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Stock Status and Escapement Goals for Coho Salmon Stocks in Southeast Alaska

by

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February 2003

Alaska Department of Fish and Game **Southeast Region**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used in Division of Sport Fish Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications without definition. All others must be defined in the text at first mention, as well as in the titles or footnotes of tables and in figures or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

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

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

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

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
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
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

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	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
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.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
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
standard length	SL
total length	TL
variance	Var

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ABSTRACT

The status of coho salmon stocks in Southeast Alaska was assessed from information on escapement, smolt abundance, marine survival and total adult abundance from coded-wire tagged indicator stocks and streams that were surveyed for escapement. The escapement trend since the early to mid-1980s has been relatively level for most stocks, with a peak in the early to mid-1990s and generally high escapements in 2001 and 2002. Escapements have generally tracked the pattern of total abundance and marine survival, with smolt production estimates in most systems showing no trend.

We assessed escapements relative to established objectives for stocks that have goals. With very few exceptions, observed escapements were within or above goal since 1990. The only substantial exception, Jordan Creek near Juneau, had peak survey counts that were within or above goal in all but one year during 1981–1994 but declined to below goal every year in 1996–2000 and were proportionately far below other Juneau roadside systems during that period. However, the Jordan Creek escapement was within goal in 2001 and increased dramatically in 2002 to nearly double the record for the previous 21 years. Although smolt production from Auke Creek declined by 35% over a 24-year period, spawning escapements have been above goal in 20 of 23 years, including the last 7 years. Effects of extensive urbanization may be a possible explanation for the apparent decline in Auke Creek production and recent highly variable production from Jordan Creek. We identified no coho salmon stocks of concern in Southeast Alaska.

Marine survival has been the primary factor influencing coho salmon returns, accounting for an average of 61% (range 57–70%) of variability in run size of all wild indicator stocks in all years, compared with 39% (range 30–43%) for freshwater factors including spawning escapement. Synchrony in run strength among systems, in marine survival and to a lesser extent in smolt production, facilitates management of mixed-stock fisheries based on information on fishery performance and indicator stock abundance.

A recent reduction in exploitation caused by reduced fishing effort associated with low salmon prices has resulted in exceptionally large escapements in 2002 that were far in excess of needs. While substantial surplus escapements may continue under current salmon market trends, we do not expect them to adversely affect future returns. Under 2002 exploitation rates, future runs would have to be substantially lower than the smallest runs in the past two decades for escapements to indicator systems to fall below goal. Until the fisheries return to their historical levels of effort and exploitation, the primary concern for managers in most years will be to assist harvesters in accessing and utilizing the stocks in a cost effective manner.

Key words: coho salmon, *Oncorhynchus kisutch*, escapement, escapement goals, smolts, marine survival, exploitation rates, Auke Creek, Berners River, Taku River, Ford Arm Lake, Hugh Smith Lake, Chuck Creek, Unuk River, Slippery Creek

INTRODUCTION

Coho salmon (*Oncorhynchus kisutch*) are important to a variety of commercial, sport and subsistence users. Trollers have accounted for over 60% of the commercial catch, on average, but coho salmon are also important to seine, drift gillnet and set gillnet fisheries. Recreational fisheries occur in both fresh and saltwater areas and have constituted an increasing component of the catch in recent years. Directed subsistence fisheries have been very limited, but regulations allowing directed subsistence fishing for coho salmon have been recently expanded under federal rules in many freshwater areas.

The commercial catch of wild stocks has probably tracked overall regional stock abundance since the 1940s when the troll fishery for coho salmon became widely established (Figure 1). However, the 2002 catch of 1.89 million fish clearly does not track wild stock abundance, because exploitation rates declined sharply with deteriorating market conditions. Stocks recovered in the early 1980s from a prolonged period of low abundance extending for 26 years. Whereas poor marine survival was likely a major factor driving poor catches from 1956–1981, improved marine survival has been an important factor influencing larger wild-stock catches during 1982–2002.

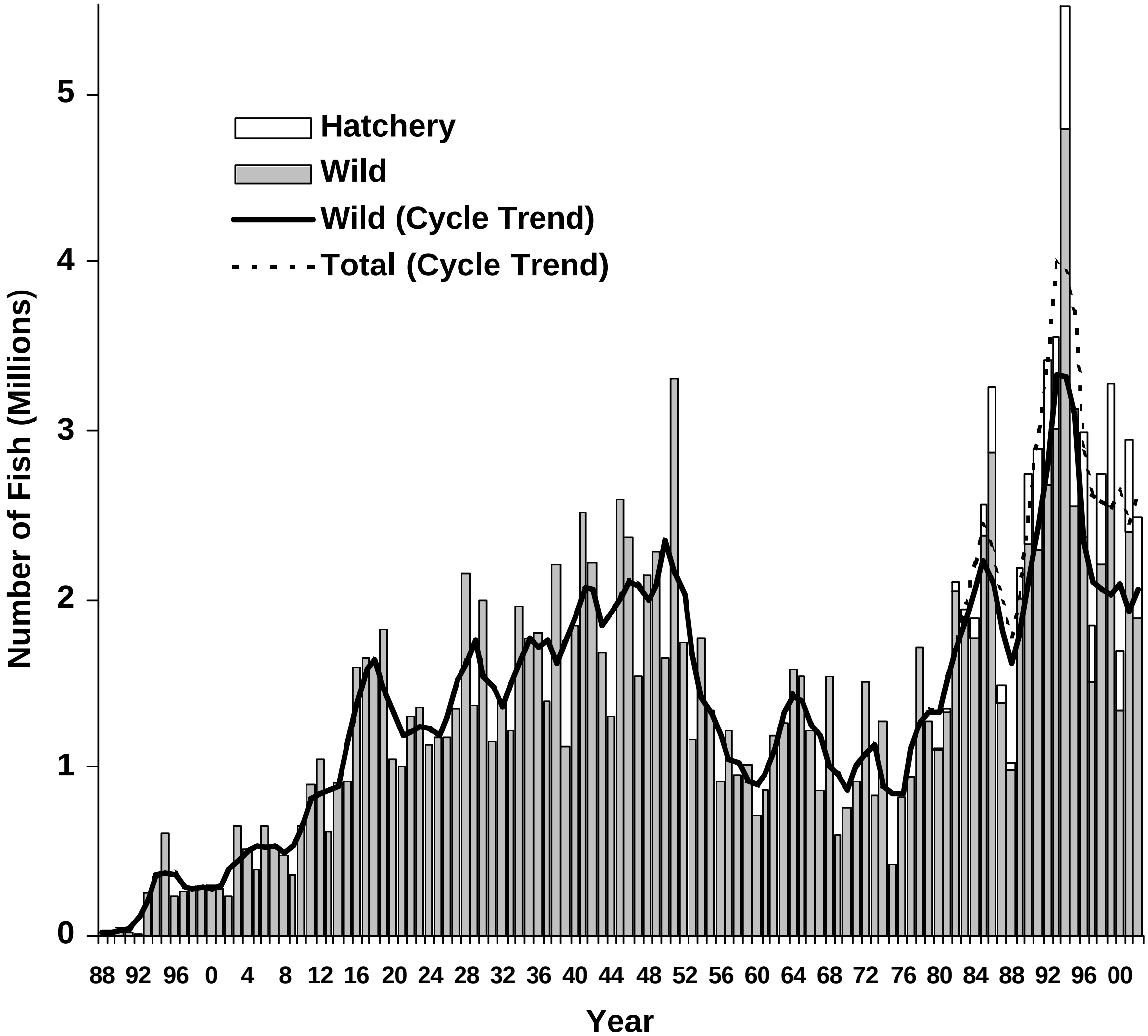

Figure 1. Commercial harvest of wild and hatchery coho salmon in Southeast Alaska, 1888–2002. Also shown is a 3½-year 'cycle trend' that approximates the average age of returning adult coho salmon in Southeast Alaska.

Excellent coho salmon habitat occurs throughout Southeast Alaska (Figure 2). In addition to wild stocks within Southeast, important contributions to the region's total harvest are made by local hatchery stocks, the transboundary rivers, and by natural systems and hatcheries on the northern British Columbia coast. Coho salmon are produced by thousands of streams and by 13 hatcheries in Southeast Alaska. Many of the streams are small producers about which little is known. During 1998–2002, hatcheries contributed an average of 22% (range 13–28%) of the Southeast Alaska commercial catch of which over 97% was produced by Alaskan facilities.

The Alaska Department of Fish and Game implemented an improved stock assessment program in the early 1980s to better understand and manage coho salmon stocks. New assessment projects were implemented to monitor population and fishery parameters for indicator stocks (Shaul 1994; Shaul and Crabtree 1998). In addition, a systematic escapement survey program was developed. These programs have improved understanding among fishery researchers and managers of the status of Southeast Alaska coho salmon stocks and have formed the basis for improved management.

The principal management objective for Southeast Alaska fisheries for coho salmon is to achieve maximum sustained yield (MSY) from wild stocks. Hatchery contributions and natural production are identified inseason in key fisheries using

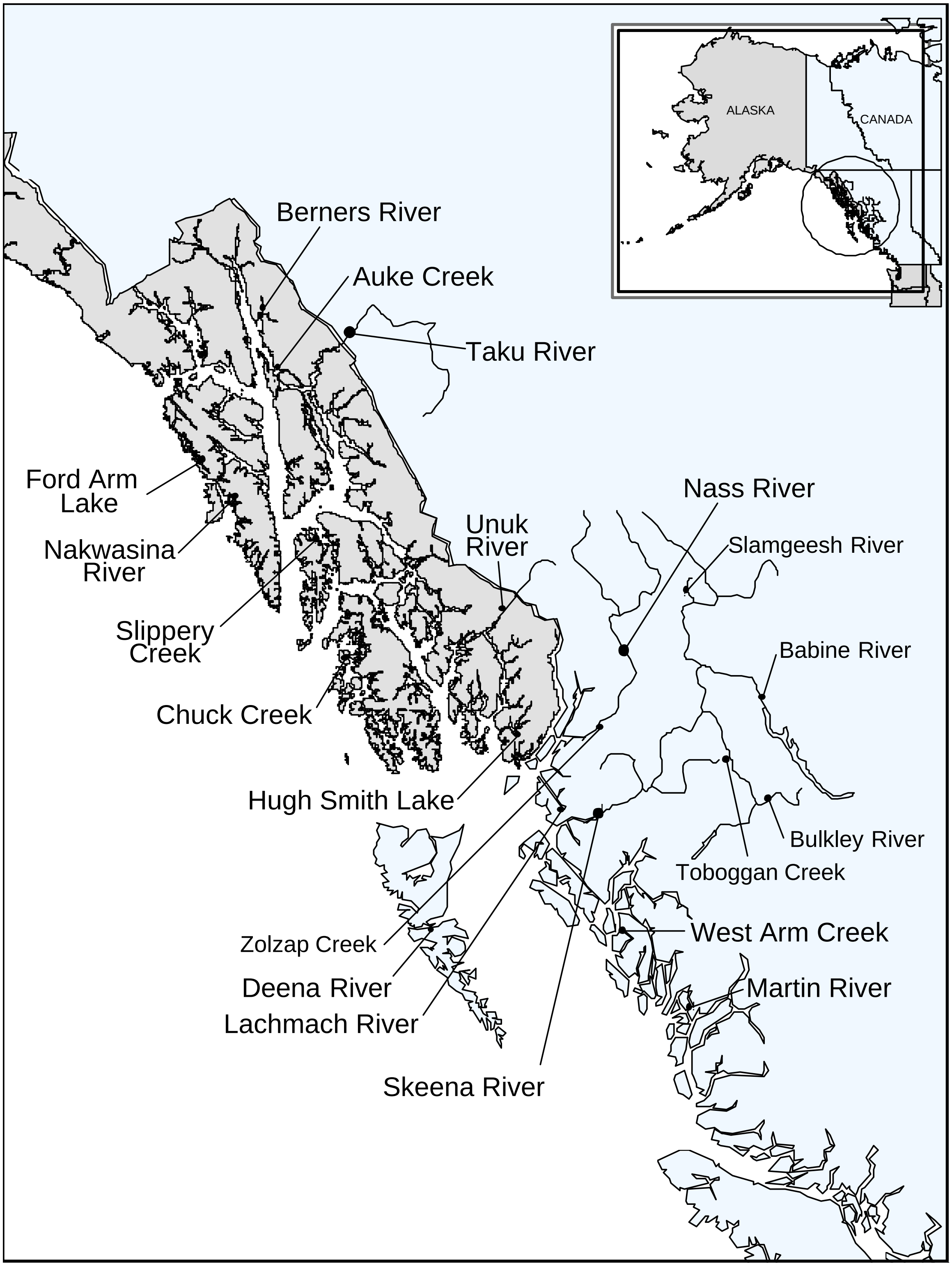

Figure 2. Map of Southeast Alaska and northern British Columbia, showing the locations of coho salmon full indicator stock assessment projects.

coded-wire tags. Fisheries directed primarily at coho salmon are managed based on wild stock fishery performance to achieve adequate escapement while harvesting the surplus. Biological escapement goal ranges have been established for a number of wild indicator stocks and surveyed systems.

A secondary management objective is to achieve long-term commercial gear-type allocations that were established by the Alaska Board of Fisheries in 1989. These allocations preserve a 1969–1988 historical base distribution of 61% for troll gear, 19% for purse seine gear, 13% for drift gillnet gear, and 7% for set gillnet gear.

The wide distribution of coho salmon production across thousands of small stream systems necessitates that much of the harvest occur in highly mixed-stock fisheries where the stocks intermingle. Except for years of strong deviations from average abundance, trollers fish a relatively stable season and harvest a relatively stable proportion of the total run. This results in a more even distribution of the troll harvest across all stocks in the region, thereby realizing some harvest from all stocks, while insuring that more heavily exploited inside stocks are able to support some harvest in inside fisheries and still achieve escapement. Most active management to harvest surpluses and achieve escapements is conducted in gillnet fisheries based on returns to single major systems or local concentrations of productive systems. Nearly all of the harvest of many small to medium stocks on the outer coast and along inside passages occurs in the troll fishery, with a small incidental harvest by purse seine fisheries for pink salmon.

The commercial fisheries are managed under specific management plans for each fishery. The troll management plan for coho salmon contains several decision points that potentially trigger early or midseason closures for conservation and allocation, and an extension of the troll coho season for up to 10 days after the regulatory closing date of September 20. Most provisions of the plan were written in the late 1970s and 1980s when direct information on coho stocks was very limited, aside from fishery catch and effort. In recent years, fishery managers have tried to balance the specific provisions of the management plan with increasing capability to assess stocks and their escapement needs. Inseason management has increasingly focused on escapement goals that produce MSY as a specific priority objective. Managers have also accommodated recent changes in the fisheries, including a price-driven reduction in participation by commercial users that has reduced the overall capability of the fisheries to exploit the stocks.

In addition to provisions specified in the management plans, the Pacific Salmon Treaty (PST) contains provisions for the conservation of northern British Columbia coho stocks. The PST provisions are essentially the same as Board of Fisheries management plan provisions for potential early and midseason troll fishery closures. However, the PST also contains provisions that trigger a closure of the troll fishery in boundary areas of Southern Southeast and in northern British Columbia when abundance of northern B.C. stocks is indicated to be low based on fishery performance.

Marine sport fisheries are managed primarily under a six-fish bag limit. The same bag limit applies in most freshwater systems, except for some more-accessible streams where the bag limit is two fish. The sport fishery has accounted for a small but increasing component of the catch, reaching 10% of the all-user region harvest in 2000. Although emergency inseason management actions have been less frequent in the recreational fisheries, seasons have been closed or bag limits reduced in both marine and freshwater fisheries in response to inseason indicators of low abundance. Bag limits were increased in some locations to harvest the very large 1994 return.

Small subsistence coho salmon fisheries occur in Southeast Alaska, primarily in terminal areas near Yakutat and Angoon. These fisheries have not been actively managed, but harvest levels are monitored through permit returns. The reported harvest during 1992–2001 averaged only 2,700 fish.

STOCK STATUS

Status of coho salmon stocks in the Southeast region was judged by trends in abundance and escapement of indicator stocks relative to established goals. Coho salmon stocks are very widely distributed and are believed to be present in over 2,500 primary anadromous streams. Stock assessment projects can only be carried out on a small fraction of those streams. Most direct assessment of the stocks occurs at two levels: full indicator stock and escapement indicator.

Full Indicator Stocks

Full indicator stocks are marked as smolts or presmolts with coded-wire tags, which makes it possible to estimate their smolt production (from the marked rate at return) and contribution to the fisheries by systematically sampling fishery harvests and escapements.

Full indicator stock programs have been expanded in recent years and are now well established in nine systems in the region (Figure 2). The data series extends from the early 1980s for four systems (Auke Creek, Berners River, Ford Arm Lake and Hugh Smith Lake). Programs have been expanded in the 1990s to include the Taku River, Unuk River, Nakwasina River, and Slippery Creek. In addition, Chuck Creek, which was added as an indicator stock in 2001, has total run estimates for three earlier years (1982, 1983 and 1985).

Full indicator stock programs provide detailed population information needed to establish and manage for biological escapement goals. Specific parameters that are estimated for these stocks include: total adult abundance, spawning escapement (including age, size and sex), smolt production (abundance, age, size), marine survival, fishery contributions by area, gear type and time, and exploitation rates. Over time, these parameters are used to evaluate the relationship between spawning escapement and production and to establish biological escapement goals that maximize sustained yield. One major advantage of the smolt estimation programs associated with coho indicator stocks is that they make it possible to filter out variation in return abundance caused by variation in marine survival and to improve resolution of the relationship between escapement and brood-year production.

In 1994, biological escapement goals were established for the four long-term indicator stocks based on Ricker spawner-recruit relationships (Clark et al. 1994). Also, for the Taku River a minimum inriver abundance goal of 38,000 spawners is specified in the 1999 Pacific Salmon Treaty (PST). In practical terms, the abundance goal upriver of the US/Canada border translates into an escapement goal of about 35,000 fish after inriver harvests by commercial, food and test fisheries.

Escapement Indicators

Foot or helicopter surveys have been systematically carried out on sets of streams in the Juneau, Sitka and Ketchikan areas. These projects provide greater coverage but a much lower level of resolution about stock status compared with full indicator stocks. High and variable rainfall in the fall months makes it difficult to obtain consistent surveys. In the Juneau area, repetitive foot surveys are conducted on five streams of which all have individual goals. In the Sitka area, five local streams have been surveyed on foot most years since 1985 and the Black River north of Sitka has been surveyed by helicopter since 1984. In the Ketchikan area, surveys have been conducted by helicopter on 14 streams since 1987.

Only peak survey counts that met standards for timing, survey conditions, and completeness were included in the indexes. Interpolations were made for missing counts under the assumption that the expected value is determined for a given stream and year in a multiplicative way (i.e., counts across streams for a given year are multiples of counts for other years, and counts across years for a stream are multiples of counts for other streams). The estimated expected count for a given stream in a given year is then equal to the sum of all counts for the year times the sum of all counts for the stream divided by the sum of counts over all streams and years. If there is more than one missing value, an iterative procedure, as described by Brown (1974), must be used since the sums change as missing counts are filled in at each step. Most of the consistent indicators of coho salmon escapement were established in the early to mid- 1980s (Table 1).

Table 1. Southeast Alaska coho salmon escapement estimates and index counts, 1980–2002.

Year	Auke Creek	Juneau Roadside Index[a]	Berners River	Taku River	Ford Arm Lake	Black River	Sitka Survey Index[b]	Hugh Smith Lake	Unuk River	Ketchikan Survey Index[c]	Chuck Creek	Slippery Creek
1980	698											
1981	646	1,552										
1982	447	1,545	7,505		2,662		1,533	2,144			1,017	
1983	694	1,287	9,840		1,938		456	1,490			1,238	
1984	651	1,312	2,825			425	2,061	1,408				
1985	942	1,466	6,169		2,324	1,628	1,245	903			956	
1986	454	887	1,752		1,546	312	590	1,783				
1987	668	945	3,260	55,457	1,694	262	275	1,118		4,819		
1988	756	1,127	2,724	39,450	3,028	280	402	513		5,007		
1989	502	1,241	7,509	56,808	2,177	181	576	433		6,761		
1990	697	2,518	11,050	72,196	2,190	842	566	870		3,487		
1991	808	2,641	11,530	127,484	2,761	690	1,510	1,826		5,721		
1992	1,020	4,405	15,300	84,853	3,847	866	1,899	1,426		7,017		
1993	859	2,351	15,670	109,457	4,202	764	1,718	830		7,270		
1994	1,437	2,916	15,920	96,343	3,228	758	1,965	1,753		8,690		
1995	460	1,405	4,945	55,710	2,445	1,265	1,487	1,781		8,627		
1996	515	1,291	6,050	44,635	2,500	500	1,451	958		8,831		
1997	609	1,471	10,050	32,345	4,965	686	809	732		5,034		
1998	862	1,516	6,802	61,382	7,049	1,520	1,242	983	12,422	7,015		632
1999	845	1,762	9,920	60,844	3,598	1,590	777	1,246	25,778	8,038		
2000	683	1,355	10,650	64,700	2,287	880	803	600	15,746	8,634		411
2001	865	1,760	19,290	104,460	2,178	1,080	1,465	1,580	40,540	10,273	1,350	2,674
2002	1,176	4,543	27,700	219,789	7,109	1,194	1,868	3,291	57,610	12,203	2,189	5,341
Goal Range												
Lower	200	500 [d]	4,000	35,000 [e]	1,300			500				
Upper	500	1,425 [d]	9,200		2,100			1,100				

[a] The Juneau roadside index is the sum of peak survey counts on five streams.

[b] The Sitka survey index is the sum of peak survey counts on five streams.

[c] The Ketchikan survey index is the sum of peak survey counts on 14 streams.

[d] Goal bounds shown for Juneau roadside streams are the sum of upper bounds and the sum of lower bounds for individual streams.

[e] The listed Taku River lower bound is the inriver run threshold of 38,000 specified in the Pacific Salmon Treaty minus an allowance of 3,000 fish caught in inriver fisheries.

Juneau Area Stocks

Escapement to Auke Creek and the aggregate count for five roadside streams have been consistently within or above escapement goal ranges since the early 1980s (Figure 3, Table 2). However, counts for individual surveyed streams have been below goal in nine out of 133 cases during 1981–2002. This was probably related in some cases to variable weather conditions that made surveys very difficult in some years. For example, very difficult conditions with sequential freshets in 1986 likely contributed to the very low peak count of only 60 fish in Montana Creek, the largest stream in the Juneau index. On the other hand, the abrupt decline in Jordan Creek escapements to levels below goal (and proportionately far below other local streams)

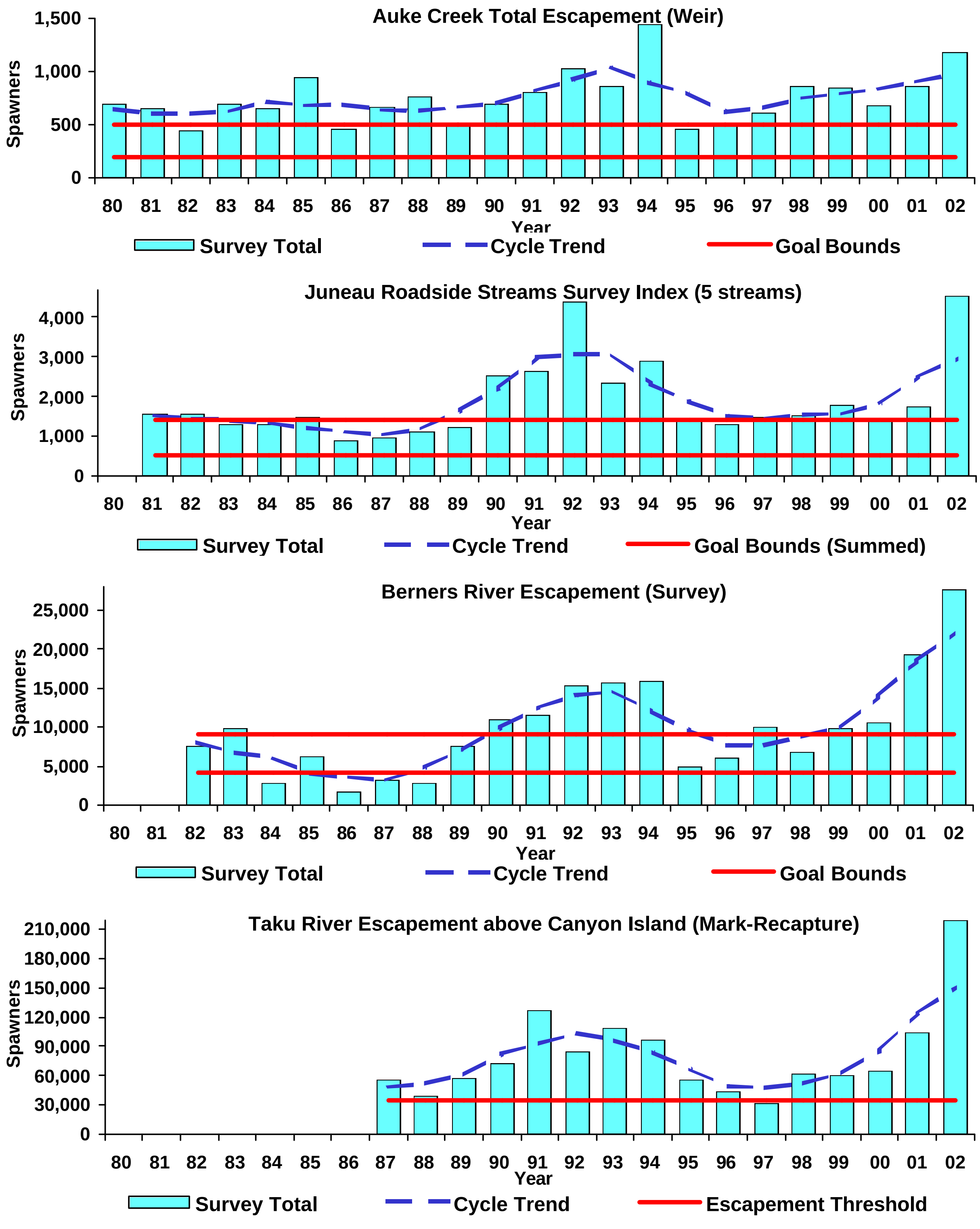

Figure 3. Coho salmon escapement estimates and indexes for streams in the Juneau area (Districts 111 and 115). Also shown are 3½-year moving average 'cycle' trends and escapement goal ranges. The threshold of 35,000 shown for the Taku includes the inriver run threshold of 38,000 under the Pacific Salmon Treaty minus an allowance for a catch of 3,000 fish in inriver commercial, food, personal use and test fisheries.

Table 2. Peak coho salmon escapement survey counts for Juneau roadside streams and total count of wild adult coho salmon at the Auke Creek weir, 1981–2002.

Year	Montana Creek	Steep Creek	Jordan Creek	Switzer Creek	Peterson Creek	Total for Surveyed Streams	Auke Creek (Weir)
1980							698
1981	227	515	482	109	219	1,552	646
1982	545	232	368	80	320	1,545	447
1983	636	171	184	77	219	1,287	694
1984	581	168	251	123	189	1,312	651
1985	810	186	72	122	276	1,466	942
1986	60	247	163	54	363	887	454
1987	314	128	251	48	204	945	668
1988	164	155	215	51	542	1,127	756
1989	566	222	133	78	242	1,241	502
1990	1,711	185	216	82	324	2,518	697
1991	1,415	267	322	227	410	2,641	808
1992	2,512	612	785	93	403	4,405	1,020
1993	1,352	471	322	94	112	2,351	859
1994	1,829	200	371	198	318	2,916	1,437
1995	600	409	77	42	277	1,405	460
1996	798	134	54	42	263	1,291	515
1997	1,018	182	18	67	186	1,471	609
1998	1,160	149	63	42	102	1,516	862
1999	1,000	392	47	51	272	1,762	845
2000	961	88	30	74	202	1,355	683
2001	1,119	366	119	50	106	1,760	865
2002	2,448	380	1,396	124	195	4,543	1,176
Average	992	266	270	88	261	1,877	752
Goals:							
Point	450	150	150	50	200	1,000	340
Lower	200	100	75	25	100	500	200
Upper	500	300	200	75	350	1,425	500

for five consecutive years (1996–2000) probably reflected reduced smolt production. Jordan Creek flows through an area of heavy residential and commercial development. Peak escapement counts in the creek showed a sharp drop after 1994 and remained consistently below 100 spawners until 2001 (Table 2). The 2001 count of 119 spawners was within the goal range of 75–200.

In 2002, a record 1,396 spawners were counted in Jordan Creek which was nearly seven times the upper end of the goal range and far higher than the prior record of 785 fish in 1992. Surprisingly, the 2002 count was proportionately higher in Jordan Creek than other Juneau roadside streams, even when compared with pre-1995 average escapements prior to the decline in Jordan Creek.

The reason for the tremendous resurgence in the run in Jordan Creek in 2002 is unknown but was consistent with a weir count of 25,909 smolts (>70 mm) from the system in 2001 (B. Glynn, Alaska Department of Fish and Game, Douglas, personal communication). If marine survival for the 2002 return was similar to the Auke Creek stock (26.6%), the Jordan Creek smolt count would have equated to an adult return of about 6,900 fish and an escapement of about 5,060 spawners which is not inconsistent with a peak survey count of nearly 1,400 spawners. Fewer than one-third as many smolts (8,312) were counted from the system in Spring 2002, suggesting that the 2001 smolt migration was an unusual occurrence.

The large 2002 return does not appear to have been related to an increase in spawning escapement because peak brood year spawner counts were only 63 in 1998 and 47 in 1999. The sudden surge in smolt production suggests that the stock may be particularly sensitive to variable environmental conditions affecting freshwater survival. There is also a possibility that juveniles move intermittently into Jordan Creek from other systems prior to final sea-migration. In spring 2002, a coded-wire tagged smolt was recovered in Jordan Creek that had been marked in May 2001 in the Chilkat River in upper Lynn Canal (B. Glynn, Alaska Department of Fish and Game, Douglas, personal communication).

Strong escapements relative to goals for most streams in most years reflect high marine survival rates and moderate exploitation rates for roadside stocks since the early 1980s. Estimated marine survival of Auke Creek smolts to adulthood has averaged 20.1%, while the exploitation rate on the stock has averaged only 40.5%. Auke Creek and surveyed stocks on the Juneau roadside are harvested primarily in highly mixed-stock troll, seine and sport fisheries, with only light exploitation in inside gillnet fisheries.

The Berners River in lower Lynn Canal, north of Juneau, has been an indicator system since 1982. This stock is atypical of Southeast Alaska coho runs in that the escapement is compressed in time within a highly visible area, making it possible to routinely count most of the escapement in a single foot and helicopter survey in mid to late October. The stock fell short of the existing escapement goal during 4 years in the mid-1980s (Figure 3; Table 1) due primarily to intensive exploitation in the Lynn Canal gillnet fishery, which targeted Chilkat River chum salmon with record effort ranging from 2,725 to 4,923 fall boat-days during 1982–1988 (Shaul 1998).

An abrupt and persistent decline in fall chum abundance after 1988 resulted in greatly reduced fishing effort, while Berners River coho runs increased in the early 1990s. This combination has resulted in escapements ranging from well within to substantially above the goal of 4,000–9,200 spawners since 1989. Sequential record high escapements occurred in 2001 and 2002. The 2002 estimate of 27,700 spawners was three times the upper end of the goal range.

The Taku River south of Juneau may be the single largest coho salmon producing system in the region. Escapement estimates were first made in 1987 and run reconstruction estimates are available since 1992 (Elliott and Bernard 1994; McPherson et al. 1994, 1997, 1998; McPherson and Bernard 1995, 1996; Yanusz et al. 1999, 2000). The escapement past Canyon Island near the US/Canada boundary is estimated using a mark-recapture technique. Marking is done at research fishwheel sites in the Canyon while recovery sampling is done in commercial and test fisheries in Canada. Results of a 1991 radiotelemetry study indicated that the fishwheel estimate represented about 78% of the total system escapement with about 22% spawning in Alaskan waters below Canyon Island (Eiler *In press*). In the 1999 PST agreement, the U.S. agreed to manage for a minimum run above Canyon Island of 38,000 fish. Allowing for a probable harvest of up to 3,000 fish above Canyon Island from an inriver run of 38,000 fish results in a de facto current threshold goal of about 35,000 spawners.

The escapement estimate past Canyon Island has exceeded 35,000 spawners in all years except 1997 when the estimate was only 32,345 spawners (Figure 3, Table 1), despite timely implementation of extensive inseason restrictions in troll, gillnet and sport fisheries. In the early 1990s, the Taku River coho run increased sharply and greatly exceeded the current threshold goal despite increased fishing effort in the District 111 gillnet fishery, which targets the stock in late August and September.

Since 1998, Taku River escapements have ranged above the goal by an increasing margin because of increasing run sizes and low exploitation rates due to low gillnet effort levels. Recent fall openings in District 111 have been limited to 3 days per week to protect the Taku River chum stock, which has declined sharply from historical levels (Tobler 2002). Limited fishing time combined with a lower number of participating vessels in recent years has substantially reduced the exploitation rate of the gillnet fishery on the coho stock. At the same time, the ability of the Canadian fishery to harvest Taku coho salmon within the river has been limited by fall weather and other logistical and economic limitations associated with a remote fishing area.

Sitka Area Stocks

Ford Arm Lake is the only indicator stock in the Sitka area that has a long-term escapement database and an established biological escapement goal (Figure 4, Table 3). This stock is available along the coast from early July through early September and is harvested intensively by local directed commercial troll and marine sport fisheries, and incidentally to pink salmon in the Khaz Bay seine fishery. In 20 years, the goal of 1,300–2,900 spawners has been met in 12 years and exceeded in eight (Figure 3). The goal has been exceeded more often since 1992.

The escapement to Black River, located north of Ford Arm Lake, has been surveyed once annually by helicopter since 1984. Escapement to this system was relatively low during 1986–1989 with counts ranging from 181 to 312, but trended upward since the late 1980s.

The sum of peak escapement surveys for five small streams near Sitka trended downward in the late 1980s but increased sharply in the early 1990s (Tables 1 and 3; Figure 4). The counts declined again in 1997–2000 before increasing in 2001 and 2002.

Southern Southeast Stocks

Hugh Smith Lake is the only full indicator stock in southern Southeast that has a long-term data series and an established escapement goal (Tables 1 and 4; Figure 5). However, additional indicator stocks have recently been added including the Unuk River on the mainland northeast of Ketchikan (Jones et al. 1999, 2001a, 2001b), Chuck Creek on the southern outside coast, and Slippery Creek, west of Petersburg (Beers 1999, 2001). Three total escapement counts for Chuck Creek from the 1980s (Shaul et al. 1991) are available for comparison with recent counts in 2001 and 2002.

Over the past 21 years, the escapement goal range of 500–1,100 spawners in Hugh Smith Lake (Clark et al. 1994) has been achieved eight times (Figure 5). Escapements have been below the range only once (1989) and above it twelve times.

Escapement to the Unuk River is estimated using a mark-recapture technique and total run reconstruction and smolt estimates have been made based on coded-wire tags since 1998. Escapement estimates have trended upward from 12,422 spawners in 1998 to 57,610 spawners in 2001 (Table 1 and Figure 5).

The Ketchikan area survey index of peak helicopter counts for 14 streams has followed a generally upward trend since 1987 to a record count of 12,203 spawners in 2002 (Tables 1 and 4; Figure 5).

Weir counts in Chuck Creek, on the outer coast of southern Southeast, totaled 1,350 spawners in 2001 and 2,189 spawners in 2002 compared with counts during 1982–1985 that ranged from 956 to 1,238 spawners (Shaul et al. 1991).

Yakutat Stocks

Yakutat stocks are harvested primarily in set gillnet and sport fisheries that target runs to discrete systems, but trollers fishing on mixed stocks off the coast account for some of the catch. Biological escapement goals exist for seven stocks in this area (Clark and Clark 1994),

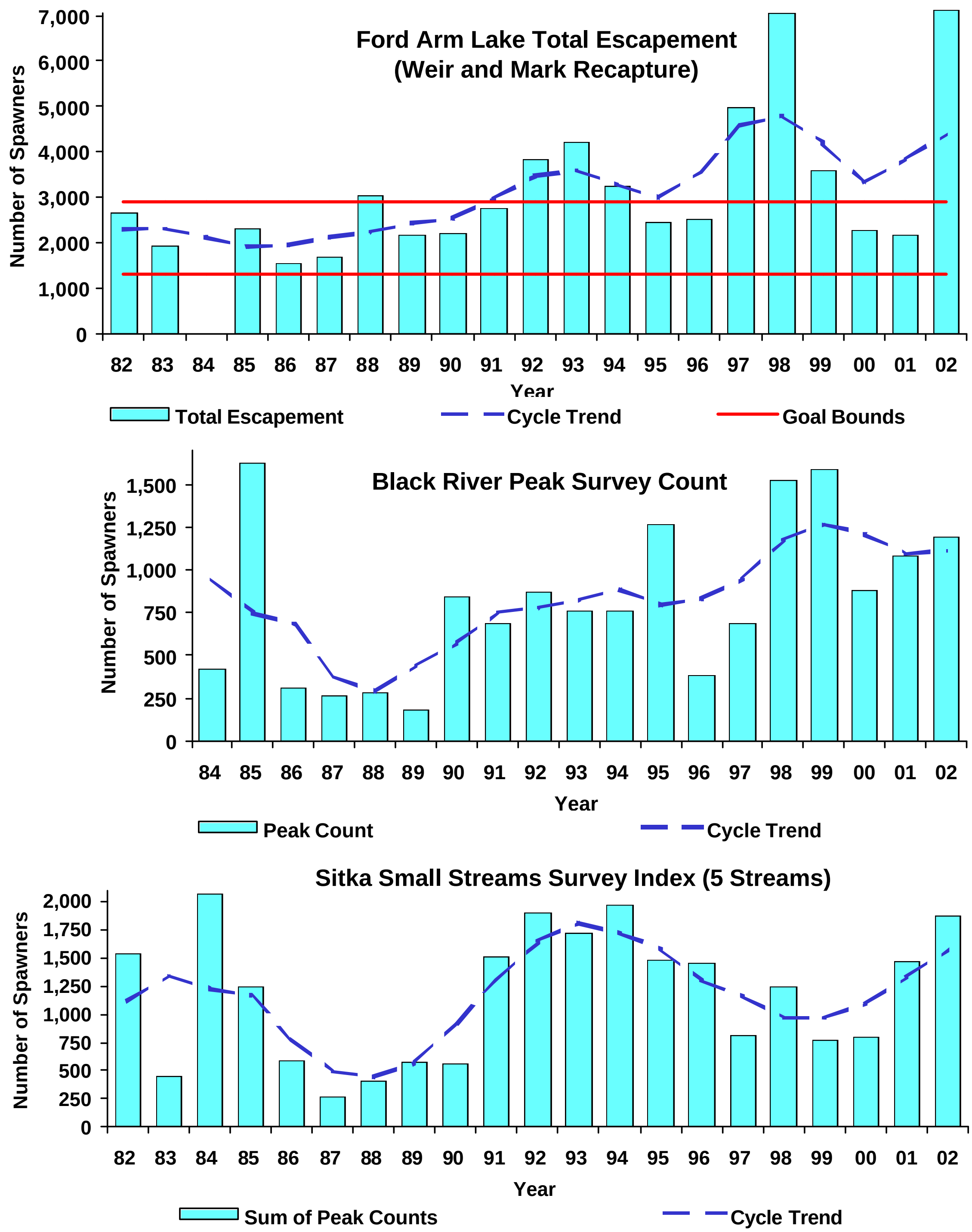

Figure 4. Coho salmon escapement estimates and indexes for streams in the Sitka area (District 113) and 3½-year moving average 'cycle' trends.

Table 3. Peak coho salmon survey counts for five streams near Sitka and the Black River, and the total adult coho salmon escapement to Ford Arm Lake, 1982–2002. Interpolated values are shown in shaded bold italic print.

Year	Starrigavan Creek	Sinitsin Creek	St. John's Creek	Nakwasina River	Eagle River	Sitka Survey Total	Black R. Survey Count	Ford Arm Lake (Weir- M/R)
1982								2,662
1983								1,938
1984							425	
1985	317	46	79	359	***316***	1,117	1,628	2,324
1986	45	***31***	***12***	217	205	510	312	1,546
1987	385	160	***154***	715	420	1,834	262	1,694
1988	193	144	109	408	***366***	1,220	280	3,028
1989	57	61	45	275	245	683	181	2,177
1990	36	21	40	47	167	311	842	2,190
1991	45	56	71	104	273	549	690	2,761
1992	101	76	89	129	131	526	866	3,847
1993	39	80	38	195	214	566	764	4,202
1994	142	186	107	621	454	1,510	758	3,228
1995	241	265	110	654	629	1,899	1,265	2,445
1996	256	213	90	404	511	1,474	500	2,500
1997	304	313	227	400	717	1,961	686	4,965
1998	274	152	99	626	336	1,487	1,520	7,049
1999	59	150	201	***553***	***488***	1,451	1,590	3,598
2000	55	90	68	300	296	809	880	2,287
2001	123	109	57	653	300	1,242	1,080	2,178
2002	227	169	100	713	659	1,868	1,194	7,109
Average	157	127	94	392	357	1,126	830	3,060

but comparable peak escapement surveys have been conducted relatively consistently in recent years on only three systems, the Lost, Situk and Tsiu rivers.

Although the data series starts in 1972, the quality and comparability of peak survey counts in the Yakutat area are somewhat lower than other areas. Most aerial and foot surveys on these systems have been conducted early in the run to support inseason management of the set gillnet fisheries.

Utility of the peak survey counts in assessing historical escapement is limited by decreasing survey effort near the peak of spawner abundance at the end of the fishery and by frequently deteriorating weather conditions after mid-September. Survey effort on these systems declined during 1995–2000, but has improved in 2001 and 2002. Escapement goals have been attained in most years (Table 5, Figure 6).

Smolt Production

Smolt production estimates are available for four years or more for five systems while pre-smolt estimates in the summer prior to smolt emigration are available for Ford Arm Lake (Table 6). Estimates are listed by adult return year for the smolt emigration in the previous year.

Table 4. Peak coho salmon survey counts for 14 streams in the Ketchikan area and total adult coho salmon escapement to Hugh Smith Lake, 1987–2002. Total index is the sum of counts and interpolated values. Interpolated values are shown in shaded bold italic print.

Year	Herman Creek	Grant Creek	Eulachon River	Klahini River	Indian River	Barrier Creek	King Creek	Choca Creek
1987	92	***80***	154	***60***	***355***	***96***	***244***	***136***
1988	72	150	205	20	300	50	175	150
1989	75	101	290	15	925	450	510	200
1990	150	30	235	150	***257***	***69***	35	***99***
1991	245	50	285	50	550	100	300	220
1992	115	270	860	90	675	100	250	150
1993	90	175	460	50	475	325	110	300
1994	265	220	755	200	560	175	325	225
1995	250	94	435	165	600	220	415	180
1996	94	92	383	40	570	230	457	220
1997	75	***83***	420	60	***371***	***100***	***255***	175
1998	94	130	460	120	220	50	411	190
1999	75	127	657	150	356	25	627	225
2000	135	94	600	110	380	72	620	180
2001	80	110	929	151	1,140	***204***	512	450
2002	88	138	1,105	20	920	70	700	220
Average	127	120	475	95	516	151	350	207

Year	Carroll River	Blossum River	Keta River	Marten River	Humpback Creek	Tombstone River	Combined Survey Count	Hugh Smith Lake (Weir)
1987	180	700	800	740	650	532	4,819	1,118
1988	193	790	850	600	52	1,400	5,007	513
1989	70	1,000	650	1,175	350	950	6,761	433
1990	***127***	800	550	575	135	275	3,487	870
1991	375	725	800	575	671	775	5,721	1,826
1992	360	650	627	1,285	550	1,035	7,017	1,426
1993	310	850	725	1,525	600	1,275	7,270	830
1994	475	775	1,100	2,205	560	850	8,690	1,753
1995	400	800	1,155	1,385	82	2,446	8,627	1,781
1996	240	829	1,506	1,924	440	1,806	8,831	958
1997	140	1,143	571	759	35	847	5,034	732
1998	***255***	1,004	1,169	1,961	285	666	7,015	983
1999	425	598	1,895	1,518	520	840	8,038	1,246
2000	275	1,354	1,619	1,421	102	1,672	8,634	600
2001	173	956	***1,475***	1,956	506	***1,631***	10,273	1,580
2002	270	1,359	1,368	2,302	2,004	1,639	12,203	3,291
Average	267	865	1,033	1,307	369	1,133	7,015	1,113

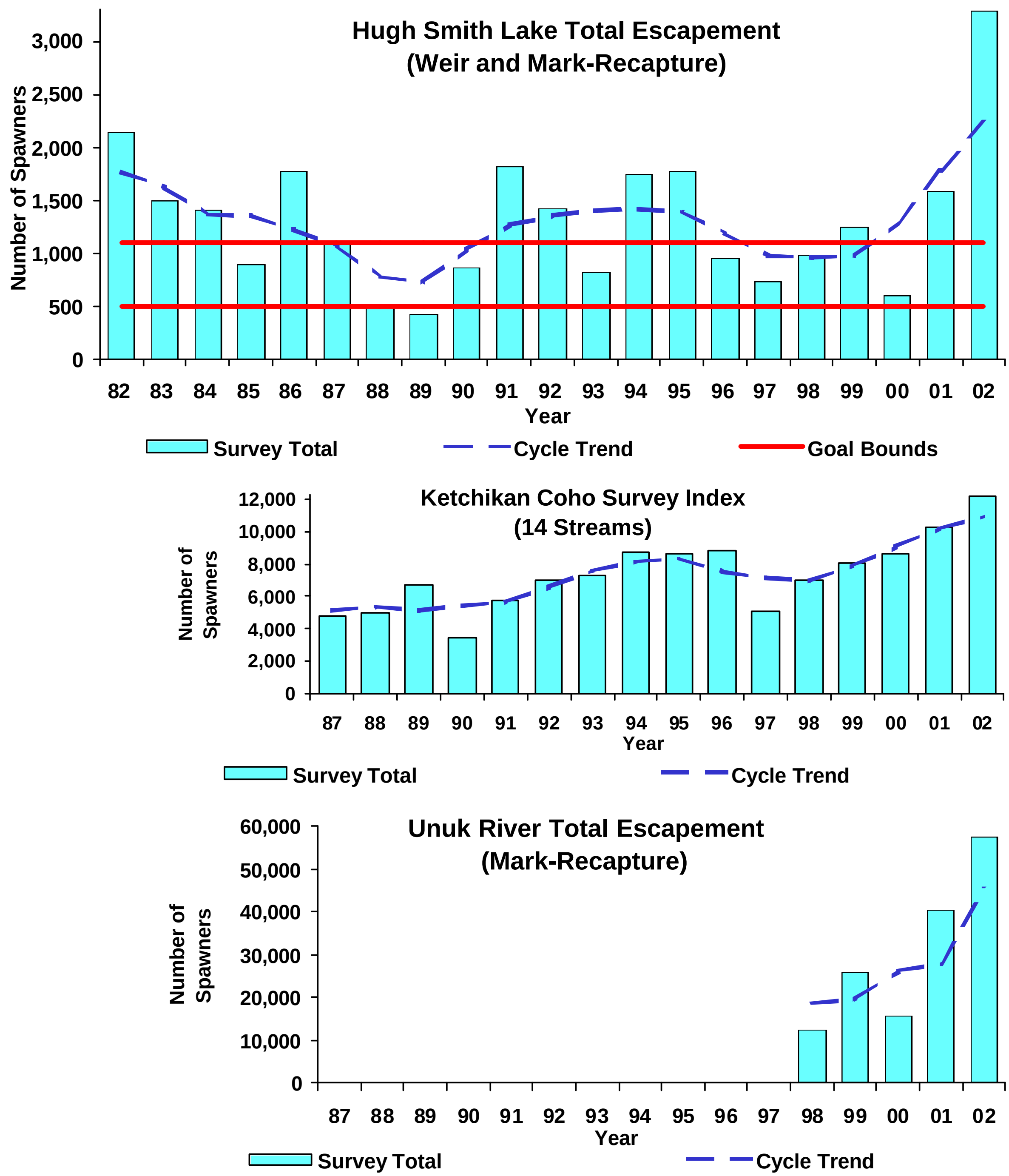

Figure 5. Coho salmon escapement estimates and indexes for streams in the Ketchikan area (District 101). Also shown are 3½-year moving average 'cycle' trends.

Table 5. Yakutat area coho salmon peak escapement survey counts, 1972–2002.

Year	Lost River	Situk River	Tsiu River	Total Count[a]
1972	3,800	5,100		26,361
1973	1,978	1,719	30,000	33,697
1974	2,500	4,260	15,000	21,760
1975	1,300	4,500	8,150	13,950
1976	1,200	3,280	30,000	34,480
1977	4,050	3,750	25,000	32,800
1978	3,450	3,850	40,000	47,300
1979	8,450	7,000	25,000	40,450
1980	5,700	8,100	18,000	31,800
1981	7,363	8,430	20,000	35,793
1982	10,400	9,180	40,000	59,580
1983	8,110	5,300	16,500	29,910
1984	6,780	14,000	30,000	50,780
1985	3,300	6,490	52,350	62,140
1986	3,610	3,162	14,100	20,872
1987	5,482	2,000	8,500	15,982
1988	2,600	11,000	16,000	29,600
1989	2,190	3,900	38,000	44,090
1990	9,460	1,630	16,800	27,890
1991	1,786	NA	16,600	23,441
1992	4,235	13,820	30,800	48,855
1993	5,436	10,703	18,500	34,639
1994	6,000	21,960	55,000	82,960
1995	2,642	NA	30,000	41,616
1996	4,030	NA	19,000	29,361
1997	2,550	9,780	22,000	34,330
1998	NA	NA	12,000	18,116
1999	NA	NA	NA	NA
2000	1,572	NA	12,000	17,303
2001	3,190	5,030	17,000	25,220
2002	8,093	40,000	31,000	79,093
Average	4,526	8,318	24,390	36,472
Lower Bound	2,200	3,300	10,000	
Upper Bound	6,500	9,800	29,000	

[a] Total includes interpolations for systems without counts (see Escapement Indicators section for a description of the method used).

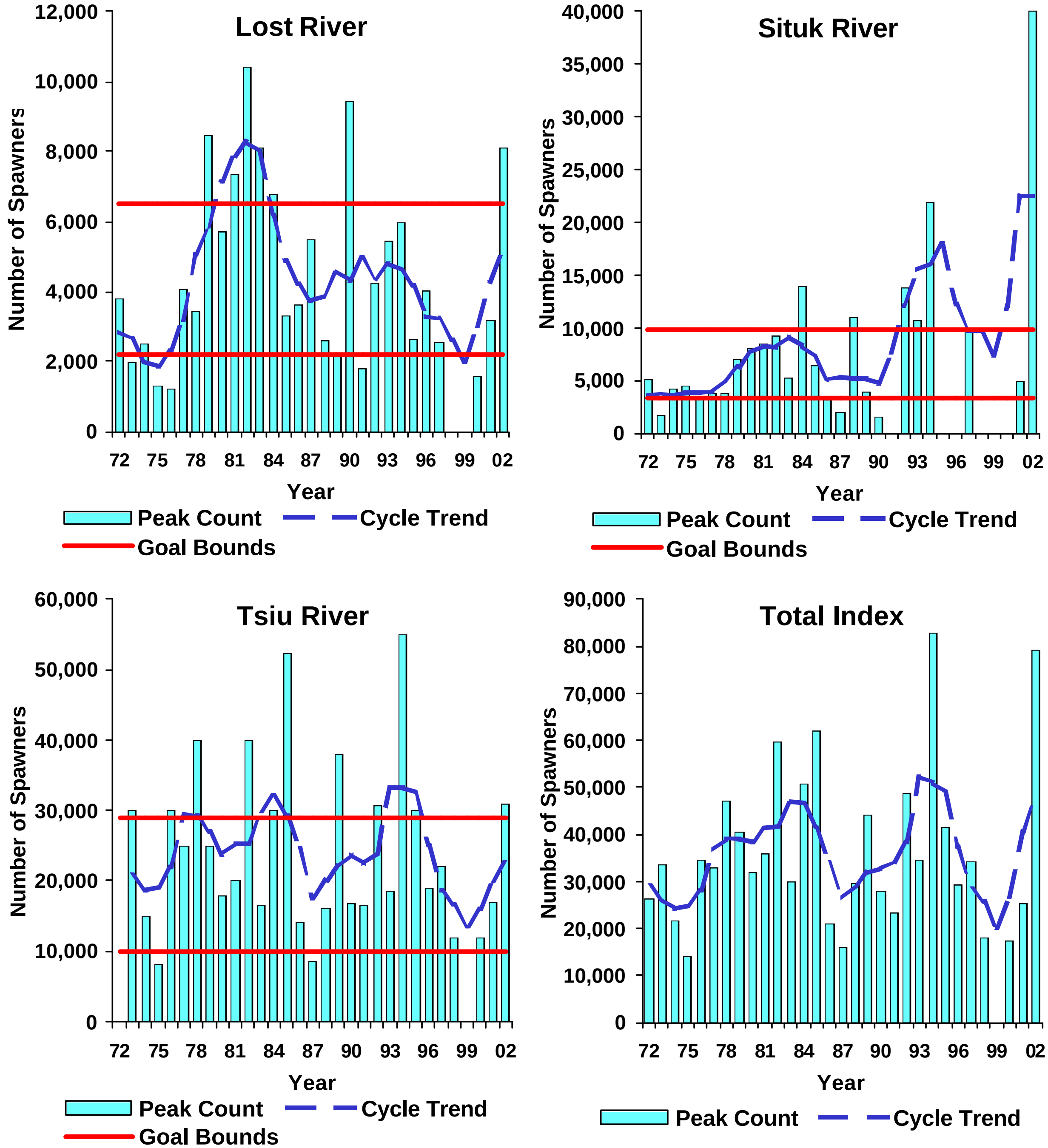

Figure 6. Peak coho salmon escapement survey counts for three systems in the Yakutat area and the combined count for all three systems, 1972–2002, with 3½-year moving average 'cycle' trends. The total index includes interpolations for systems without counts in all years except 1999 (see Escapement Indicators section for a description of the method used).

Table 6. Total coho smolt and pre-smolt production estimates for six wild coho salmon-producing systems in Southeast Alaska by age .1 return year, 1980–2002. Smolts migrated from the stream in the year prior to the return year.

Return Year	Auke Creek Smolts	Berners River Smolts	Taku River Smolts	Ford Arm Lake Pre-smolts	Hugh Smith Lake Smolts	Unuk River Smolts
1980	8,789					
1981	10,714					
1982	6,967			78,682		
1983	6,849			65,186		
1984	6,901				51,789	
1985	6,838			38,509	32,104	
1986	5,852			46,422	23,499	
1987	5,617			73,272	21,878	
1988	7,014			88,649	36,218	
1989	7,685			43,354	23,336	
1990	7,011	164,356		55,803	26,620	
1991	5,137	141,154		56,284	32,925	
1992	5,690	187,715	1,080,551	61,724	23,326	
1993	6,596	326,126	1,510,032	57,401	32,853	
1994	8,647	255,431	1,475,874	83,686	48,433	
1995	7,495	181,503	1,525,330	134,640	49,288	
1996	4,884	194,019	986,489	91,843	22,413	
1997	3,934	133,629	759,763	66,528	32,294	
1998	6,111	139,959	853,662	80,567	37,898	809,677
1999	7,420	252,199	1,184,195	132,607	29,830	562,217
2000	5,233	183,023	1,387,399	62,444	19,902	802,762
2001	4,969	268,468	1,720,387	106,531	23,343	581,488
2002	5,980	264,772	2,292,949	102,010	36,531	660,848
2003	3,644	[a]	[a]	[a]	[a]	[a]
Average	6,499	207,104	1,343,330	76,307	31,815	683,398

[a] Estimates for these systems are unavailable pending mark-recovery sampling of 2003 returning adults.

Despite relatively level escapements to Auke Creek that have trended above the biological goal (Figure 3, Table 2), smolt production from the system has trended gradually lower since the early 1980s (Table 6, Figure 7). Decade averages were 7,323 smolts for 1980–1989 adult returns, 6,292 smolts for 1990–1999 and 4,832 smolts for 2000–2003. An analysis of the trend in Auke Creek smolt production over 24 years using the method presented in Geiger and Zhang (2002) indicates a decline of 35% (1.45% of the year-zero reference value per year), or a loss of about 2,662 smolts (111/year) from a beginning population of about 7,660 smolts.

Smolt estimates for the Taku and Berners Rivers have followed short-term cycles with common peaks for 1993–1994 and 2001–2002 and low smolt production from both systems for 1997 and 1998 returns (Table 6). Smolt production from the two systems was positively correlated over 11 years ($R^2 = 0.45$, $p = 0.024$). The 2002 return to

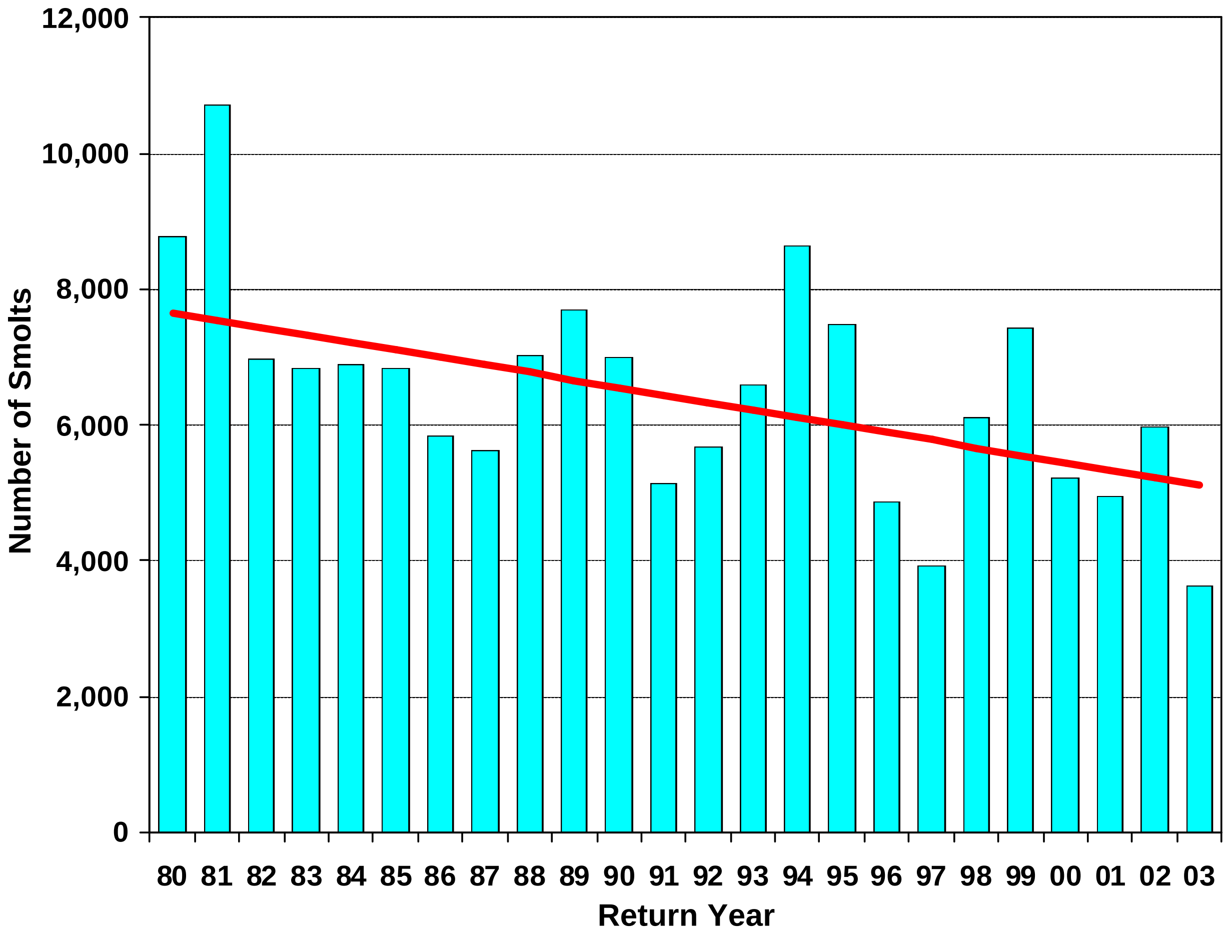

Figure 7. Total number of wild coho salmon smolts that migrated from Auke Creek in 1979–2002 (corresponding to 1980–2003 adult returns). Also shown is the trend computed after Geiger and Zhang (2002).

the transboundary Taku system was produced by a record seaward migration estimated at 2.29 million smolts.

Smolt production has followed no evident trend for either the Hugh Smith Lake stock since 1984, or for the Unuk River stock since 1998. Estimated midsummer pre-smolt abundance in the Ford Arm Lake system has trended upward from an average of 62,000 pre-smolts for returns in the 1980s to 82,100 in the 1990s and 90,300 in 2000–2002.

No physical habitat changes have been noted that might explain this increase but escapements of all salmon species in the system, particularly pink and sockeye salmon, have shown an increasing trend in recent years. Increased carcass inputs may have enhanced habitat productivity through nutrient enrichment.

Marine Survival

Marine survival rates increased in the early 1980s and reached a peak in the early to mid-1990s before declining to more moderate levels from 1995 to 2002 (Figure 8; Table 7).

While smolt production from Auke Creek declined after 1981, marine survival increased in the early to mid-1980s and reached a peak of 35.3% in 1994. Overall, Auke Creek marine survival averaged 20.1% during 1980–2002.

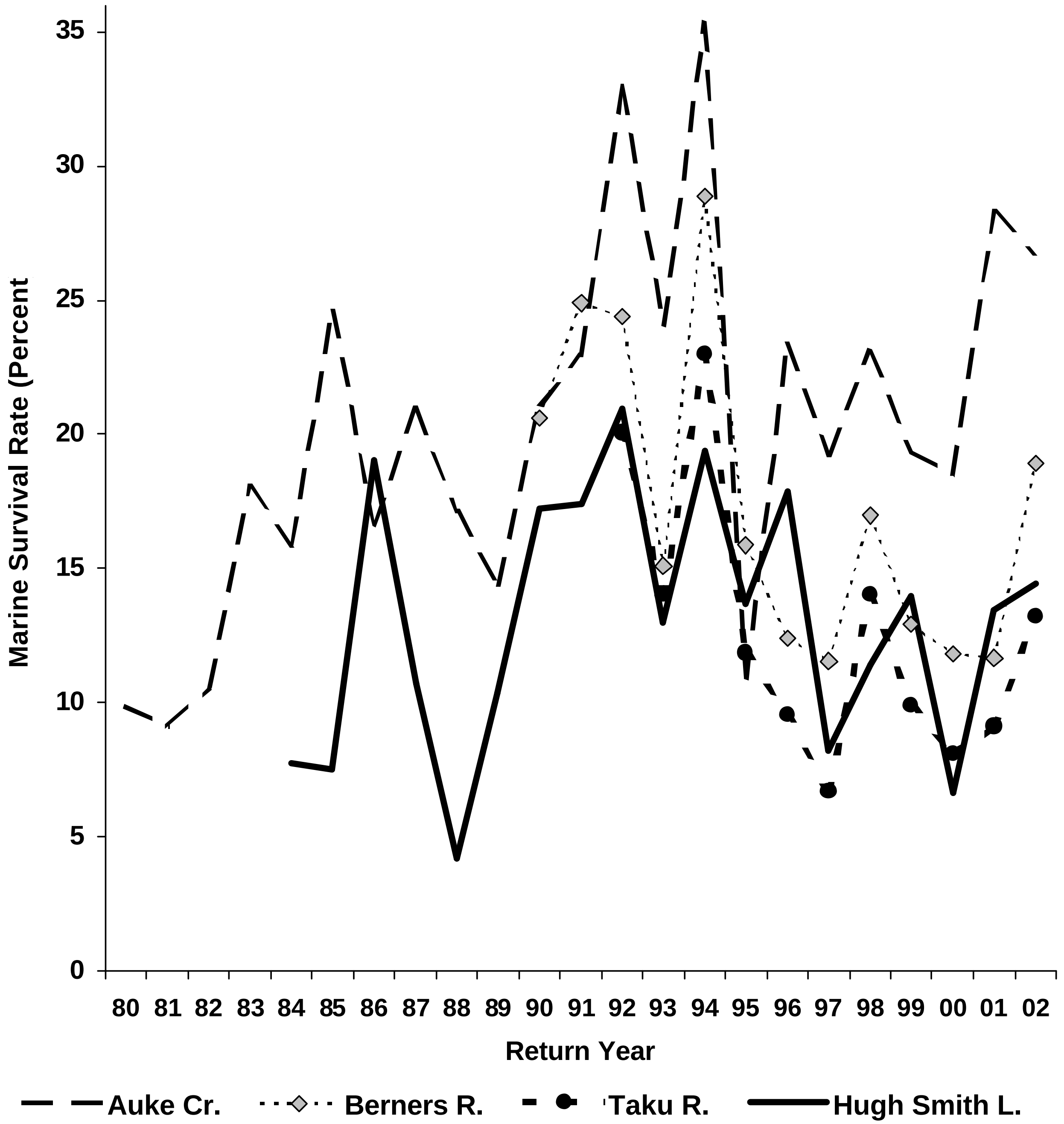

Figure 8. **Estimated marine survival rate for coho salmon smolts from four indicator stocks in Southeast Alaska, 1980–2002.**

Table 7. Estimated survival rate (percent) of coho salmon smolts and pre-smolts from six wild Southeast Alaska indicator stocks from the time of tagging until return to the fisheries.

Return Year	Auke Creek Smolts	Berners River Smolts	Taku River Smolts	Ford Arm Lake Pre-smolts	Hugh Smith Lake Smolts	Unuk River Smolts
1980	9.9					
1981	9.1					
1982	10.6			6.0		
1983	18.1			9.5		
1984	15.9				7.7	
1985	24.6			12.3	7.5	
1986	16.6			8.8	19.0	
1987	21.0			4.4	10.7	
1988	17.1			6.7	4.2	
1989	14.4			13.3	10.4	
1990	21.1	20.6		9.4	17.3	
1991	23.0	24.9		10.8	17.4	
1992	33.0	24.4	20.1	15.0	21.0	
1993	24.1	15.1	14.0	22.0	13.0	
1994	35.3	28.9	23.0	13.8	19.4	
1995	10.9	15.9	11.9	5.5	13.7	
1996	23.4	12.4	9.6	6.5	17.9	
1997	19.2	11.6	6.7	15.3	8.2	
1998	23.1	17.0	14.0	19.9	11.4	7.1
1999	19.3	12.9	9.9	7.4	14.0	9.8
2000	18.5	11.8	8.1	12.8	6.6	3.8
2001	28.3	11.7	9.1	8.2	13.5	11.4
2002	26.8	18.9	13.2	14.7	14.5	11.0
Average	20.1	17.4	12.7	11.1	13.0	8.6

Hugh Smith Lake had lower average marine survival than Auke Creek, but shows a similar trend with high survival rates in 1992 and 1994. Fishery performance indicators and direct survival indicators both point to a regionwide peak in marine survival in the early to mid-1990s (Shaul 1998). Marine survival has remained higher for the Auke Creek stock compared with the other inside indicator stocks (Berners and Taku Rivers, and Hugh Smith Lake) since 1996 (Figure 8).

Among the three stocks in the northern inside area, survival was inversely related to average stock size, with marine survival rates for 1992–2002 returns averaging 23.8% for Auke Creek (small producer), 16.4% for the Berners River (medium producer) and 12.7% for the Taku River (large producer). A similar pattern was noted among three closely situated stocks (Nass River, Lachmach River, Hugh Smith lake) in the northern boundary area (Joint Northern Boundary Technical Committee 2002).

Marine survival of smolts from the two northern inside river systems, Berners and Taku, was closely correlated over a period of 11 years (R^2 = 0.94, p <0.001), but Taku River smolts consistently had lower survival, averaging only 76% of Berners River smolt survival.

Hugh Smith Lake smolts survived at an average rate of 13.0% during 1984–2002 and have been positively correlated in survival with Berners smolts over 13 years (R^2 = 0.53, p = 0.005) and with Taku smolts over 11 years (R^2 = 0.54, p = 0.010). The positive correlation with Auke Creek smolts over 19 years is weaker (R^2 = 0.25, p = 0.030).

Survival of Ford Arm pre-smolts has averaged a relatively high 11.1% (range 4.4–22.0%) over 20 years.

Total Stock Abundance

Total return abundance of the stocks, including catch and escapement, is the product of smolt production and marine survival. For the full indicator stocks, estimates of total escapement and harvest are shown in Tables 8–13 and Figures 9–11.

The three long-term indicator stocks in inside areas of Southeast show similar patterns in abundance since the early 1980s. The Auke Creek, Berners River and Hugh Smith Lake stocks all show relatively level long-term trends, with a period of high abundance in the early 1990s and a spectacular peak in 1994 (Figure 9). The Hugh Smith stock experienced a record low return of 1,314 fish in 2000, resulting from a combination of record low smolt production (19,900 smolts) and a marine survival rate that was the second lowest on record (6.6%). However, despite the exceptionally low return, the escapement of 600 spawners was within the goal range. The 2002 return of 5,285 adults was the fifth highest in 21 years.

The Ford Arm Lake stock on the outer coast was also abundant in 1992–1994, but returned in proportionately greater abundance than inside stocks during 1997–2001 and reached a peak in 1998.

The estimated Taku River total return (Figure 10; Table 12) has been closely correlated with the Berners River stock over the past 11 years (R^2 = 0.88, p < 0.001). Following a peak in abundance estimated at 339,600 fish in 1994, the stock declined to a very low return of only 50,900 fish in 1997. The Taku run has increased since 1997, reaching 303,600 fish in 2002. The Hugh Smith run has been strongly correlated with runs to the Taku River (R^2 = 0.59, p = 0.006) and Berner River (R^2 = 0.59, p =0.005).

Return estimates for other indicator stocks, including Unuk River, Chuck Creek and Slippery Creek, are too limited to infer trends (Figure 11; Table 13).

Variation in marine survival has been a greater influence on adult returns than the combined influence of freshwater factors (including spawning escapement) expressed as variation in smolt production. We computed the coefficient of variation squared (CV^2) for marine survival and smolt production for all available years for Auke Creek (23 years), Berners River (13 years), Taku River (11 years) and Hugh Smith Lake (19 years). Because CV^2 is approximately additive for independent factors (Goodman 1960), we were then able to apportion variation in return abundance to marine survival versus freshwater factors, including spawning escapement (Table 14). The mean-average proportion of variation accounted for by marine survival for all stocks in all years was 61% compared with 39% for smolt production. The marine components of variation in run size by stock were as follows: Auke Creek 70%, Berners River 57%, Taku River 60%, and Hugh Smith Lake 59%.

For Ford Arm Lake, the variation in adult production attributed to survival after tagging as pre-smolts (with about 10 months of remaining freshwater residence) was 60%, which was comparable with the influence of pure marine survival on the other stocks. This observation and the observed high average survival rate (11.1%) of Ford Arm pre-smolts (Table 7) both suggest that the strong compensatory processes that affect coho salmon survival in fresh water were largely complete when the pre-smolts were tagged in July. In fact, spawning escapement at

Table 8. **Estimated harvest by gear type, escapement, and total run of coho salmon returning to Auke Creek, 1980–2002.**

Year	Fishery Sample Size	Number of Fish: Troll	Seine	Drift Gillnet	Sport	Total Catch	Escapement	Total Return
1980	15	117	0	29	24	170	698	868
1981	70	280	0	31	19	330	646	976
1982	45	149	117	24	2	292	447	739
1983	129	385	10	28	122	545	694	1,239
1984	124	372	8	13	51	444	651	1,095
1985	177	594	3	71	73	741	942	1,683
1986	110	421	2	60	37	520	454	974
1987	145	438	2	48	23	511	668	1,179
1988	145	306	12	72	55	445	756	1,201
1989	182	533	7	15	49	604	502	1,106
1990	168	635	15	57	78	785	697	1,482
1991	47	200	8	152	11	371	808	1,179
1992	53	603	10	196	46	855	1020	1,875
1993	169	611	8	92	19	730	859	1,589
1994	330	1064	224	218	112	1618	1437	3,055
1995	82	264	5	65	26	360	460	820
1996	160	446	11	133	36	626	515	1,141
1997	43	94	4	0	50	148	609	757
1998	157	437	17	43	54	551	862	1,413
1999	160	485	5	58	42	590	845	1,435
2000	103	228	6	23	29	286	683	969
2001	149	435	10	41	55	541	865	1,406
2002	125	288	8	77	51	424	1176	1,600
Average		408	21	67	46	543	752	1,295

Ford Arm Lake has been more variable (CV^2 = 0.247) than freshwater and marine survival after marking (CV^2 = 0.185), while pre-smolt abundance estimates have varied substantially less than either of these factors (CV^2 = 0.125).

Exploitation Rates

Most Southeast Alaska coho salmon stocks accumulate substantial exploitation rates in mixed-stock fisheries. Some inside stocks run a gauntlet of fisheries from troll and marine sport fisheries along the outer coast through net, sport and troll fisheries in corridor areas, and through intensive inside gillnet fisheries concentrated near some estuaries. In some cases, there are significant freshwater sport harvests as well. The overall intensity of the gauntlets has lessened substantially in the past 2 or 3 years because of market and price pressures on the fisheries.

The Auke Creek stock has been exploited at a relatively low average rate of 41% (range 20–55%) during 1980–2002, owing mainly to lack of

Table 9. Estimated harvest by gear type, escapement and total run of coho salmon returning to the Berners River, 1982–2002.

		Number of Fish								
Year	Fishery Sample Size	Troll	Seine	Drift Gillnet	Sport	B.C. Net	Cost Recovery	Total Catch	Escapement	Total Run
1982	48	12,887	0	10,568	0	0	0	23,455	7,505	30,960
1983	125	17,153	0	6,978	65	0	0	24,196	9,840	34,036
1984									2,825	
1985	93	10,865	198	7,015	0	0	0	18,078	6,169	24,247
1986	157	13,560	0	8,928	395	0	0	22,883	1,752	24,635
1987	53	7,448	0	3,301	48	0	0	10,797	3,260	14,057
1988	102	5,926	181	6,141	0	0	0	12,248	2,724	14,972
1989	58	10,515	0	1,664	0	0	0	12,179	7,509	19,688
1990	470	14,751	149	7,339	525	0	0	22,764	11,050	33,814
1991	1,025	6,417	579	16,519	117	0	0	23,632	11,530	35,162
1992	701	15,337	344	14,677	192	0	0	30,550	15,300	45,850
1993	1,496	19,353	192	14,239	140	0	0	33,924	15,670	49,594
1994	2,647	27,319	1,686	27,907	891	5	0	57,808	15,920	73,728
1995	1,384	8,847	22	14,869	117	0	0	23,855	4,945	28,800
1996	601	10,524	380	6,434	412	0	0	17,750	6,050	23,800
1997	312	2,454	282	2,477	179	0	0	5,392	10,050	15,442
1998	613	10,427	435	5,716	380	0	0	16,958	6,802	23,760
1999	948	12,877	208	9,317	261	0	0	22,663	9,920	32,583
2000	693	5,362	145	5,296	196	0	6	11,005	10,650	21,655
2001	745	8,840	195	3,499	123	0	0	12,657	19,290	31,947
2002	788	8,671	228	13,014	471	0	0	22,384	27,700	50,084
Average		11,477	261	9,295	226	0	0	21,259	9,831	31,441

Table 10. Estimated harvest by gear type, escapement, and total run of coho salmon returning to Ford Lake, 1982–2002.

		Number of Fish							
Year	Fishery Sample Size	Alaska Troll	Seine	Drift Gillnet	Sport	Canadian Troll	Total Catch	Escapement	Total Run
1982	38	1,948	106	0	0	0	2,054	2,662	4,716
1983	93	3,344	912	0	0	0	4,256	1,938	6,194
1984									
1985	49	2,438	0	0	0	0	2,438	2,324	4,762
1986	87	2,500	62	0	0	0	2,562	1,546	4,108
1987	71	1,456	79	0	0	0	1,535	1,694	3,229
1988	151	2,857	46	0	0	30	2,933	3,028	5,961
1989	221	3,777	185	0	0	0	3,962	2,177	6,139
1990	174	2,979	108	0	0	0	3,087	2,190	5,277
1991	193	3,208	44	10	0	0	3,262	2,761	6,023
1992	199	5,252	208	0	0	0	5,460	3,847	9,307
1993	349	7,847	443	0	201	0	8,491	4,202	12,693
1994	236	6,918	1,234	0	112	0	8,264	3,228	11,492
1995	91	3,577	1,468	0	0	0	5,045	2,445	7,490
1996	64	3,148	0	0	332	0	3,480	2,500	5,980
1997	241	4,883	0	0	373	0	5,256	4,965	10,221
1998	315	7,835	435	20	679	0	8,969	7,049	16,018
1999	145	5,872	66	0	441	0	6,379	3,598	9,977
2000	193	4,603	926	13	221	0	5,763	2,287	8,050
2001	131	6,023	97	0	479	0	6,599	2,178	8,777
2002	246	5,756	1,260	0	998	0	8,014	7,109	15,123
Average		4,311	384	2	192	2	4,890	3,186	8,077

Table 11. Estimated harvest by gear type, escapement, and total run of coho salmon returning to Hugh Smith Lake, 1982–2002.

		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	2,780	627	203	0	0	264	78	0	3,952	2,144	6,096
1983	189	1,373	424	277	49	0	211	51	0	2,385	1,490	3,875
1984	151	1,260	501	470	18	0	325	28	0	2,602	1,408	4,010
1985	212	868	287	137	5	0	199	13	0	1,509	903	2,412
1986	257	1,585	515	315	2	14	234	26	0	2,691	1,783	4,474
1987	100	656	95	249	0	23	153	50	0	1,226	1,118	2,344
1988	42	408	230	122	0	0	234	23	0	1,017	513	1,530
1989	91	1,213	375	237	0	41	105	20	0	1,991	433	2,424
1990	263	1,810	538	504	24	0	794	53	0	3,723	870	4,593
1991	408	2,102	195	881	0	54	630	43	0	3,905	1,826	5,731
1992	497	1,852	674	601	0	42	286	9	0	3,464	1,426	4,890
1993	162	2,259	262	677	0	0	197	43	0	3,438	830	4,268
1994	846	4,339	1,125	1,424	0	59	684	53	13	7,697	1,753	9,450
1995	433	2,030	908	1,651	0	101	241	28	13	4,972	1,781	6,753
1996	496	1,581	640	478	0	104	126	36	0	2,965	950	3,915
1997	481	1,286	121	397	0	27	89	0	0	1,920	732	2,652
1998	666	1,772	471	980	0	113	0	0	0	3,336	983	4,319
1999	493	1,761	291	727	0	153	0	0	0	2,932	1,246	4,178
2000	141	487	44	116	0	67	0	0	0	714	600	1,314
2001	312	684	489	324	0	58	7	0	0	1,562	1,580	3,142
2002	432	892	451	555	0	91	5	0	0	1,994	3,291	5,285
Average		1,571	441	539	5	45	228	26	1	2,857	1,317	4,174

Table 12. Estimated catch and escapement of coho salmon bound for the Taku River above Canyon Island, 1987–2002.

		Number of Fish							
Year	Fishery Sample Size	Troll	Seine	Gillnet	Marine Sport	Canadian Inriver	Total Catch	Escapement	Total Return
1987						6,519		55,457	
1988						3,643		39,450	
1989						4,033		56,808	
1990						3,685		72,196	
1991						5,439		127,484	
1992	129	41,733	5,062	76,325	3,337	5,541	131,998	84,853	216,851
1993	121	61,129	2,675	31,440	2,513	4,634	102,392	109,457	211,849
1994	178	97,040	26,352	86,198	19,018	14,693	243,301	96,343	339,644
1995	201	45,042	1,853	56,820	7,857	13,738	125,310	55,710	181,020
1996	136	24,780	220	17,067	2,461	5,052	49,580	44,635	94,215
1997	66	8,823	550	1,490	4,963	2,690	18,516	32,345	50,861
1998	231	28,827	742	19,371	4,428	5,090	58,458	61,382	119,840
1999	252	36,229	2,881	7,507	4,170	5,575	56,361	60,844	117,205
2000	229	21,018	1,577	9,935	9,552	5,447	47,529	64,700	112,229
2001	351	32,454	2,096	11,542	3,325	3,033	52,450	104,460	156,910
2002	396	39,025	3,457	30,894	7,076	3,802	84,254	219,360	303,614
1992-2002 Average		39,645	4,315	31,690	6,245	6,300	88,195	84,917	173,113
1987-2002 Average		-	-	-	-	5,788	-	80,343	-

Table 13. Estimated harvest by gear type, escapement and total run of coho salmon returning to Chuck Creek, Unuk River and Slippery Creek, 1982–2002.

Year	Fishery Sample Size	Number of Fish						
		Troll	Seine	Gillnet	Sport	Total Catch	Escapement	Total Return
Chuck Creek								
1982	28	1,320	418			1,738	1,017	2,755
1983	11	551	618			1,169	1,238	2,407
1985	29	1,906	975			2,881	956	3,837
2001							1,350	
2002							2,189	
Average		1,259	670			1,929	1,350	3,000
Unuk River								
1998	140	25,940	4,600	9,046	5,803	45,389	12,422	57,811
1999	260	18,009	4,174	5,441	1,647	29,271	25,778	55,049
2000	138	9,412	1,945	2,312	872	14,541	15,746	30,287
2001	232	11,126	9,315	2,568	2,031	25,040	40,540	65,580
2002	141	7,240	3,458	3,411	1,276	15,385	57,610	72,995
Average		14,345	4,698	4,556	2,326	25,925	30,419	56,345
Slippery Creek								
1998	528	2,196	672	4	60	2,932	632	3,564
1999								
2000	226	1,659	495	7	32	2,193	411	2,604
2001	247	2,507	636	35	90	3,268	2,674	5,942
2002	236	1,257	640	0	93	1,990	5,341	7,331
Average		1,905	611	12	69	2,596	2,265	4,860

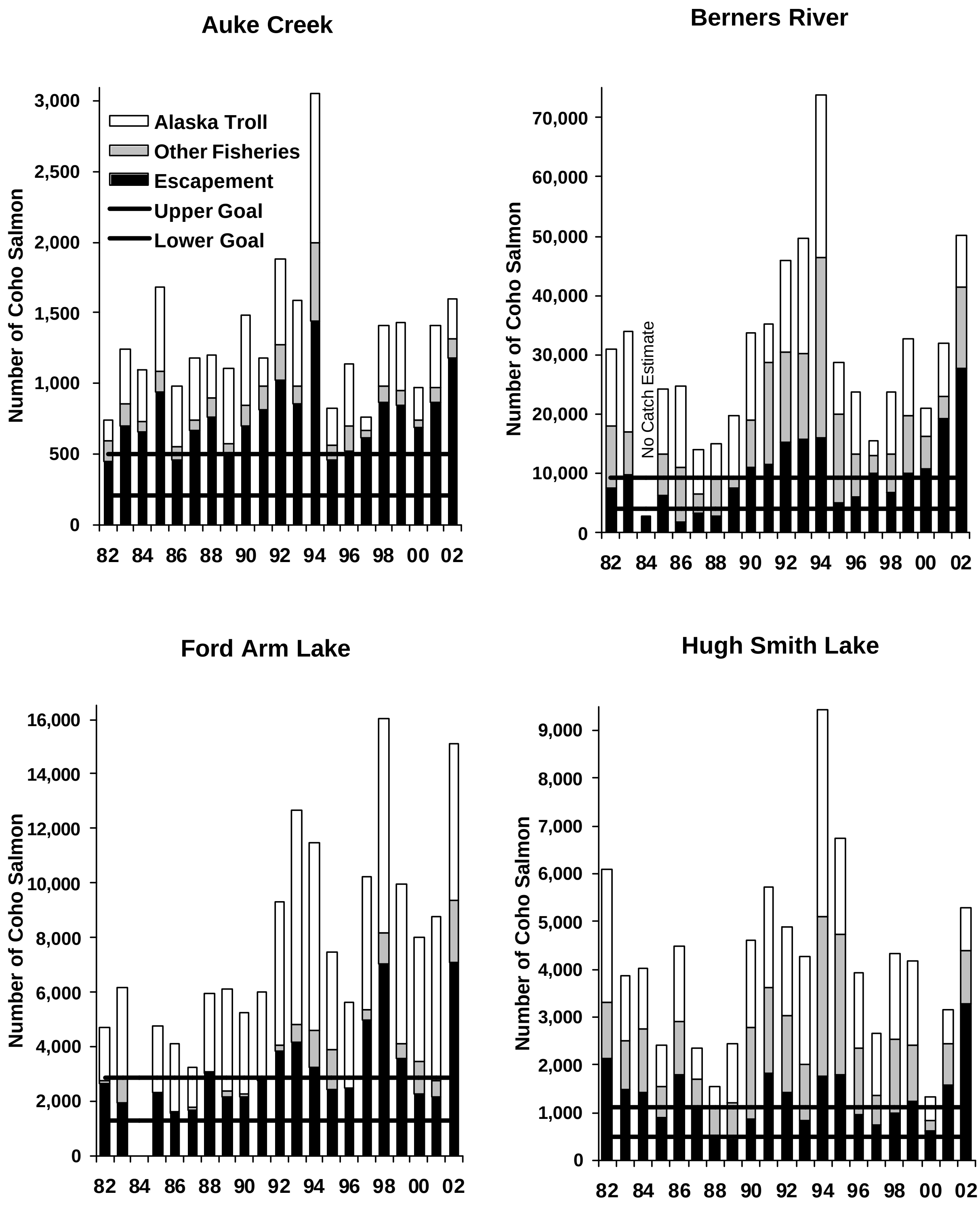

Figure 9. Total run size, catch, escapement and biological escapement goal range for four wild Southeast Alaska coho salmon indicator stocks, 1982–2002.

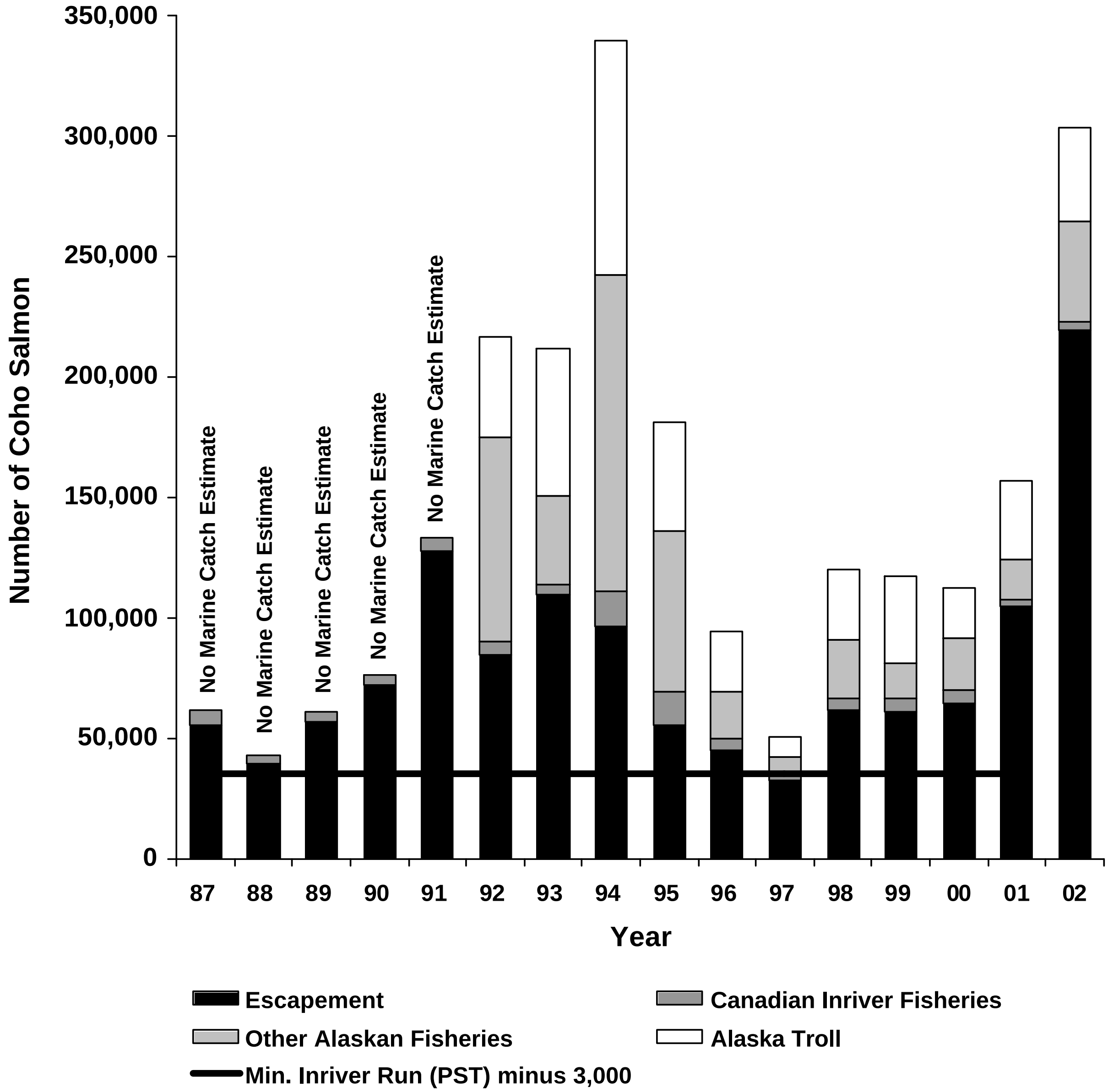

Figure 10. Total estimated run size, catch and escapement of coho salmon bound for the Taku River above Canyon Island, 1987–2002. There are no catch estimates for 1987–1991.

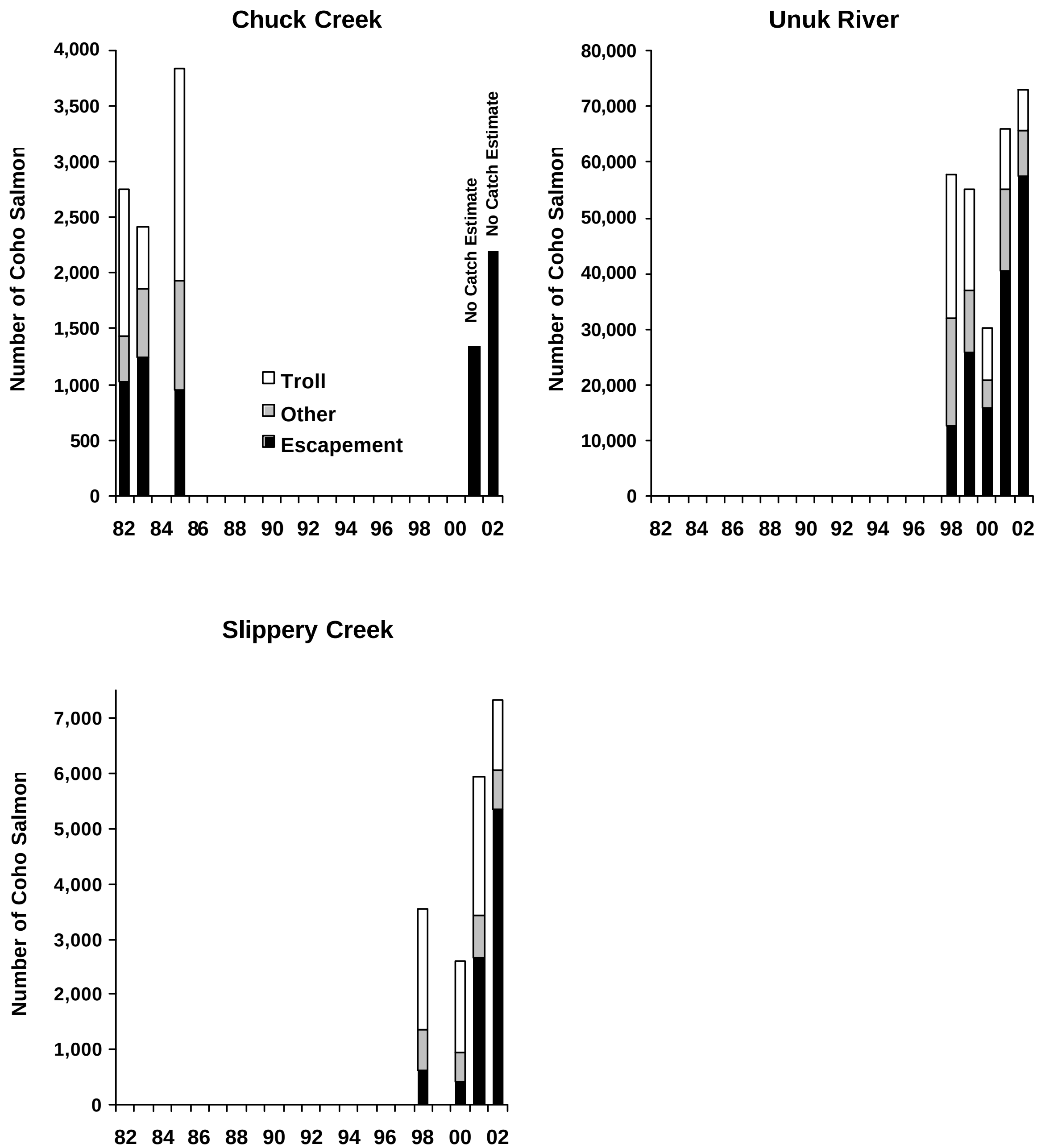

Figure 11. **Total run size, catch and escapement for three wild coho salmon stocks in southern Southeast Alaska, 1982–2002.**

Table 14. Smolt migration and marine survival rate estimates for three wild coho salmon stocks, showing the coefficient of variation (CV), CV^2 and the percent of variation in total run size attributed to smolt abundance and marine survival.

Return Year	Auke Creek Smolts	Auke Creek Survival (%)	Berners River Smolts	Berners River Survival (%)	Taku River Smolts	Taku River Survival (%)	Hugh Smith Lake Smolts	Hugh Smith Lake Survival (%)
1980	8,789	9.9						
1981	10,714	9.1						
1982	6,967	10.6						
1983	6,849	18.1						
1984	6,901	15.9					51,789	7.7
1985	6,838	24.6					32,104	7.5
1986	5,852	16.6					23,499	19.0
1987	5,617	21.0					21,878	10.7
1988	7,014	17.1					36,218	4.2
1989	7,685	14.4					23,336	10.4
1990	7,011	21.1	164,356	20.6			26,620	17.3
1991	5,137	23.0	141,154	24.9			32,925	17.4
1992	5,690	33.0	187,715	24.4	1,080,551	20.1	23,326	21.0
1993	6,596	24.1	326,126	15.1	1,510,032	14.0	32,853	13.0
1994	8,647	35.3	255,431	28.9	1,475,874	23.0	48,433	19.4
1995	7,495	10.9	181,503	15.9	1,525,330	11.9	49,288	13.7
1996	4,884	23.4	194,019	12.4	986,489	9.6	22,413	17.9
1997	3,934	19.2	133,629	11.6	759,763	6.7	32,294	8.2
1998	6,111	23.1	139,959	17.0	853,662	14.0	37,898	11.4
1999	7,420	19.3	252,199	12.9	1,184,195	9.9	29,830	14.0
2000	5,233	18.5	183,023	11.8	1,387,399	8.1	19,902	6.6
2001	4,969	28.3	268,468	11.7	1,720,387	9.1	23,343	13.5
2002	5,980	26.8	264,772	18.9	2,292,949	13.2	36,531	14.5
CV	0.225	0.343	0.291	0.332	0.327	0.396	0.306	0.370
CV^2	0.051	0.118	0.085	0.110	0.107	0.157	0.094	0.137
Percent of Variation	30.1	69.9	43.4	56.6	40.5	59.5	40.6	59.4

Mean-Average Percent of Variation in Adult Abundance Attributed to Smolt Abundance = 38.6%
Mean-Average Percent of Variation in Adult Abundance Attributed to Marine Survival = 61.4%

intensive net fishing in its migratory pathway during the fall (Figures 12 and 13; Table 15). The troll fishery has accounted for the majority of the harvest, exploiting the stock at an average rate of 31% (range 12–48%) with less than 5% each attributed to seine, gillnet and sport fisheries.

The Berners River stock was exploited intensively in the Lynn Canal drift gillnet fishery during the 1980s (Figures 12 and 13; Table 16). During that period, coho salmon were taken in the gillnet fishery primarily as incidental harvest to fall Chilkat River chum salmon. The decline in fall chum abundance, described earlier, coincided with a peak in marine survival of coho salmon in the 1990s, resulting in dispersal of fall gillnet effort to other districts and a reduction in exploitation of Berners River coho salmon.

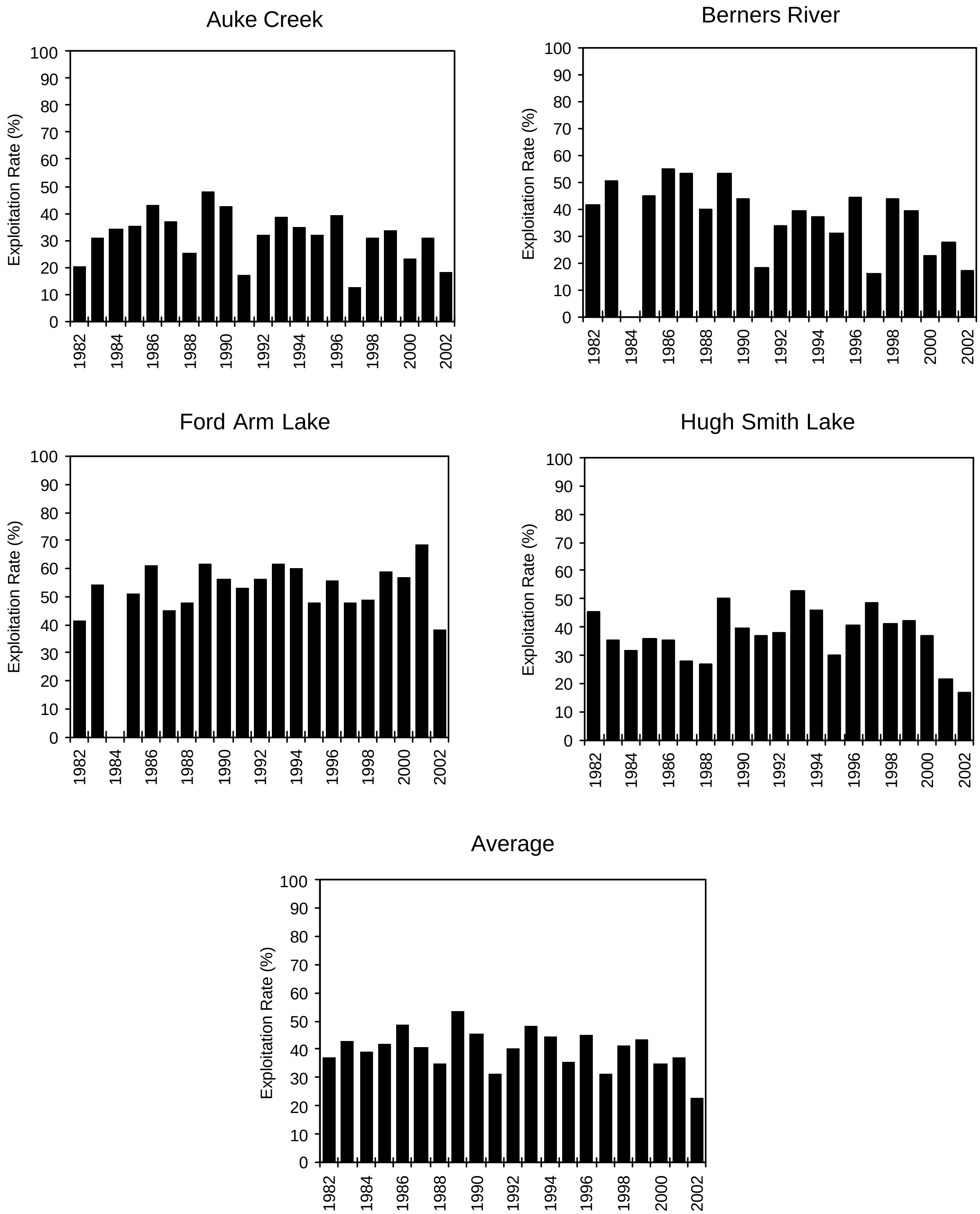

Figure 12. Estimated exploitation rates by the Alaskan troll fishery for four coded-wire tagged Southeast Alaska coho stocks, 1982–2002.

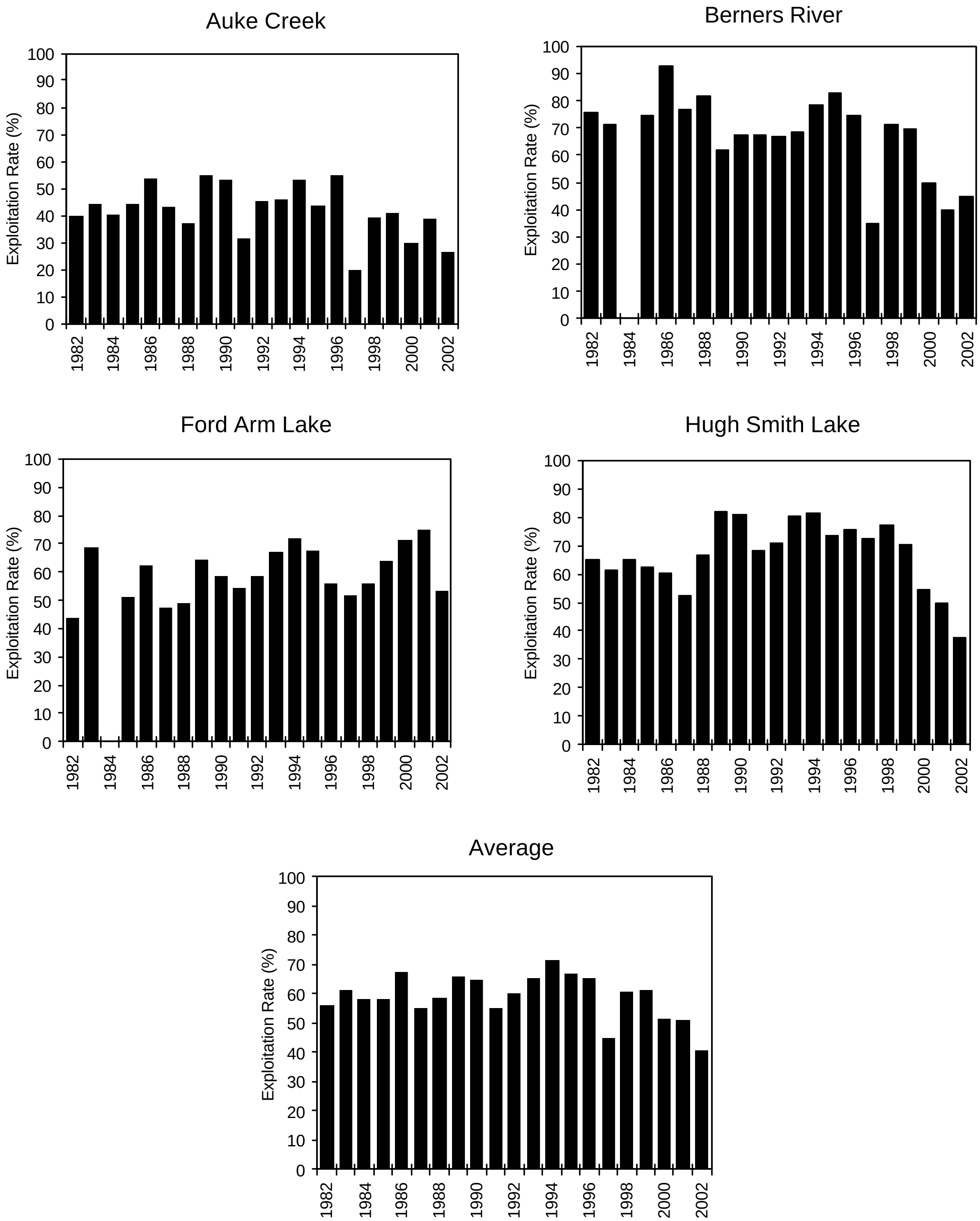

Figure 13. Estimated total exploitation rates by all fisheries for four coded-wire tagged Southeast Alaska coho stocks, 1982–2002.

Table 15. Estimated percent harvest by gear type, escapement, and total run of coho salmon returning to Auke Creek, 1980–2002.

Year	Fishery Sample Size	Percent of Total Run						
		Troll	Seine	Drift Gillnet	Sport	Total Catch	Escapement	Total Return
1980	15	13.5	0.0	3.3	2.8	19.6	80.4	100.0
1981	70	28.7	0.0	3.2	1.9	33.8	66.2	100.0
1982	45	20.2	15.8	3.2	0.3	39.5	60.5	100.0
1983	129	31.1	0.8	2.3	9.8	44.0	56.0	100.0
1984	124	34.0	0.7	1.2	4.7	40.5	59.5	100.0
1985	177	35.3	0.2	4.2	4.3	44.0	56.0	100.0
1986	110	43.2	0.2	6.2	3.8	53.4	46.6	100.0
1987	145	37.2	0.2	4.1	2.0	43.3	56.7	100.0
1988	145	25.5	1.0	6.0	4.6	37.1	62.9	100.0
1989	182	48.2	0.6	1.4	4.4	54.6	45.4	100.0
1990	168	42.8	1.0	3.8	5.3	53.0	47.0	100.0
1991	47	17.0	0.7	12.9	0.9	31.5	68.5	100.0
1992	53	32.2	0.5	10.5	2.5	45.6	54.4	100.0
1993	169	38.5	0.5	5.8	1.2	45.9	54.1	100.0
1994	330	34.8	7.3	7.1	3.7	53.0	47.0	100.0
1995	82	32.2	0.6	7.9	3.2	43.9	56.1	100.0
1996	160	39.1	1.0	11.7	3.2	54.9	45.1	100.0
1997	43	12.4	0.5	0.0	6.6	19.6	80.4	100.0
1998	157	30.9	1.2	3.0	3.8	39.0	61.0	100.0
1999	160	33.8	0.3	4.0	2.9	41.1	58.9	100.0
2000	103	23.5	0.6	2.4	3.0	29.5	70.5	100.0
2001	149	30.9	0.7	2.9	3.9	38.5	61.5	100.0
2002	125	18.0	0.5	4.8	3.2	26.5	73.5	100.0
Average		30.6	1.5	4.9	3.6	40.5	59.5	100.0

Exploitation rate estimates declined from an average of 76% in the 1980s to 68% in the 1990s and averaged only 45% (range 40–51%) in 2000–2002.

Like other stocks, a market-driven reduction in fishing effort was largely responsible for the recent drop in exploitation of the Berners River stock. The exploitation rate by the troll fishery, which has accounted for about half of the harvest of the stock, fell to only 17% in 2002 from a 1990s average of 41% despite a total run that was the second largest on record (Figure 9 and Table 9). The decline in the troll exploitation rate and small number of participating gillnetters was mitigated to some extent by special gillnet openings in Berners Bay, resulting in a gillnet exploitation rate of 26% that was only moderately lower than the 1990s average of 31%. Despite these measures, the total exploitation rate in 2002 was only 45%, and the escapement of 27,700 spawners was the largest on record.

The Ford Arm Lake stock has been harvested at moderate to high exploitation rates, primarily in the region troll fishery, which is most intensive in waters near this system. The stock is available

Table 16. Estimated percent harvest by gear type, escapement and total run of coho salmon returning to the Berners River, 1982–2002.

		Percent of Total Run								
Year	Fishery Sample Size	Troll	Seine	Drift Gillnet	Sport	B.C. Net	Cost Recovery	Total Catch	Escapement	Total Run
1982	48	41.6	0.0	34.1	0.0	0.0	0.0	75.8	24.2	100.0
1983	125	50.4	0.0	20.5	0.2	0.0	0.0	71.1	28.9	100.0
1984										
1985	93	44.8	0.8	28.9	0.0	0.0	0.0	74.6	25.4	100.0
1986	157	55.0	0.0	36.2	1.6	0.0	0.0	92.9	7.1	100.0
1987	53	53.0	0.0	23.5	0.3	0.0	0.0	76.8	23.2	100.0
1988	102	39.6	1.2	41.0	0.0	0.0	0.0	81.8	18.2	100.0
1989	58	53.4	0.0	8.5	0.0	0.0	0.0	61.9	38.1	100.0
1990	470	43.6	0.4	21.7	1.6	0.0	0.0	67.3	32.7	100.0
1991	1,025	18.2	1.6	47.0	0.3	0.0	0.0	67.2	32.8	100.0
1992	701	33.5	0.8	32.0	0.4	0.0	0.0	66.6	33.4	100.0
1993	1,496	39.0	0.4	28.7	0.3	0.0	0.0	68.4	31.6	100.0
1994	2,647	37.1	2.3	37.9	1.2	0.0	0.0	78.4	21.6	100.0
1995	1,384	30.7	0.1	51.6	0.4	0.0	0.0	82.8	17.2	100.0
1996	601	44.2	1.6	27.0	1.7	0.0	0.0	74.6	25.4	100.0
1997	312	15.9	1.8	16.0	1.2	0.0	0.0	34.9	65.1	100.0
1998	613	43.9	1.8	24.1	1.6	0.0	0.0	71.4	28.6	100.0
1999	948	39.5	0.6	28.6	0.8	0.0	0.0	69.6	30.4	100.0
2000	693	24.8	0.7	24.5	0.9	0.0	0.0	50.8	49.2	100.0
2001	745	27.7	0.6	11.0	0.4	0.0	0.0	39.6	60.4	100.0
2002	787	17.3	0.5	26.0	0.9	0.0	0.0	44.7	55.3	100.0
Average		37.7	0.8	28.4	0.7	0.0	0.0	67.6	32.4	100.0

in nearby waters over most of the summer, making it highly available to hook-and-line fisheries. The exploitation rate by the troll fishery has averaged 53% (Figure 12; Table 17) while intermittent seine harvests and increasing marine sport fishing have brought the long-term average exploitation rate by all fisheries up to 60%. During the most recent 5-year period (1998–2002), the marine sport fishery based primarily out of Sitka has accounted for an average of 564 Ford Arm Lake fish or about 5% of the total run.

The overall exploitation rate on the Ford Arm stock has remained higher compared with other stocks during the recent decline in regional fishing effort. In 2001, the Ford Arm Lake stock was exploited at a record 75% while the 2002 exploitation rate of 53% was down only moderately from the historical average of 60% (Figure 13 and Table 17).

The Hugh Smith Lake stock is an example of a stock that traverses an extended gauntlet of mixed stock fisheries along the coast and is exposed to fisheries outside of state jurisdiction in Canada and around Annette Island. During 1982–1988, the Hugh Smith Lake stock was exploited at moderate rates for coho salmon, averaging 62% (Figures 12 and 13; Table 18).

However, exploitation became markedly more intense during 1989–1999 at an average rate of 76% (range 68–82%). The increase was split between the troll fishery in northern Southeast and gillnet fisheries in southern Southeast.

Although the increase in exploitation in gillnet fisheries could be attributed to more liberal

Table 17. **Estimated percent harvest by gear type, escapement, and total run of coho salmon returning to Ford Arm Lake, 1982–2002.**

		Percent of Total Run							
Year	Fishery Sample Size	Alaska Troll	Seine	Drift Gillnet	Sport	Canadian Troll	Total Catch	Escapement	Total Run
1982	38	41.3	2.2	0.0	0.0	0.0	43.6	56.4	100.0
1983	93	54.0	14.7	0.0	0.0	0.0	68.7	31.3	100.0
1984									
1985	49	51.2	0.0	0.0	0.0	0.0	51.2	48.8	100.0
1986	87	60.9	1.5	0.0	0.0	0.0	62.4	37.6	100.0
1987	71	45.1	2.4	0.0	0.0	0.0	47.5	52.5	100.0
1988	151	47.9	0.8	0.0	0.0	0.5	49.2	50.8	100.0
1989	221	61.5	3.0	0.0	0.0	0.0	64.5	35.5	100.0
1990	174	56.5	2.0	0.0	0.0	0.0	58.5	41.5	100.0
1991	193	53.3	0.7	0.2	0.0	0.0	54.2	45.8	100.0
1992	199	56.4	2.2	0.0	0.0	0.0	58.7	41.3	100.0
1993	349	61.8	3.5	0.0	1.6	0.0	66.9	33.1	100.0
1994	236	60.2	10.7	0.0	1.0	0.0	71.9	28.1	100.0
1995	91	47.8	19.6	0.0	0.0	0.0	67.4	32.6	100.0
1996	64	52.6	0.0	0.0	5.6	0.0	58.2	41.8	100.0
1997	241	47.8	0.0	0.0	3.6	0.0	51.4	48.6	100.0
1998	315	48.9	2.7	0.1	4.2	0.0	56.0	44.0	100.0
1999	145	58.9	0.7	0.0	4.4	0.0	63.9	36.1	100.0
2000	193	57.2	11.5	0.2	2.7	0.0	71.6	28.4	100.0
2001	131	68.6	1.1	0.0	5.5	0.0	75.2	24.8	100.0
2002	246	38.1	8.3	0.0	6.6	0.0	53.0	47.0	100.0
Average		53.5	4.4	0.0	1.8	0.0	59.7	40.3	100.0

management, it appears that the increase in the troll fishery exploitation rate was due at least in part to a shift in the migratory pattern of the stock more into northern waters where the fishery was more intense.

Exploitation rates on Hugh Smith Lake coho salmon have subsequently plunged to only 54% in 2000, 50% in 2001 and 38% in 2002. The Alaska troll exploitation rate on the Hugh Smith stock dropped from an average of 39% in 1982–1999 to 37% in 2000, 22% in 2001 and 17% in 2002 (Figure 12; Table 18).

Exploitation rate estimates for the Taku River stock were relatively low considering the fact that the stock has been exposed to a gauntlet of fisheries extending from offshore waters into the system. Total exploitation rate estimates for the stock averaged 51% in 1992–2002 (Table 19). The troll exploitation rate during that period averaged only 24% compared with averages of 30% and 32%, respectively, for nearby Auke Creek and Berners River stocks that migrate through the same waters with somewhat later timing. Exploitation of the Taku River run by all fisheries has declined markedly since 1999 and in 2002 was only about half of the 1992–1999 average.

In 2002, the total exploitation rate was estimated at only 28% compared with the 1992–1999 average of 57%. Decreases by fishery from the period 1992–1999 to 2002 were as follows: troll 26% to 13%, seine 2% to 1%, marine gillnet 21% to 10%, marine sport 3% to 2%, and inriver gillnet 5% to 1%. In 2002, mean-average exploitation rates for the four long-term indicator stocks were the lowest recorded, having declined from 62% in 1990–1999 to 40% in 2002 (Figure 13), while the Alaska troll component declined from 41% in the 1990s to 23% in 2002 (Figure 12).

ESCAPEMENT GOALS

Biological escapement goals (BEGs) were established for the four long-term indicator stocks in 1994 using Ricker analysis (Clark et al. 1994). Subsequently, Clark (1995) developed goals for the five surveyed roadside streams in the Juneau area. These BEG ranges are designed to maintain wild stocks at high levels of productivity, and to maintain yields near maximum. The goals represent a range of escapements that were estimated to produce 90% or more of MSY.

The Taku River has a minimum goal for the number of coho salmon passing above Canyon Island specified in the 1999 Pacific Salmon Treaty (PST). The Transboundary Technical Committee of the Pacific Salmon Commission is expected to develop a BEG for this stock in 2003–2004. The current above-border goal of 38,000 effectively translates to an escapement goal of about 35,000 spawners after harvests in commercial, food and test fisheries.

Goals have not yet been formally developed for newer indicator stocks and surveyed streams that lack adequate data series for spawner-recruit analysis.

One major problem with spawner-recruit analysis of northern coho salmon stocks has been difficulty in accurately determining freshwater age. Farrington and Taylor (1994) found most Auke Creek smolts to be over-aged by one or two years. Whereas most smolts from that system had been believed to be age 3, with age 1 smolts almost nonexistent, Farrington and Taylor found most to be age 1, based on marked known-age samples.

Table 18. Estimated harvest by gear type, escapement and total run of coho salmon returning to Hugh Smith Lake, 1982–2002.

		Percent of Total Run										
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	45.6	10.3	3.3	0.0	0.0	4.3	1.3	0.0	64.8	35.2	100.0
1983	189	35.4	10.9	7.1	1.3	0.0	5.4	1.3	0.0	61.5	38.5	100.0
1984	151	31.4	12.5	11.7	0.4	0.0	8.1	0.7	0.0	64.9	35.1	100.0
1985	212	36.0	11.9	5.7	0.2	0.0	8.3	0.5	0.0	62.6	37.4	100.0
1986	257	35.4	11.5	7.0	0.0	0.3	5.2	0.6	0.0	60.1	39.9	100.0
1987	100	28.0	4.1	10.6	0.0	1.0	6.5	2.1	0.0	52.3	47.7	100.0
1988	42	26.7	15.0	8.0	0.0	0.0	15.3	1.5	0.0	66.5	33.5	100.0
1989	91	50.0	15.5	9.8	0.0	1.7	4.3	0.8	0.0	82.1	17.9	100.0
1990	263	39.4	11.7	11.0	0.5	0.0	17.3	1.2	0.0	81.1	18.9	100.0
1991	408	36.7	3.4	15.4	0.0	0.9	11.0	0.8	0.0	68.1	31.9	100.0
1992	497	37.9	13.8	12.3	0.0	0.9	5.8	0.2	0.0	70.8	29.2	100.0
1993	162	52.9	6.1	15.9	0.0	0.0	4.6	1.0	0.0	80.6	19.4	100.0
1994	846	45.9	11.9	15.1	0.0	0.6	7.2	0.6	0.1	81.4	18.6	100.0
1995	433	30.1	13.4	24.4	0.0	1.5	3.6	0.4	0.2	73.6	26.4	100.0
1996	496	40.4	16.3	12.2	0.0	2.7	3.2	0.9	0.0	75.7	24.3	100.0
1997	481	48.5	4.6	15.0	0.0	1.0	3.4	0.0	0.0	72.4	27.6	100.0
1998	666	41.0	10.9	22.7	0.0	2.6	0.0	0.0	0.0	77.2	22.8	100.0
1999	493	42.1	7.0	17.4	0.0	3.7	0.0	0.0	0.0	70.2	29.8	100.0
2000	141	37.0	3.4	8.8	0.0	5.1	0.0	0.0	0.0	54.3	45.7	100.0
2001	312	21.8	15.6	10.3	0.0	1.8	0.2	0.0	0.0	49.7	50.3	100.0
2002	432	16.9	8.5	10.5	0.0	1.7	0.1	0.0	0.0	37.7	62.3	100.0
Average		37.1	10.4	12.1	0.1	1.2	5.4	0.7	0.0	67.0	33.0	100.0

Their findings have spurred age-verification studies on other systems including Hugh Smith Lake and the Berners River. The findings at Hugh Smith Lake are similar to Auke Creek and may be applicable to other systems that are dominated by lake habitat. Somewhat different and less severe aging error rates have been found in Berners River samples. The primary problem in accurate freshwater aging appears to be formation in scale patterns of false checks that are mistaken for annuli.

A project is underway using the Sustainable Salmon Fund to further develop and analyze the data series of known-age samples to develop aging criteria and protocols that increase the accuracy of age composition estimates. The historical scale collection for the indicator stocks will then be re-aged and BEGs updated, with completion planned for 2005.

A major advantage of coho salmon indicator stocks for spawner-recruit analysis is the ability to account for varying marine survival, thereby avoiding spurious results from shifts in ocean survival (Geiger 2001). Most indicator stock programs provide estimates of total population size after the freshwater phase (smolts) and after the ocean phase (returning adults). Because of the territorial nature of coho salmon, average smolt size varies relatively little with brood year abundance, so there is probably very little effect of brood year abundance on marine survival. The ability to account for approximately 60% of the variability in adult production (see Total Stock Abundance section) is a major advantage in determining the underlying relationship between brood year escapement and resulting stock abundance.

An analysis of spawner-recruit data from coho salmon stocks from Oregon through central British Columbia by Bradford et al. (1999) indicates that smolt production is typically unrelated to spawner abundance above a minimum threshold level that represents full seeding. The authors found that the most consistent best fit was provided by a simple "hockey stick" model with return proportionate to brood-year escapement up to a threshold escapement level above which returns are stable at all escapement levels. Above the threshold escapement, juvenile coho salmon are limited in their ability to survive and grow by territorial effects that result in unequal access to food and

Table 19. Estimated percent of harvest by gear type, escapement, and total run of coho salmon returning to the Taku River above Canyon Island, 1992–2002.

		Percent of Total Run							
Year	Fishery Sample Size	Troll	Seine	Gillnet	Marine Sport	Canadian Inriver	Total Catch	Escapement	Total Return
1992	129	19.2	2.3	35.2	1.5	2.6	60.9	39.1	100.0
1993	121	28.9	1.3	14.8	1.2	2.2	48.3	51.7	100.0
1994	178	28.6	7.8	25.4	5.6	4.3	71.6	28.4	100.0
1995	201	24.9	1.0	31.4	4.3	7.6	69.2	30.8	100.0
1996	136	26.3	0.2	18.1	2.6	5.4	52.6	47.4	100.0
1997	66	26.3	0.2	18.1	2.6	5.4	52.6	47.4	100.0
1998	231	24.1	0.6	16.2	3.7	4.2	48.8	51.2	100.0
1999	252	30.9	2.5	6.4	3.6	4.8	48.1	51.9	100.0
2000	229	18.7	1.4	8.9	8.5	4.9	42.4	57.7	100.0
2001	351	20.7	1.3	7.4	2.1	1.9	33.4	66.6	100.0
2002	396	12.9	1.1	10.2	2.4	1.3	27.8	72.2	100.0
Average		23.8	1.8	17.5	3.5	4.0	50.5	49.5	100.0

promote uneven growth and mortality rates within the population. This system of population regulation tends to produce a relatively constant number of smolts of a consistent size from highly variable levels of seeding of fry by spawners. We have found no indication that spawner-recruit relationships for Southeast Alaska coho stocks are substantially different from the southern stocks investigated by Bradford et al. (1999). Recent escapements that were two or three times the BEGs reflect foregone harvest opportunity but are unlikely to significantly reduce future returns.

In some regions, habitat measurements have been used to estimate production capability in order to develop escapement goals. For example, Holtby et al. (1999) generated an estimate of MSY escapement for the Babine system in interior northern British Columbia based on spawner densities of 13 females/km and 41 spawners per mile that were determined to approximate MSY escapement, based on studies of coastal streams in southern British Columbia and Oregon, respectively.

We find a habitat-based approach to estimating carrying capacity to be of doubtful utility in Southeast Alaska. Habitat capability of northern coho salmon systems appears to be highly variable relative to system size. For example, Shaul and Van Alen (2001) reported average smolt production density estimates varying nearly three fold for the four long-term coastal indicator systems in Southeast Alaska, ranging from 1,148 smolts/km in the Auke Creek system to 4,140 smolts/km in the Ford Arm Lake system. Comparable estimates for two tributaries in the interior Taku River drainage were only 213 smolts/km and 420 smolts/km respectively. We believe that applying spawner density factors to measures of habitat will result in escapement goals that are unrealistic relative to actual sustained yield needs.

As an alternative, we suggest using average observed smolt production (excluding production from brood years when escapement was particularly low) as the best estimate of system capability. Given that escapement in most systems is at or near historic highs, smolt production in succeeding years should provide further evidence of the productive capacity of these systems. If an adequate data series is unavailable for direct spawner-recruit analysis, productivity estimates from longer-term full indicator stocks can be scaled to habitat capability estimates for other stocks to generate an initial escapement goal. Based on information from Southeast Alaska indicator stocks and estimates presented in Bradford et al. (1999), MSY for most stocks appears to fall in the range of about 30 to 60 smolts per spawner. For Hugh Smith Lake where production has averaged about 31,800 smolts (Table 5), the current escapement goal range of 500–1,100 spawners (with predicted returns of 90% or more of MSY) corresponds with 29–64 smolts per spawner.

In cases where the available data series consists only of escapement survey counts, smolt production associated with those counts can be estimated using marine survival and exploitation rate estimates for full indicator stocks in the same area. When aging validation work is completed, an updated analysis of spawner-recruit relationships will be done for the full indicator stocks. This in turn will aid in establishing goals for more of the surveyed systems.

DISCUSSION

Southeast Alaska coho salmon stocks are currently in excellent overall condition. We found no stocks of concern from a fishery management perspective. Stocks that have biological escapement goals have been within or above target ranges in the vast majority of cases. For most stocks, escapements peaked in the early to mid-1990s when runs were exceptionally strong and have reached relatively high levels again in 2000–2002 because of strong runs combined with declining exploitation.

Fishing effort in troll and net fisheries has declined substantially because of downward pressure on markets for salmon. Until effort increases again, fisheries will rarely require inseason restrictions to achieve escapement goals and escapements will greatly exceed goals when runs are strong. For example, spawning escapement in 2002 was triple the upper end of the biological goal range for two key inside indicator stocks (Berners River and Hugh Smith Lake). These exceptionally large escapements represent substantial foregone harvest but we do not expect them to adversely affect future returns.

Until the late 1990s, the Berners River and Hugh Smith Lake stocks were intensively exploited by a gauntlet of fisheries at rates that were commonly in the 70–80% range. If 2002 exploitation rates of 45% and 38% persist, the Berners River and Hugh Smith Lake stocks will not fall under escapement objectives unless their returns are less than 51% and 61%, respectively, of the lowest run sizes in the past 21 years. Until the capacity for the fisheries to exploit the stocks increases again, the primary concern of fishery managers and industry participants will be to create opportunities to economically exploit and extract value from available surplus production. Sport fishing in marine waters has increased substantially in the past decade but still exploits most indicator stocks at rates of only 3 to 5%.

Fishery performance indicators like the troll catch of wild coho salmon indicate that Southeast Alaska coho stocks have been at historically high abundance since 1982 after a protracted period of low production from 1956–1981 (Shaul and Van Alen 2001). The primary long-term indicator stock projects were initiated at about the time that abundance improved. Within the period of stronger runs since the early 1980s, total return estimates for specific stocks indicate a generally level overall trend, except for a peak in the early to mid-1990s. The primary factor that has driven both short and long-term fluctuations in abundance is marine survival, which has accounted for about 61% (range 57–70%) of the observed variability in abundance of wild indicator stocks since 1980, while only about 39% (range 30–43%) was attributed to freshwater factors including spawning escapement. The relative influence of survival might appear even greater if it were possible to estimate its effect over a broader period that transited poor as well as favorable trends in ocean conditions.

Strong positive correlations in returns to systems over broad geographic areas facilitate use of indicator stocks as a tool to manage highly mixed-stock fisheries (Shaul 1998, Shaul et al. 1998, Shaul and Van Alen 2001). Smolt production as well as marine survival can be strongly correlated for systems of the same habitat type over substantial geographic areas, as evidenced by strong positive relationships in smolt production and survival between the Taku River and Berners River stocks that are separated by 90 km. Marine survival of stocks in systems entering inside marine waters can be strongly correlated over longer distances up to at least 490 km (the distance between Berners River and Hugh Smith Lake).

Although we identified no stocks of concern from a fishery management perspective, the Joint Northern Boundary Technical Committee (2002) described land-use practices in the region that have likely reduced habitat capability for coho salmon. Most habitat loss is a long-term ongoing process resulting from historical forestry practices that have resulted in loss and reduced recruitment of woody debris in stream channels. Problems have also been identified with improperly installed culverts that block fish passage under logging roads. These effects apply primarily to smaller streams in areas where timber has been harvested. Most wetland habitat that is essential to coho salmon production in larger mainland river systems is in nearly pristine condition.

Urbanization impacts are minor over most of the region, but we noted decreases in two Juneau roadside stocks that may have been related to the ongoing process of urban development. The declines appear unrelated to fishery effects on spawning escapement, but natural habitat changes and ecological shifts cannot be ruled out.

The Auke Creek stock has undergone a gradual decline in smolt production of about 1.45% of the year-zero reference point per year over the 24-year history of the indicator stock, for a total decline of 35%. The reason for the decline is unclear but does not appear related to a limitation in the number of spawners, as average escapement has increased from 650 fish in 1980-1990 to 840 fish in 1991–2002. Spawner-recruit analysis may shed more light on the influence of escapement on smolt production.

However, the trend may be related to habitat change in the system. The surrounding area has undergone substantial development and noticeable changes have included increased residential development and large bed-load shifts in Lake Creek, the main inlet stream that serves as the primary spawning area and provides some rearing habitat (Jerry Taylor, National Marine Fisheries

Service, personal communication). Bishop (1987) noted an absence of large woody debris in lower sections of Lake Creek, which may have reduced pool rearing habitat and subjected spawning habitat to increased bed-load movement. He also noted low and intermittent winter flows in Lake Creek. Its possible that the system has undergone an ecological shift that has favored species other than coho salmon. Such a shift might also have increased predation on rearing coho salmon. Dolly Varden and cutthroat trout have both increased substantially in abundance since the early 1980s (Taylor and Lum 2002).

Jordan Creek, located in a heavily developed section of the Mendenhall Valley, experienced a sharp drop in escapement beginning in 1995, with escapements falling under the goal for five consecutive years. The decline was disproportionate with changes in escapement in other Juneau roadside streams. However, there was a surprisingly strong record escapement in Jordan Creek in 2002 that was nearly double the previous record and proportionately higher than escapements in nearby systems. The recent history of highly variable escapements in Jordan Creek, combined with widely disparate smolt counts in 2001 and 2002, suggests that survival and smolt production from the system has recently been particularly sensitive to environmental conditions.

One stock that has experienced a substantial increase in freshwater production since the early 1980s is Ford Arm Lake, a virtually pristine watershed in a wilderness area on the outer coast. There have been no obvious changes in the physical features of the habitat that would indicate increased production, but it's possible that the coho salmon stock has benefited from increasing nutrient inputs from recent large pink, sockeye and coho salmon escapements in that system.

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