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Hetta and Eek Lakes Subsistence Sockeye Salmon Project 2004 Annual Report

by

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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 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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The Division of Sport Fish Fishery Data Series was established in 1987 for the publication of technically oriented results for a single project or group of closely related projects. Since 2004, the Division of Commercial Fisheries has also used the Fishery Data Series. Fishery Data Series reports are intended for fishery and other technical professionals. Fishery Data Series reports 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

In 2004, we estimated the sockeye (*Oncorhynchus nerka*) escapement into Hetta and Eek lakes, using mark-recapture methods and visual surveys on the spawning grounds in both lakes. A local crew interviewed subsistence fishers to obtain a complete census of sockeye salmon harvested in the Hydaburg subsistence fishery. We also estimated the sockeye fry population and zooplankton biomass by species in Hetta Lake. We estimated 2,000 sockeye spawners returned to Hetta Lake and 700 returned to Eek Lake in 2004. The Hetta Lake sockeye escapement estimate was probably biased low, because the spawning period was not over when the study ended late in October. The estimate for Eek Lake may be unreliable due to very small samples. Total subsistence harvest of sockeye salmon in Hydaburg was about 3,000 sockeye salmon, of which about 20% were harvested from Hetta Cove, 20% from Eek Inlet, 1% from Kasook Inlet, and 60% from Hunter Bay. Low sockeye numbers at Hetta Cove may have caused some subsistence fishers to travel to more distant areas, such as Hunter Bay, to fish. Sticklebacks made up a relatively large proportion of the small pelagic fish population in Hetta Lake, when compared with other sockeye rearing lakes in Southeast Alaska: we estimated 471,000 sockeye fry and 413,300 sticklebacks. The zooplankton biomass was low, compared to other Southeast Alaska lakes in 2004 and the larger *Daphnia*, preferred by sockeye fry, contributed only 4% to total seasonal mean biomass. Food may be limiting fry densities in Hetta Lake due to intraspecific and interspecific (stickleback) competition.

Key words: sockeye salmon, *Oncorhynchus nerka*, subsistence, Hetta Lake, Eek Lake, Kasook Inlet, Hunter Bay, Hydaburg, Prince of Wales Island, escapement, mark-recapture, fry, hydroacoustic, harvest census, zooplankton

INTRODUCTION

Historically, Tlingit tribes occupied villages in Hetta Inlet before Haida tribes displaced them in the late 17th century (Langdon 1977). Archeological evidence, including pictographs along Hetta Inlet, document the Haida's claim to this area. In 1911, Haida villages were combined into the modern settlement of Hydaburg, located, in part, due to the nearby sockeye salmon (*Oncorhynchus nerka*) resources in Hetta Cove and Eek Inlet (Betts et al. 1997). In modern times, Hydaburg residents depend heavily upon salmon resources near the village. A recent survey reported that 100% of Hydaburg households use subsistence fisheries resources; 82% of these households reported using sockeye salmon (Betts et al. 1997).

Sockeye production in Hetta Inlet declined in the early 1900s due to intense commercial fishing. Canneries reported harvesting 140,000 to 250,000 sockeye salmon in Hetta Inlet in the 1890s (Moser 1899). Over 9,000 sockeye salmon were harvested in Eek Inlet in the late 1890s (Appendix A; Rich and Ball 1933). Although it is unclear how many of these fish were bound for Hetta and Eek Lakes, these numbers demonstrate the high productivity of these systems at the turn of the last century. Commercial catches continued to be relatively high; up to 66,000 sockeye salmon were harvested in Hetta Inlet in 1914 (Rich and Ball 1933; Roppel 1982).

Depletion of Hetta Lake stocks continued between 1899 and 1918, when ineffective hatcheries took about 221,000 female sockeye salmon and an unknown number of males for broodstock[1] (Roppel 1982); some fish were collected using barricades in the outlet stream. By 1918, fisheries managers estimated that fewer than 10,000 sockeye salmon were escaping annually into Hetta Lake (Roppel 1982). In addition, depletion of Eek Lake stocks may have occurred because of a barricade in the outlet stream that was observed by Moser (1899). However, it is unclear how long the barricade was in use.

[1] The number of female sockeye salmon taken for broodstock is based on hatchery records of egg counts and a fecundity estimate of 3,500 eggs per female.

An unknown number of Hetta and Eek lake sockeye salmon contribute to modern, mixed-stock commercial purse seine fisheries in Hetta Inlet (Sub-district 103-25) and Cordova Bay (Sub-districts 103-11 and 103–21). Since 1960, commercial sockeye catches have fluctuated from 0 to 23,000 fish in Hetta Inlet (Appendix B). Commercial catches were the highest during the 1960s; at that time, the average annual harvest was about 5,000 sockeye salmon.

A weir was operated on the outlet stream of Hetta Lake from 1967 to 1971, and in 1982. The median annual weir count of sockeye returns between 1967 and 1971 was three times higher than that recorded in 1982 (Table 1). Somewhat later, holders of subsistence fishing permits for Hetta Cove reported total annual harvests ranging from 507 to 2,424 sockeye salmon between 1985 and 2000 (Appendix C). The size of the reported harvest did not appear to be large compared with known escapements, but because the reporting system was to some extent voluntary and not validated with another type of estimate, the true size of the harvest was not known. Some Hydaburg residents perceived a decline in the size of the sockeye run at Hetta Cove and wondered if over-harvesting or other problems might be restricting the run size (A. Christianson, Hydaburg Cooperative Association, personal communication).

Table 1.–Historical sockeye escapement counts from a weir located on the outlet stream of Hetta Lake.

Year	Sockeye count
1967	24,164
1968	17,599
1969	16,202
1970	20,542
1971	15,779
1982	5,387

In 2001, Alaska Department of Fish and Game (ADF&G), the USDA Forest Service, and the Hydaburg Cooperative Association initiated the Hetta Lake subsistence sockeye salmon project to assess both escapement and harvest of sockeye salmon in this system. Hydaburg Cooperative Association added Eek Lake to the study in 2003 and 2004, because this lake is close to Hydaburg and consequently is considered an alternate source of subsistence sockeye salmon in years when Hetta sockeye returns are not good. In Hetta Lake, a subpopulation or spawning group of sockeye salmon spawning in the main inlet stream was identified and its size was estimated to range from 300 to 2,400 sockeye salmon in 2001 to 2003 (Cartwright et al. 2005). We also identified a different subpopulation or group of beach spawning sockeye salmon that appeared later in the season, but because these fish were highly dispersed among areas that were difficult to sample, estimation of their numbers was more difficult. These spawners also appear to persist on the spawning grounds until very late in the fall or early winter (R. Sanderson, Hydaburg Cooperative Association, personal communication), past the time when normal sampling operations are feasible. Nevertheless, in 2003 we managed to obtain a rough estimate of the size of this spawning group (Cartwright et al. 2005). In 2004, we continued using mark-recapture studies to estimate the sockeye spawning population in Hetta Lake. We estimated the number of spawners in Hetta Creek with the same methods used in 2001–2003, and as in 2003, we used mark-recapture studies combined with visual survey counts to estimate the number of beach spawners in the lake. We used a simple mark-recapture study and visual surveys to estimate the sockeye spawning population size in Eek Lake in 2004. Sockeye spawners were also sampled for scales and length measurements in both lakes to determine the age and size composition of these populations as in previous years.

In 2004, we also continued to conduct subsistence harvest surveys in the village of Hydaburg to census the sockeye harvest in nearby streams including Hetta and Eek Creeks. In 2001–2003 we found the subsistence sockeye harvest from both Hetta Cove and Eek Inlet to be substantially larger than what was reported on returned permits, so time spent by crew members interviewing fishery participants was well justified (Cartwright et al. 2005).

Studies of the freshwater fish population and its zooplankton prey base were continued in Hetta Lake in 2004. Using sonar transects coupled with net tows, we have observed very high densities of planktivorous fish compared to other Southeast Alaska lakes. In 2001, most of these fish were estimated to be sockeye fry, but the proportion of three-spine sticklebacks rose to about half the total population by 2003 (Cartwright et al. 2005). Zooplankton populations were lower than in other Southeast Alaska lakes (Cartwright et al. 2005; Conitz and Cartwright 2005a). We also continued seasonal measurements of water column light and temperature.

OBJECTIVES

1. Estimate sockeye escapement in Hetta and Eek Lakes, with mark-recapture studies on the spawning grounds, so that the coefficient of variation is less than 15%.
2. Census the subsistence harvest of sockeye salmon by Hydaburg residents, by fishing area and hours fished, using interviews conducted in Hydaburg harbor and on the fishing grounds of Hetta Cove and Eek Inlet.
3. Estimate the age composition of the sockeye escapement in Hetta and Eek Lake so that the coefficient of variation is 10% or less for the two major age classes.
4. Estimate number of sockeye fry in Hetta Lake using hydroacoustic and trawl survey methods, so that the estimated sockeye fry population has a coefficient of variation less than 15%.
5. Collect baseline data on productivity of Hetta Lake using established ADF&G limnological sampling procedures.

METHODS

STUDY SITE

Hetta Lake

Hetta Lake (ADF&G stream no. 103-25-047; lat 55^{o}10.17’N long 132^{o}34.03W) is located on the southwestern side of Prince of Wales Island (Figure 1). This dimictic oligotrophic lake has stained water, a surface area of 207 ha, an elevation of 9.4 m, a mean depth of 48.0 m, and a maximum depth of 92 m (Figure 2). The volume of the lake is 99.4 million m^3, and the estimated residence time is 12.6 months. The Hetta Lake watershed is covered with 24 km^2 of steep spruce, cedar, and hemlock forest, which was extensively logged in the 1950s. The main sockeye spawning areas in Hetta Lake are the inlet stream Hetta Creek, and the beach in front of Old Hatchery Creek. We also observed several small pockets of sockeye spawners in other beach areas around the lake. The outlet stream, Outlet Creek, empties into Hetta Cove approximately 600 m from the lake. Native fish species include cutthroat trout (*O. clarki*), Dolly Varden (*Salvelinus malma*), three-spine stickleback (*Gasterosteus aculeatus*), cottids (*Cottus* sp.), steelhead (*O. mykiss*), pink (*O. gorbuscha*), chum (*O. keta*), coho (*O. kisutch*), and sockeye salmon.

Eek Lake

Eek Lake (ADF&G stream no. 103-25-009; lat 55°09.45'N long 132°40.02W) is located on the southern side of Prince of Wales Island approximately 12 km southeast from Hydaburg (Figure 1). Two small dimictic lakes connected by a short 120 m high gradient riffle are collectively referred to as Eek Lake. Eek Lake has an elevation of 30 m, surface area of 79 ha, and maximum depth of 13.5 m. The lake has a 2.2 km inlet stream and a very short outlet stream, Eek Creek, that drains directly into Eek Inlet. Native fish species include sockeye, coho, pink, and chum salmon, cutthroat and steelhead trout, Dolly Varden char, three-spine stickleback, and cottids.

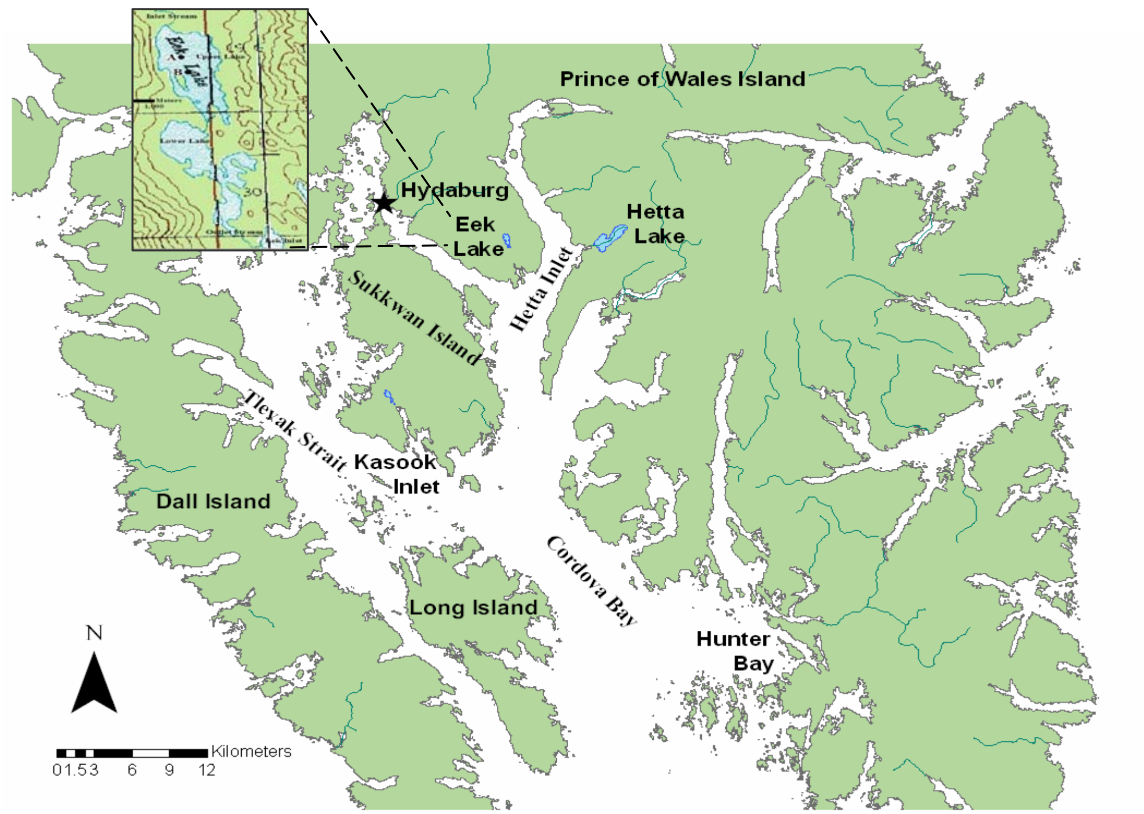

Figure 1.–The geographic location of Hetta and Eek Lakes and subsistence fishing areas of Hunter Bay and Kasook Inlet are shown in relationship to Hydaburg, located on the southeast area of Prince of Wales Island.

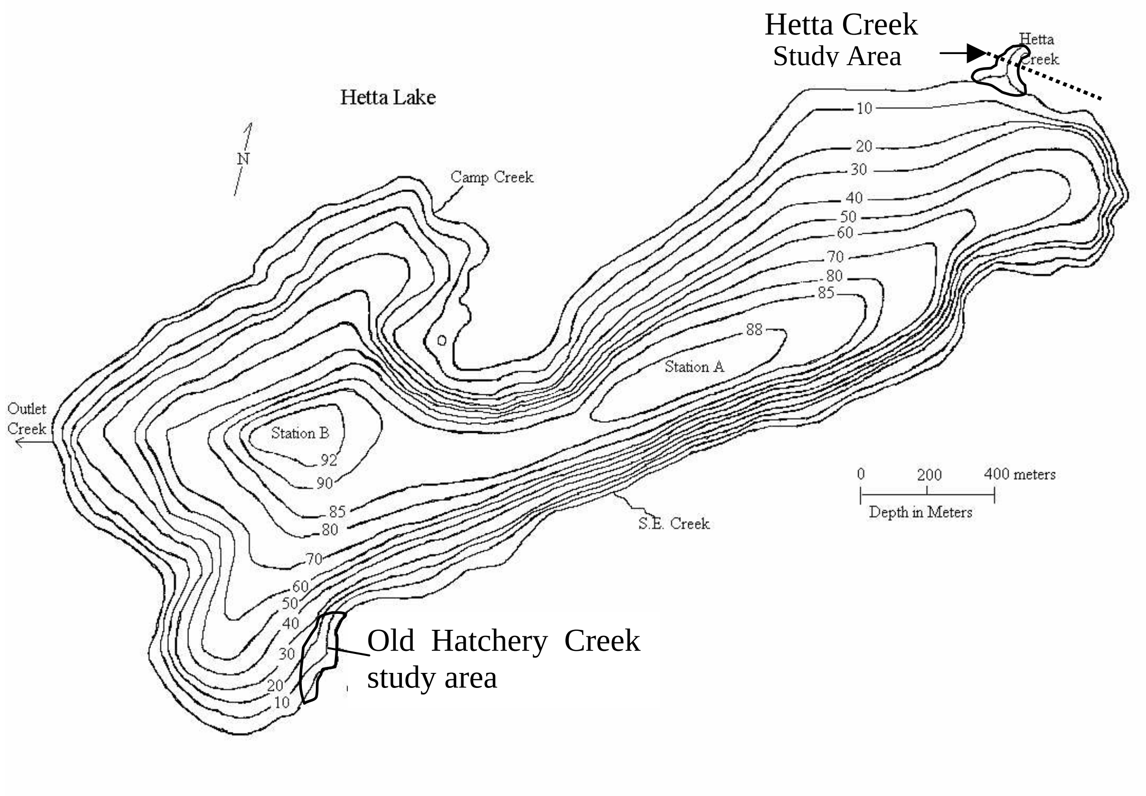

Figure 2.–Hetta Lake bathymetric map with locations of the limnological sampling stations (A and B).

SOCKEYE ESCAPEMENT ESTIMATES

We conducted mark-recapture studies on the sockeye spawning grounds in Hetta and Eek Lakes to estimate the number of sockeye spawners that returned in 2004. In Hetta Lake, separate mark-recapture study areas were designated at Hetta Creek and Old Hatchery, and we assumed that there was no exchange between these two spawning populations (Figure 2). Hetta Creek (lat 55°11.26’N long 132°31.88’W), the main inlet stream, and the beach areas around its mouth were defined as the stream study area, and a section of beach near Old Hatchery Creek (lat 55°09.98’N long 132°33.28’W) was designated as the beach study area. In Eek Lake, the mark-recapture study was conducted in the inlet stream, and the study area was defined as the first kilometer of the stream and 10 m on each side of the stream mouth.

Stream Spawning Population

We used a stratified, two-sample mark-recapture procedure to estimate escapement into Hetta and Eek creeks (Arnason et al. 1996). The first sample, or marking phase, was conducted at the mouth of each creek, using a 20 m long and 4 m deep beach seine to capture the fish. Only sockeye salmon without marks from previous sampling events were marked. We recorded the number and type of mark observed from previous trips and the number of marks applied for the current trip. We stratified the marking by time, using a unique punch shape in the left operculum for each trip: trip 1–round, trip 2–triangle, and trip 3–square.

The second sample or recovery phase was mainly conducted within the creek using dip nets, but some sampling was also conducted with the beach seine at the stream mouth. We examined and recorded the number of live and dead fish with and without marks and recorded the type of marks observed. We applied a second mark (right opercular punch) on all fish examined to prevent duplicate sampling at a later time (sampling without replacement). We caught and examined as many sockeye salmon as possible until recaptures from the trip exceeded 50% of the fish caught. All parts of the stream were sampled as evenly as possible during each recapture sampling trip.

Beach Spawning Population

For the beach-spawning population (Hetta Lake only), we used a study design based on the methods described in Schwarz et al. (1993) for estimating salmon escapements and further modified for estimating spawning populations in beach spawning sockeye systems (Cook 1998). Specifically, we used a simple Petersen estimator (Seber 1982) to estimate the number of spawners present at each sampling event, and a modified Jolly-Seber model to estimate the super population, or total number of fish entering the study area throughout the season (Seber 1982; Schwarz et al. 1993; Cook 1998). We give details in the data analysis section below. Each sampling event consisted of two consecutive days of sampling. On each day, the crew captured sockeye salmon on the spawning grounds with a beach seine. They first inspected each sockeye salmon for previous marks, then marked the fish with an opercular punch or pattern of punches identifying the sampling event and day, and released it with a minimum of stress. The crew leader recorded the total sample size, the number of new fish marked, and the number of recaptured fish with each type of mark. Sampling in these small populations continued until the number of same-day recaptures exceeded the number of new fish caught. Left opercular punches used to identify each sampling event were: first event—round, second event—triangle, third event—square, fourth event—two round. A right opercular punch was given each fish caught on the second day of each event to indicate the fish had already been caught and should not be recounted during that event. In order to generate a simple Petersen estimate for each event, fish were marked on one day and examined for marks the next day. For the super population estimate, fish marked on both days of a given event were counted, and on subsequent sampling events, recaptures of these marks were recorded. We used the number of recaptures from each previous event and the Petersen estimates of abundance from each event to generate the super population estimate.

Visual Surveys

In both Hetta and Eek Lakes, prior to each mark-recapture event crew members recorded visual counts of spawning sockeye salmon around the entire lake shore and in the inlet streams. In Hetta Lake, separate counts were made within the inlet stream study area, Hetta Creek, and the beach study area, near Old Hatchery Creek. The crew surveyed Hetta Creek on foot from its mouth to the barrier falls, about 1 km. Other inlet streams on Hetta Lake were only checked for presence of sockeye spawners to 100 m upstream from the mouth, because no fish have been observed in them. The Eek Lake inlet and outlet streams were also surveyed on foot, and the perimeters of both lakes were surveyed by boat.

In Hetta Lake, the number of beach spawners was estimated in the Old Hatchery Creek study area, but not in other areas of the lake. We used the visual survey counts to determine the average proportion of all beach spawners found within the study area over the spawning period.

Then we used the proportion of spawners in the study area to expand the study area estimate to a rough estimate of all beach spawners in Hetta Lake. No expansion was needed for the stream study areas in Eek and Hetta Lakes, because we assumed all parts of these spawning streams were adequately sampled.

Data Analysis

Stream Spawning Population

The two-sample Petersen method is a simple model for estimating total escapement based on the total number of fish marked as they move into the stream (first sample), the total number of fish subsequently sampled for marks (second sample), and the number of marks recovered in the second sample (Seber 1982, p. 59; Pollock et al. 1990). Stratified mark-recapture models extend the two-sample Petersen method over two or more sampling occasions or events in both the marking (first) and mark-recovery (second) samples. Stratified models are widely used for estimating escapement of salmonids as they migrate into the spawning grounds (Arnason et al. 1996). Spawning migrations may last for a month or more, during which there can be substantial variation in biological parameters such as daily immigration or mortality rates. A fundamental assumption of the Petersen and related mark-recapture models is that capture probabilities for individual animals are equal (Pollock et al. 1990). The natural variation typical of salmon escapements presents many possibilities for individual capture probabilities to vary, but if the assumptions of equal probability of capture required by the Petersen model are met, then a simplified model can be used. Briefly stated, the 3 assumptions of equal probability of capture are: 1) all fish have an equal probability of capture in the first sample (marking), 2) all fish have an equal probability of capture in the second sample (mark-recovery), and 3) fish mix completely between the first and second sample. Generally, if one or more of these assumptions are met, data from all marking and all mark-recovery samples can be pooled, thereby providing the most precise estimate. However, if none of the assumptions are met, the pooled estimate can be badly biased (Arnason et al. 1996).

We used the Stratified Population Analysis System (SPAS) software as an aid in analyzing and interpreting our mark-recapture results (Arnason et al. 1996; for details, refer to http://www.cs.umanitoba.ca/~popan/). SPAS calculates Darroch and "pooled Petersen" estimates, and provides two goodness-of-fit tests to compare observed and expected capture probabilities in the marking (first) and mark-recovery (second) samples (Arnason et al. 1996). This program also provides associated standard errors of the estimates. The test of the assumption of complete mixing is incorporated into the test for equal probability of capture in the second sample. We considered a test statistic with p-value ≤ 0.05 as "significant."

We looked at sample sizes and capture probabilities in each marking and mark-recovery stratum, and considered any problems such flooding or missed sampling events. We then checked the Darroch estimate for possible problems, such as a failure of the SPAS program to converge to a solution, or estimates much larger or smaller than the pooled Petersen estimate. Followed the guidelines and suggestions in Arnason et al. (1996) we searched for a pooling scheme that led to the fewest number of strata with non-significant test statistics and an absence of other diagnostic problems.

Beach Spawning Population

We used a two-stage mark-recapture study design to estimate the sockeye escapement in the beach study area in Hetta Lake. For the first-stage analysis, the beach study area was assumed closed for the short period between Day 1 and Day 2 of each sampling event. We used Chapman's form of the Petersen mark-recapture estimator to estimate the number of sockeye spawners within the study area at each sampling event (Seber 1982, p. 60). For a given sampling event, i, we let K_i denote the number of fish marked on the first day of the event in a random sample from a population of size N_i. We let C_i denote the number of fish sampled and examined for marks on the second day of event i, and let R_i denote the number of fish in the second day's sample with a mark. The estimated number of fish in the population at event i, $\hat{N}_i$, was calculated by,

$$\hat{N}_i = \frac{(K_i + 1)(C_i + 1)}{(R_i + 1)} - 1 .$$

Using the Petersen estimates of spawner abundance at each event, and the number of recaptures from previous events, we estimated the super population, or total spawning population within the study area, N^*. Given s sampling events, we let $\hat{N}_i$ denote the Petersen estimate from each sampling event i ($i=1,...,s$). The $\hat{N}_i$ values were used in place of the usual Jolly-Seber derived parameter estimates of the number of animals alive in the system at each sampling event (J. Blick ADF&G, personal communication 1998; Cook 1998). We let n_i represent the number of unmarked fish and fish marked on previous trips, caught at sampling occasion i, and we let m_i represent the number of fish marked in previous events, caught at sampling event i.

We also defined the parameters (Schwarz et al. 1993; Cook 1998):

> M_i = number of marked fish alive at time i (i=1,…,s; M_1=0),
>
> ϕ_i = probability that a fish alive at time i is also alive at time i+1 (i=1,…,s-1; *i.e.* the survival rate),
>
> B_i = number of fish that enter the system after event i and are still alive at event i+1 (i=1,…,s-1; *i.e.* immigration). B_0 is the number of fish that entered the population before the first sample and are still alive at the time of the first sample.
>
> N^* = total number of animals that enter the system before the last sampling event.

M_i was estimated as $\hat{M}_i = m_i \hat{N}_i / n_i$ (M_1=0);

ϕ_i was estimated as $\hat{\phi}_i = \hat{M}_{i+1} / (\hat{M}_i - m_i + n_i)$;

B_i was estimated as $\hat{B}_i = \hat{N}_{i+1} - \hat{\phi}_i \hat{N}_i$.

Seber (1982:204) recommended that m_i should be greater than 10 for satisfactory performance of these bias-adjusted estimators.

We assumed the interval between the last (s^{th}) sampling event, and the next-to-last (s-1^{th}) sampling event was so short that the number of fish entering the population during this interval was negligible. Furthermore, we assumed that sampling extended to a time when immigration had ended, and the number of fish entering the population was negligible. Escapement can be estimated as the sum of the $\hat{B}_i$, estimated numbers of fish that entered the population between sampling events. However, the $\hat{B}_i$ are numbers of fish that entered the population after sampling event i and were alive at sampling event i+1. These estimates exclude those fish in the escapement that entered after sampling event i but died before sampling event i+1. Consequently, Jolly-Seber estimates of B_i underestimate spawning recruitment, except when all fish are known to survive from their entry to the next sampling event. To account for those fish that entered the system after sampling event i but died before sampling event i+1, we adjusted $\hat{B}_i$ by a probability distribution approach (Schwarz et al. 1993). Let B_i^* denote the total number of new fish entering the population between sampling events (including those that die before the next sampling event). When recruitment and mortality are assumed to occur uniformly between sampling events, the maximum likelihood estimator (MLE) for B_i^* is

$$\hat{B}_i^* = \hat{B}_i \frac{\log(\hat{\phi}_i)}{\hat{\phi}_i - 1}.$$

$\hat{B}_0$, $\hat{B}_1$, and $\hat{B}_{s-1}$ are confounded parameters and cannot be estimated without further assumptions (Schwarz et al. 1993). However, we assume recruitment has virtually ended before the last sampling occasion, so we set $\hat{B}_{s-1}$ to zero. The number of fish alive in the population on the second sampling occasion, N_2, can be estimated as,

$$\hat{N}_2 = \hat{B}_0 \phi_1 + \hat{B}_1.$$

So a reasonable estimate of the number of fish that enter the system before the first sampling occasion and between the first and second sampling occasions, including those that enter the system and die before and between these sampling occasions, is

$$\hat{N}_2 \frac{\log(\hat{\phi}_1)}{\hat{\phi}_1 - 1}$$ (Schwarz et al. 1993).

We then estimated the total escapement as

$$N^* = \hat{N}_2 \frac{\log(\hat{\phi}_1)}{\hat{\phi}_1 - 1} + \sum_{i=2}^{k-1} \hat{B}_i^*.$$

A parametric bootstrap method (Buckland 1984) was used to construct a confidence interval for the population estimate. Let each bootstrap step be indexed by j (j=1...G; for our purposes G=1,000). The parametric bootstrap distribution for $\hat{N}_i$ was developed by drawing G bootstrap observations of a hypergeometrically distributed random variable (that is, r_i) using parameters based on the observed values of C_i, K_i, and $\hat{N}_i$ at each sampling event i. At each step the Petersen estimate $\hat{N}_i(j)$ is developed as previously described. Denote each bootstrap observation in the Petersen estimation process as the pair of $r_i(j)$ and $\hat{N}_i(j)$, for j=1...G. Before proceeding on to simulation of the modified Jolly-Seber estimation process, the variance of the number of recaptures across all bootstrap replicates was calculated and denoted sb_i, for each sampling event i (i.e. $\mathrm{Var}_j(r_i(j)) = sb_i$). Note that this standard deviation is calculated from the bootstrap distribution of just second day recaptures at each sampling event. To simulate the Jolly-Seber portion, for each bootstrap step, a bootstrap observation, $m_i(j)$, was drawn from a normal distribution with the mean determined from the actual observed value of m_i, and the standard deviation given by sb_i. Because this standard deviation is based on the simulated variability only from second day recaptures in a given sampling event, it may tend to understate the sampling variability of m_i, which is the number of recaptures from all previous marking events. Even so, this assumption should provide a sensible approximation. We conditioned on the sample size, which we assumed to be fixed and not a random variable, so that $n_i = n_i(j)$, for all j bootstrap observations. We then estimated $\hat{M}_i(j)$, $\hat{\phi}_i(j)$, and so on, as previously described, for all j=1, ...G. The confidence interval for each parameter was found from the quantiles of the bootstrap distribution (Rice 1995) for that estimate.

The Jolly-Seber estimate of escapement in the beach study area was expanded to obtain an estimate of all sockeye spawners along the shores of Hetta Lake. We used the visual survey counts of the number of sockeye spawners inside and outside the beach study area to estimate the proportion of sockeye salmon in the study area for each event. The proportion of fish in the study area over the entire season was estimated by taking the mean of proportions in the study area at each sampling event, weighted by the estimated spawning population size at each event (the first stage or Petersen estimate).

SOCKEYE ESCAPEMENT AGE AND LENGTH COMPOSITION

From 31 August to 25 October 2004, we sampled about 380 sockeye salmon for scales, mid-eye-to-fork length, and sex to describe the age and size structure of the Hetta Lake sockeye population by sex. In Eek Lake, the crew sampled 200 sockeye salmon from the inlet stream between 26 August and 9 September in 2004. To avoid re-sampling a fish previously caught, we only sampled unmarked sockeye spawners. In Hetta Creek, we sampled up to 200 fish for scales and length on each trip. Because the Eek Lake sockeye population was small, we sampled as many unmarked fish as possible. Age and length information was paired from each fish. Three scales were taken from the preferred area of each fish (INPFC 1963) and prepared for analysis (Clutter and Whitesel 1956). Scale samples were assigned to an age class at the ADF&G Aging Laboratory in Douglas, Alaska. Age classes were designated by the European aging system where freshwater and saltwater years are separated by a period (e.g. 2.3 denotes 2-year freshwater and 3-year saltwater; Koo 1962). We measured the length of each fish to the nearest millimeter (mm). The proportion of each age-sex group was estimated for the sockeye population along with its associated standard error, using standard statistical techniques assuming a binominal distribution, described in common references, such as Thompson (1992).

SUBSISTENCE HARVEST ESTIMATE

Subsistence fishers from Hydaburg were interviewed on the fishing grounds in Hetta Cove or Eek Inlet or in the Hydaburg harbor to determine the total harvest by salmon species, fishing time, area fished, and gear type for each boat or boat party (2 boats fishing together). This survey was considered a census, because the crew interviewed every party that fished at each fishing site. To determine the total harvest by species, we simply summed all harvest in each area and by species and gear type.

SOCKEYE FRY ASSESSMENT

In 2004, we used hydroacoustic and mid-water trawl sampling methods to estimate abundance and age and size distributions of sockeye fry and other small pelagic fish in Hetta Lake. To increase the precision in year-to-year comparisons, we used the same fourteen transects that were randomly chosen (two random transects from each of seven sampling sections of the lake) in 2002 (Lewis and Cartwright 2004).

Hydroacoustic survey

During the acquisition of acoustic targets, we surveyed each selected transect from shore to shore, beginning and ending the sampling at the depth of 10 m. Sampling was conducted during the darkest part of the night. A constant boat speed of about 2.0 $m \cdot sec^{-1}$ was attempted for all transects. The acoustic equipment used on the survey was the Biosonics DT-4000™ scientific echosounder (420 kHz, 6° single beam transducer) and we used version 4.0.2 of the Biosonics Visual Acquisition© software to collect and record the data. The ping rate was set at 5 $pings \cdot sec^{-1}$ and the pulse width at 0.4 ms. Only target strengths ranging from –40 dB to –68 dB were recorded because this range represented fish within the size range of sockeye fry and other small pelagic fish.

Trawl Sampling

Midwater trawl sampling was conducted in conjunction with hydroacoustic surveys to determine species composition of pelagic fish and age distribution of sockeye fry. A 2 m x 2 m elongated beam-trawl net with a cod-end was used for trawl sampling. Trawl sampling was conducted in the area and depth of the lake with highest concentration of fish, identified during the hydroacoustic survey. Within this area, replicate tows were conducted at each depth. The second tow, at a given depth, was started at the termination point of the first tow. Direction of the second tow, was selected so a different area from the first tow would be sampled. Trawl duration was 5 to 20 minutes, depending on target density and lake depth. If warranted, a second complete set of tows was conducted in a morphologically distinct section of the lake or in a second area of high fish density.

All adult fish caught in the midwater trawl were identified, counted, and released. All small fish from the trawl net were euthanized with MS 222. Fish were preserved with 90% alcohol. Samples from each tow were preserved in separate bottles. The bottle was labeled with the date, lake name, tow number, tow depth, time of tow, and initials of collectors.

In the laboratory, fish were re-hydrated by soaking in water for 60 minutes prior to measurement. All fish were identified to species, and snout-fork length (to the nearest millimeter) and weight (to the nearest 0.1 gram) were measured on each fish. All sockeye fry under 50 mm were assumed to be age-0. Scales were collected from sockeye fry over 50 mm and mounted onto a microscope slide for age determination. Sockeye fry scales were examined through a Carton microscope with a video monitor and aged using methods outlined in Mosher (1968). Two trained technicians independently aged each sample. Results of each independent scale ageing were compared. In instances of discrepancy between the 2 age determinations, a third independent examination was conducted.

The proportion of each species caught in the trawls was used to allocate hydroacoustic target estimates into species categories; the estimates of sockeye fry abundance were further allocated into sockeye fry age classes. The process of capturing juvenile fish with a trawl was modeled with a hierarchical Bayesian model, assuming a separate random rate for each category of sonar target in each trawl pass. Rates of sockeye acquisition for each specific trawl pass were assumed to follow a beta sampling distribution, with a common set of parameters for the whole lake.

Fry Data Analysis

We used Biosonics Visual Analyzer © version 4.0.2 software to analyze the sonar record. Echo integration was used to generate an estimate of target density (targets $\cdot$ m^{-2}) for each sample transect (MacLennan and Simmonds 1992). We divided the lake into seven sampling sections, with two transects per section selected randomly. Mean target density for each section was estimated from the target density estimates for these two transects. We calculated a sample variance for each section estimate with one degree of freedom. The mean target density for the whole lake was estimated as the average of the target-density estimates for each section, weighted by surface area of each section. The estimate of total targets in the lake was estimated as the sum of target population estimates for each section. Because we sampled each section independently from other sections, the estimated sampling variance for the whole-lake target population estimate was simply the sum of the section variances. The estimate of total targets was partitioned into two categories, sockeye fry and other small fish, by means of the trawl-net sampling. Commonly, researchers assume that the proportion of sockeye fry in such a sample follows a binomial distribution, an assumption of convenience, but not necessarily a realistic assessment of the sampling conditions. We know from previous experience with many sockeye-producing lakes that the number of sockeye fry in a trawl sample is often much more variable than the usual binomial sampling model predicts. Thus, in practice, the confidence intervals based on binomial sampling assumptions can be biased and far too short.

We developed the following Bayesian procedure to measure uncertainty in the estimated proportion of sockeye fry. Let T denote the actual value of the total targets in the lake, and let $\hat{T}$ denote the estimate of T, derived from the echo integration analysis of the sonar record. Conditioned on total number of fish caught in the i^{th} trawl sample, we let number of sockeye fry in each trawl follow a binomial sampling distribution. For the i^{th} trawl pass, we denote trawl sample size as n_i and we denote number of sockeye fry in this sample as y_i. We let parameter p_i denote the unknown underlying proportion of sockeye fry in the i^{th} trawl sample, and we assume p_i is a key parameter in the sampling distribution of y_i. We assume each trawl sample has its own sampling distribution, possibly different from any other in the lake. Next, we suppose that p_i is itself drawn from a beta probability distribution with mean $p_\mu = \dfrac{\alpha}{\alpha + \beta}$.

In other words, let y_i be distributed as a binominal random variable with parameters p_i and n_i, and let p_i follow a beta probability distribution with parameters α and β. Again, α and β are the same for each transect in the lake at the occasion of trawl sampling. The hyperparameters α and β can be estimated through all of the trawl hauls.

We chose a uniform distribution between 0 and 10 for both α and β hyperparameters after experimenting with this distribution and truncated normal distributions. This prior distribution limits influence of prior distributions on posterior distributions and ensures that the data have adequate influence if sample size is large. For example, for sample sizes less than 10, the posterior distribution will be almost entirely controlled by prior distribution. However, for sample sizes approaching 100, the prior distribution will have little influence on mean of the posterior distribution for each individual p_i. We note that if posterior probability is allowed to build up on larger and larger values of α and β, the posterior means of the p_i's will become more alike and the posterior variance of p_μ will decline unrealistically. Therefore, limiting maximum values of both α and β to 10 seemed to provide a compromise between allowing posterior means of individual p_i's to be either alike or unalike, and still allow data (likelihood) to dominate posterior distribution.

Let S denote the number of targets assigned to sockeye fry. To compare and combine an estimate of S and T in the same context as the Bayesian estimate of p_μ, we assumed the posterior distribution of T would be approximately normally distributed. We then generated at least 5,000 random draws from a normal distribution with the same mean and variance as the sample mean and sample variance for T. We previously generated 5,000 observations of posterior distribution of p_μ. Denoting each random draw with subscript j, we calculated a random draw from posterior distribution of S as $S_j = p_j T_j$. From there we noted the mean of the 5,000 simulated values of S and we generated 95% credible intervals, the Bayesian counterpart to a 95% confidence interval, using 2.5 and 97.5 percentiles of simulated posterior distributions of S. All analyses were performed with the Winbugs software.

LIMNOLOGY SAMPLING

In 2004, we conducted limnology sampling at stations A and B (Figure 2) in Hetta Lake on 8 June, 23 July, 31 August, and 13 October to measure euphotic zone depth (EZD) and temperature and to collect zooplankton samples. Physical measurements were only made at station A and zooplankton samples were collected both stations at each sampling date.

Light and Temperature Profiles

We recorded underwater light intensity from just below the surface to the depth where measured intensity was one percent of the surface light reading, at 0.5 m intervals, using an electronic light sensor and meter (Protomatic). The natural log (ln) of the ratio of light intensity just below the surface to light intensity at depth z (I_0/I_z) was calculated for each depth. The vertical light extinction coefficient (K_d) was estimated as the slope of $\ln(I_0/I_z)$ versus depth. The euphotic zone depth (EZD) was defined as the depth at which light has attenuated to one percent of the intensity just below the lake surface [photosynthetically available radiation (400 to 700nm)] (Schindler 1971) and was calculated from the equation EZD = 4.6205/ K_d (Kirk 1994).

We measured temperature profiles in ^{o}C with a Yellow Springs Instrument (YSI) Model 58 dissolved oxygen (DO) meter and probe. Measurements were made at 1 m intervals to the first 10 m or the lower boundary of the thermocline (defined as the depth at which the change in temperature changes 1 ^{o}C per meter), and thereafter at 5 m intervals to within 2 m from the bottom (or 50 m).

Secondary Production

Because the usual diet of sockeye fry consists of zooplankton and *Daphnia* spp. are the preferred species, we estimated zooplankton density and biomass, by species, to estimate the amount of food available, compared to numbers of sockeye fry rearing in Hetta Lake. Zooplankton samples were collected at both stations using a 0.5 m diameter, 153 um mesh, 1:3 conical net. Vertical zooplankton tows were pulled from a maximum depth of 50 m, at a constant speed of 0.5 m/sec. The net was rinsed prior to removing the organisms, and all specimens were preserved in neutralized 10% formalin (Koenings et al. 1987). Each zooplankton tow was sub-sampled in the laboratory, and technicians identified to species or genus, counted, and measured organisms in the sub-samples (Koenings et al. 1987). Density (individuals per m^2 of lake surface area) was extrapolated from counts by taxon in the sub-samples, and seasonal mean density was estimated by taking the simple average of densities across sampling dates. The seasonal mean length for each taxon, weighted by density at each sampling date, was estimated and used to calculate a seasonal mean biomass estimate (weight per m^2 surface area) based on known length-weight relationships (Koenings et al. 1987). Total seasonal mean zooplankton biomass and density were estimated by summing across all species.

RESULTS

SOCKEYE ESCAPEMENT ESTIMATES

Hetta Lake

Mark-recapture sampling for both stream and beach spawning sockeye populations was conducted during six sampling events in Hetta Lake between 31 August and 27 October in 2004. The stream spawning population in Hetta Creek was sampled during three marking and three recovery events between 31 August and 28 September. The beach spawning population was sampled during three two-day mark-recapture events in the study area near Old Hatchery Creek.

Stream Spawning Population

We marked and released 337 sockeye salmon at the mouth of Hetta Creek during three marking events on 31 August and 9 and 18 September; most fish were marked and released in the first two events (Table 2). A total sample of 225 sockeye salmon was caught and examined for marks on 10, 19, and 28 September, and overall, 58% of those sampled fish had marks. In all, 39% of all fish marked during the marking phase were recovered. The percentages of marks recovered declined by marking stratum, from 52% of stratum 1 marks to only 9% of stratum 3 marks.

Table 2.–Number of sockeye salmon marked and released and numbers and percentages of marked fish recaptured from each marking stratum; numbers of fish sampled and number and percentage with marks in each recapture stratum, in Hetta Creek in 2004.

				Number of marked fish recaptured, by event				
Marking stratum	**Mark type**	**Marking dates**	**Number marked**	**Event 1 10–Sep**	**Event 2 19–Sep**	**Event 3 28–Sep**	**All events**	**Percent of marks recovered**
1	Left circle	31–Aug	163	60	20	4	84	52%
2	Left triangle	9–Sep	131	0	33	9	42	32%
3	Left square	18–Sep	43	0	0	4	4	9%
Total			337	60	53	17	130	39%
Number of fish examined for marks				108	95	22	225	
Percent with marks				56%	56%	77%	58%	

We estimated a population of 600 sockeye spawners (CV=9%) in Hetta Creek in 2004; the 95 % confidence interval for the true population was 500 to 700 sockeye spawners. A Darroch estimate could not be formed from the fully stratified data. Goodness-of-fit tests performed to determine appropriateness of pooling strata indicated no violation of the assumption of equal proportions (X^2 = 3.80, df = 2, p = 0.15), but a possible violation of the assumption of complete mixing (X^2 = 29.45, df = 2, $p \leq 0.005$). Because one of the goodness-of-fit tests passed (i.e. $p >$ 0.05), the pooled Petersen estimate was used (Arnason et al. 1996).

Beach Spawning Population

Three mark-recapture events were performed in the beach spawning study area around Old Hatchery Creek between 27 September and 27 October, 2004. Only eight fish, out of 25 marked in the first event and 44 marked in the second event, were later recaptured (Table 3). A minimum of ten recaptures is recommended for satisfactory performance of the estimators (Seber 1982). Because we had fewer than ten recaptures, we recognized the possibility of bias or other problems with the Jolly-Seber estimator. With that caution, we estimated a small population of about 170 sockeye spawners (95% confidence interval 120–250) in the Old Hatchery Creek study area. This estimate appears reasonable in comparison with the visual survey counts in the Old Hatchery Creek study area (Table 4).

Table 3.–Numbers of sockeye spawners marked, sampled, and recaptured in the Old Hatchery Creek study area in Hetta Lake in 2004. To generate first stage estimates, fish were marked on Day 1 of each event and examined for marks on Day 2. For second stage estimates, fish caught on both days of an event were given a unique mark for that event and were also examined for marks given on previous events.

		First stage		
Sampling event	**Sampling dates**	**Number marked (Day 1)**	**Number sampled (Day 2)**	**Number recaps From Day 1**
1	27–28 Sep	15	25	15
2	14–15 Oct	21	36	13
3	26–27 Oct	9	11	4
		Second stage		
Sampling event	**Sampling dates**	**Number marked (Day 1+ Day 2)**	**Recaps from event 1**	**Recaps from event 2**
1	27–28 Sep	25	-	-
2	14–15 Oct	44	4	-
3	26–27 Oct	16	0	4

Visual Survey

We conducted seven visual surveys between 23 August and 26 October 2004 in Hetta Lake. Hetta Creek was the only inlet stream in which sockeye salmon were present. The peak count of stream spawners was on 19 September, and no fish were seen in the stream after 28 September. All other sockeye salmon were counted in beach spawning areas along the lake shoreline. The total count of spawners throughout the system increased through 14 October, with beach spawners contributing most or all of the highest two counts (Table 4).

From the visual survey counts of sockeye spawners, we estimated a seasonal average of 12% of all beach spawners, weighted by abundance at each sampling event, in the Old Hatchery Creek study area. We expanded the Jolly-Seber estimate for the Old Hatchery Creek study area by this proportion, to obtain a rough total population estimate of 1,400 beach or lake spawning sockeye salmon in Hetta Lake.

Table 4.–Number of sockeye spawners counted in Hetta Creek and Hetta Lake beach spawning areas during visual surveys in 2004. The stream mark-recapture study was conducted in Hetta Creek; this study area included the area around the mouth of the creek. The beach mark-recapture study was conducted in the Old Hatchery Creek study area; the proportion of visual counts within this area compared with all beach spawning areas was used to expand the beach spawning population estimate to the whole lake.

Survey date	Hetta Creek	Old Hatchery Creek (beach) study area	All beach spawning areas	Lake total
23–Aug	0	0	0	0
1–Sep	103	0	4	107
10–Sep	60	0	94	154
19–Sep	304	18	45	349
28–Sep	114	70	285	399
14–Oct	0	23	462	462
26–Oct	0	40	271	271

Eek Lake

Stream Spawning Population and Visual Survey

A total of 102 fish was marked and released at the mouth of the Eek Lake spawning stream on 3 September, 2004, and 17 additional fish were marked and released on 14 September. None of the fish marked on this second date were recovered, so consequently, this marking stratum was dropped. On 15 September, 2004, 141 fish were sampled in the stream, and 15% (21 fish) of these had marks. No fish were captured during the last sampling event on 22 September, during heavy rains. With just one marking and one recapture stratum, we calculated a simple Petersen estimate of escapement for Eek Lake of about 700 sockeye salmon (CV=21%); the 95 % confidence interval for the true population was 500 to 1,100 sockeye salmon.

Four visual surveys were conducted in Eek Lake between 23 August and 22 September, 2004. During these surveys, sockeye spawners were present only in the inlet stream and around its mouth. No fish were seen in the lake or stream on the first survey, 23 August, or on the last survey, 22 September, which suggests that our survey dates captured the entire run (Table 5). The water level in the creek was very low on 23 August, then very high on 22 September with flooding and wash-outs.

Table 5.–Number of sockeye spawners counted in the inlet stream of Eek Lake during visual surveys in 2004. The inlet stream was the only area where sockeye spawners were observed.

Date	Stream mouth	Stream	Stream total
23–Aug	0	0	0
3–Sep	130	8	138
15–Sep	119	188	307
22–Sep	0	0	0

SOCKEYE ESCAPEMENT AGE AND LENGTH COMPOSITION

Hetta Lake

The dominant age class in the 2004 escapement in Hetta Lake was age-1.3 (53.9%), followed by age-1.2 (31.4%; Table 6). The sockeye spawning population was composed of about 8% 3-year olds, 32% 4-year olds, 57% 5-year olds, and 4% 6-year olds. An estimated 93% of fish in the escapement had one freshwater year. The sample included 29 age-1.1 jacks; their mean length was 321 mm. The mean fork length was 556 mm for age-1.3 fish and 515 mm for age-1.2 fish. Sockeye salmon that spent three years in the ocean (age-1.3 and -2.3) had a greater average length than those that spent only two years in the ocean (age-1.2 and -2.2; Table 7).

Table 6.–Age composition of sockeye salmon in Hetta Lake escapement by sex, brood year, and age class; sampled 31 August–25 October, 2004. Std. error represents the standard error of the estimated percentage in each age class.

Brood year	2001	2000	1999	1999	1998	
Age	1.1	1.2	1.3	2.2	2.3	Total
Male						
Sample size	29	50	90	2	7	178
Percent	7.6	13.1	23.6	0.5	1.8	46.6
Std. error	1.4	1.7	2.2	0.4	0.7	2.6
Female						
Sample size	-	70	116	9	9	204
Percent		18.3	30.4	2.4	2.4	53.4
Std. error		2.0	2.4	0.8	0.8	2.6
All Fish						
Sample size	29	120	206	11	16	382
Percent	7.6	31.4	53.9	2.9	4.2	
Std. error	1.4	2.4	2.6	0.9	1.0	

Table 7.–Mean fork length (mm) of sockeye salmon in Hetta Lake escapement by brood year, sex, and age class, sampled 31 August to 25 October, 2004.

Brood year	2001	2000	1999	1999	1998
Age	1.1	1.2	1.3	2.2	2.3
Male					
Mean length (mm)	321	514	568	517	569
Std. error	4.5	4.2	2.0	18.5	9.6
Sample size	29	50	90	2	7
Female					
Mean length (mm)	-	516	546	514	547
Std. error		2.3	1.9	9.9	13.1
Sample size		70	116	9	9
All Fish					
Mean length (mm)	321	515	556	515	557
Std. error	4.5	2.2	1.6	8.4	8.7
Sample size	29	120	206	11	16

Eek Lake

The dominant age class in the Eek Lake escapement in 2004 was age-1.2 (54.1%); the second largest was age-1.3 (36.2%; Table 8). The sockeye spawning population was composed of about 5% 3-year olds, 55% 4-year olds, 39% 5-year olds, and 1% 6-year olds. An estimated 95% of the escapement were fish that had spent one year in the lake as juveniles. Nine age-1.1 jacks and two age-2.1 jacks were included in the sample. Sockeye salmon that returned to Eek Lake to spawn after spending three years in the ocean (age-1.3 and -2.3) had a greater fork length than salmon that returned to spawn after two years in the ocean (age-1.2 and -2.2; Table 9).

Table 8.–Age composition of sockeye salmon in Eek Lake escapement by sex, brood year, and age class; sampled 26 August–9 September, 2004. Std. error represents the standard error of the estimated percentage in each age class.

Brood year	**2001**	**2000**	**1999**	**2000**	**1999**	**1998**	
Age	**1.1**	**1.2**	**1.3**	**2.1**	**2.2**	**2.3**	**Total**
Male							
Sample size	9	47	31	2	4	1	94
Percent	4.6	24.0	15.8	1.0	2.0	0.5	48.0
Std. error	1.5	3.0	2.6	0.7	1.0	0.5	3.6
Female							
Sample size	-	59	40	-	2	1	102
Percent		30.1	20.4		1.0	0.5	52.0
Std. error		3.3	2.9		0.7	0.5	3.6
All Fish							
Sample size	9	106	71	2	6	2	196
Percent	4.6	54.1	36.2	1.0	3.1	1.0	
Std. error	1.5	3.6	3.4	0.7	1.2	0.7	

Table 9.–Mean fork length (mm) of sockeye salmon in Eek Lake escapement by brood year, sex, and age class, sampled 26 August–9 September, 2004.

Brood year	**2001**	**2000**	**1999**	**2000**	**1999**	**1998**
Age	**1.1**	**1.2**	**1.3**	**2.1**	**2.2**	**2.3**
Male						
Mean length (mm)	354	529	586	296	540	590
Std. error	5.7	3.6	4.5	19.0	12.4	
Sample size	9	47	31	2	4	1
Female						
Mean length (mm)	-	520	566	-	525	545
Std. error		3.0	3.6			
Sample size		59	40		2	1
All Fish						
Mean length (mm)	354	524	574	296	535	568
Std. error	5.7	2.3	3.1	19.0	8.5	22.5
Sample size	9	106	71	2	6	2

SUBSISTENCE HARVEST ESTIMATE

Totals of 3,065 sockeye, 185 coho, 12 chum, and 149 pink salmon were harvested by subsistence users in fishing areas near Hydaburg: Hetta Cove, Eek Inlet, Hunter Bay, and Kasook Inlet (Table 10; Appendix D). Forty-nine boat groups, 17 on the fishing grounds and 32 in the harbor, were interviewed from 27 June to 4 September, 2004. Subsistence fishers used seines, gillnets, and dipnets, but only seines were used in Hetta Cove and Kasook Inlet (Table 11). The largest subsistence harvest of sockeye salmon occurred in Hunter Bay, with nine participants. Effort and harvest was about equal between Hetta Cove and Eek Inlet, with about 20 participants and about 600 sockeye salmon harvested in each location. Only one boat group fished Kasook Inlet, late in the season on 29 August. Regardless of gear type, the number of sockeye salmon caught per hour fished was much higher in Hunter Bay than in the other areas fished (Table 11).

Table 10.–Summary of subsistence fishing participation and harvest in fishing grounds located near Hydaburg in 2004. Harvest amounts were determined by direct interviews of all participants and considered a complete harvest census.

Harvest area	Dates	Interviews on grounds	Interviews in harbor	Number of fish harvested, by species			
				Sockeye	Coho	Chum	Pink
Hetta Cove	27 Jun–14 Aug	7	13	630	0	0	0
Eek Inlet	4 Jul–14 Aug	10	9	594	18	0	98
Hunter Bay	18 July–7 Aug	0	9	1,811	167	0	0
Kasook Inlet	29 Aug	0	1	30	3	12	51
Totals		17	32	3,065	188	12	149

Table 11.–Average number of sockeye salmon harvested per hour of fishing, by gear type and area.

Area	Gear	Hours fished	Number sockeye harvested	Average harvest per hour
Hetta Cove	seine	78	630	8
Eek Inlet	seine	76	580	8
	gillnet	6	14	2
Hunter Bay	seine	30	1,760	59
	dipnet	2	51	26
Kasook Inlet	seine	4	30	8

SOCKEYE FRY ASSESSMENT

We conducted hydroacoustic and mid-water trawl sampling on 14 and 15 October, 2004. From the hydroacoustic sampling, we estimated a total of 884,000 targets (CV=7%). Apportionment of targets by species was based on results of twenty tows of 5–20 minutes duration, sampling a total of 2,110 small pelagic fish (Table 12). Using the trawl samples, we estimated the proportion of sockeye fry in the lake to be 0.48, and applying this proportion to the total number of targets, we estimated a population of about 420,000 sockeye fry (Table 12). Using a Bayesian approach with 5,000 random trials, the posterior mean of the proportion of sockeye fry was 53.3% with a 95% credible interval of 45–61%. Because we normally sample fewer than 20 trawl tows, we also resampled the 20 trawl samples and estimated the mean proportion of sockeye fry in 10 and 5 trawl tows to be 53.5% and 51.4%, respectively. The estimates of the proportion of sockeye fry were very similar whether we used 10 or 20 trawl samples. Using 20 trawls, our posterior coefficient of variation for *S* was 11%. From the product of the posterior means for $\hat{T}$ (estimate of total targets) and $\hat{p}$ (proportion of sockeye fry estimated from Bayesian approach), we estimated 470,000 sockeye fry, with a credible interval of 380,000 to 570,000 fry and a posterior standard deviation of 51,000. Estimated sockeye fry density was about 23 fry per 100 m^2, with a range of 18–28 fry per 100 m^2.

Table 12.–Summary of Hetta Lake trawl sampling results by tow, depth (m), time duration (min), and species, in 2004. Seventeen of the sockeye fry were not aged; all other sockeye fry were age-0.

Tow	Depth (m)	Duration of tow (min)	Total Fish	Stickleback	Sockeye fry	Proportion sockeye fry
1	12.5	20	108	22	86	0.796
2	2.5	20	200	151	49	0.245
3	7.5	15	81	22	59	0.728
4	12.5	15	58	9	49	0.845
5	1.5	15	173	82	91	0.526
6	5.0	15	81	29	52	0.642
7	10.0	15	60	13	47	0.783
8	12.5	15	35	23	12	0.343
9	2.5	15	279	233	46	0.165
10	7.5	15	141	50	91	0.645
11	5.0	10	117	38	79	0.675
12	12.5	10	66	12	54	0.818
13	2.0	10	294	197	97	0.330
14	12.5	7	98	50	48	0.490
15	5.0	5	142	71	71	0.500
16	12.5	1	18	7	11	0.611
17	12.5	5	59	33	26	0.441
18	12.5	1	20	13	7	0.350
19	5.0	5	45	31	14	0.311
20	12.5	5	35	20	15	0.429
	Totals		**2,110**	**1,106**	**1,004**	**0.476**

All aged sockeye fry were age-0 (n = 987 fish). The mean snout to fork length was 40 mm, with a range of 30 to 57 mm, and the mean weight was 0.5 g, with a range of 0.2 to 1.6 g. The length frequency distribution for age-0 sockeye fry was skewed to the right; the median was 39 mm and the mode 37 mm (Figure 3). Because sticklebacks were the only other fish species caught in the trawl surveys, we assumed the remaining targets were sticklebacks. The mean snout to fork length of the sticklebacks was 36 mm with a range of 19 to 64 mm, and the mean weight was 0.5 g, with a range of 0.1 to 2.2 g across all age classes.

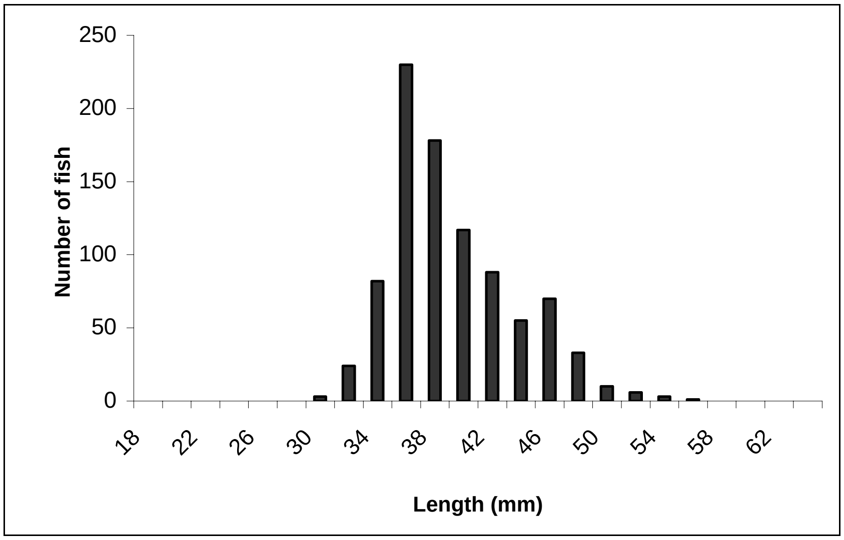

Figure 3.–Length frequency distribution of age-0 sockeye fry caught in the Hetta Lake mid-water trawl samples in 2004.

LIMNOLOGY SAMPLING

Limnology sampling was conducted on Hetta Lake on 8 June, 23 July, 31 August, and 13 October in 2004. Physical data (light and temperature) were collected at the main Station A, and a zooplankton sample was collected at both Stations A and B on each date.

Light and Temperature Profiles

The euphotic zone depth fluctuated very little throughout the 2004 season; the greatest change occurred at the end of the season, with the euphotic zone depth becoming 2 m shallower by 13 October (Table 13). Similar to previous years, the thermocline formed by the beginning of June, expanded and deepened through July, and began to disappear in October (Table 14).

Table 13.–Euphotic zone depths for Hetta Lake in 2004.

Date	Depth (m)
08–Jun	11.3
23–Jul	10.9
31–Aug	10.2
13–Oct	7.9
Seasonal mean	10.1

Table 14.–Water column temperature (ºC) profiles in Hetta Lake, 2004, by sample date and depth (m). The shaded temperature values represent the upper and lower thermocline depth for each sample date.

Depth (m)	8-Jun	23-Jul	31-Aug	13-Oct
1	14.7	20.8	19.5	11.2
2	14.7	20.4	19.2	11.0
3	13.9	19.9	19.0	10.9
4	11.1	18.6	19.0	10.9
5	11.9	18.0	18.9	10.8
6	10.3	16.7	18.8	10.8
7	8.7	14.1	16.0	10.7
8	7.4	13.0	13.5	10.7
9	6.8	11.1	11.6	10.6
10	6.5	10.3	10.4	10.5
11	5.9	8.2	8.8	10.5
12	5.6	7.0	7.5	10.4
13	--	6.5	6.8	10.3
14	--	6.5	6.3	9.3
15	5.2	5.9	5.9	8.0
16	--	5.7	5.6	6.4
17	--	5.5	5.4	5.8
18	--	5.4	5.3	5.5
19	--	5.2	5.1	5.3
20	4.7	5.1	5.0	5.1
25	4.5	4.7	4.7	4.8
30	4.4	4.6	4.5	4.6
35	4.4	4.5	4.5	4.5
40	--	4.4	4.4	4.4
45	--	4.4	4.4	4.4
50	--	4.4	4.4	4.4

Secondary Production

The estimated seasonal mean density of all zooplankton in Hetta Lake was about 81,600 zooplankters per m^2, and the seasonal mean biomass was about 40 mg per m^2 (Table 15). *Bosmina* sp. was the most abundant taxon, comprising 59% of the zooplankton population numerically. However, *Cyclops* sp. represented the largest percentage of the seasonal mean biomass (65%), due to their large size and numbers. The large cladoceran, *Daphnia longiremis*, represented only 1% of zooplankton numbers, but because of its larger size, it represented 4% of the mean biomass.

Table 15.–Zooplankton seasonal mean densities, lengths, and biomass for Hetta Lake in 2004, averaged between Stations A and B. Seasonal mean length and biomass values were weighted by numerical density at each sampling date.

Taxon	Estimated seasonal means				
	Density		Length (mm)	Biomass	
	Number·m^{-2}	Percent		mg·m^{-2}	Percent
Cyclops	17,300	21%	0.65	26	65%
Ovig. *Cyclops*	100	0%	1.09	0	1%
Harpaticus	0	0%	--	--	--
Nauplii	12,200	15%	--	--	--
Bosmina	43,800	54%	0.29	11	27%
Ovig. *Bosmina*	3,700	5%	0.31	1	3%
Daphnia longiremis	1,000	1%	0.69	2	4%
Holopedium	0	0%	0.50	0.0	0%
Immature *Cladocera*	3,500	4%	--	--	--
Totals	**81,600**			**40**	

Maximum observed zooplankton abundance in Hetta Lake occurred in late August, with *Bosmina* sp. strongly dominant at that time (Table 16). This seasonal timing was reflected by all the cladoceran taxa (*Bosmina*, *Daphnia*, and *Holopedium*), while the copepod taxon *Cyclops* sp. had maximum numbers early in the season (8 June) and declined after that.

Table 16.–Zooplankton densities (number·m^{-2}) in Hetta Lake, 2004, by species, sample date, and station.

Zooplankton species	8–Jun	23–Jul	31–Aug	13–Oct	Seasonal mean
	Station A				
Cyclops	54,500	7,400	18,300	7,400	21,900
Ovig. *Cyclops*	200	100	300	100	180
Harpaticus	0	0	0	0	0
Nauplii	17,000	1,900	8,700	26,600	13,600
Bosmina	18,100	48,800	85,800	28,700	45,400
Ovig. *Bosmina*	900	1,100	1,900	1,800	1,400
Daphnia longiremis	0	1,700	0	500	600
Holopedium	100	0	0	0	0
Immature *Cladocera*	2,100	4,700	6,500	2,200	3,900
Station A Totals	92,900	65,700	121,500	67,300	86,800
	Station B				
Cyclops	29,600	5,500	10,700	5,200	12,800
Ovig. *Cyclops*	0	100	0	0	0
Harpaticus	0	100	0	0	0
Nauplii	11,800	2,100	8,700	21,100	10,900
Bosmina	7,500	15,400	100,500	45,600	42,300
Ovig. *Bosmina*	500	15,700	800	7,000	6,000
Daphnia longiremis	1,100	100	2,900	2,000	1,500
Holopedium	0	0	0	0	0
Immature *Cladocera*	900	1,900	5,900	3,600	3,100
Station B Totals	51,400	40,900	129,500	84,500	76,600

DISCUSSION

Combining the estimated populations of stream spawning and lake or beach spawning sockeye salmon in Hetta Lake in 2004, estimated total escapement was 2,000 sockeye salmon (Table 17). This escapement was about 35% lower than our 2003 estimate of 3,100 sockeye salmon and very low compared with what we know about earlier years' returns to this lake (Cartwright et al. 2005). However, the 2003 and 2004 estimates are at best a rough guess due to the very approximate methods used to expand the mark-recapture estimate to the whole lake population, and the low numbers and proportion of fish in the study area. Furthermore, we may have underestimated sockeye escapement, because the timing our sampling in the beach spawning areas probably did not capture the entire spawning period. Lake or beach spawners in Hetta Lake have a protracted spawning period. We have observed that sockeye spawners continue to move into beach spawning areas through October or later; for example, in 2004, counts of beach spawners were still relatively high on our last visual survey on 26 October. Elders from the community of Hydaburg remember fishing for spawning sockeye salmon as late as January along the lake's beaches (B. Sanderson, Hydaburg Cooperative Association, personal communication). Because of safety concerns, logistics, and cost, we cannot extend the study past the end of October to sample these late spawners. Due to these difficulties in obtaining a mark-recapture estimate, we installed and operated a weir in the outlet stream of Hetta Lake in 2005.

Table 17.–The number of beach and stream spawners estimated from mark-recapture studies in Hetta Lake from 2001 to 2004. The number of beach spawners was estimated for the study area and expanded to all beaches using the weighted average percent of beach spawners observed in the study area during visual surveys.

Year	Total spawners	Stream spawners	Total beach spawners	Beach spawners in study area	Percent of beach spawners in study area
2001	-	2,400	-	-	-
2002	-	300	-	-	-
2003	3,100	800	2,300	500	22%
2004	2,000	600	1,400	170	12%

The sockeye escapement into Eek Lake in 2004 (700 fish) was only about half the size of the escapement estimated in 2003 (1,200 fish; Conitz et al. 2005a), paralleling the change in Hetta Lake escapements. Although we had only limited samples to work with, we are reasonably confident that we sampled the entire run. However, it is possible we missed fish that moved into the system before our first sampling event or after our last sampling event. In 2003, we observed live sockeye salmon in the stream for a period of five weeks compared to only two weeks in 2004 (Conitz et al. 2005a).

Inter-annual differences in the subsistence harvest of sockeye salmon from the four major subsistence fishing areas (Hetta Cove, Eek Inlet, Hunter Bay, and Kasook Inlet) appear to reflect changes in the Hetta Lake sockeye run. We compared run sizes between years by adding the estimate of stream spawning escapement in Hetta Creek to the subsistence sockeye harvest in Hetta Cove to obtain a rough index of total run size to this system for 2001–2004 (Table 18). The larger run size indices correspond with years of higher sockeye harvests in Hetta Cove (Figure 4). Sockeye salmon were harvested in other areas in all years, but the other areas contributed more to the total harvest in years when the harvest and run size were low at Hetta. In 2004, the average sockeye catch per hour of fishing effort was much lower than in 2001 and 2003 (nine sockeye salmon per hour fished in 2004 compared with 22 sockeye salmon per hour fished in 2001 and 2003; Cartwright et al. 2005). Consequently, fishermen left Hetta Cove for "better fishing." In 2004, about 60% of the total subsistence harvest came from Hunter Bay; the catch per hour fished was much higher there than in other areas (Table 11), suggesting Hunter Bay had a large sockeye run relative to the other streams.

Table 18.–Sockeye salmon spawning population in Hetta Creek only, and subsistence harvest from Hetta Cove, were summed to produce an index of the Hetta Lake sockeye run size for comparison between years for 2001–2004. The total sockeye escapement for Hetta Lake is not included in this index.

Year	Sockeye spawners in Hetta Creek only	Subsistence harvest	Sockeye run size index
2001	2,400	4,500	6,900
2002	300	1,000	1,300
2003	800	5,800	6,600
2004	600	600	1,200

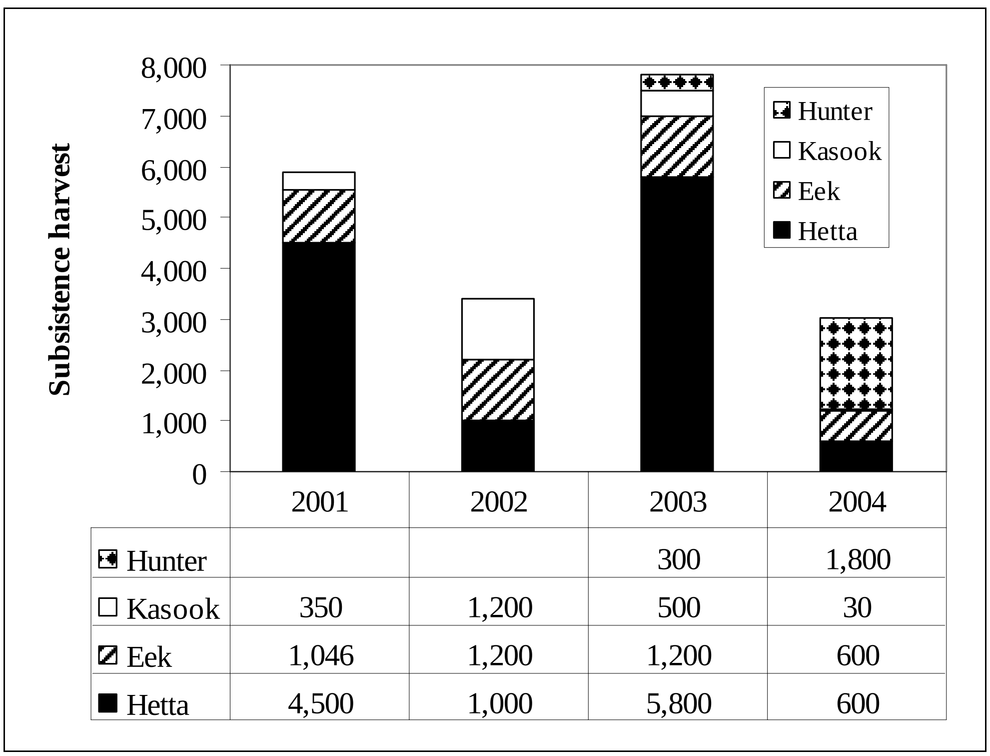

Figure 4.–Hydaburg subsistence sockeye harvest by year and fishing area.

Our 2004 subsistence harvest census, consistent with previous years' results, suggest that the total subsistence harvest reported on returned permits from Hydaburg is lower than the actual harvest. Assuming our subsistence harvest census represents true harvest, those returning subsistence permits reported only 16–55% of the total Hetta Cove subsistence harvest between 2001 and 2003 (Cartwright et al. 2005). In 2004, the reported harvest was much closer to the census figure: permit holders reported harvesting 531 sockeye salmon and the census indicated 600 fish were harvested, so about 89% of the total harvest was reported (Figure 4; Appendix C). Similarly, reported sockeye harvests from Eek Inlet represented only 12–39% of the total harvest indicated in the harvest census, between 2001 and 2004 (Conitz et al. 2005a; Figure 4; Appendix C). We attribute the difference between our harvest census and the harvest reported on permits to employing local tribal members to collect harvest information directly from fishermen during the season.

The freshwater environment for sockeye fry in Hetta Lake has been characterized by large fish populations, increasing numbers of three-spine sticklebacks, and low zooplankton populations, compared to other Southeast Alaska sockeye lakes (Tables 19 and 20). In these circumstances, competition and food availability may limit sockeye production (Koenings and Burkett 1987). From 2001 to 2004, the estimated total population of small pelagic fish in Hetta Lake has declined, while the proportion of three-spine sticklebacks has increased substantially (Cartwright et al. 2005; Table 19). As competitors with sockeye fry, sticklebacks may limit sockeye fry production when food resources are low, by consuming some of the same prey base (Beauchamp and Overman 2004). The average weights of age-0 fry sampled in Hetta Lake were also low compared to other Southeast Alaska lakes in 2001–2004, and the low weights were associated with relatively high fish densities. With reduced fish densities in 2003 and 2004, age-0 sockeye fry weights were somewhat higher (Table 20).

Table 19.–Estimated population sizes of small pelagic fish, from trawl and hydroacoustic surveys, and estimated densities of zooplankton and preferred sockeye prey, *Daphnia*, in Hetta Lake for 2001 to 2004 (Cartwright et al. 2005).

Year	Survey date	Number of sockeye fry	Number of stickleback	Total fish	Zooplankton density (number·m^{-2})	*Daphnia* density (number·m^{-2})
2001	11-Jul	2,870,000	170,000	3,040,000	43,700	100
2002	18-Jul	1,030,000	250,000	1,280,000	53,400	2,000
2003	29-Jul	330,000	420,000	750,000	60,200	500
2004	14 Oct	470,000	410,000	880,000	81,700	1,000

Table 20.–Percentages of three-spine sticklebacks in small pelagic fish populations; population densities of small pelagic, planktivorous fish; and average weights of age-0 sockeye fry, in selected sockeye rearing lakes in Southeast Alaska, 2001 to 2004 (Cartwright et al. 2005; Cartwright and Conitz 2006; Cartwright et al. 2006; Conitz et al. 2005b; Conitz and Cartwright 2005a, b; Riffe 2006; ADF&G unpublished data).

	Percent stickleback				**Total fish density (number of fish·m^{-2})**				**Average weight age-0 sockeye fry (g)**			
Lake	**2001**	**2002**	**2003**	**2004**	**2001**	**2002**	**2003**	**2004**	**2001**	**2002**	**2003**	**2004**
Hetta	6%	20%	56%	47%	0.8	0.55	0.39	0.43	0.3	0.3	0.7	0.5
Klag	78%	33%	-	-	0.45	0.34	-	-	1.3	1.1	-	-
Hoktaheen	0%	0%	-	-	0.32	0.18	-	-	0.5	1.4	-	-
Gut	0%	5%	-	-	0.17	0.27	-	-	0.6	0.5	-	-
Luck	20%	2%	13%	6%	0.06	0.24	0.17		0.5	0.4	0.6	-
Sitkoh	0%	2%	-	-	0.06	0.11	-	-	0.7	1.1	-	-
Falls	0%	39%	-	-	0.06	0.03	-	-	0.6	0.7	-	-
Klawock	0%	12%	19%	-	0.06	0.05	0.05		0.2	1.8	0.8	1.7
Salmon Bay	7%	30%	-	-	0.03	0.03	-	-	0.7	1	-	-
Kook	0%	0%	-	-	0.02	0.02	-	-	0.7	0.8	-	-
Kanalku	0%	25%	-	-	0.01	0.04	-	-	-	1	-	-
Hugh Smith	-	-	-	17%	-	-	-	0.1	-	-	-	-
Chilkoot	52%	0%	1%	6%	-	-	0.22	0.15	0.8	-	0.6	0.6

In interpreting our pelagic fish data, we caution that differences in the 2004 and previous years' hydroacoustic estimates may have been confounded by the timing of the survey, which shifted from mid to late July in 2001–2003 to late October in 2004 (Table 19). Stickleback estimates may have been biased low in 2001 through 2003, because some young-of-the-year stickleback do not move into the pelagic zone until August (M. Cartwright, ADF&G, personal communication 2005). We recommend continuing trawl and hydroacoustic surveys to look for trends in relative abundances of sockeye fry and sticklebacks. Surveys should be conducted in the fall for a better estimate of the stickleback population.

Our observations of high planktivorous fish densities in Hetta Lake seem to contradict the recent small escapement sizes. Meanwhile, the subsistence harvest in Hetta Cove, at least in the more recent period, is one of the largest in Southeast Alaska. With only four consecutive recent years of observation in this system, we cannot rule out the possibility of wide cyclic fluctuations in run size. We do know from the 1968 to 1971 weir counts that sockeye escapements in Hetta Lake can be much higher, and even these were during a period of low sockeye salmon production in Southeast Alaska and the Gulf of Alaska (Quinn and Marshall 1989; Beamish and Bouillon 1993; Mantua et al. 1997). In order to better understand the relationships between past and current sockeye escapement sizes, subsistence harvest and escapement, and escapement and juvenile production in Hetta Lake, we first need to obtain more accurate estimates of escapement. For that purpose, a weir was installed and operated on the Hetta Lake outlet in 2005, and should be continued at least until some of the seemingly contradictory information about this system can be resolved.

Eek Lake is a neighboring sockeye system which supports a small sockeye run, probably averaging about 2,000 fish, of which approximately 50% may be harvested in subsistence fisheries in some years (Conitz et al. 2005a). The subsistence harvest at Eek Inlet should continue to be monitored, along with the other primary fishing streams near Hydaburg. A few visual surveys of the Eek Lake spawning stream each season may be enough to monitor sockeye escapement, with the intention that escapements should be maintained at a level that can support the recent observed level of subsistence harvest.

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APPENDICES

Appendix A.–Historical commercial harvest of sockeye salmon from Eek Inlet and Eek Point (Rich and Ball 1933).

Year	Eek Inlet	Eek Point
1896	8,688	-
1897	9,213	-
-	-	-
1908	4,413	-
1909	4,752	-
1910	6,684	-
1911	3,917	-
1912	6,917	-
1913	-	-
1914	903	-
1915	70	-
1916	2,656	1,068
1917	-	-
1918	2,009	2,550
1919	3,000	69
-	-	-
1922	-	2,703
1923	2	608
1924	-	994
1925	-	-
1926	-	87
1927	-	641

Appendix B.–Commercial harvest of sockeye salmon by purse seine fishing vessels in Hetta Inlet (sub-district 103-25) and Cordova Bay (sub-districts 103-11 and 103-21) from 1960 to 2004 (ADF&G Division of Commercial Fisheries database 2004).

	Harvest by Sub-District		
Year	**103-11**	**103-21**	**103-25**
1960	65	217	9,686
1961	3,016	5,707	3,336
1962	435	687	15
1963	1,592	932	4,010
1964	429	213	37
1965	1,481	4,047	23,259
1966	2,393	2,034	1,736
1967	384	825	4,873
1968	682	871	2,871
1969	14	328	0
1970	441	966	1,184
1971	590	2,204	5,158
1972	194	2,160	34
1973	172	387	534
1974	729	780	88
1975	72	3,510	2,321
1976	106	1,012	1,630
1977	1,145	3,262	670
1978	89	184	57
1979	1,126	653	750
1980	1,894	3,612	152
1981	5,062	3,434	8,166
1982	356	80	--
1983	347	586	--
1984	526	460	87
1985	3,955	2,645	2,192
1986	2,337	1,895	1,140
1987	1,197	221	35
1988	1,121	332	74
1989	3,420	2,917	1,509
1990	5,534	1,891	251
1991	2,919	1,326	70
1992	1,179	825	69
1993	1,949	3,828	1,795
1994	1,994	1,946	2,514
1995	1,989	450	12
1996	458	4,895	8,092
1997	688	0	--
1998	666	596	102

-continued-

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Year	Harvest by Sub-District 103-11	103-21	103-25
1999	9	49	--
2000	1,421	1,495	2,787
2001	350	174	11
2002	109	823	308
2003	91	153	113
2004	55	90	0
Annual Averages by Decade			
1960-1969	1,049	1,586	4,982
1970-1979	466	1,512	1,243
1980-1989	2,022	1,618	1,669
1990-1999	1,739	1,581	1,613
2000-2004	405	547	644
Annual Average, All Years	**1,217**	**1,460**	**2,237**

Appendix C.–Subsistence harvest of sockeye salmon at Hetta Cove (ADF&G stream no. 103-25-20) and Eek Inlet (ADF&G stream no. 103-25-009), reported by permit-holders on the ADF&G subsistence permits for years 1985 to 2005 (ADF&G database).

Location	Year	Number of permits	Reported sockeye harvest	Mean sockeye harvest per permit
Hetta Cove	1985	57	1,265	22
	1986	73	1,911	26
	1987	44	1099	25
	1988	21	507	24
	1989	27	1,135	42
	1990	25	879	35
	1991	22	680	31
	1992	33	1,982	60
	1993	55	1,778	32
	1994	41	2,424	59
	1995	42	1,491	36
	1996	27	1,014	38
	1997	34	1,407	41
	1998	26	726	28
	1999	58	2,298	40
	2000	46	1,483	32
	2001	20	1,129	56
	2002	17	553	33
	2003	23	954	41
	2004	12	531	44
average 1985–2004		**35**	**1,262**	**37**
Eek Inlet	1988	3	49	16
	1989	4	115	29
	1990	4	44	11
	1991	14	754	54
	1992	12	295	25
	1993	12	260	22
	1994	16	448	28
	1995	11	292	27
	1996	16	739	46
	1997	13	520	40
	1998	17	601	35
	1999	25	657	26
	2000	13	223	17
	2001	5	124	25
	2002	8	245	31
	2003	7	153	22
	2004	8	236	30
average 1988–2004		**11**	**339**	**28**

Appendix D.–Numbers of Pacific salmon harvested in the subsistence fisheries located near Hydaburg by statistical week in 2004. A total harvest census was conducted by interviewing all fishery participants in the harbor and on the fishing grounds during the 2004 season.

Harvest area	Stat. week	Dates	Interviews on grounds	Interviews in harbor	Number of fish harvested, by speciesNu			
					Sockeye	Coho	Chum	Pink
Hetta Cove	27	6/27–7/03	1	2	76	--	--	--
	28	7/04–7/10	2	1	124	--	--	--
	29	7/11–7/17	2	--	43	--	--	--
	30	7/18–7/24	2	--	42	--	--	--
	31	7/25–7/31	--	3	85	--	--	--
	32	8/01–8/07	--	1	86	--	--	--
	33	8/08–8/14	--	6	174	--	--	--
	Total		**7**	**13**	**630**	**--**	**--**	**--**
Eek Inlet	28	7/04–7/10	--	--	--	--	--	--
	29	7/11–7/17	--	--	--	--	--	--
	30	7/18–7/24	3	2	173	--	--	14
	31	7/25–7/31	2	4	246	6	--	46
	32	8/01–8/07	3	1	112	12	--	30
	33	8/08–8/14	1		1	--	--	8
	Total		**10**	**9**	**594**	**18**	**--**	**98**
Hunter Bay	30	7/18–7/24	--	3	233	65		
	31	7/25–7/31	--	4	1,335	62		
	32	8/01–8/07	--	2	243	40		
	Total		**--**	**9**	**--**	**167**		
Kasook Inlet	36	8/29	**--**	**1**	**30**	**3**	**12**	**51**
Total all areas			**17**	**32**	**3,065**	**188**	**12**	**149**