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Coho Salmon Stock Status and Escapement Goals in Southeast Alaska

by

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

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

Alaska Department of Fish and Game	ADF&G
Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	\$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

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

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

The status of coho salmon stocks in Southeast Alaska was assessed from information on escapement, smolt abundance, marine survival, and total abundance from coded-wire tagged indicator stocks and from stocks returning to 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. Although escapements to most systems have remained within or above *biological escapement goal* ranges during 2005–2007, there have been some shortfalls due to a recent downturn in marine survival combined with lower smolt production from some systems. However, we identified no coho salmon *stocks of concern* in Southeast Alaska. With very few exceptions, observed escapements were within or above goal since 1990. Smolt and pre-smolt production has been variable among systems, declining for more than 2 decades in Auke Creek and more recently, in the Berners River while trending higher in the Taku River and Ford Arm Lake and remaining stable at Hugh Smith Lake. Recent average marine survival rates during 2005–2007 dropped well below the 1982–2004 average for most systems and 2007 estimates were the lowest on record for the Berners (7.5%), Taku (3.3%) and Chilkat (5.5%) rivers. Adult return strength has been strongly correlated among most inside stocks since 1982 while returns to outer coastal systems were poorly correlated with both inside stocks and other outer coastal stocks. Exploitation rates remained moderate during 2004–2007 with averages by stock of 60% for Chuck Creek, 63% for Ford Arm Lake, 59% for Hugh Smith Lake, 59% for Berners River, 51% for Chilkat River, 54% for Taku River, 38% for Auke Creek and 33% for Nakwasina River. Recent exploitation rates for most systems rebounded substantially following a period of low estimates that were likely influenced by low salmon prices during 2000–2003.

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, Chilkat River, Nakwasina River, Chuck Creek, Situk River, Lost River.

INTRODUCTION

Coho salmon (*Oncorhynchus kisutch*) are important to a variety of commercial, sport, and subsistence users in Southeast Alaska. 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. This report updates an earlier assessment (2005) of the stocks that support these fisheries through the 2007 return.

Full development of a troll fishery targeting coho salmon occurred around 1940, and the commercial catch (Figure 1) provides an indication of the trend in coho salmon abundance after that time. Stocks recovered in the early 1980s from a prolonged period of low abundance extending for over 2½ decades. Whereas low marine survival was likely a major factor driving poor catches from 1956 to 1981, improved marine survival has been an important factor influencing larger wild stock catches since 1982. However, commercial wild coho salmon catches of 1.58 million fish in 2006 and 1.52 million fish in 2007 were the 5th and 6th lowest catches during the 26 years of the post–1981 period.

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, several 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 to 2007, hatcheries contributed an average of 20% (range 14% to 24%) 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

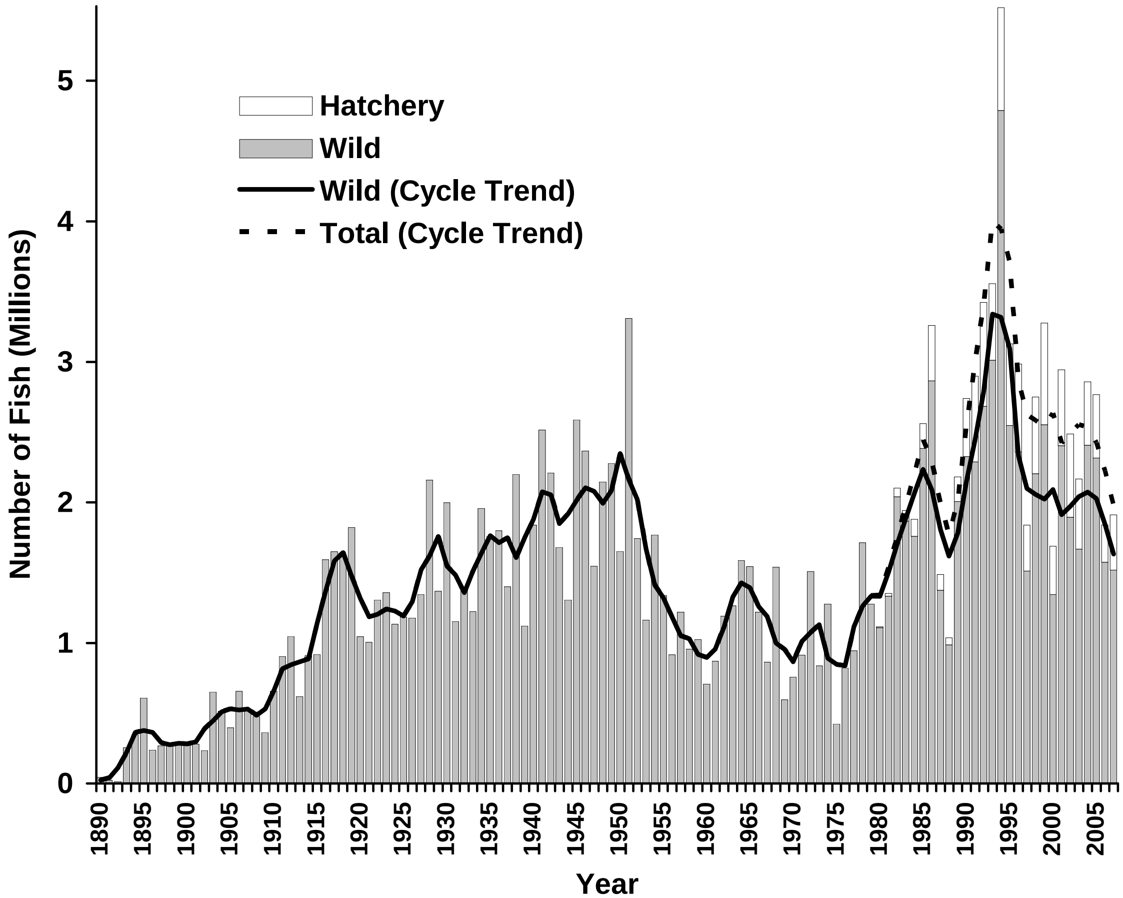

Figure 1.–Commercial harvest of wild and hatchery coho salmon in Southeast Alaska, 1890–2007.

and fishery parameters for indicator stocks (Shaul 1994; Shaul and Crabtree 1998). In addition, a systematic escapement survey program was developed. These programs have bettered the 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* from wild stocks. Hatchery contributions and natural production are identified inseason in key fisheries using 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 to 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, commercial trollers fish a relatively stable season and harvest a relatively stable proportion of the total run. This pattern of fishing 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

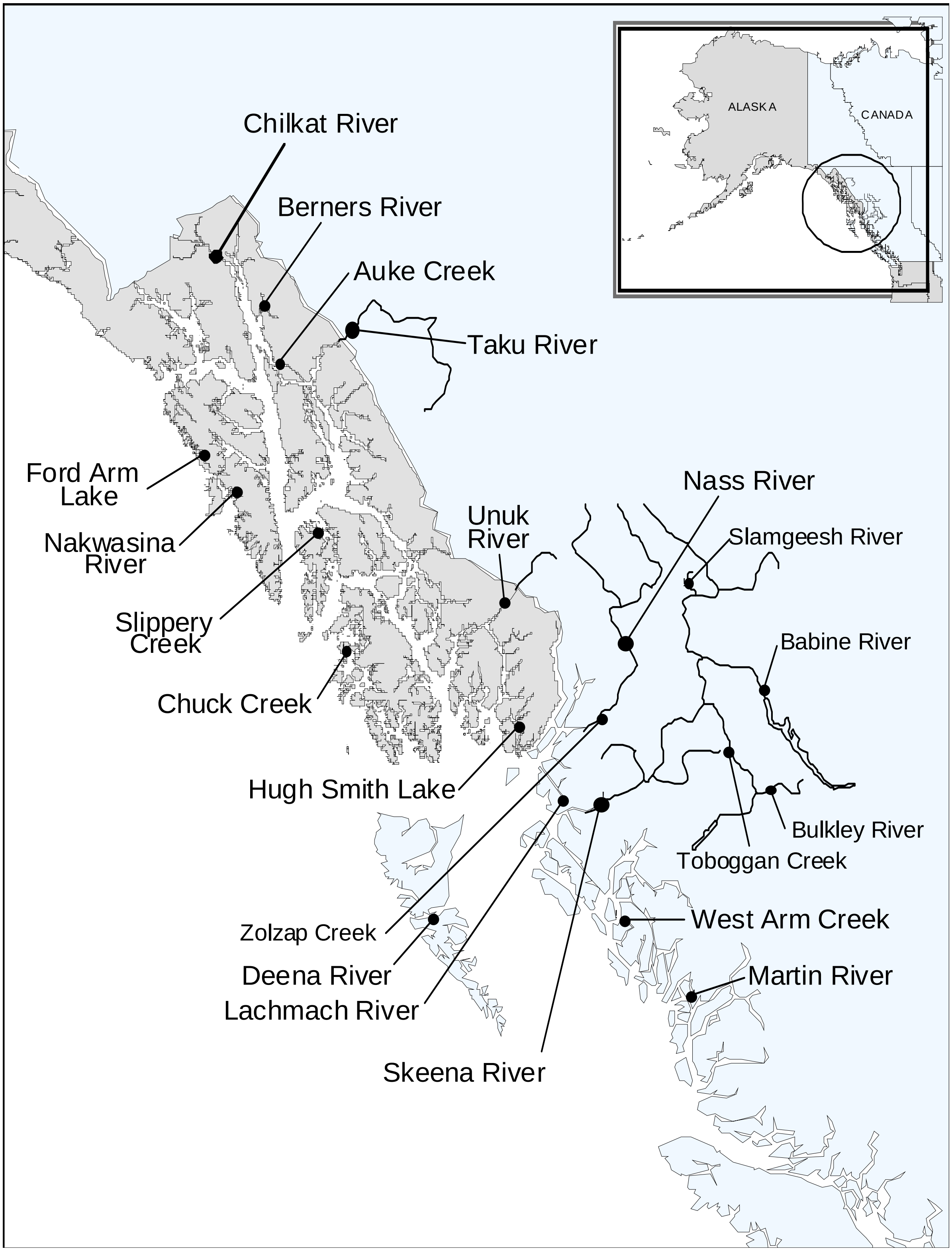

Figure 2.–Map of Southeast Alaska and northern British Columbia, showing the locations of coho salmon full indicator stock assessment projects.

fisheries while still maintaining 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 commercial troll and marine sport fisheries, with a small incidental harvest by purse seine fisheries targeting 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/or 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 *maximum sustained yield* as a specific priority objective.

In addition to provisions specified in the management plans, the Pacific Salmon Treaty contains provisions for the conservation of northern British Columbia coho stocks. The Pacific Salmon Treaty provisions are essentially the same as Board of Fisheries management plan provisions for potential early and midseason troll fishery closures. However, the Pacific Salmon Treaty 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 British Columbia stocks is indicated to be low based on fishery performance.

Marine sport fisheries are managed primarily under a 6-fish bag limit. The same bag limit applies in most freshwater systems, except for some more accessible streams where the bag limit is 2 fish. The sport fishery has accounted for a small, but increasing, component of the catch, reaching a peak estimated harvest of 409,300 fish in 2005 (Figure 3). Sport fisheries have accounted for an increasing share of the harvest since the mid–1970s and averaged 12% of the all-user regional harvest during 2003–2007. 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 1998–2007 subsistence and personal use harvest averaged only 2,080 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; however, it is practical and feasible to conduct stock assessment projects on only 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 pre-smolts 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.

These programs have been expanded in recent years and are now well established in eight 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 were expanded in the 1990s to include the Taku River, Nakwasina River, Chilkat River, Unuk River and Slippery Creek. The latter two

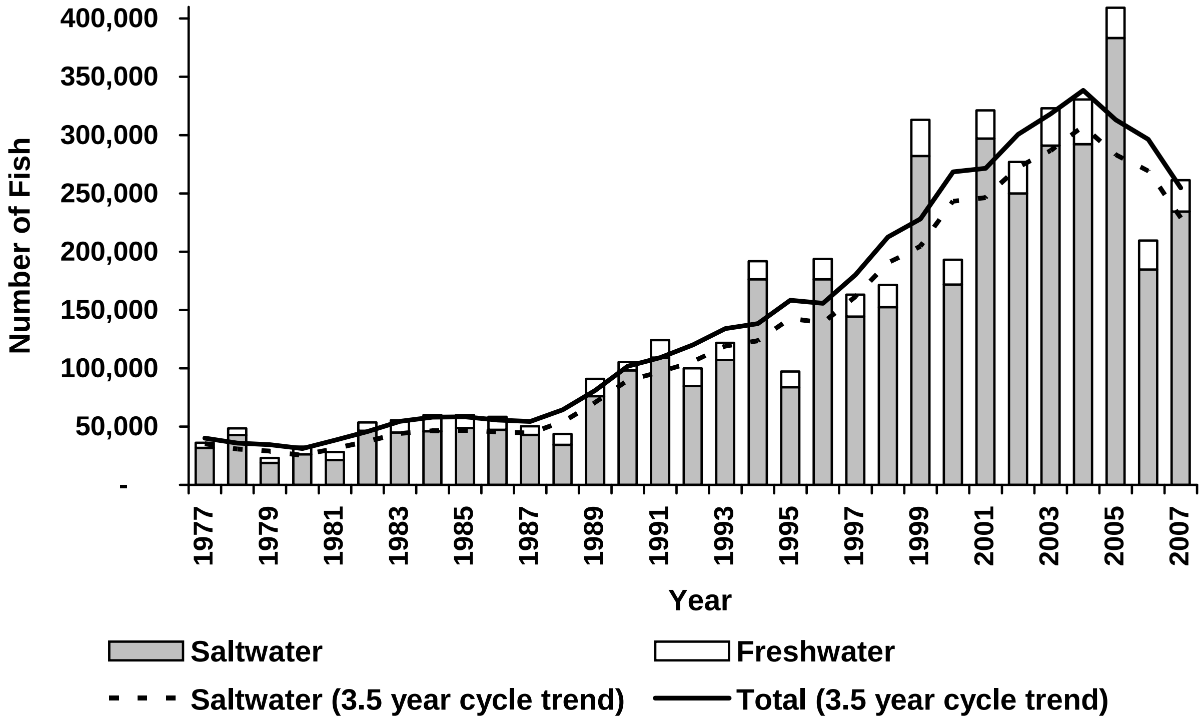

Figure 3.–Sport harvest in saltwater and freshwater of coho salmon in Southeast Alaska, 1977–2007.

projects were discontinued in 2003 and 2005, respectively. 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* (*BEG*s). Specific parameters that are estimated for these stocks include: total adult abundance, spawning escapement (including age, size, and sex), smolt production (abundance, age, and 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 produce *maximum 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 stock-recruit relationships (Clark et al. 1994). A *biological escapement goal* of 30,000–70,000 spawners was recently developed for the Chilkat River (Ericksen and Fleischman 2006). Also, for the Taku River a minimum inriver abundance goal of 38,000 spawners is specified in the 1999 Pacific Salmon Treaty. 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, Haines, 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 Montana and Peterson Creeks, which have individual goals (Clark 2005). In the Haines area, surveys are conducted on four tributaries of the

Chilkat River. These counts are expanded to total system escapement using an average expansion factor based on 5 years of paired counts and mark–recapture estimates. Ericksen and Fleischman (2006) developed a goal for the Chilkat River system. 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. *Biological escapement goal*s for the aggregate survey counts in the Ketchikan and Sitka areas were developed by Shaul and Tydingco (2006).

Only peak survey counts that met standards for timing, survey conditions, and completeness were included in the indices. 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).

NORTHERN INSIDE AREA STOCKS

Escapement to Auke Creek, a stream with a weir on the Juneau road system, has been consistently within or *above its BEG* since the early 1980s (Figure 4, Table 2). The goal for the largest surveyed Juneau roadside producer, Montana Creek, was increased from 200–500 spawners to 400–1,200 spawners, while the goal for Peterson Creek was changed from 100–350 spawners to 100–250 spawners by Clark (2005). Both were established as *sustainable escapement goals* (*SEG*s). Goals were eliminated for the other three Juneau roadside streams (Steep, Jordan and Switzer Creeks). The current goal for Peterson Creek has been met or exceeded annually since surveys were initiated in 1981, while the current goal for Montana Creek was not met in 7 years out of 24, including three recent years (2004, 2005, and 2007). These three stocks 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, Chilkat River in upper Lynn Canal, and the Taku River south of Juneau all had relatively strong escapements at or above goal during 1998–2006, with a peak in 2002 (Figure 4; Table 2). However, escapements in the Berners and Chilkat Rivers were below goal in 2007. All three of these systems have similar mainland valley rearing habitat, including wetlands, ponds, and sloughs, and their coho salmon runs are targeted by drift gillnet fisheries in addition to the troll fishery.

The Berners River is a compact system with concentrated high quality coho spawning and rearing habitat. Although a substantially smaller producer than the Taku and Chilkat Rivers, it is an important contributor to the fisheries in northern Southeast. Escapement counts in the Berners River peaked at 27,700 spawners in 2002, but declined to only 3,915 spawners in 2007.

The Taku River 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; Jones III et al. 2006). The inriver run past Canyon Island near the U.S./Canada boundary is estimated using a mark–recapture technique. Marking is done at research fish wheel sites in the Canyon while recovery sampling is done in test and Canadian commercial fisheries. Results of a 1991 radio-telemetry study indicated that the fish wheel estimate represented about 78% of the total system escapement with about 22% spawning in Alaskan waters below Canyon Island (Eiler et al. *In prep*).

Based on the 1999 Pacific Salmon Treaty agreement, the management intent of the U.S. is to ensure a minimum above-border inriver run of

Table 1.–Southeast Alaska coho salmon escapement estimates and index counts from 1980 to 2007.

Year	Auke Creek	Montana Creek	Peterson Creek	Berners River	Chilkat River	Taku River	Ford Arm Lake	Black River	Sitka Survey Index[a]	Hugh Smith Lake	Ketchikan Survey Index[b]	Chuck Creek
1980	698											
1981	646	227	219									
1982	447	545	320	7,505			2,662		1,545	2,144		1,017
1983	694	636	219	9,840			1,938		457	1,490		1,238
1984	651	581	189	2,825				425	2,063	1,408		
1985	942	810	276	6,169			2,324	1,628	1,246	903		956
1986	454	60	363	1,752			1,546	312	702	1,783		
1987	668	314	204	3,260	37,432	55,457	1,694	262	293	1,118	4,933	
1988	756	164	542	2,724	29,495	39,450	3,028	280	403	513	5,007	
1989	502	566	242	7,509	48,833	56,808	2,177	181	576	433	6,761	
1990	697	1,711	324	11,050	79,807	72,196	2,190	842	566	870	3,533	
1991	808	1,415	410	11,530	84,517	127,484	2,761	690	1,510	1,826	5,721	
1992	1,020	2,512	403	15,300	77,588	84,853	3,847	866	1,899	1,426	7,017	
1993	859	1,352	112	15,670	58,217	109,457	4,202	764	1,716	830	7,270	
1994	1,437	1,829	318	15,920	194,425	96,343	3,228	758	1,965	1,753	8,690	
1995	460	600	277	4,945	56,737	55,710	2,445	1,265	1,487	1,781	8,627	
1996	515	798	263	6,050	37,331	44,635	2,500	385	1,451	950	8,831	
1997	609	1,018	186	10,050	43,519	32,345	4,965	686	809	732	5,063	
1998	862	1,160	102	6,802	50,758	61,382	7,049	1,520	1,242	983	7,070	
1999	845	1,000	272	9,920	57,140	60,844	3,598	1,590	776	1,246	8,038	
2000	683	961	202	10,650	88,620	64,700	2,287	880	803	600	8,634	
2001	865	1,119	106	19,290	108,698	104,460	2,178	1,080	1,515	1,580	11,475	1,350
2002	1,176	2,448	195	27,700	205,429	219,360	7,109	1,194	1,868	3,291	12,223	2,189
2003	585	808	203	10,110	134,340	183,038	6,789	1,055	1,101	1,510	11,859	614
2004	416	364	284	14,450	67,465	132,405	3,539	380	1,124	840	9,904	606
2005	450	351	139	5,220	38,589	91,830	4,257	160	1,668	1,732	14,840	646
2006	582	1,110	439	5,470	80,683	140,028	4,737	1,100	2,647	891	6,912	409
2007	352	324	226	3,915	25,493	49,632	2,567	745	1,066	1,244	4,488	425
Goal Range												
Lower	200	400	100	4,000	30,000	35,000[c]	1,300		400	500	4,250	
Upper	500	1,200	250	9,200	70,000		2,900		800	1,600	8,500	

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

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

[c] For the Taku River stock of coho salmon, the management objective of the U.S. is to insure a minimum above-border run of 38,000 fish as specified in the Pacific Salmon Treaty. The listed figure of 35,000 fish, shown for comparison with spawning escapement estimates, reflects a probable Canadian catch above the border of up to 3,000 fish in non-coho directed fisheries when the total above-border run is 38,000 fish.

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 from 1981 to 2007.

	Juneau Roadside				Chilkat River		
Year	Auke Cr. (Weir)	Montana Creek	Peterson Creek	Berners River	Index Count	Expanded Estimate	Taku River
1981	646	227	219				
1982	447	545	320	7,505			
1983	694	636	219	9,840			
1984	651	581	189	2,825			
1985	942	810	276	6,169			
1986	454	60	363	1,752			
1987	668	314	204	3,260	1,113	37,432	55,457
1988	756	164	542	2,724	877	29,495	39,450
1989	502	566	242	7,509	1,452	48,833	56,808
1990	697	1,711	324	11,050	3,383	79,807[a]	72,196
1991	808	1,415	410	11,530	2,513	84,517	127,484
1992	1,020	2,512	403	15,300	2,307	77,588	84,853
1993	859	1,352	112	15,670	1,731	58,217	109,457
1994	1,437	1,829	318	15,920	5,781	194,425	96,343
1995	460	600	277	4,945	1,687	56,737	55,710
1996	511	798	263	6,050	1,110	37,331	44,635
1997	609	1,018	186	10,050	1,294	43,519	32,345
1998	862	1,160	102	6,802	1,460	50,758[a]	61,382
1999	845	1,000	272	9,920	1,699	57,140	60,844
2000	683	961	202	10,650	2,635	88,620	64,700
2001	842	1,119	106	19,290	3,232	108,698	104,460
2002	1,112	2,448	195	27,700	5,660	205,429[a]	219,360
2003	585	808	203	10,110	3,950	134,340[a]	183,038
2004	416	364	284	14,450	2,006	67,465	132,405
2005	450	351	139	5,220	977	38,589[a]	91,830
2006	582	1,110	439	5,470	2,399	80,683	140,028
2007	352	324	226	3,915	758	25,493	49,632
Average	700	918	261	9,447	2,287	76,434	89,639
Goals:							
Point	340			6,300	1,550	50,000	
Lower	200	400	100	4,000	950	30,000	38,000[b]
Upper	500	1,200	250	9,200	2,200	70,000	

[a] Mark–recapture estimates of Chilkat River escapement. Other estimates are expanded index counts.

[b] For the Taku River stock of coho salmon, the management objective of the U.S. is to insure a minimum above-border run of 38,000 fish as specified in the Pacific Salmon Treaty. The listed figure of 35,000 fish, shown for comparison with spawning escapement estimates, reflects a probable Canadian catch above the border of up to 3,000 fish in non-coho directed fisheries when the total above-border run is 38,000 fish.

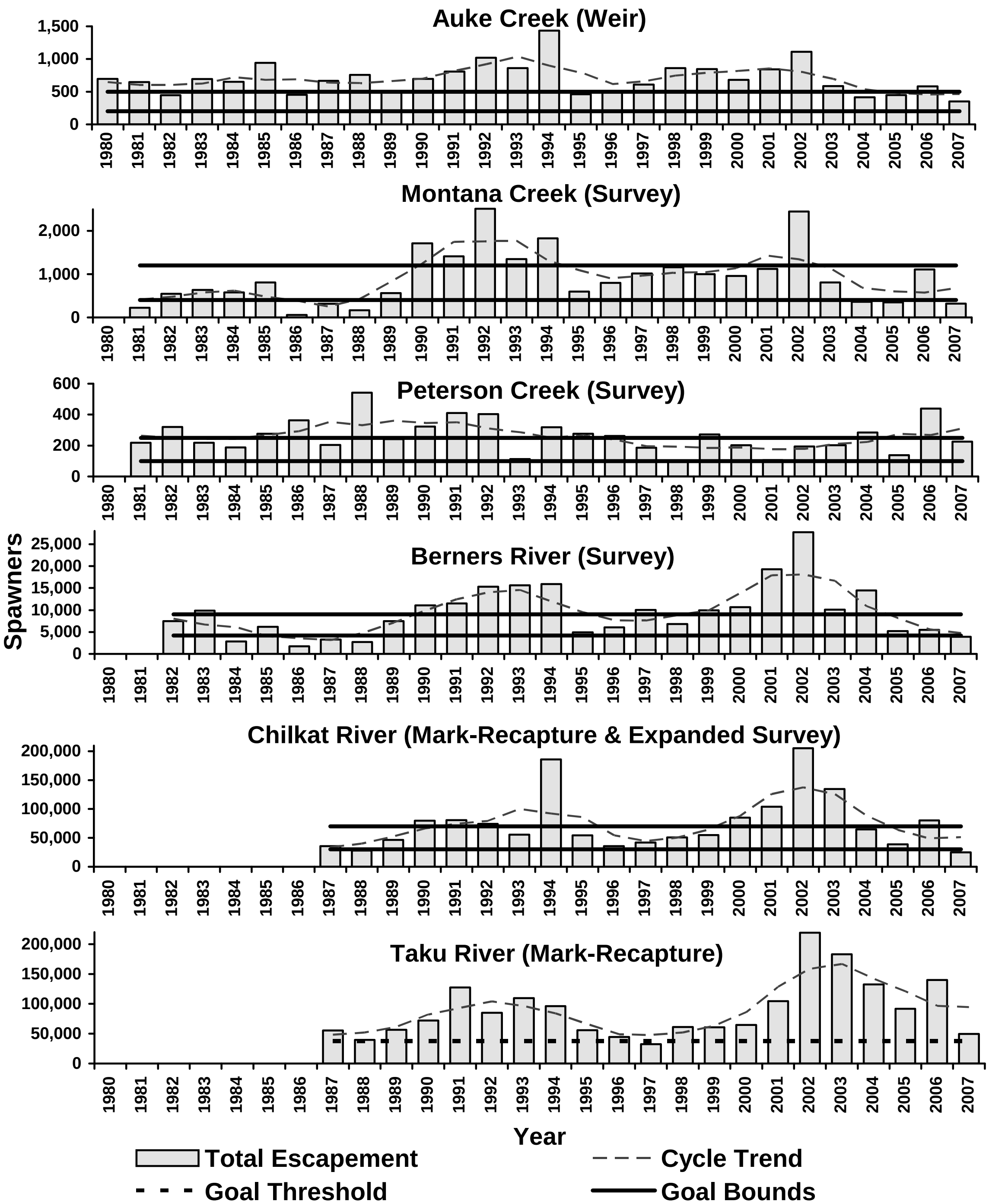

Figure 4.–Coho salmon escapement estimates and indices for streams in the Northern Inside area (Districts 111 and 115). Also shown are 3½-year moving average "cycle" trends and escapement goal ranges. The threshold of 35,000 shown for the Taku includes the inriver run threshold of 38,000 under the Pacific Salmon Treaty minus an allowance for a catch of 3,000 fish from inriver commercial, food, personal use, and test fisheries.

38,000 coho salmon with the following provisions: (1) no numerical limit on the Taku River coho salmon catch will apply in Canada during the directed sockeye salmon fishery (through Statistical Week 33); depending on inseason projections of above-border run size, directed Canadian harvests are: (2) 3,000 coho salmon for above-border runs less than 50,000, (3) 5,000 coho salmon for above-border runs between 50,000 and 60,000, (4) 7,500 coho salmon for above-border runs between 60,000 and 75,000, and (5) 10,000 coho salmon for above-border runs above 75,000. Further, the agreement reached within the Pacific Salmon Commission in May of 2008 specifies that the annual catch limits specified for the Canadian harvest of coho salmon in the Taku River may be exceeded provided that bilaterally agreed inseason run assessments indicate that salmon passage into Canada has exceeded or is projected to exceed the specified Canadian harvest limit, plus bilaterally agreed spawning requirements.

The inriver run estimate past Canyon Island has exceeded 38,000 spawners in all years except 1997 when the border passage estimate was only 35,035 fish, including an inriver catch of 2,690 fish. Thus, the escapement estimate was only 32,345 spawners (Table 2), 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 management goal despite increased fishing effort in the District 111 gillnet fishery, which targets the stock in late August and September. Following the poor 1997 return, Taku inriver run estimates have ranged well above the management threshold goal. The peak escapement estimate of 219,360 spawners occurred in 2002. In 2007, the escapement estimate of 49,632 spawners was the third lowest estimate in 21 years.

The Chilkat River has produced nearly as many returning coho salmon as the Taku River, on average. Mark–recapture estimates obtained in 5 years (1991, 1998, 2002, 2003, and 2005) were used to calibrate a standardized peak survey count in spawning areas. Escapement estimates peaked at 205,429 spawners in 2002 and met or exceeded the goal range of 30,000–70,000 spawners (Ericksen and Fleischman 2006) before declining to below goal at only 25,493 spawners in 2007 (Table 2).

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 (Tables 1 and 3; Figure 5). 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. The goal range of 1,300–2,900 spawners has been achieved in 13 years and exceeded in 12 years during the 25-year history of the project (Figure 5). The goal has been exceeded more often since 1992.

Escapement to Black River, located north of Ford Arm Lake, has been surveyed once annually by helicopter since 1984. Escapement survey counts in this system were relatively low during 1986 to 1989 (181 to 312 spawners), but increased to a range from 776 to 1,965 spawners during 1991–2003 and fluctuated widely from 160 to 1,100 spawners in 2005–2007.

The sum of peak escapement survey counts for five small streams near Sitka trended downward in the late 1980s, but increased sharply in the early 1990s (Tables 1 and 3; Figure 5). The counts declined again from 1997 to 2000 before increasing again and reaching a peak of 2,647 spawners in 2006. Shaul and Tydingco (2006) recommended a goal of 400–800 spawners for the aggregate count in the five streams based on an analysis that assumes productivity (smolts per spawner at *MSY*) for Sitka Sound stocks to be average for coho stocks that have been studied. Escapements above the current lower goal bound have been achieved in every year except one (1987), while escapements have exceeded the range in 9 of the 10 most recent years.

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 6). An escapement goal range of 500–1,100 spawners was established in 1994 (Clark et al. 1994) and was recently revised to 500–1,600 spawners (Shaul et al. *In Prep.-b*).

Table 3.–Peak counts of coho salmon in the Sitka escapement survey index (sum of five streams), mark–recapture estimates of the Nakwasina River escapement, a helicopter survey count of the Black River escapement, and a combination of weir counts and mark–recapture estimates of the Ford Arm Lake escapement[a].

Year	Starrigavan Creek	Sinitsin Creek	St. John's Creek	Nakwasina River	Eagle River	Sitka Survey Index	Nakwasina River M/R Estimate [b]	Black R. Survey Count	Ford Arm Lake Weir-M/R
1982	317	46	***116***	***580***	***486***	1,545			2,662
1983	45	31	20	217	***144***	457			1,938
1984	385	160	154	715	***649***	2,063		425	
1985	193	144	109	408	***392***	1,246		1,628	2,324
1986	57	***72***	***53***	275	245	702		312	1,546
1987	36	21	***22***	47	167	293		262	1,694
1988	45	56	71	104	***127***	403		280	3,028
1989	101	76	89	129	***181***	576		181	2,177
1990	39	80	38	195	214	566		842	2,190
1991	142	186	107	621	454	1,510		690	2,761
1992	241	265	110	654	629	1,899		866	3,847
1993	256	213	90	***644***	513	1,716		764	4,202
1994	304	313	227	404	717	1,965		758	3,228
1995	274	152	99	626	336	1,487		1,265	2,445
1996	59	150	201	553	488	1,451		385	2,500
1997	55	90	68	300	296	809		686	4,965
1998	123	109	57	653	300	1,242		1,520	7,049
1999	167	48	25	291	***245***	776		1,590	3,598
2000	144	62	30	459	108	803	2,000	880	2,287
2001	133	132	80	753	417	1,515	2,992	1,080	2,178
2002	227	169	100	713	659	1,868	3,141	1,194	7,109
2003	95	102	91	440	373	1,101	2,063	1,055	6,789
2004	143	112	79	399	391	1,124	3,867	380	3,539
2005	76	67	173	892	460	1,668	3,539	160	4,257
2006	386	152	121	996	992	2,647	5,698	1,100	4,737
2007	130	39	86	385	426	1,066	1,000	745	2,567
Avg.	161	117	93	479	400	1,250	3,038	794	3,425

[a] Total index is the sum of counts and interpolated values. Interpolated values are shown in shaded bold italic print.

[b] The Nakwasina River mark–recapture estimate for 2007 is preliminary.

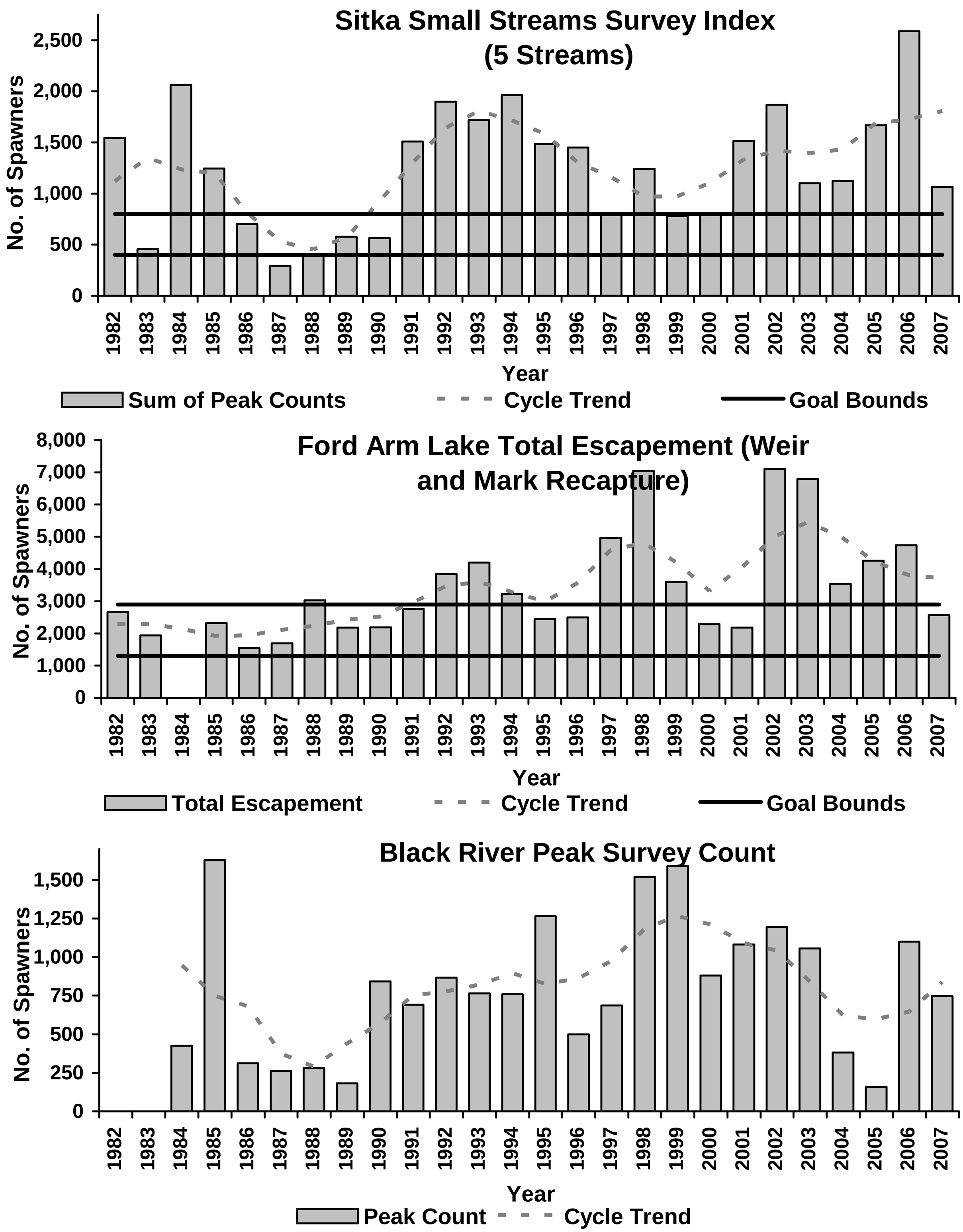

Figure 5.–Coho salmon escapement estimates and indices for streams in the Sitka area (District 113). Also shown are 3½-year moving average "cycle" trends and escapement goal bounds.

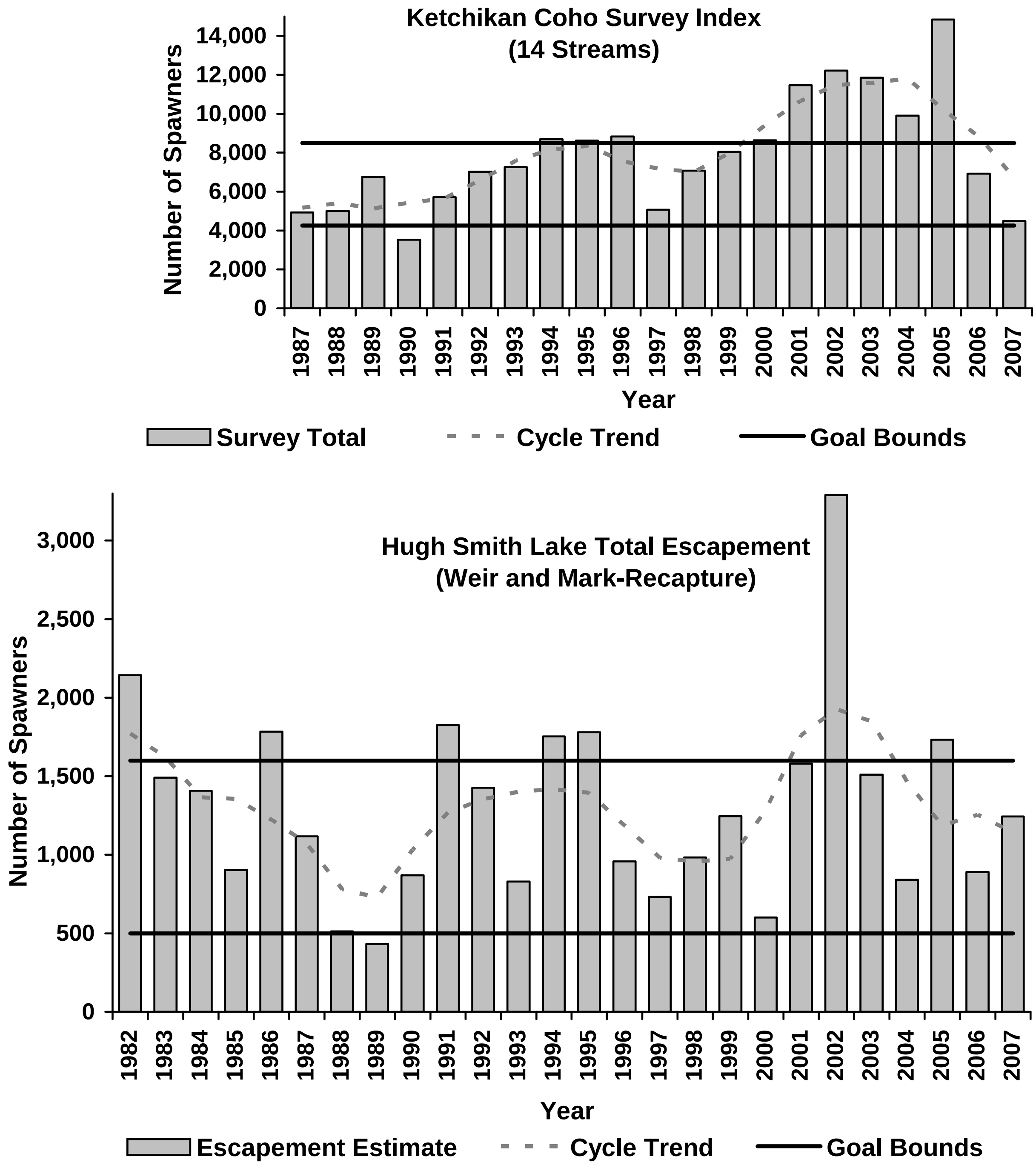

Figure 6.–Sum of peak coho salmon escapement survey counts for 14 streams in the Ketchikan area (top graph) and coho salmon escapement counts and estimates for Hugh Smith Lake (bottom graph). Also shown are 3 1/2 year "cycle" trends, the escapement goals for Hugh Smith Lake (500–1,600 spawners) and the combined peak counts for Ketchikan surveyed streams (4,250–8,500 spawners).

Table 4.–Peak coho salmon survey counts for 14 streams in the Ketchikan area and total adult coho salmon escapement to Hugh Smith Lake from 1987 to 2007. Combined survey count 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	Carroll River	Blossom River	Keta River	Marten River	Humpback Creek	Tombstone River	Combined Survey Count	Hugh Smith L. (Weir)
1987	92	***88***	154	***62***	***387***	***98***	***304***	***145***	180	700	800	740	650	532	4,933	1,118
1988	72	150	205	20	300	50	175	150	193	790	850	600	52	1,400	5,007	513
1989	75	101	290	15	925	450	510	200	70	1,000	650	1,175	350	950	6,761	433
1990	150	30	235	150	***282***	***72***	35	***105***	***139***	800	550	575	135	275	3,533	870
1991	245	50	285	50	550	100	300	220	375	725	800	575	671	775	5,721	1,826
1992	115	270	860	90	675	100	250	150	360	650	627	1,285	550	1,035	7,017	1,426
1993	90	175	460	50	475	325	110	300	310	850	725	1,525	600	1,275	7,270	830
1994	265	220	755	200	560	175	325	225	475	775	1,100	2,205	560	850	8,690	1,753
1995	250	94	435	165	600	220	415	180	400	800	1,155	1,385	82	2,446	8,627	1,781
1996	94	92	383	40	570	230	457	220	240	829	1,506	1,924	440	1,806	8,831	958
1997	75	***85***	420	60	***371***	***94***	***292***	175	140	1,143	571	759	32	847	5,063	732
1998	94	130	460	120	304	50	411	190	***255***	1,004	1,169	1,961	256	666	7,070	983
1999	75	127	657	150	356	25	627	225	425	598	1,895	1,518	520	840	8,038	1,246
2000	135	94	600	110	380	72	620	180	275	1,354	1,619	1,421	102	1,672	8,634	600
2001	80	110	929	151	1,140	***212***	891	450	173	1,561	***1,612***	1,956	506	***1,704***	11,475	1,580
2002	88	138	1,105	20	940	70	700	220	270	1,359	1,368	2,302	2,004	1,639	12,223	3,291
2003	242	***197***	875	39	690	57	1,140	380	***427***	1,940	1,934	1,980	214	1,745	11,859	1,510
2004	150	230	801	170	935	250	640	180	455	1,005	1,200	1,835	1,230	823	9,904	840
2005	510	300	1,240	360	890	190	810	270	500	3,680	3,290	1,130	500	1,170	14,840	1,732
2006	165	***124***	190	176	280	30	405	130	***272***	2,300	645	335	260	1,600	6,912	891
2007	134	***75***	***298***	35	245	15	290	210	***171***	990	970	351	3	***701***	4,489	1,244
Avg.	152	137	554	106	565	137	462	215	291	1,183	1,192	1,311	463	1,179	7,947	1,246

Over the past 26 years, escapements have been below the new goal range only once (1989) and above it 7 times.

The Ketchikan area survey index of peak helicopter counts for 14 streams has followed a generally upward trend from 1987 to the early to mid-2000s before declining to numbers well below the long-term average in 2006 and 2007 (Tables 1 and 4; Figure 6). A goal range of 4,250 to 8,500 spawners was established in 2006 based on the recommendation of Shaul and Tydingco (2006). During 1987–2007, escapements have fallen short of the proposed range once, within the range 11 times, and above the range 9 times.

Chuck Creek on the southern outside coast was recently added as a full indicator stock (McCurdy 2005 and *in prep*). Three total escapement counts for Chuck Creek from the early to mid–1980s (Shaul et al. 1991) ranged from 956 to 1,238 spawners. Although weir counts totaling 1,350 spawners in 2001 and 2,189 spawners in 2002 were similar to the earlier counts, escapements have since declined to only 409 spawners in 2006 and 425 spawners in 2007 (Table 1). Productivity of Chuck Creek for coho salmon may have been affected by heavy logging activity in the drainage during the 1970s and 1980s, followed by rapid re-growth.

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 7 stocks in this area (Clark and Clark 1994), but comparable peak escapement surveys have been conducted relatively consistently in recent years on only 3 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 is the case in other areas of the Southeast Region. Most aerial and foot surveys on these systems have been conducted early in the run to support inseason management of the set gillnet fisheries. Mark–recapture experiments were conducted from 2004 to 2006 to estimate escapement of Situk River coho salmon (Waltemyer et al. 2005, Eggers and Tracy 2007, (Shaul et al. *In Prep.-a*) and conducted in the Lost River in 2003 and 2004 (Clark et al. 2005 and 2006) in hopes of providing a calibration of the index counts. Mark–recapture estimates were not consistent with index counts and as a result, meaningful expansion factors could not be estimated (Table 5). Index counts were substantially lower than total escapement in all years (Table 5) and accounted for minor and variable portions of the total escapements.

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 from 1995 to 2000, but has improved during 2001–2007. Escapement goals have been attained in most years, although combined counts for the three systems were well below average during 2005–2007 (Table 5; Figure 7).

SMOLT PRODUCTION

Smolt production estimates are available for 10 years or more for four 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.

Shaul et al. (2005) noted a long-term linear decline in Auke Creek smolt production of about 1.5% per year or 38.4% (2,956 smolts) during 1980–2004 based on a robust trend (Geiger and Zhang 2002). Recent counts of 4,287–4,549 smolts in 2005–2007 rebounded from the record lows of 3,616–3,695 smolts in 2003–2004 but remained far below the 1980s average of 7,323 smolts (Table 6). The decline in Auke Creek smolt production does not appear to be related to reduced escapement levels, as brood year escapements remained relatively level during the decline and escapements have remained within or above goal (Figure 4, Table 1).

The estimated number of smolts migrating from the Berners River has recently declined from 133,629–326,312 (average 198,398) smolts during 1990–2005 to only 124,070 smolts in 2006 and 115,845 smolts in 2007 (Table 6). The recent decrease in smolt production, in combination with

Table 5.–Yakutat area coho salmon peak escapement survey counts from 1972 to 2007 and available total escapement estimates.

	Lost River		Situk River		Tsiu River	Total
Year	Count	Mark–Recap.	Count	Mark–Recap.	Count	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				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				30,000	41,616
1996	4,030				19,000	29,361
1997	2,550		9,780		22,000	34,330
1998					12,000	18,116
1999						
2000	1,572				12,000	17,303
2001	3,190		5,030		17,000	25,220
2002	8,093		40,000		31,000	79,093
2003	6,396	23,685	6,814		35,850	39,127
2004	5,047	47,566	10,284	49,582		45,410
2005	1,241		2,514	33,644	16,600	20,355
2006	3,500		7,900	23,169	14,500	25,900
2007	2,542		5,763		14,000	22,305
Average	4,411	35,625	8,041	35,465	23,886	35,636
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).

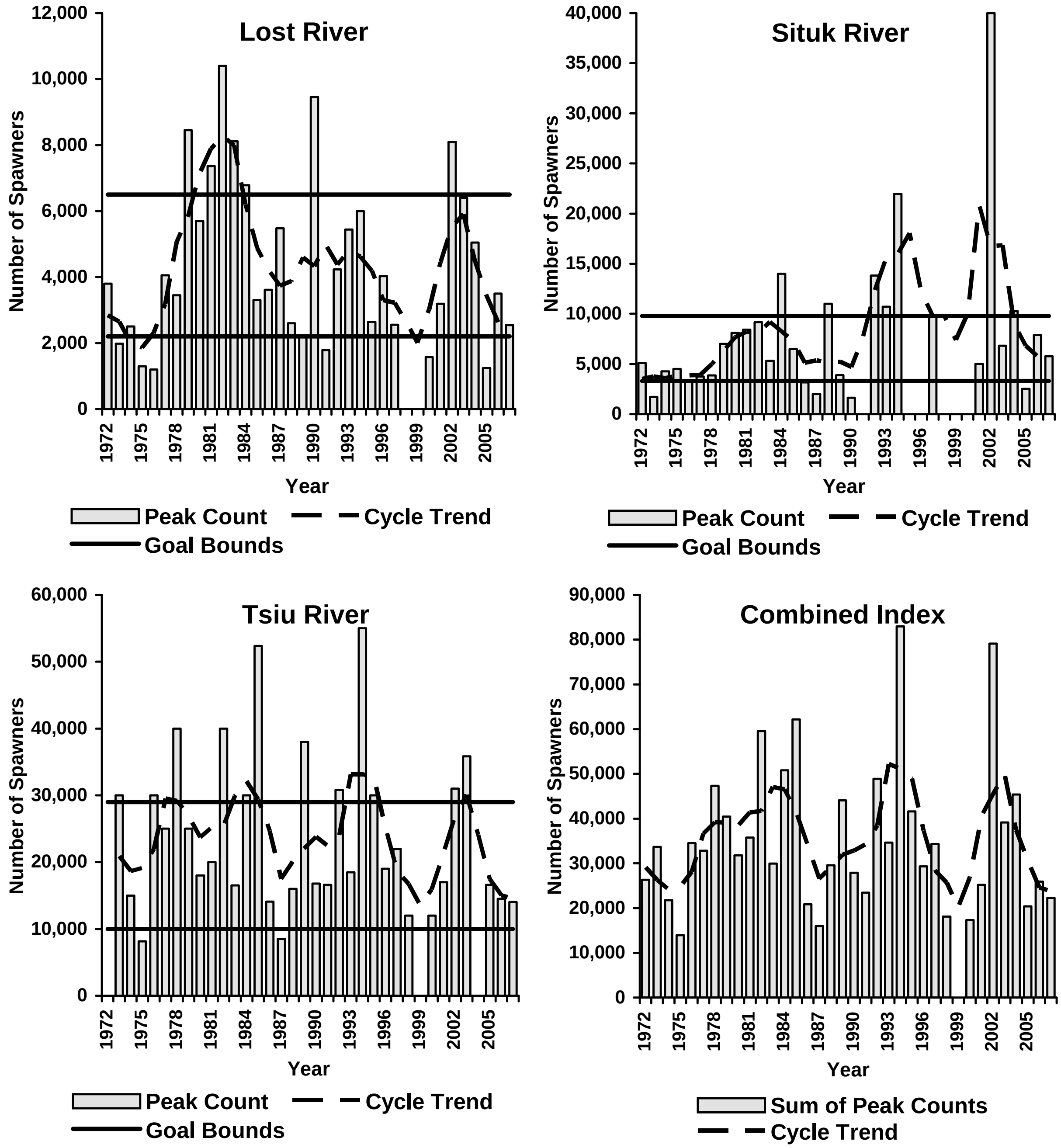

Figure 7.–Peak coho salmon escapement survey counts for 3 systems in the Yakutat area and the combined count for all 3 systems from 1972 to 2007. Also shown are 3½-year moving average "cycle" trends and escapement goal ranges. The total index includes interpolations for systems without counts in all years except 1999 (see Escapement Indicators section for a description of the method used).

lower marine survival rates, has resulted in a dramatic decrease in adult returns.

Flow from the Berners River valley is restricted by bed load deposited from the neighboring Lace River against the base of Loin's Head Mountain near the confluence of the two streams. The result is classic wetland habitat that absorbs and retains water from precipitation events and releases it gradually over a period of days. With greater precipitation, more of the valley is inundated for a longer period so that available habitat and access to it by rearing juveniles increases. A significant ($p<0.01$) positive relationship was noted between summer–fall precipitation at the Juneau airport and the estimated Berners River smolt migration the following spring for the 1989–2002 smolt years (Figure 8). However, smolt production estimates for 2003–2005 all fell 11–28% below the prediction based on the 1989–2002 relationship, while the 2006 smolt migration was 62% below the prediction. Therefore, the recent decline in smolt production appears not to be explained by a decrease in precipitation. No significant physical changes in habitat have been observed during the period that would likely explain the decrease to date.

Production associated with the 2000–2007 adult returns to the Chilkat River averaged 1.56 million smolts and peaked at nearly 3 million smolts in 2002. Smolt production was under 1 million fish in 2005 and 2007.

In contrast to Berners and Chilkat River production, smolt estimates for the Taku River above Canyon Island have increased in recent years and peaked at 3.14 million smolts for the 2007 adult return. Smolt production from the Taku River was low during 1996–1998 with estimates of 0.8–1.0 million annually but has increased to about 2–3 million annually starting in 2002 (Table 6). Estimates for the Taku River since 1992 have averaged 1.77 million smolts. The reason for the recent upward trend in estimates is unclear. However, beginning in 2000, Jones et al. (2006) found that use of the simple Chapman's estimate employed in earlier years produced smolt estimates that were biased low (~12% over five years) due to size selectivity in

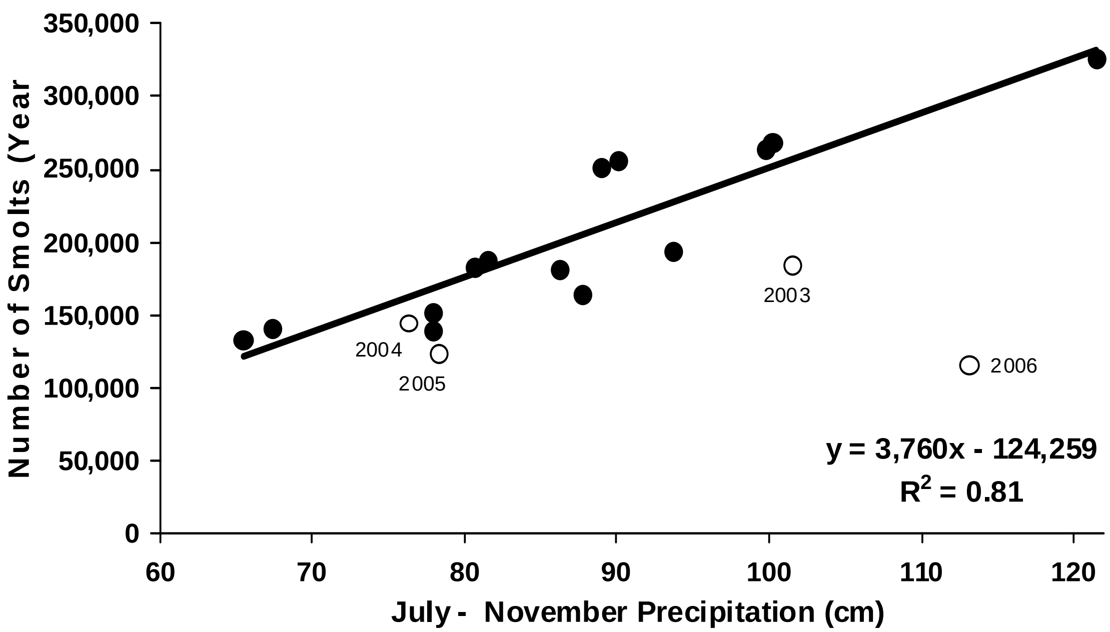

Figure 8.–Linear relationship between July–November Juneau Airport precipitation and Berners River coho salmon smolt production the following spring for the 1989–2002 smolt years (filled dots) compared with observations for the 2003–2006 smolt years (open dots).

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, 1980–2007.

Return Year	Auke Creek Smolts	Berners River Smolts	Chilkat River Smolts[a]	Taku River Smolts	Ford Arm Lake Pre-smolts	Hugh Smith Lake Smolts	Chuck Creek Smolts	Nakwasina River Smolts[a]	Situk 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	163,998			55,803	26,620			
1991	5,137	141,291			56,284	32,925			
1992	5,690	187,688		1,080,551	61,724	23,326			
1993	6,596	326,312		1,510,032	57,401	32,853			1,197,290
1994	8,647	255,519		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			
1999	7,420	252,168		1,184,195	132,607	29,830		102,794	
2000	5,233	183,023	1,237,056	1,387,399	62,444	19,902		47,571	
2001	4,969	268,777	1,185,804	1,720,387	106,409	23,346		46,575	
2002	5,980	264,599	2,970,458	2,292,949	101,860	36,497		43,630	
2003	3,616	151,980	1,696,212	2,988,349	77,081	26,897	12,487	22,472	
2004	3,695	185,125	1,938,322	2,941,525	101,579	23,074	29,302	55,424	
2005	4,549	144,778	776,934	1,969,608	124,492	40,033	17,507	47,573	1,057,275
2006	4,287	124,070	1,807,837	2,540,250	98,470	28,153	10,306	64,164	847,305
2007	4,515	115,845	875,478	3,138,853	84,017	37,311	15,604	37,785	
Avg.	6,178	189,682	1,561,013	1,772,201	80,460	31,663	17,041	51,999	1,033,957

[a] Estimates for the Chilkat and Nakwasina Rivers in 2007 are preliminary.

smolt tagging. Stratified estimates that account for this bias were employed beginning in 2002. Shaul et al. (2005) noted an upward trend in pre-smolt production in the Ford Arm Lake system and speculated that it may have resulted from increased carcass nutrient input. Estimated mid-summer pre-smolt abundance in the Ford Arm Lake system trended upward from an average of 62,000 pre-smolts for returns in the 1980s to 82,100 in the 1990s, and 94,500 from 2000 to 2007.

Smolt production from Hugh Smith Lake has shown no evident long-term trend different from the long-term average. Production averaged about 31,700 smolts during 1984–2007 (Table 6).

Estimates of smolt production from the Situk River are available for the 1993 return (Ericksen and McPherson 1997) and the 2005 and 2006 returns (Shaul et al. *In Prep.-a*).The lowest estimate of 847,305 smolts for the 2006 return may have been affected by a very dry summer in 2004 that likely restricted available rearing habitat. The estimate of 1,197,290 smolts associated with the 1993 return was the highest of the three estimates. Decreased surface flow and flooded rearing area in streams and sloughs around the Situk-Ahrnklin Lagoon has been observed over the past three decades (Gordie Woods, Fishery Management Technician, ADF&G, Commercial Fisheries Division, Yakutat; personal communication). This process, an apparent effect of glacial rebounding, may reduce future smolt production from rivers in the area.

MARINE SURVIVAL

Marine survival rates for indicator stocks increased in the early 1980s and reached a peak in the early to mid-1990s before declining to more

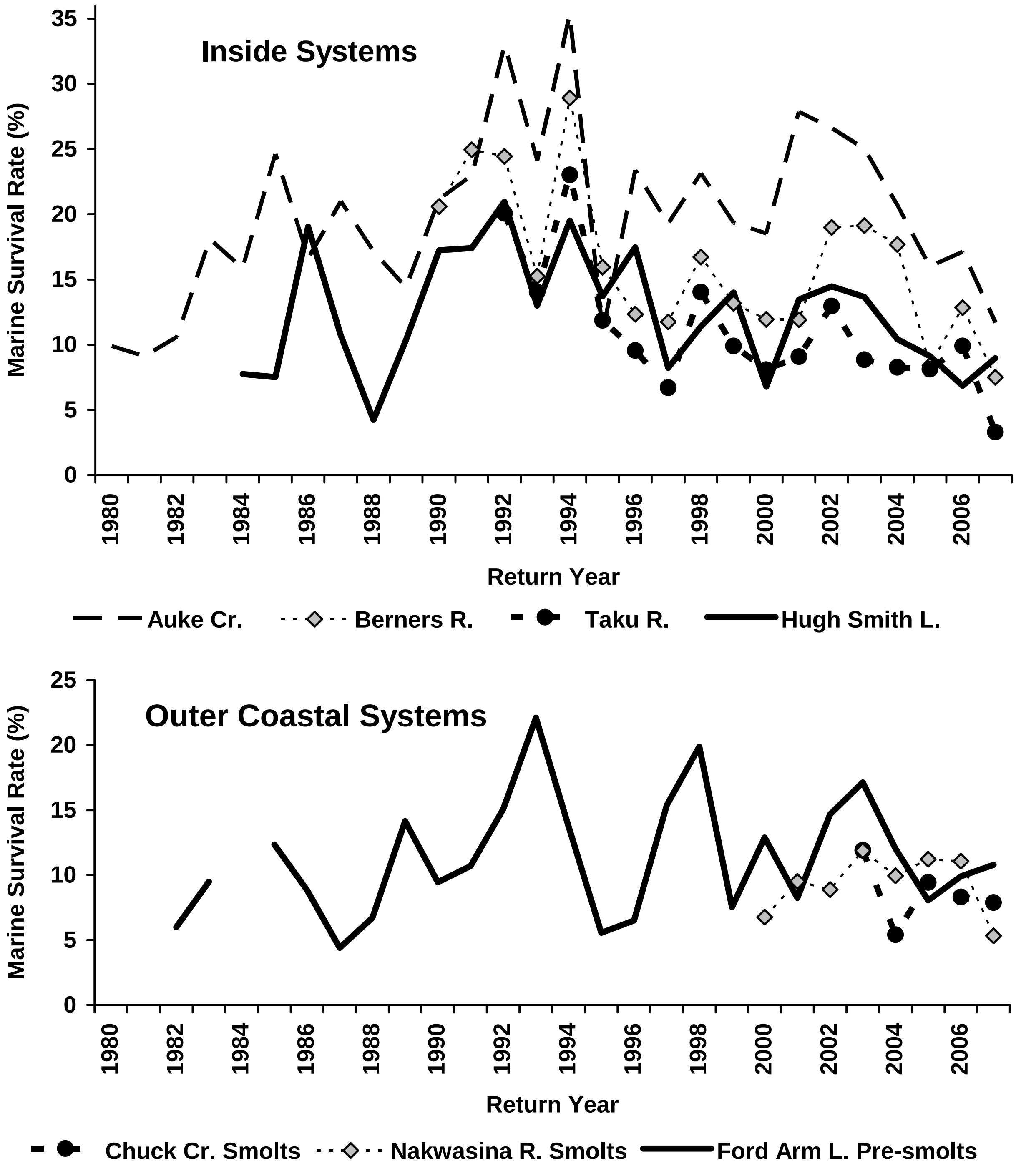

Figure 9.–Estimated marine survival rate for wild coho salmon smolts from four systems in inside areas of Southeast Alaska (upper graph) and smolts from two systems and presmolts from one system on the outer coast of Southeast Alaska (lower graph), 1980–2007. The estimates for Ford Arm Lake pre-smolts include approximately 10 months of mortality from July to May.

Table 7.–Estimated survival rate (percent) of coho salmon smolts and pre-smolts from 8 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	Chuck Creek Smolts	Nakwasina River Smolts	Chilkat River Smolts	Situk 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			12.4	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			14.2	10.4				
1990	21.1	20.6		9.5	17.3				
1991	23.0	24.9		10.7	17.4				
1992	33.0	24.4	20.1	15.1	21.0				
1993	24.1	15.3	14.0	22.1	13.0				
1994	35.3	28.9	23.0	13.7	19.5				
1995	10.9	15.9	11.9	5.6	13.7				
1996	23.4	12.3	9.6	6.5	17.5				
1997	19.2	11.8	6.7	15.4	8.2				
1998	23.1	16.7	14.0	19.9	11.4				
1999	19.3	13.2	9.9	7.5	14.0				
2000	18.5	12.0	8.1	12.9	6.8		6.8	10.5	
2001	27.9	11.9	9.1	8.2	13.5		9.5	13.2	
2002	26.6	19.0	13.0	14.7	14.5		8.9	11.5	
2003	25.0	19.1	8.8	17.1	13.7	11.9	11.9	12.9	
2004	20.7	17.7	8.3	12.0	10.4	5.4	9.9	10.0	
2005	16.0	8.4	8.1	8.1	9.1	9.4	11.2	8.9	5.4
2006	17.1	12.8	9.9	9.9	6.9	8.3	11.1	8.2	4.9
2007	11.7	7.5	3.3	10.8	9.0	7.9	5.3	5.5	
Avg.	19.8	16.2	11.1	11.3	12.3	8.6	9.3	10.1	5.2

moderate levels from 1995 to 2004 (Table 7; Figure 9). During 2005–2007, survival rates for most systems have been below the long-term average. Estimated marine survival rates for 2007 returns to the Berners, Taku, and Chilkat Rivers in the northern inside area were the lowest on record for each system at 7.5%, 3.3%, and 5.5%, respectively. During 2005–2007, the survival rate for Hugh Smith Lake smolts was consistently below 10% and well below the 1984–2004 average of 13%.

Survival of Ford Arm Lake pre-smolts exhibited a relatively high average of 11.1% (range 4.4–22.1%) over a 25-year period despite exposure to approximately 10 months of freshwater morality after tagging, but before entering the marine environment. Survival of the Ford Arm stock improved from an average of 9% during 1982–1989 to 13% in the 1990s before decreasing slightly to about 12%, on average, during 2000–2007.

Marine survival associated with the 2005 and 2006 returns to the Situk River near Yakutat was estimated at 5.4% and 4.9%, respectively. Those estimates were about half of the average of 10.2% (range 6.9–17.1%) for comparable estimates for eight indicator stocks in Southeast Alaska.

TOTAL STOCK ABUNDANCE

Total return abundance, 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 8–14, and for longer-term indicators in Figures 10 and 11.

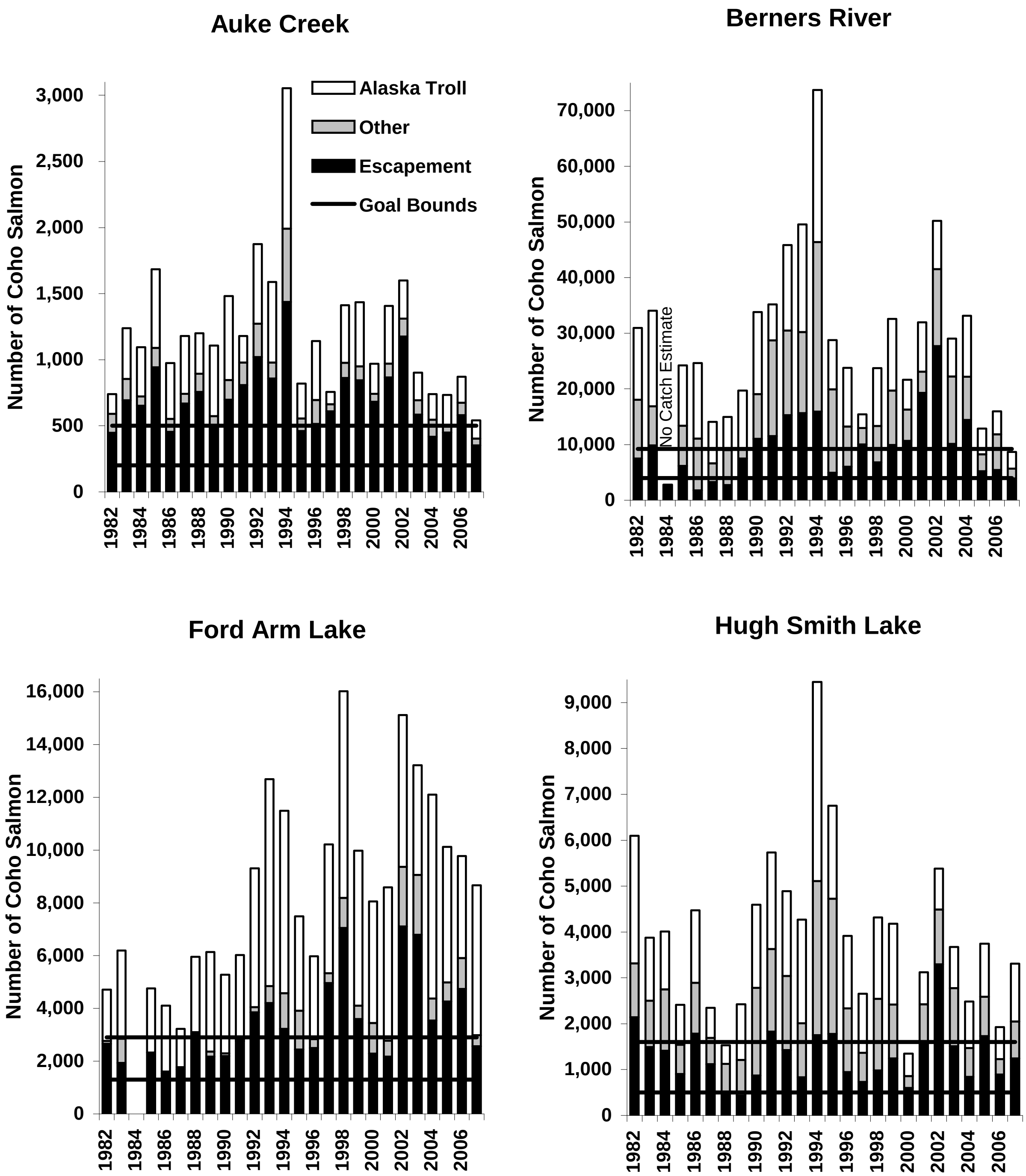

Figure 10.–Total run size, catch, escapement and biological escapement goal range for 4 wild Southeast Alaska coho salmon indicator stocks from 1982 to 2007.

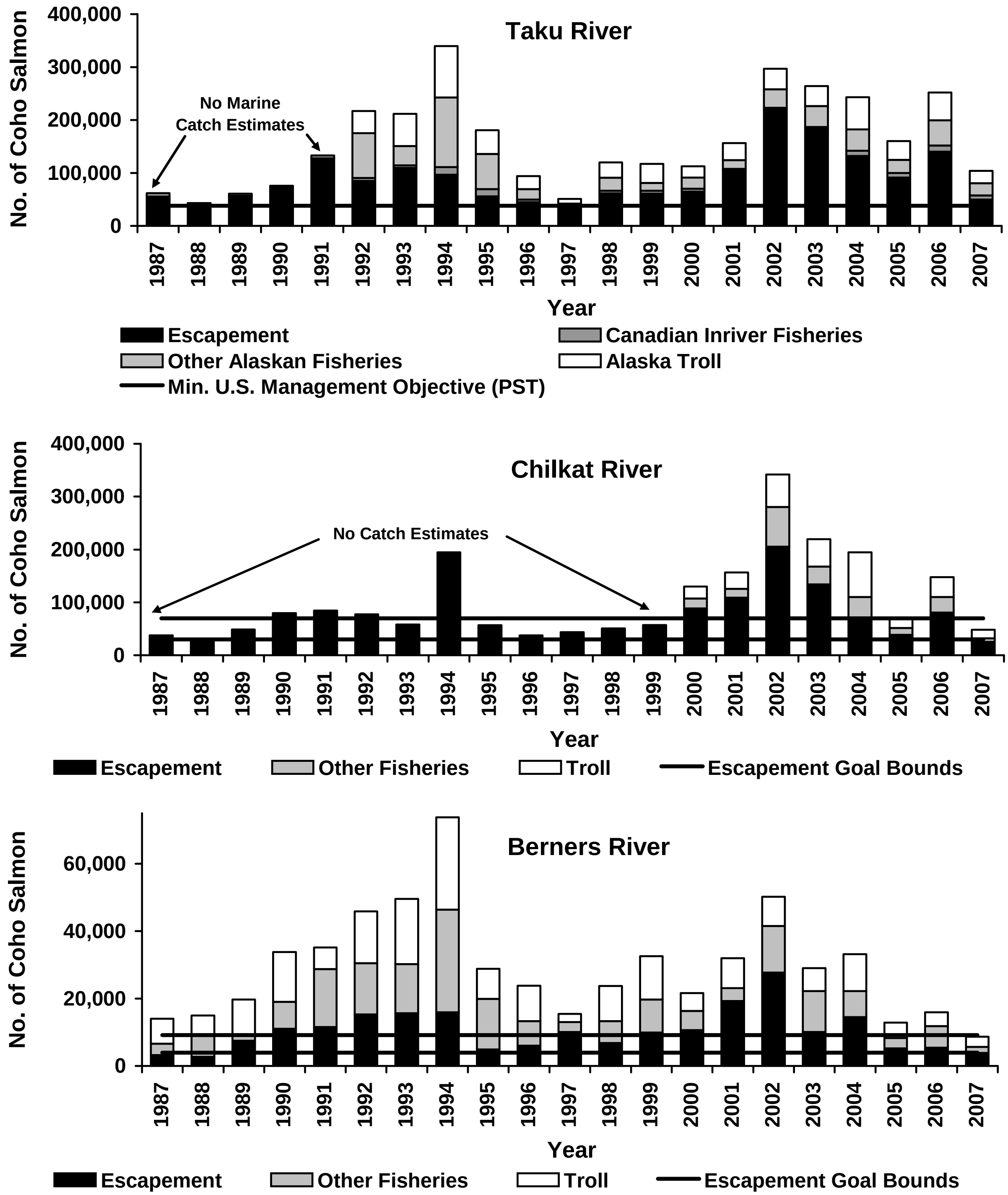

Figure 11.–Total estimated run size, catch, and escapement of coho salmon bound for the Taku River (above Canyon Island) and the Chilkat and Berners Rivers, 1987–2007.

Table 8.–Estimated harvest by gear type, escapement, and total run of coho salmon returning to Auke Creek from 1980 to 2007.

		Number of Fish						
Year	Fishery Sample Size	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	1,020	1,875
1993	169	611	8	92	19	730	859	1,589
1994	330	1,064	224	218	112	1,618	1,437	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	1,176	1,600
2003	97	211	4	59	45	319	585	904
2004	62	199	47	71	15	332	416	748
2005	66	240	0	6	31	277	450	727
2006	80	196	0	77	17	290	582	872
2007	47	137	6	30	15	188	352	540
Average		370	20	64	42	496	703	1,199

The three longest studied indicator stocks in inside areas of Southeast show similar patterns in abundance since the early 1980s. The Auke Creek, Berners River, Taku 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 10; Tables 8, 9 and 11) that coincided with a similar peak in the commercial catch of wild coho salmon (Figure 1). A second lower peak occurred in 2002 that, in combination with low exploitation rates, resulted in very large escapements in those systems. However, combined low smolt production and marine survival in 2007 resulted in record low returns to Auke Creek and the Berners and Chilkat Rivers while the return to Hugh Smith Lake was below average. The estimated 2007 return to the Taku River above Canyon Island of about 103,700 fish was the smallest return since 1997 (Figure 11; Table 12).

Shaul et al. (2005) noted that the Ford Arm Lake stock on the outer coast has followed an upward trend in total return that was best described by a 5.2% exponential rate of increase in total adult run size, leading to a tripling of abundance from 1982 to 2004. The increase in total run size resulted from increases in both pre-smolt production and survival from the pre-smolt to adult life stages. However, while remaining consistently higher than 1982–1991 returns, total returns decreased slightly each year after 2002 (Figure 10; Table 10).

Return estimates for other indicator stocks, including Nakwasina River and Chuck Creek (Table 14), are too limited to infer trends. Total

Table 9.–Estimated harvest by gear type, escapement and total run of coho salmon returning to the Berners River from 1982 to 2007.

		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	471	14,851	141	7,352	369	0	0	22,713	11,050	33,763
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	748	8,854	195	3,499	123	0	0	12,671	19,290	31,961
2002	788	8,671	228	13,014	471	0	0	22,384	27,700	50,084
2003	1,326	6,866	247	11,302	455	0	0	18,870	10,110	28,980
2004	756	10,941	92	7,376	278	0	0	18,687	14,450	33,137
2005	400	4,701	163	2,546	175	0	0	7,585	5,220	12,805
2006	701	4,100	0	6,341	97	0	0	10,537	5,470	16,007
2007	296	2,992	34	1,659	82	0	0	4,767	3,915	8,682
Average		10,370	230	8,605	218	0	0	19,423	9,447	29,136

returns to the Nakwasina River have varied widely during the 2000–2007 period of estimates, ranging from 2,667 adults in 2003 to 7,106 adults in 2006.

Recent estimated Chuck Creek returns of 857–1,650 (average 1,361) adults during 2003–2007 were far smaller than 1982–1985 returns averaging 3,000 (range 2,407–3,837) adults. However, escapement counts of 1,350 in 2001 and 2,189 in 2002 suggest total returns were strong in those years.

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 and subsistence harvests as well.

Exploitation rates were low for most systems in 2002 and 2003 because of market and cost pressures on the fisheries. However, that pattern appeared to be reversed by 2004 (Figures 12 and 13; Tables 15–21) in apparent response to improved prices, particularly in the troll fishery.

The Auke Creek stock has been exploited at a relatively low average rate of 40% (range 20% to 55%) during 1980 to 2007, owing mainly to lack of 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 30% (range 12% to 48%) with less than 5% each

Table 10.–Estimated harvest by gear type, escapement, and total run of coho salmon returning to Ford Lake from 1982 to 2007.

		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	5,818	115	0	480	0	6,412	2,178	8,590
2002	246	5,751	1,260	0	998	0	8,009	7,109	15,118
2003	225	4,154	504	0	1,770	0	6,428	6,789	13,217
2004	153	7,722	523	0	319	0	8,564	3,539	12,103
2005	81	5,134	60	0	672	0	5,866	4,257	10,123
2006	137	3,869	367	0	803	0	5,039	4,737	9,776
2007	188	5,673	217	6	202	0	6,098	2,567	8,665
Average		4,503	375	2	304	1	5,184	3,425	8,609

attributed to seine, gillnet, and sport fisheries. During 2005–2007, total exploitation rate estimates for this stock were slightly below the long-term average, ranging from 33–38% (Table 15). The troll fishery exploitation rate during those years ranged from 23% to 33%.

During 2004–2007, total exploitation rate estimates for the Berners River stock ranged from 55% to 66% and averaged 59%. The troll fishery has been the largest harvester of that stock, on average. However, the drift gillnet fishery has also accounted for a substantial portion of the run, particularly in years like 2006 when the run was heavily harvested in Berners Bay (Figures 12 and 13; Table 16).

Exploitation rate estimates for the Taku River run during 1992–2007 ranged from 43–52% (average 47%; Table 19). Trollers accounted for 22% of the run, on average, while drift gillnetters accounted for 15%. The drift gillnet exploitation rate ranged from 15% to 35% during 1992–1998 (except for 1997 when the District 111 gillnet fishery was closed early) and declined to only 6–9% in 1999–2002 before increasing again to 16–17% in 2006 and 2007. Seine, marine sport, and Canadian inriver fisheries have accounted for an average of 2%, 4%, and 4% of the run, respectively.

Troll fishery exploitation rate estimates for the Chilkat River stock during 2000–2007 averaged higher than estimates for the Taku River (26% compared with 20%), but displayed a similar pattern with the highest estimate in 2004 (Table 20). Chilkat River fish were also exploited more heavily by the drift gillnet fishery, on average, at rates ranging from 9–20% (average 14%) during

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

2000–2007 compared with 11% (range 7–17%) for the Taku run. Total exploitation rate estimates for the Chilkat River increased sharply from 32–40% in 2000–2003 to 67% in 2004 before decreasing again to 44–47% in 2005–2007.

The Ford Arm Lake stock has been harvested at moderate to high exploitation rates, primarily in the regional troll fishery, which is most intensive in waters near this system. The exploitation rate by the troll fishery has averaged 53% since 1982 (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%. The stock forages in coastal waters throughout the summer and is, therefore, substantially more available to intensive hook-and-line fisheries in the vicinity of Sitka and Pelican compared with more migratory stocks like the nearby Nakwasina River. The Ford Arm stock has become one of the most heavily fished stocks by the expanding sport charter fishery with recent exploitation rate estimates ranging as high as 13% in 2003. The Khaz Bay seine fishery also harvests a substantial fraction (up to 20%) of the stock in some years.

In contrast to higher exploitation rates on the Ford Arm stock, the Nakwasina River stock in Sitka Sound was exploited at an average estimated rate of 31% (range 19–50%) by all fisheries since 2000 (Table 21). The troll fishery accounted for most of the catch with an average exploitation rate of 26% while the marine sport and purse seine fisheries followed with about 4% and 1%, respectively. The Nakwasina River stock is later and more migratory compared with the Ford Arm Lake stock (Shaul et al. 2005).

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. From 1982 to 1988,

Table 12.–Estimated catch and escapement of coho salmon bound for the Taku River above Canyon Island from 1987 to 2007.

		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	221	21,090	1,577	9,935	9,552	5,447	47,601	64,700	112,301
2001	344	31,992	2,066	11,378	3,278	3,099	51,813	104,460	156,272
2002	397	39,012	3,457	24,481	7,076	3,802	77,828	219,360	297,188
2003	195	38,081	3,812	28,953	6,665	3,717	81,228	183,038	264,266
2004	223	60,622	5,256	29,286	5,924	9,804	110,892	132,153	243,045
2005	90	35,552	3,154	17,898	3,560	8,392	68,556	91,552	160,108
2006	319	52,299	653	40,180	6,898	11,803	111,833	140,022	251,855
2007	150	22,982	3,759	17,316	2,048	8,012	54,117	49,632	103,749
1992–2007 Average		40,327	4,004	29,728	5,859	6,943	86,861	95,655	182,517
1987–2007 Average		-	-	-	-	6,400	-	89,613	-

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 to 1999 at an average rate of 76% (range 68% to 82%) before decreasing sharply to 39-66% (average 55%) in 2000–2007. The decrease was spread across all commercial fisheries, with exploitation of the stock by sport fisheries increasing in both Alaska and British Columbia. Following a period of dramatic fishery curtailment beginning in 1998, fisheries in British Columbia began to exploit the Hugh Smith Lake stock again beginning in 2001 at an average combined rate of about 4%, which was about half of the pre-1998 average of about 8%.

The Chuck Creek stock on the southern outside coast was exploited at an average rate of 60% (range 52–65%) in 2003–2007 compared with 62% (range 49–75%) in 1982, 1983, and 1985 (Table 21). Most of the harvest of Chuck Creek coho salmon is taken in the troll and seine fisheries, although recent development of the sport charter fishery has resulted in significant sport exploitation rates averaging about 4% during 2003–2007.

CORRELATION AMONG INDICATORS

The large number and broad distribution of coho salmon-producing streams in the region necessitates that management be evaluated based on selected "indicator stocks" that represent the overall aggregate of stocks available to the fisheries. Active abundance-based management of mixed-stock fisheries is more effective if the stocks they harvest are closely correlated in run size. On average, smolt production and marine

Table 13.–Estimated harvest by gear type, escapement and total run of coho salmon returning to the Chilkat River, 1987–2007.

		Number of Fish								
Year	Fishery Sample Size	Troll	Seine	Drift Gillnet	Marine Sport	FW Sport	Subsistence	Total Catch	Escapement	Total Run
1987									37,432	
1988									29,495	
1989									48,833	
1990									79,807	
1991									84,517	
1992									77,588	
1993									58,217	
1994									194,425	
1995									56,737	
1996									37,331	
1997									43,519	
1998									50,758	
1999									57,140	
2000	265	22,201	835	15,786	1,246	819	199	41,086	88,620	129,706
2001	250	30,629	673	13,436	719	2,132	126	47,716	108,698	156,414
2002	325	61,829	812	66,541	3,166	3,722	574	136,644	205,429	342,073
2003	424	51,778	1,268	26,587	2,079	2,881	498	85,091	134,340	219,431
2004	252	84,282	1,131	35,873	2,176	3,062	455	126,979	67,465	194,444
2005	141	17,646	325	10,597	495	1,368	335	30,765	38,589	69,354
2006	200	37,300	83	26,102	1,054	2,027	355	66,922	80,683	147,604
2007	73	16,460	0	5,601	0	540	107	22,708	25,493	48,201
2000–2007 Avg		40,266	641	25,065	1,367	2,069	331	69,739	93,665	163,403

survival have been of nearly equal importance in their contribution to variation in adult returns. Shaul et al. (2007) found that, on average, 46% of variation in adult abundance for 12 coho salmon stocks from Washington State to Southeast Alaska was attributed to smolt production while 54% was attributed to marine survival. Those percentages were the same for the four Southeast Alaska stocks included in the analysis as for stocks from other regions.

We examined relationships between indicator stocks for smolt production, marine survival and total return. Squared linear correlation coefficients (R^2) between indicator stocks are shown in Tables 22 and 23. Significant relationships ($p<0.05$) are shown in bold while those that were highly significant ($p<0.01$) are both shaded and bold.

Correlations among systems for smolt abundance were relatively weak (overall average $R^2 = 0.15$) with average R^2 values for individual stocks compared with all other stocks ranging from 0.06 (Hugh Smith Lake) to 0.24 (Chuck Creek). Statistically significant correlations ($p<0.05$) occurred in only three pairs (Auke Creek and Berners River; Auke Creek and Hugh Smith Lake; and Auke Creek and Nakwasina River). Correlations in smolt abundance were not particularly strong for the first two pairs with R^2 values of only 0.27 and 0.18, respectively, but were significant because of the relatively large number of observations (18 years and 24 years, respectively). No pairs of systems had R^2 values over 0.50 for smolt abundance.

Average correlations were somewhat stronger for survival (Table 22), with an average R^2 value for all paired systems of 0.28. Average R^2 values for individual stocks compared with all other stocks ranged from 0.11 (Ford Arm Lake) to 0.40 (Chilkat River). When Ford Arm Lake pre-smolts were excluded, R^2 values for marine survival ranged from 0.16 (Nakwasina River) to 0.40 (Hugh Smith Lake) and averaged 0.31. Overall, inside stocks were more strongly correlated in

Table 14.–Estimated harvest by gear type, escapement and total run of coho salmon returning to the Nakwasina River and Chuck Creek from 1982 to 2007.

		Number of Fish								
Year	Fishery Sample Size	Alaska Troll	Alaska Seine	Alaska Sport	B.C. Troll	B.C. Net	B.C. Sport	Total Catch	Escapement	Total Return
Nakwasina River										
2000	33	1,089	70	60				1,219	2,000	3,219
2001	93	1,178	39	222				1,439	2,992	4,431
2002	48	598	0	133				731	3,141	3,872
2003	47	489	0	115				604	2,063	2,667
2004	97	1,381	63	200				1,644	3,867	5,511
2005	75	1,642	16	138				1,796	3,539	5,335
2006	74	1,125	0	283				1,408	5,698	7,106
2007	65	912	34	66				1,012	1,000	2,012
Average		1,052	28	152				1,232	3,038	4,269
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	
2003	192	539	252	83				874	614	1,488
2004	203	725	179	76				980	606	1,586
2005	160	652	232	120				1,004	646	1,650
2006	84	401	32	8	7			448	409	857
2007	140	584	126	30	10	5	45	805	425	1,230
Average		835	354	63	9	5		1,237	945	1,976

survival with other stocks, while stocks on the outer coast (Ford Arm Lake, Nakwasina River, Chuck Creek) were weakly correlated with other systems, including other outer coastal systems. Correlations were much stronger among inside stocks with average R^2 values for individual stocks ranging from 0.48 for Hugh Smith Lake to 0.58 for the Taku River (average 0.55). Correlations were all highly significant ($p<0.01$) among the four inside stocks with 16 or more years of observations. Correlations among the four northern inside systems (Chilkat, Berners, Auke, and Taku) had mean–average R^2 values of 0.59 (range 0.56–0.65). Correlations in marine survival between Hugh Smith Lake located southeast of Ketchikan and the four northern inside stocks were all highly significant, with R^2 values averaging 0.48, and were strongest with the Berners River (R^2 = 0.57) and the Taku River (R^2 = 0.56) over periods of 16 years and 18 years, respectively.

For total run size, R^2 values averaged 0.28 for all paired stocks, the same as for marine survival alone. Again, inside stocks were most strongly correlated. R^2 values for correlations among the five inside systems averaged 0.49 with the Berners River being most strongly correlated with the other four inside systems (average R^2 = .65). The only pair of inside stocks that were not significantly correlated were Hugh Smith Lake and the Chilkat River (R^2 = 0.28; n = 8). However, the correlation between the Taku River and Auke Creek was similarly weak, although significant (R^2 = 0.28; $p<0.05$) over a period of 16 years. Although marine survival was strongly correlated between those systems, recent smolt estimates have trended lower at Auke Creek and higher for the Taku River (Table 6). The strongest correlation in total run size was between the Berners and Chilkat Rivers, both located in Lynn Canal (R^2 = 0.89; n = 8).

Among the three outer coastal stocks, total run size was significant at $p<0.05$ only between Ford Arm Lake and Chuck Creek (R^2 = 0.58; n = 5). Interestingly, there was no correlation (R^2 = 0.00) in total return estimates over 8 years for Ford Arm

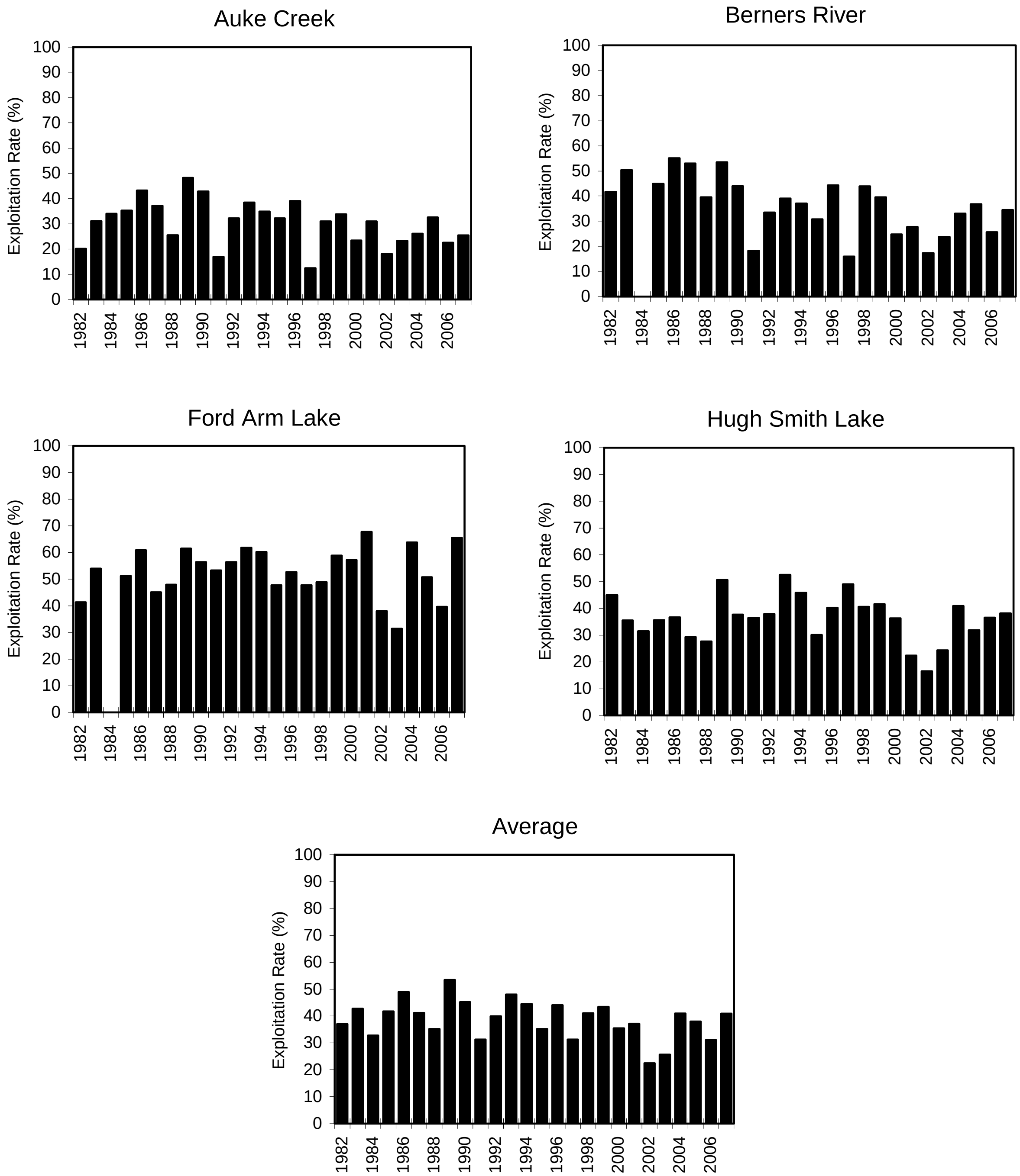

Figure 12.–Estimated exploitation rates by the Alaskan troll fishery for 4 coded wire tagged Southeast Alaska coho stocks from 1982 to 2007.

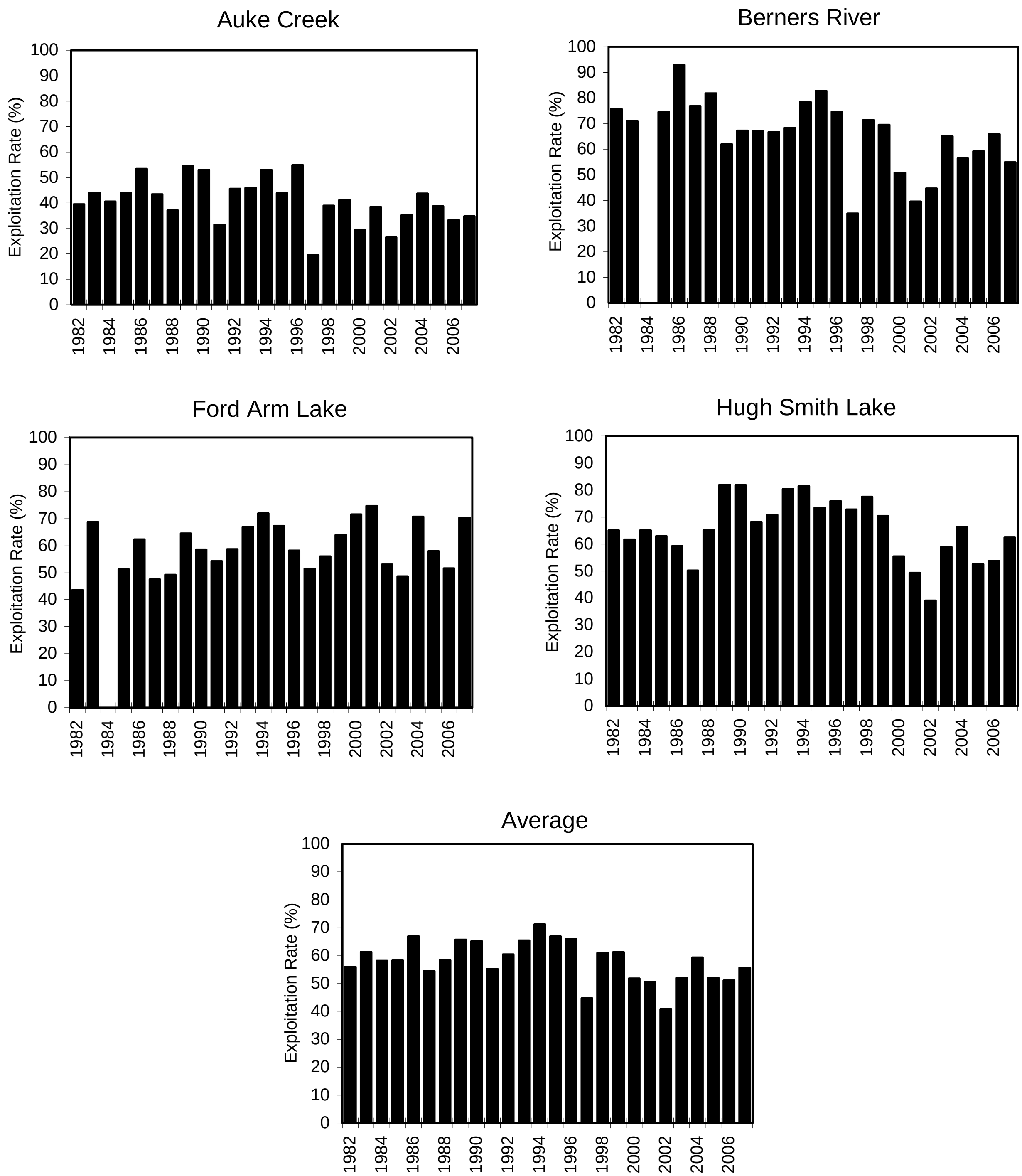

Figure 13.–Estimated total exploitation rates by all fisheries for 4 coded wire tagged Southeast Alaska coho stocks from 1982 to 2007.

Table 15.–Estimated percent harvest by gear type, escapement, and total run of coho salmon returning to Auke Creek from 1980 to 2007.

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
2003	97	23.3	0.4	6.5	5.0	35.3	64.7	100.0
2004	62	26.6	6.3	9.5	2.0	44.4	55.6	100.0
2005	66	33.0	0.0	0.8	4.3	38.1	61.9	100.0
2006	80	22.5	0.0	8.8	1.9	33.3	66.7	100.0
2007	47	25.0	1.1	5.6	2.6	34.3	65.7	100.0
Average		29.8	1.5	5.1	3.5	39.9	60.1	100.0

Lake and the Nakwasina River, located only 50 km apart on the outer coast north of Sitka. The absence of any relationship between those systems appears attributed to uncorrelated survival (R^2 = 0.00) rather than smolt or pre-smolt production (R^2 = 0.42). The survival rate for Nakwasina River smolts averaged only 9.3% for 2000–2007 returns (Table 22), compared with 11.7% for Ford Arm pre-smolts that faced 10 additional months of freshwater residence before migrating to sea. The low average survival rate for Nakwasina River smolts and poor correlation with Ford Arm Lake pre-smolt survival may be related to the consistently small average size of Nakwasina River smolts that had a mean-average fork length during 2000–2004 of only 80 mm (Tydingco 2003, 2005a, 2005b, 2006).

Correlations between indicator stock run size and two measures of aggregate wild coho salmon abundance were also examined. The first measure of aggregate abundance was the wild catch which consisted of the total all-gear commercial catch minus the estimated contribution by hatchery releases. The second was a measure of total abundance of wild coho salmon available to the troll fishery arrived at 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 Auke Creek, Ford Arm Lake and Hugh Smith Lake. 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

Table 16.–Estimated percent harvest by gear type, escapement and total run of coho salmon returning to the Berners River from 1982 to 2007.

		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	471	44.0	0.4	21.8	1.1	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	748	27.7	0.6	10.9	0.4	0.0	0.0	39.6	60.4	100.0
2002	788	17.3	0.5	26.0	0.9	0.0	0.0	44.7	55.3	100.0
2003	1,326	23.7	0.9	39.0	1.6	0.0	0.0	65.1	34.9	100.0
2004	756	33.0	0.3	22.3	0.8	0.0	0.0	56.4	43.6	100.0
2005	400	36.7	1.3	19.9	1.4	0.0	0.0	59.2	40.8	100.0
2006	701	25.6	0.0	39.6	0.6	0.0	0.0	65.8	34.2	100.0
2007	296	34.5	0.4	19.1	0.9	0.0	0.0	54.9	45.1	100.0
Average		36.3	0.7	28.3	0.7	0.0	0.0	66.1	33.9	100.0

because it has had a substantially higher average troll exploitation rate compared with most stocks that have been studied in the region.

Correlations with both aggregate measures (wild catch and wild abundance) were strongest for the Berners River and Hugh Smith Lake with R^2 values ranging from 0.54 to 0.60 ($p<0.01$; Table 23). Correlations with the Auke Creek return were also very significant ($p<0.01$) for both variables. The Taku River run was significantly correlated with the aggregate wild abundance estimate at the $p<0.05$ level. However, the remaining four indicator stocks were not significantly correlated with either aggregate measure (catch or abundance). The weakest correlations with estimated aggregate wild abundance were found for the Chuck Creek and Ford Arm Lake stocks (R^2 = 0.02 and 0.12, respectively).

ESCAPEMENT GOAL DEVELOPMENT

Biological escapement goals were established for the 4 long-term indicator stocks in 1994 using Ricker analysis (Clark et al. 1994). Using the same technique, Clark (1995) developed goals for the 5 surveyed roadside streams in the Juneau area while Clark and Clark (1994) developed escapement goals for 7 streams in the Yakutat area. These goal ranges were 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*.

Revision of these goals has been delayed by discovery of substantial errors in determining freshwater age. Aging validation studies were

Table 17.–Estimated percent harvest by gear type, escapement, and total run of coho salmon returning to Ford Arm Lake from 1982 to 2007.

		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	67.7	1.3	0.0	5.6	0.0	74.6	25.4	100.0
2002	246	38.0	8.3	0.0	6.6	0.0	53.0	47.0	100.0
2003	225	31.4	3.8	0.0	13.4	0.0	48.6	51.4	100.0
2004	153	63.8	4.3	0.0	2.6	0.0	70.8	29.2	100.0
2005	81	50.7	0.6	0.0	6.6	0.0	57.9	42.1	100.0
2006	137	39.6	3.8	0.0	8.2	0.0	51.5	48.5	100.0
2007	188	65.5	2.5	0.1	2.3	0.0	70.4	29.6	100.0
Average		52.8	4.1	0.0	2.7	0.0	59.7	40.3	100.0

initiated for the Berners River and Hugh Smith Lake populations in 1996. The results have been used to re-age the historical scale collections and updating of goals is underway using more accurate ages and different stock-recruit models (i.e., Beverton-Holt and Logistic Hockey Stick) that appear more appropriate to the species than the Ricker model.

The 1999 Pacific Salmon Treaty specifies a minimum objective for the number of coho salmon passing above Canyon Island in the Taku River. The current above-border minimum goal of 38,000 adults effectively translates to an effective sustainable escapement goal of about 35,000 spawners after projected minimal harvests in commercial, food, and test fisheries from an above-border run of that size. The Transboundary Technical Committee of the Pacific Salmon Commission is currently developing a revised escapement goal for Taku River coho salmon.

In the meantime, goals have been developed for other systems, including the Chilkat River (Ericksen and Fleischman 2006), aggregates of streams that are surveyed in the Ketchikan and Sitka areas (Shaul and Tydingco 2006), and Hugh Smith Lake (Shaul et al. *In Prep.-b*). In addition, Clark (2005) revised goals for two Juneau roadside streams (Montana and Peterson Creeks) and recommended elimination of goals for the other three streams (Steep, Jordan, and Switzer Creeks).

Overall, 14 systems or groups of systems have goals, including 10 with *BEG*s, 3 with *SEG*s, and one (Taku River) with a *management threshold* (Appendix A1).

Table 18.–Estimated harvest by gear type, escapement and total run of coho salmon returning to Hugh Smith Lake from 1982 to 2007.

		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	45.0	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	38.1	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

HUGH SMITH LAKE

The *biological escapement goal* for the Hugh Smith Lake stock was recently revised. Shaul et al. (*In Prep.-b*) recommended that the current goal for Hugh Smith Lake be revised from 770 (range 500–1,100) spawners to 850 (range 500–1,600 spawners) based on 23 years of brood year escapements and associated smolt production estimates multiplied by average marine survival. Total production shows an overall positive relationship with escapement over the range of observations and is best fit with a Beverton-Holt model (Figure 14). The model predicts that 90% or more of *MSY* can be achieved over a relatively broad range of escapements from 417 to 1,566 spawners. The goal range was rounded up to 500–1,600 spawners, with the lower bound maintained at 500 spawners because the production response from low escapement levels is poorly defined by the range of observations and because a logistic hockey stick model fit suggests that the lower 90% of *MSY* bound should be about 593 spawners.

CHILKAT RIVER

Ericksen and Fleischman (2006) developed a *biological escapement goal* for the Chilkat River stock based on peak survey counts over an 18-year period in standardized locations within the drainage (Table 2; Figure 4). They expanded historical index counts based on companion mark–recapture estimates of escapement to the entire Chilkat drainage in 4 years (1990, 1998, 2002, and 2003). A goal range of 950–2,200 spawners with a point goal of 1,550 spawners was proposed for the sum of index counts. The recommended target for total system escapement estimates is 30,000 to 70,000 spawners, with a point goal of 50,000 spawners.

Table 19.–Estimated percent of harvest by gear type, escapement, and total run of coho salmon returning to the Taku River above Canyon Island from 1992 to 2007.

Year	Fishery Sample Size	Troll	Seine	Gillnet	Marine Sport	Canadian Inriver	Total Catch	Escapement	Total Return
		Percent of Total Run							
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	17.3	1.1	2.9	9.8	5.3	36.4	63.6	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	221	18.8	1.4	8.8	8.5	4.9	42.4	57.6	100.0
2001	344	20.5	1.3	7.3	2.1	2.0	33.2	66.8	100.0
2002	397	13.1	1.2	8.2	2.4	1.3	26.2	73.8	100.0
2003	195	14.4	1.4	11.0	2.5	1.4	30.8	69.3	100.0
2004	223	24.9	2.2	12.0	2.5	4.0	45.6	54.4	100.0
2005	90	22.2	2.0	11.2	2.2	5.2	42.8	57.2	100.0
2006	319	20.8	0.3	16.0	2.8	4.7	44.4	55.6	100.0
2007	150	22.2	3.6	16.7	2.0	7.7	52.2	47.8	100.0
1992–2007 Avg.		22.3	1.9	15.1	3.6	4.2	47.1	52.9	100.0

Table 20.–Estimated percent of harvest by gear type, escapement, and total run of coho salmon returning to the Chilkat River, 2000–2007.

Year	Fishery Sample Size	Troll	Seine	Drift Gillnet	Marine Sport	FW Sport	Subsistence	Total Catch	Escapement	Total Run
		Percent of Total Run								
2000	265	17.1	0.6	12.2	1.0	0.6	0.2	31.7	68.3	100.0
2001	250	19.6	0.4	8.6	0.5	1.4	0.1	30.5	69.5	100.0
2002	325	18.1	0.2	19.5	0.9	1.1	0.2	39.9	60.1	100.0
2003	424	23.6	0.6	12.1	0.9	1.3	0.2	38.8	61.2	100.0
2004	252	43.3	0.6	18.4	1.1	1.6	0.2	65.3	34.7	100.0
2005	141	25.4	0.5	15.3	0.7	2.0	0.5	44.4	55.6	100.0
2006	200	25.3	0.1	17.7	0.7	1.4	0.2	45.3	54.7	100.0
2007	73	34.1	0.0	11.6	0.0	1.1	0.2	47.1	52.9	100.0
2000–2007 Avg.		25.8	0.4	14.4	0.7	1.3	0.2	42.9	57.1	100.0

Table 21.–Estimated percent of harvest by gear type, escapement, and total run of coho salmon returning to the Nakwasina River and Chuck Creek, 1982–2007.

		Number of Fish								
Year	Fishery Sample Size	Alaska Troll	Alaska Seine	Alaska Sport	B.C. Troll	B.C. Net	B.C. Sport	Total Catch	Escapement	Total Return
Nakwasina River										
2000	33	33.8	2.2	1.9				37.9	62.1	100.0
2001	93	26.6	0.9	5.0				32.5	67.5	100.0
2002	48	15.4	0.0	3.4				18.9	81.1	100.0
2003	47	18.3	0.0	4.3				22.6	77.4	100.0
2004	97	25.1	1.1	3.6				29.8	70.2	100.0
2005	75	30.8	0.3	2.6				33.7	66.3	100.0
2006	74	15.8	0.0	4.0				19.8	80.2	100.0
2007	65	45.3	1.7	3.3				50.3	49.7	100.0
Average		26.4	0.8	3.5				30.7	69.3	100.0
Chuck Creek										
1982	28	47.9	15.2	0.0	0.0	0.0	0.0	63.1	36.9	100.0
1983	11	22.9	25.7	0.0	0.0	0.0	0.0	48.6	51.4	100.0
1985	29	49.7	25.4	0.0	0.0	0.0	0.0	75.1	24.9	100.0
2003	192	36.2	16.9	5.6	0.0	0.0	0.0	58.7	41.3	100.0
2004	203	45.7	11.3	4.8	0.0	0.0	0.0	61.8	38.2	100.0
2005	160	39.5	14.1	7.3	0.0	0.0	0.0	60.8	39.2	100.0
2006	84	46.8	3.7	0.9	0.8	0.0	0.0	52.3	47.7	100.0
2007	140	47.7	10.3	2.4	0.8	0.4	3.7	65.3	34.7	100.0
Average		42.0	15.3	2.6	0.2	0.1	0.5	60.7	39.3	100.0

The recommended goal for the Chilkat River was based upon three different analyses (traditional multiplicative Ricker stock-recruit, Bayesian age-structured spawner-recruit, and a "hockey stick" model described by Barrowman and Myers (2000) using estimated freshwater production) that produced nearly identical point estimates. All analyses included the stock assessment information from survey counts, mark–recapture estimates, harvest and smolt estimates from coded wire tagging of several broods, and age-structure data. The goal represents a best estimate of the range required to provide for maximum sustained yield and is designed to produce at least 90% of *MSY* while reflecting the uncertainty associated with the data.

KETCHIKAN AND SITKA AGGREGATE SURVEY COUNTS

In 2006, goals for aggregate spawner counts in 14 streams in the Ketchikan area and five streams in the Sitka area (Tables 3 and 4; Figures 5 and 6) were established based on an analysis by Shaul and Tydingco (2006). Lack of adequate stock specific information on age composition, harvest and survey efficiency precluded conventional stock-recruit analysis. Instead, they incorporated exploitation rate and marine survival estimates for nearby wild indicator stocks (Hugh Smith Lake for Ketchikan; Nakwasina River for Sitka) to estimate smolt production associated with the aggregate survey counts. They estimated habitat capacity as average smolt production associated with primary brood years having higher levels of escapement, indicating probable full seeding of available rearing habitat. Average productivity estimates for coho stocks based on literature were incorporated to estimate the number of smolts/spawner associated with *MSY* and a range producing an even proportion (84% or more) of *MSY* in which the upper goal bound was at least double the lower bound.

JUNEAU ROADSIDE SURVEY COUNTS

Clark (2005) developed escapement goals for Montana and Peterson Creeks based on theoretical stock-recruit analysis. He used Auke Creek exploitation rates to determine an equilibrium point for potential Ricker relationships and applied a range of probable alpha values to

Table 22.–Squared correlation coefficients (R2) for linear relationships among wild coho salmon indicator stocks for estimates of smolt production and marine survival, 1982–2007[a].

	Number of Smolts (R^2)							
	Chilkat River	Berners River	Auke Creek	Taku River	Hugh Smith Lake	Ford Arm Lake	Nakwasina River	Chuck Creek
Chilkat R.	—	0.23	0.09	0.03	0.00	0.00	0.01	0.03
Berners R.	0.23	—	**0.27**	0.05	0.00	0.01	0.12	0.64
Auke Cr.	0.09	**0.27**	—	0.21	**0.18**	0.01	**0.50**	0.11
Taku R.	0.03	0.05	0.21	—	0.00	0.02	0.34	0.11
Hugh Smith L.	0.00	0.00	**0.18**	0.00	—	0.16	0.00	0.09
Ford Arm L.	0.00	0.01	0.01	0.02	0.16	—	0.42	0.61
Nakwasina R.	0.01	0.12	**0.50**	0.34	0.00	0.42	—	0.06
Chuck Cr.	0.03	0.64	0.11	0.11	0.09	0.61	0.06	—
Average	0.06	0.19	0.20	0.11	0.06	0.18	0.21	0.24

	Marine Survival (R^2)							
	Chilkat River	Berners River	Auke Creek	Taku River	Hugh Smith Lake	Ford Arm Lake	Nakwasina River	Chuck Creek
Chilkat R.	—	0.41	**0.89**	0.41	0.48	0.14	0.21	0.24
Berners R.	0.41	—	**0.50**	**0.78**	**0.57**	0.08	0.18	0.01
Auke Cr.	**0.89**	**0.50**	—	**0.58**	**0.31**	**0.19**	0.16	0.14
Taku R.	0.41	**0.78**	**0.58**	—	**0.56**	0.11	0.28	0.04
Hugh Smith L.	0.48	**0.57**	**0.31**	**0.56**	—	0.00	0.08	0.24
Ford Arm L.	0.14	0.08	**0.19**	0.11	0.00	—	0.00	0.22
Nakwasina R.	0.21	0.18	0.16	0.28	0.08	0.00	—	0.17
Chuck Cr.	0.24	0.01	0.14	0.04	0.24	0.22	0.17	—
Average	0.40	0.36	0.39	0.39	0.32	0.11	0.16	0.15

[a] Linear regression relationships significant at P<0.05 are shown in bold; relationships significant at P<0.01 are shaded (based on a one-tailed significance test). Estimates for Ford Arm Lake were for presmolts with approximately 10 months remaining in fresh water.

Table 23.–Squared correlation coefficients (R2) for linear relationships for estimates of total adult return among wild coho salmon indicator stocks and estimated wild commercial catch and aggregate wild coho salmon abundance in Southeast Alaska, 1982–2007[a].

	Total Return (R^2)							
	Chilkat	Berners	Auke	Taku	Hugh Smith	Ford Arm	Nakwasina	Chuck
Chilkat R.	—	**0.89**	0.56	0.68	0.28	**0.72**	0.00	0.01
Berners R.	**0.89**	—	**0.65**	**0.50**	**0.55**	0.13	0.00	0.18
Auke Cr.	**0.56**	**0.65**	—	**0.28**	**0.29**	0.04	0.00	**0.59**
Taku R.	**0.68**	**0.50**	0.28	—	**0.25**	0.19	0.13	0.01
Hugh Smith L.	0.28	**0.55**	**0.29**	**0.25**	—	0.03	0.07	0.07
Ford Arm L.	**0.72**	0.13	0.04	0.19	0.03	—	0.00	**0.58**
Nakwasina R.	0.00	0.00	0.00	0.13	0.07	0.00	—	0.07
Chuck Cr.	0.01	0.18	**0.59**	0.01	0.07	**0.58**	0.07	—
Average	0.45	0.41	0.34	0.29	0.22	0.24	0.04	0.22
Wild Catch	0.01	**0.60**	**0.51**	0.24	**0.57**	0.03	0.17	0.33
Wild Abundance	0.22	**0.54**	**0.31**	**0.25**	**0.58**	0.12	0.22	0.02

[a] Linear regression relationships significant at P<0.05 are shown in bold; relationships significant at P<0.01 are shaded (based on a one-tailed significance test).

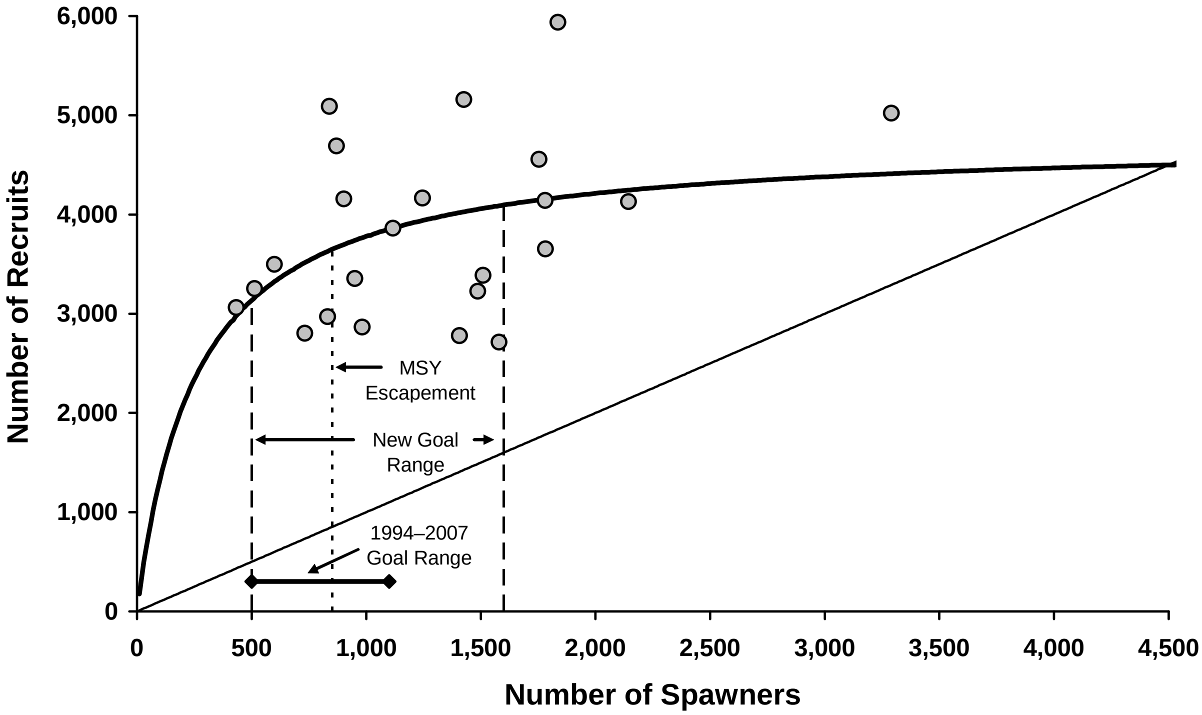

Figure 14.–Spawner–recruit relationship for Hugh Smith Lake coho salmon, 1982–2004 brood years.

establish a goal range likely to encompass 90% or more of *MSY*. His recommended goals are 400–1,200 spawners for Montana Creek and 100–250 spawners for Peterson Creek. These target ranges replace goals developed by Clark (1995) of 200–500 spawners and 100–350 spawners, respectively. Montana and Peterson Creeks both have freshwater sport fisheries that can be actively managed for escapement goals. Clark (2005) recommended that goals for three other Juneau Roadside streams without freshwater fisheries (Steep, Jordan, and Switzer Creeks) be eliminated.

SITUK AND LOST RIVERS

Recent studies of escapements, smolt production, marine survival, and exploitation rates for the Situk River stock provided a reference for evaluating the current *biological escapement goal* developed by Clark and Clark (1994) as well as recent mark–recapture estimates. Shaul et al. (*In Prep.-a*) assumed that average observed production of about 1,034,000 smolts during 3 years represented habitat capability for the Situk system. A range of 25.4–50.8 smolts per spawner was applied to that estimate based on a literature survey of coho salmon productivity estimates (Shaul and Tydingco 2006), resulting in a likely optimal range of about 20,400–41,700 spawners. Based on an average estimated peak survey expansion factor of 7.04, the current index goal of 3,300–9,800 spawners translates to a slightly higher expanded goal of about 23,200–69,000 spawners. Shaul et al. (*In Prep.-a*) recommended that the current goal be retained based on these results and in consideration of the variability in survey expansion estimates. They concluded that recent escapement estimates ranging from about 24,000 to 54,000 spawners in 2004–2006 were likely near optimal to produce *MSY*, assuming that the productivity of the Situk River stock is about average for more extensively studied stocks.

After applying a similar approach for the Lost River, Shaul et al. (*In Prep.-a*) estimated that the current goal of 2,200–6,500 spawners (Clark and Clark 1994) for that system was also slightly conservative and recommended that it be retained, as well, pending more information on escapement and production from the stock. The Lost River has drained into the Situk-Ahrnklin lagoon since a shift in its mouth in the winter of 1999–2000. As a result, the Lost River stock is harvested in common with other stocks in the lagoon and there is little opportunity to directly manage the stock. In 2008, the Southeast Region Escapement Goal Team recommended that the lower bound of the biological escapement goal be converted to a *sustainable escapement goal* and that the upper bound be deleted. A similar approach has been taken for Lost River sockeye salmon.

DISCUSSION

Southeast Alaska coho salmon stocks appear to be in excellent overall condition as a whole. We found no *stocks of concern* from a fishery management perspective. Stocks that have *BEGs* have been within or above target ranges in the vast majority of cases.

However, we have identified recent patterns in marine survival and smolt production that warrant caution for some systems. During 2005–2007, marine survival declined substantially from the 1982–2004 average in most systems. Although we cannot predict whether this trend will continue, if it does, more conservative management will be required for some stocks, particularly those also suffering a downturn in smolt production. In 2007, record low smolt production combined with a record low marine survival rate resulted in a total Berners River run that was only 29% of the previous average of about 30,000 adults. The initial 2007 return estimated at about 8,700 adults was by far the smallest run on record and the escapement count of only 3,915 spawners was under the goal range of 4,000–9,200 spawners despite conservative management of the Lynn Canal gillnet fishery. Preliminary indications based on smolt capture rates in 2007 and 2008 indicate that Berners River smolt production has continued to decline and will likely depress returns in 2008 and 2009.

Escapement goals for Southeast Alaska coho salmon stocks can usually be achieved or exceeded under recent average exploitation pressure, except in cases when poor smolt production coincides with poor marine survival. Fortunately, pre-season and inseason methods have been developed to assess both smolt production and marine survival for some indicator stocks. Precise preseason counts or estimates of smolt production are available for some systems, including Auke Creek and Chuck Creek, while lower quality preseason estimates are available for most other systems based on smolt capture success or mark–recapture estimates generated from jack returns. The mark–recapture estimates of smolt abundance are bolstered during the later portion of the fishing season from sampling of adult spawners at weirs and fish wheels.

Inseason estimates of marine survival are also generated for those stocks for which the cumulative troll fishery harvest of tagged coho salmon as a proportion of tagged smolts released is strongly correlated with marine survival. For example, the inseason troll tag recovery rate for the Hugh Smith Lake stock becomes a useful predictor of marine survival by early August (Shaul et al. *In Prep.-b*). Preliminary smolt production estimates combined with inseason survival predictions are very useful for predicting the adult return and total escapement to several indicator systems well in advance of significant escapement counts. These estimates are used in conjunction with fishery performance measures of aggregate abundance, including catch and CPUE, to assess returns in season.

The regression analysis indicates that returns to indicator systems, particularly those on the outer coast, are relatively poorly correlated with other systems. The degree of variability among stocks and the poor correlation between some stocks and measures of aggregate coho salmon abundance constrain options to manage highly mixed-stock fisheries for theoretical maximum sustained yield. At the same time, the broad distribution of production among hundreds of systems limits the potential to focus fisheries on specific stocks, with the exception of larger stocks in the Yakutat area.

However, the disadvantage to fishery management resulting from variability among individual populations is offset by population characteristics of the species that provide resilience and flexibility under mixed-stock fishery management in which fishing effort and patterns tend to be stable. Most coho salmon stocks appear to perform well under a broad range of escapements and have high intrinsic productivity that provides resilience and quick recovery from low escapement events. The Beverton-Holt spawner-recruit relationship for the Hugh Smith Lake stock (Figure 14) indicates that yields within 10% of *MSY* can be obtained from a broad range of escapements with the upper escapement bound estimated at 3.76 times the lower bound. The minimum goal of 500 spawners would be achieved or exceeded under an exploitation rate of 65% under all run sizes observed during 26 years except one (1,346 adults in 2000).

There is very little evidence for over-compensation and reduced returns from large escapements in coho salmon stock-recruit data series. Most stock-recruit data sets are best described by either a hockey stick relationship that predicts level production above a threshold level of escapement (Barrowman and Myers 2000) or a Beverton-Holt relationship that predicts slightly higher returns from larger escapements over a broad range (Barrowman et al. 2003). In fact, to the extent that higher brood year escapements above *MSY* may produce larger returns (i.e., Beverton-Holt model), the fisheries may be slightly more efficient (i.e., achieve the same harvest from a larger return) and gain a slight buffer against poor marine survival in the following cycle. The flexible population response characteristic of the species is relatively forgiving of management error in either direction and is compatible with the pattern of primarily mixed-stock fishing in Southeast Alaska.

Despite the fact that some inside stocks are subjected to a more extensive gauntlet of fisheries, exploitation rates have been relatively evenly distributed over geographic stock groupings. During 2004–2007, substantial but moderate average exploitation rates ranging from 51–63% were achieved from six stocks that have very different migratory characteristics and are exposed to very different but overlapping complexes of fisheries. The Chuck Creek and Ford Arm Lake stocks on the outer coast were exploited at average rates of 60% and 63%, respectively, distributed primarily over coho-directed troll and marine sport fisheries and as incidental harvest in purse seine fisheries. Meanwhile, the return to Hugh Smith Lake, a southern inside stock that migrates through a gauntlet of mixed-stock troll, seine, gillnet and marine sport fisheries in three management jurisdictions (state managed waters, Annette Island Reserve, and northern British Columbia) was exploited at an average rate of 59% (down substantially from an average of 75% in the 1990s). The Berners River, Chilkat River, and Taku River stocks that were harvested by another gauntlet of troll, seine, and marine sport fisheries followed by intensive gillnet fisheries were exploited at average rates estimated at 59%, 51%, and 54%, respectively, for the same recent 4-year period. Two other indicator stocks, Nakwasina River and Auke Creek, had markedly lower average exploitation rates during the period at 33% and 38%, respectively, because of their particular migratory patterns relative to fishing effort.

Some inside indicator stocks, including the Berners and Chilkat Rivers, were strongly correlated with each other and with regionwide abundance indices, indicating that management based on inseason abundance indicators can be effective within geographic stock groupings such as Lynn Canal that are harvested by a common fishery like the District 115 gillnet fishery. Most inside stocks were significantly correlated.

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.

Overall, we believe variation in smolt production and adult runs have been influenced primarily by environmental conditions rather than variations in escapement. Recent spawning escapements have been abundant by historical comparison in most streams, and escapement goals have usually been met or exceeded, suggesting that available rearing habitat has been near fully seeding in most cases. Nevertheless, the recent declining trend in smolt production from the Berners River is of concern and will require close monitoring and conservative management to insure that the escapement goal is met.

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APPENDIX A

Appendix A1.–Estimated coho salmon escapements for systems with formal escapement goals in Southeast Alaska, 2003–2008.

System	Escapement Data	Type	Escapement Goal	Year Established	Escapement 2003	2004	2005	2006	2007	2008	2008 EG Team Recommendation
Hugh Smith Lake	Weir	BEG	500–1,600	2008	1,510	840	1,732	891	1,224	1,741	Replace BEG 500–1,100
Taku River[a]	MR	Manage Threshold	>35,000	1995	183,038	132,405	91,830	140,028	49,632	80,393	NC
Auke Creek	Weir	BEG	200–500		585	416	450	582	352	600	NC
Juneau Roadside Index											NC
Montana Creek	FS, IE	SEG	400–1,200	2005	808	364	351	1,110	324	405	NC
Peterson Creek	FS, IE	SEG	100–250	2005	203	284	139	439	226	660	NC
Ketchikan Survey Index	HS	BEG	4,250–8,500	2005	11,859	9,904	14,840	6,912	4,488	16,680	NC
Sitka Survey Index	FS, IE	BEG	400–800	2005	1,101	1,124	1,668	2,647	1,066	1,118	NC
Ford Arm Lake	Weir	BEG	1,300–2,100	1994	6,789	3,539	4,257	4,737	2,567	5,173	NC
Berners River	MR	BEG	4,000–9,200	1994	10,110	14,450	5,220	5,470	3,915	6,870	NC
Chilkat River Escapement	MR	BEG	30,000–70,000	2005	134,340	67,465	38,589	80,683	25,493	57,376	NC
Chilkat Survey Index	AS/FS-IE	BEG	950–2,200	2005	3,950	2,006	977	2,399	758	1,706	NC
Lost River	FS,IE	SEG	2,200	1994	6,394	5,047	1,241	3,500	2,542	na	Replace BEG of 2,200 to 6,500
Situk River	BS,IE	BEG	3,300–9,800	1994	6,009	10,284	2,514	7,900	5,763	na	NC
Tsiu/Tsivat Rivers	AS,IE	BEG	10,000–29,000	1994	35,850	na	16,600	14,500	14,000	25,200	NC

[a] For the Taku River stock of coho salmon, the management intent of the U.S. is to ensure a minimum above border run (i.e., inriver run) of 38,000 fish as detailed in the Pacific Salmon Treaty. The management threshold for escapement is the inriver run minus the allowed Canadian inriver harvest of 3,000 at runs less than 50,000.

AS = peak aerial survey, FS = foot survey, BS = boat survey

IE = index escapement

MR = mark–recapture

NC = no change