Fishery Data Series No. 04-12

Dolly Varden and Cutthroat Trout Migrations at Auke Creek in 2002, and Abundance of Cutthroat Trout in Auke Lake, Southeast Alaska

ADDENDUM

12/01/2005

This addendum submits the following 6 changes, to correct errors in the original publication. The text below is linked to the corrections to the original document.

1) On page 16, text has been corrected to account for the corrections to Figure 14.
2) On page 17, the text (which summarizes results in Table 8) is corrected.
3) On page 17, Figure 14 is revised with corrected data.
4) On page 18, all data and statistics in Panel C of Table 8 are corrected.
5) On page 19, the text has been corrected, to account for the corrections to Table 12.
6) On page 21, Table 12 contains corrected data and stats.

by

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and

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August 2004

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)

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

FISHERY DATA SERIES NO. 04-12

DOLLY VARDEN AND CUTTHROAT TROUT MIGRATIONS AT AUKE CREEK IN 2002, AND ABUNDANCE OF CUTTHROAT TROUT IN AUKE LAKE, SOUTHEAST ALASKA

by

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ABSTRACT

The Auke Creek weir near Juneau, Alaska, was operated in 2002 to count migrating sea-run Dolly Varden *Salvelinus malma*, cutthroat trout *Oncorhynchus clarki*, and other species of Pacific salmon *Oncorhynchus*. The number of Dolly Varden emigrants, 4,858, was the third lowest in seven years and lower than the 23-year average of 6,359. The number of Dolly Varden immigrants, 4,341, was the third lowest observed since accurate immigration counts for this species began in 1997. Average fork length of emigrant Dolly Varden was 253 mm (SD = 67 mm). Emigrant and immigrant wild cutthroat trout counts were 210 and 241, respectively. Average fork length of emigrant cutthroat trout was 263 mm (SE = 53 mm). Estimated abundance of cutthroat trout ≥180 mm in Auke Lake during 2001 was 631 (SE = 146) during mid April; this estimate is higher than the estimates made by trip and by year made in previous years using the JS open population model and the Peterson model for closed populations.

Key words: Alaska, Auke Lake, Auke Creek, cutthroat trout, Dolly Varden, sea-run, weir, abundance, length, timing, PIT, VI, tag retention, population estimate, Petersen model, Jolly-Seber model

INTRODUCTION

The Auke Lake system, north of Juneau, Alaska, has native populations of Dolly Varden *Salvelinus malma;* cutthroat trout *Oncorhynchus clarki;* steelhead *O. mykiss;* and pink *O. gorbuscha*, chum *O. keta*, sockeye *O. nerka*, and coho salmon *O. kisutch*. Chinook salmon *O. tshawytscha* have returned to Auke Creek since 1986 as a result of releases of hatchery smolts in Auke Bay near the mouth of Auke Creek. A weir has been operated on Auke Creek, the outlet stream of Auke Lake, since 1962. A permanent structure was constructed in 1980, and in 1997 the weir was modified to capture, in addition to several other species, all immigrant Dolly Varden and cutthroat trout (Table 1). The Auke Creek database on emigrant and immigrant species is the longest and most complete in Southeast Alaska. 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), fund a seasonal biologist to assist with studies at Auke Creek weir, under an interagency cooperative agreement. Fish data collected at the weir are used as indicators of the status of local stocks and help to guide management decisions for the Juneau area. Studies at Auke Creek weir have provided important insights into life history, behavior, age composition, maturity, run timing, and growth of fish present in the Auke Lake system (Neimark 1984a,b; Taylor and Lum 1999, 2000, 2001, 2002, 2003; Lum et al. 1998, 1999, 2000, 2001, 2002). An annual report for Auke Creek weir summarized the operations and fish counts for 2002 (Taylor and Lum 2003).

DOLLY VARDEN

Dolly Varden have a very complex life history among salmonids (Armstrong and Morrow 1980), and new features are still being learned. Long-term trends in abundance, age structures, growth patterns, and migration timing for Dolly Varden populations in Alaska are largely unknown. Data from the Auke Creek weir will help to close this information gap, and the weir provides managers indicators of Dolly Varden population status around Juneau as urban development in this area continues.

Dolly Varden are important in the local Juneau sport fishery, and Auke Lake provides important overwintering and rearing habitat for local Dolly Varden. Some spawning undoubtedly occurs in the lake system; however, spawner numbers and annual production of smolts remain unknown. Emigrant Dolly Varden at Auke Creek were counted in 1970 and since 1980 have been counted annually. There were 4 years in which all or most of the emigrant Dolly Varden were fin-marked or tagged when they were captured at Auke Creek weir. Emigrant Dolly Varden were also checked for missing fins and tags, and a subsample (or all) of the emigrants were measured to determine inter- and intra-annual changes in size.

Table 1.–Average number of migrant fish of all species counted at Auke Creek, 1980–2002. Hatchery chinook salmon are not allowed to move above Auke Creek weir.

Annual average	Pink salmon	Coho salmon	Sockeye salmon	Chum salmon	Chinook salmon	Dolly Varden	Cutthroat trout	Steelhead
Spring	106,883	6,304	16,896	4,066	0	6,359	261	10 [a]
Fall	10,265	722	5,205	792	248[b]	4,610 [a]	268 [a]	4 [a]

[a] Average of 1997–2002 weir counts, when these species were tallied.

[b] Average of 1987–2002 weir counts; fish are sacrificed at the weir.

CUTTHROAT TROUT

Coastal cutthroat trout have a life history that is characterized by a diversity of expressions within individuals and among populations. There can be resident and sea-run cutthroat trout within the same system. Resident cutthroat trout spend time in a riverine or lacustrine phase before migrating into inlet streams to spawn, never leaving the freshwater system. Sea-run cutthroat trout typically spend several years in a resident, riverine, or lacustrine phase before migrating to seawater for a period of up to a few months. They return to freshwater to spawn or overwinter, and may repeat this cycle (or a variation) one or more times (Northcote 1997, Trotter 1997). Comprehensive time series of data on the distribution, abundance, age structure, growth, and migration timing for this species are rare, as they are for Dolly Varden. Such data are important to understanding the impact that directed fisheries can have on small populations of cutthroat trout (Behnke 1979, Spense 1990, Wright 1992).

Cutthroat trout are caught in Auke Lake through the ice during the winter and from the beach or boats during the remainder of the year (Table 2). Anecdotal information suggests that the cutthroat trout fishery in Auke Lake was more productive than at present. Strategic planning exercises, con-

Table 2.–Estimates of sport fishing effort, total catch, and harvest of cutthroat trout and Dolly Varden in the Auke Creek drainage, 1990–2001. All estimates for Auke Creek drainage were derived from low sample sizes. Unpublished mail survey estimates from Research and Technical Services database, ADF&G, Anchorage.

				Cutthroat trout		Dolly Varden[a]	
Year	Anglers	Trips	Days	Catch	Harvest	Catch	Harvest
1990	34	34	34	17	17	0	0
1991	16	33	23	0	0	0	0
1992	75	87	75	18	0	0	0
1993	50	325	271	391	224	49	0
1994	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]
1995	29	32	29	26	0	0	0
1996	40	397	375	1,104	0	485	0
1997	45	47	47	16	0	54	0
1998	46	100	113	101	17	177	0
1999	33	12	33	9	0	0	0
2000	54	22	54	195	0	0	0
2001	86	307	353	807	24	216	0

[a] Auke Lake is closed to the harvest of Dolly Varden.

[b] – No estimates were made in 1994.

ducted by ADF&G in 1989, identified improvement of the cutthroat trout fishery in Auke Lake as a goal to help satisfy the demand for sport fisheries along the Juneau roadside (Schwan 1990). The current research program grew from that planning exercise. The result of this effort is the longest and most complete data set across the range of the species.

The first significant trout tagging program at Auke Creek began in 1994. A mark-recapture program to estimate annual spring or summer abundance in the lake began in 1997. Fish tagged in the lake in the spring of 1997 were recovered by anglers in marine waters over the next few summers, suggesting that Juneau roadside fisheries for anadromous cutthroat trout (Table 3) partly depend on stocks that overwinter or reside in Auke Lake.

Trout research at Auke Creek and Auke Lake, particularly the passive integrated transponder (PIT) tagging program started in 1997, has yielded valuable and unique information from an anadromous cutthroat trout system. Growth rates on individual cutthroat trout allow managers to set size-based harvest regulations and describe recruitment into the harvestable size class. Tracking the migration histories of individual fish in and out of the lake is allowing us to describe use of the lake as an anadromous rearing area. Recoveries of tagged fish in local fisheries yield data on saltwater migration patterns and the opportunity to observe the intra- and interannual movements between and within watersheds. As urbanization spreads in the Juneau area, these results will help us to recognize critical habitats and to document effects of habitat change.

The purpose of this report is to summarize counts and biological characteristics of Dolly Varden and cutthroat trout at the Auke Creek weir in 2002, as well as results of mark-and-recapture experiments to estimate abundance of cutthroat trout residing in Auke Lake. Our objectives were:

1. Count emigrant Dolly Varden and cutthroat trout at Auke Creek from March 1 through the end of the emigration (usually June 30);
2. Estimate the size composition of Dolly Varden and cutthroat trout emigrants;
3. Count immigrant Dolly Varden and cutthroat trout at Auke Creek from June 30 through the end of the immigration (usually October 30);
4. Measure all tagged cutthroat trout immigrants;
5. Estimate the abundance of cutthroat trout in Auke Lake during spring 2001, using a Jolly-Seber (JS) model.

Table 3.–Estimates of sport fishing effort, total catch, and harvest of cutthroat trout and Dolly Varden in the marine areas surrounding Auke Creek, 1990–2001. All estimates for surrounding marine area were derived from low sample sizes. Included in the counts are fishing in Auke Bay by boat along shore, and fishing near the mouth of Auke Creek by boat or by shore. Unpublished mail survey estimates from Research and Technical Services database, ADF&G, Anchorage.

				Cutthroat trout		Dolly Varden	
Year	Anglers	Trips	Days	Catch	Harvest	Catch	Harvest
1990	516	447	571	0	0	103	52
1991	294	343	322	0	0	12	12
1992	623	1359	1494	0	0	8	0
1993	1862	3416	3860	0	0	76	0
1994	2639	5345	7101	0	0	391	103
1995	2273	3471	5225	0	0	109	61
1996	1989	2313	2926	58	11	244	109
1997	1577	2142	2944	28	0	998	197
1998	1735	2088	2797	15	15	150	150
1999	1847	2445	3885	67	29	654	97
2000	2770	3575	5588	45	9	828	108
2001	2429	3916	4841	12	0	486	43

STUDY SITE

The Auke Lake system is a mainland watershed of 1,072 ha located approximately 19 km north of downtown Juneau, Alaska (58°23′, 134°37′), on the Juneau road system. Auke Lake has a surface area of 67 ha and is fed by 5 tributaries. Lake Creek is the largest tributary, with a watershed of 648 ha. The greatest depth of Auke Lake is 31 m, and the surface elevation is approximately 19 m. Auke Creek weir is about 400 m downstream from the lake, at the head of tidewater at Auke Bay (Figure 1). The shoreline of Auke Lake is bordered by forested terrain, which varies from gentle slopes to steep-sided banks. The shoreline zone of water consists of areas dominated by emergent vegetation of *Equisetum* spp. and *Nuphar* spp. and other areas characterized by large numbers of submerged and floating conifers anchored to the lakeshore and bottom by their large root wads. At least 50% of the shoreline has been urbanized by residential development.

METHODS

EMIGRANT POPULATIONS

The Auke Creek weir was operated from March 1 through June 28 to intercept all emigrant salmonids. During this time, fish cannot move upstream through the weir. The weir is designed such that water spills through 5 inclined traps and vertical aluminum panels covered with 3-mm perforations that are effective at both high and low flows. Fish and water that exit the inclined traps are diverted through an aluminum trough to a fiberglass holding tank downstream from the weir. A separate water source supplies the holding tank to keep the fish alive. Fish were sorted by species, counted, sampled, tagged and released each day. The fish were not anesthetized.

All Dolly Varden were counted and examined for Floy tags and adipose finclips. Length composition was estimated by using a systematic sampling procedure. Daily, every 10th Dolly Varden captured at the weir was measured to the nearest 5 mm from the tip of snout to fork of tail (FL). Average length of Dolly Varden emigrants sampled at the weir was estimated:

$$\bar{y} = \frac{1}{n}\left(y_1 + y_2 + \ldots + y_n\right) = \frac{1}{n}\sum_{i=1}^{n} y_i \qquad (1)$$

where $\bar{y}$ is the sample mean or the average of the y-values in the sample, and n is the number sampled for length. The standard error of $\bar{y}$ was estimated as:

$$se(\bar{y}) = \sqrt{\left(1 - \frac{n}{N}\right)\frac{1}{n*(n-1)}\sum_{i=1}^{n}\left(y_i - \bar{y}\right)^2} \qquad (2)$$

where N is the weir count. The finite population correction factor (fpc) of $1\text{-}{}^{n}\!/\!_{N}$ is included because of the exactly known and relatively high sampling rate.

All cutthroat trout were counted, measured to the nearest millimeter, FL, and examined for Floy or visual implanted (VI) tags and missing fins. Possible fin marks on cutthroat trout in 2002 included: (1) adipose-clipped fish carrying a PIT tag placed between 1997 and 2002; (2) VI tagged and adipose-clipped fish marked during emigrations from the lake in 1994-1996; (3) left ventral-clipped hatchery fish released in 1994; (4) right ventral-clipped hatchery fish released in 1991; and (5) adipose-clipped hatchery fish released in 1986 and 1987. All cutthroat trout missing the adipose fin were checked with an electronic scanner for a PIT tag (the rate of PIT tag loss has been less than 1%). Each PIT tag has a unique 10 character alphanumeric code or number. Before 2000, PIT tags were inserted under the skin in the dorsal sinus, next to the basal fin rays of the dorsal fin. Starting in 2000, tags were inserted under the skin immediately posterior and parallel to the midpoint of the cleithrum. To prevent fishermen from accidentally biting down on the tag or ingesting the tag in situations where the fish was cooked whole and not filleted this tag location was chosen.

All unmarked, emigrant cutthroat trout were PIT tagged, adipose finclipped, and given a red photonic dye marks on the anal fin before release. One or two drops of cyanoacrylate (super glue) were used to close the PIT tag wound and prevent tag loss and infection. Newly tagged cutthroat trout were held for 24 hours to check for short-term tag loss.

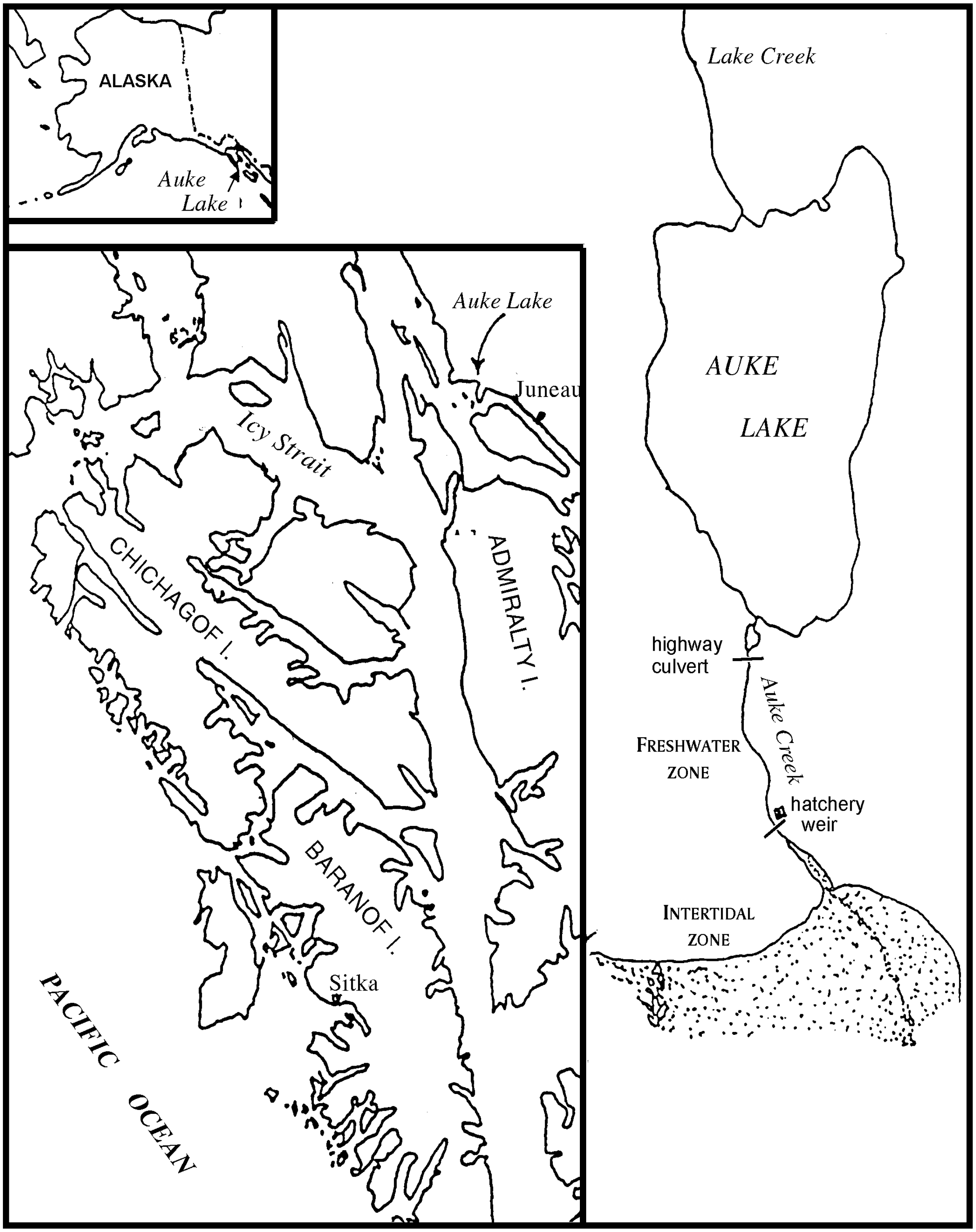


Figure 1.–The Auke Lake system in northern Southeast Alaska and location of the Auke Creek weir.

All cutthroat trout mortalities were measured and sampled for scales and otoliths, and screened for PIT tags, which were removed if present. Scales from cutthroat trout mortalities were taken from the left side of the caudal peduncle immediately above the lateral line (Brown and Bailey 1949, Laasko and Cope 1956). Each fish was wiped with the blunt side of a knife to remove excess mucus before collecting a sample of scales. A sample of 15 to 20 scales from each fish was spread on a microscope slide so that no scales were overlapping and sandwiched between another slide (Ericksen 1999). The slides were stored in a labeled coin envelope inscribed with the sample number and date.

IMMIGRANT POPULATIONS

The weir was converted to count immigrants on June 28 and operated through October 31. Vertical slotted aluminum panels, 90 x 178 cm, were inserted into the weir structure to divert fish into the adult trap without restricting the water flow. The weir captured all small fish, including Dolly Varden, cutthroat trout, coho juveniles, and chinook salmon mini-jacks (0-ocean) as well as adult salmon that moved upstream, while blocking any downstream movements. Aluminum plates, 45 x 90 cm, with 1.5 x 10 cm horizontal slots were placed on the bottom half of the lowest weir panels to prevent passage of small fish. Before 1997, small fish passed through the weir panels and were not counted. Small fish were captured in two trout traps, 1.5 x 2.4 x 0.8 m high, attached to the upstream side of the weir. Pickets on the trap entrance were spaced 2.5 cm apart to prevent larger salmonids from entering the trout traps. Square mesh plastic netting, with 6 mm x 6 mm openings, was used to cover the walls of the trout traps and the adult trap to retain smaller fish, specifically juvenile coho immigrating in the fall.

All immigrating Dolly Varden and cutthroat trout were counted and released upstream, except that early in the immigration captured cutthroat were kept below the weir to reduce the incidence of injury and death due to low stream flows, high temperatures, and the fish's fragile condition (see Lum et al. 1998 for details). Dolly Varden were examined for adipose finclips and Floy tags from other studies, and marked fish were measured to the nearest 5 mm FL to enable estimates of growth. Cutthroat trout were measured to the nearest 1 mm FL and examined for marks. Cutthroat missing their adipose fins were checked for dye marks on all fins, and scanned for PIT tag code. Unmarked cutthroat trout were marked with a red dye on the anal fin (blue was used in 2000) but not PIT tagged, since high levels of mortality can result (ADF&G unpublished data from 1996).

Marine residence of cutthroat trout was defined as the number of days between emigration and immigration at Auke Creek, recognizing of course, that some fish probably did not spend the whole period in salt water. Marine growth (mm and mm/day) of individual fish with a PIT tag was calculated as the increase in fork length during their hiatus from the lake.

Any fish found dead in the creek were sampled for FL (nearest mm), scales, and otoliths, and checked for tags. Cutthroat trout mortalities carrying a PIT tag were examined for scarring or encysting, tag placement, and migration of the tag into the body cavity or out through the skin.

CUTTHROAT TROUT IN AUKE LAKE

Abundance, survival, and birth rates of cutthroat trout ≥180 mm FL in Auke Lake during 1998, 1999, 2000, and 2001 were estimated using the "full" JS model (Seber 1982), which provides k-2 abundance estimates and k-2 survival rate estimates (k = number of the sampling events). Two JS analyses were made: one with data aggregated by sampling trip to yield an 9-event (by trip) model, and one with data pooled by sampling year to yield a 5-event (by year) model. Fish captured several times during a sampling period were treated as being caught only once. Data for the analysis was collated in SAS (SAS 1990) and an electronic spreadsheet, and input to POPAN (Arnason et al. 1998) to estimate population parameters and obtain capture histories. Parameter estimates were constrained to admissible values in POPAN using the procedures in Schwarz et al. (1993) and Schwarz and Arnason (1996). GOF statistics for the JS model were obtained using program JOLLY (Pollock et al. 1990). JS estimates were also compared to our previous closed population (CP) estimates (Lum et al. 1999, 2000 and 2001).

Three separate lake sampling trips were made in 1998 between July 8 and August 14 (Lum et al. 1999), two sampling trips were made in 1999 between May 25 and June 16 (Lum et al. 2000), two sampling trips were made in 2000 between May 2 and May 25 (Lum et al. 2001), one sampling trip was made between April 16 and

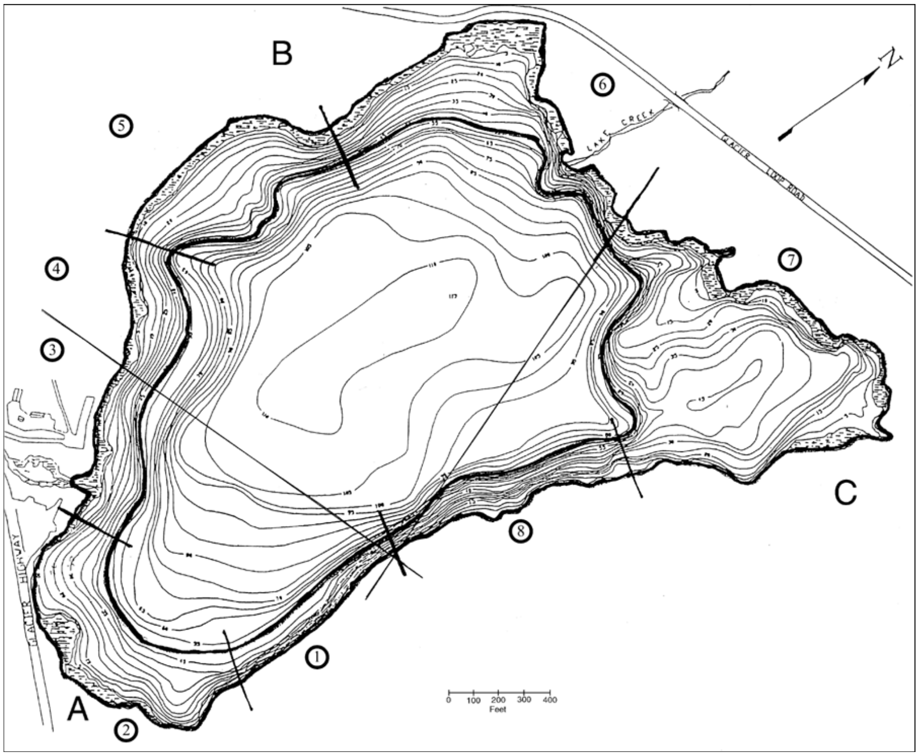


Figure 2.–Bathymetric map of Auke Lake showing location of sampling areas in 2002. The lake area inside the inner bold line was excluded from sampling as depths were >15 m. The two intersecting straight lines indicate the separation between the three strata (A, B, and C) used in analysis.

April 25, 2001, and one sampling trip was made between June 4 and June 13, 2002. As sampling dates advanced in 2000, and especially in 2001, emigrations were not completed prior to lake sampling. The current sampling was scheduled during June to exclude fish, which emigrate during the sampling event.

Trout were captured with traps baited with chinook salmon eggs, and by casting small spoons, spinners, and other lures. Trap soak-times were typically 22 to 24 hours. Traps were plastic-mesh cylindrical devices 1 m long x 0.5 m diameter, with a funnel entrance at each end (Rosenkranz et al. 1999). Captured trout were inspected for tags or marks and measured for fork length. Fish missing the adipose fin were scanned to determine PIT tag number. Unmarked cutthroat trout ≥180 mm FL were tagged with a uniquely numbered PIT tag, given red dye mark on the left ventral fin, and had their adipose fin excised. Fish caught more than once during the sampling trip were treated similarly (except for tagging) and "recapture" was noted in comments. Trout were handled without using anesthesia and released in the area where they were captured.

The lake was divided into 8 areas to facilitate sampling and accurate recording of locations where cutthroat trout were captured (Figure 2, above). Data from these areas were then pooled into 3 strata (A, B, C) for testing experimental assumptions. Fishing occurred only in areas ≤15 m deep (Figure 2) since previous work in Auke Lake showed trout were not captured at greater depths during the summer (NMFS unpublished data, Juneau, Alaska). Four baited hoop traps, in addition to the other 16 traps, were set in water deeper than 15 m across the middle of Auke Lake to determine whether the depth limitations still held true. Sixteen traps were fished each day using a fathometer to determine depth. Overall, the fishing effort (number of traps set and hours of hook and line effort) in each area was proportional to the lake surface area ≤15 m (Table 4). The depth, sampling area, and number of fish caught were recorded by trap set.

Assumptions of the standard (full) JS model (Seber 1982) include:

1. every fish in the population has the same probability of capture in the i^{th} sample;
2. every marked fish has the same probability of surviving from the i^{th} to the $(i+1)^{th}$ sample and being in the population at the time of the $(i+1)^{th}$ sample;
3. every fish caught in the i^{th} sample has the same probability of being returned to the population;
4. marked fish do not lose their marks between sampling events and all marks are reported on recovery; and
5. all samples are instantaneous (sampling time is negligible).

A goodness of fit (GOF) test (of marked fish seen before versus not seen before, against seen again versus not seen again, Pollock et al. 1990) was used to test for homogeneous capture and survival probabilities by tagged status. The first component of the GOF test is equivalent to the Robson (1969) test for short-term mortality. Pollock et al. (1990:24) report the second test component to be better at detecting heterogeneous survival probabilities. The sum of the chi-squares from each component forms an omnibus test for violations of the first three assumptions listed above; i.e. equal probability of capture, survival, and return to the population. Because these GOF statistics were highly significant for the annual (pooled data) model, a generalization of the JS model which allows survival rates for newly captured animals and previously captured animals to differ ("Analysis 3" in POPAN, "Model 2 in JOLLY") was considered.

The condition that the probability of capture is the same for all fish within a sampling event can be waived (with respect to sampling location) if marked and unmarked fish mix completely between sampling events (Seber 1982: 211). Such a test was made by comparing the marked fraction (R/C, where R is the number of recaptures and C is the number of captures) of fish caught in strata A, B, and C, using only fish marked in the previous year. If $(R/C)_A = (R/C)_B = (R/C)_C$ complete mixing was indicated; otherwise incomplete mixing was indicated. A chi-square statistic (from a 3 x 3 contingency table, $\alpha = 0.05$) was used for the test. Since few fish were captured by using hook-and-line each year, comparisons based on gear type were not attempted.

Table 4.-Distribution of sampling effort in Auke Lake by area in 2002. Sampling effort was uniformly distributed across each of the eight areas (Figure 2) of the lake in direct proportion to the amount of lake surface (<15m depth) present, given a total effort of 144 traps and 20 rod-hours during the 9 day sampling trip.

Area no.	Analysis stratum	Area[a] (km^2)	Prop.[a]	Hook and line effort (hrs)	No. of traps set each day	Total trap effort (sets)
1	A	0.5463	0.0459	1:00	1	9
2	A	2.6098	0.2195	4:23	3 - 4	29
3	A	1.0583	0.0890	1:47	2	18
4	B	0.8275	0.0696	1:23	1	9
5	B	1.4691	0.1236	2:28	2	18
6	B	1.4562	0.1225	2:27	2	18
7	C	3.1297	0.2632	5:16	4	36
8	C	0.7932	0.0667	1:20	1	9
mid-H_20	NA	NA	NA	NA	3 - 4	34
Totals		11.8901	1.0000	20:04	16[b]	146[b]

[a] Tabulated area and proportions are estimates for 0–15 m depths.

[b] Total does not include the traps set in the mid-H_20 sets.

The equal probability of capture assumption can also be violated if sampling is size selective. Considerable experience with sampling gear used at Auke Lake shows that our gear is not significantly size selective for fish over 180 mm FL (Lum et al. 1999, 2000).

The assumption that all fish have the same chance of surviving from the i_{th} to the $(i+1)_{th}$ sampling implies the absence of significant age dependent mortality rates for cutthroat trout ≥180 mm FL. Little evidence of age-dependent mortality was found for cutthroat trout ≥180 mm FL in Florence Lake (Rosenkranz et al. 1999). However, since sea-run cutthroat trout probably spawn in Auke Lake (Lum et al. 2001) and maturing fish probably reside (rear) in the lake prior to their spawning migrations, tagged groups of these fish could experience a different (lower) capture probability in subsequent years than a group of previously tagged resident fish.

Assumption 3 was evaluated by direct examination of the capture histories (mortality status by year) from each event. The number of fish killed or released alive without tags was usually <1% per sampling occasion. Assumption 4 was addressed by double marking trout with different combinations of finclips and photonic dye marks each year and estimating the annual rate of tag loss. Because individual sampling trips span but 9 days, significant violations of assumption 5 were not expected in the 9-event (trip-by-trip) model. However, a large emigration by the weir during a trip, or between 2 trips within a year would contribute to a violation of this assumption. Even though marked fish that leave in the spring are removed from the database prior to analysis, the total number of fish moving from the area might be underestimated. Also, estimates of significant "birth" and/or "mortality" rates between sample periods within a year from the detailed (9-trip) model would suggest assumption 5 was violated for an annual (5-trip) model.

The fraction p_a of cutthroat trout in 20-mm size increments in Auke Lake was estimated:

$$\hat{p}_a = \frac{n_a}{n} \tag{3}$$

$$var[\,\hat{p}_a\,] = (1-\frac{n}{\hat{N}})\frac{\hat{p}_a(1-\hat{p}_a)}{n-1} \tag{4}$$

where n is the number of fish measured for length, n_a is the subset of n that belong to length group a, and a fpc is again included because of the high sampling rate and availability of an abundance estimate N from the mark-recapture experiment.

RESULTS

MIGRANT DOLLY VARDEN

Emigrant and immigrant Dolly Varden populations were counted at Auke Creek in 2002. A total of 4,858 Dolly Varden emigrated in 2002. The emigration was below the historical 23-year average of 6,359 (Table 5, Figure 3), but shows a decline between 1995 and 2001. The first Dolly Varden was captured April 11 and the last June 14

Table 5.–Annual counts of spring emigration for wild Dolly Varden and cutthroat trout at Auke Creek, 1980–2002 (hatchery-produced or lake-stocked cutthroat trout not included in this table).

Year	Dolly Varden	Midpoint of emigration	Cutthroat trout	Midpoint of emigration
1980	3,110	13-May	85	18-May
1981	6,461	5-May	157	14-May
1982	4,136	24-May	157	31-May
1983	3,718	7-May	149	15-May
1984	4,512	8-May	198	14-May
1985	3,052	14-May	112	21-May
1986	4,358	13-May	99	24-May
1987	6,443	6-May	250	17-May
1988	6,770	30-Apr	294	9-May
1989	7,230	8-May	259	18-May
1990	6,425	5-May	417	11-May
1991	5,579	17-May	237	20-May
1992	6,839	4-May	219	16-May
1993	5,074	8-May	174	14-May
1994	7,600	4-May	422	13-May
1995	11,732	9-May	412	13-May
1996	11,323	4-May	462	7-May
1997	10,506	7-May	418	12-May
1998	7,532	1-May	336	11-May
1999	6,393	14-May	341	16-May
2000	5,254	6-May	249	13-May
2001	7,356	12-May	337	20-May
2002	4,858	12-May	210	20-May
Mean	6,359	9-May	261	16-May

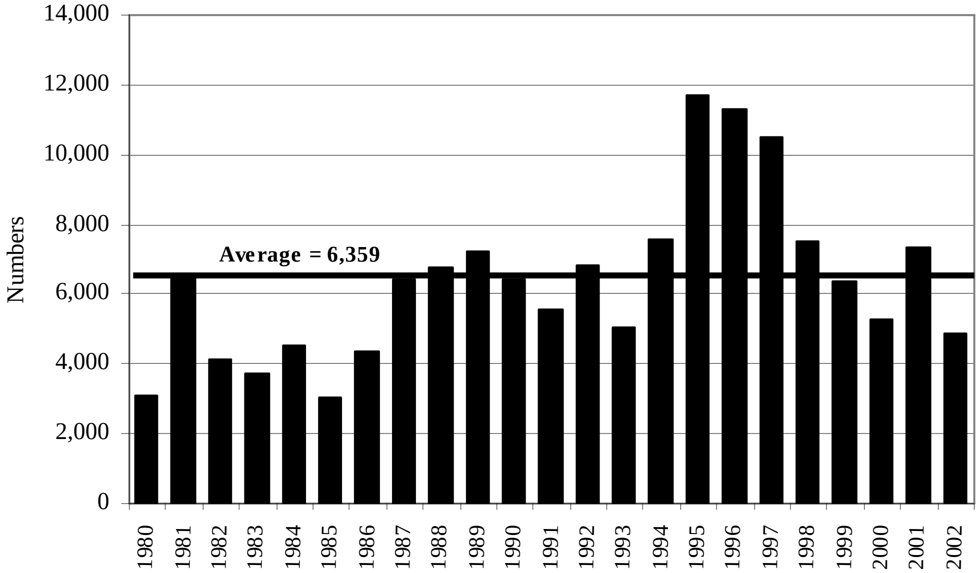


Figure 3.–Annual spring emigration of Dolly Varden at Auke Creek, 1980–2002.

(Appendix A1, Figure 4). The midpoint of the emigration was May 12, and the average mid-point date of the emigration, 1980–2002, was May 9, range April 30 to May 24. Average fork length of emigrant Dolly Varden in 2002 was 253 mm (SD = 67), range 95 to 475 mm (n = 513). The weekly average length of Dolly Varden declined during the migration; i.e. larger fish emigrated earlier (Figure 5). Total length composition was estimated for the entire Dolly Varden emigration and shows fewer than 100 fish contributing to >400 mm size class (Table 6, Figure 6).

The Dolly Varden immigration of 4,341 fish began on July 3 when the upstream trap was installed, and the last fish was captured October 31 when the weir was removed (Figure 4, Appendix A2). This was slightly below the five-year average of 4,610. Immigration counts for 1997-2001 were 5,705, 4,993, 4,709, 3,665, and 4,249 Dolly Varden. Major peaks in immigration occurred intermittently in July and September, following heavy rainfall.

MIGRANT CUTTHROAT TROUT

A total of 210 cutthroat trout emigrated in 2002. The emigration count for wild fish has been declining since 1996, but is within the historical range. The 2002 count of 210 was below the 23-year average of 261 wild fish (Table 5, Figure 7). The first emigrant was captured April 11, and the last June 28, after which the weir was converted to an upstream migrant trap (Figure 8, Appendix A1). The midpoint of emigration was May 20, and the average median date of emigration is May 16 (1980–2002); range May 7 to May 31 (Table 5). Water temperatures during the emigration in 2002 ranged between 2.7° and 17.5°C.

Of the 210 emigrant cutthroat trout in 2002, 84 were missing their adipose fin, and 126 were not marked or tagged. All fish missing an adipose fin in 2002 had a PIT tag (tag retention was 100%). The marked fish included 21 wild fish tagged before 2001, 57 wild fish tagged in 2002, 2 fish tagged in Auke Lake during 2001 and 4 tagged in Auke Lake during the lake abundance project in spring 2002. Average fork length for emigrant wild sea-run cutthroat trout was 263 mm (SD = 53 mm) and ranged from 137 to 398 mm. The weekly average length of all emigrants declined over time (Figure 9). Of the 210 emigrant cutthroat trout, 28 (13%) were males, 44 (21%) were females, and 137 (65%) showed no obvious signs of gender. Twenty-four percent (24%) of the emigrants were obviously ripe, 12% (25/210) attributed to ripe males, and 12% (26/210) to

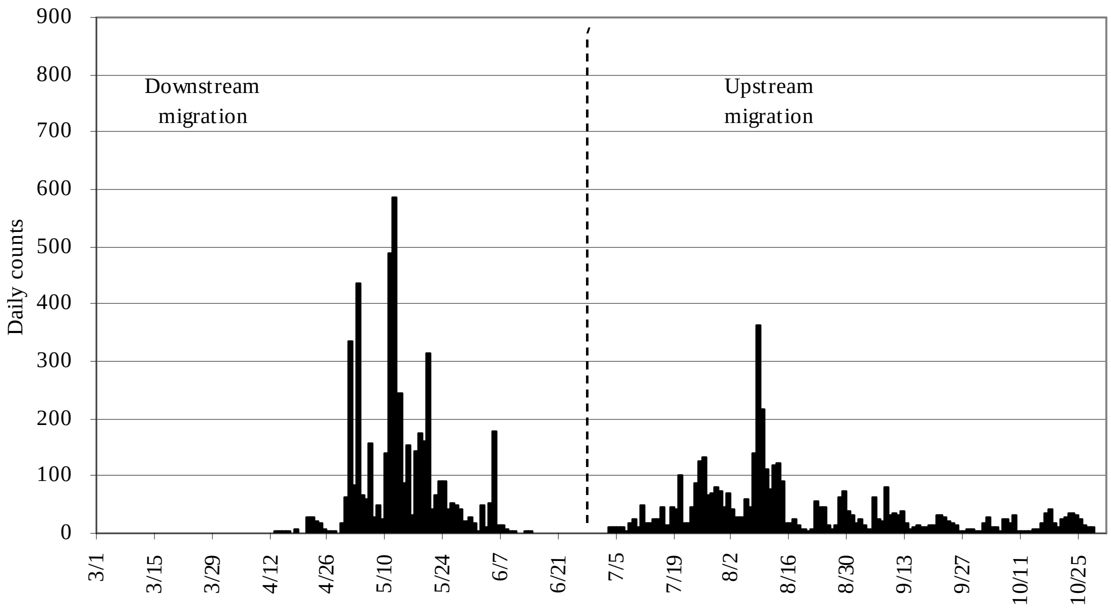


Figure 4.–The 2002 spring emigration and fall immigration of Dolly Varden at Auke Creek. Spring emigration started April 11 and ended June 14. Fall immigration started July 3 and ended October 31 at which time the upstream weir was removed. Vertical dashed line delineates when the weir was converted to count fall immigrants, June 28.

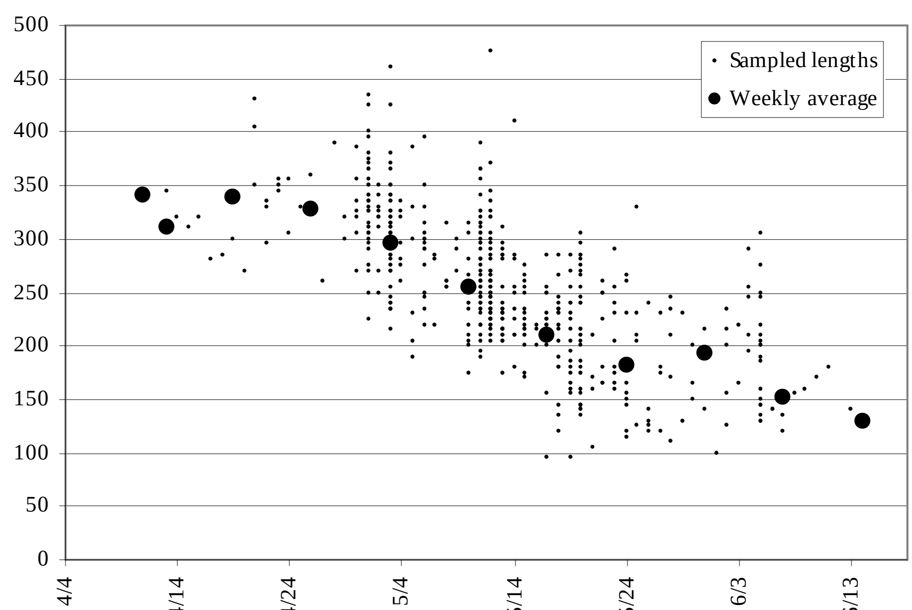


Figure 5.–Dolly Varden lengths (mm) over time during the spring emigration at Auke Creek, 2002. Average lengths for each migration week are overlaid upon sampled length data.

Table 6.–Length composition and estimated abundance at length for emigrating Dolly Varden at Auke Creek, 2002. Number sampled (n_k), proportion (p_k), abundance (N_k), and standard error (SE) are shown for each 20-mm length class.

Length k, mm FL	n_k	p_k	SE(p_k)	N_k	SE(N_k)
0-100	3	0.01	0.00	28.35	15.45
101-140	27	0.05	0.01	255.19	45.25
141-160	23	0.04	0.01	217.38	41.93
161-179	19	0.04	0.01	179.58	38.27
180-200	28	0.05	0.01	264.64	46.03
201-220	62	0.12	0.01	585.98	66.06
221-240	75	0.15	0.01	708.85	71.60
241-260	65	0.13	0.01	614.34	67.41
261-280	45	0.09	0.01	425.31	57.33
281-300	44	0.09	0.01	415.86	56.74
301-320	44	0.09	0.01	415.86	56.74
321-340	36	0.07	0.01	340.25	51.76
341-360	17	0.03	0.01	160.67	36.27
361-380	11	0.02	0.01	103.96	29.35
381-400	7	0.01	0.00	66.16	23.51
401-420	2	0.00	0.00	18.90	12.63
421-440	4	0.01	0.00	37.81	17.82
441-460	1	0.00	0.00	9.45	8.94
461-480	1	0.00	0.00	9.45	8.94
481-500	0	0.00	0.00	0.00	0.00
n =	514		N =	4858	

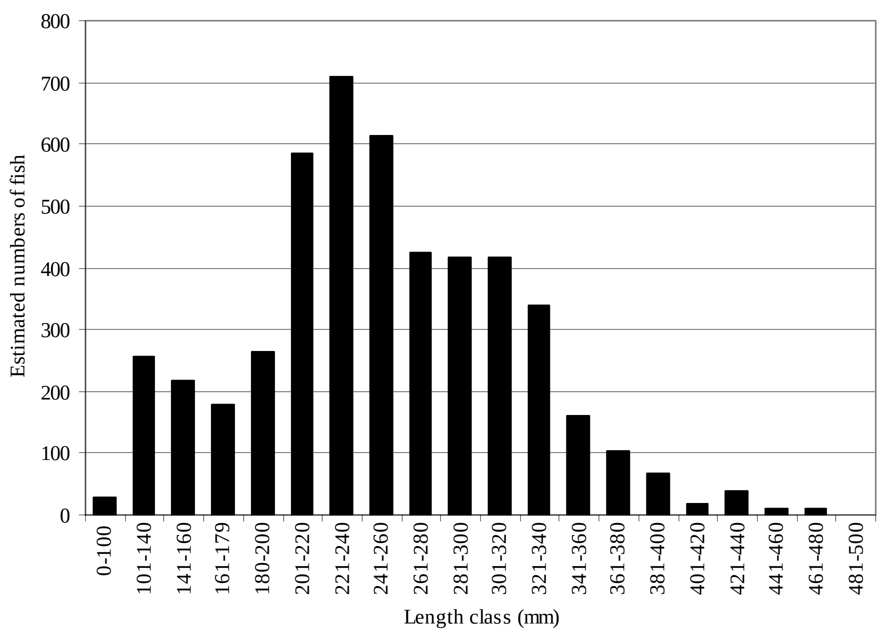


Figure 6.–Estimated length composition of emigrating Dolly Varden at Auke Creek, 2002. Estimated abundance at length are shown for 20-mm length class.

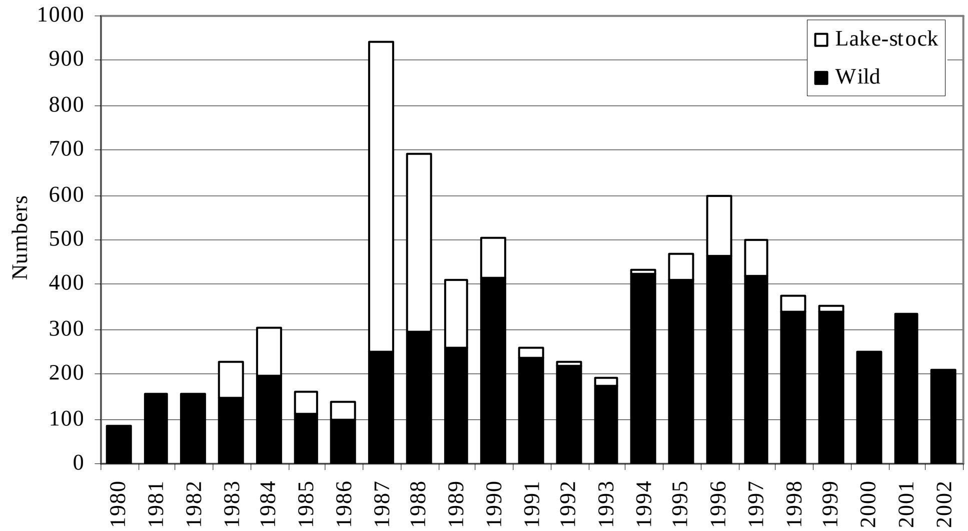


Figure 7.–Annual spring emigration for cutthroat trout at Auke Creek, 1980–2002. Hatchery cutthroat trout were stocked in Auke Lake in 1983 (1,286 right ventral marked and 4,078 left ventral marked fish); 1986 (3,489 adipose marked fish); 1987 (1,1719 adipose marked fish); 1991 (2,465 right ventral marked fish); and 1994 (3,098 left and right ventral marked fish).

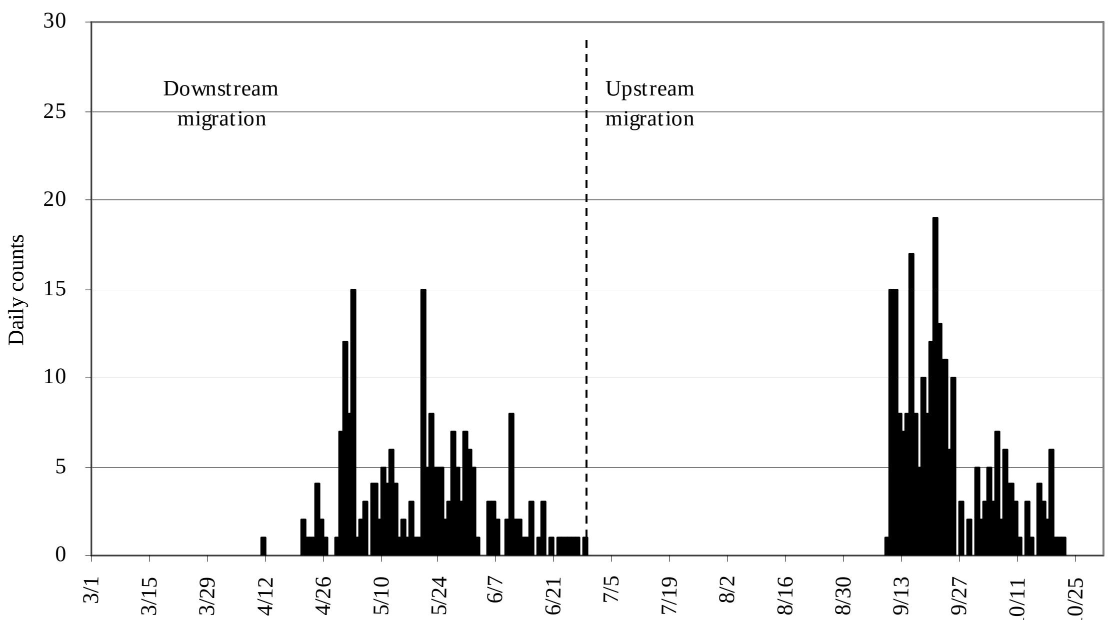


Figure 8.–The cutthroat trout spring emigration and fall immigration at Auke Creek, 2002. Spring emigration started April 11 and ended June 28. Fall immigration started September 9 and ended October 22. The fall weir was removed on October 31. The vertical dashed line delineates when the weir was converted to count fall immigrants, June 28.

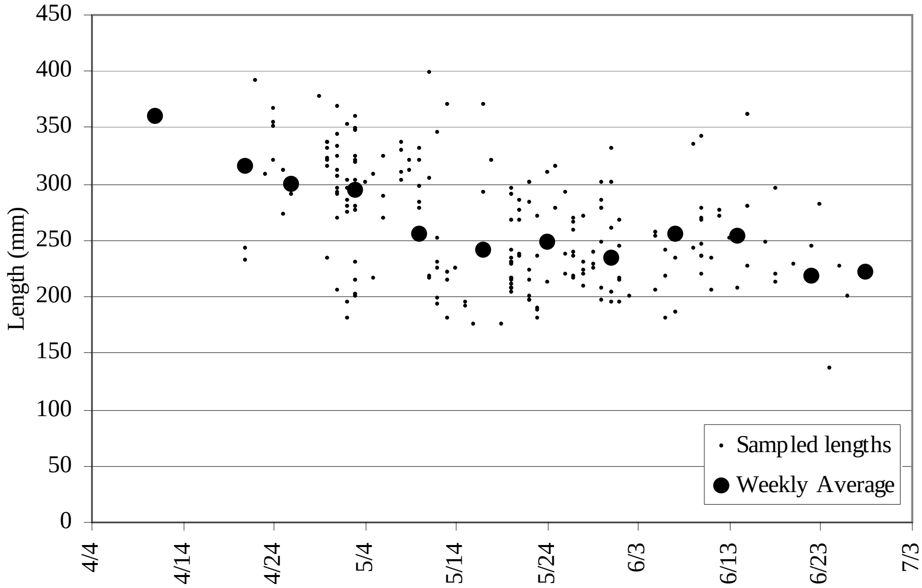


Figure 9.–Cutthroat trout lengths (mm) over time during the spring emigration at Auke Creek, 2002. Average lengths for each migration week are overlaid upon sampled length data.

ripe females. Ripeness of maturing fish started to decline after May 1 and the last ripe fish was seen on June 15. “Ripeness” or “ripe” was defined as being ready to spawn, and “obviously ripe” was defined as fish that easily extruded gametes or dripped gametes.

A total of 241 cutthroat trout immigrated and were examined for marks and PIT tags in 2002, and 82 were adipose clipped and had an operating PIT tag. We started recording immigrant cutthroat trout in 1997, with prior counts being 467, 361, 205, 36, and 105, respectively. No cutthroat trout migrated upstream in August, 180 did in September, and 63 in October. As noted in the methods, some cutthroat trout were not ready to remain in freshwater when captured at the weir early in the immigration, and they were placed back downstream. Run timing data is biased, but we do not know how to avoid this, given that releasing the fish above the weir too early results in high mortality.

PIT tag retention on immigrant cutthroat trout returning in 2002 with an adipose clip was 100% (80/80). Immigrant cutthroat trout averaged 246 mm (SD = 58 mm), ranging from 88 to 425 mm. Average lengths of immigrating cutthroat trout did not vary greatly over time (Figure 10). The length frequency distribution for both fall and spring migrants is skewed towards shorter lengths (Figure 11).

Growth rate tends to decrease, as the size of the fish gets larger (Figure 12). Marine residence and growth of cutthroat trout was determined for fish with PIT tags that emigrated and immigrated at Auke Creek in 2002. PIT-tagged cutthroat trout that returned to Auke Creek in the summer and fall 2002 had an average hiatus of 122 days (SE = 2, range 77–167 days) from Auke Lake, compared to 126 days in 1998, 133 days 1999, 149, and 131 days in 2001. The data did not show a relationship between emigration time and the immigration (return) time for cutthroat trout leaving Auke Creek in 2002, but there was a linear relationship between size at emigration and the duration of marine residence (R^2 = 0.63). The time between emigration and return to Auke Creek decreased for cutthroat trout leaving later from Auke Lake (Figure 13). Average growth during the hiatus was 55 mm (SE = 2 mm) and ranged from 20 to 96 mm. The average growth rate during the hiatus was 0.467 mm/day (SE = 0.018),

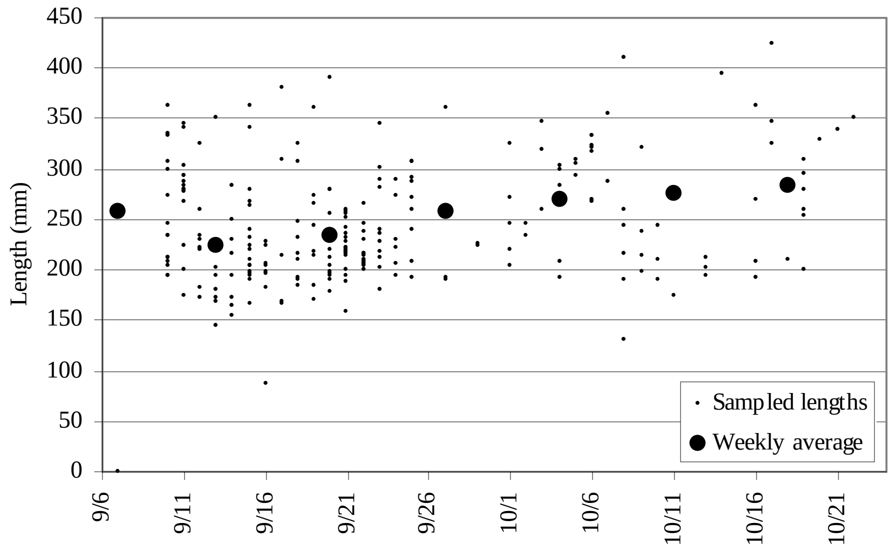


Figure 10.–Cutthroat trout lengths (mm) over time during the fall immigration at Auke Creek, 2002. Average lengths for each migration week are overlaid upon sampled length data.

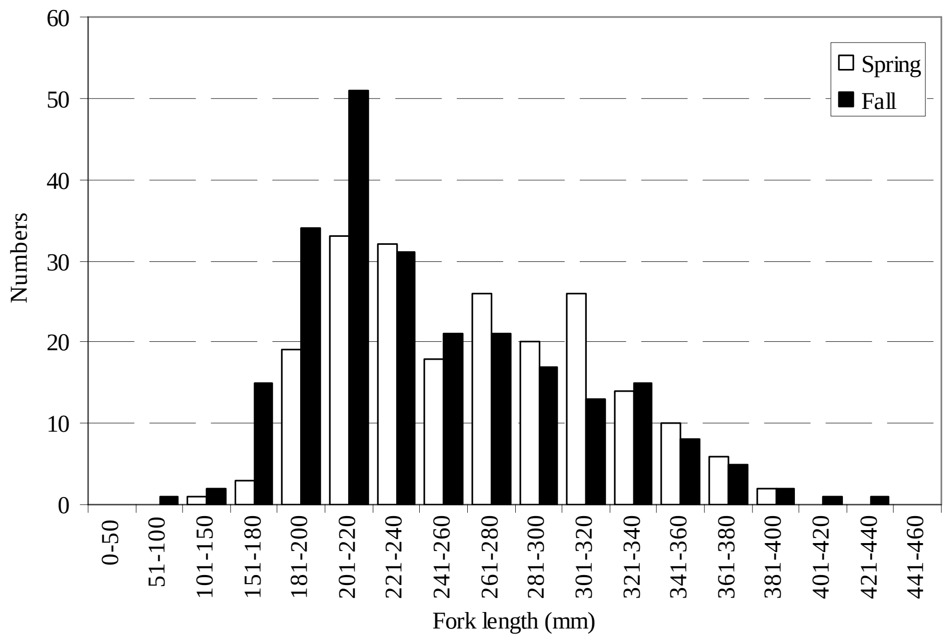


Figure 11.–Length frequency distributions of cutthroat trout captured at Auke Creek weir, spring emigration and fall immigration, 2002.

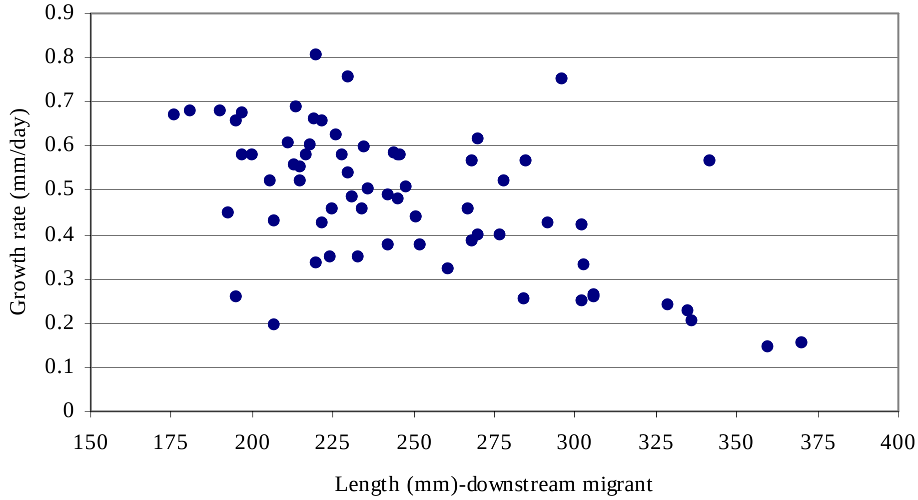


Figure 12.-Cutthroat trout growth (mm/day) during time between spring emigration and fall immigration plotted against their size at the time of spring emigration and tagging, Auke Creek, 2002.

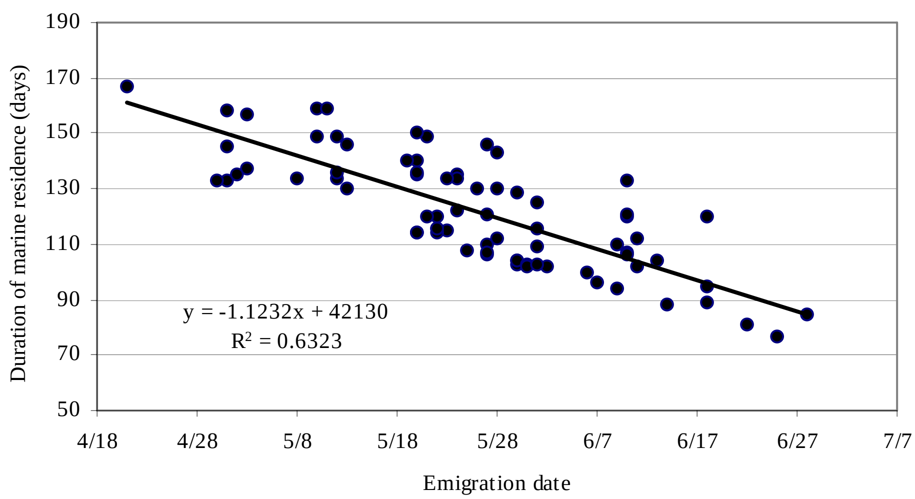


Figure 13.–Linear relationship between the emigration date and the period of marine residence (days).

which was similar to 4 of the previous 5 years (0.48, 0.49, 0.45, 0.30, and 0.47 mm/day observed in 1997–2001, respectively) (Lum et al. 2002).

CUTTHROAT TROUT IN AUKE LAKE

We captured a total of 392 cutthroat trout in Auke Lake in 2002, all of which were caught in large minnow traps and hoop traps. Although 343 cutthroat trout were ≥180 mm FL, the largest numbers of fish were in the ~~241–260~~ 180-200 mm FL size class (Table 7, Figure 14).

~~Two hundred fifty-seven~~ (~~257~~ 258) ~~unmarked~~ unique cutthroat trout between 180 and 368 mm FL were captured and released during 2002. ~~Ninety-one (91~~ Eighty-five (85) were captured more than once in ~~2001~~ 2002 and were thus "redundant" within this sampling event. Tag loss ~~in~~ of fish tagged in 2001 was insignificant (0 fish). Summary statistics and capture histories for the annual and trip-by-trip JS models are shown in Appendices A3 and A4.

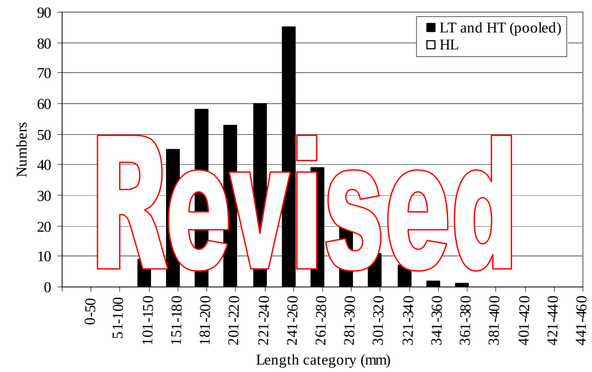
This text has been corrected, 12/05/2005, with the corrected text displayed in red.

Table 7.–Sampling effort (hours), cutthroat trout catch, and catch per unit effort (CPUE, fish per hour) by sampling gear and fish length-class, Auke Lake, 2002.

Sampling event	Gear type	Effort (hours)	≥180 mm Catch	≥180 mm CPUE	<180 mm Catch	<180 mm CPUE	Combined Catch	Combined CPUE
June 4–13	hook and line	20	0	0.000	0	0.000	0	0.000
	large traps	3,240	324	0.100	48	0.015	372	0.115
	hoop traps	216	19	0.088	1	0.005	20	0.093
	hoop trap + large traps (pooled)	3,456	343	0.099	49	0.014	392	0.113
	hoop traps-mid water	864	0	0.000	0	0.000	0	0.000
	all gear	4,340	343	0.079	49	0.011	392	0.090

Tested the similarities between the LT and the HT to determine whether they could be pooled. Chi-square = 0.806, and P = 0.369, df = 1.

Figure 14 was made using incorrect data in the original publication. The corrected figure is shown below.



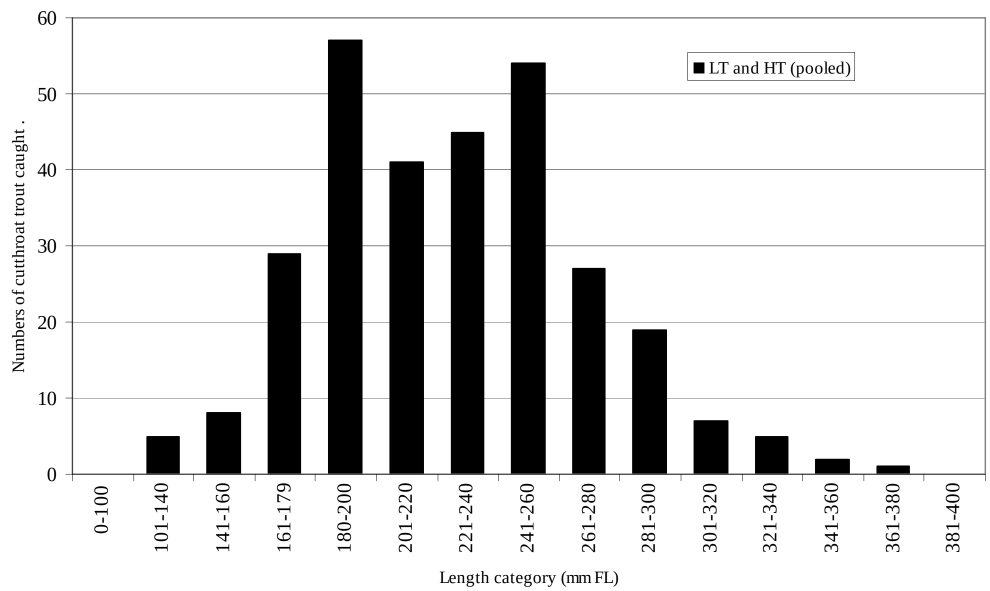


Figure 14.–Length frequency of cutthroat trout captured at Auke Lake by gear type, 2002.

Marked fish were homogeneously mixed into the unmarked population ~~between sample years 1999 and 2000 (χ^2 = 3.15, P = 0.207), and between sample years 2000 and 2001 (χ^2 = 3.20, P = 0.202,~~ Table 8). These results were not unexpected, as Auke Lake is relatively small. ~~However, between sample years 2001 and 2002, the marked fish were not equally mixed into the unmarked population (χ^2 = 8.21, P = 0.016, Table 8).~~

In contrast, the component 1 GOF test for homogeneous capture/survival probabilities by tag group (Robson's test for short-term mortality) suggests the JS model does not fit the annual data well (p = 0.022, Table 9), but it does fit the trip-by-trip data (p = 0.686). Details of the component 1 GOF test for annual data (Table 10) reveals that,

Correction to highlighted text:
Marked fish were homogeneously mixed into the unmarked population between all sample years, P ≥ 0.2 **(Table 8). These results were not unexpected, as Auke Lake is relatively small.**

Table 8.–Number of cutthroat trout marked, captured, and recaptured by stratum between sampling years, 1998–2002, and chi-square test for mixing between years.

PANEL A: Marking in 1999, sampling in 2000

Stratum fish was marked	Total fish marked	Number recaptured by stratum A[a]	B[b]	C[c]	Total (all strata)	Number unseen	Proportion recaptured
A	165	24	12	7	43	122	0.26
B	102	6	10	7	23	79	0.23
C	85	4	9	11	24	61	0.28
Total	352	34	31	25	90	262	0.26
Unmarked fish caught		57	72	73	202		
Total caught in recapture event		91	103	98	292		
Marked fraction		0.37	0.30	0.26	0.31		

χ^2 = 3.15, 2 df, P = 0.207, *Accept H_o: marked fraction is constant across recovery strata*

PANEL B: Marking in 2000, sampling in 2001

Stratum fish was marked	Total fish marked	Number recaptured by stratum A[a]	B[b]	C[c]	Total (all strata)	Number unseen	Proportion recaptured
A	91	0	3	3	6	85	0.07
B	103	1	9	7	17	86	0.17
C	98	1	2	11	14	84	0.14
Total	292	2	14	21	37	255	0.13
Unmarked fish caught		32	59	105	196		
Total caught in recapture event		34	73	126	233		
Marked fraction		0.06	0.19	0.17	0.16		

χ^2 = 3.20, 2 df, P = 0.202, *Accept H_o: marked fraction is constant across recovery strata*

PANEL C: Marking in 2001, sampling in 2002

Stratum fish was marked	Total fish marked	Number recaptured by stratum A[a]	B[b]	C[c]	Total (all strata)	Number unseen	Proportion recaptured
A	63	19	6	9	34	29	0.54
B	110	4	15	8	27	83	0.25
C	88	3	2	18	26	65	0.26
Total	261	26	23	35	84	177	0.32
Unmarked fish caught		46	90	61	197		
Total caught in recapture event		72	113	96	281		
Marked fraction		0.36	0.20	0.36	0.30		

χ^2 = 8.21, 2 df, P = 0.016, *Reject H_o: marked fraction is not constant across recovery strata*

PANEL C: Marking in 2001, sampling in 2002

Stratum fish was marked	Total fish marked	Number recaptured by stratum A[a]	B[b]	C[c]	Total (all strata)	Number unseen	Proportion recaptured
A	61	6	7	2	15	46	0.25
B	109	5	15	13	33	76	0.30
C	88	6	4	16	26	62	0.30
Total	258	17	26	31	74	184	0.29
Unmarked fish caught		74	110	113	297		
Total caught in recapture event		91	136	144	371		
Marked fraction		0.19	0.19	0.19	0.20		

χ^2 = 0.375, 2 df, P = 0.829, *Accept H_o: marked fraction is constant across recovery strata*

[a] Study areas 1, 2, and 3. [b] Study areas 4, 5, and 6. [c] Study areas 7 and 8.

ADDENDUM
12/01/2005

The 2002 sampling data has been corrected.

All data and statistics in Panel C of Table 8 are changed. Original data is in yellow highlight, with the corrected data displayed below in a revised Panel C, in red text.

Table 9.–Summary of goodness-of-fit tests for homogeneous capture/survival probabilities by tag group. Asterisks denote tests which contained a cell with an expected value of less than 2. Overall chi-squares are the sum of the individual test statistics.

		Component 1		Component 2	
Year	Period	Test statistic	P-value	Test statistic	P-value
Annual model					
1999		3.543	0.0598		
2000		4.635	0.0313	0.344	0.842*
2001		1.412	0.2348	11.004	0.004*
Overall statistics:		9.590	0.0224	8.918	0.003*
Trip-by-trip model					
1998	2	2.187	0.139		
"	3	0.130	0.719*	3.732	0.155*
1999	4	0.315	0.575	2.011	0.336*
"	5	0.052	0.820	3.669	0.160*
2000	6	0.007	0.931	9.858	0.007
"	7	1.307	0.253	1.280	0.527*
2001	8	1.412	0.235	1.673	0.433
Overall statistics:		3.093	0.686	18.860	0.016

in contrast to a "typical" (undesired) pattern when tagging and/or handling leads to a short-term *reduction* in mortality, the probability of later recapturing fish first captured (and tagged) in a given year was *three to five times higher* than for recapturing previously marked fish also captured in that year.

The second GOF test (component 2) for homogeneous capture/survival probabilities was less useful, because key capture histories were absent in the annual data (owing to the small sample size in 1998) and sample sizes are very low for nearly every test (Tables 10 and 11).

The significant heterogeneity by tag group in the annual data suggests a generalization of the JS model having different survival rates for newly captured and previously captured fish might be useful (Brownie and Robson 1983). Such an analysis (model "2" in JOLLY and "model 3" in POPAN) is effective when a one-period *reduction* in survival due to tagging is present. However, we discounted this approach because, (a) the absence of key capture histories (noted above) meant we could not verify a statistical gain (GOF) by using the generalized JS model, (b) abundance estimates from such an analysis ($\hat{N}_{1999}$=559, $\hat{N}_{2000}$=353) were significantly higher than trip-by-trip JS and other inseason Peterson estimates (discussed below), and (c) it is unclear whether the generalized analysis is appropriate when previously tagged fish are recaptured at *lower rates* than newly marked fish.

Estimates of abundance, survival, and recruitment of cutthroat trout ≥180 mm FL in Auke Lake using the annual and trip-by-trip models are summarized in Table 11. Estimates using the annual model are suspect for the reasons noted above. Also, some mortality between trips in early 1999 and 2000 violates the instantaneous sampling assumption if data are pooled. Estimates from the trip-by-trip model result from constraining the first (i.e., trip 1 to trip 2) survival and first and last recruitments to admissible values. Abundance decreases by trip in 2000, as it should, because the annual emigration was occurring during sampling. Reported annual harvests at Auke Lake are <30 fish and annual harvest for the surrounding marine area is <70 fish from 1998 through 2001 (Tables 2 and 3), so estimates of survival are essentially estimates of natural rates.

Length data collected during 2001 were used to estimate the length composition of cutthroat trout ≥180 mm FL (Table 12). Cutthroat trout ≥ 180 mm caught in the lake averaged ~~215~~ 224 mm (SD = ~~36~~ 30 mm) and ranged from 180 to 315 mm. About ~~50~~ 52% of the population in 2001, using the ~~average trip-by-trip~~ annual abundance estimate (~~631~~ 667), were ≤220 mm FL. By regulation, harvest of cutthroat trout in Auke Lake is restricted to fish ≥356 mm FL (14 inches TL); none of the cutthroat trout in Auke Lake during June exceeded the 14" minimum size limit.

Of the 38 PIT-tagged cutthroat trout that immigrated into Auke Lake in fall 2000 (Lum et al. 2001), 28 had emigrated from the lake in spring

The text on this page has been corrected 12/5/2005. The changed text is in red type.

Table 10.–Breakdown of statistics for homogeneous capture/survival probabilities by tag group for the annual JS experiment (p = probability of capture for each group). Results of component-1 tests for 1999 and 2000 indicate heterogeneity by tag group; results of component-1 test for 2001 indicates no heterogeneity by tag group; lack of recoveries from 1998 essentially invalidates the component-2 test.

Component 1 test for 1999		First captured in 1998	First captured in 1999
Captured in 1999 and recaptured in 2000		2.00	92.00
Captured in 1999 and not recaptured in 2000		19.00	232.00
χ^2 = 3.5431, 1 df, P = 0.0598	$\hat{p} \rightarrow$	0.095	0.284

Component 1 test for 2000		First captured in 1999	First captured in 2000
Captured in 2000 and recaptured in 2001		9.00	35.00
Captured in 2000 and not recaptured in 2001		84.00	141.00
χ^2 = 4.6353, 1 df, P = 0.0313	$\hat{p} \rightarrow$	0.097	0.199

Component 2 test for 2000		Captured in 1998, not in 1999	Captured in 1998 and 1999	First captured in 1999
Captured in 2000		4.00	2.00	88.00
Captured in 2001, not in 2000		0.00	0.00	4.00
χ^2 = 0.3436, 2 df, P = 0.842	$\hat{p} \rightarrow$	n.a.	n.a.	0.957

Component 1 test for 2001		First captured in 2000	First captured in 2001
Captured in 2001 and recaptured in 2002		4.00	33.00
Captured in 2001 and not recaptured in 2002		29.00	123.00
χ^2 = 1.4115, 1 df, P = 0.2348	$\hat{p} \rightarrow$	0.121	0.212

Component 2 test for 2001		Captured in 1999, not in 2000	Captured in 1999 and 2000	First captured in 2000
Captured in 2001		3.00	2.00	28.00
Captured in 2002, not in 2001		2.00	7.00	7.00
χ^2 = 11.004, 2 df, P = 0.0041	$\hat{p} \rightarrow$	0.60	0.222	0.80

2001, leaving 10 that either chose to remain in Auke Lake or died overwinter, because of either natural or fishing-related mortality. None of the 10 fish were caught while sampling the lake in 2001. We estimate that minimum overwinter survival of these fish was 74%, assuming all fish that stayed in the lake died. Estimated over-winter survival rates for PIT-tagged fall immigrants were 67% in 1997–1998, 58% in 1998–1999, and 60% in 1999–2000 (Lum et al. 1999, 2000, 2001).

Overwinter survival of PIT-tagged sea-run migrants averaged 65% (annual estimates were 68%, 59%, 60%, and 74%). These survival rates are significantly greater than the JS "overwinter" survival rate for all Auke Lake fish in this study (38% SE = 6%, and 39% SE = 4% estimated for 1998 and 1999, respectively) or similar lake-bound populations in Neck Lake (51%, SE = 6%, Harding et al. 1999) or Florence Lake (40–52%, SE = 2-3%, Rosenkranz et al. 1999). This difference is in part due to presence of immature

Table 11.–Jolly Seber estimates of abundance (N), survival (ϕ), and births (B) of cutthroat trout ≥180 mm FL at Auke Lake, 1998–2002.

Year	$\hat{N}$	$SE(\hat{N})$	$\hat{\phi}$	$SE(\hat{\phi})$	$\hat{B}$	$SE(\hat{B})$
Annual model						
1998			0.400	0.088		
1999	559	122	0.342	0.045	162	46
2000	353	40	0.378	0.079	498	127
2001	631	146				
Trip-by-trip model [a]						
1998 (1)			0.817	0.219		
1998 (2)	281	14	1.000 [b]	0.465	0 [b]	137
1998 (3)	204	105	0.308	0.136	388	107
1999 (1)	451	107	0.906	0.077	22	97
1999 (2)	431	40	0.398	0.043	256	45
2000 (1)	428	50	0.759	0.084	0 [b]	33
2000 (2)	279	28	0.451	0.098	506	128
2001 (1)	631	146				
2002 (1)						

[a] Estimates constrained to admissible values (Schwarz and Arnason 1996)

[b] Constrained value.

Table 12.–Length composition of cutthroat trout ≥180 mm FL, Auke Lake, 2001. Number sampled (n_k), proportion (p_k), abundance (N_k), and standard error (SE) are shown for each 20-mm length class. Estimate of length composition made from fish sampled in one trip.

Revised

Length k,	n_k	p_k	$SE(p_k)$	N_k	$SE(N_k)$
180–200	[illegible]	0.231	[illegible]022	145.62	[illegible]3.81
201–220	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]4.89
221–240	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]3.24
241–260	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]2.34
261–280	10	0.043	0.011	26.97	6.63
281–300	8	0.034	0.009	21.57	5.96
301–320	6	0.026	0.008	16.18	5.18
Total			N(est) = 631		

Length k,	n_k	p_k	$SE(p_k)$	N_k	$SE(N_k)$
180–200	54	0.231	0.022	154	35.62
201–220	68	0.291	0.024	194	43.85
221–240	48	0.205	0.021	137	32.09
241–260	40	0.171	0.020	114	27.36
261–280	10	0.043	0.011	29	9.21
281–300	8	0.034	0.010	23	7.90
301–320	6	0.026	0.008	17	6.53
Total	234		N(est) = 667		

All data and stats in Table 12 are corrected. The correct data/stats are shown above.

anadromous fish that leave the lake at some point (deflating the annual survival statistic). In fact, a JS analysis of the capture history data for 1998–2001 (described above), which excludes all fish ever observed at the weir, yields an annual survival estimate of 0.51 (SE = 0.065), similar to that found in other studies in Southeast Alaska. We note that overwinter survival rates also do not include the spawning and spawning migration period when mortality may be substantial. List of archived computer files for the Auke Creek weir and Auke Lake trout studies is shown in Appendix A5.

DISCUSSION AND RECOMMENDATIONS

The Dolly Varden and cutthroat trout assessments in Auke Lake/Creek provide a rare time series of abundance, survival, growth, migration timing, and other life history information for these species. The data series for cutthroat trout is the longest and most complete of its kind in existence and should be continued. The continuity of the dataset will become increasingly important as urban development continues in the Juneau area. Tagging of emigrant cutthroat trout at Auke Creek provides particularly valuable information on an anadromous population and should be continued. Tagging for both trout and char migrants at Auke Creek also blends well with other local trout/salmon projects where the tagged fish may be sampled and movement between systems may be recorded. Information on salt- and freshwater migrations and habitat preferences are important because these species utilize other watersheds for spawning and juvenile rearing. While anecdotal in nature, the pre-1960 population of cutthroat trout in Auke Lake may have been substantially larger than it is now, and the recent pattern of declining numbers of emigrants and immigrants at Auke Creek may be of concern if it continues.

Sampling the lake in late May and early June improved catch rates but presented significant problems because of the possible occurrence of incomplete spawning and smolt emigration. Sampling prior to spawning (e.g., April) would avoid this problem, but it is difficult to predict when ice-out will occur, and if it is possible after ice-out to complete sampling without running into the spawning season (when some fish immigrate into inlet streams and become unavailable to sampling) or the annual emigration. Thus, the best time to sample Auke Lake appears to be after the emigration is complete, and while water temperatures remain low. This window of opportunity will vary from year to year and require adapting schedules to actual spring conditions. A continued evaluation of photonic dye marks, with a focus on extending their visibility over time is also recommended.

Before 2002, the sampling in Auke Lake followed a sampling protocol where traps were set in areas around the lake, starting in one subarea and moving in a clockwise fashion daily, meeting sampling requirements for each area as we moved. Because of prior difficulties with the model selection for the JS estimate and the possibility of undetected fish movement, the sampling scheme was modified. Although we still maintained one 9-day trip, we set traps in all subareas of the lake each day. Dividing the 9 days by the total amount of effort needed for each area, we were able to perform this with only the addition of one extra trap to the total sampling gear. Although this proved to be slightly more arduous during the first day of setting the traps, in the long run it proved to save time and made for efficient sampling and a more thorough coverage. In the end, we still had difficulties with model selection but the sample design ensured that all fish were available to the gear. Mid-water traps were also set to reaffirm what was found in 1997 that no cutthroat trout were caught in waters deeper than 15 m.

It is interesting to note that this year's catches proved to be quite different. Although hook and line gear had never been very effective, in 2002 *no* fish were caught using hook and line. The trap catches proved fairly good, but one subarea each day had higher catch rates than others. This year, unlike years in the past, few fish of other species were caught, especially yearling coho par and sculpins. Both species are normally caught in high numbers throughout all the subareas surrounding the lake perimeter. In particular for coho par, this is troubling because it indicates a possible age-class failure, during a time when numbers of emigrating coho smolts have been declining for five years. The scarcity of sculpins suggests a change in benthic habitat conditions.

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APPENDIX A

Appendix A1.–Daily counts of spring emigrant salmonids at Auke Creek, 2002.

	Daily counts							
	Water temp	Pink salmon fry	Coho salmon smolts	Sockeye salmon smolts	Chum salmon fry	Dolly Varden	Cut-throat trout	Steel-head
March 1	1.0	0	0	0	0	0	0	0
2	1.1	25	0	0	0	0	0	0
3	1.5	205	0	0	9	0	0	0
4	1.6	311	0	0	13	0	0	0
5	1.4	141	0	0	2	0	0	0
6	1.5	190	0	0	5	0	0	0
7	1.5	220	0	0	13	0	0	0
8	1.6	196	0	0	9	0	0	0
9	1.5	260	0	0	12	0	0	0
10	1.8	165	0	0	9	0	0	0
11	1.8	252	0	0	13	0	0	0
12	1.8	243	0	0	15	0	0	0
13	1.6	256	0	0	20	0	0	0
14	1.5	211	0	0	12	0	0	0
15	1.2	227	0	0	17	0	0	0
16	1.3	219	0	0	17	0	0	0
17	1.1	236	0	0	17	0	0	0
18	1.2	226	0	0	11	0	0	0
19	1.2	250	0	0	7	0	0	0
20	1.1	235	0	0	8	0	0	0
21	1.4	223	0	0	12	0	0	0
22	1.6	326	0	0	15	0	0	0
23	1.6	525	0	0	17	0	0	0
24	1.8	395	0	0	40	0	0	0
25	1.8	462	0	0	41	0	0	0
26	2.0	325	0	0	41	0	0	0
27	2.1	544	0	0	28	0	0	0
28	2.1	248	0	0	46	0	0	0
29	2.3	281	0	0	35	0	0	0
30	2.3	589	0	0	47	0	0	0
31	2.2	600	0	0	59	0	0	0
April 1	2.2	993	0	0	75	0	0	0
2	2.0	435	0	0	84	0	0	0
3	2.3	687	0	0	81	0	0	0
4	2.3	1,015	0	0	72	0	0	0
5	2.2	446	0	0	59	0	0	0
6	2.5	749	0	0	64	0	0	0
7	2.6	777	0	0	50	0	0	0
8	2.3	549	0	0	59	0	0	0
9	2.7	838	0	0	48	0	0	0
10	2.9	785	0	0	46	0	0	0
11	3.1	1,423	0	0	48	1	1	0
12	3.1	2,537	0	0	49	0	0	0
13	2.7	2,128	0	0	54	3	0	0
14	3.3	4,170	0	0	57	2	0	0
15	3.6	3,304	0	0	47	2	0	0
16	3.1	7,207	0	0	60	2	0	0
17	3.7	6,600	0	0	48	1	0	0
18	3.7	5,754	0	0	32	8	0	0
19	4.2	7,338	0	0	34	1	0	0
20	4.1	12,618	0	0	59	1	0	0

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	Daily counts							
	Water temp	Pink salmon fry	Coho salmon smolts	Sockeye salmon smolts	Chum salmon fry	Dolly Varden	Cut-throat trout	Steel-head
April 21	3.8	18310	0	0	65	28	2	0
22	4.0	19851	0	0	32	29	1	0
23	4.1	5999	0	0	28	21	1	0
24	3.8	6424	0	0	15	19	4	0
25	4.3	4787	0	0	18	8	2	0
26	4.0	3928	0	0	11	5	1	0
27	4.2	3287	0	0	16	2	0	0
28	4.3	4655	0	0	7	1	0	0
29	4.0	4830	0	1	11	17	1	0
30	4.9	3070	0	0	14	63	7	0
May 1	5.7	1483	6	0	6	336	12	0
2	5.7	2501	2	0	10	82	8	0
3	5.8	101	3	1	1	437	15	0
4	5.8	746	2	3	1	68	1	0
5	5.1	349	5	8	3	60	2	0
6	5.6	256	7	7	0	156	3	0
7	5.8	56	4	3	0	28	0	0
8	6.0	46	3	5	0	49	4	0
9	6.2	52	3	5	0	23	2	0
10	6.5	26	2	2	0	140	5	0
11	6.5	55	14	21	0	489	4	0
12	6.7	34	35	27	0	587	6	0
13	7.2	21	44	25	0	245	4	0
14	6.9	17	59	58	0	86	1	0
15	6.9	7	218	353	0	155	2	1
16	7.3	9	106	107	0	30	1	0
17	8.0	7	70	119	0	143	3	0
18	8.5	7	150	133	0	176	1	0
19	9.2	6	157	245	0	162	1	0
20	10.8	1	217	1325	0	314	15	3
21	11.6	7	293	792	0	43	5	3
22	10.9	6	328	805	0	67	8	0
23	10.4	1	291	766	1	89	5	1
24	11.0	1	254	1925	0	0	5	0
25	11.1	2	167	510	2	41	2	0
26	12.7	0	232	2240	0	53	3	1
27	10.8	0	157	1321	0	49	7	3
28	11.4	0	45	1196	0	41	5	1
29	10.3	0	84	943	0	20	3	0
30	9.8	0	93	720	0	28	7	1
31	10.4	2	74	596	0	17	6	0
June 1	10.4	2	46	400	0	5	5	0
2	10.3	0	44	301	0	48	1	0
3	10.5	0	27	222	0	12	0	0
4	11.4	0	25	300	0	51	0	0
5	11.8	10	32	405	0	177	3	0
6	11.8	171	39	638	1	13	3	0
7	10.7	44	15	118	1	14	2	0
8	11.9	28	6	165	0	6	0	0
9	12.4	9	10	116	0	3	2	0
10	12.4	4	17	88	0	2	8	0
11	12.4	1	7	54	0	1	2	0
12	12.6	0	14	93	0	0	2	0
13	13.2	0	4	86	0	2	1	0

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	Water temp	Pink salmon fry	Coho salmon smolts	Sockeye salmon smolts	Chum salmon fry	Dolly Varden	Cut-throat trout	Steel-head
	Daily counts							
June 14	14.3	0	4	75	0	4	1	0
15	16.0	1	9	95	0	0	3	0
16	16.9	0	3	73	0	0	0	0
17	17.5	0	1	28	0	0	1	0
18	17.3	0	3	22	0	0	3	0
19	16.7	0	0	17	0	0	0	0
20	15.9	0	3	11	0	0	1	0
21	15.6	0	0	4	0	0	0	0
22	15.3	0	0	6	0	0	1	0
23	17.6	0	0	2	0	0	1	0
24	16.7	0	0	3	0	0	1	1
25	16.7	0	0	2	0	0	1	0
26	15.6	0	0	1	0	0	1	0
27	15.1	0	0	2	0	0	0	0
28	15.0	0	0	5	0	0	1	0
Totals		150,149	3,434	17,594	1,959	4,858	210	15

Appendix A2.–Daily counts of fall immigrant salmonids at Auke Creek weir, 2002. Counts do not include sockeye or coho jacks (0-ocean; < 400 mm MEF), or chinook mini-jacks (0-ocean).

	Daily counts								
	Water temp	Sockeye salmon adults	Pink salmon adults	Chum salmon adults	Coho salmon adults	Chinook salmon adults	Dolly Varden	Cut-throat trout	Steel-head
June 29	15.6	0	0	0	0	0	0	0	0
30	15.5	0	0	0	0	0	0	0	0
July 1	15.7	0	0	0	0	0	0	0	0
2	14.8	0	0	0	0	0	0	0	0
3	14.3	125	0	0	0	0	10	0	0
4	13.8	340	0	0	0	0	10	0	0
5	13.4	177	0	0	0	0	12	0	0
6	13.1	259	0	0	0	0	12	0	0
7	14.2	57	0	0	0	0	2	0	0
8	15.5	79	0	0	0	0	17	0	0
9	14.7	92	0	0	0	0	25	0	0
10	15.5	31	0	0	0	0	9	0	0
11	15.0	51	0	0	0	0	49	0	0
12	14.8	52	0	0	0	0	18	0	0
13	15.2	91	0	0	0	0	19	0	0
14	14.8	174	0	0	0	0	24	0	0
15	14.5	194	0	1	0	0	23	0	0
16	15.4	107	0	2	0	0	47	0	0
17	15.2	54	0	5	0	0	13	0	0
18	15.1	23	0	4	0	0	47	0	0
19	15.7	4	0	7	0	3	43	0	0
20	16.4	15	0	0	0	0	100	0	0
21	16.6	1	0	0	0	0	17	0	0
22	15.8	5	0	10	0	0	18	0	0
23	16.0	7	0	21	0	0	46	0	0
24	15.9	46	2	49	0	0	86	0	0
25	14.8	232	8	54	0	0	127	0	0
26	14.7	94	6	22	0	8	134	0	0
27	14.5	48	4	23	0	6	67	0	0
28	14.3	133	5	53	0	6	69	0	0
29	14.3	27	7	68	0	2	81	0	0
30	14.4	38	7	104	0	7	75	0	0
31	15.0	6	4	44	0	12	45	0	0
Aug. 1	15.7	4	7	66	0	4	69	0	0
2	16.4	9	1	36	0	1	43	0	0
3	16.3	13	5	49	0	2	29	0	0
4	18.2	0	3	47	0	6	28	0	0
5	17.0	10	17	25	0	1	58	0	0
6	17.8	5	1	33	0	2	45	0	0
7	16.7	14	104	218	0	0	139	0	0
8	14.9	149	411	139	0	33	362	0	0
9	13.3	60	476	72	0	105	217	0	0
10	13.8	8	125	60	0	22	112	0	0
11	13.8	6	95	45	0	1	78	0	0
12	12.6	13	195	70	0	24	118	0	0
13	12.8	12	372	66	0	68	121	0	0
14	13.0	2	226	40	0	71	90	0	0

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Appendix A2.– Page 2 of 3.

		Daily counts							
	Water temp	Sockeye salmon adults	Pink salmon adults	Chum salmon adults	Coho salmon adults	Chinook salmon adults	Dolly Varden	Cut-throat trout	Steel-head
Aug. 15	13.3	2	74	26	0	15	18	0	0
16	14.2	0	74	17	0	5	18	0	0
17	13.8	0	27	19	0	5	26	0	0
18	13.3	0	39	9	0	3	13	0	0
19	13.1	0	31	8	0	16	7	0	0
20	13.4	1	78	11	0	3	2	0	0
21	12.7	2	121	15	0	22	6	0	0
22	12.5	0	443	11	0	44	56	0	0
23	12.4	7	254	13	0	12	47	0	0
24	12.5	0	172	4	0	23	46	0	0
25	12.4	1	73	3	0	14	14	0	0
26	12.5	0	48	5	0	3	6	0	0
27	12.4	0	54	2	0	10	15	0	0
28	11.8	0	170	3	0	19	63	0	0
29	12.4	1	241	2	0	12	74	0	0
30	12.4	1	181	1	0	13	37	0	0
31	12.0	0	125	3	1	10	32	0	0
Sept. 1	12.2	0	111	0	0	37	19	0	0
2	12.2	0	127	1	0	16	24	0	0
3	12.7	0	101	0	0	4	13	0	0
4	12.7	0	34	0	0	2	6	0	0
5	13.5	0	55	0	0	4	64	0	0
6	13.6	0	42	0	0	3	24	0	0
7	13.3	0	75	0	0	5	20	0	0
8	12.5	0	47	0	0		81	0	0
9	11.8	0	18	0	0	3	31	1	0
10	12.4	0	10	0	35		34	15	0
11	11.8	0	7	0	32	1	32	15	0
12	11.9	0	5	0	13	0	40	8	0
13	11.9	0	5	0	5	0	19	7	0
14	11.7	0	1	0	47	0	7	8	0
15	11.6	0	3	0	51	0	10	17	0
16	11.6	0	0	0	13	0	15	8	0
17	11.3	0	1	0	17	0	10	5	0
18	10.7	0	0	0	69	0	11	10	0
19	10.6	0	0	0	179	0	14	8	0
20	10.5	0	0	0	114	0	14	12	0
21	10.5	0	0	0	116	0	30	19	1
22	10.5	0	0	0	114	0	28	13	0
23	10.5	0	0	0	50	0	22	11	0
24	10.6	0	0	0	6	0	16	6	0
25	10.6	0	0	0	22	0	13	10	0
26	10.4	0	0	0	0	0	2	0	0
27	10.7	0	0	0	0	0	5	0	0
28	10.6	0	0	0	16	0	7	0	0
29	10.4	0	0	0	26	0	6	0	0
30	10.2	0	0	0	27	0	4	0	0
Oct. 1	8.6	0	0	0	9	0	4	5	0

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Appendix A2.– Page 3 of 3.

	Daily counts								
	Water temp	Sockeye salmon adults	Pink salmon adults	Chum salmon adults	Coho salmon adults	Chinook salmon adults	Dolly Varden	Cut-throat trout	Steel-head
Oct. 2	9.8	0	0	0	18	0	17	2	0
3	9.9	0	0	0	12	0	29	3	0
4	9.8	0	0	0	19	0	12	5	0
5	9.1	0	0	0	11	0	12	3	0
6	9.5	0	0	0	14	0	3	7	0
7	9.5	0	0	0	41	0	24	2	0
8	9.3	0	0	0	28	0	18	6	0
9	9.1	0	0	0	5	0	32	4	0
10	8.7	0	0	0	6	0	5	3	0
11	8.7	0	0	0	1	0	4	1	0
12	8.5	0	0	0	0	0	4	0	1
13	8.4	0	0	0	6	0	4	3	0
14	8.6	0	0	0	1	0	6	1	1
15	8.5	0	0	0	1	0	8	0	0
16	8.8	0	0	0	0	0	18	4	0
17	8.2	0	0	0	12	0	35	3	0
18	8.3	0	0	0	7	0	41	2	0
19	8.6	0	0	0	3	0	16	6	0
20	8.4	0	0	0	0	0	10	1	0
21	9.0	0	0	0	1	0	24	1	0
22	8.4	0	0	0	2	0	29	1	0
23	8.6	0	0	0	1	0	35	0	0
24	8.5	0	0	0	0	0	31	0	0
25	8.4	0	0	0	0	0	26	0	0
26	8.4	0	0	0	1	0	14	0	0
27	8.3	0	0	0	1	0	11	0	0
28	8.1	0	0	0	0	0	12	0	0
29	7.8	0	0	0	0	0	1	0	0
30	7.5	0	0	0	0	0	0	0	0
31	7.3	0	0	0	0	0	1	0	0
Total		2,882	4,928	1,587	1,176	688	4,341	241	3

Appendix A3.–Summary statistics for Jolly-Seber models, Auke Lake, 1998–2002.

Year	n_i	m_i	R_i	r_i	z_i
Annual model					
1998	89	0	89	25	0
1999	345	21	345	94	4
2000	269	93	269	44	5
2001	189	33	189	37	16
2002	257	53	257	0	0
Trip-by-trip model					
1998 (1)	40	0	40	16	0
1998 (2)	42	4	42	17	12
1998 (3)	19	8	19	4	21
1999 (1)	184	12	184	121	13
1999 (2)	265	113	265	77	21
2000 (1)	165	51	165	93	47
2000 (2)	190	128	190	37	12
2001 (1)	189	33	189	37	16
2002 (1)	257	53	257	0	0

n_i = number of fish caught, marked, and released in sample i.

m_i = number of marked fish caught in sample i.

R_i = number returned to the population alive with marks from sample i.

r_i = number caught in sample i which are recaptured later.

z_i = number not caught in sample i which were previously captured and are recaptured later.

Appendix A4.–Capture probabilities by tag group and sampling trip for the two JS goodness-of-fit tests. See Table 2 for companion summary statistics and Appendix Figure 1 for additional details on the 2 tests.

	Component 1		Component 2		
	First captured	First captured	First captured	First captured	First captured
Year(trip[s])	before sample *i*	before sample *i*	before sample *i*	before sample *i*	before sample *i*
Annual model					
1998 (1-3)	-	-	-	-	-
1999 (1,2)	0.095	0.284	-	-	-
2000 (1,2)	0.097	0.199	-	-	0.957
2001 (1)	0.121	0.212	0.600	0.222	0.800
2002 (1)	-	-	-	-	-
Mean	0.104	0.232	0.600	0.222	0.879
Trip-by-trip model					
1998 (1)	-	-	-	-	-
1998 (2)	0.75	0.368	-	-	0.25
1998 (3)	0.25	0.182	0.333	0.667	0.143
1999 (1)	0.582	0.663	0.524	0.000	0.50
1999 (2)	0.283	0.296	0.692	0.714	0.868
2000 (1)	0.569	0.561	0.286	0.719	0.489
2000 (2)	0.172	0.242	0.894	0.966	0.906
2001 (1)	0.121	0.212	0.583	0.636	0.80
2002 (1)	-	-	-	-	-
Mean	0.390	0.361	0.552	0.617	0.565

Appendix A5.–Capture histories for Jolly-Seber models, Auke Lake, 1998–2002.

Capture history[a]	Frequency	Capture history[a]	Frequency	Capture history[a]	Frequency
Annual model					
10000	64				
10100	4				
11000	19				
11100	2				
01000	232				
01001	2				
01010	3				
01100	78				
01101	7				
01110	1				
01111	1				
00100	141				
00101	7				
00110	25				
00111	3				
00010	123				
00011	33				
00001	204				
Trip-by-trip model					
111000000	2	001010000	1	000011000	7
110100000	1	001000000	9	000010101	3
110000000	1	000111101	1	000010100	18
101010000	2	000111100	12	000010010	1
101000000	2	000111000	10	000010001	1
100110000	2	000110101	1	000010000	107
100100100	1	000110100	7	000001111	2
100100000	1	000110010	1	000001110	10
100010000	3	000110000	67	000001101	2
100000100	1	000101100	1	000001100	44
100000000	24	000101000	4	000001011	1
011000000	2	000100100	8	000001010	3
010110000	3	000100010	1	000001001	2
010100100	1	000100001	1	000001000	50
010100000	2	000100000	58	000000110	12
010010000	3	000011111	1	000000101	3
010001000	1	000011110	1	000000100	47
010000100	2	000011101	1	000000011	33
010000000	24	000011100	11	000000010	123
001100000	1	000011001	1	000000001	204

[a] A "0" signifies not captured during that particular sampling event while a "1" signifies a capture; i.e., a capture history of 1,1,1,0 represents a group of fish that were captured during the 1st, 2nd, and 3rd sampling events and not captured during the 4th event. The sampling events correspond to trips within years in which sampling occurred, in this case: 1998(1), 1998(2), 1998(3), 1999(1), 1999(2), 2000(1), 2000(2), 2001(1), and 2002(1).

Appendix A6.–List of computer data files archived from this study.

Data file	Description
Cut02.xls	Excel file of length information for emigrant and immigrant cutthroat trout, Auke Creek weir, 2002.
Down2002.xls	Excel file of the counts of emigrant salmonids at Auke Creek weir, 2002.
DV2002.xls	Excel file of the lengths of marked and unmarked Dolly Varden emigrating at Auke Creek weir, 2002.
Grwct02.xls	Excel file of recovered tagged cutthroat trout with lengths and growth information for the 2002 field season.
Lake02-1.xls	Excel file of cutthroat trout PIT tagging information for the abundance study in Auke Lake, 2002.
Pit02.xls	Excel file of PIT tagging information from spring tagging and fall recoveries of cutthroat trout at Auke Creek weir, 2002.
Up2002.xls	Excel file of the counts of immigrant salmonids at Auke Creek weir, 2002.