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Coho Salmon Studies at Hugh Smith Lake, 1982–2007

by

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

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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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ABSTRACT

The coho salmon population at Hugh Smith Lake was monitored from 1982 to 2007 for smolt production, marine survival, return abundance, fishery exploitation and removal rates, and spawning escapement. Smolt estimates ranged from 19,902 to 53,227 fish (average 31,788); marine survival rates varied from 4.1 to 20.9% (average 12.3%). Smolt production and marine survival respectively accounted for 35% and 65% of variation in total returns. Total returns ranged from 1,346 to 9,464 adults (average 3,874). Smolt numbers trended nearly level. Marine survival trended downward; after peaking during 1990 to 1996 (average survival rate 17.2%; range 13.0–20.9%), the 2005–2007 average marine survival rate was 8.3% (range 6.8–9.1%). The stock is harvested by several gear types in Southeast Alaska and northern British Columbia. Average all-gear exploitation rates increased from 61.3% for 1982–1988 (range 50.2–65.2%) to 75.9% for 1989–1999 (range 68.2–82.0%), before declining to 54.9% for 2000–2007 (range 39.1–66.3%). Exploitation rates in the Alaska troll fishery were relatively level (averaging 36.5%), except for 2001–2003 (range 16.5–24.3%). Removal rates averaged higher (42.6%) in inside fisheries in the SE quadrant, compared within the fisheries initially encountered by the stock in the NW, NE and SW quadrants (34.6%). Escapement estimates ranged from 433 to 3,291 adult spawners (average 1,303). Of three spawner-recruit models tested, the Beverton-Holt model produced the best statistical fit to 23 paired estimates of brood year escapement and adult return, adjusted to average marine survival. Based on the results, we recommend that the current goal of 770 spawners (range 500–1,100) be increased to 850 spawners, and broadened to a range of 500–1,600 spawners. Forecasting methods for the stock's returns inseason and escapements are presented based on smolt estimates, tagging rates, coded-wire tag recoveries, exploitation rate estimates and weir counts.

Key words: coho salmon, Southeast Alaska, *Oncorhynchus kisutch*, escapement, escapement goals, smolts, marine survival, exploitation rates, removal rates, Hugh Smith Lake

INTRODUCTION

The coho salmon (*Oncorhynchus kisutch*) population in Hugh Smith Lake is one of four wild coho salmon stocks in Southeast Alaska that have been monitored for over 25 years. In the 1970s and 1980s, substantial concern arose among fishery managers about the sustainability of the region's coho salmon fisheries because of the extensive gauntlet of commercial troll, net and sport fisheries encountered by many stocks. In order to address this concern, juvenile marking and adult recovery projects were implemented to evaluate migration patterns, timing and exploitation rates. The studies were first carried out in inside areas of northern Southeast using fluorescent pigment to mark specific stocks (Gray et al. 1978) and were later expanded using coded wire tags to mark stocks in outer coastal and southern areas of the region (Shaul et al. 1985). In May 1982, a panel of salmon research experts was convened to chart the future of coho salmon research in Southeast Alaska (ADF&G 1983). The panel recommended that detailed, long-term studies be undertaken on specific streams in the region. Hugh Smith Lake was one of the systems recommended for long-term monitoring.

A detailed study of population and fishery parameters has been conducted at Hugh Smith Lake since 1982 (Shaul 1994, Shaul et al. 1985, 1986, 1991 and 2005) and an escapement goal was established in 1994 based on a Ricker spawner-recruit analysis by Clark et al. (1994). During 1982–2007, the stock has served as the primary indicator stock for management of wild coho salmon populations in the inside portion of southern Southeast Alaska. The annual count or estimate of spawners entering the system has been the only consistently gathered estimate of total escapement of any wild stock in the Ketchikan area. Since 1987, the total escapement estimate for Hugh Smith Lake has been supplemented by an index of peak helicopter survey counts on 14 additional systems in District 101 (Shaul and Tydingco 2006).

In this paper, we will update biological and fishery information collected for the stock since the early 1980s. We will review the current *biological escapement goal* developed by Clark et al. (1994) and recommend a revised goal based on (1) updated escapement and production data, (2) revised freshwater age estimates based recent aging validation work, and (3) spawner-recruit models that are more appropriate to coho salmon compared with the Ricker model. We will also examine the migratory characteristics of the stock and changes in rates and patterns of exploitation over a period of 2 ½ decades. Finally, we will present and discuss methods that have been developed to forecast the total number of returning adults and the spawning escapement to Hugh Smith Lake during the fishing season.

STUDY SITE

Hugh Smith Lake (55° 06' N, 134° 40' W) is located 97 km southeast of Ketchikan on the mainland of Southeast Alaska in Misty Fjords National Monument (Figure 1). The lake, referred to as Quadra Lake by J. F. Moser (1899), was later named Hugh Smith Lake for Hugh M. Smith (1865–1941) an early Commissioner of the U.S. Bureau of Fisheries (Orth 1967). The lake is organically stained, with a surface area of 320 ha, a mean depth of 70 m and a maximum depth of 121 m (Figure 2). It is meromictic, and water located below 60 m does not interact with the upper freshwater layer of the lake. It drains into Boca de Quadra inlet via 50-m long Sockeye Creek and is supplied by two major inlet streams: Buschmann Creek flows northwest 4 km to the head of the lake and Cobb Creek flows north 8 km to the southeast head of the lake. Cobb Creek has a barrier to anadromous migration approximately 0.8 km upstream from the lake.

The sockeye salmon (*Oncorhynchus nerka*) population attracted substantial interest by the early commercial fishing industry in Southeast Alaska and a cannery was built in Boca de Quadra in 1883. In 1897, the run was fished with 16 seines from 200 to 240 fathoms in length that were used to supply three canneries and a saltery with 137,000 sockeye salmon (Moser 1899). During 1895–1912, the reported Boca de Quadra sockeye salmon catch ranged from 42,804–209,799 fish (average 105,434 fish) but declined sharply after 1912 (Rich and Ball 1933). A hatchery for sockeye salmon was operated just east of Buschmann Creek from 1900 to 1936 (Roppel 1982).

Local coho salmon runs were also exploited by fisheries in Boca de Quadra with the reported harvest reaching a peak of 12,500 fish in 1908. However, interest in Hugh Smith Lake salmon stocks declined with depletion of the sockeye run and development of more mixed-stock fishing patterns throughout the region. In the late 1970s, the sockeye salmon population was recognized as a candidate for restoration and enhancement. An adult weir and a smolt weir were installed at the outlet and hydro acoustic surveys were conducted to monitor the status of the sockeye population and the effectiveness of enhancement efforts (Piston et al. 2006).

The advantage provided by an existing camp facility and weirs made the system a logical candidate for a long-term coho salmon research project in southern Southeast Alaska. Coho salmon rear in both inlet streams and around the shoreline of the lake. Much of the shoreline is relatively steep and rocky with limited vegetation, however, a large log-jam in the outlet area and numerous deadfalls and rock slides around the shoreline provide important habitat structure for rearing juveniles. Production from Hugh Smith Lake is relatively low compared with other Southeast Alaska lake systems for the amount of surface area (Shaul et al. 1985) and relatively low for the length of stream and shoreline area (Shaul and Van Alen 2001). Most returning adult coho salmon enter the lake from mid-August through late October and spawn from late October until early February (Shaul et al. 1985).

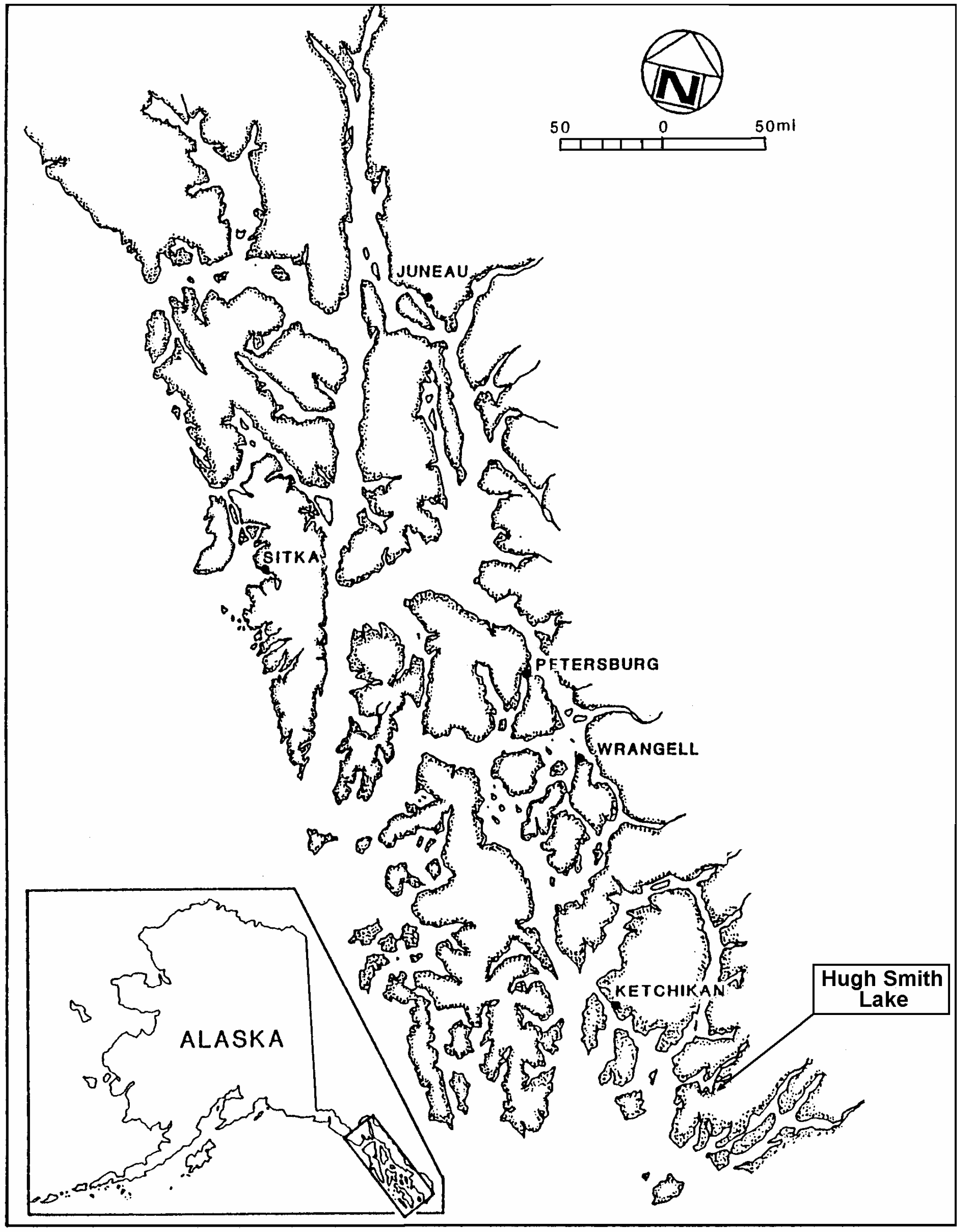

Figure 1.–The location of Hugh Smith Lake in Southeast Alaska.

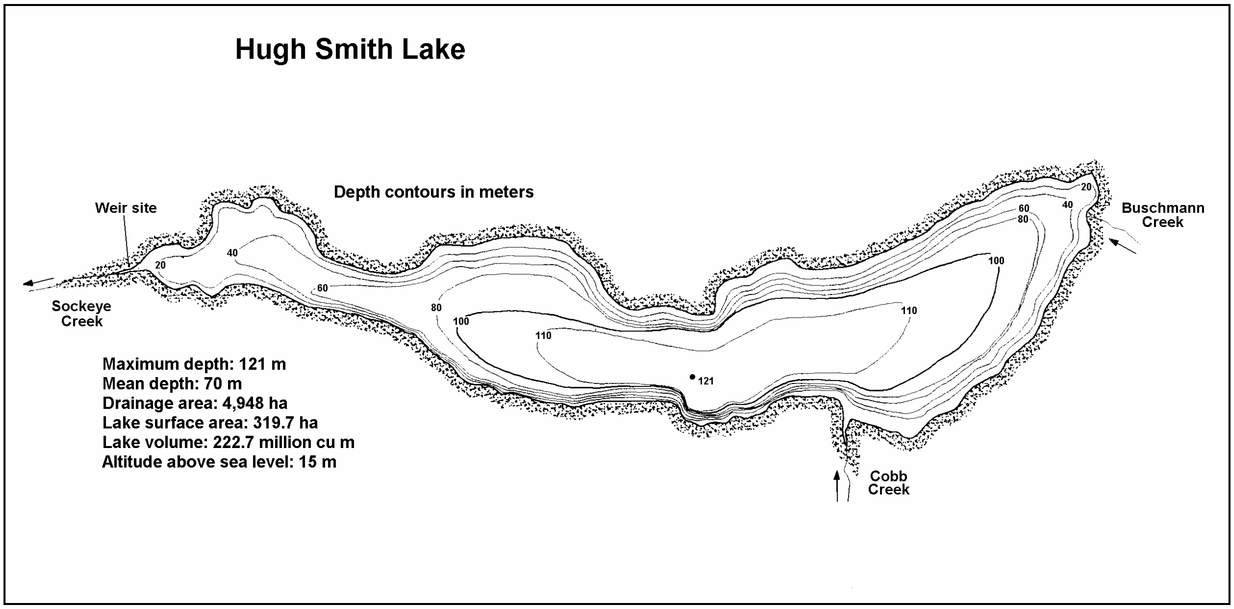

Figure 2.–Bathymetric map of Hugh Smith Lake, Southeast Alaska, showing the location of the weir site, location of inlet streams and other features of the lake system.

METHODS

Smolt Capture and Marking

A smolt weir was installed and operated annually at the outlet of Hugh Smith Lake (Figures 2 and 3). The channel was sealed as thoroughly as possible with 1/4" Vexar plastic mesh supported on 3" ABS plastic pipe frames in the main channel and by vertically driven 10' stakes of ¾" EMT conduit near the margins (Olmsted 1998). The panels and stakes were supported by ½" cable stretched and anchored to large rocks on the banks and a large stump lodged in the channel near the west shore. The vertical dimension of the panels was sized from 1.7 to 3.2 m and the panels were arranged to approximate bottom contour. They were attached together at the ends in a rigid fashion with a section of ¾" EMT pipe driven through two eye bolts mounted on each pipe frame. The panels were assembled together in proper order while floating upstream of the cable and were tipped into a nearly vertical position (slanted somewhat downstream) by applying sand bags to a bottom skirt and using the pressure of the current. An incline plane trap mounted on foam-filled wooden pontoons was installed near the middle of the group of panels, with a short panel spanning the gap under the trap. Vexar skirts attached to the bottom and sides of the panels were used to seal gaps between panels and the bottom, the incline plane trap and other panels. One panel section had an opening that tapered in a cone shape on the upstream side. The opening was covered with a solid cone which was removed periodically to allow adult steelhead to pass upstream through the weir while the opening was under observation.

Installation of the smolt weir was usually accomplished with two people in snorkel gear and dry suits working in the water with another person assisting from a boat or floating platform. The bottom of the skirt and fence was sealed with sandbags from shore to shore. Wherever possible, sunken woody debris was cleared before positioning and sealing the bottom of the weir. After installation, the weir was periodically inspected for holes.

Coho smolts captured in the trap were usually netted in a dip net and transferred to floating net pens while most sockeye smolts and other species were sorted and released. However, during occasions when sockeye smolts were very abundant and greatly outnumbered coho smolts, some coho salmon were counted and released directly from the dipnet in order to avoid excessive fish stress and labor during sorting. Before release, smolts larger than 80 mm in snout-to-fork length were carried in buckets to the tagging shed where they were anesthetized, adipose clipped and coded-wire tagged using methods described by Magnus et al. (2006).

ESCAPEMENT ESTIMATION AND SAMPLING

An adult salmon weir was operated during 1982–2007 at a point in the outlet just downstream from the location of the smolt weir (Figure 3). The weir and its trap were constructed of vertical pickets of 3/4" EMT conduit supported in three 8' sections of aluminum channel drilled to accommodate 43 evenly spaced pickets per section, with a larger hole on each end for 1 ½ " inside diameter black iron pipe. To provide extra height in high water, the weir was extended from the top of the pickets to the catwalk handrail using a 2" x 2" 12 gauge galvanized hardware cloth. During 1982–2007, the weir structure was supported every 8' by wooden tripods that were replaced in 1989 with a much stronger aluminum bipod structure.

Figure 3.–The outlet of Hugh Smith Lake showing the smolt weir and the adult weir support structure.

The weir was installed annually in early June to mid-June to enumerate sockeye salmon, well before the first adult coho salmon arrived in the system. The weir operation was terminated between late October and late November depending on run timing and stream flow. Fish remaining in Sockeye Creek downstream of the weir were counted before the weir was removed and were added to the count. In recent years, 4–6 mil clear plastic sheeting has been applied to the upstream face of the weir during low-flow conditions to concentrate flow and draw fish into the trap. This measure has reduced the number of fish remaining downstream at the end of the weir operation.

Freshets accompanied by extreme flows are common in the fall at this location. Provisions were made for a mark-recapture estimate as insurance against incomplete escapement figures caused by a breach or failure of the weir structure. All healthy coho salmon that passed through the weir were captured in an 8’x 8’ trap, sampled for coded-wire tags and marked with an appropriate mark before being released upstream.

In earlier years of the project, mark recovery sampling was conducted only when problems occurred with the weir that likely allowed fish to pass uncounted. In some years when a problem was evident, fish were sampled for tags on the spawning grounds from late October until early February, necessitating return trips to the lake. In more recent years, limited sampling for marks was conducted routinely before the weir was removed in late October and early November to test for leakage of fish through the weir. During that time, the earlier spawners in Cobb Creek were usually captured with a beach seine or dipnet while later spawning fish holding in the lake off Buschmann Creek were sampled using spinning rods and assorted spoons and spinners. All fish sampled above the weir were given a single left opercular punch for a secondary mark and released. All marks (ad clip, left or right ventral clip, dorsal clip, opercular punch) on new recovery samples were recorded and the fish were classified as adults (age .1) or jacks (age .0).

Methods of estimation varied and additional details for specific years are given in the results section. In 1982 and 1983, fish were tagged with numbered floy tags (Shaul et al. 1985 and 1986). A stratified estimate of the 1982 escapement was generated using the technique developed by Schaefer (1951). In later years, most estimates were made using a single stratum estimator based on Chapman’s modification of Petersen’s estimator for closed populations (Seber 1982, p. 60).

A strategy was settled upon in which three fin marks were used to represent different periods that corresponded to historical average thirds of the run (beginning through Sept. 15, Sept 16–Oct. 6, Oct 7 through end). The marks used for each of these periods were a partial dorsal clip, a left ventral clip and a right ventral clip, respectively. The dorsal clip was accomplished by shearing the posterior three rays of the dorsal fin with wire cutters approximately 1 cm above the fish's back.

Commonly, unmarked spawners were thought to have escaped during a specific identifiable period when there was an evident opportunity for fish to pass the weir unmarked. In those cases, a Chapman estimate could be made based only on unmarked fish and those marked during the period of concern. Fish marked at the weir during the two other periods were assumed to represent a complete census of escapement during those periods and were added to the Chapman estimate.

A Chapman estimate was usually used in cases where apparent escapees could not be identified from a specific period. Selection of the Chapman estimator was based on 1982 and 1983 findings using numbered tags that indicated relatively low bias in a single stratum estimator, assuming that unmarked fish are not concentrated particularly early or late in the run and that all run segments can be sampled on the spawning ground. However, a mark-recapture estimate was not used in 1991 when the weir was largely destroyed late in the run and even recovery sampling of spawners was not accomplished. In that case, the count during the period of effective weir operation encompassing most of the run was divided by the average proportion counted during that period in years when the weir was effectively operated throughout the run.

During 1982–1984, ending dates for the weir operation ranged from November 26–30. During 1987–1992, the ending date was moved a month earlier to October 20–28 based on observations that few if any spawners entered the system from saltwater after late October. During 1993–2007, the operation was extended slightly to end during November 1–8 to help insure a thorough count and to provide the crew an opportunity to sample enough spawners for marks (minimum target 50 fish) above the weir to validate its effectiveness.

A record was made of every individual coho salmon captured in the weir trap. Fish were classified by sex and as jacks or adults based on length. Initially, males under 450 mm (mid eye to fork length) were classified as jacks while females and larger males were classified as adults. However, the length distribution of early migrants was plotted and a different (usually smaller) length criterion was applied in some years when fish were unusually small, based on the least frequently observed length occurring between the peaks for age .0 jacks and age .1 adults. In 1993, for example, the length used to discriminate between jacks and adults was reduced to 410 mm. Males between 410 mm and 450 mm classified as jacks before the change was made were then reclassified as adults. Counts of jacks were likely incomplete in all years because smaller jacks were often small enough to pass between the pickets.

All coho salmon that were captured in the trap were sampled for the presence or absence of an adipose fin. In initial years of the project during 1982–1985, a sample of 20–50 adipose clipped adults was sacrificed, a numbered cinch tag was attached to each head, and the heads were sent to the ADF&G Mark, Tag and Age Laboratory in Juneau for tag removal and decoding. These small samples limited the sampling mortality impact on the spawning population but provided a relatively imprecise estimate of tag retention. During 1986–2002, all adipose clipped fish were examined with a magnetic field detector to determine if a tag was present. A trough style detector was used in earlier years prior to development of a more portable and water resistant wand detector. Before 2003, fish that did not elicit a consistent signal on the magnetic field detector were sacrificed and their heads sent to the laboratory for further examination while those that elicited a consistent signal were released. Based on examination in the laboratory, experienced crews using a wand detector were found to accurately determine the absence of tag. Therefore, all adipose clipped fish examined after 2002 were released live after sampling with the wand. Thereafter, marked fish that did not register a positive signal on the detector were assumed not to have a tag and were released rather than sacrificed.

The total season objective for age-length-sex samples was 600 adults distributed as evenly as possible throughout the run. In earlier years, the sampling rate was initially established near 100% at the beginning of the run and reduced with evidence that the escapement was substantially larger than the season goal. Beginning in the mid–1990s, a total goal of 630 samples from adults and jacks combined was apportioned across fixed weekly targets based on average run timing. Samples were selected randomly between adults and jacks.

Each fish sampled for age-length-sex was anesthetized in a solution of tricaine methanesulfonate (MS-222) or clove oil (Woolsey et al. 2004), placed in a padded measuring trough and measured to the nearest millimeter (mid eye to fork length). Four scales were taken from the left side of the fish approximately two rows above the lateral line in an area posterior of the dorsal fin to anterior of the anal fin (INPFC 1963). Scales were mounted on gum cards and impressions were later made in cellulose acetate (Clutter and Whitesel 1956).

ESTIMATION OF SMOLT PRODUCTION AND HARVEST

Returning adults were sampled for coded-wire tags to generate a Chapman estimate of the smolt migration and to estimate the proportion of each population that carried coded-wire tags implanted at Hugh Smith Lake (Θ). The estimated harvest of coded-wire tagged fish was then divided by $\hat{\theta}$ to estimate the total contribution of each stock by area, time and gear type.

Estimation of Smolt Abundance

The abundance of coho salmon smolts (NS) was estimated using Chapman's modification of Petersen's estimator for closed populations in equation 1 (Seber 1982, p. 60). A sample of smolts was marked and tagged and a combined sample of jacks returning the same year and adults returning the following year was inspected for marks. During the period at sea the population was open to mortality but was assumed closed to recruitment.

$$\hat{N}_S = \frac{(M+1)(C+1)}{(R+1)} - 1 \qquad (1)$$

where *M* is the number of smolts marked and released in a year and *R* is the number of adipose clip marks in a sample of *C* returning spawners inspected for marks.

In this equation, *R* is the random variable, and *C* and *M* are assumed to be constants. In mark-recapture sampling, *R* follows a hypergeometric distribution by definition, which can be approximated with the Poisson distribution (Thompson 1992). By simplifying the Petersen mark-recapture equation, we have

$$\frac{1}{\hat{N}_S} \approx \frac{R}{CM}. \qquad (2)$$

In the Poisson approximation for *R*, the mean and variance are the same, so that the variance (var), standard error (SE), and coefficient of variation (CV) of $\frac{1}{\hat{N}}$ are calculated as follows:

$$\text{var}\left(\frac{1}{\hat{N}_S}\right) \approx \frac{R}{(CM)^2}; \qquad (3)$$

$$\text{SE}\left(\frac{1}{\hat{N}_S}\right) = \frac{\sqrt{R}}{CM}\text{; and,} \qquad (4)$$

$$\text{CV}\left(\frac{1}{\hat{N}_S}\right) = \frac{1}{\sqrt{R}} \cdot 100. \qquad (5)$$

If the numbers of mark-recoveries are moderate or large, the pooled Petersen estimate should meet the criteria outlined above. The distribution for *R* can then be approximated with the normal distribution. Under these circumstances, we will assume $\frac{1}{\hat{N}_S}$ is approximately normally distributed, and we will generate 95% confidence intervals for $\frac{1}{N_S}$ as,

$$\frac{1}{\hat{N}_S} \pm 1.96 \cdot \mathrm{SE}(\frac{1}{\hat{N}_S}) . \tag{6}$$

Finally, 95% confidence intervals for N_S were generated by inverting the confidence intervals for $\frac{1}{N_S}$.

Estimation of Harvest

The harvest (H) of Hugh Smith Lake coho salmon in mixed-stock fisheries was estimated from recoveries of coded-wire tags. Data on recoveries in Alaskan fisheries were obtained from a computer database maintained by the ADF&G Mark, Tag, and Age Lab located in Juneau. Recovery data for Canadian fisheries was downloaded from the Regional Mark Processing Center database maintained by the Pacific States Marine Fisheries Commission. Methods described in Bernard and Clark (1996; Table 2) were used to estimate the commercial and marine sport harvest of coho salmon from Hugh Smith Lake using information from stratified catch sampling programs. Commercial catch and sample data for Alaska net fisheries were summarized by ADF&G statistical week and district (Figure 4). Tag recoveries from the Alaska troll fishery were expanded by period and quadrant for most basic parameter estimates but by statistical week and quadrant for analysis of harvest timing. Tag recoveries from random dockside sampling of the marine sport harvest were expanded by port over biweekly periods. Tag recoveries from troll and net fisheries in British Columbia were expanded by gear type, catch region and statistical week.

Resultant estimates of the harvest of coded-wire tags were divided by the proportion tagged ($\hat{\theta}$) to estimate the contribution by the stock to the fishery in each stratum.

Estimation of Run Size, Exploitation Rate and Marine Survival

Estimates of the run size (N_A) of coho salmon returning to the Hugh Smith Lake and the associated exploitation rates (U) in commercial and sport fisheries are based on the sum of estimates of harvest (H) and escapement (E):

$$\hat{N}_A = \hat{H} + \hat{E} \tag{7}$$

$$\hat{U} = \frac{\hat{H}}{\hat{H} + \hat{E}} \tag{8}$$

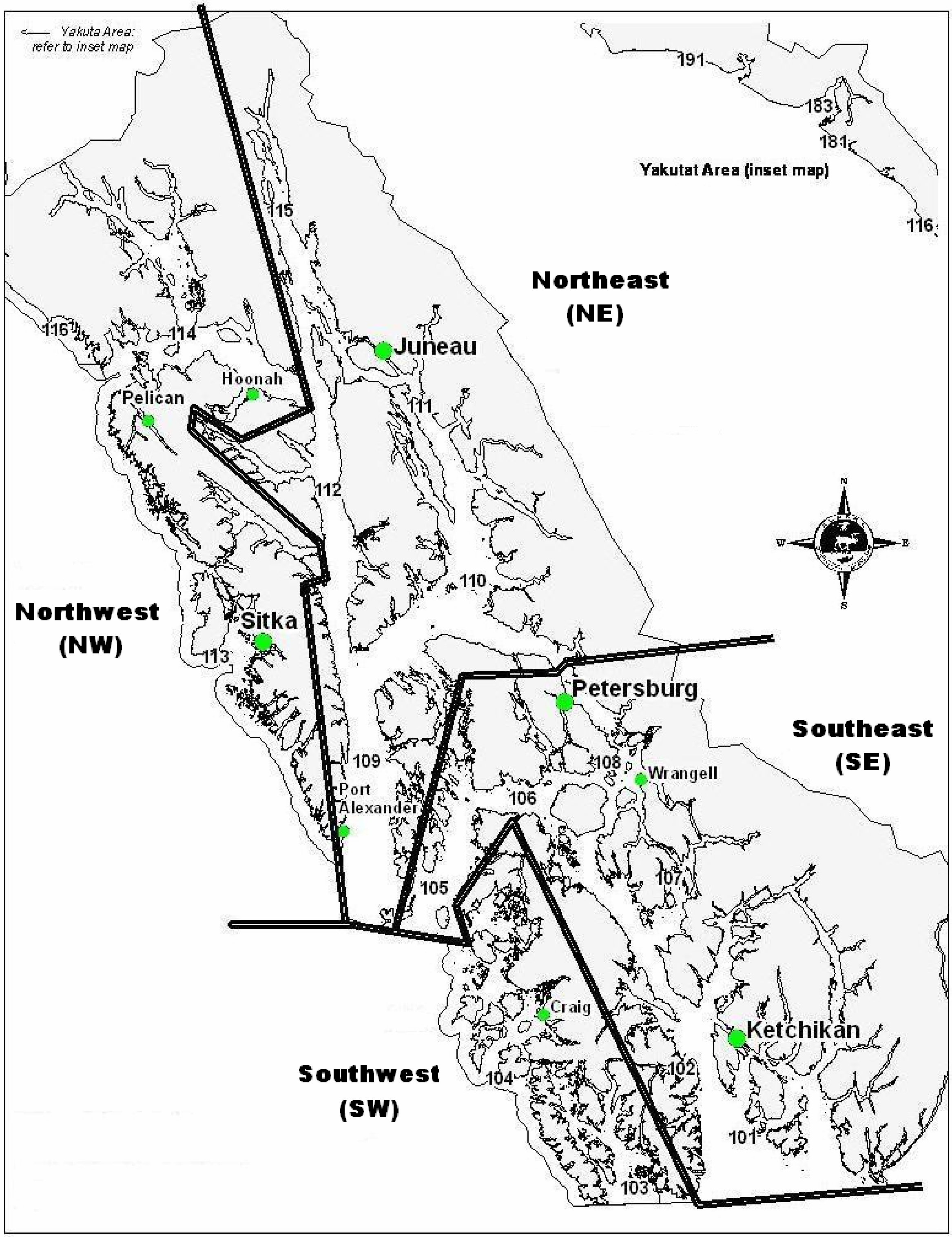

Figure 4.–Map of Southeast Alaska showing fishing districts used to expand seine and gillnet coded-wire tag recoveries, quadrants used to expand troll recoveries and ports used to expand marine sport fishery recoveries.

Survival rate of smolts to adults (μ) was estimated as:

$$\hat{\mu} = \frac{\hat{N}_A}{\hat{N}_S} \qquad (9)$$

Estimation of Removal Rates

The removal rate is defined as the total harvest within a specific fishery divided by the total number of fish available to that fishery. The number of available fish is the total return (N_A) minus fish harvested in preceding fisheries.

The removal rate provides a more accurate measure than the exploitation rate of a fishery's relative impact on escapement in isolation from other fisheries. The advantage of comparing removal rates is that they provide an objective comparison of how relative management changes in specific fisheries will likely affect escapement. For example, in a series of three fisheries that each exert a 25% exploitation rate totaling 75%, a 5% reduction (from 25% to 20%) in the exploitation rate by the first fishery in the sequence will increase escapement by 5% while the same exploitation rate reduction in the third fishery will increase escapement by 10% because the third fishery removes its harvest from the remaining 50% of the original run. Any fish that escape the third fishery will likely enter the system to spawn while half of the savings from the same reduction in the first fishery likely will be reallocated to catch in the remaining two fisheries, with only half expected to pass through to spawn. A comparable 5% reduction in the intermediate fishery would increase escapement by 6.7%. These calculations assume no effort response by downstream fisheries to changes in abundance.

It is necessary to assume a direction of migration in order to estimate removal rates. For this analysis, the direction of migration of Hugh Smith Lake coho salmon was assumed to be the most direct route from the open ocean toward the system of origin through three sequential fishing areas. The stock was assumed to be available first in outer coastal and northern areas of the region included within the NW, NE and SW quadrants before passing through northern British Columbia waters and finally through waters of the SE quadrant surrounding the natal system. This sequence is supported by harvest timing of the stock in the three respective areas, although some returning Hugh Smith Lake fish likely pass directly from the NE and SW quadrants into the SE quadrant via Sumner Strait north of Prince of Wales Island without exposure to British Columbia fisheries.

The removal rate in the first fishing area (R_1) is the same as the exploitation rate in that area (U_1). For subsequent fisheries where i>1, R_i was estimated as follows:

$$\hat{R}_i = \frac{\hat{U}_i}{1 - \Sigma U_{i-1}}$$

Spawner-Recruit Analysis

We evaluated the spawner-recruit relationship for Hugh Smith Lake coho salmon by applying three models (logistic hockey stick, Beverton-Holt and Ricker) to paired estimates of spawning escapement and production.

In order to filter out variation in marine survival, which was assumed to be density independent, we adjusted adult returns to reflect a constant average marine survival rate. This was accomplished by dividing estimated adult production in a particular return year by the corresponding estimated smolt–adult survival rate, and multiplying the result by the average survival rate for all years. Age composition estimates based on scale samples taken at the weir were then applied to apportion total adult production by brood year. In effect, we estimated smolt production by brood year and converted smolts to adults (based on average survival) to compute the brood year return.

The simple hockey stick model (Barrowman and Myers 2000) transitions abruptly from a proportionate response by production to escapement (at low population sizes) to a constant return independent of escapement above a fixed reference point. Bradford et al. (2000) applied the model to 14 coho salmon populations in from Oregon to southern British Columbia. Although the simple hockey stick (HS) model transitions abruptly between these functions, a logistic version allows a smoother transition. We applied the logistic hockey stick (LHS) model using the method presented by Barrowman and Myers (2000).

The second model applied was the Beverton–Holt model based on methods described in Beverton and Holt (1957). This model is compatible with data sets that show an overall positive relationship between escapement and production, without overcompensation. Barrowman et al. (2003) fitted the Beverton–Holt model to the same coho salmon stocks analyzed by Bradford et al. (2000) using the HS model. While both models adequately described the spawner-recruit relationship for many stocks, each appeared to fit better for specific stocks.

Finally, for comparison, we applied the Ricker model that has been widely used for salmon populations based on the methods presented in Ricker (1975). The Ricker model has an overcompensation feature that predicts declining production from higher levels of escapement above a peak population size. However, overcompensation appears inconsistent with most spawner–recruit datasets for coho salmon (Barrowman et al. (2003).

RESULTS

SMOLT ESTIMATES

The first smolt abundance estimate for the Hugh Smith Lake coho salmon stock was made in 1982 and estimates during 1982–2006 have averaged 31,788 fish with a range from 19,902 fish in 1999 to 53,227 fish in 1983 (Table 1). Smolt production has been relatively stable (Figure 5). However, a robust trend computed after Geiger and Zhang (2002) indicates a very slight linear rate of decline of about 0.2% per year or 4.8% (1,452 smolts) over the entire 25-year period. The relative precision ($p = 0.05$) of estimates has improved substantially over time from an average of 16% in for the first 10 years in the data series (1982–1991) to 7% in the most recent 10-year period (1997–2006).

The efficiency of the weir in capturing smolts for counting was dependent in part on how well the vexar skirt was sealed against the lake bottom. Also, efficiency was adversely affected by occasional holes opened in panels caused by otter activity or drifting logs, as well as water flowing over the weir during extreme freshets. In addition, some fry or juveniles may emigrate from the system and rear in marine waters or in other stream systems before returning to spawn (Crabtree et al. (*in prep*). To the extent that this life history pattern occurs, it may also contribute to higher mark-recapture estimates relative to weir counts.

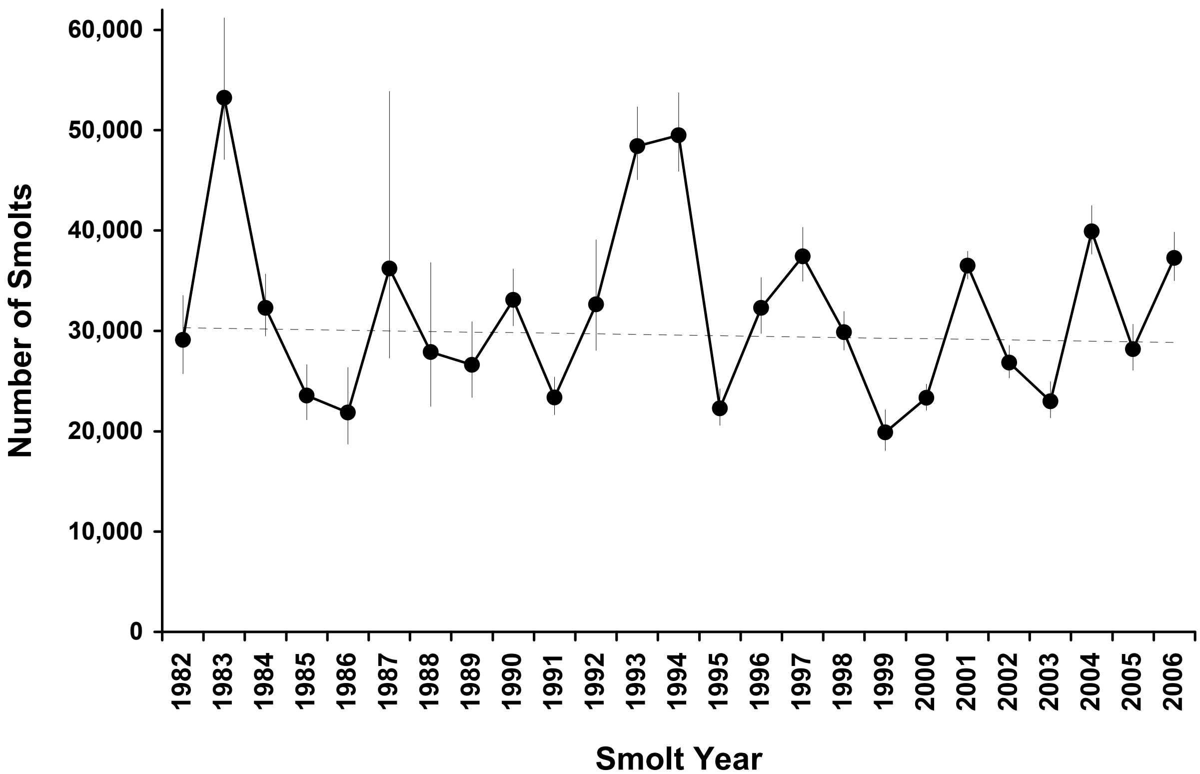

Figure 5.–Estimated coho salmon smolt production from Hugh Smith Lake with 95% confidence bounds showing a robust trend (dashed line).

ESCAPEMENT ESTIMATES

Efforts to obtain a complete count of the coho salmon escapement to Hugh Smith Lake met with mixed success. Mark-recapture estimation was critical to obtaining a complete accounting of escapement in many years. Before 1989, pickets occasionally had to be removed during severe flooding conditions to reduce pressure and risk of structural failure. Use of an aluminum bipod structure beginning in 1989 greatly improved the strength of the weir and eliminated most events in which a large fraction of the run escaped uncounted.

During the first year of operation in 1982, the weir was non-functional for 63 hours during October 9–12. Shaul et al. (1985) applied a Schaefer estimator (Schaefer 1951) that indicated about 60% of the total adult escapement had entered the system uncounted (Tables 2 and 3). The Schaefer estimate of 2,144 adults was lower than the single stratum Peterson estimate of 2,302 adults but used because it was likely less biased. Schaefer (1951) provided no method for computing confidence bounds but an estimate of variance based on a single stratum estimator suggests a 95% confidence range from 1,775–2,513 spawners.

Table 1.–Annual Hugh Smith Lake coho salmon smolt weir counts and total population estimates in 1982–2006 and estimated survival to adulthood the following year.

Smolt Year	Smolt Weir Count	Number Marked (M)	Returns Sampled (C)	Adjusted Ad Clips (R)[a]	Smolt Estimate (N)	95% C.I. Lower Bound	95% C.I. Upper Bound	Marine Survival (%)	Total Adult Return
1982	5,925	5,573	1,160	221	29,117	25,738	33,519	13.3	3,875
1983	27,552	9,647	1,242	224	53,227	47,087	61,209	7.6	4,024
1984	22,803	16,928	806	422	32,283	29,474	35,683	7.6	2,440
1985	11,111	9,833	692	288	23,572	21,136	26,643	18.5	4,365
1986	6,819	5,716	508	132	21,878	18,705	26,349	10.3	2,244
1987	4,965	4,819	262	34	36,218	27,276	53,883	4.1	1,473
1988	5,319	5,292	341	64	27,904	22,463	36,824	8.6	2,404
1989	7,187	7,187	736	198	26,620	23,376	30,910	18.0	4,794
1990	11,106	11,106	1,582	530	33,101	30,507	36,177	17.4	5,767
1991	13,371	13,269	1,059	601	23,373	21,643	25,402	20.9	4,895
1992	5,519	5,514	835	140	32,657	28,042	39,092	13.0	4,242
1993	19,422	19,401	1,719	688	48,434	45,069	52,341	19.5	9,464
1994	15,993	15,941	1,919	617	49,516	45,898	53,752	13.5	6,708
1995	12,586	12,585	1,034	584	22,267	20,597	24,230	17.7	3,948
1996	24,243	24,220	699	524	32,294	29,748	35,316	8.3	2,696
1997	26,791	26,367	1,061	747	37,436	34,932	40,327	11.7	4,371
1998	20,522	20,213	1,370	927	29,875	28,068	31,930	14.1	4,221
1999	12,001	11,999	616	371	19,902	18,066	22,154	6.8	1,346
2000	19,668	19,663	1,443	1,216	23,327	22,086	24,716	13.4	3,119
2001	30,335	29,388	3,282	2,643	36,487	35,147	37,933	14.8	5,406
2002	19,326	18,935	1,497	1,056	26,841	25,315	28,564	13.7	3,676
2003	16,317	15,572	929	629	22,997	21,331	24,946	10.8	2,492
2004	24,379	23,517	1,807	1,064	39,924	37,662	42,476	9.1	3,652
2005	17,799	17,795	935	590	28,184	26,080	30,656	6.8	1,926
2006	26,128	25,375	1,339	911	37,267	34,996	39,854	8.9	3,310
Avg.	16,287	15,034	1,155	617	31,788	28,818	35,795	12.3	3,874

[a] Number of adipose clipped fish in escapement samples multiplied by the fraction of total observed tag recoveries in fisheries and escapement from smolts tagged in the year shown.

In 1983, another freshet resulted in the weir being out of operation for about 45 hours near the peak of the run on Sept. 25–27. Shaul et al. (1986) reported a Schaefer estimate of 1,490 adults which was very close to a Chapman estimate of 1,487 adults. On reviewing the estimates, we elected to use the Chapman estimate with its associated 95% confidence range from 1,284 to 1,767 fish. About 21% of the escapement was estimated to have passed uncounted.

No evident problems with the integrity of the weir were noted during 1984 and 1985 but no recapture sampling was conducted to validate the estimate in those years or in the first two seasons after installation of the aluminum bipod structure (1989 and 1990). However, serious problems with freshets occurred during critical periods of the run in 1986 and 1987.

In 1986, the weir was ineffective for 32 hours during October 6–7. Mark-recovery sampling was conducted that resulted in a Chapman estimate of 1,782 adults (95% C.I. 1,370–2,555) which indicated that about 60% of the run passed uncounted. A similar problem occurred during 1987 within a shorter period (18 hours) but earlier in the season (September 30–October 1) and closer to the normal peak of the run. A relatively imprecise estimate of the 1987 escapement (1,117 adults; 95% C.I. 754–2,170) was made using the Chapman estimator, indicating that about 35% of adults escaped uncounted. Efforts at mark-recovery sampling in 1986 and 1987 were considerably less successful during return trips to the lake than in 1982 and 1983. In 1987, only 37 samples were obtained during trips to the spawning grounds during December 10–11 and January 20.

The weir was operated without evident problems during the last year of the old weir structure in 1988, and during 1989 and 1990 when the new aluminum bipod structure was in place. The new weir greatly reduced the potential for structural failure and could be operated with all pickets in place through severe freshets. The new weir also provided superior support for the wire extension above the pickets and held fish back more reliably during extreme flows that topped the pickets. These features reduced dependence on less precise mark-recapture estimates.

In 1991, however, the weir was heavily damaged and became ineffective during an extreme freshet on October 11. Approximately 35 logs floated downstream from a logjam in the lower lake and lodged against the weir. The structure remained in place, in part because pickets vibrated in the strong current and cored into the granite bedrock, but a gap that enabled fish passage developed under a bipod that had tipped backward under the stress. Recovery sampling of adult spawners in and around the inlet streams during October 17–23 and November 20–22 yielded 190 adult samples of which 165 fish were marked with partial adipose clips applied at the weir. The Chapman estimator produced a relatively precise escapement estimate of 1,647 (95% C.I. 1,430–1,942) adults.

However, marks on 1991 spawners were clearly concentrated in the early and middle portions of the run whereas recovery sampling was also concentrated on earlier spawners. We examined the potential for bias in the 1991 estimate based on an examination of the detailed 1982 marking and recovery data using numbered tags (Shaul et al. 1985) and concluded there was a probable 15% negative bias in the 1991 Chapman estimate. Since the breach occurred relatively late in the run, we divided the escapement count through October 11 by the average proportion (77.9%) of escapement through that date for 19 years in which precise counts or estimates were available (1984–1985, 1989–1990 and 1993–2007). The resultant escapement estimate of 1,836 spawners (95% C.I. 1,482–2,414) was 4% lower than an estimate of 1,908 spawners made by correcting for bias in the proportion marked, as suggested from 1982 marking and recovery results.

We elected to use the average proportion estimate based on average run timing instead of the mark-recapture estimate for the 1991 escapement. In all other years, mark-recapture estimates were used whenever they suggested that fish had migrated past the weir uncounted.

Based on the difficulty in obtaining an unbiased single-stratum estimate in 1991, three fin clips were applied in later years to early, middle and late portions of the run including a partial dorsal clip through September 15, a left ventral clip during September 16–October 6 and a right ventral clip after October 6. Application of varying marks over the run was aimed at generating an unbiased stratified estimate of the total annual escapement.

Table 2.–Total weir count of adult coho salmon spawners at Hugh Smith Lake, 1982–2007 with mark-recapture summary statistics and the estimated percent marked with coded-wire tags (Θ).

Year	Weir Ending Date	Weir Count	Alternative Estimate[a]	Best Estimate	95% C.I. Lower Bound	95% C.I. Upper Bound	Estimated Percent Uncounted	Mark-Recapture Statistics Number Marked	Mark-Recapture Statistics Number Sampled	Mark-Recapture Statistics #Marks Recovered	Percent w/CWTs (Θ)
1982	26-Nov	852	2,144	2,144	1,775	2,513	60.3	821	237	84	10.22
1983	30-Nov	1,180	1,487	1,487	1,284	1,767	20.6	1,117	192	147	23.72
1984	26-Nov	1,407	None	1,407	—	—	—	1,133	—	—	17.78
1985	11-Nov	903	None	903	—	—	—	772	—	—	52.84
1986	28-Oct	718	1,782	1,782	1,370	2,555	59.7	542	137	40	41.49
1987	21-Oct	722	1,117	1,117	754	2,170	35.3	465	37	15	26.05
1988	20-Oct	513	None	513	—	—	—	303	7	0	13.25
1989	24-Oct	433	None	433	—	—	—	301	—	—	16.78
1990	23-Oct	870	None	870	—	—	—	700	—	—	26.56
1991	11-Oct	1,431	1,836	1,836	1,482	2,414	22.1	1,427	190	165	33.88
1992	25-Oct	1,020	1,426	1,426	1,049	2,226	28.5	969	43	29	56.23
1993	4-Nov	832	832	832	688	1,063	0.0	768	72	72	16.48
1994	1-Nov	1,679	1,753	1,753	1,641	1,945	4.2	1,611	117	108	39.63
1995	3-Nov	1,781	1,781	1,781	1,448	2,318	0.0	1,756	70	70	31.91
1996	4-Nov	950	958	950	822	1,163	0.9	811	100	98	56.28
1997	4-Nov	732	732	732	588	988	0.0	657	49	49	75.38
1998	8-Nov	983	983	983	767	1,370	0.0	981	48	48	69.93
1999	8-Nov	1,246	1,246	1,246	979	1,721	0.0	1,221	49	49	67.32
2000	2-Nov	600	600	600	434	974	0.0	599	26	26	59.77
2001	1-Nov	1,340	1,580	1,580	1,460	1,844	15.2	343	35	27	83.95
2002	4-Nov	3,291	3,291	3,291	2,705	4,206	0.0	3,260	80	80	81.56
2003	8-Nov	1,440	1,510	1,510	1,320	1,764	4.6	1,426	191	182	70.87
2004	2-Nov	826	840	840	684	1,089	1.7	826	74	73	66.38
2005	5-Nov	1,685	1,732	1,732	1,558	2,067	2.7	669	41	38	57.91
2006	5-Nov	891	917	891			2.8	314	10	9	63.19
2007	4-Nov	1,244	1,284	1,244			3.1	714	32	30	68.82

[a] Alternative estimates to the weir count were based on the mark–recapture technique in all years except 1991 when the count through October 11 was expanded by dividing by the cumulative count by the average proportion counted through that date in 19 years during which there were precise total counts or estimates.

In practice, however, it has often been possible to apply a single stratum estimate to a portion of the run because breaches in the weir that allowed unaccounted escapement were usually limited to brief identifiable periods. A 100 percent marking policy at the weir made it possible to generate a Chapman estimate for the period in which a breach occurred using a recapture sample consisting only of unmarked fish and marks applied during the period of the breach, and adding the number of fish marked at the weir in the other two periods. In cases when a limited breach occurred in the early or middle portion of the run, this strategy made it possible to avoid difficult and expensive sampling trips for December and January spawners.

Table 3.–Observed operational problems during the late summer and fall at Hugh Smith Lake Weir.

Year	Observed Problem(s)
1982	Weir out 63 hrs. during flood during Oct. 9–12; Schaefer estimate from Shaul et al. (1985).
1983	Weir out 45 hrs. during flood during Sept. 25–27; Schaefer estimate from Shaul et al. (1986).
1984	Weir out 24 hrs. during flood during Nov. 22–23. An estimated 200 fish holding behind weir were assumed to have escaped uncounted. One Whitman Lake stray was removed from count.
1985	None.
1986	Weir out 32 hrs. during flood during Oct. 6–7.
1987	Weir out 18 hrs. during flood on Sept. 30–Oct. 1.
1988	Weir out 7.5 hrs. on Sept. 27, estimate from before and after downstream count.
1989	None —new bipod weir installed.
1990	None.
1991	Weir destroyed on October 11 by 35 logs; run timing estimator used based on 1982–1985 and 1989–1990 average proportion counted through October 11. Mark-recapture estimate, 1,647 (95% C.I. 1,430–1,942) was likely biased low because escapees came from the late part of the run, while sampling in Oct. 17–23 and Nov. 20–22 was biased toward early spawners.
1992	Hole in weir for unknown duration during flood (Sept. 28–Oct.1).
1993	None.
1994	Hole discovered on Sept. 15 (duration unknown).
1995	None.
1996	No obvious problem; 8 known passed unmarked at weir; used count instead of modified Peterson (pooled 1st two periods).
1997	No evident breaches in the weir.
1998	No evident breaches in the weir.
1999	No evident breaches in the weir.
2000	No evident breaches in the weir.
2001	No evident breaches in the weir; assume unmarked fish passed before September 16.
2002	No evident breaches in the weir.
2003	Extreme flood on October 26; several holes for unknown duration (Oct. 26–28)
2004	No evident breaches in the weir.
2005	No evident breaches in the weir; assume unmarked fish passed before September 16 with sockeye salmon.
2006	No evident breaches in the weir; assume unmarked fish passed before September 16 with sockeye salmon.
2007	No evident breaches in the weir; 4 adults passed unmarked so used count; two sections slid 15 cm downstream in the highest flood.

In later years, large numbers of enhanced sockeye salmon were passed through the weir in August without being detained in the trap. Occasional coho salmon were counted but not marked during periods of heavy sockeye passage, while others may have been misidentified as sockeye salmon. In those cases, all unmarked fish in the mark recovery sample were assumed to have passed the weir in the first marking period unless an identifiable breach had occurred in a later period. A double trap consisting of two side-by-side enclosures was installed beginning in 2006 in order to better control the flow of fish and allow for a better opportunity to identify fish passing through the trap. The fish passed from one trap into the other before exiting through an opening upstream which gave the crew time to identify coho salmon and close the trap and net them out before resuming passage of other species.

The combined weir count and downstream count was used instead of a mark-recapture estimate in cases were unmarked fish in the recovery sample occurred at a rate that was consistent with the proportion of unmarked fish observed passing the weir.

In 2003, a severe flood during October 26–28 opened several potential escape passages through the weir. In order to separate fish that passed the weir after the event from those that passed during October 7–25, a left pectoral clip was applied to the latter group. However, based on recapture results through November 9, there was evidence of some fish escaping uncounted before the flood (perhaps misidentified as sockeye salmon) but no evidence of a large number passing through during the flood. Therefore, a single stratum Chapman estimate was used to generate the escapement estimate of 1,510 spawners (95% C.I. 1,320–1,764 spawners).

RUN RECONSTRUCTION ESTIMATES

The estimated annual escapement, harvest by fishery, and total run size are shown in Table 4 and Figure 6. More detailed estimates are shown in Appendix A3.

Table 4.–Estimated harvest by gear type, escapement and total run of coho salmon returning to Hugh Smith Lake, 1982–2007.

		Number of Fish										
Year	**Fishery Sample Size**	**Alaska Troll**	**Alaska Seine**	**Alaska Gillnet**	**Alaska Trap**	**Alaska Sport**	**B.C. Troll**	**B.C. Net**	**B.C. Sport**	**Total Catch**	**Escapement**	**Total Return**
1982	91	2,758	628	203	0	0	316	84	0	3,988	2,144	6,132
1983	185	1,374	424	277	49	0	214	50	0	2,388	1,487	3,875
1984	151	1,266	504	471	18	0	331	27	0	2,617	1,407	4,024
1985	213	868	287	137	5	0	201	39	0	1,537	903	2,440
1986	256	1,598	493	213	0	16	236	28	0	2,583	1,782	4,365
1987	99	657	82	148	4	28	155	53	0	1,127	1,117	2,244
1988	41	406	207	78	0	0	242	27	0	960	513	1,473
1989	91	1,217	320	247	0	62	106	20	0	1,971	433	2,404
1990	263	1,803	566	637	23	0	840	54	0	3,924	870	4,794
1991	399	2,103	190	941	0	38	614	44	0	3,931	1,836	5,767
1992	497	1,854	676	600	0	40	289	10	0	3,469	1,426	4,895
1993	155	2,227	269	666	0	0	207	41	0	3,410	832	4,242
1994	838	4,333	1,123	1,450	0	45	694	53	13	7,711	1,753	9,464
1995	432	2,018	947	1,588	0	98	236	28	11	4,927	1,781	6,708
1996	502	1,585	623	487	0	125	125	38	14	2,998	950	3,948
1997	480	1,321	108	397	0	45	91	0	0	1,964	732	2,696
1998	668	1,771	471	980	0	150	0	0	15	3,388	983	4,371
1999	623	1,757	283	726	0	180	0	0	30	2,975	1,246	4,221
2000	161	489	45	116	0	97	0	0	0	746	600	1,346
2001	314	696	454	324	0	58	7	0	0	1,539	1,580	3,119
2002	434	892	451	555	0	91	65	0	61	2,115	3,291	5,406
2003	335	894	354	690	0	106	91	31	0	2,166	1,510	3,676
2004	244	1,017	196	243	0	60	48	20	69	1,652	840	2,492
2005	256	1,163	122	532	0	59	36	8	0	1,920	1,732	3,652
2006	169	703	64	170	0	7	34	0	58	1,035	891	1,926
2007	294	1,263	175	300	0	74	57	11	186	2,066	1,244	3,310
Average		1,463	387	507	4	53	201	26	18	2,658	1,303	3,961

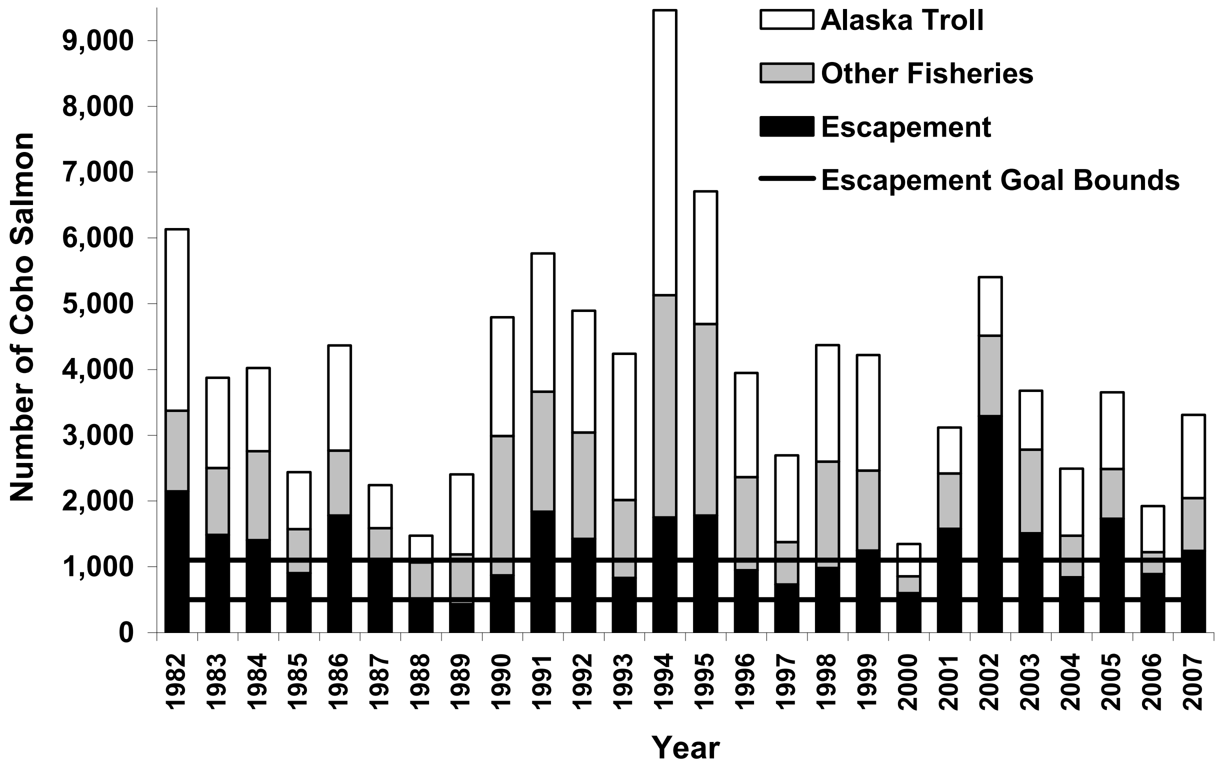

Figure 6.–Total run size, catch, escapement and biological escapement goal range for Hugh Smith Lake coho salmon, 1982–2007. The displayed escapement goal range of 500–1,100 spawners was in effect during 1994 to 2007.

The Alaska troll fishery was the single most important harvesting fishery in all years, accounting for an average of 1,463 (range 406–4,333) coho salmon during 1982–2007. Alaska gillnetters harvested an average of 507 (range 78–1,588) fish while Alaska seiners harvested an average of 387 (range 82–1,123) fish.

Trollers in northern British Columbia accounted for a substantial number of Hugh Smith Lake coho salmon before the fishery was severely restricted in 1998. The harvest by that fishery during 1982–1997 averaged 306 (range 91–840) fish but was zero during 1998–2000 when the fishery was closed to coho salmon retention for a full population cycle in response to upper Skeena River coho salmon conservation concerns. The recent estimated harvest by British Columbia trollers (ranging from 34–91 fish in 2002–2007) was well below the historical average owing to continued fishery restrictions and a substantially reduced fishing fleet. Canadian net fisheries were also restricted and show a pattern of reduced harvest of Hugh Smith Lake coho salmon since the mid-1990s.

Sport fisheries in both Southeast Alaska and northern British Columbia have increased in participation since the early 1980s while catch monitoring and sampling have improved. Marine sport harvests of Hugh Smith Lake coho salmon have averaged just over 50 fish with a peak estimated catch of 180 fish in 1999. About half of the Alaska sport harvest of the stock has occurred in the Ketchikan sport fishery, with the remainder taken in outer coastal fisheries, primarily around Sitka and Craig, with trace numbers harvested out of Elfin Cove and Yakutat. The first tags were reported from British Columbia marine sport fisheries in 1994 and small estimated harvests of Hugh Smith Lake fish have occurred in most years since, reaching a peak of 186 fish in 2007 based on three tags recovered at Langara Island during August 22–28.

The Annette Island trap fishery accounted for sporadic annual catches estimated at fewer than 50 Hugh Smith Lake coho salmon before it was discontinued in 1994. In 1987, a single tag expanded to an estimated catch of 4 adult coho salmon was recovered from a test fishery conducted in Subdistrict 102-10 near Cape Chacon in early July.

During 1982–2007, the estimated total contribution to all fisheries by the Hugh Smith Lake coho salmon population averaged 2,658 fish with a relatively broad range from 746 fish in 2000 to 7,711 fish in 1994. Escapement estimates during the period ranged from 433 adults in 1989 to 3,291 adults in 2002, with the average being 1,303 adults.

The total run size including catch and escapement combined during 1982–2007 averaged 3,961 fish and ranged from 1,346 fish in 2000 to 9,464 fish in 1994, with the latter run coinciding with an all-time record coho salmon catch in Southeast Alaska. Runs were generally large in the 1990s with an average of 5,110 adults returning during that decade compared with 3,202 adults in the first 8-year period (1982–1989) and 3,116 adults in the most recent 8-year period (2000–2007).

EXPLOITATION RATE ESTIMATES

Overall, harvest accounted for an average of 65.5% of the return (range 39.1%–82.0%) while the proportion escaping into the system averaged 34.5% but was highly variable, ranging from 18.0% to 60.9% (Table 5). More detailed exploitation rates by area are presented in Appendix A4.

Total exploitation estimates for the Hugh Smith Lake stock during the early years of the stock assessment project (1982–1988) averaged a moderate 61.3% and ranged from 50.2–65.2% (Table 5; Figure 7). However, exploitation rates then increased abruptly in 1989–1999 to an average of 75.9% (range 68.2–82.0%) during a period that generally coincided with large returns. Exploitation rates then decreased markedly to an average of 54.7% (range 39.1–66.3%) during 2000–2007. The record low exploitation rate of 39.1% occurred in 2002 (coincident with the 5th largest observed run) and resulted in a record escapement of 3,291 spawners. The record low 2002 exploitation rate appears to have resulted primarily from very low prices for coho salmon compared with Chinook salmon which commanded a higher price and were a more attractive target for trollers who were given extended fishing time to harvest a large allocation of the species. Over the long–term, Alaska trollers have accounted for an estimated average of 36.5% of the run (range 16.5–52.5%; Table 5).

The high total exploitation rates during 1989–1999 resulted from increased exploitation by both trollers and gillnetters. The troll fishery exploitation rate dipped sharply from an average of 38.9% during 1982–2000 to only 21.0% (range 16.5–24.3%) in 2001–2003 followed by a substantial rebound to 36.8% (range 30.8–40.8%) in 2004–2007. The average gillnet exploitation rate was only 6.3% during 1982–1988 but increased to 15.8% during 1989–1999 before decreasing to 12.0% in 2000–2003 and 10.5% in 2004–2007. The purse seine exploitation rate followed a relatively stable trend around an average of 10.0% during 1982–2004 and reached a peak of 23.7% in 1995, but has been much lower in the three most recent years, averaging only 4.0% (range 3.3–5.3%) during 2005–2007.

Table 5.–Estimated percent of total return coho salmon returning to Hugh Smith Lake, 1982–2007, by gear type, escapement and total run.

Year	Fishery Sample Size	Number of Fish										
		Alaska Troll	Alaska Seine	Alaska Gillnet	Alaska Trap	Alaska Sport	B.C. Troll	B.C. Net	B.C. Sport	Total Catch	Escapement	Total Return
1982	91	45.0	10.2	3.3	0.0	0.0	5.2	1.4	0.0	65.0	35.0	100.0
1983	185	35.5	10.9	7.1	1.3	0.0	5.5	1.3	0.0	61.6	38.4	100.0
1984	151	31.5	12.5	11.7	0.5	0.0	8.2	0.7	0.0	65.0	35.0	100.0
1985	213	35.6	11.8	5.6	0.2	0.0	8.2	1.6	0.0	63.0	37.0	100.0
1986	256	36.6	11.3	4.9	0.0	0.4	5.4	0.7	0.0	59.2	40.8	100.0
1987	99	29.3	3.6	6.6	0.2	1.3	6.9	2.4	0.0	50.2	49.8	100.0
1988	41	27.6	14.0	5.3	0.0	0.0	16.4	1.8	0.0	65.2	34.8	100.0
1989	91	50.6	13.3	10.3	0.0	2.6	4.4	0.8	0.0	82.0	18.0	100.0
1990	263	37.6	11.8	13.3	0.5	0.0	17.5	1.1	0.0	81.9	18.1	100.0
1991	399	36.5	3.3	16.3	0.0	0.7	10.6	0.8	0.0	68.2	31.8	100.0
1992	497	37.9	13.8	12.3	0.0	0.8	5.9	0.2	0.0	70.9	29.1	100.0
1993	155	52.5	6.3	15.7	0.0	0.0	4.9	1.0	0.0	80.4	19.6	100.0
1994	838	45.8	11.9	15.3	0.0	0.5	7.3	0.6	0.1	81.5	18.5	100.0
1995	432	30.1	14.1	23.7	0.0	1.5	3.5	0.4	0.2	73.5	26.5	100.0
1996	502	40.2	15.8	12.3	0.0	3.2	3.2	1.0	0.4	75.9	24.1	100.0
1997	480	49.0	4.0	14.7	0.0	1.7	3.4	0.0	0.0	72.8	27.2	100.0
1998	668	40.5	10.8	22.4	0.0	3.4	0.0	0.0	0.3	77.5	22.5	100.0
1999	623	41.6	6.7	17.2	0.0	4.3	0.0	0.0	0.7	70.5	29.5	100.0
2000	161	36.3	3.4	8.6	0.0	7.2	0.0	0.0	0.0	55.4	44.6	100.0
2001	314	22.3	14.6	10.4	0.0	1.9	0.2	0.0	0.0	49.3	50.7	100.0
2002	434	16.5	8.3	10.3	0.0	1.7	1.2	0.0	1.1	39.1	60.9	100.0
2003	335	24.3	9.6	18.8	0.0	2.9	2.5	0.8	0.0	58.9	41.1	100.0
2004	244	40.8	7.9	9.7	0.0	2.4	1.9	0.8	2.8	66.3	33.7	100.0
2005	256	31.8	3.4	14.6	0.0	1.6	1.0	0.2	0.0	52.6	47.4	100.0
2006	169	36.5	3.3	8.8	0.0	0.4	1.8	0.0	3.0	53.7	46.3	100.0
2007	294	38.2	5.3	9.1	0.0	2.2	1.7	0.3	5.6	62.4	37.6	100.0
Average		36.5	9.3	11.9	0.1	1.6	4.9	0.7	0.5	65.5	34.5	100.0

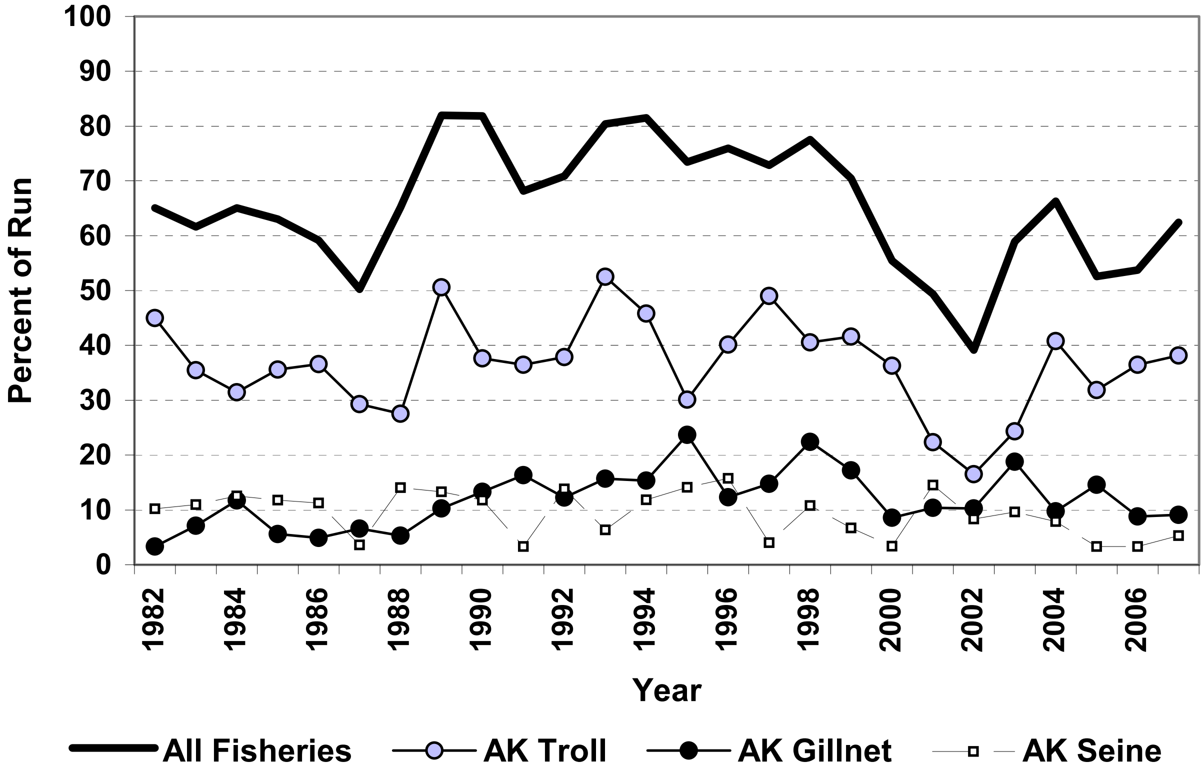

Figure 7.–Estimated exploitation rate on Hugh Smith Lake coho salmon by Alaska gillnet and seine fisheries, the Alaska troll fishery and all fisheries combined, 1982–2007.

MARINE SURVIVAL ESTIMATES

Marine survival rate estimates have ranged from 4.1% for 1987 smolts to 20.9% for 1991 smolts and have averaged 12.3% (Table 1 and Figure 8). Marine survival trended upward from about 10% in the early to mid–1980s to a peak around 17–18% in the early 1990s but has since followed an overall declining trend interrupted by a lower peak at 13–15% during 2000–2002. Survival rates for smolts migrating in the three most recent years (2004–2006) were substantially lower at 7–9%.

Exceptionally poor survival for Hugh Smith Lake smolts (4.1%) occurred in 1987 and appeared to be typical for southern Southeast in that year based on fishery performance indicators and survival estimates for hatchery smolts. The department responded to resulting low abundance in 1988 with troll fishery closures that totaled 23 days region-wide and 40 days in southern Southeast, with additional restrictions in gillnet fisheries.

During 1989–1995, survival rates remained relatively high from 13.0–20.9% (average 17.2%) before dipping well below 10% in 1996 and 1999. After reaching a recent peak of 14.8% in 2001, survival declined to 6.8–9.1% in 2004–2006. The 2004–2006 average rate of 8.3% was lower than the 1982–1988 average of 10.0%.

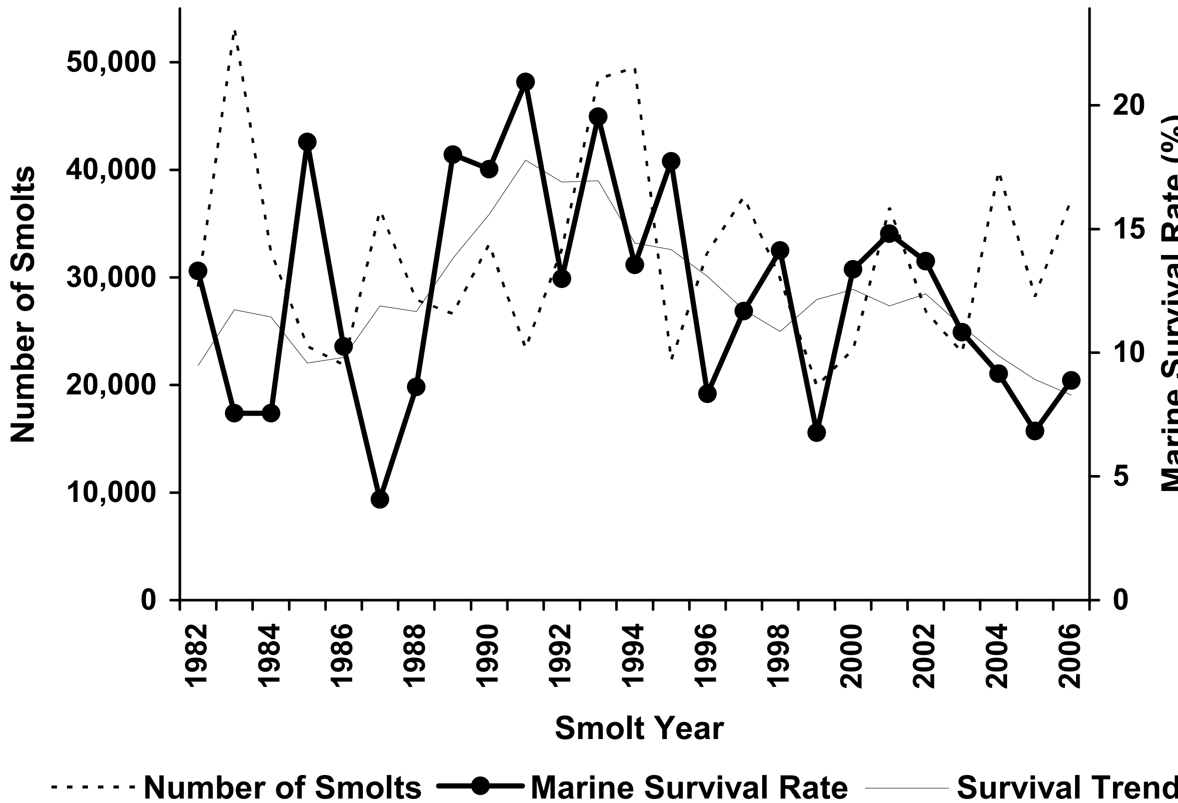

Figure 8.–Estimated coho salmon smolt production from Hugh Smith Lake and marine survival rate by smolt year, 1982–2006. Also shown is a 5-year symmetrical moving average trend in the marine survival rate.

Marine survival has been more variable than smolt production over a 25-year period with a coefficient of variation of 0.385 compared with 0.282 for smolt abundance. Marine survival accounted for 65% of observed variation in adult returns in 1983–2007 compared with 35% of variation attributable to smolt production, based on a comparison of squared coefficients of variation.

MIGRATORY TIMING

The estimated average weekly percent of the total troll harvest of Hugh Smith Lake coho salmon in four different areas is shown in Figure 9. The dip in harvest in mid-August reflects the timing of a region-wide troll fishery closure ranging from 2–10 days in most years. The stock was harvested earliest in northern Southeast (NW and NE quadrants combined), closely followed by the SW quadrant and then northern British Columbia (NBC) and the SE quadrant.

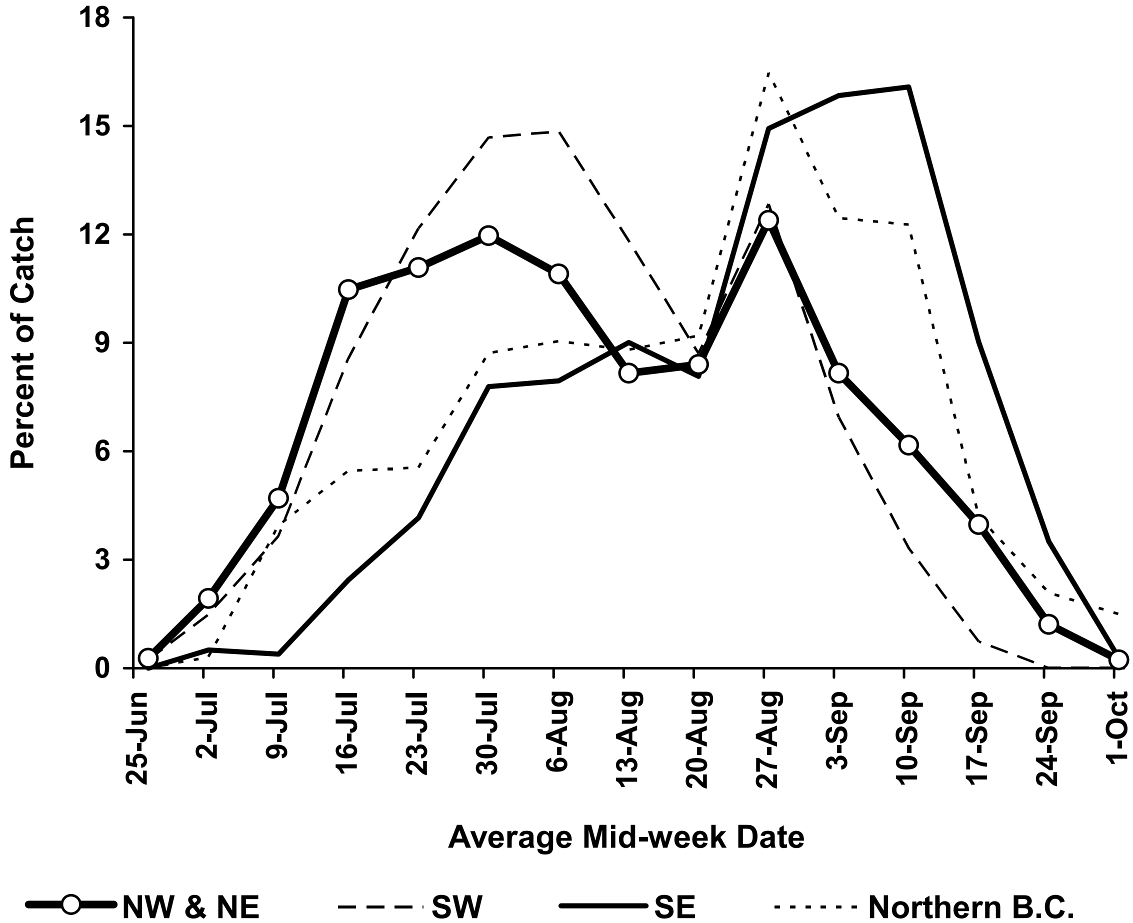

Figure 9.–Average weekly percent of the total troll catch of Hugh Smith Lake coho salmon in the NW and NE quadrants (combined), the SW quadrant, the SE quadrant and in northern British Columbia, 1982–2007. Estimates for Southeast Alaska areas exclude 1988 while northern British Columbia includes only 1982–1997.

Estimates of the weekly exploitation rate by trollers in four fishing areas (Figure 10) show the relative distribution of the troll harvest by both area and time. They also indicate a predominant direction of migration and suggest a sequence of availability by Hugh Smith Lake coho salmon through the gauntlet of fisheries. Returning fish have nearly identical harvest timing in northern Southeast (NW and NE quadrants) and in the SW quadrant and, therefore, most fish appear to first encounter fisheries in that combined area. Their timing in the NBC troll fishery is notably later, suggesting that most fish spend the majority of their time feeding on the outer coast of Southeast Alaska before entering Canadian waters as they approach the final fishing area in the SE quadrant that includes their natal stream. Timing in NBC and in the SE quadrant was similar with the average peak harvest in both areas occurring in the last week of August and first two weeks of September compared with a broad peak in outer coastal areas from late July through late August.

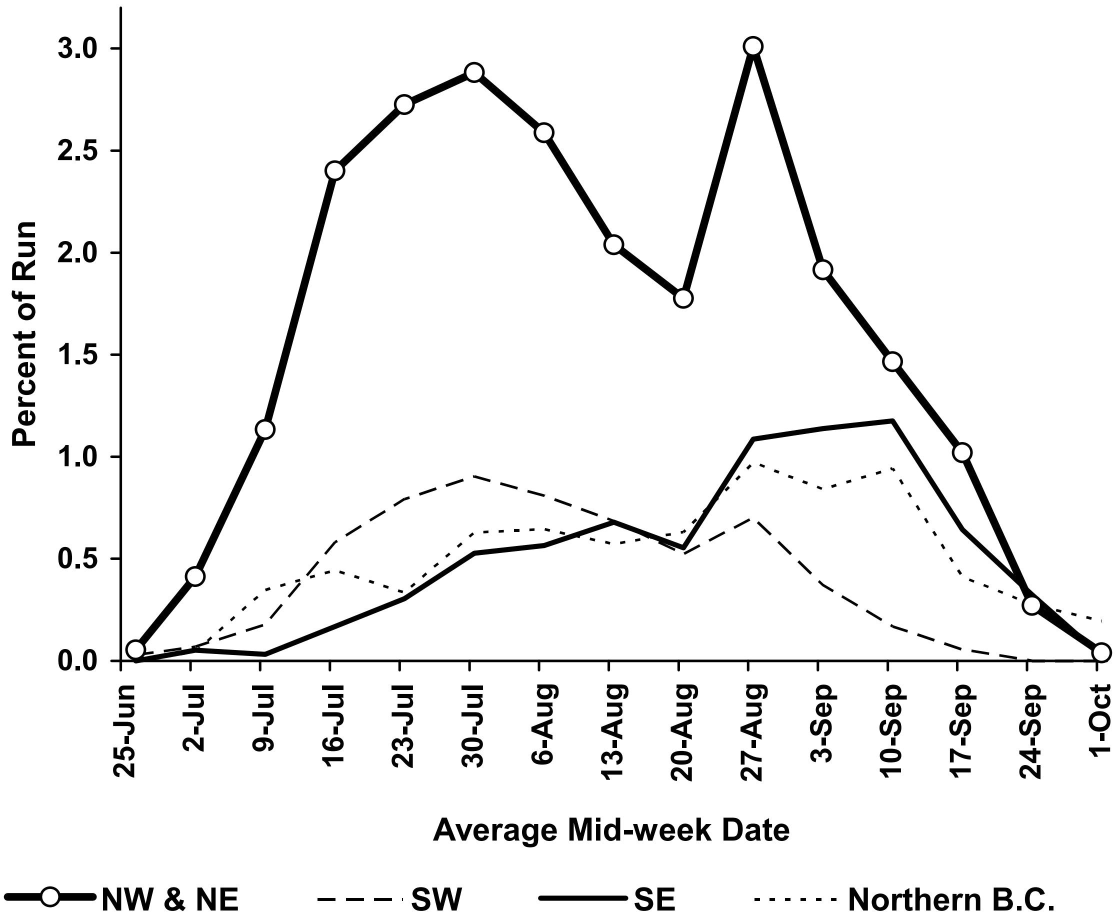

Figure 10.–Average weekly percent of the total run of Hugh Smith Lake coho salmon harvested by troll fisheries in the combined NW and NE quadrants, the SW quadrant, and the SE quadrant combined with northern British Columbia, 1982–2007. Estimates for Southeast Alaska areas exclude 1988, while northern British Columbia includes only 1982–1997.

The mid-point of the Alaska region-wide troll harvest of Hugh Smith Lake coho salmon has occurred around August 13 (statistical week 33), on average (Table 6). The timing pattern of the average troll harvest as a percent of the total run shows a dip in mid–August between peaks around July 30 and August 27 (Figure 11). The pattern suggests that recent region-wide troll fishery closures timed around the third week of August have had a near-maximum effect on the troll harvest of this stock.

Hugh Smith Lake coho salmon begin building rapidly in the Tree Point gillnet fishery after mid–August and the stock typically peaks and reaches a mid-point in that fishery around September 10 (statistical week 37), about 4 weeks after its mid-point in the troll fishery. In many years the Tree Point gillnet fishery was closed after statistical week 38 (about September 20) so the timing curve shown in Figure 11 is somewhat truncated.

The timing of escapement into the lake has been highly variable. However, on average, escapement was relatively insignificant before mid–August after which it increased steadily to a peak around September 17 before declining through the remainder of September and October (Figure 11).

Table 6.–Average weekly and cumulative percent of the total number of Hugh Smith Lake coho salmon caught in the Alaska troll and Tree Point gillnet fisheries and counted at the weir.

Stat. Week	Average Mid-week Date	Alaska Troll Fishery Average Weekly	Average Cum.	SD Cum.	Tree Point Gillnet Fishery Average Weekly	Average Cum.	SD Cum.	Escapement Average Weekly	Average Cum.	SD Cum.
25	18-Jun	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	25-Jun	0.3	0.3	0.9	0.0	0.0	0.0	0.0	0.0	0.0
27	2-Jul	1.5	1.7	1.9	0.2	0.2	0.7	0.0	0.0	0.0
28	9-Jul	3.6	5.3	3.7	0.2	0.4	1.3	0.0	0.0	0.1
29	16-Jul	8.6	14.0	6.6	0.2	0.6	1.4	0.0	0.1	0.1
30	23-Jul	9.8	23.8	8.8	0.5	1.1	1.7	0.1	0.1	0.1
31	30-Jul	11.5	35.3	10.0	3.4	4.5	6.9	0.3	0.4	0.5
32	6-Aug	10.5	45.8	11.7	4.0	8.5	8.8	0.5	0.9	0.9
33	13-Aug	9.6	55.4	9.9	4.3	12.8	10.9	1.3	2.2	1.7
34	20-Aug	8.2	63.6	9.5	7.4	20.2	16.1	3.0	5.2	4.2
35	27-Aug	12.2	75.7	9.9	12.0	32.2	17.8	6.9	12.1	7.5
36	3-Sep	10.7	86.5	7.6	14.9	47.1	18.6	10.8	22.9	9.3
37	10-Sep	7.5	94.0	4.9	23.2	70.4	13.0	14.2	37.2	14.2
38	17-Sep	4.4	98.3	2.5	20.5	90.9	9.1	16.2	53.3	13.5
39	24-Sep	1.5	99.8	0.4	8.0	98.8	3.1	13.1	66.4	11.5
40	1-Oct	0.2	100.0	0.0	0.9	99.7	1.4	9.4	75.8	10.3
41	8-Oct	0.0	100.0	0.0	0.3	100.0	0.0	6.1	81.9	9.7
42	15-Oct	0.0	100.0	0.0	0.0	100.0	0.0	6.3	88.2	6.0
43	22-Oct	0.0	100.0	0.0	0.0	100.0	0.0	4.9	93.1	6.2
44	29-Oct	0.0	100.0	0.0	0.0	100.0	0.0	4.2	97.3	3.9
45	5-Nov	0.0	100.0	0.0	0.0	100.0	0.0	2.7	100.0	0.0

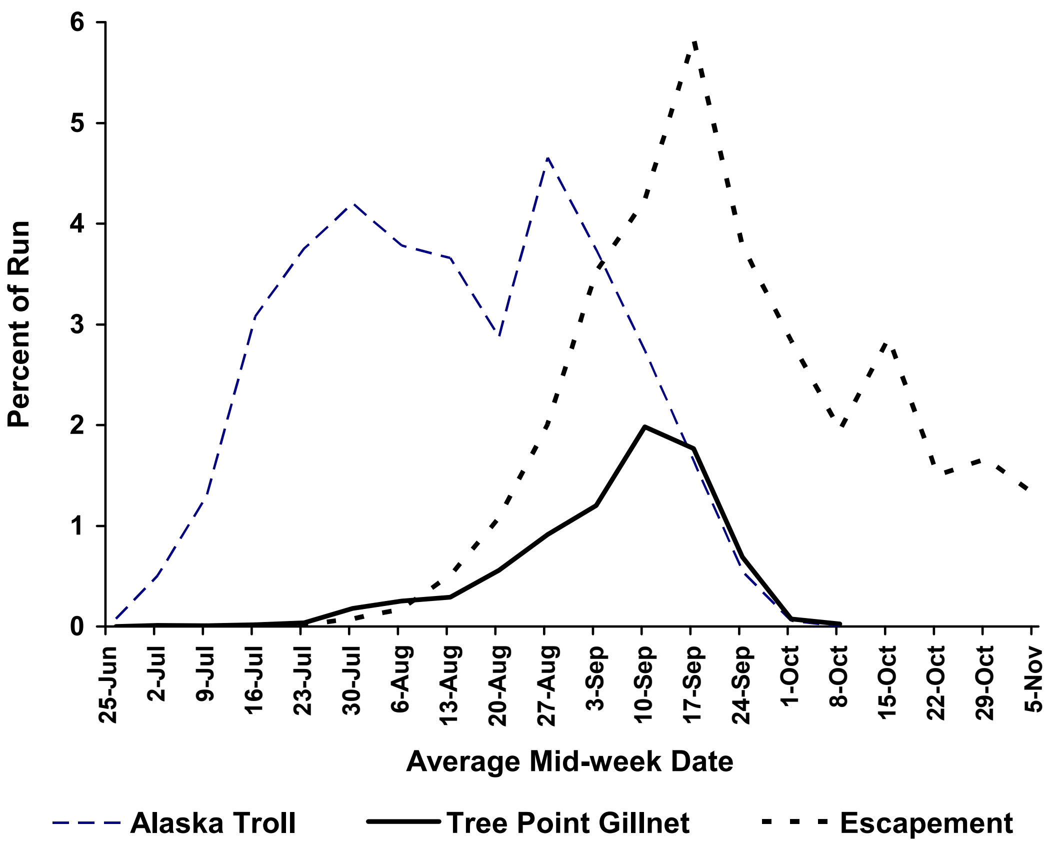

Figure 11.–Average weekly harvest by the Alaska troll and Tree Point gillnet fisheries and escapement as a percent of the total coho salmon return to Hugh Smith Lake.

REMOVAL RATE ESTIMATES

Based on the timing patterns shown in Figures 10 and 11, we designated as R1 all fisheries in the NW, NE and SW quadrants that were assumed to have access to the total initial abundance of returning fish. Combined NBC fisheries were designated R2 and were assumed to operate on that portion of the original adult run that had survived R1 fisheries, even though some fish migrating through Sumner and Upper Clarence Straits likely passed directly from R1 to R3 and were probably unavailable in NBC. The SE quadrant was designated R3, and only fish that were not harvested in R1 and R2 were assumed to be available to R3 fisheries in the SE quadrant.

On average, fishery impacts and management opportunity have been greatest in fisheries in the final area in the gauntlet (SE quadrant) where the all-gear removal rate has averaged 42.6% compared with 34.6% in the initial fisheries encountered in the NW, NE and SW quadrants (Table 7 and Figure 12). Prior to recent restrictions beginning in 1998, the NBC fisheries removed an estimated average of 13.0% of available Hugh Smith Lake coho salmon with peak estimates in 1988 and 1990 of 28.3% and 28.7%, respectively. Removal rate estimates for those fisheries decreased substantially to an average of 3.8% when new restrictions were implemented after 1997 but estimates have increased recently to 12.4% in 2007.

Table 7.–Removal rates for returning adult Hugh Smith Lake coho salmon in three sequential fishing areas including outer coastal and northern areas of Southeast Alaska (NW, NE and SW quadrants), northern British Columbia (NBC) and the Southeast (SE) quadrant in Southeast Alaska.

Year	NW,NE,SW Quadrants All-Gear	Northern B.C. (NBC) All-Gear	SE Quadrant									Total Exploitation Rate
			Troll	Seine	Tree Pt. Gillnet	Annette Gillnet	101 GN Subtotal	106–108 Gillnet	Sport	Trap & Misc.	SE Subtotal	
1982	37.5	10.5	18.9	12.7	—	—	5.9	0.0	0.0	0.0	37.5	65.0
1983	28.9	9.6	13.6	13.7	—	—	5.8	5.3	0.0	2.0	40.3	61.6
1984	30.2	12.7	12.3	10.3	—	—	18.6	0.7	0.0	0.7	42.5	65.0
1985	31.4	14.3	10.2	16.8	—	—	9.2	0.3	0.0	0.4	37.0	63.0
1986	39.4	10.0	7.6	7.9	—	—	5.9	3.1	0.7	0.0	25.1	59.2
1987	29.3	13.1	5.1	0.9	—	—	10.7	0.0	2.0	0.3	19.0	50.2
1988	35.5	28.3	10.3	3.0	—	—	11.5	0.0	0.0	0.0	24.7	65.2
1989	46.3	9.8	25.6	10.7	8.0	5.9	13.9	7.3	5.3	0.0	62.8	82.0
1990	35.1	28.7	16.5	14.4	21.0	2.6	23.6	5.1	0.0	1.1	60.7	81.9
1991	29.7	16.2	16.0	1.2	12.9	7.2	20.1	7.5	1.1	0.0	45.9	68.2
1992	38.9	10.0	11.4	11.9	13.8	4.8	18.6	3.6	1.5	0.0	47.1	70.9
1993	44.3	10.5	20.4	8.8	9.3	4.7	14.0	17.5	0.0	0.0	60.6	80.4
1994	47.4	15.3	18.7	4.8	19.5	5.5	25.0	9.3	0.6	0.0	58.4	81.5
1995	32.5	6.1	8.6	10.1	24.0	7.5	31.5	5.9	2.0	0.0	58.1	73.5
1996	38.8	7.4	18.0	15.4	6.9	3.5	10.4	11.3	2.4	0.0	57.6	75.9
1997	46.4	6.3	11.5	4.0	19.1	7.7	26.8	2.5	1.1	0.0	46.0	72.8
1998	44.2	0.6	10.3	5.5	26.5	5.5	32.1	8.4	3.2	0.0	59.4	77.5
1999	40.2	1.2	12.7	5.7	18.5	3.0	21.5	7.6	2.6	0.0	50.0	70.5
2000	40.6	0.0	4.5	0.6	10.7	1.8	12.5	2.0	5.4	0.0	25.0	55.4
2001	21.6	0.3	5.6	15.4	5.1	6.1	11.1	2.1	1.0	0.0	35.2	49.3
2002	13.8	2.7	6.0	8.8	5.8	4.5	10.3	1.9	0.4	0.0	27.4	39.1
2003	21.5	4.2	10.9	8.3	15.7	1.8	17.5	7.5	1.1	0.0	45.3	58.9
2004	30.1	7.8	19.4	10.7	11.4	1.5	12.9	2.2	2.5	0.0	47.7	66.3
2005	25.7	1.6	10.9	3.6	14.8	1.0	15.8	4.1	0.6	0.0	35.1	52.6
2006	31.6	6.9	10.7	2.4	10.6	0.7	11.4	2.5	0.5	0.0	27.4	53.7
2007	37.8	12.4	10.1	3.2	7.4	2.3	9.7	7.0	1.0	0.0	31.0	62.4
Avg.	34.6	9.5	12.5	8.1	13.7	4.1	15.6	4.8	1.3	0.2	42.6	65.5

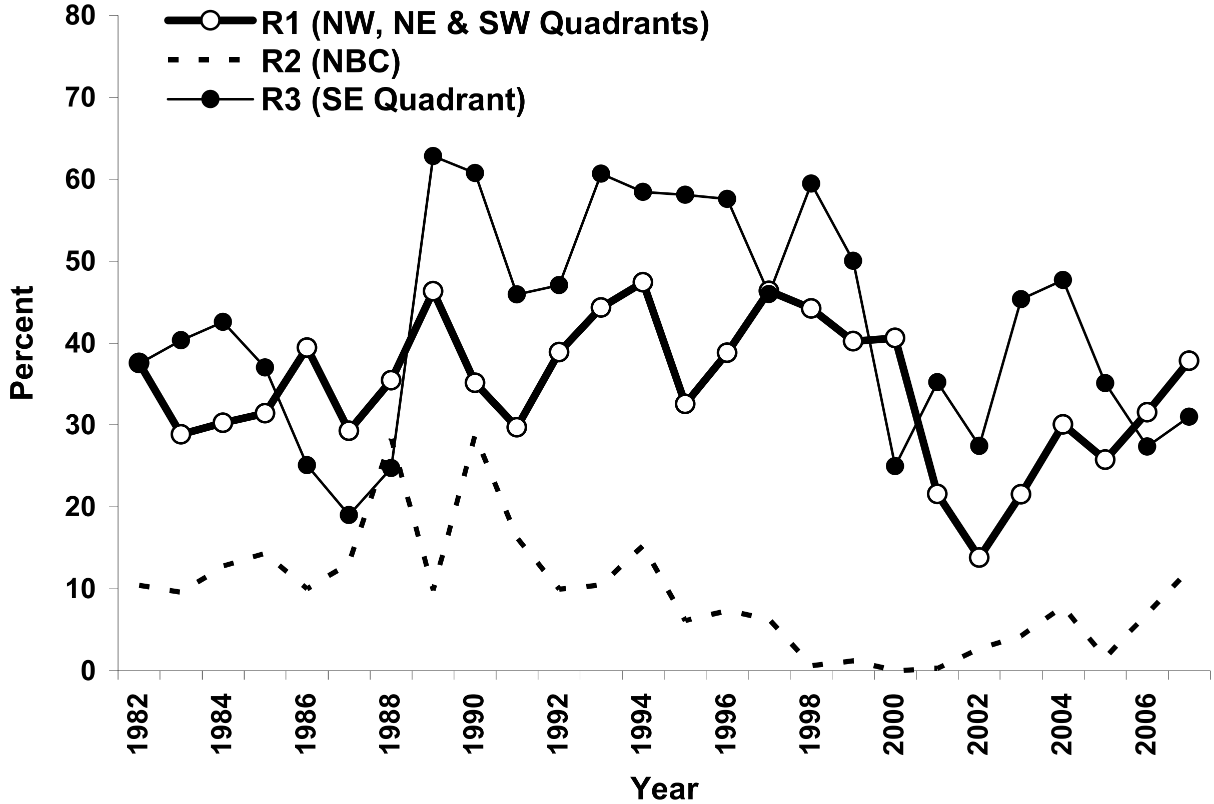

Figure 12.–Removal rate for Hugh Smith Lake coho salmon by fishing area. The removal rate is the percent of the remaining run removed after harvest in other "upstream" areas. The run is assumed to be available first in the NW, NE and SW quadrants followed by northern British Columbia (NBC) and finally the SE Quadrant.

Within the SE quadrant, the combined gillnet fisheries (Tree Point, Annette Island and Districts 106–108) have accounted for the majority of the removal rate, followed by the troll fishery (Table 7). The overall annual removal rate in that area remained relatively high, averaging 55.2%, during 1989–1999 (Figure 13). Gillnet removal rates were relatively high, on average, from 1989–1999. During the same period, seine fishery removal rates remained similar to the long-term average.

AGE COMPOSITION AND BROOD YEAR RETURN

Adult coho salmon sampled from the Hugh Smith Lake escapement were represented by two age classes (1.1 and 2.1) that corresponded with freshwater rearing periods (from egg to smolt) of approximately 18 months and 30 months, respectively (Table 8). All sampled adults spent approximately 16 months in the ocean and most remained in the lake for a month or two, on average, before spawning. Therefore, the total age of adults used for assigning brood year production was 3 years (for age class 1.1) or four years (for age class 2.1).

Table 8.–Estimated age composition of the total adult coho salmon return to Hugh Smith Lake, 1985–2007.

Return Year	No. Agable Scales by Age Class			Percent Age Scales by Age Class			Est. No. Adults by Age Class		
	1.1	2.1	Total	1.1	2.1	Total	1.1	2.1	Total
1985	461	48	509	90.6	9.4	100.0	2,210	230	2,440
1986	368	83	451	81.6	18.4	100.0	3,562	803	4,365
1987	266	125	391	68.0	32.0	100.0	1,526	717	2,244
1988	159	43	202	78.7	21.3	100.0	1,159	314	1,473
1989	167	39	206	81.1	18.9	100.0	1,949	455	2,404
1990	370	134	504	73.4	26.6	100.0	3,519	1,274	4,794
1991	351	196	547	64.2	35.8	100.0	3,700	2,066	5,767
1992	454	130	584	77.7	22.3	100.0	3,805	1,090	4,895
1993	367	95	462	79.4	20.6	100.0	3,370	872	4,242
1994	553	186	739	74.8	25.2	100.0	7,082	2,382	9,464
1995	434	139	573	75.7	24.3	100.0	5,081	1,627	6,708
1996	458	114	572	80.1	19.9	100.0	3,161	787	3,948
1997	353	86	439	80.4	19.6	100.0	2,168	528	2,696
1998	376	158	534	70.4	29.6	100.0	3,078	1,293	4,371
1999	473	153	626	75.6	24.4	100.0	3,189	1,032	4,221
2000	337	104	441	76.4	23.6	100.0	1,029	318	1,346
2001	409	197	606	67.5	32.5	100.0	2,105	1,014	3,119
2002	606	158	764	79.3	20.7	100.0	4,288	1,118	5,406
2003	471	106	577	81.6	18.4	100.0	3,001	675	3,676
2004	324	128	452	71.7	28.3	100.0	1,786	706	2,492
2005	548	89	637	86.0	14.0	100.0	3,142	510	3,652
2006	415	124	539	77.0	23.0	100.0	1,483	443	1,926
2007	512	95	607	84.3	15.7	100.0	2,792	518	3,310
Avg.	401	119	520	77.2	22.8	100.0	2,965	903	3,868

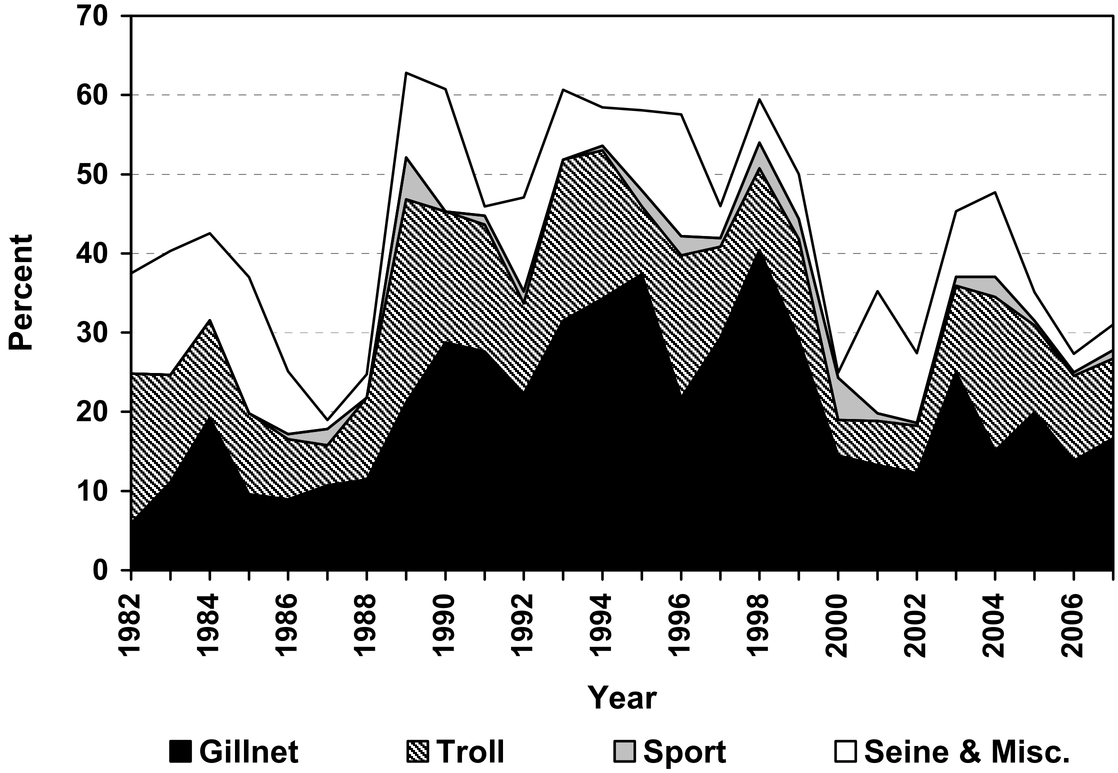

Figure 13.–Removal rate for Hugh Smith Lake coho salmon by fisheries in the SE quadrant. Grouped with the seine harvest is a very small harvest by miscellaneous fisheries that include the Annette Island trap fishery and hatchery cost recovery fisheries.

Despite samples of 4 scales per fish, many samples (commonly about 20%) could not be aged because of regeneration. Successfully aged scale samples totaled only 202 in 1988 and 206 in 1989, but exceeded 400 adults in most other years and averaged 520 samples annually during 1985–2007. The entire collection was aged by the same scale reader (Molly Kemp) whose accuracy likely benefited from an extensive collection of known-age smolt scales from Hugh Smith Lake used as a reference. The average age composition over the entire period was estimated at about 77.2% age 1.1 and 22.8% age 2.1 (standard deviation = 6.2%) with the age 1.1 component ranging from 64.2% in 1991 to 90.6% in 1985.

SPAWNER-RECRUIT ANALYSIS

Spawning escapement estimates were paired with resulting returns that were standardized to a 1984–2007 average marine survival rate of 12.3%. Standardization to average survival removed variability in marine survival that was assumed to be largely density independent from adult return estimates. Escapement estimates ranged from 433–3,291 spawners while adjusted brood year returns ranged from 2,714–5,936 adults (Table 9).

A symmetrical moving median return for seven paired observations ranked by escapement level indicates a generally positive relationship between escapement and return over the range of observations (Figure 14, upper left graph). Larger escapements have, on average, produced larger returns. The median estimated return from escapements over 1,500 spawners (n = 8) is 4,136 adults compared with 3,609 adults produced from escapements from 900–1,500 spawners (N = 7) and 3,253 adults from escapements with fewer than 900 spawners (N = 8).

Table 9.–Total Hugh Smith Lake adult coho salmon return and total return adjusted to 1984–2007 average marine survival (12.3%), by brood year.

Brood Year	Est. No. of Spawners in Escapement	Number of Fish by Age for Total Return			Number of Fish by Age for Total Return, Adjusted to Average Survival		
		3	4	Total	3	4	Total
1982	2,144	2,210	803	3,013	3,597	534	4,131
1983	1,487	3,562	717	4,279	2,366	860	3,227
1984	1,407	1,526	314	1,840	1,831	948	2,780
1985	903	1,159	455	1,614	3,507	650	4,157
1986	1,782	1,949	1,274	3,223	2,783	871	3,654
1987	1,117	3,519	2,066	5,585	2,404	1,459	3,863
1988	513	3,700	1,090	4,790	2,613	640	3,253
1989	433	3,805	872	4,677	2,235	826	3,061
1990	870	3,370	2,382	5,752	3,191	1,500	4,691
1991	1,836	7,082	1,627	8,709	4,459	1,478	5,936
1992	1,426	5,081	787	5,868	4,614	546	5,160
1993	832	3,161	528	3,689	2,193	778	2,972
1994	1,753	2,168	1,293	3,461	3,195	1,363	4,557
1995	1,781	3,078	1,032	4,110	3,243	898	4,141
1996	950	3,189	318	3,507	2,777	577	3,354
1997	732	1,029	1,014	2,043	1,871	933	2,804
1998	983	2,105	1,118	3,223	1,937	928	2,865
1999	1,246	4,288	675	4,963	3,560	607	4,167
2000	600	3,001	706	3,707	2,695	801	3,497
2001	1,580	1,786	510	2,296	2,028	686	2,714
2002	3,291	3,142	443	3,585	4,225	798	5,023
2003	1,510	1,483	518	2,001	2,670	718	3,387
2004	840	2,792	***916***	3,707	3,867	***1,222***	5,089
Average	1,305	2,965	933	3,898	2,951	897	3,847

Note: The age 4 return for the 2004 brood year (bolded and in italics) was extrapolated based on the average age 4 proportion of 1982–2003 brood year returns (0.247).

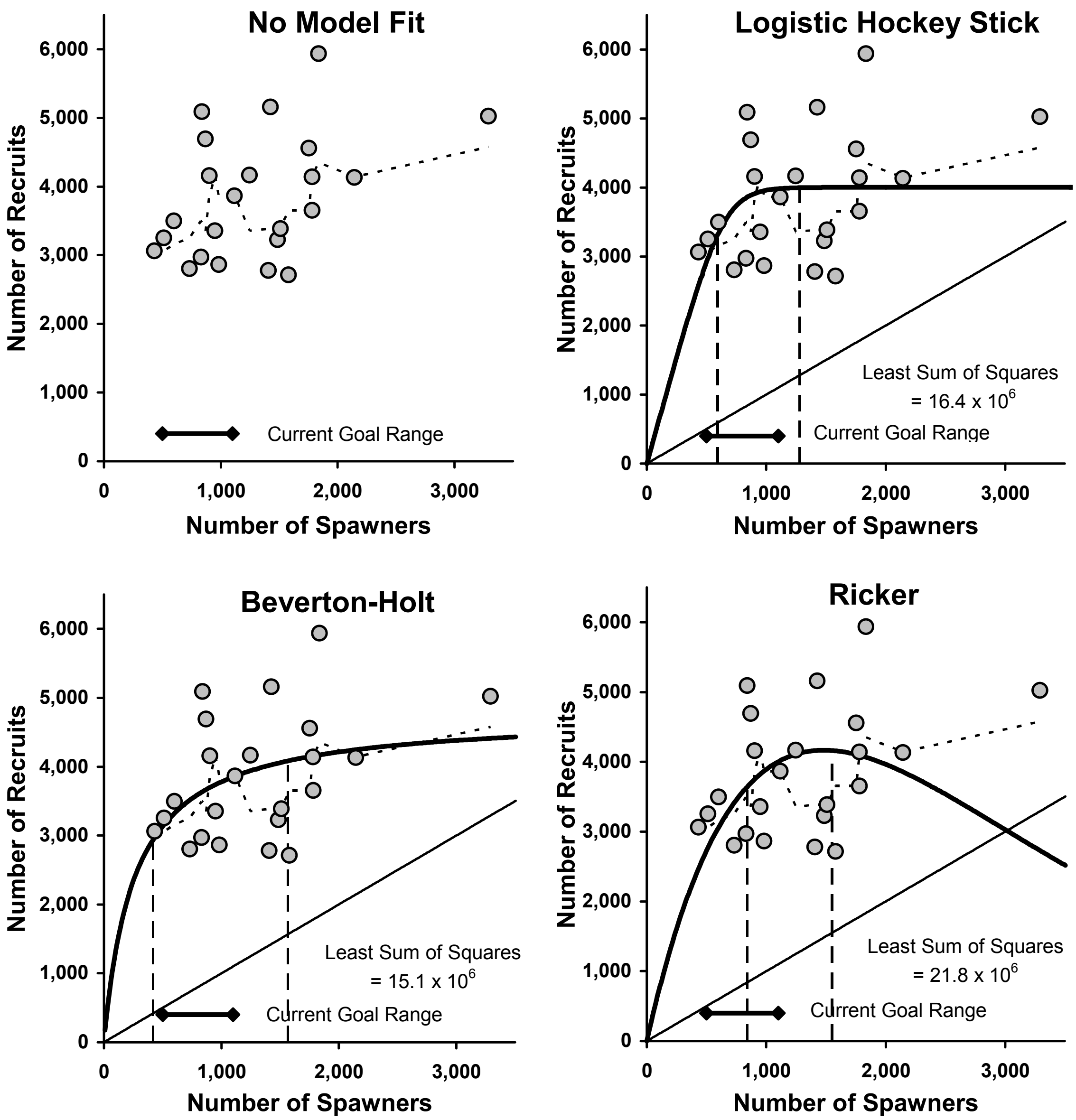

Figure 14.–Spawner-recruit relationship for Hugh Smith Lake coho salmon fitted with three different stock-recruitment models showing escapement ranges estimated to produce 90% or more of MSY. The effect of marine survival is removed by standardizing returns to the long-term marine survival rate of 12.3%. Also shown are the current goal range and a symmetrical median return (dashed line) for the seven closest spawning escapements (truncated at the lowest and highest observed escapements).

Of the three spawner-recruit models tested, the Beverton-Holt model displayed the best fit based on the least sum of squared residuals, followed by the logistic hockey stick (LHS) model (Table 10). The Ricker model which assumes overcompensation at higher escapement levels produced the poorest fit. A strong overcompensation mechanism is generally inconsistent with the life history and ecology of coho salmon and the Ricker model has typically produced an inferior statistical fit compared with hockey stick and Beverton-Holt models in coho salmon populations from Oregon to central British Columbia (Bradford et al. 2000; Barrowman et al. 2003).

Table 10.–Spawner-recruit parameter estimates for the Hugh Smith Lake coho salmon population based on the Logistic Hockey Stick (LHS), Beverton-Holt and Ricker spawner-recruit models.

	Model			
Parameter	**LHS**	**Beverton-Holt**	**Ricker**	**Current Goal**
Slope at Origin (Alpha)	6.282	18.373	7.643	—
Theta (LHS)	0.200	—	—	—
Mew (LHS)	632	—	—	—
A (Beverton-Holt)	—	4,759	—	—
B (Beverton-Holt)	—	259	—	—
Beta (Ricker)	—	—	6.747×10^{-5}	—
Max. Sustained Yield (MSY)				
Point Estimate of MSY	3,020	2,798	2,903	—
Return at MSY	3,864	3,649	3,988	—
Escapement at MSY	844	851	1,085	770
Lower Esc. Bound (90% of MSY)	593	417	685	500
Upper Esc. Bound (90% of MSY)	1,279	1,566	1,550	1,100
Exploitation Rate at MSY	78.2%	76.7%	72.8%	—
Maximum Return (R_{max})				
Point Estimate of R_{max}	4,002	4,500	4,167	—
Escapement at R_{max}	1,586	4,500	1,480	—
Exploitation Rate at R_{max}	60.4%	0.0%	64.5%	—
Carrying Capacity (K)				
Point Estimate of K	4,002	4,500	3,014	—
Best Model Fit				
Sum of Squared Residuals	16,407,173	15,134,955	21,786,608	—

The LHS and Beverton-Holt models produced similar estimates of escapement at maximum sustained yield (E_{MSY}) of 844 spawners and 851 spawners, respectively, compared to the current point goal of 770 spawners (Table 10). Escapement ranges estimated to produce 90% or more of MSY were 593–1,279 spawners (LHS model) and 417–1,566 spawners (Beverton-Holt model). MSY is estimated at 3,020 fish for the LHS model compared with 2,798 fish for the Beverton-Holt model while carrying capacity (K) is estimated at 4,002 adults and 4,500 adults, respectively.

The 1982–2007 average estimated harvest of 2,658 fish (Table 4) represents 95% of estimated MSY of 2,798 adults based on the Beverton-Holt model, indicating that while escapements have averaged well above $E_{MSY,}$ the stock has been nearly fully utilized. The estimated equilibrium exploitation rate at MSY based on the Beverton-Holt model is 76.7% compared with the 1982–2007 average exploitation rate of 65.5% (Table 5). The average exploitation rate during the 1990s, a decade of high average abundance, was 75.3%.

The Beverton-Holt model provides a substantially higher estimate of intrinsic productivity (α) at 18.4 returns/spawner compared with 6.3 for the LHS model and 7.6 for the Ricker model. There is substantial uncertainty in all of these estimates because there have been no observed returns from escapements near the origin where the compensatory mechanism is nearly saturated. Smolt production estimates at α for 14 sets of coho spawner-smolt data reported by Barrowman et al. (2003) averaged 71.5 smolts per spawner (Beverton-Holt model) and 53.0 smolts per spawner (hockey stick model). Their estimates converted to adults (based on our average marine survival estimate of 12.3%) correspond with 8.8 returns per spawner (Beverton-Holt model) and 6.5 returns per spawner (hockey stick model). Those estimates are similar to our LHS and Ricker estimates of α for the Hugh Smith Lake stock but less than half of our Beverton-Holt estimate.

Escapement Goal

The three models examined assume widely varying relationships between spawners and returns over the full range of potential escapements. We favor the Beverton-Holt model because it provides the best overall statistical fit (8% better than LHS and 31% better than Ricker) and tracks most closely with the symmetrical median over the range of observations. We recommend that the point goal be revised from 770 (Clark et al. 1994) to 850 spawners based on the Beverton-Holt model E_{MSY} estimate of 851 spawners. That proposed goal is also supported by the LHS model E_{MSY} estimate of 844 spawners (Table 10).

Although the Beverton-Holt model predicts that it is possible to achieve 90% of MSY from an escapement of only 417 spawners (compared with 593 spawners indicated by the LHS model), there has been only one recorded observation below the current lower goal bound of 500 spawners (i.e. 433 spawners in 1989). We suggest it is prudent to maintain the lower goal bound of no fewer than 500 spawners, given the poorly defined lower portion of the spawner-recruit relationship and an apparent positive response at escapement levels substantially above 500 spawners.

On the other hand, results for all three models suggest that it would be beneficial to increase the upper goal bound above the current level of 1,100 spawners. We recommend that the upper bound be shifted to 1,600 spawners, which is slightly above the highest escapement estimated to produce 90% or more of MSY (based on the Beverton-Holt model). The Beverton-Holt relationship more closely parallels the replacement line over a broad range of escapements compared with the other models (Figure 14) and, therefore, the predicted yield is relatively insensitive to escapement within that range. We recommend a broad goal range of 500–1,600 spawners that is relatively consistent with 90% of MSY bounds predicted by the Beverton-Holt model (417–1,566 spawners) and is also close to a range of 498–1,586 spawners predicted by the LHS model to produce 80% or more of MSY.

INSEASON ABUNDANCE ESTIMATION

In this section we will describe efforts to forecast the total return and spawning escapement for the Hugh Smith Lake stock. A summary of the sources of information and recent methods used to forecast abundance and escapement will be presented without any effort to statistically evaluate the overall accuracy and precision of predictive models.

The Hugh Smith Lake return has tracked reasonably closely (R^2 = 0.58) with an index of aggregate coho salmon abundance in the region (Figure 15). The index was calculated by subtracting the estimated hatchery contribution to the troll catch from the total troll catch and dividing the result by an index of the troll exploitation rate based on the Auke Creek, Ford Arm Lake and Hugh Smith Lake stocks. Auke Creek and Hugh Smith Lake were each given a 40% weighting while Ford Arm Lake was given only a 20% weighting because it, like Auke Creek is also located in northern Southeast, and because it has had a substantially higher average troll exploitation rate compared with most stocks that have been studied in the region.

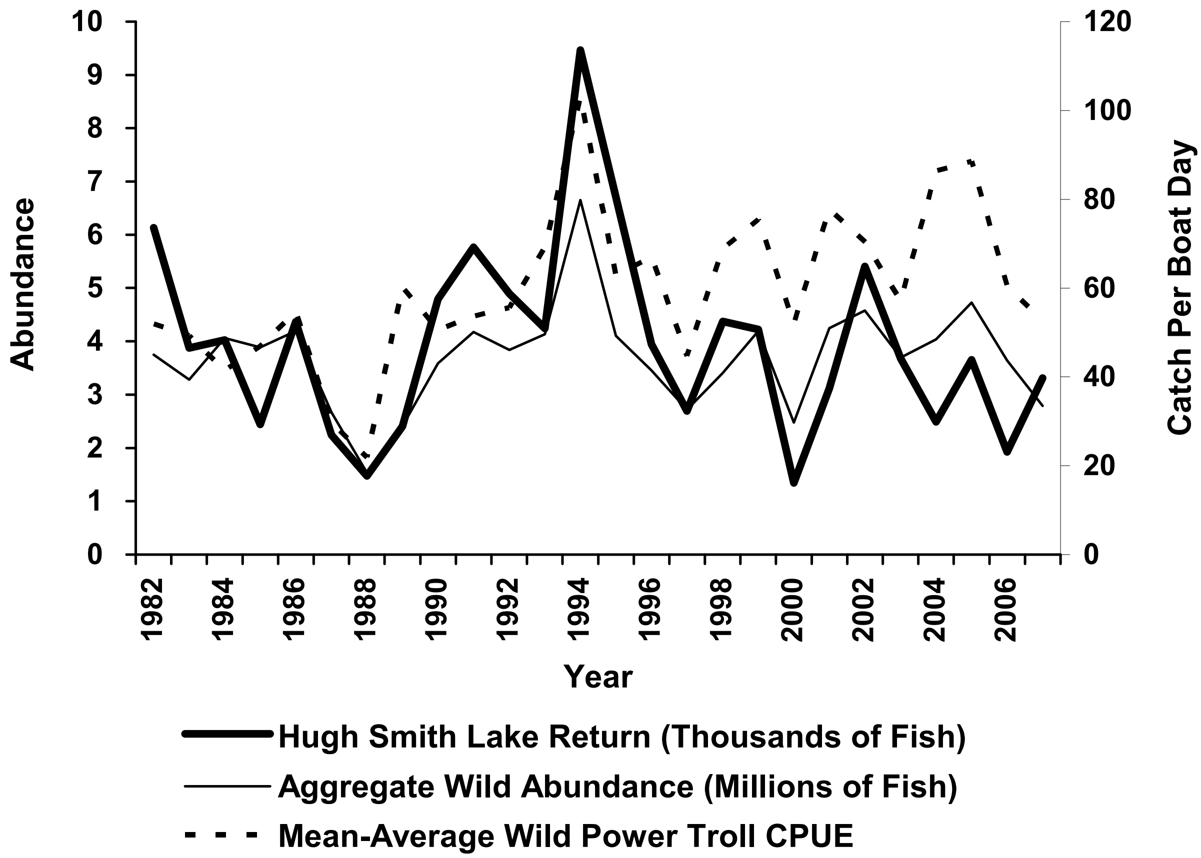

Figure 15.–Estimated total coho salmon return to Hugh Smith Lake compared to the mean–average catch-per-boat-day of wild coho salmon by the Alaska troll fishery in statistical weeks 29–36 and an index of total regional coho salmon abundance.

The correlation with the aggregate abundance index was relatively strong during 1982–1999 (R^2 = 0.75) but has decreased during 2000–2007 (R^2 = 0.40) when the Hugh Smith Lake return was sharply lower relative to the index in 2000, 2004 and 2006. Overall, the Hugh Smith Lake stock appears to be a reasonably representative indicator in the regional coho stock assessment program, even though the system has contributed, on average, about 1 fish (and a maximum of 2) per 1,000 wild coho salmon harvested in Southeast Alaska.

Unfortunately, inseason CPUE indicators have not been as closely correlated with either the Hugh Smith Lake stock or aggregate wild coho salmon abundance over the longer term. There was a sharp upward divergence after 1995 in region-wide power troll fishery CPUE relative to both the Hugh Smith Lake run and the indicator of aggregate wild coho salmon abundance (Figure 15). As fish prices declined in the mid-1990s, there was a decrease in both the number of trollers participating and the number of boat-days fished coincident with an apparent increase in the effectiveness of a boat-day of effort. Although departure of lower producing fishermen from the fishery may have contributed to increased fleet efficiency, the primary factor appears to have been increasing pressure on revenues and costs that have made it unattractive for trollers to continue fishing in a location when catch rates were low. As a result, over the entire period from 1982–2007, the harvest by trollers has been a more stable indicator of the abundance index than has CPUE. Although CPUE estimates collected by dockside technicians are still an important inseason indicator used by fishery managers, frequent recalibration is required for accurate prediction of overall coho salmon abundance.

Despite the management challenges posed by highly mixed-stock fisheries that occur far in advance of entry into freshwater, methods have been developed to assess abundance and predict escapement specifically for Hugh Smith Lake and other indicator stocks in the region.

The success of these methods depends upon intensive marking of smolts, combined with a comprehensive catch sampling program and rapid sample and data processing by the ADF&G Mark, Tag and Age Laboratory. These programs provide the essential elements needed to estimate abundance and forecast escapement.

An inseason forecast of total adult abundance (N_A) is the product of real-time estimates for two parameters: the number of smolts (N_S) and the marine survival rate (μ):

$$\hat{N}_A = \hat{N}_S \hat{\mu}$$

The resulting forecast of N_A is combined with a prediction for the all-gear exploitation rate (U) to predict the number of adults that will escape to Hugh Smith Lake to spawn (E):

$$\hat{E} = \hat{N}_A (1 - \hat{U})$$

In the following sections, we will describe recent methods used to obtain estimates for the three key parameters (N_S, μ, and U) used to assess abundance and predict escapement.

Preseason and Inseason Smolt Estimates

Final estimates of smolt production are dependent upon sampling of returning spawners for adipose clips and coded-wire tags and are, therefore, unavailable for inseason management. However, preliminary working estimates can be made using one or both of two methods: (a) expand the smolt count at the weir by an average factor, or (b) generate a preliminary Chapman estimate based on a sample of jack returns.

Unfortunately smolt weir efficiency (number captured/smolt estimate) has been highly variable over the course of the operation, ranging from 13.7% in 1987 to 84.3% in 2000. However, efforts to tighten the smolt weir with frequent diving and placement of sandbags improved capture efficiency by the mid-1990s to an average of 70.9% (range 60.3–84.3%) during 1996–2006. For the period from 1996–2007, smolt estimates based on a constant expansion factor of 1.41 have a similar linear fit with final smolt abundance estimates (R^2 = 0.80) compared with Chapman estimates based on the sampled jack return (R^2 = 0.76).

The choice of estimates hinges primarily on two factors. Operational problems with the weir (including topping by floodwaters, evident holes or abnormal timing) favor the Chapman estimate. On the other hand, a scarcity of jacks would favor expansion of the smolt count. In some years, jacks are scarce or are smaller than usual with many being able to slip through the weir uncounted and unsampled. For example, while an average of 85 jacks was sampled annually during 1996–2006, only 17 were sampled in 1999 and 23 were sampled in 2001. It may be advisable in some years to employ a blended estimate weighted by the relative statistical strength of the estimates developed using both methods.

Daily communication from the field of the cumulative adult count and the number with adipose clips improves precision in the Chapman estimate as the number of adult spawners increases in the system from the first week of August onward. The cumulative adult sample for adipose clips and tags during the spawning migration is added to the total sample of jacks in the prior year to generate a best estimate of smolt production.

MARINE SURVIVAL ESTIMATION

Inseason estimation of adult abundance depends on the ability to estimate marine survival, which has accounted for 65% of observed variation in returns over a 25-year period (compared with 35% due to smolt abundance).

The traditional summer Alaska troll fishery operates relatively continuously over a broad area and range of depths beginning in early July. That feature gives it the potential to act as useful test fishery for the run strength of returning coho salmon. However, because of its highly mixed stock nature, the utility of the troll fishery as an indicator of run strength for individual indicator stocks depends upon a timely method of identifying specific stocks in the catch. Fortunately, coded-wire tagging and fishery sampling programs provide timely information on the harvest of marked fish. We have used the linear relationships depicted in Figure 16 to estimate marine survival based on the estimated cumulative harvest rate of tags released in the prior year for the most recent week for which it can be reliably estimated. Estimates of marine survival, when combined with preliminary smolt estimates described above, can then be used to estimate the total adult return.

We excluded outlying points in the years 2001–2003 from the linear relationships shown in Figure 16 because troll fishery exploitation rates on the Hugh Smith Lake stock were very low during that period (average 21%; range 16–24%) compared with an average of 39% (range 28–51%) for the other 23 years in study. Underlying reasons for the very low exploitation rates in those years appear to include a very low average price for coho salmon and a substantially higher price for Chinook salmon (2001) and high abundance of Chinook salmon (2002 and 2003).

The recovery rate of tags in the troll fishery becomes a useful predictor of total marine survival by early to mid-August. A linear relationship between marine survival and cumulative expanded recoveries in the traditional Alaska troll fishery (as a percentage of tagged smolts released) reaches an R^2 value of 0.66 by the end of statistical week 30 which has an average ending date of July 26. A preliminary estimate through week 30 is available at the point when a decision is usually made about a mid-season troll closure beginning in mid-August. The predictive value of troll fishery tag recoveries in estimating marine survival improves until about statistical week 36 or about September 6 ($R^2 = 0.92$).

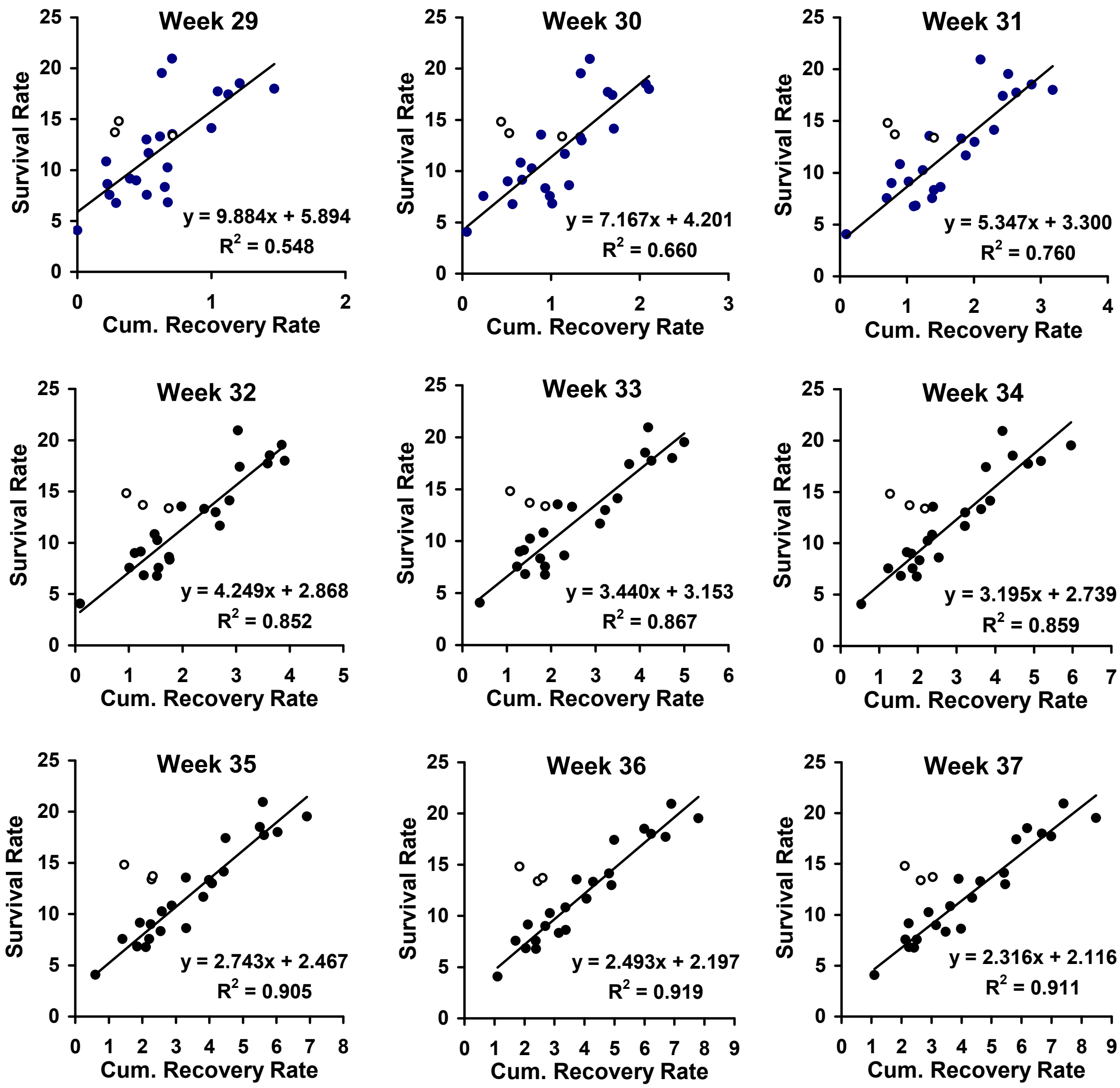

Figure 16.–Weekly linear relationships between the estimated cumulative harvest of coded-wire tagged Hugh Smith Lake coho salmon in the traditional Alaska troll fishery by statistical week as a percent of tagged smolts released and the marine survival rate for the stock, 1983–2007. The years 2001–2003 (open circles) were excluded from the regression calculations because of exceptionally low troll fishery exploitation rates compared with other years in the data series.

There is a lag of 1 to 2 weeks between the end of a statistical week and the point at which the harvest of tagged fish can be calculated with reasonable confidence. An estimate through statistical week 36 would likely be available in time for a decision about whether to extend the Tree Point Gillnet fishery beyond statistical week 38 or the troll fishery beyond September 20.

Cox et al. (2003) developed and evaluated a model to forecast marine survival of specific northern British Columbia coho stocks based on catch-per-unit-of-effort (CPUE) of tags in the Alaska troll fishery. We have also examined relationships based on cumulative CPUE of tags in the troll fishery to predict marine survival of some Southeast Alaska stocks. This method has an advantage in accounting for variable effort and is slightly timelier than catch-based estimates. Weekly power troll coho salmon CPUE estimates are obtained for six major fishing areas from dockside interviews by the Fishery Performance Data (FPD) program and are quickly entered into an accessible database. These estimates of total coho salmon CPUE can then be multiplied by the appropriate weekly estimate of the concentration of the tag codes of interest in the catch based on coded-wire tag samples received and decoded at the Mark, Tag and Age Laboratory. Entry of both fishery performance and coded-wire tag sample information often precedes availability of reliable total catch estimates which depend to some extent on mailing or delivery of fish tickets to the Department by processors (in addition to data entry).

Despite the apparent advantages of using CPUE of tags rather than catch, we have found CPUE to be generally an inferior predictor of marine survival. The reasons for this are probably the same as those noted above for the inconsistent relationship between power troll CPUE and total abundance (Figure 16). However, we recommend that the usefulness of CPUE be re-examined in the future if the efficiency of a boat-day of power troll effort stabilizes.

FORECASTING ESCAPEMENT

The total adult return (N_A) is estimated during the fishing season by multiplying the best available estimate of the number of smolts that migrated to sea in the prior year (N_s) by the best available estimate of the marine survival rate (μ). However, while an estimate of the total abundance of returning adults is useful, the primary objective of the fishery manager is to achieve a number of spawners (E) within a biological goal range around E_{MSY}, regardless of total returning abundance. Spawning escapement can be predicted in two ways.

The most useful method early in the season is to apply a best estimate of the all-gear exploitation rate (U) to the predicted adult return. Based on no other available information, U might be most reliably predicted based on the most recent 2 or 3 year average. However, fishing patterns and intensity can vary substantially from year-to-year depending on fish prices, abundance of other target species, etc. Therefore, it is often useful to incorporate information on current fishing patterns compared with past years in judging the most likely overall exploitation rate during the current season. Many factors may play into such an estimate including: the number of trollers observed during overflight surveys, the number of fishing-days restricted by poor weather, the amount of purse seining occurring in districts where the stock of interest is available, the probable amount of fall gillnet effort based on fish prices and abundance of other target species, the level of effort in Canadian fisheries, etc. All of these parameters invite experienced judgments that tend to provide more effective management than can be achieved by strict adherence to model results. Typically, a range of probable exploitation rates is applied to the best run size estimate to provide a range of probable escapements.

Predicting the exploitation rate becomes more critical with more intensive fishing. Within the high range of exploitation rates (averaging 76%) that the stock was subjected to during 1989–1999, minor variations in the exploitation rate had a disproportionately large effect on escapement. More moderate exploitation rates averaging 55% during 2000–2007 have increased the proportion of returning adults that escape to spawn by an average of 88%, while reducing the coefficient of variation in the proportion escaping from 0.21 to 0.18. Estimation error becomes more critical as fishing intensity increases when employing escapement forecasting methods based on predictions of the abundance and exploitation rate of a returning stock.

The second method for forecasting escapement is to extrapolate the inseason weir count based on historical escapement timing. The weir count is an imprecise predictor of escapement before mid-September. Nevertheless, early counts prove very useful in some years. For example, if the weir count is 300 spawners by late August, there is very little chance that the lower goal bound of 500 spawners will not be achieved, and a manager can reasonably bet on a larger escapement with little risk of falling short. On the other hand, a more typical cumulative escapement of only 130 spawners in late August could end in a wide range of outcomes, given variable timing, and provides no reason for either comfort or alarm.

Typically, both the weir count and the CWT-based prediction are weighed in predicting escapement, depending on the point in the season. The weir count provides a valuable direct observation of escapement that supplements the CWT-based prediction.

DISCUSSION

Several measures have been implemented since the 1980s to insure quality as well as efficiency in escapement estimates. Early problems with the escapement estimation program have been addressed in a variety of ways. Construction of a more solid, well-anchored structure with well-supported heavy wire extensions above the catwalk and on each end have markedly increased the flow conditions under which the weir can effectively detain fish. The weir is heavily sandbagged where pickets meet the bottom and inspected regularly for potential holes throughout the season. Intermittent use of clear plastic covering to concentrate flow during low flow conditions has helped draw fish into the trap, resulting in more of the run passing through the weir where it can be more precisely counted and sampled. During many years, a policy of 100% sampling and marking using three different marks at the weir, has made it possible to generate relatively precise estimates for known periods when the count is questionable without sampling spawners evenly throughout the entire spawning period. Use of sport gear for mark recovery sampling off the inlet streams has improved sampling rates for late spawners without requiring mid-winter trips to the lake.

Termination of the weir operation in the first week of November is a reasonable compromise that provides thorough coverage of the run while giving the crew an adequate opportunity for mark-recovery sampling before leaving the system. Earlier spawners in October and November in Cobb Creek can be sampled with a beach seine in late October and early November while later fish accumulating off the mouth of Buschmann Creek can usually be effectively sampled at the same time with sport gear, reducing the potential need for December and January trips. These strategies have reduced dependence on mark-recapture estimation while still effectively using it to validate the weir count and we recommend that they be continued.

Based on the spawner-recruit analysis results, we recommend that the current escapement goal for Hugh Smith Lake coho salmon of 770 spawners (range 500–1,100) be increased to 850 spawners (range 500–1,600). This recommendation is based primarily on the Beverton-Holt model which best fits the spawner-recruit data, predicting E_{MSY} at 851 spawners and yield that is 90% or more of MSY from an escapement range of 417–1,566 spawners. We recommend that the lower goal bound of 500 fish be maintained given the uncertainty in model estimates of α and considering the lower 90% bound of 593 spawners indicated by the LHS model. Expanding the LHS model's yield range to 80% or more of MSY, results in an indicated escapement range of 498–1,586 spawners, a range that is very close to our proposed goal of 500–1,600 spawners.

The Hugh Smith Lake spawner-recruit observations indicate an overall positive response with larger escapements producing larger average returns. The results are consistent with findings by Barrowman et al. (2003) that a Beverton-Holt model provided a good fit for several coho salmon stocks from Oregon to southern British Columbia.

The hockey stick model with its assumption of a fixed level of smolt production above a saturation level may be over-simplistic in its representation of coho salmon life history in some systems. The presumption behind the hockey stick model is that stream habitat strictly limits the number of juveniles that can rear to smolthood based on limited available territories. Although territoriality also appears to be important in regulating smolt production from lakes and ponds, it may impose a less stringent limitation in those environments. In addition, recent evidence for marine rearing of juveniles (Crabtree et al. *In prep*) suggests that estuaries and inside waters of Southeast Alaska may act as an overflow area for fry in excess of the capacity of the freshwater rearing habitat. Density dependence may be less important in regulating populations in those environments. Finally, an increase in nutrient delivery in stream systems in the form of more carcasses potentially increases habitat capability by increasing food available to progeny of a more abundant spawning population (Wipfli et al. 1999 and 2003; Bilby et al. 1998; Cederholm et a1. 1999; and others).

In addition to biological factors, practical economic and fishery management considerations also favor a broad escapement goal range. The broad temporal and spatial distribution of the harvest of the stock in mixed-stock and mixed-species fisheries involving different management jurisdictions limits the range within which fishery managers can easily control escapement. Opportunities for active inseason management of southern inside area coho salmon stocks are concentrated primarily in the later part of the region-wide troll season and in directed fall troll, gillnet and sport fisheries in southern Southeast. In practice, fishing patterns and exploitation rates have been relatively stable.

Thus far, this management regime appears to have served the fisheries well from a socioeconomic standpoint by providing participants flexibility in allocating their time and resources within a relatively predictable management framework. At the same time, little potential yield was foregone under variable escapements averaging about 1,300 spawners compared with a constant E_{MSY} of about 850 spawners. An estimated 95% of potential yield has been achieved while maintaining the adult population at a slightly (5–6%) larger average size than predicted had the stock been held to a constant E_{MSY} goal. Larger average run sizes and lower exploitation rates promote greater economic efficiency in the fisheries by increasing CPUE while providing a potential population buffer when survival conditions are poor. The proposed broad goal range promotes continuation of the overall conservative management pattern that has served well for the past 25 years while providing a reasonable threshold target for inseason conservation restrictions in years of poor returns.

Escapements have fallen under the proposed goal range only once (433 spawners in 1989) and above it in 7 years. The lower portion of the range (500–850 spawners) has been achieved in 5 years while half of all escapements (13) have fallen within the upper portion (850–1,600 spawners). The average historical escapement of about 1,300 spawners has exceeded the estimate of E_{MSY} by 53% but falls well within the upper part of the range.

Unless there are substantial decreases in marine survival or smolt production, escapement goals are likely to be met in most years with little variation in management. However, recent survival rates ranging from 6.8–9.1% for the 2005–2007 adult returns represent a decline from the long-term average of 12.3%. A continued lower trend in marine survival would increase the likelihood of a shortfall in escapement in years when smolt production is low.

At an equilibrium run size of 4,500 adults, the Beverton-Holt model predicts MSY at an exploitation rate of about 77% which is above the long-term average exploitation rate of 65%. While exploitation rates were higher in the 1990s, averaging 75%, run sizes in that decade were also relatively high so that escapements averaged 1,241 spawners, well above the point estimate of E_{MSY} (851 spawners).

The Hugh Smith Lake stock is representative of late-run inside stocks in southern Southeast that potentially accumulate a high exploitation rate over a gauntlet of mixed-stock fisheries. At the same time, average marine survival rates for Hugh Smith Lake coho salmon have been lower than is the case for some northern Southeast stocks including the Berners River and Auke Creek (Lynch and Skannes 2008). Therefore, the Hugh Smith Lake stock likely represents stocks in the region that are most taxed for intrinsic productivity (α) and are, therefore, most vulnerable to over-exploitation. The favorable recent escapement status of this stock and surveyed stocks in other systems in District 101 (Shaul and Tydingco 2006) bodes well for the status of other coho salmon stocks in the region. The Hugh Smith Lake stock remains one of the most important wild indicator stocks in the region and is the primary indicator stock in the Ketchikan area.

The CWT-based and cumulative escapement models that have been used to track the total return and escapement during the fishing season might potentially be improved and better understood through more rigorous statistical analysis. However, some parameters such as the expected exploitation rate may be difficult to accurately predict using only a model. Accurate, responsive management of fisheries for biological goals will always depend to some extent upon the judgment and experience of fishery managers in understanding and weighing a complex interaction of physical, biological, economic and social influences.

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APPENDIX

Appendix A.–Number of observed recoveries of tagged Hugh Smith Lake coho salmon from random fishery samples.

Fishery	Area	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Alaska Troll	NW	35	42	34	65	99	15	14	30	61	94	159	56	234
	NE	5	11	1	3	13	10	0	4	10	10	7	6	30
	SW	4	20	9	19	16	20	4	10	23	62	39	19	108
	SE	20	34	23	27	27	7	4	17	24	44	53	20	121
	Subtotal	64	107	67	114	155	52	22	61	118	210	258	101	493
Alaska Seine	101	7	13	11	30	20	1	1	3	9	2	20	3	1
	102	0	8	0	5	0	0	0	2	0	3	6	2	2
	103	0	0	0	0	0	0	0	0	1	0	0	0	0
	104	5	4	6	4	15	4	3	4	11	15	54	5	62
	105	0	0	0	0	0	0	0	0	0	0	0	0	0
	106	0	2	0	0	0	0	0	0	0	0	0	0	7
	107	0	0	0	0	0	0	0	0	0	0	1	0	0
	109	0	0	1	0	0	0	0	0	1	0	0	0	4
	112	0	0	0	0	0	0	0	0	0	0	0	0	0
	113	0	1	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	12	28	18	39	35	5	4	9	22	20	81	10	76
Alaska Gillnet	Tree Pt.	—	—	—	—	—	—	—	2	35	29	68	7	125
	Annette Is.	—	—	—	—	—	—	—	8	11	61	29	13	62
	101 Total	4	20	40	35	32	27	7	10	46	90	97	20	187
	106	0	12	2	1	7	0	0	4	8	16	13	15	20
	108	0	2	0	0	1	0	0	0	0	0	0	0	0
	212	0	0	0	0	0	0	0	0	0	1	0	0	1
	Subtotal	4	34	42	36	40	27	7	14	54	107	110	35	208
Alaska Trap	101	0	4	2	2	0	0	0	0	2	0	0	0	0
Alaska NR	102	0	0	0	0	0	1	0	0	0	0	0	0	0
Alaska Sport	Craig	0	0	0	0	0	0	0	0	0	0	0	0	2
	Elfin Cove	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ketchikan	0	0	0	0	1	1	0	1	0	2	2	0	1
	Sitka	0	0	0	0	0	0	0	0	0	0	0	0	0
	Yakutat	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	0	0	0	0	1	1	0	1	0	2	2	0	3
Alaska Total		80	173	129	191	231	86	33	85	196	339	451	146	780
B.C. Troll	NBC	9	9	21	20	23	9	7	4	61	54	44	6	48
B.C. Net	NBC	2	3	1	2	2	4	1	2	6	6	2	3	9
B.C. Sport	NBC	0	0	0	0	0	0	0	0	0	0	0	0	1
B.C. Total		11	12	22	22	25	13	8	6	67	60	46	9	58
Total Catch		91	185	151	213	256	99	41	91	263	399	497	155	838
Escapement		219	353	250	477	739	291	68	73	231	622	802	137	695
Total Tags		310	538	401	690	995	390	109	164	494	1,021	1,299	292	1,533

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Appendix A.–Page 2 of 2

Fishery	Area	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
Alaska Troll	NW	103	121	226	209	177	69	89	110	78	65	70	53	152	95
	NE	4	19	10	54	46	6	8	15	15	12	19	21	7	13
	SW	41	100	41	60	57	23	63	56	53	46	29	21	22	37
	SE	35	86	39	106	91	13	48	94	62	49	28	21	20	43
	Subtotal	183	326	316	429	371	111	208	275	208	172	146	116	201	188
Alaska Seine	101	12	11	2	8	5	0	10	28	13	7	3	6	5	9
	102	2	12	1	0	4	1	6	4	4	3	0	0	1	3
	103	0	0	0	1	0	0	0	0	2	0	0	1	0	0
	104	30	37	10	17	13	8	3	3	2	3	0	2	14	13
	105	2	0	1	0	0	0	0	0	1	0	0	0	0	0
	106	0	0	2	3	1	0	4	0	1	0	1	0	3	1
	107	1	0	0	0	0	0	0	0	0	1	1	0	0	0
	109	3	0	0	6	4	0	1	2	1	1	1	0	0	1
	112	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	113	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	50	60	16	35	27	9	25	37	24	15	6	9	23	27
Alaska Gillnet	Tree Pt.	100	34	77	114	129	22	28	60	27	22	72	22	23	52
	Annette	48	23	45	17	24	4	26	19	5	2	2	2	2	21
	101 Total	148	57	122	131	153	26	54	79	32	24	74	24	25	60
	106	20	26	9	50	43	3	10	19	38	4	14	8	10	14
	108	0	0	0	1	1	0	0	0	0	0	0	0	1	0
	212	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	168	83	131	182	197	29	64	98	70	28	88	32	36	74
Alaska Trap	101	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alaska NR	102	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alaska Sport	Craig	1	0	1	2	3	2	3	4	0	2	3	0	0	1
	Elfin Cove	0	0	0	0	0	0	0	1	0	0	0	1	0	0
	Ketchikan	4	4	1	11	7	3	8	4	8	9	2	2	4	3
	Sitka	0	2	0	7	16	7	4	9	13	1	3	0	14	3
	Yakutat	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Subtotal	5	6	2	20	27	12	15	18	21	12	8	3	18	7
Alaska Total		406	475	465	666	622	161	312	428	323	227	248	160	278	296
B.C. Troll	NBC	32	51	59	106	98	40	32	18	223	208	162	34	275	32
B.C. Net	NBC	9	12	5	21	12	14	4	3	14	15	5	7	21	9
B.C. Sport	NBC	0	0	0	0	0	0	0	0	0	0	0	0	5	0
B.C. Total		26	27	15	2	1	0	2	6	12	17	8	9	16	19
Total Catch		432	502	480	668	623	161	314	434	335	244	256	169	294	315
Escapement		568	535	552	687	839	359	1,326	2,684	1,070	558	1,003	563	856	637
Total Tags		1,000	1,037	1,032	1,355	1,462	520	1,640	3,118	1,405	802	1,259	732	1,150	952

Appendix B.–Number of expanded recoveries of tagged Hugh Smith Lake coho salmon from random fishery samples.

Fishery	**Area**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**
Alaska Troll	NW	131	170	135	300	489	54	36	99	266	338	731	219	1,034
	NE	42	18	3	11	34	25	0	12	40	35	24	22	74
	SW	42	57	34	70	65	73	8	43	76	155	115	55	297
	SE	66	80	54	78	75	18	9	50	97	185	173	71	312
	Subtotal	282	326	225	459	663	171	54	204	479	713	1,043	367	1,717
Alaska Seine	101	44	52	45	101	78	3	3	9	85	4	149	20	2
	102	0	25	0	26	0	0	0	11	0	10	27	11	26
	103	0	0	0	0	0	0	0	0	20	0	0	0	0
	104	20	17	42	24	126	18	25	33	43	51	200	14	301
	105	0	0	0	0	0	0	0	0	0	0	0	0	0
	106	0	3	0	0	0	0	0	0	0	0	0	0	53
	107	0	0	0	0	0	0	0	0	0	0	4	0	0
	109	0	0	3	0	0	0	0	0	3	0	0	0	64
	112	0	0	0	0	0	0	0	0	0	0	0	0	0
	113	0	2	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	64	101	90	152	204	21	27	54	150	65	380	44	445
Alaska Gillnet	Tree Pt.	—	—	—	—	—	—	—	16	124	148	209	32	327
	Annette Is.	—	—	—	—	—	—	—	11	16	83	73	16	92
	101 Total	21	34	81	70	58	38	10	27	139	231	282	49	419
	106	0	28	3	3	29	0	0	14	30	87	55	61	155
	108	0	4	0	0	1	0	0	0	0	0	0	0	0
	212	0	0	0	0	0	0	0	0	0	1	0	0	1
	Subtotal	21	66	84	72	88	38	10	41	169	319	337	110	575
Alaska Trap	101	0	12	3	3	0	0	0	0	6	0	0	0	0
Alaska NR	102	0	0	0	0	0	1	0	0	0	0	0	0	0
Alaska Sport	Craig	0	0	0	0	0	0	0	0	0	0	0	0	8
	Elfin Cove	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ketchikan	0	0	0	0	7	7	0	10	0	13	22	0	10
	Sitka	0	0	0	0	0	0	0	0	0	0	0	0	0
	Yakutat	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	0	0	0	0	7	7	0	10	0	13	22	0	18
Alaska Total		367	504	402	686	962	239	92	309	805	1,109	1,783	521	2,755
B.C. Troll	NBC	32	51	59	106	98	40	32	18	223	208	162	34	275
B.C. Net	NBC	9	12	5	21	12	14	4	3	14	15	5	7	21
B.C. Sport	NBC	0	0	0	0	0	0	0	0	0	0	0	0	5
B.C. Total		41	63	64	127	110	54	36	21	237	223	168	41	301
Total Catch		408	566	465	812	1,072	294	127	331	1,042	1,332	1,950	562	3,056
Escapement		219	353	250	477	739	291	68	73	231	622	802	137	695
Total Tags		627	919	716	1,289	1,811	585	195	403	1,273	1,954	2,752	699	3,751

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Appendix B.–Page 2 of 2.

Fishery	Area	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
Alaska Troll	NW	410	431	763	724	692	222	325	377	273	305	260	212	620	370
	NE	11	59	38	196	132	19	31	45	47	62	109	79	26	46
	SW	107	176	78	144	145	30	114	84	100	101	135	69	98	95
	SE	116	227	117	175	213	21	114	221	214	207	169	83	125	126
	Subtotal	644	892	996	1,239	1,183	292	585	727	634	675	673	444	869	637
Alaska Seine	101	68	74	12	55	45	0	227	260	113	63	29	18	27	61
	102	58	120	5	0	40	3	66	66	38	10	0	0	2	21
	103	0	0	0	81	0	0	0	0	53	0	0	4	0	6
	104	150	157	40	128	53	24	60	26	31	11	0	18	80	65
	105	6	0	19	0	0	0	0	0	5	0	0	0	0	1
	106	0	0	6	37	10	0	22	0	7	0	8	0	11	6
	107	5	0	0	0	0	0	0	0	0	41	18	0	0	3
	109	15	0	0	28	43	0	4	16	4	5	15	0	0	8
	112	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	113	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	302	351	82	329	190	27	381	368	251	130	71	40	120	171
Alaska Gillnet	Tree Pt.	326	87	195	449	310	51	104	214	308	122	229	82	92	180
	Annette	101	45	79	94	51	9	125	166	35	16	15	6	28	56
	101 Total	427	131	274	543	361	60	228	381	260	131	244	88	120	181
	106	80	143	25	134	119	9	44	72	146	23	64	19	79	55
	108	0	0	0	8	8	0	0	0	0	0	0	0	8	1
	212	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	507	274	300	685	489	69	272	452	406	154	308	107	207	237
Alaska Trap	101	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Alaska NR	102	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alaska Sport	Craig	4	0	23	22	14	11	15	21	0	10	14	0	0	5
	Elfin Cove	0	0	0	0	0	0	0	1	0	0	0	1	0	0
	Ketchikan	27	31	11	55	43	26	20	14	22	27	9	4	13	14
	Sitka	0	40	0	29	61	21	13	38	53	3	10	0	38	12
	Yakutat	0	0	0	0	3	0	0	0	0	0	0	0	0	0
	Subtotal	31	71	34	105	121	58	49	74	75	40	34	5	51	32
Alaska Total		1,484	1,587	1,411	2,359	1,983	446	1,287	1,622	1,366	999	1,087	596	1,247	1,077
B.C. Troll	NBC	75	71	69	—	—	—	6	53	65	32	21	21	39	69
B.C. Net	NBC	9	22	—	—	—	—	—	—	22	13	5	—	8	8
B.C. Sport	NBC	3	8	—	11	20	—	—	50	—	46	—	37	128	12
B.C. Total		88	100	69	11	20	0	6	103	87	91	25	58	175	89
Total Catch		1,572	1,687	1,480	2,369	2,003	446	1,292	1,725	1,452	1,089	1,112	654	1,422	1,166
Escapement		568	535	552	687	839	359	1,326	2,684	1,070	558	1,003	563	856	637
Total Tags		2,141	2,222	2,032	3,057	2,842	805	2,619	4,409	2,522	1,647	2,115	1,217	2,278	1,803

Appendix C.–Estimated number of Hugh Smith Lake coho salmon harvested by fishery and escaping to spawn, 1982–2007.

Fishery	Area	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Alaska Troll	NW	1,286	716	757	568	1,178	209	273	591	1,001	998	1,300	1,332	2,608
	NE	411	77	17	21	82	97	0	74	151	104	43	132	188
	SW	413	242	191	132	157	282	62	254	285	456	205	333	749
	SE	649	338	301	147	180	70	70	298	366	545	307	430	788
	Subtotal	2,758	1,374	1,266	868	1,598	657	406	1,217	1,803	2,103	1,854	2,227	4,333
Alaska Seine	101	435	221	251	192	188	12	20	56	319	12	264	120	6
	102	0	107	0	50	0	0	0	68	0	28	48	66	65
	103	0	0	0	0	0	0	0	0	75	0	0	0	0
	104	193	73	238	46	304	70	187	195	161	150	356	83	759
	105	0	0	0	0	0	0	0	0	0	0	0	0	0
	106	0	13	0	0	0	0	0	0	0	0	0	0	133
	107	0	0	0	0	0	0	0	0	0	0	8	0	0
	109	0	0	15	0	0	0	0	0	11	0	0	0	160
	112	0	0	0	0	0	0	0	0	0	0	0	0	0
	113	0	10	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	628	424	504	287	493	82	207	320	566	190	676	269	1,123
Alaska Gillnet	Tree Pt.	—	—	—	—	—	—	—	93	465	437	372	197	824
	Annette Is.	—	—	—	—	—	—	—	68	58	245	131	99	232
	101 Total	203	145	455	132	140	148	78	162	524	682	502	296	1,056
	106	0	117	16	5	70	0	0	85	114	256	98	370	391
	108	0	15	0	0	4	0	0	0	0	0	0	0	0
	212	0	0	0	0	0	0	0	0	0	4	0	0	4
	Subtotal	203	277	471	137	213	148	78	247	637	941	600	666	1,450
Alaska Trap	101	0	49	18	5	0	0	0	0	23	0	0	0	0
Alaska NR	102	0	0	0	0	0	4	0	0	0	0	0	0	0
Alaska Sport	Craig	0	0	0	0	0	0	0	0	0	0	0	0	20
	Elfin Cove	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ketchikan	0	0	0	0	16	28	0	62	0	38	40	0	25
	Sitka	0	0	0	0	0	0	0	0	0	0	0	0	0
	Yakutat	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	0	0	0	0	16	28	0	62	0	38	40	0	45
Alaska Total		3,588	2,123	2,259	1,298	2,319	919	691	1,845	3,030	3,273	3,170	3,162	6,952
B.C. Troll	NBC	316	214	331	201	236	155	242	106	840	614	289	207	694
B.C. Net	NBC	84	50	27	39	28	53	27	20	54	44	10	41	53
B.C. Sport	NBC	0	0	0	0	0	0	0	0	0	0	0	0	13
B.C. Total		400	264	358	239	264	208	269	126	893	658	298	248	759
Total Catch		3,988	2,388	2,617	1,537	2,583	1,127	960	1,971	3,924	3,931	3,469	3,410	7,711
Escapement		2,144	1,487	1,407	903	1,782	1,117	513	433	870	1,836	1,426	832	1,753
Total Tags		6,132	3,875	4,024	2,440	4,365	2,244	1,473	2,404	4,794	5,767	4,895	4,242	9,464

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Fishery	Area	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
Alaska Troll	NW	1,286	766	1,012	1,036	1,028	371	388	462	385	460	449	336	901	834
	NE	33	104	50	280	196	31	37	55	66	94	189	125	37	104
	SW	334	312	104	206	216	51	136	103	141	152	233	110	143	231
	SE	365	403	156	250	317	36	136	271	302	311	292	131	181	294
	Subtotal	2,018	1,585	1,321	1,771	1,757	489	696	892	894	1,017	1,163	703	1,263	1,463
Alaska Seine	101	214	131	15	79	68	0	271	318	159	95	51	29	39	137
	102	181	213	7	0	59	5	78	81	53	14	0	0	3	43
	103	0	0	0	115	0	0	0	0	75	0	0	6	0	10
	104	471	278	53	183	78	40	71	32	44	17	0	29	116	163
	105	19	0	25	0	0	0	0	0	6	0	0	0	0	2
	106	0	0	8	53	14	0	27	0	10	0	14	0	16	11
	107	16	0	0	0	0	0	0	0	0	62	31	0	0	5
	109	47	0	0	41	63	0	5	19	6	8	26	0	0	15
	112	0	0	0	0	0	0	2	0	0	0	0	0	0	0
	113	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	947	623	108	471	283	45	454	451	354	196	122	64	175	387
Alaska Gillnet	Tree Pt.	1,021	154	259	643	461	85	123	262	435	183	396	131	133	351
	Annette	317	79	105	134	76	15	148	204	49	24	25	9	41	108
	101 Total	1,338	233	364	777	537	100	272	467	484	208	421	139	174	386
	106	250	254	34	191	177	16	52	88	206	35	111	30	115	118
	108	0	0	0	12	12	0	0	0	0	0	0	0	11	2
	212	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	1,588	487	397	980	726	116	324	555	690	243	532	170	300	507
Alaska Trap	101	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Alaska NR	102	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alaska Sport	Craig	12	0	31	31	20	18	18	26	0	15	25	0	0	8
	Elfin Cove	0	0	0	0	0	0	0	1	0	0	0	2	0	0
	Ketchikan	86	55	15	78	64	43	24	18	31	41	16	6	19	27
	Sitka	0	71	0	41	90	36	16	46	75	4	18	0	55	17
	Yakutat	0	0	0	0	4	0	0	0	0	0	0	0	0	0
	Subtotal	98	125	45	150	180	97	58	91	106	60	59	7	74	53
Alaska Total		4,652	2,820	1,872	3,373	2,945	746	1,533	1,989	2,044	1,515	1,876	943	1,811	2,413
B.C. Troll	NBC	236	125	91	0	0	0	7	65	91	48	36	34	57	201
B.C. Net	NBC	28	38	0	0	0	0	0	0	31	20	8	0	11	26
B.C. Sport	NBC	11	14	0	15	30	0	0	61	0	69	0	58	186	18
B.C. Total		275	178	91	15	30	0	7	126	122	136	44	92	254	245
Total Catch		4,927	2,998	1,964	3,388	2,975	746	1,539	2,115	2,166	1,652	1,920	1,035	2,066	2,658
Escapement		1,781	950	732	983	1,246	600	1,580	3,291	1,510	840	1,732	891	1,244	1,303
Total Tags		6,708	3,948	2,696	4,371	4,221	1,346	3,119	5,406	3,676	2,492	3,652	1,926	3,310	3,961

Appendix D.–Estimated percent of the total Hugh Smith Lake coho salmon return harvested by fishery and escaping to spawn, 1982–2007.

Fishery	Area	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Alaska Troll	NW	21.0	18.5	18.8	23.3	27.0	9.3	18.5	24.6	20.9	17.3	26.6	31.4	27.6
	NE	6.7	2.0	0.4	0.9	1.9	4.3	0.0	3.1	3.2	1.8	0.9	3.1	2.0
	SW	6.7	6.3	4.7	5.4	3.6	12.6	4.2	10.6	6.0	7.9	4.2	7.9	7.9
	SE	10.6	8.7	7.5	6.0	4.1	3.1	4.8	12.4	7.6	9.4	6.3	10.1	8.3
	Subtotal	45.0	35.5	31.5	35.6	36.6	29.3	27.6	50.6	37.6	36.5	37.9	52.5	45.8
Alaska Seine	101	7.1	5.7	6.2	7.9	4.3	0.5	1.4	2.3	6.7	0.2	5.4	2.8	0.1
	102	0.0	2.8	0.0	2.0	0.0	0.0	0.0	2.8	0.0	0.5	1.0	1.6	0.7
	103	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0
	104	3.1	1.9	5.9	1.9	7.0	3.1	12.7	8.1	3.4	2.6	7.3	2.0	8.0
	105	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	106	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4
	107	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
	109	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	1.7
	112	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	113	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	10.2	10.9	12.5	11.8	11.3	3.6	14.0	13.3	11.8	3.3	13.8	6.3	11.9
Alaska Gillnet	Tree Pt.	—	—	—	—	—	—	—	3.9	9.7	7.6	7.6	4.6	8.7
	Annette Is.	—	—	—	—	—	—	—	2.8	1.2	4.3	2.7	2.3	2.5
	101 Total	3.3	3.7	11.3	5.4	3.2	6.6	5.3	6.7	10.9	11.8	10.3	7.0	11.2
	106	0.0	3.0	0.4	0.2	1.6	0.0	0.0	3.5	2.4	4.4	2.0	8.7	4.1
	108	0.0	0.4	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	212	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
	Subtotal	3.3	7.1	11.7	5.6	4.9	6.6	5.3	10.3	13.3	16.3	12.3	15.7	15.3
Alaska Trap	101	0.0	1.3	0.5	0.2	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
Alaska NR	102	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alaska Sport	Craig	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	Elfin Cove	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ketchikan	0.0	0.0	0.0	0.0	0.4	1.3	0.0	2.6	0.0	0.7	0.8	0.0	0.3
	Sitka	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Yakutat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	0.0	0.0	0.0	0.0	0.4	1.3	0.0	2.6	0.0	0.7	0.8	0.0	0.5
Alaska Total		58.5	54.8	56.1	53.2	53.1	40.9	46.9	76.7	63.2	56.7	64.8	74.5	73.5
B.C. Troll	NBC	5.2	5.5	8.2	8.2	5.4	6.9	16.4	4.4	17.5	10.6	5.9	4.9	7.3
B.C. Net	NBC	1.4	1.3	0.7	1.6	0.7	2.4	1.8	0.8	1.1	0.8	0.2	1.0	0.6
B.C. Sport	NBC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
B.C. Total		6.5	6.8	8.9	9.8	6.1	9.3	18.3	5.3	18.6	11.4	6.1	5.8	8.0
Total Catch		65.0	61.6	65.0	63.0	59.2	50.2	65.2	82.0	81.9	68.2	70.9	80.4	81.5
Escapement		35.0	38.4	35.0	37.0	40.8	49.8	34.8	18.0	18.1	31.8	29.1	19.6	18.5
Total Tags		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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Appendix D.–Page 2 of 2.

Fishery	Area	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
Alaska Troll	NW	19.2	19.4	37.5	23.7	24.4	27.5	12.4	8.6	10.5	18.4	12.3	17.5	27.2	20.9
	NE	0.5	2.6	1.8	6.4	4.6	2.3	1.2	1.0	1.8	3.8	5.2	6.5	1.1	2.7
	SW	5.0	7.9	3.8	4.7	5.1	3.8	4.4	1.9	3.8	6.1	6.4	5.7	4.3	5.8
	SE	5.4	10.2	5.8	5.7	7.5	2.7	4.3	5.0	8.2	12.5	8.0	6.8	5.5	7.2
	Subtotal	30.1	40.2	49.0	40.5	41.6	36.3	22.3	16.5	24.3	40.8	31.8	36.5	38.2	36.5
Alaska Seine	101	3.2	3.3	0.6	1.8	1.6	0.0	8.7	5.9	4.3	3.8	1.4	1.5	1.2	3.4
	102	2.7	5.4	0.3	0.0	1.4	0.4	2.5	1.5	1.4	0.6	0.0	0.0	0.1	1.1
	103	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.3	0.0	0.3
	104	7.0	7.1	2.0	4.2	1.9	3.0	2.3	0.6	1.2	0.7	0.0	1.5	3.5	3.9
	105	0.3	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1
	106	0.0	0.0	0.3	1.2	0.3	0.0	0.9	0.0	0.3	0.0	0.4	0.0	0.5	0.2
	107	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.9	0.0	0.0	0.1
	109	0.7	0.0	0.0	0.9	1.5	0.0	0.2	0.4	0.2	0.3	0.7	0.0	0.0	0.3
	112	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	113	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	14.1	15.8	4.0	10.8	6.7	3.4	14.6	8.3	9.6	7.9	3.4	3.3	5.3	9.3
Alaska Gillnet	Tree Pt.	15.2	3.9	9.6	14.7	10.9	6.3	4.0	4.9	11.8	7.4	10.8	6.8	4.0	8.0
	Annette	4.7	2.0	3.9	3.1	1.8	1.1	4.8	3.8	1.3	1.0	0.7	0.5	1.2	2.4
	101 Total	19.9	5.9	13.5	17.8	12.7	7.4	8.7	8.6	13.2	8.3	11.5	7.2	5.3	9.1
	106	3.7	6.4	1.3	4.4	4.2	1.2	1.7	1.6	5.6	1.4	3.0	1.6	3.5	2.7
	108	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1
	212	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	23.7	12.3	14.7	22.4	17.2	8.6	10.4	10.3	18.8	9.7	14.6	8.8	9.1	11.9
Alaska Trap	101	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Alaska NR	102	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alaska Sport	Craig	0.2	0.0	1.1	0.7	0.5	1.3	0.6	0.5	0.0	0.6	0.7	0.0	0.0	0.2
	Elfin Cove	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
	Ketchikan	1.3	1.4	0.5	1.8	1.5	3.2	0.8	0.3	0.8	1.6	0.4	0.3	0.6	0.8
	Sitka	0.0	1.8	0.0	0.9	2.1	2.7	0.5	0.9	2.1	0.2	0.5	0.0	1.7	0.5
	Yakutat	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	1.5	3.2	1.7	3.4	4.3	7.2	1.9	1.7	2.9	2.4	1.6	0.4	2.2	1.6
Alaska Total		69.3	71.4	69.5	77.2	69.8	55.4	49.1	36.8	55.6	60.8	51.4	49.0	54.7	59.4
B.C. Troll	NBC	3.5	3.2	3.4	0.0	0.0	0.0	0.2	1.2	2.5	1.9	1.0	1.8	1.7	4.9
B.C. Net	NBC	0.4	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.2	0.0	0.3	0.7
B.C. Sport	NBC	0.2	0.4	0.0	0.3	0.7	0.0	0.0	1.1	0.0	2.8	0.0	3.0	5.6	0.5
B.C. Total		4.1	4.5	3.4	0.3	0.7	0.0	0.2	2.3	3.3	5.5	1.2	4.8	7.7	6.1
Total Catch		73.5	75.9	72.8	77.5	70.5	55.4	49.3	39.1	58.9	66.3	52.6	53.7	62.4	65.5
Escapement		26.5	24.1	27.2	22.5	29.5	44.6	50.7	60.9	41.1	33.7	47.4	46.3	37.6	34.5
Total Tags		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0