composition of emigrant and immigrant cutthroat trout at Auke Creek in 2007.

Length, mm FL	Spring emigrants	Fall immigrants[a]
< 120	1	0
121–140	0	0
141–160	0	0
161–180	4	4
181–200	10	11
201–220	16	13
221–240	29	8
241–260	24	9
261–280	14	6
281–300	22	7
301–320	24	14
321–340	8	7
341–360	6	10
361–380	1	3
381–400	0	0
401–420	1	0
421–440	1	0
n =	161[b]	92[c]

[a] The 2007 immigration length composition may be biased as modifications to the weir may have allowed fish <200 mm FL to pass through weir without being captured.

[b] 1 fish not measured.

[c] 2 fish not measured.

Of these 162 emigrant cutthroat trout, 55 were missing adipose fins (54 of which had a PIT tag) and 107 were not marked or tagged. Fork lengths for emigrants averaged 264 mm, had a SD of 50 mm, and ranged in size from 113 to 440 mm (Table 2, Figure 4). Fork length of emigrant cutthroat appeared to decrease over time (Figure 5).

The size distribution of upstream migrants may be biased since the upstream weir was not modified to capture "small" fish (<200 mm FL) during the fall 2007 immigration. A total of 94 cutthroat immigrants were captured during the upstream weir operation (Appendix A2, Table 2, Figure 2). Of these 94 immigrants, 15 were adipose clipped, 78 displayed no external marks or PIT tags, and one fish escaped without being analyzed. Of the 15 adipose-clipped fish captures, 14 had a PIT tag.

The first cutthroat trout immigrant was captured and released upstream on September 6 (Appendix A2). Even though cutthroat trout arrived and were captured at the weir earlier in the season, they were released back downstream because high mortality can occur if cutthroat are placed above the one-way structure before they can osmoregulate in freshwater. This subjective decision leads to biased run-timing data but is necessary to ensure survival (Lum and Taylor 2004). Fork length of immigrant cutthroat trout averaged 266 mm, had a SE of 6 mm, and ranged in size from 163 to 375 mm (Table 2, Figure 4). There was no trend in the length of immigrants over time (Figure 6).

Growth rates were determined for PIT-tagged cutthroat trout that emigrated from and then immigrated back into Auke Creek in 2007. Because immigration data were biased by not allowing fish to move upstream prior to September 6, relationships between emigration and immigration timing and between emigration date and length of marine residence are not reported. The average hiatus of these fish was 119 d (SD = 15 range = 93-143 d, n = 14). Average growth during the hiatus was 34 mm (SD = 16 mm) and ranged from 11 to 61 mm. The average growth rate during the hiatus was 0.292 mm/d (SD = 0.151), and the growth rate tended to decrease as the size of the fish got larger (Figure 7).

MIGRANT DOLLY VARDEN

A total of 4,300 Dolly Varden emigrated in 2006. This count is lower than the previous 27-year average of 6,068 (Appendix A1, Table 1, Figure 8). The first Dolly Varden was captured on April 10 and the last on June 12 (Appendix A1); the midpoint of emigration occurred on May 17 (Figure 9). Average fork length of emigrating Dolly Varden was 244 mm (SE = 3 mm) and ranged from 105 to 440 mm (n = 479).

Length of emigrants declined over time (Figure 10). The estimated length composition of the emigration suggests that 18% of the run was over 300 mm (Table 3, Figure 11), which is the smallest length at which Dolly Varden are estimated to be mature (ADF&G 1994).

Weir captures of Dolly Varden immigrants began on July 11 and continued through October 31; the midpoint of immigration occurred on September 7 (Appendix A2, Figure 9). A total of 1,202 Dolly Varden immigrants were captured at Auke Creek weir in 2007 (Appendix A2). This was below the 10-year average of 3,973 (Table 1).

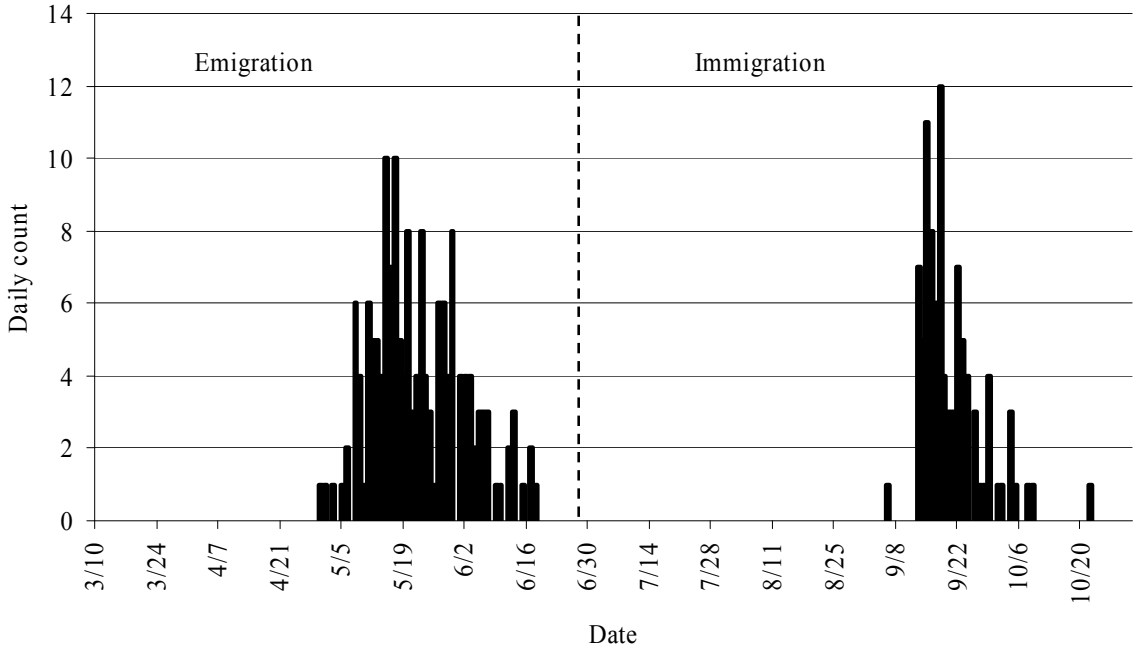

Figure 2.–Spring emigration and fall immigration counts for cutthroat trout at Auke Creek in 2007. The 2007 immigration count may not be complete as modifications to the weir may have allowed fish <200 mm FL to pass through weir without being captured.

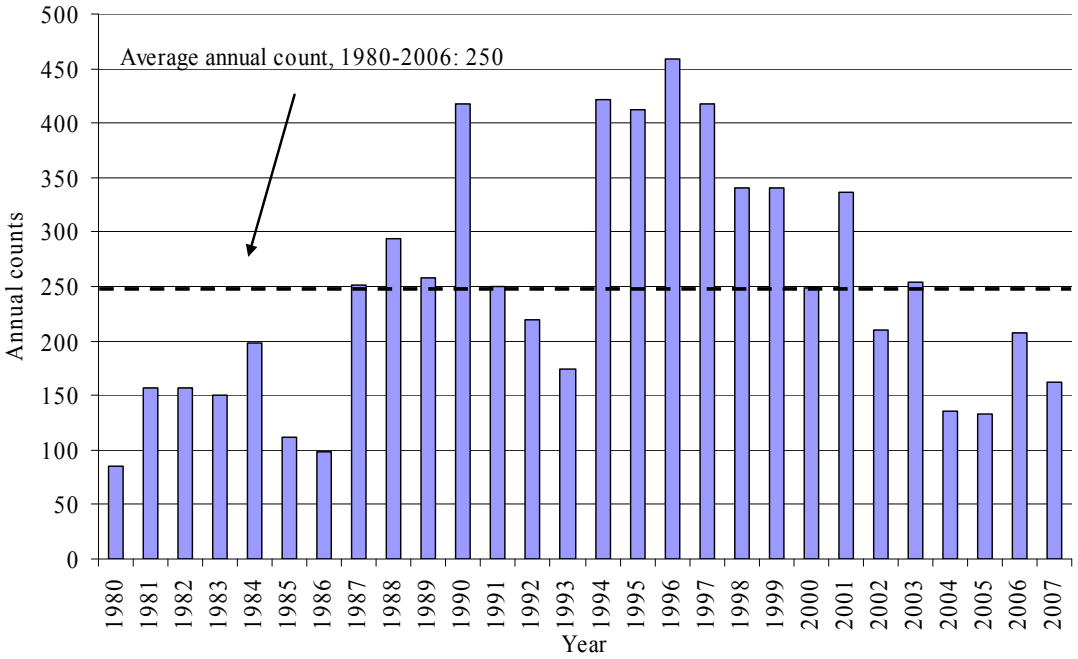

Figure 3.–Annual emigration counts of cutthroat trout at Auke Creek, 1980–2007.

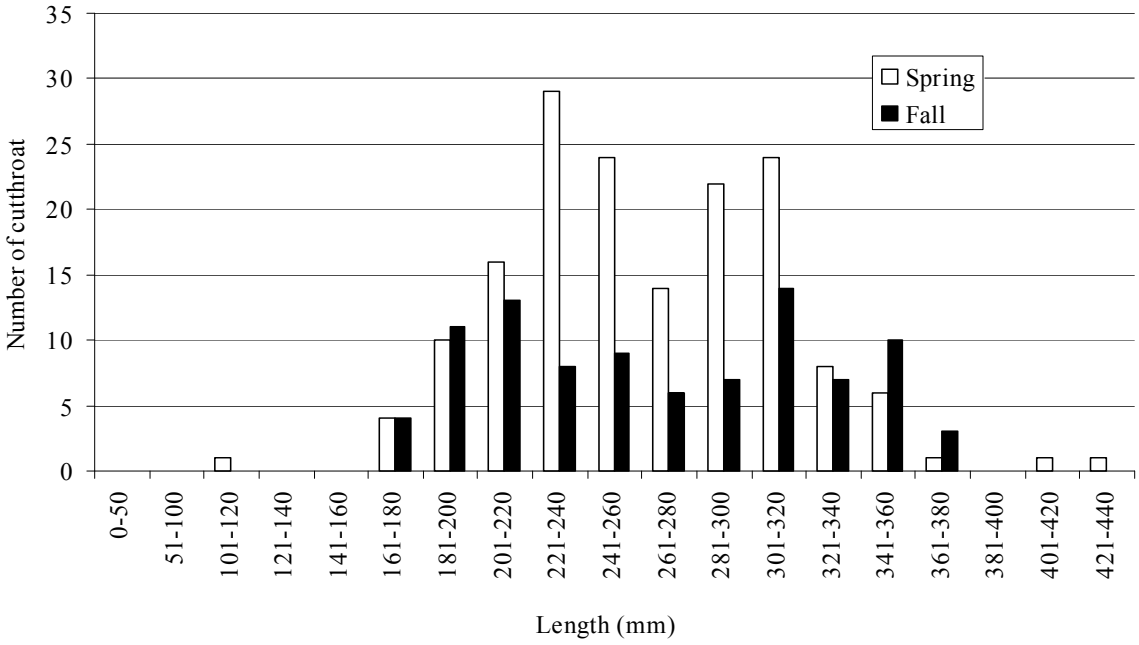

Figure 4.–Lengths of cutthroat trout, pooled by 20 mm groups, during the spring emigration and the fall immigration at the Auke Creek weir in 2007. The 2007 immigration length composition may be biased as modifications to the weir may have allowed fish <200 mm FL to pass through weir without being captured.

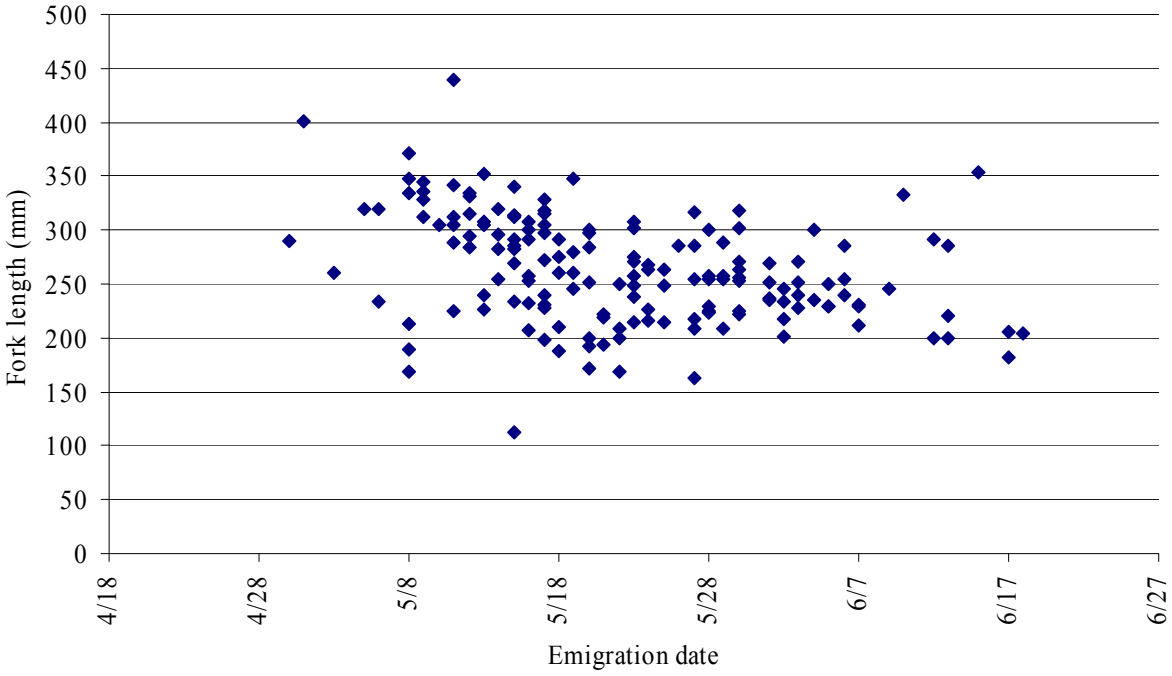

Figure 5.–Cutthroat trout fork lengths versus emigration date at Auke Creek in 2007.

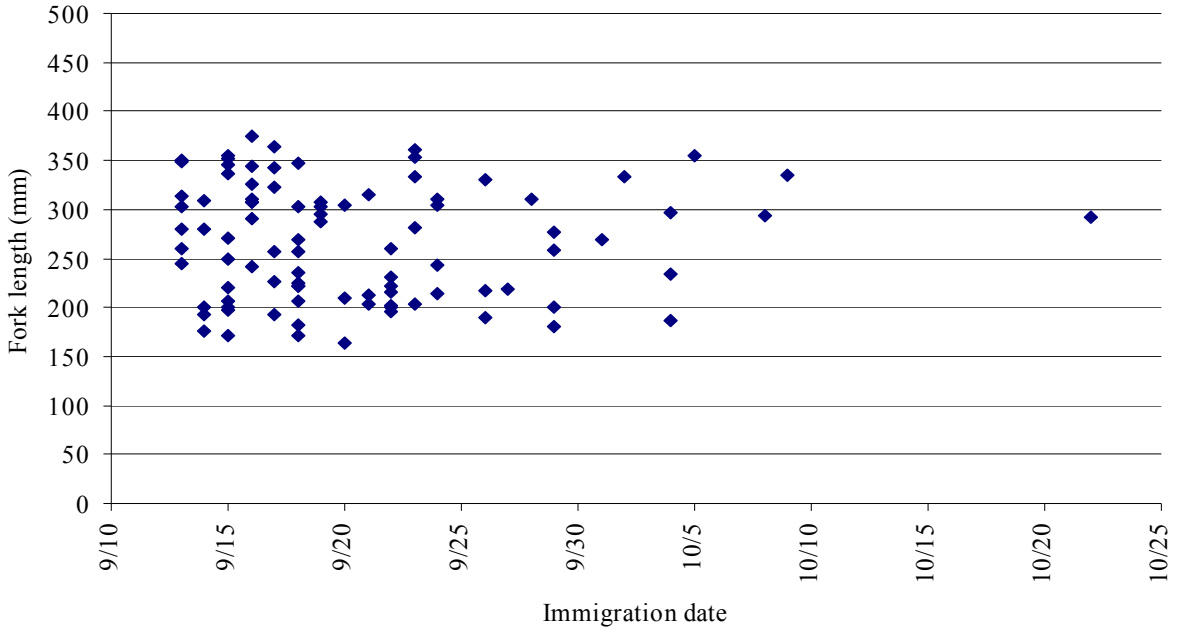

Figure 6.–Cutthroat trout fork lengths versus immigration date at Auke Creek in 2007. The 2007 immigration length composition may be biased as modifications to the weir may have allowed fish <200 mm FL to pass through weir without being captured.

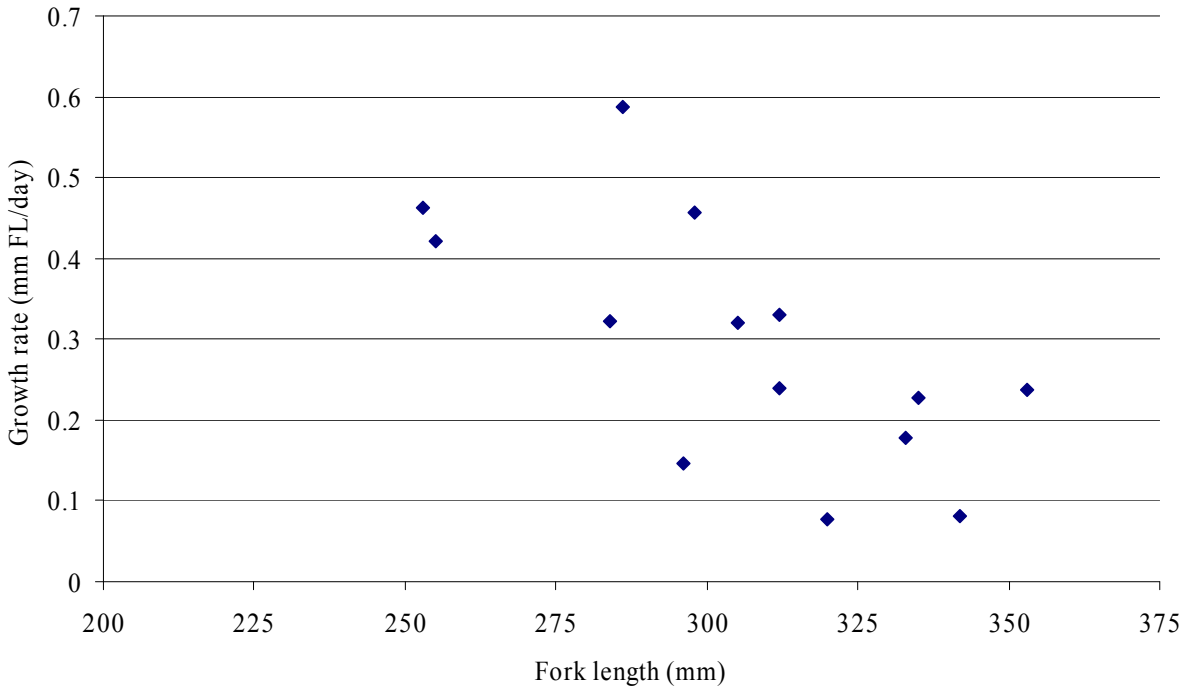

Figure 7.–Growth rate of tagged cutthroat trout between emigration and immigration in 2007 versus length at emigration from Auke Lake.

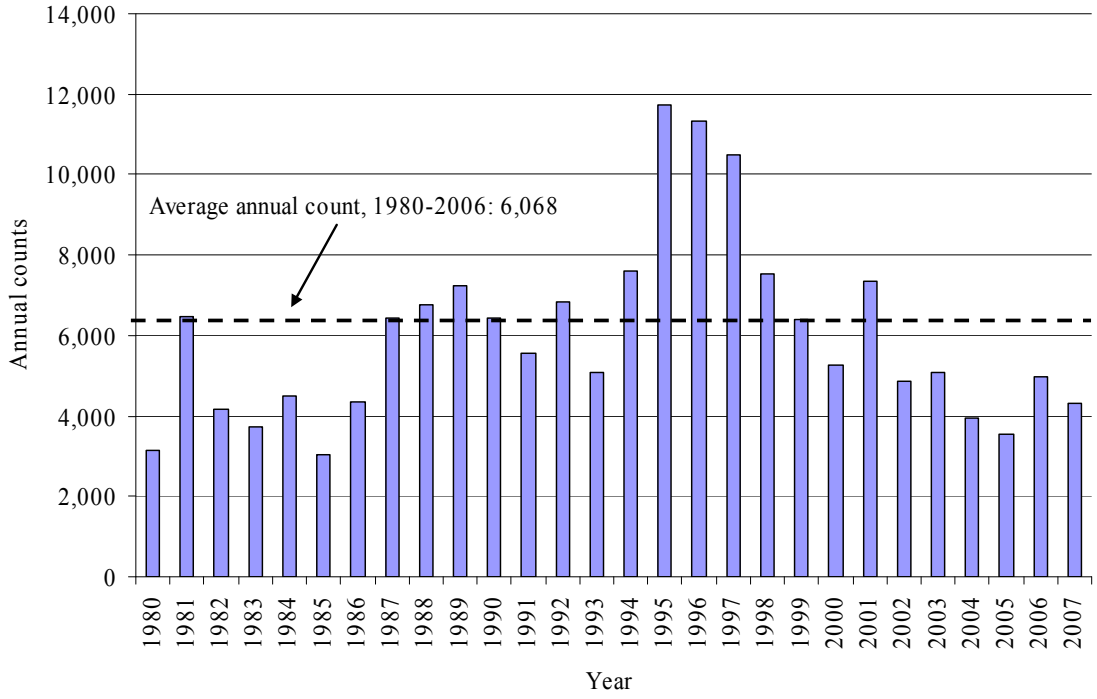

Figure 8.–Annual emigration counts of Dolly Varden at Auke Creek, 1980–2007.

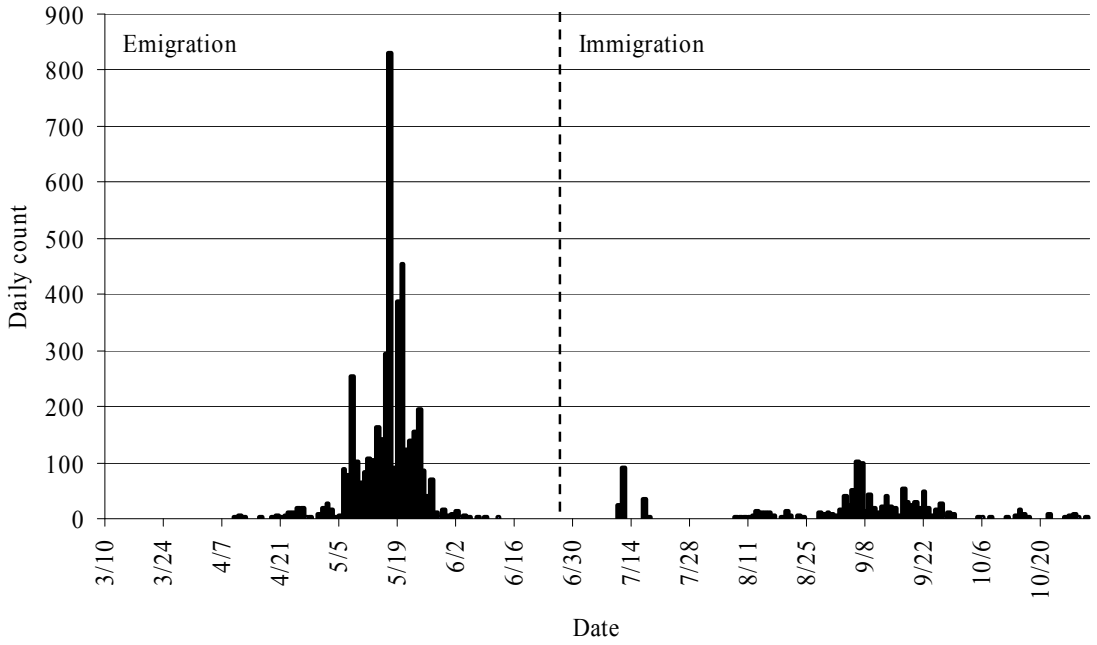

Figure 9.–Emigration and immigration counts of Dolly Varden at Auke Creek in 2007. The 2007 immigration count may not be complete as modifications to the weir may have allowed fish <200 mm FL to pass through the weir without being captured.

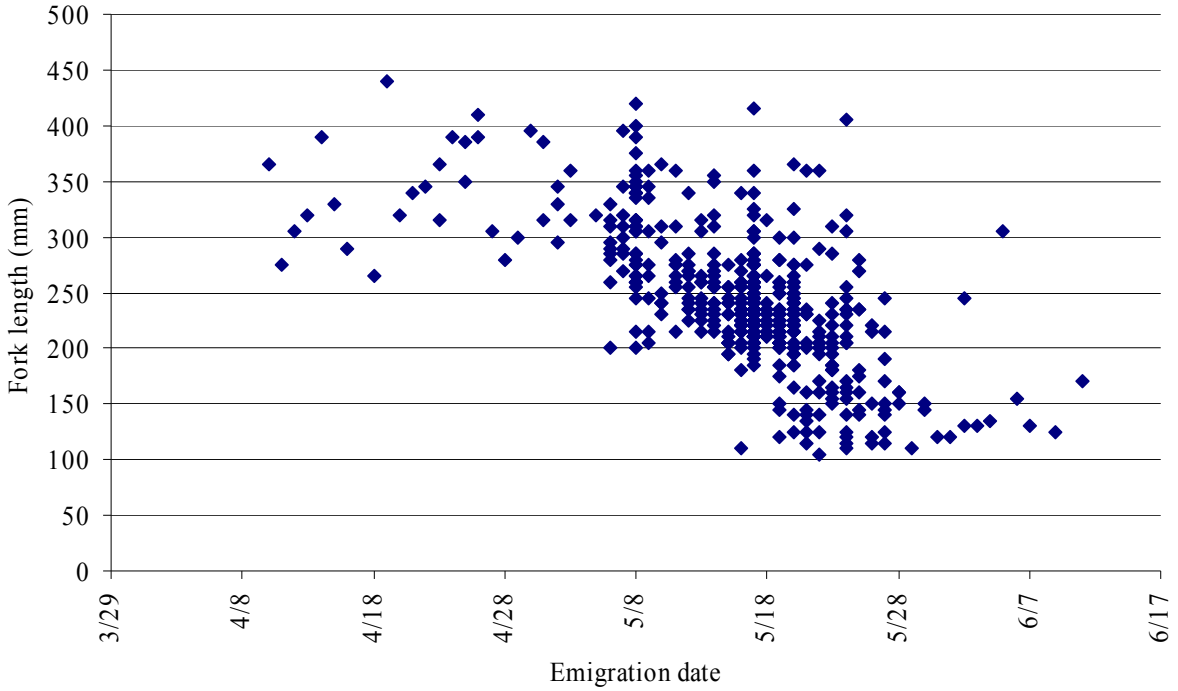

Figure 10.–Dolly Varden lengths versus date during the spring emigration at Auke Creek in 2007.

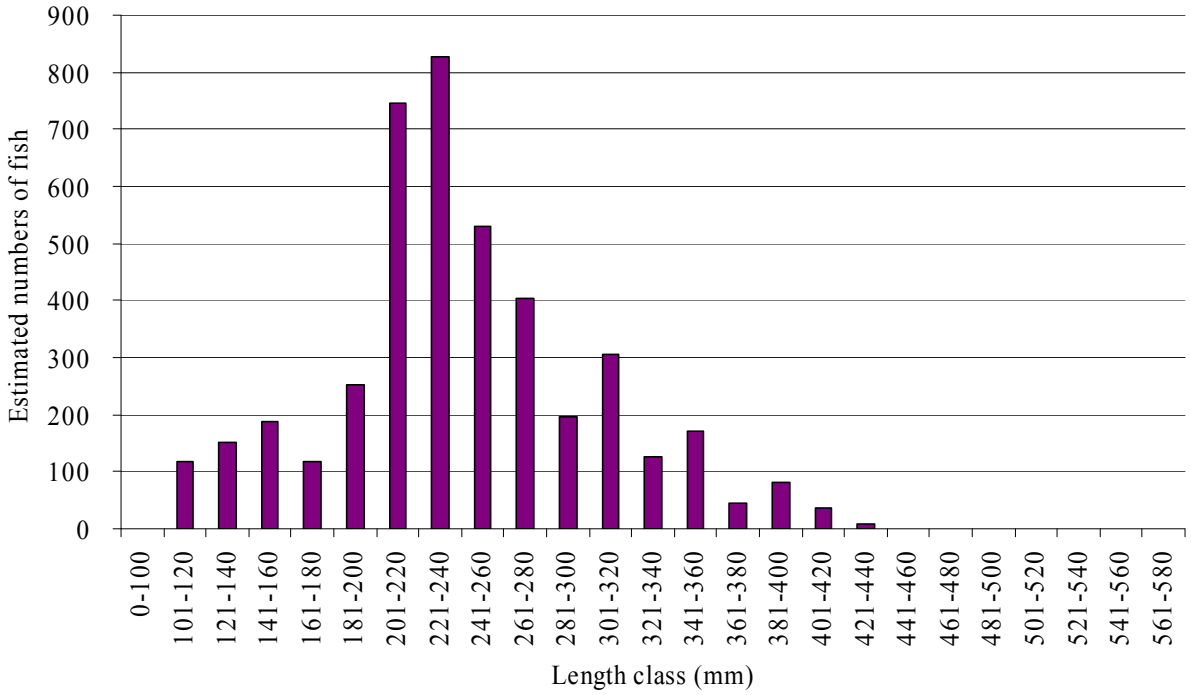

Figure 11.–Estimated length composition of emigrating Dolly Varden at Auke Creek in 2007.

Table 3.–Length composition and estimated abundance-at-length for emigrating Dolly Varden at Auke Creek in 2007. Number sampled (n_ℓ), proportion ($\hat{p}_\ell$), abundance ($\hat{N}_\ell$), and standard error (SE) are shown for each 20-mm length class.

Length, mm FL	n_ℓ	$\hat{p}_\ell$	SE($\hat{p}_\ell$)	$\hat{N}_\ell$	SE($\hat{N}_\ell$)
< 100	0	0.00	0	0	0
101–120	13	0.03	0.01	117	32
121–140	17	0.04	0.01	153	36
141–160	21	0.04	0.01	189	40
161–180	13	0.03	0.01	117	32
181–200	28	0.06	0.01	251	46
201–220	83	0.17	0.02	745	74
221–240	92	0.19	0.02	826	77
241–260	59	0.12	0.02	530	65
261–280	45	0.09	0.01	404	57
281–300	22	0.05	0.01	197	41
301–320	34	0.07	0.01	305	51
321–340	14	0.03	0.01	126	33
341–360	19	0.04	0.01	171	38
361–380	5	0.01	0.00	45	20
381–400	9	0.02	0.01	81	27
401–420	4	0.01	0.00	36	18
421–440	1	0.00	0.00	9	9
441–460	0	0.00	0.00	0	0
461–480	0	0.00	0.00	0	0
481–500	0	0.00	0.00	0	0
n =	479			N = 4,300[a]	

[a] Tabled values may not add up to the exact number of observed Dolly Varden immigrants due to rounding.

SALMON SMOLT COUNTS, CODED WIRE TAGGING, AGE, WEIGHT, AND LENGTH

Coho smolt began their emigration from Auke Creek on May 1, 2007. The migration lasted through June 24 (Appendix A1), and its midpoint was May 25. A total of 4,071 coho smolt were captured (Appendix A1), 4,056 of which were successfully marked with CWT and released downstream with an adipose finclip. This is less than the 27-year historical average of 5,992 (Table 1).

An estimated 38% of coho smolts emigrating in 2007 were age 1. and 62% were age 2. The mean length and weight for all smolts sampled was 118 mm (SE = 0.6 mm) and 16 g (SE = 0.24 g, Table 4). Age-1. smolts averaged 106 mm (SE = 0.7 mm) and 11 g (SE = 0.23 g), and age-2. smolts averaged 126 mm (SE = 0.6 mm) and 18 g (SE = 0.28 g, Table 4). Age-1. smolt lengths ranged from 81 to 134 mm, and age-.2 smolt lengths ranged from 108 to 151 mm (Figure 12). The weight of age-1. smolt ranged from 5 to 22 g, and the weight of age-2. smolt ranged from 10 to 32 g (Figure 13).

Sockeye smolt began their emigration from Auke Creek on May 8, 2007. The migration lasted through June 27 (Appendix A1), and its midpoint was May 29. A total of 13,716 sockeye smolt were captured in 2007 (Appendix A1). This count was lower than the 27-year historical average of 17,245 (Table 1).

ESCAPEMENT, AGE, SEX AND LENGTH

The jack coho salmon immigration began on September 6, ended on October 22 (Appendix A2), and the midpoint was September 17. A total of 106 coho jacks were counted at the weir in 2007 (Appendix A2), 30 of which were sampled. The estimated age composition of jacks was 3% age 1.0 and 97% age 2.0 (Table 5). Scales from two fish were not readable. The length of the only age-1.0 jack was 265 mm, and the average length for age-2.0 fish was 303 mm MEF (SE = 4 mm, Table 6).

The first adult coho salmon immigrant was passed upstream on September 12th and the last immigrant was passed on October 13 (Appendix A2). The midpoint of the immigration was September 18, but this date may be skewed as several immigrant fish captured in the weir prior to September 12 were returned downstream in an effort to reduce handling mortality. Observations during prior years have documented that these first immigrants are unable to successfully osmoregulate in freshwater and high mortality can occur if fish are placed above the one-way weir structure too early. A total of 352 coho adults were counted at the weir in 2007 (Appendix A2) of which 210 were sampled for sex, length, and scales. This number of immigrants is less than the 27-year historical average of 716 (Table 1).

The estimated age composition of adults was 55% age-1.1 and 45% age-2.1 (Table 7). About 14% of the total scales sampled were not readable. Based on visual examination to determine sex, an estimated 50% of adult coho salmon were male and 50% were female (Table 7). Estimates of sex composition based on summing abundance by sex at age are slightly different (51% male, 49% female) because sex composition of all fish

Table 4.–Estimated freshwater age composition and abundance, and mean length and weight-at-age of coho salmon smolt emigrating from Auke Creek in 2007.

	Brood year and freshwater age			
	2005 Age-1.	2004 Age-2.	2003 Age-3.	All smolt
n	207	188	0	395
Age composition	0.382	0.618		
SE (age composition)	0.020	0.020		
Abundance	1,555	2,516	0	4,071
SE (abundance)	80	80		0
n	207	188	0	400
Mean length (mm FL)	106.3	125.5		118.3
SE (mean length)	0.7	0.6		0.6
n	207	188	0	400
Mean weight. (g)	11.3	18.4		15.7
SE (mean weight)	0.23	0.28		0.24

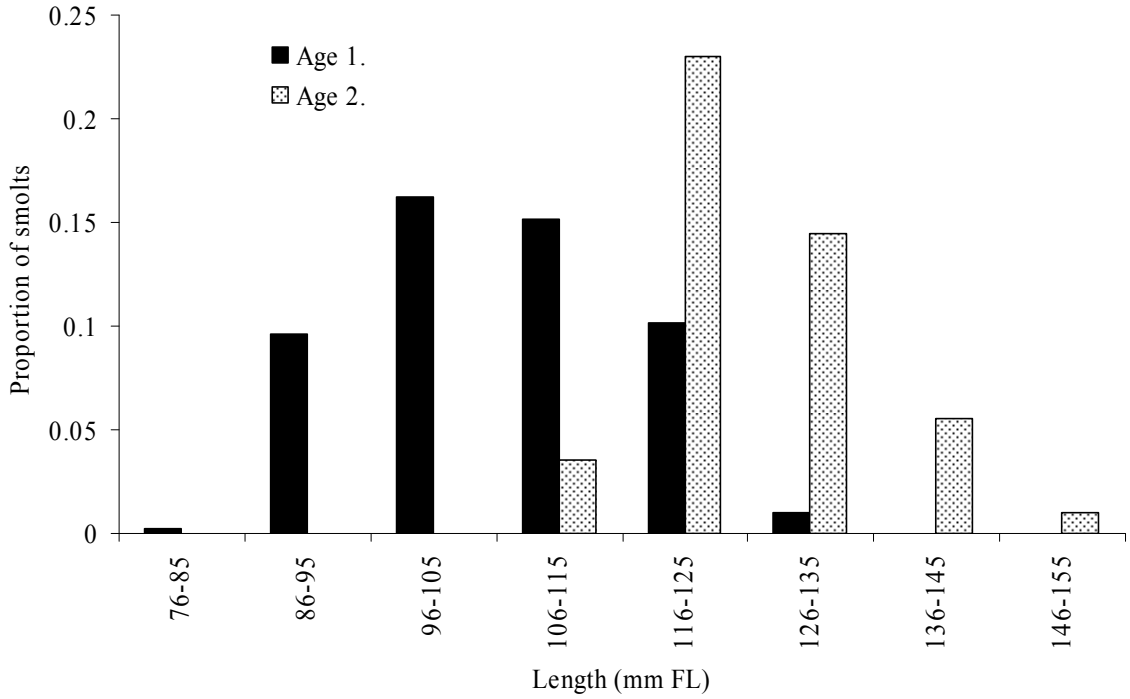

Figure 12.–Length distribution of coho salmon smolts sampled at Auke Creek in 2007.

sampled varied slightly from that for aged fish. The average length for age-1.1 male coho salmon was 591 mm MEF (SE = 5 mm), while the average length for age-2.1 males was 607 mm MEF (SE = 6 mm). The average length for age-1.1 female coho salmon was 590 mm MEF (SE = 4), while the average for age-2.1 females was 613 mm MEF (SE = 4; Table 8; Figure 14). The adult sockeye salmon immigration began on July 9, ended on September 18, 2007 (Appendix A2), and the midpoint was July 12. A total of 2,754 sockeye adults (Appendix A2) and 188 jacks were counted at the weir. This is less than the 27-year historical average of 3,341 (Table 1).

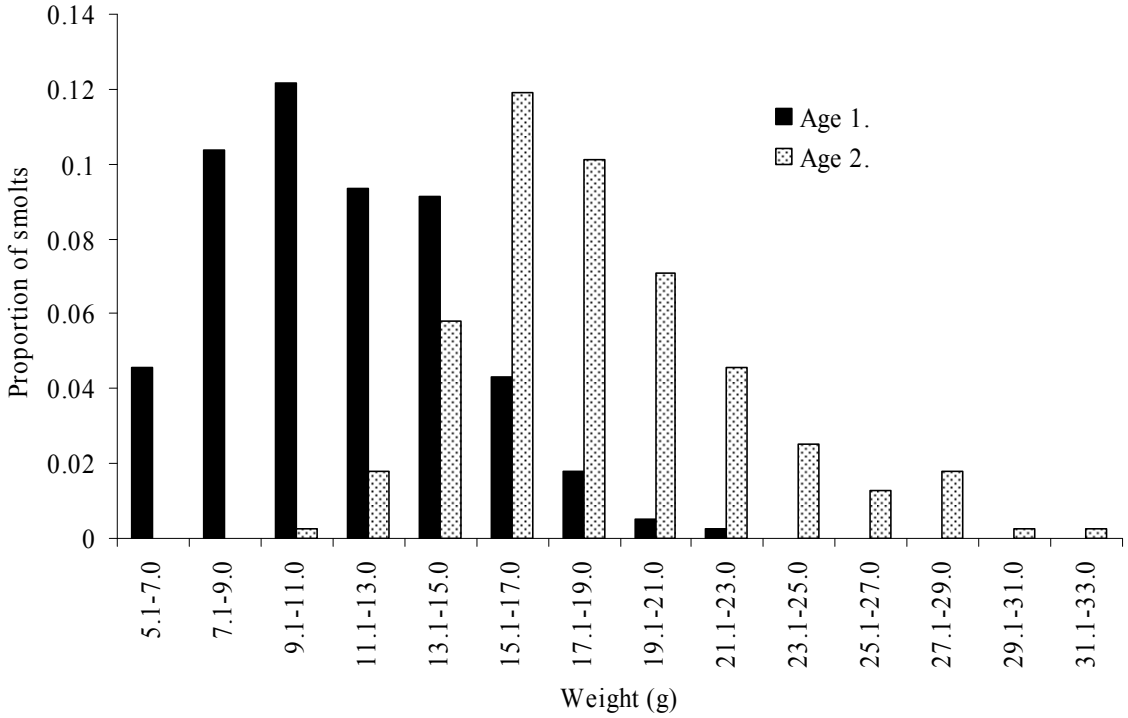

Figure 13.–Weight distribution of coho salmon smolts sampled at Auke Creek in 2007**.**

Table 5.–Estimated age composition and abundance of jack coho salmon returning to Auke Creek in 2007.

	Brood year and age class			
	2005	2004	2003	
	1.0	2.0	3.0	All
n	1	27	0	30
Fraction male	1.0	1.0		1.0
n	1	27	0	28
Age composition	0.03	0.97		
SE (age composition)	0.03	0.03		
Escapement	3	103	0	106
SE (escapement)	3	3		0

Table 6.–Estimated mean length-at-age of jack coho salmon returning to Auke Creek in 2007.

	Brood year and age class			
	2005	2004	2003	
	1.0	2.0	3.0	All
n	1	27	0	30
Mean length (mm MEF)	265	303	0.0	301
SE (mean length)	0	4	0.0	3.3

Table 7.–Estimated age and sex composition and abundance of adult coho salmon returning to Auke Creek in 2007.

	Brood year and age class			
	2004	2003	2002	
	1.1	2.1	3.1	All
All fish				
n	100	81	0	181
Age composition	0.55	0.45		
SE (age composition)	0.03	0.03		
Escapement	194	158	0	352
SE (escapement)	9	9		0
Male				
n	50	42	0	105
Fraction male	0.50	0.51		0.50
SE (fraction male)	0.04	0.04		0.02
Escapement	96	81	0	175[a]
SE (escapement)	8	8		8[a]
Female				
n	50	39	0	105
Fraction female	0.50	0.49		0.50
SE (fraction female)	0.04	0.04		0.02
Escapement	97	78	0	177[a]
SE (escapement)	8	8		8[a]

[a] Sex composition based on all fish sexed differs from that based on aged fish. Thus, total numbers by sex differ from totals based on sums by sex over age.

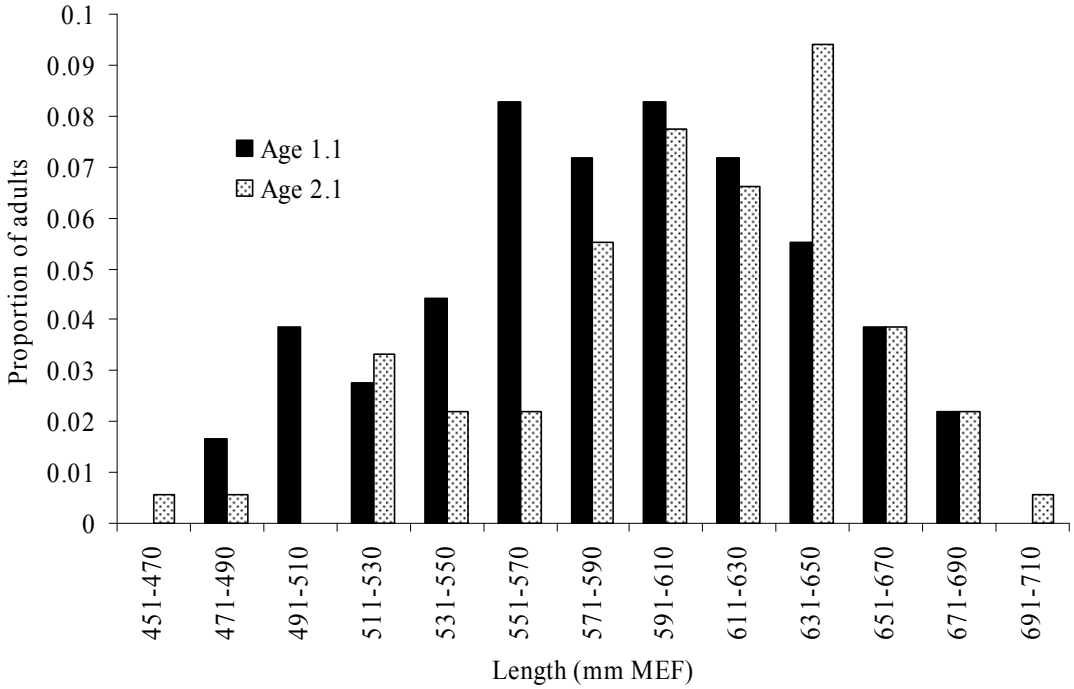

Figure 14.–Length distribution by age of adult coho salmon at Auke Creek in 2007.

Table 8.–Estimated mean length-at-age by sex of adult coho salmon returning to Auke Creek in 2007.

	Brood year and age class			
	2004	2003	2002	All
	1.1	2.1	3.1	Adults
All Fish				
n	100	81	0	210
Mean length (mm MEF)	591	610		599
SE (mean length)	3	4		2
Male				
n	50	42	0	105
Mean length (mm MEF)	591	607		596
SE (mean length)	5	6		3
Female				
n	50	39	0	105
Mean length (mm MEF)	590	613		602
SE (mean length)	4	4		3

MARINE HARVEST, TOTAL ABUNDANCE, MARINE SURVIVAL, AND EXPLOITATION

A total of 49 coho salmon were recovered from commercial fisheries in 2007 that had previously been marked with CWT at Auke Creek. Two additional CWTs were recovered from sport fisheries during this same time (Appendix B1). Expansion of these numbers generates an estimate of 200 (SE = 27) Auke Creek adult coho salmon that were harvested in 2007 (Appendix B1). Combining this harvest with the number counted at the weir yielded a total return of 552 (SE = 30) adults.

Coho salmon smolt-to-adult marine survival at Auke Creek was estimated to be 15% (SE = 0.7%) for all coho tagged in 2006 (4,506 (4,115 - 9 smolt not marked); Hoover 2008). The exploitation rate of Auke Creek coho salmon was estimated to be 36% (SE = 2.2%) in 2007 marine fisheries.

OTHER SPECIES

Pink salmon fry began their emigration from Auke Creek on March 10, 2007. The migration lasted through May 31 (Appendix A1) and its midpoint was April 26. A total of 81,899 pink salmon fry were counted (Appendix A1), which is less than the 27-year historical average of 106,280 (Table 1). Wild pink salmon adults began their immigration on August 4, and the migration lasted through September 21 (Appendix A2). The midpoint of immigration was September 2, and 2,944 wild pink salmon adults were counted (Appendix A2). Of these, 54% (SE = 0.46%) were estimated to be male and 46% (SE = 0.54%) were female.

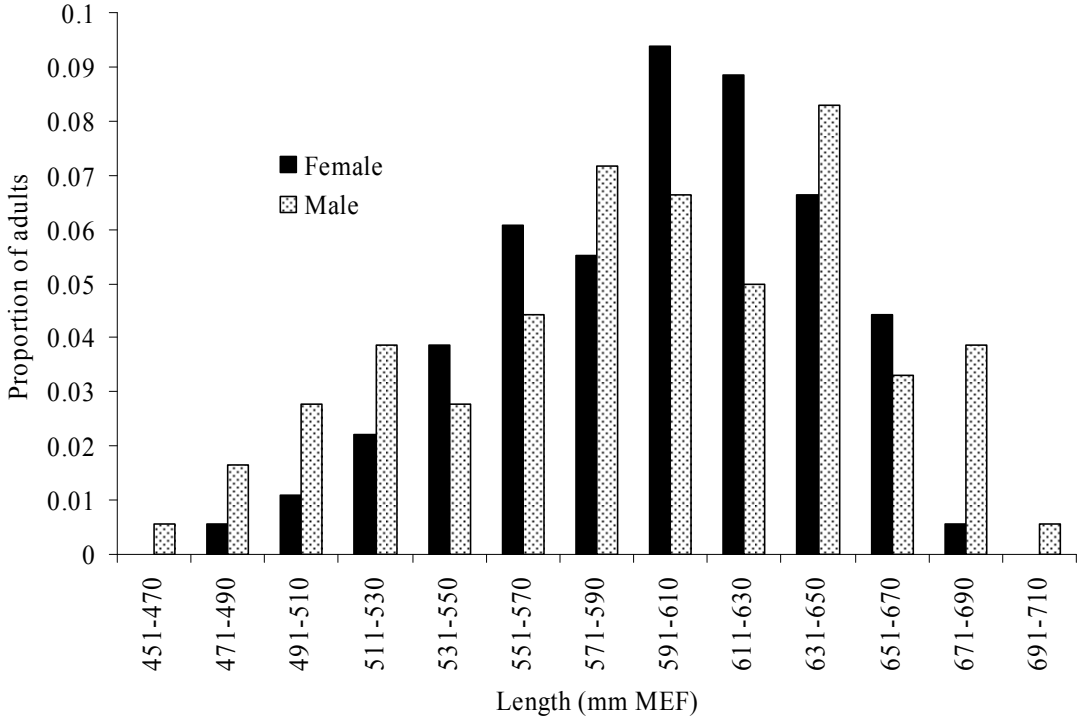

Figure 15.–Length distribution by sex of adult coho salmon at Auke Creek in 2007.

The first chum salmon fry emigrant was captured on March 10, 2007 and emigration continued through June 26. The midpoint of the emigration was April 22 and a total of 12,839 chum salmon fry were counted (Appendix A1). Chum salmon adults began their immigration on July 24 and the migration lasted through September 8 (Appendix A2); the midpoint of immigration was August 9. A total of 719 chum salmon adults immigrants were counted (Appendix A2) during 2007, which is about half the 27-year historical average of 1,443 (Table 1).

Few juvenile steelhead were seen during either migration period in 2007. A total of 6 steelhead emigrated from Auke Lake between May 21 and June 5 (Appendix A1), and only 1 immigrated to the lake on October 3 (Appendix A2).

STREAM TEMPERATURE

Water temperatures at the Auke Creek weir throughout 2007 ranged from 0.1°C to 18.8°C (mean = 7.0°C). During the emigration period temperatures ranged from 0.1°C to 16.9°C (mean = 6.0°C, Appendix A1), and during immigration temperatures were between 6.0°C and 18.8°C (mean = 13.2°C, Appendix A2).

DISCUSSION

The general downward trend of low emigrant cutthroat trout and Dolly Varden counts at the Auke Creek weir since the late 1990s continued during 2007. The cutthroat trout emigration was approximately 65% of the 1980–2006 average of 250, and the Dolly Varden emigration was approximately 71% of the 1980–2006 average of 6,068. Auke Lake is one of the primary overwintering lakes for both cutthroat trout and Dolly Varden in the Juneau area. Cutthroat trout emigrants from Auke Lake are known to disperse and are believed to spawn in at least 10 streams in the Juneau area (Jones and Seifert 1997). Various Dolly Varden tagging studies provide evidence that Juneau area Dolly Varden utilize Auke Lake during several life stages and that Auke Lake emigrants contribute to the Juneau area and northern Southeast Alaska sport fisheries (Neimark 1984b; Bernard et al. 1995; Jones and Harding 1998).

Due to high adult chum salmon immigration in 2006, the chum fry count for 2007 is more than twice the 27-year historical average of 4,572, and is the fourth highest chum fry count on record. This is the only 2007 weir count that is greater than the corresponding historical average (Table 1). Increases in numbers of adult chum salmon returning to Auke Creek over the last two decades have coincided with local chum salmon hatchery programs.

Efforts were first made in 1990 to differentiate between emigrant cutthroat trout and steelhead and the annual emigrant steelhead counts have ranged from 4 to 36. Immigrant juvenile steelhead have been counted passing through the weir between 1999 and 2006 when the trout screen panels (see methods section for description) were used to capture all immigrant fish >200 mm FL. The immigrant juvenile steelhead counts have ranged from no fish in 2003 to 20 fish observed in 2005. It is unknown whether any juvenile steelhead migrated upstream in 2007 because the trout screens were not used. No adult steelhead immigrant has ever been captured at the Auke Creek weir nor does the system contain any resident rainbow trout. Thus, it is believed that the steelhead smolt emigrants enter the system sometime during the previous fall and overwinter in Auke Lake. It is unknown whether these fish are a form of sea-run coastal rainbow trout but physical characteristics (i.e., silver color and loose scales) suggest these fish are most likely steelhead smolt which simply utilize Auke Lake as an overwintering site (Roger Harding, ADF&G, personal communication).

The 2007 Auke Creek weir count of immigrant coho salmon was approximately half of the 1980–2006 historic average and 60% of the 2006 immigration. The 2007 emigrant weir count of coho salmon was also below the historic average, but was 90% of the 2006 emigration total. The sockeye salmon emigration was also well below the 1980–2006 average, and only 54% of that observed in 2006. While the cause for declines in salmon migrations are unknown, contributing factors may include increased urbanization, introduction of hydrocarbons by recreational use of Auke Lake (Rice et al. 2008), and observed changes in streambed and flow characteristics (i.e. decreased spawning and rearing habitat) of Lake Creek.

The information garnered from the Auke Creek weir and Auke Lake system is one of the most comprehensive long-term data sets available for multiple species of salmon, trout, and char. The historical data set describes abundance, survival, growth, migration timing, and other life history information for the species present in this system, and is used by fisheries managers to monitor immigration and emigration trends in salmon, trout, and char species. The Auke Creek project also contributes to other research efforts on the system and makes long-term monitoring possible as urban development in the area continues.

ACKNOWLEDGMENTS

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APPENDIX A

Appendix A1.–Daily count of spring emigrants at Auke Creek, 2007.

	Cutthroat trout	Dolly Varden	Sockeye smolt	Pink fry	Chum fry	Coho smolt	Juvenile steelhead	Water temp
March 10	0	0	0	5	1	0	0	0.5
11	0	0	0	1	1	0	0	0.4
12	0	0	0	9	2	0	0	0.5
13	0	0	0	19	3	0	0	0.4
14	0	0	0	13	1	0	0	0.4
15	0	0	0	19	6	0	0	0.4
16	0	0	0	14	13	0	0	0.3
17	0	0	0	6	8	0	0	0.3
18	0	0	0	6	7	0	0	0.3
19	0	0	0	3	4	0	0	0.3
20	0	0	0	50	27	0	0	0.2
21	0	0	0	18	10	0	0	0.3
22	0	0	0	13	11	0	0	0.5
23	0	0	0	37	31	0	0	0.5
24	0	0	0	55	33	0	0	0.4
25	0	0	0	50	30	0	0	0.4
26	0	0	0	53	24	0	0	0.5
27	0	0	0	59	28	0	0	0.4
28	0	0	0	80	38	0	0	0.4
29	0	0	0	62	24	0	0	0.4
30	0	0	0	121	39	0	0	0.3
31	0	0	0	111	41	0	0	0.3
April 1	0	0	0	103	41	0	0	0.2
2	0	0	0	28	35	0	0	0.1
3	0	0	0	45	34	0	0	0.1
4	0	0	0	54	37	0	0	0.1
5	0	0	0	52	41	0	0	0.3
6	0	0	0	56	53	0	0	0.4
7	0	0	0	132	43	0	0	0.5
8	0	0	0	866	109	0	0	0.7
9	0	0	0	1,749	291	0	0	1.5
10	0	4	0	1,691	590	0	0	1.9
11	0	5	0	1,445	685	0	0	1.8
12	0	3	0	1,159	362	0	0	1.7
13	0	1	0	898	267	0	0	1.7
14	0	1	0	1,427	330	0	0	1.7
15	0	1	0	1,055	302	0	0	1.7
16	0	2	0	1,066	361	0	0	1.8
17	0	0	0	1,501	309	0	0	1.8
18	0	1	0	1,099	397	0	0	2.0
19	0	3	0	1,729	414	0	0	2.1
20	0	6	0	1,325	412	0	0	2.2
21	0	2	0	3,318	519	0	0	2.3
22	0	5	0	3,944	519	0	0	2.4
23	0	12	0	4,685	609	0	0	2.4
24	0	10	0	3,781	414	0	0	2.4
25	0	20	0	4,454	354	0	0	2.5
26	0	18	0	5,228	442	0	0	2.5
27	0	3	0	3,426	344	0	0	2.5
28	0	2	0	2,724	239	0	0	2.6

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Appendix A1.–Page 2 of 3.

	Cutthroat trout	Dolly Varden	Sockeye smolt	Pink fry	Chum fry	Coho smolt	Juvenile steelhead	Water temp
April 29	0	1	0	4,289	376	0	0	2.6
30	1	9	0	5,592	469	0	0	2.7
May 1	1	19	0	2,112	262	1	0	2.8
2	0	27	0	3,427	426	0	0	3.3
3	1	17	0	3,327	360	1	0	3.5
4	0	4	0	2,569	260	0	0	3.6
5	1	5	0	2,599	213	0	0	3.7
6	2	89	0	826	88	0	0	3.7
7	0	78	0	1,542	82	2	0	3.7
8	6	254	1	1,132	55	4	0	4.0
9	4	101	1	1,086	67	2	0	4.4
10	1	64	0	930	64	1	0	4.5
11	6	82	0	786	75	0	0	5.1
12	5	106	2	249	30	7	0	5.2
13	5	104	5	257	25	8	0	5.2
14	4	164	1	332	32	6	0	6.2
15	10	141	13	273	29	15	0	6.6
16	7	295	12	160	13	33	0	7.2
17	10	831	35	164	14	81	0	6.9
18	5	91	18	175	21	98	0	7.0
19	4	386	57	61	6	202	0	8.2
20	8	453	78	32	6	138	0	8.7
21	3	122	167	31	6	247	2	9.3
22	4	139	429	33	7	461	1	10.4
23	8	156	211	25	52	345	0	11.9
24	4	194	384	19	75	277	0	12.5
25	3	85	674	4	35	268	0	12.7
26	1	40	216	10	55	140	1	11.5
27	6	69	3,432	11	36	512	0	10.9
28	6	10	918	0	17	257	0	9.9
29	4	3	331	1	8	121	1	10.6
30	8	17	948	0	6	140	0	9.2
31	0	6	1,009	1	16	153	0	8.3
June 1	4	8	1,097	0	8	112	0	9.6
2	4	13	1,177	0	7	84	0	11.3
3	4	2	477	0	20	50	0	12.1
4	2	5	478	0	111	32	0	13.1
5	3	2	474	0	86	41	1	13.1
6	3	1	234	0	105	27	0	12.7
7	3	3	173	0	21	18	0	10.8
8	0	0	124	0	9	17	0	11.2
9	1	2	153	0	22	29	0	13.1
10	1	0	95	0	30	22	0	13.2
11	0	1	83	0	16	22	0	13.7
12	2	2	74	0	30	26	0	13.1
13	3	0	12	0	6	9	0	12.8
14	0	0	19	0	16	13	0	14.0
15	1	0	41	0	15	14	0	15.5
16	0	0	17	0	12	12	0	16.5
17	2	0	17	0	10	8	0	16.9

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Appendix A1.–Page 3 of 3.

	Cutthroat trout	Dolly Varden	Sockeye smolt	Pink fry	Chum fry	Coho smolt	Juvenile steelhead	Water temp
June 18	1	0	10	0	14	3	0	16.0
19	0	0	2	0	19	4	0	15.7
20	0	0	1	0	12	0	0	16.4
21	0	0	3	0	5	2	0	16.3
22	0	0	5	0	14	1	0	16.2
23	0	0	5	0	12	3	0	15.6
24	0	0	2	0	8	2	0	14.8
25	0	0	0	0	4	0	0	13.9
26	0	0	0	0	6	0	0	13.7
27	0	0	1	0	0	0	0	14.6
28	0	0	0	0	0	0	0	15.1
Totals	162	4,300	13,716	81,899	12,839	4,071	6	

Appendix A2.–Daily count of summer/fall immigrants at Auke Creek, 2007.

	Cutthroat trout	Dolly Varden	Sockeye adults	Pink adults	Chum adults	Coho adults	Coho jacks	Juvenile steelhead	Water temp
June 29	0	0	0	0	0	0	0	0	15.7
30	0	0	0	0	0	0	0	0	15.3
July 1	0	0	0	0	0	0	0	0	15.2
2	0	0	0	0	0	0	0	0	15.7
3	0	0	0	0	0	0	0	0	15.9
4	0	0	0	0	0	0	0	0	16.4
5	0	0	0	0	0	0	0	0	15.4
6	0	0	0	0	0	0	0	0	15.4
7	0	0	0	0	0	0	0	0	15.9
8	0	0	0	0	0	0	0	0	16.0
9	0	0	2	0	0	0	0	0	15.9
10	0	0	357	0	0	0	0	0	16.0
11	0	24	868	0	0	0	0	0	16.0
12	0	91	265	0	0	0	0	0	15.5
13	0	0	88	0	0	0	0	0	15.7
14	0	0	81	0	0	0	0	0	15.7
15	0	0	6	0	0	0	0	0	15.6
16	0	0	0	0	0	0	0	0	16.7
17	0	34	96	0	0	0	0	0	16.1
18	0	3	66	0	0	0	0	0	16.5
19	0	0	2	0	0	0	0	0	16.9
20	0	0	13	0	0	0	0	0	16.8
21	0	0	108	0	0	0	0	0	15.9
22	0	0	84	0	0	0	0	0	16.3
23	0	0	0	0	0	0	0	0	16.6
24	0	1	63	0	2	0	0	0	16.3
25	0	0	39	0	0	0	0	0	16.4
26	0	0	0	0	0	0	0	0	17.0
27	0	0	5	0	3	0	0	0	17.1
28	0	0	10	0	5	0	0	0	17.4
29	0	0	4	0	3	0	0	0	17.4
30	0	0	14	0	9	0	0	0	17.0
31	0	0	14	0	5	0	0	0	16.5
August 1	0	0	18	0	2	0	0	0	16.4
2	0	0	3	0	6	0	0	0	16.4
3	0	0	18	0	16	0	0	0	16.4
4	0	0	2	1	18	0	0	0	16.1
5	0	0	10	0	21	0	0	0	16.1
6	0	0	11	1	41	0	0	0	15.9
7	0	0	33	16	115	0	0	0	15.5
8	0	2	70	33	100	0	0	0	15.5
9	0	2	27	17	40	0	0	0	16.5
10	0	4	24	19	43	0	0	0	16.7
11	0	3	47	18	54	0	0	0	17.4
12	0	5	25	15	45	0	0	0	17.9
13	0	14	36	21	34	0	0	0	18.1

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Appendix A2.–Page 2 of 3.

	Cutthroat trout	Dolly Varden	Sockeye adults	Pink adults	Chum adults	Coho adults	Coho jacks	Juvenile steelhead	Water temp
August 14	0	11	15	5	21	0	0	0	18.2
15	0	12	9	17	14	0	0	0	18.2
16	0	11	5	5	1	0	0	0	18.4
17	0	6	4	3	2	0	0	0	18.8
18	0	1	12	5	1	0	0	0	18.2
19	0	3	3	5	1	0	0	0	17.3
20	0	14	6	3	3	0	0	0	16.7
21	0	5	4	2	2	0	0	0	16.3
22	0	1	5	3	4	0	0	0	16.0
23	0	5	7	5	3	0	0	0	15.5
24	0	3	6	7	2	0	0	0	15.5
25	0	0	38	267	42	0	0	0	15.5
26	0	0	44	251	14	0	0	0	15.2
27	0	1	18	182	12	0	0	0	15.5
28	0	11	17	161	6	0	0	0	15.5
29	0	7	10	134	10	0	0	0	16.0
30	0	10	7	107	4	0	0	0	16.2
31	0	8	1	73	0	0	0	0	15.8
September 1	0	6	4	49	1	0	0	0	15.3
2	0	17	4	73	4	0	0	0	14.8
3	0	39	4	121	2	0	0	0	15.0
4	0	24	2	47	3	0	0	0	14.9
5	0	51	4	378	2	0	0	0	14.3
6	1	102	8	583	2	0	2	0	13.6
7	0	98	3	134	0	0	3	0	13.5
8	0	13	0	22	1	0	0	0	13.2
9	0	44	1	33	0	0	7	0	13.1
10	0	20	0	49	0	0	8	0	13.2
11	0	10	1	21	0	0	6	0	13.3
12	0	22	0	20	0	24	6	0	13.7
13	7	40	1	11	0	20	7	0	13.9
14	5	21	0	4	0	11	4	0	13.7
15	11	19	1	5	0	3	2	0	13.3
16	8	5	0	9	0	18	4	0	12.7
17	6	54	0	7	0	53	5	0	12.1
18	12	30	1	0	0	63	4	0	11.7
19	4	24	0	1	0	24	5	0	11.6
20	3	29	0	0	0	24	4	0	11.2
21	3	19	0	1	0	29	2	0	11.0
22	7	47	0	0	0	14	5	0	10.8
23	5	20	0	0	0	9	5	0	11.0
24	4	5	0	0	0	2	4	0	10.6
25	0	16	0	0	0	8	1	0	10.3
26	3	26	0	0	0	12	3	0	10.1
27	1	3	0	0	0	3	0	0	10.0
28	1	12	0	0	0	6	2	0	9.8
29	4	8	0	0	0	0	2	0	9.6
30	0	0	0	0	0	6	0	0	9.7

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Appendix A2.–Page 3 of 3.

	Cutthroat trout	Dolly Varden	Sockeye adults	Pink adults	Chum adults	Coho adults	Coho jacks	Juvenile steelhead	Water temp
October 1	1	1	0	0	0	1	0	0	9.8
2	1	0	0	0	0	9	3	0	9.4
3	0	1	0	0	0	1	3	1	9.4
4	3	1	0	0	0	2	2	0	9.2
5	1	3	0	0	0	0	1	0	8.9
6	0	3	0	0	0	0	0	0	8.7
7	0	1	0	0	0	2	0	0	8.7
8	1	2	0	0	0	4	0	0	8.4
9	1	0	0	0	0	1	0	0	8.4
10	0	0	0	0	0	0	1	0	8.5
11	0	1	0	0	0	2	0	0	8.1
12	0	4	0	0	0	0	0	0	8.0
13	0	0	0	0	0	1	0	0	7.9
14	0	5	0	0	0	0	0	0	7.9
15	0	15	0	0	0	0	0	0	7.8
16	0	8	0	0	0	0	1	0	7.9
17	0	4	0	0	0	0	0	0	7.6
18	0	1	0	0	0	0	0	0	7.4
19	0	1	0	0	0	0	2	0	7.2
20	0	1	0	0	0	0	1	0	6.9
21	0	0	0	0	0	0	0	0	6.8
22	1	8	0	0	0	0	1	0	6.8
23	0	1	0	0	0	0	0	0	6.8
24	0	0	0	0	0	0	0	0	6.6
25	0	0	0	0	0	0	0	0	6.5
26	0	3	0	0	0	0	0	0	6.4
27	0	6	0	0	0	0	0	0	6.3
28	0	7	0	0	0	0	0	0	6.3
29	0	4	0	0	0	0	0	0	6.2
30	0	1	0	0	0	0	0	0	6.1
31	0	4	0	0	0	0	0	0	6.0
Totals	94	1,202	2,754	2,944	719	352	106	1	

APPENDIX B

Appendix B1.–Harvest sampling statistics and estimated harvest of Auke Creek adult coho salmon in 2007. See bottom of table for key to the variables.

Fishery, quadrant	Stat. week, bi-week or (period)	N_i	n_i	a_i	a_i'	t_i	t_i'	m_{ij}	$\hat{r}_{ij}$	$\text{var}(\hat{r}_{ij})$	$SE(\hat{r}_{ij})$
Drift, NE	36	6,997	2,627	65	65	62	62	4	11	18	4.2
Drift, NE	37	5,280	2,139	63	63	61	61	4	10	14	3.8
Drift, NE	38	5,613	2,190	74	74	72	72	4	10	16	4.0
Drift, NE	39	4,195	1,276	46	44	41	41	3	10	24	4.9
Purse, NE	31	3,423	559	10	10	8	8	1	6	31	5.6
Troll, NW	28	59,859	17,811	301	279	207	206	2	7	18	4.2
Troll, NW	29	83,961	26,616	429	405	299	298	1	3	7	2.7
Troll, NW	31	75,180	29,571	433	428	316	316	2	5	8	2.8
Troll, NW	32	93,309	24,646	404	395	310	310	3	12	33	5.7
Troll, NE	34	12,661	1,772	21	21	13	13	1	7	44	6.6
Troll, NW	34	122,151	29,698	551	523	378	378	2	9	28	5.3
Troll, NW	35	95,804	22,140	436	416	309	309	7	32	109	10.4
Troll, NW	36	99,954	21,242	474	452	357	357	5	25	95	9.7
Troll, NW	37	119,297	29,210	808	787	640	638	8	34	106	10.3
Troll, NW	38	47,413	18,804	513	507	416	415	2	5	8	2.8
Juneau Sport	16	1,779	1,779	15	15	11	11	1	1	0	0.0
Juneau Sport	19	94	7	1	1	1	1	1	13	167	12.9
Totals		836,970	232,087	4,644	4,485	3,501	3,496	51	200	726	26.9

Notes: N_i = harvest in fishery strata i; n_i = number inspected for CWTs; a_i= number missing an adipose fin; a_i'= number of heads that arrive at the lab; t_i= number of heads with CWTs detected; t_i'= number of CWTs that are dissected from heads and decoded; m_{ij}= number of CWTs with code(s) j of interest; θ_j= fraction of the cohort tagged with code(s) j of interest; r_{ij}=estimated contribution in straum i by code j.

APPENDIX C

Appendix C1.–Computer data files containing Auke Creek data for Auke Creek in 2007.

File name	Description
2007AukeCohoAdAge.xls	Excel file which SAS program reads from and writes to for coho salmon adults sampled in 2007
2007AukeCohoJkAge.xls	Excel file which SAS program reads from and writes to for coho salmon jacks sampled in 2007
2007AukeCohoSmAge.xls	Excel file which SAS program reads from and writes to for coho salmon smolts sampled in 2007
Auke_Coho_CWT_07.xls	List of coded wire tags and related information used historically at Auke Creek
AC_Historical_07.xls	Historical information for counts of all species at Auke Creek
Auke_water_temp_07.xls	Water temperature information collected both by hand and by HOBO at Auke Creek in 2007
CT_and_SH_07.xls	Length, sex, and PIT tag codes for cutthroat trout seen in 2005. Lengths of juvenile steelhead seen in 2007.
DV_Length_Date_07.xls	Length information for Dolly Varden sampled during spring emigration in 2007
Harvest_estimates_07_Auke.xls	Tag lab harvest expansion report and marine harvest calculations for fish caught in 2007 commercial and recreational fisheries
Length_Composition_07.xls	Length composition and calculations for Dolly Varden emigrants in 2007
Scale_sampling_07.xls	Age, weight and length of coho salmon smolts, adults, and jacks sampled in 2007
Scale_temp_07.xls	Graphs and additional work done with Scale_sampling_07.xls
Strat Age Len Wt Sex.sas	SAS program used to analyze data from coho salmon adults, jacks, and smolts sampled in 2007
Weir_Counts_07.xls	Emigrant and immigrant counts of all species seen at Auke Creek in 2007