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Coho Salmon Stock Status and Escapement Goals in Southeast Alaska

by

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December 2011

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

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

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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by

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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. Escapements to monitored streams remained within or above biological escapement goal ranges during 2008–2010. We identified no coho salmon stocks of concern in Southeast Alaska. Average returns during the period increased from the prior 3-year period, due in part to a rebound in average marine survival, which increased from 9.5% in 2005–2007 to 12.8% in 2008–2010. During 2007–2010, there was a shift in marine survival of inside stocks in favor of those in southern Southeast compared with northern Southeast. Exploitation rates remained moderate during 2008–2010, with averages by stock of 59% for Chuck Creek, 62% for Ford Arm Creek, 50% for Hugh Smith Lake, 57% for Berners River, 45% for Chilkat River, 49% for Taku River, and 41% for Auke Creek (mean-average = 52%). The hatchery contribution has remained nearly unchanged over the past 2 decades at about 20% of the common property commercial catch, despite a tripling of coho salmon releases from hatcheries in the region. Size data indicate increased spatial variability in marine growth, a probable decline in growth rates in outer coastal waters, and a potential shift in the food web toward prey species favored by pink salmon. Although escapements to 2 indicator systems averaged 142–150% of E_{MSY}, realized harvests were estimated at over 90% of *MSY*. Recently updated spawner-recruit relationships show significant ($p<0.05$) positive linear relationships between escapement and production. We introduce a new spawner-recruit model consistent with our understanding of Southeast Alaska coho salmon life history that accounts for the contribution by marine-rearing nomads.

Key words: coho salmon, *Oncorhynchus kisutch*, escapement, escapement goals, smolts, nomads, marine survival, exploitation rates, weight, length, Auke Creek, Berners River, Taku River, Ford Arm Creek, Hugh Smith Lake, Chilkat River, Chuck Creek, Tsiu River, 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 harvest 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 (Shaul et al. 2008) of the stocks that support these fisheries through the 2010 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. The commercial catch reached a peak during 1990–1996 at an average of 2.86 million wild fish (3.46 million total fish), before following a lower but relatively level trend during 1997–2005 around an average of about 2.0 million wild fish and 2.5 million total fish. During 2006 and 2007, however, the catch declined to 1.52–1.58 million wild fish (1.84–1.91 million total fish). A recent rebound to 1.82–1.99 million wild fish and 2.29–2.38 million total fish in 2009–2010 suggests that the post-1981 pattern of high average survival and abundance remains intact.

Excellent coho salmon habitat occurs throughout Southeast Alaska (Figure 2). In addition to wild stocks within Southeast Alaska, 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 2001 to 2010, hatcheries contributed an average of 19% (range 14–24%) of the Southeast Alaska commercial catch. The proportionate contribution by hatcheries remained relatively unchanged from the prior decade (1991–2000) when the hatchery contribution also averaged 19% (range 13–22%), despite an increase of 73% in the average total non-fry coho salmon release from Southeast Alaska hatcheries from 9.1 million fish annually during 1990–1999 to 15.8 million fish in 2000–2009. During recent years, about 99% of the hatchery contribution to the Southeast Alaska catch was produced by Alaskan facilities.

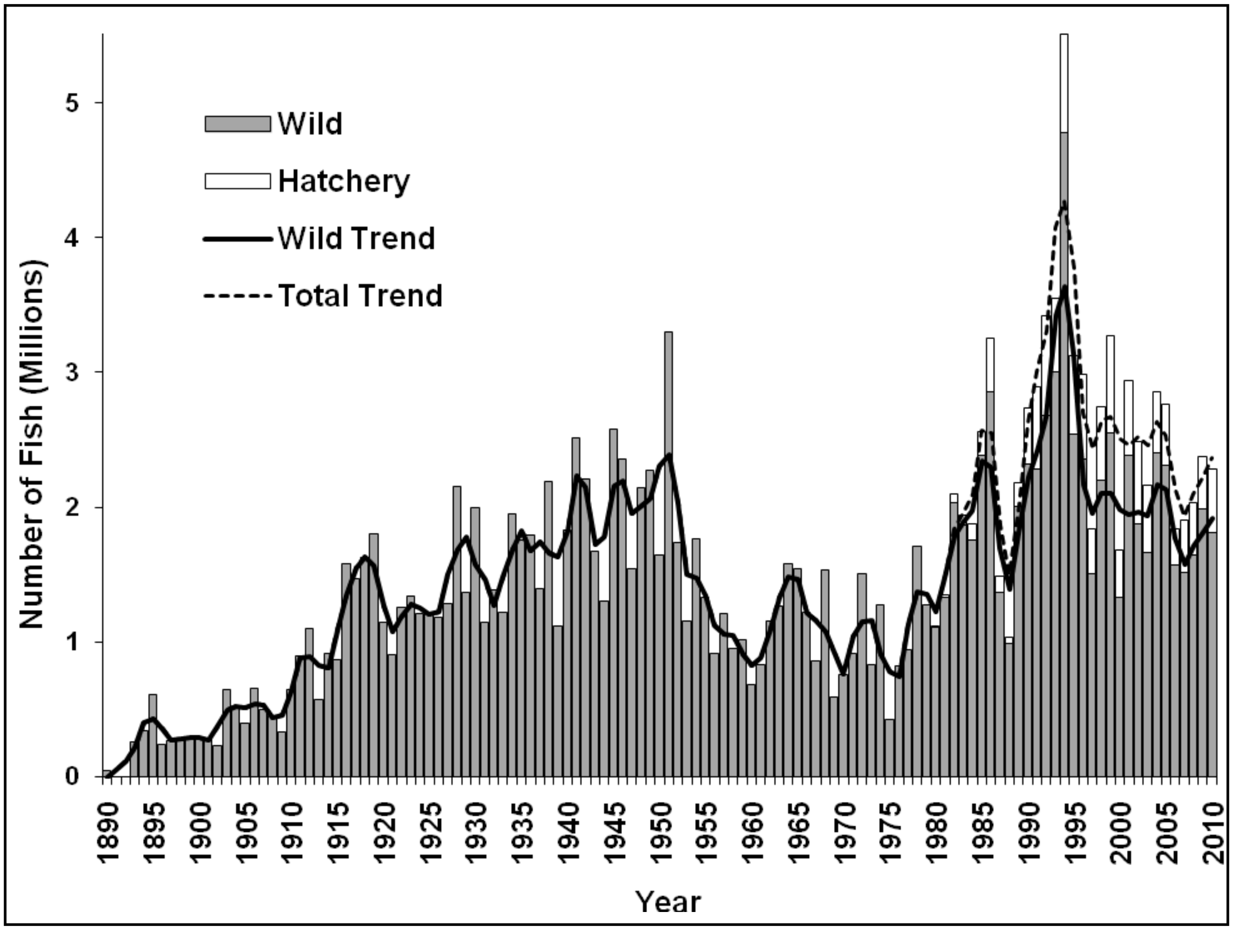

Figure 1.–Commercial harvest of wild and hatchery coho salmon in Southeast Alaska, 1890–2010, with a 0.05 LOESS trend.

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

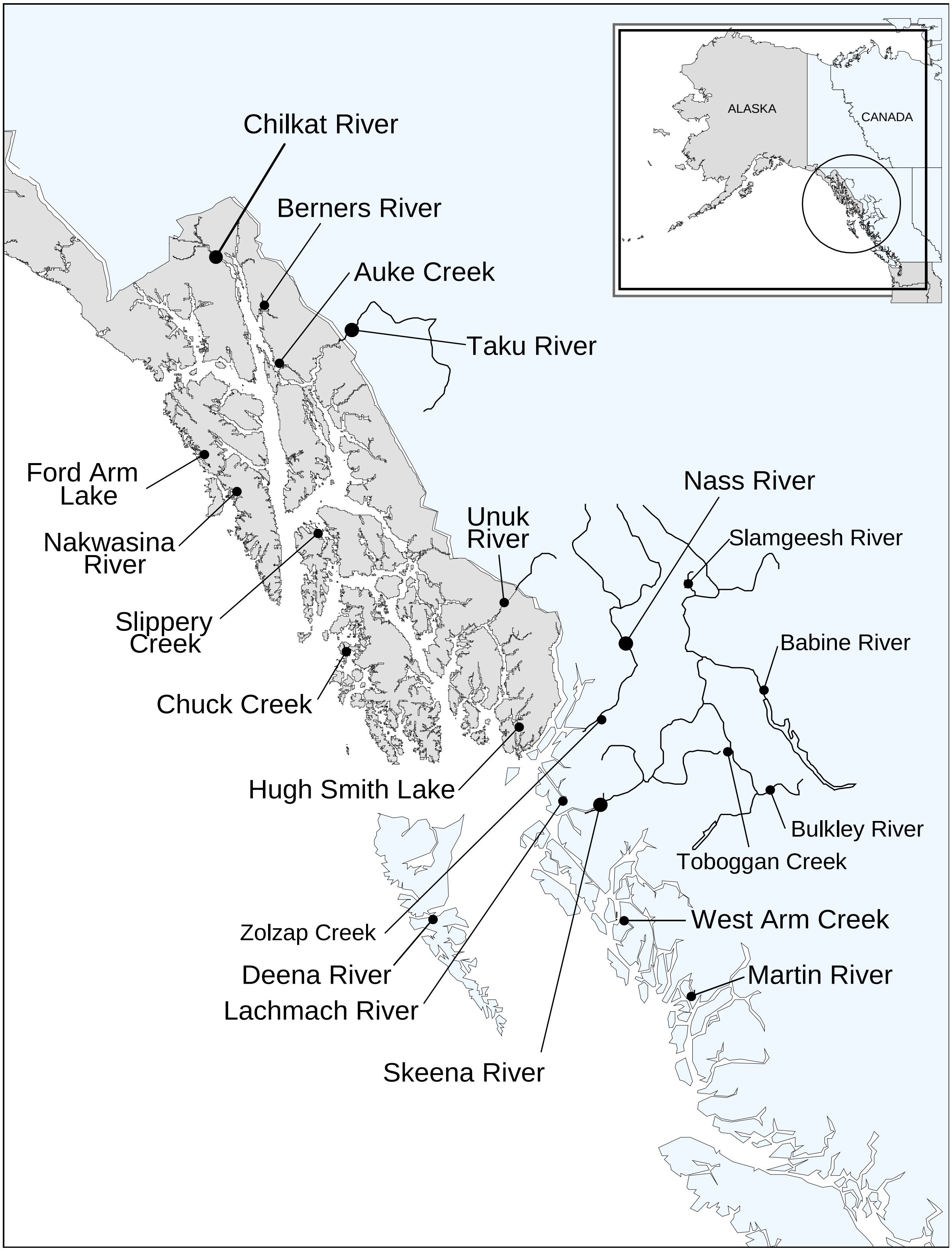

Figure 2.–Map of Southeast Alaska and northern British Columbia, showing the locations of recent coho salmon full indicator stock assessment projects.

The principal management objective for Southeast Alaska fisheries for coho salmon is to achieve *maximum sustained yield* (*MSY*) from wild stocks. Hatchery contributions and natural production are identified inseason in key fisheries using 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. 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 (board) 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 broad 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 runs. 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 ensuring that more heavily exploited inside stocks are able to support some harvest in inside 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 *MSY* as a specific priority objective.

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

Marine sport fisheries, which accounted for an average of 90% of the total recreational harvest during 1996–2010, 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 generally increasing, component of the harvest, reaching a peak estimated harvest of 409,300 fish in 2005 (Figure 3).

Concurrent with expansion of the charter industry, sport harvest accounted for an increasing share of the all-fishery harvest from the mid-1970s until the early 2000s, peaking during 2000–2009 at a range of 10–13% (average 11%) before declining to 8% in 2010. 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.

Directed subsistence fishing for coho salmon occurs in a few streams in the region, while small catches of the species are also taken incidentally to sockeye salmon in both subsistence and personal use fisheries. The 2001–2010 combined subsistence and personal use harvest, as reported on returned permits, averaged only 2,432 fish.

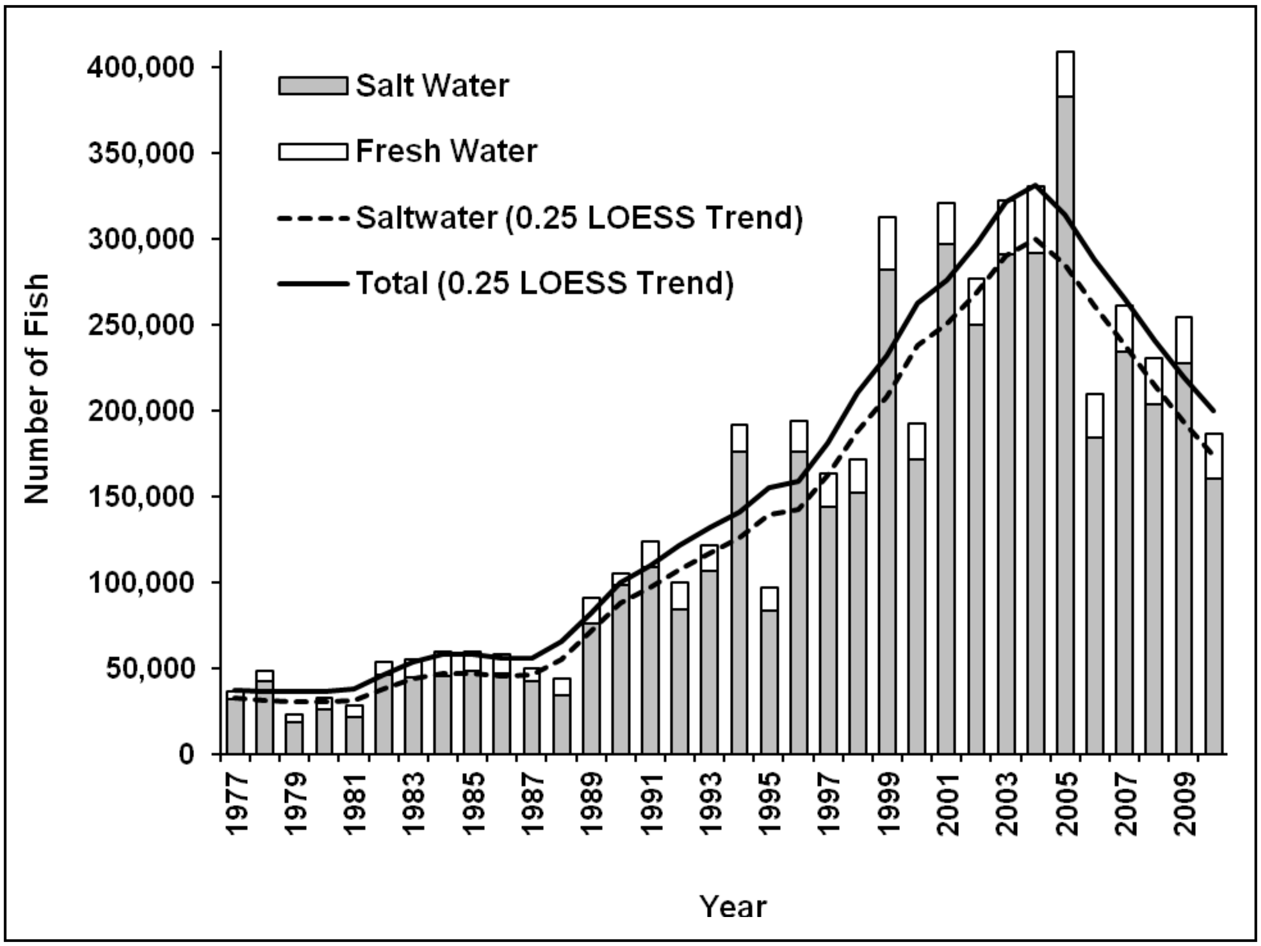

Figure 3.–Sport harvest in salt water and fresh water of coho salmon in Southeast Alaska, 1977–2010.

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. Overall, 14 systems or groups of systems have goals, including 10 with *biological* escapement goals (*BEG*), 3 with *sustainable* escapement goals (*SEG*), and one (Taku River) with a management threshold (Table 1).

Table 1.–Estimated coho salmon escapements for systems with formal escapement goals in Southeast Alaska, 2005–2010.

System	Escapement Data	Type	Escapement Goal	Year Established	Escapement					
					2005	2006	2007	2008	2009	2010
Hugh Smith Lake	Weir	BEG	500–1,600	2008	1,732	891	1,244	1,741	2,282	2,878
Taku River[a]	MR	Mgt. Threshold	>35,000	1995	135,558	121,778	74,326	95,360	104,321	126,830
Auke Creek	Weir	BEG	200–500	1994	450	581	352	600	360	417
Montana Creek	FS, IE	SEG	400–1,200	2005	351	1,110	324	405	698	630
Peterson Creek	FS, IE	SEG	100–250	2005	139	439	226	660	123	467
Ketchikan Survey Index	HS	BEG	4,250–8,500	2005	14,840	6,912	4,488	16,680	8,226	4,656
Sitka Survey Index	FS, IE	BEG	400–800	2005	1,668	2,647	1,066	1,117	1,156	1,273
Ford Arm Lake	Weir	BEG	1,300–2,900	1994	4,257	4,737	2,567	5,173	2,181	1,610
Berners River	MR	BEG	4,000–9,200	1994	5,220	5,470	3,915	6,870	4,230	7,520
Chilkat River Escapement	MR	BEG	30,000–70,000	2005	34,575	79,050	24,770	56,369	47,911	84,909
Chilkat Survey Index	AS/FS-IE	BEG	950–2,200	2005	977	2,399	758	1,706	1,453	2,650
Lost River	FS,IE	SEG	2,200	1994	1,241	3,500	2,542	NA	3,581	2,393
Situk River	BS,IE	BEG	3,300–9,800	1994	2,514	7,950	5,763	NA	5,814	11,195
Tsiu/Tsivat Rivers	AS,IE	BEG	10,000–29,000	1994	16,600	14,500	14,000	25,200	28,000	11,000

[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

Escapement goal classifications are defined in the *Policy for the Management of Sustainable Salmon Fisheries* (5 AAC 39.222) under Section (f):

> "(3) "*biological* escapement goal" or "(*BEG*)" means the escapement that provides the greatest potential for maximum sustained yield;" and
>
> "(36) "*sustainable* escapement goal" or "(*SEG*)" means a level of escapement, indicated by an index or an escapement estimate, that is known to provide for sustained yield over a 5 to 10 year period, used in situations where a *BEG* cannot be estimated or managed for."

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 2 levels: full indicator stock and escapement indicator.

FULL INDICATOR STOCKS

Full indicator stocks are marked as smolts or presmolts with coded wire tags, which makes it possible to estimate their smolt production (from the marked rate-at-return) and contribution to the fisheries by systematically sampling fishery harvests and escapements. These programs have been expanded in recent years and are now well established in 7 systems in the region (Figure 2). The data series extends from the early 1980s for 4 systems (Auke Creek, Berners River, Ford Arm Creek, and Hugh Smith Lake). Programs were expanded in the 1990s to include the Taku River, Chilkat River, Slippery Creek, Unuk River, and Nakwasina River. The latter 3 projects were discontinued in 2003, 2005, and 2008, respectively. Chuck Creek, which was added as an indicator stock in 2001, has total run estimates for 3 earlier years (1982, 1983, and 1985).

Full indicator stock programs provide detailed population information needed to establish and manage for *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 *BEG*s that produce *MSY*. 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, *BEG*s were established for the 4 long-term indicator stocks based on Ricker stock-recruit relationships (Clark et al. 1994). The goal established for the Hugh Smith Lake stock of 500–1,100 spawners was later revised to 500–1,600 spawners (Shaul et al. 2009). A recent review of the Ford Arm stock based on many more years of data, more appropriate spawner-recruit models, and more informed scale aging concluded that the original goal of 1,300–2,900 spawners remains appropriate (Shaul et al. *in prep*). The original goals for Auke Creek and the Berners River have not been revised. Analysis of an appropriate goal for the Berners River has been confounded by a recent steep decline in smolt production for reasons that, while poorly understood, do not appear related to a change in parent escapement (Shaul et al. 2008). A *BEG* of 30,000–70,000 spawners was developed for the Chilkat River based on Ricker analysis (Ericksen and Fleischman 2006). Also, for the Taku River, a minimum inriver abundance goal of 38,000 spawners is specified in the 1999 PST. In practical terms, this management threshold upriver of the U.S./Canada border translates into an escapement goal of about 35,000 fish after inriver harvests by commercial, food, and test fisheries, without directed inriver fishing.

ESCAPEMENT INDICATORS

Foot or helicopter surveys have been systematically carried out on sets of streams in the Juneau, Haines, Sitka, Ketchikan, and Yakutat areas. These projects provide greater coverage at a much lower level of resolution compared with full indicator stocks. Freshets resulting from high and variable rainfall in the fall months make 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 4 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 goals for both peak and expanded survey counts. In the Sitka area, 5 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. *BEG*s for the aggregate survey counts in the Ketchikan and Sitka areas were developed by Shaul and Tydingco (2006). Goals for the Situk, Lost, and Tsiu rivers near Yakutat were developed by Clark and Clark (1994).

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 2).

Northern Inside 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 3). In the Juneau roadside area, Clark (2005) recommended the current *SEG*s of 400–1,200 spawners for Montana Creek and 100–250 spawners for Peterson Creek. The goal for Peterson Creek has been met or exceeded annually since surveys were initiated in 1981. The lower goal bound for Montana Creek was not met in 7 years out of 30, but has been consistently met in the 3 most recent years (2008–2010). All 3 Juneau roadside stocks are harvested primarily in highly mixed-stock troll, seine, and sport fisheries, with light exploitation in inside gillnet fisheries.

The Berners River in lower Lynn Canal, the 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 3). Escapements in both the Berners and Chilkat rivers were below goal in 2007, but have been within or above goal in 2008–2010. All 3 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.

Table 2.–Southeast Alaska coho salmon escapement estimates and index counts, 1980–2010.

Year	Auke Creek	Montana Creek	Peterson Creek	Berners River	Chilkat River	Taku River	Ford Arm Creek	Black River	Sitka Survey Index[a]	Hugh Smith Lake	Ketchikan Survey Index[b]	Ketchikan Chuck Creek
1980	698	–	–	–	–	–	–	–	–	–	–	–
1981	646	227	219	–	–	–	–	–	–	–	–	–
1982	447	545	320	7,505	–	–	2,655	–	1,545	2,144	–	1,017
1983	694	636	219	9,840	–	–	1,931	–	457	1,487	–	1,238
1984	651	581	189	2,825	–	–	–	425	2,063	1,407	–	–
1985	942	810	276	6,169	–	–	2,324	1,628	1,246	903	–	956
1986	454	60	363	1,752	–	–	1,552	312	702	1,782	–	–
1987	668	314	204	3,260	37,432	55,457	1,694	262	293	1,117	4,933	–
1988	756	164	542	2,724	29,495	39,450	3,119	280	403	513	5,007	–
1989	502	566	242	7,509	48,833	56,808	2,176	181	576	433	6,761	–
1990	697	1,711	324	11,050	79,807	72,196	2,192	842	566	870	3,533	–
1991	808	1,415	410	11,530	84,517	127,484	2,761	690	1,510	1,836	5,721	–
1992	1,020	2,512	403	15,300	77,588	84,853	3,866	866	1,899	1,426	7,017	–
1993	859	1,352	112	15,670	58,217	109,457	4,202	764	1,716	832	7,270	–
1994	1,437	1,829	318	15,920	194,425	96,343	3,227	758	1,965	1,753	8,690	–
1995	460	600	277	4,945	56,737	55,710	2,446	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	4,718	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	3,800	1,590	776	1,246	8,038	–
2000	683	961	202	10,650	84,843	64,700	2,304	880	803	600	8,634	–
2001	865	1,119	106	19,290	107,697	104,394	2,209	1,080	1,515	1,580	11,475	1,350
2002	1,176	2,448	195	27,700	204,805	219,360	7,109	1,194	1,868	3,291	12,223	2,189
2003	585	808	203	10,110	133,045	183,038	6,789	1,055	1,101	1,510	11,859	614
2004	416	364	284	14,450	67,053	129,327	3,539	380	1,124	840	9,904	606
2005	450	351	139	5,220	34,575	135,558	4,257	160	1,668	1,732	14,840	646
2006	581	1,110	439	5,470	79,050	121,778	4,737	1,100	2,647	891	6,912	409
2007	352	324	226	3,915	24,770	74,326	2,567	745	1,066	1,244	4,488	425
2008	600	405	660	6,870	56,369	95,360	5,173	500	1,117	1,741	16,680	309
2009	360	698	123	4,230	47,911	104,321	2,181	590	1,156	2,281	8,226	776
2010	417	630	467	7,520	84,909	126,830	1,610	452	1,273	2,878	4,656	814
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 5 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 ensure 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.

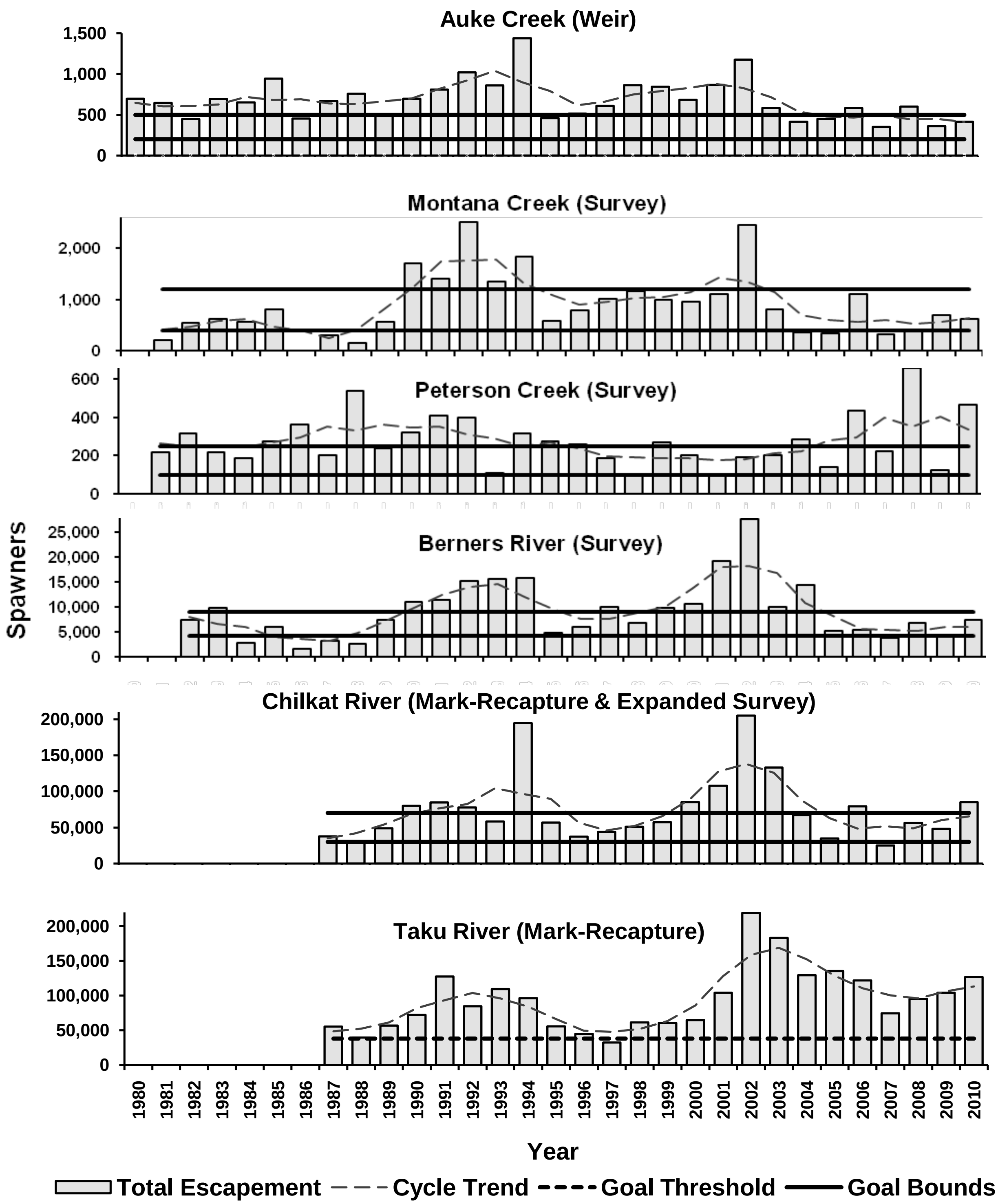

Figure 4.–Coho salmon escapement estimates and indices for streams in the Northern Inside area (districts 111 and 115), 1980–2010. Also shown are 3½-year moving average “cycle” trends and escapement goal ranges. The threshold of 35,000 shown for the Taku includes the inriver run threshold of 38,000 under the Pacific Salmon Treaty, minus an allowance for a catch of 3,000 fish from inriver commercial, food, personal use, and test fisheries.

Table 3.–Peak coho salmon escapement survey counts for Juneau roadside streams and the Berners and Chilkat rivers, mark-recapture estimates for the Taku and Chilkat rivers, and the total count of wild adult coho salmon at the Auke Creek weir, 1980–2010.

	Juneau Roadside				Chilkat River		
Year	Auke Creek. (Weir)	Montana Creek	Peterson Creek	Berners River	Index Count	Expanded Estimate	Taku River
1980	698	–	–	–	–	–	–
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	515	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	60,768
2000	683	961	202	10,650	2,635	84,843	64,700
2001	865	1,119	106	19,290	3,232	107,697	104,394
2002	1,176	2,448	195	27,700	5,660	204,805 [a]	219,360
2003	585	808	203	10,110	3,950	133,045 [a]	183,038
2004	416	364	284	14,450	2,006	67,053	129,327
2005	450	351	139	5,220	977	34,575 [a]	135,558
2006	581	1,110	439	5,470	2,399	79,050	121,778
2007	352	324	226	3,915	758	24,770	74,326
2008	600	405	660	6,870	1,706	56,369	95,360
2009	360	698	123	4,230	1,453	47,911	104,321
2010	417	630	467	7,520	2,650	84,909	126,830
Average	679	884	276	9,112	2,243	74,201	93,995
Goals:							
Point	340	–	–	6,300	1,550	50,000	–
Lower	200	400	100	4,000	950	30,000	35,000 [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 ensure 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.

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 Alaska. Escapement counts in the Berners River peaked at 27,700 spawners in 2002, but declined to only 3,915 spawners in 2007 before remaining within the goal range of 4,000–9,200 spawners in 2008–2010 (Figure 4; Table 3).

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; Jones III *In prep*). 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. *unpublished*[1]).

A *BEG* for Taku River coho salmon is under development by the Transboundary Technical Committee of the Pacific Salmon Commission (PSC). Based on the 1999 PST agreement, the management intent of the U.S. is to ensure a minimum above-border inriver run of 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. Furthermore, the agreement reached within the PSC in May of 2008 specifies that annual catch limits specified for Canadian harvest of coho salmon in the Taku River may be exceeded, provided that bilaterally agreed upon inseason run assessments indicate that salmon passage into Canada has exceeded, or is projected to exceed, the specified Canadian harvest limit, plus bilaterally agreed upon 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 above-border catch of 2,690 fish. Thus, the escapement estimate was only 32,345 spawners (Table 3), 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 threshold despite increased fishing effort in the District 111 gillnet fishery, which targets the stock in late August and September. Following the poor 1997 return, inriver run estimates have ranged well above the management threshold goal. Taku River escapement peaked in 2002 (estimate = 219,360 spawners), as did escapements in the Berners and Chilkat rivers. Escapement estimates to the Taku River in the past 4 years have increased steadily from 74,326 spawners in 2007 to 126,830 spawners in 2010.

The Chilkat River has produced nearly as many returning coho salmon as the Taku River, on average. Mark-recapture estimates obtained in 5 years (1990, 1998, 2002, 2003, and 2005) were

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[1] Eiler, J. H., M. M. Masuda, and H. R. Carlson. *Unpublished*. Stock composition, timing, and movement patterns of adult coho salmon in the Taku River drainage, 1992. National Marine Fisheries Service report, Juneau.

used to calibrate a standardized peak survey count in spawning areas. Escapement estimates peaked at 204,805 spawners in 2002 and have since met or exceeded the *BEG* of 30,000–70,000 spawners in all years except for 2007, when the estimate was only 24,770 spawners (Table 3).

Sitka Area Stocks

Ford Arm Creek is the only indicator stock in the Sitka area that has a long-term escapement data record and an established *BEG* (Figure 5; Tables 2 and 4). 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 15 years and exceeded in 13 years during the 28-year history of the project (Figure 5).

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 1986–1989 (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 2005–2010.

The sum of peak escapement survey counts for 5 small streams near Sitka trended downward in the late 1980s, but increased sharply in the early 1990s (Figure 5; Tables 2 and 4). The counts declined again from 1997 to 2000, but have remained consistently above the goal range since 2001. Shaul and Tydingco (2006) recommended a goal of 400–800 spawners for the aggregate count in the 5 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 all 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 *BEG* (Figure 6; Tables 2 and 5). 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. 2009). Over the past 29 years, escapements have been below the new goal range only once (1989), above it in 10 years, and within goal in 18 years.

The Ketchikan area survey index of peak helicopter counts for 14 streams 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 (Figure 6; Tables 2 and 5). A *BEG* of 4,250 to 8,500 spawners was established in 2006 based on the recommendation of Shaul and Tydingco (2006). During 1987–2010, escapements have fallen short of the goal once, were within the range 13 times, and above the range 10 times.

Chuck Creek on the southern outside coast was recently added as a full indicator stock (McCurdy 2010). 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 declined to only 309–425 spawners in 2006–2008, before increasing to 776–814 in 2009–2010 (Table 2). Productivity of Chuck Creek for coho salmon may have been affected by major landscape changes caused by heavy clear-cut logging activity in the drainage during the 1970s and 1980s, followed by rapid re-growth.

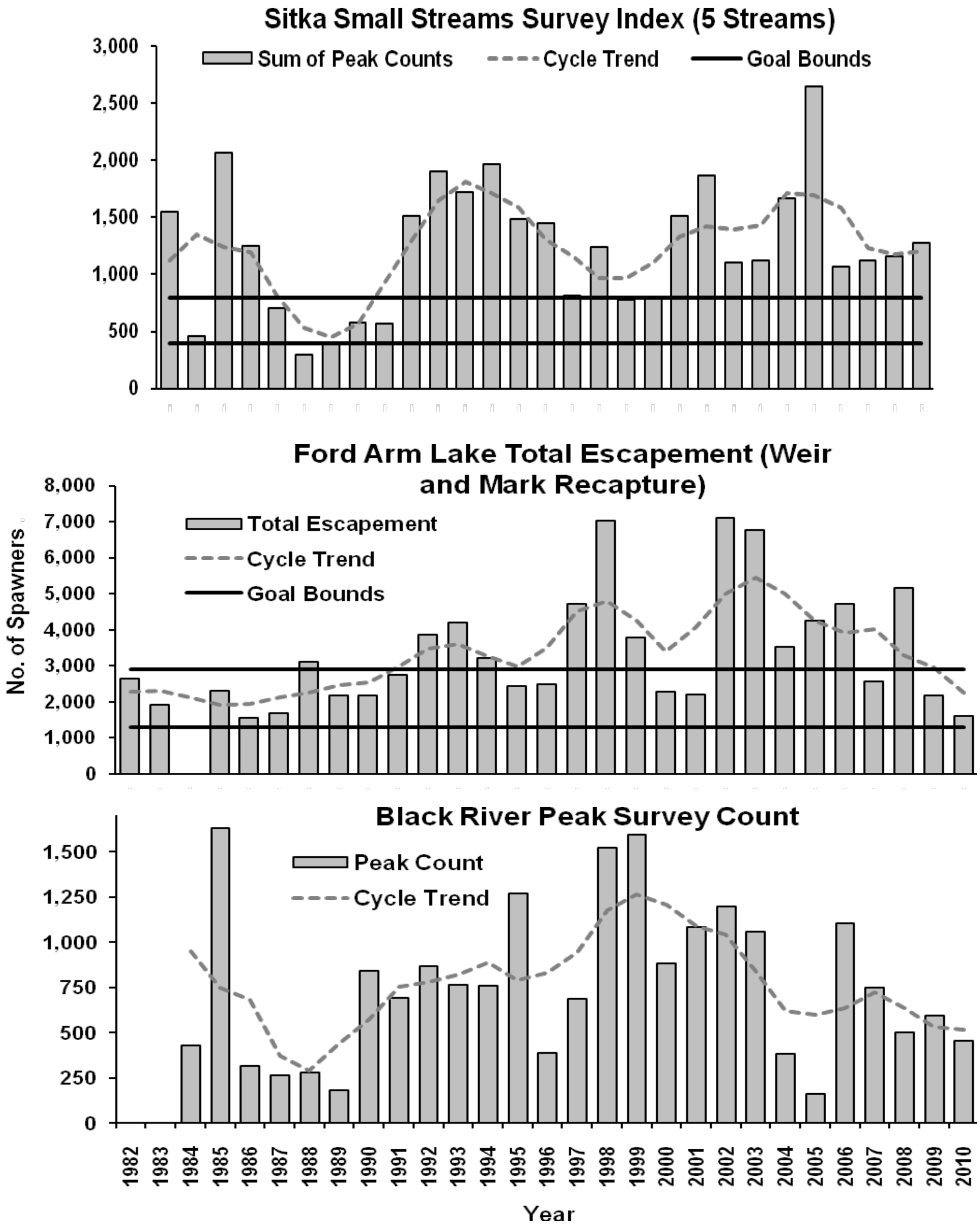
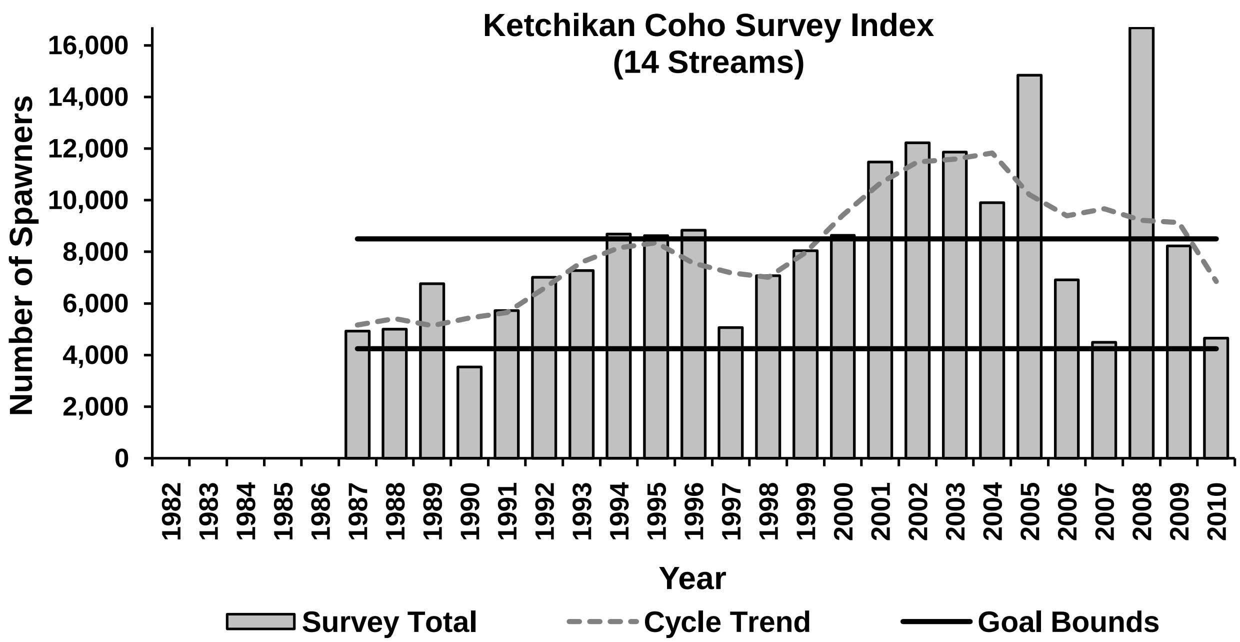


Figure 5.–Coho salmon escapement estimates and indices for streams in the Sitka area (District 113), 1982–2010. Also shown are 3½-year moving average "cycle" trends and escapement goal bounds.

Table 4.–Peak counts of coho salmon in the Sitka escapement survey index (sum of 5 streams), a helicopter survey count of the Black River escapement, and a combination of weir counts and mark-recapture estimates of the Ford Arm Creek escapement, 1982–2010.

Year	Starrigavan Creek	Sinitsin Creek	St. John's Creek	Nakwasina River	Eagle River	Sitka Index[a]	Black River	Ford Arm Creek (Weir- M/R)
1982	317	46	***116***	***580***	***486***	1,545	–	2,655
1983	45	31	20	217	***144***	457	–	1,931
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	1,552
1987	36	21	***22***	47	167	293	262	1,694
1988	45	56	71	104	***127***	403	280	3,119
1989	101	76	89	129	***181***	576	181	2,176
1990	39	80	38	195	214	566	842	2,192
1991	142	186	107	621	454	1,510	690	2,761
1992	241	265	110	654	629	1,899	866	3,866
1993	256	213	90	***644***	513	1,716	764	4,202
1994	304	313	227	404	717	1,965	758	3,227
1995	274	152	99	626	336	1,487	1,265	2,446
1996	59	150	201	553	488	1,451	385	2,500
1997	55	90	68	300	296	809	686	4,718
1998	123	109	57	653	300	1,242	1,520	7,049
1999	167	48	25	291	***245***	776	1,590	3,800
2000	144	62	30	459	108	803	880	2,304
2001	133	132	80	753	417	1,515	1,080	2,209
2002	227	169	100	713	659	1,868	1,194	7,109
2003	95	102	91	440	373	1,101	1,055	6,789
2004	143	112	79	399	391	1,124	380	3,539
2005	76	67	173	892	460	1,668	160	4,257
2006	386	152	121	996	992	2,647	1,100	4,737
2007	130	39	86	385	426	1,066	745	2,567
2008	96	73	43	839	66	1,117	500	5,173
2009	128	160	140	335	393	1,156	590	2,181
2010	70	171	85	307	640	1,273	452	1,610
Average	154	119	93	480	397	1,243	763	3,382
Goals:								
Point						500		2,050
Lower						400		1,300
Upper						800		2,900

Note: Total index is the sum of counts and interpolated values. Interpolated values are shown in shaded bold italic print.



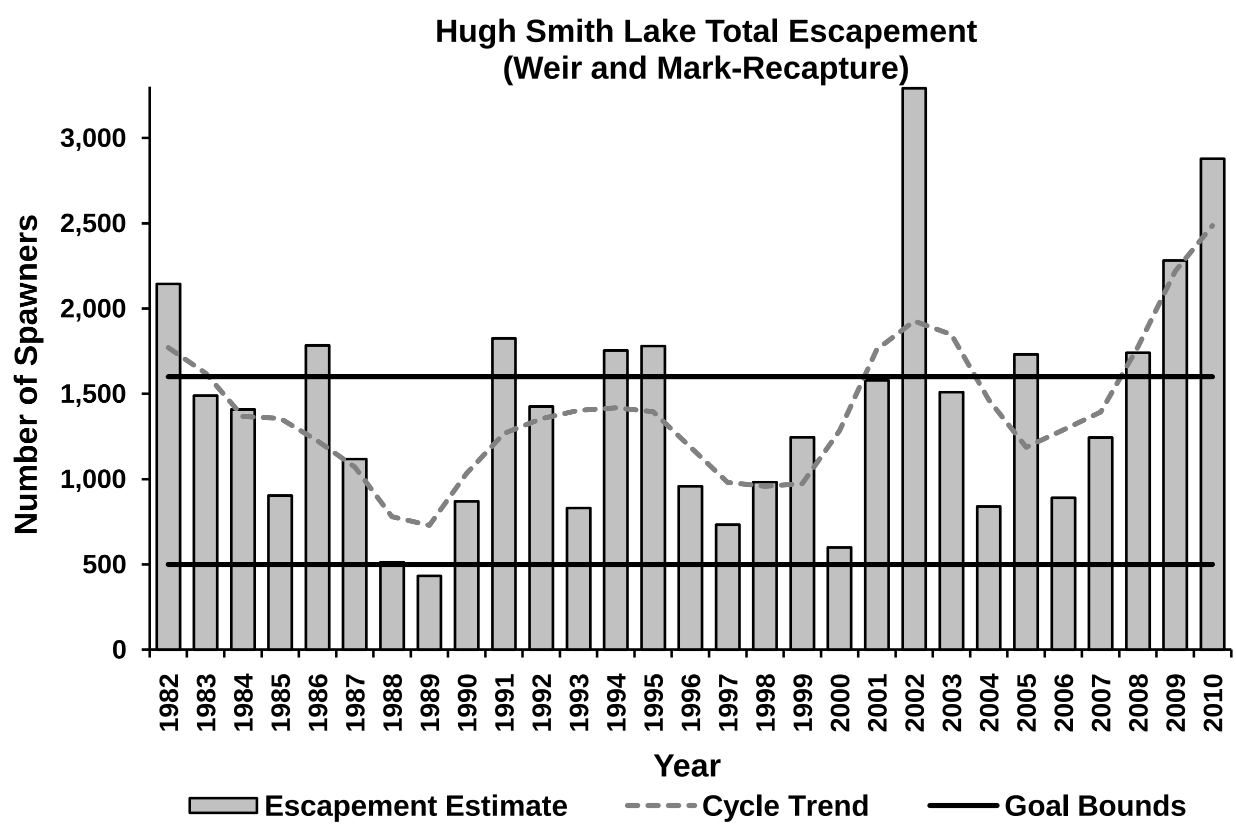


Figure 6.–Sum of peak coho salmon escapement survey counts for 14 streams in the Ketchikan area (top graph) and coho salmon escapement counts and estimates for Hugh Smith Lake (bottom graph), 1982–2010. Also shown are 3 1/2 year "cycle" trends, the escapement goals for Hugh Smith Lake (500–1,600 spawners) and the combined peak counts for Ketchikan surveyed streams (4,250–8,500 spawners).

Table 5.–Peak coho salmon survey counts for 14 streams in the Ketchikan area and total adult coho salmon escapement to Hugh Smith Lake, 1987–2010.

Year	Herman Creek	Grant Creek	Eulachon River	Klahini River	Indian River	Barrier Creek	King Creek	Choca Creek	Carroll River	Blossum River	Keta River	Marten River	Humpback Creek	Tombstone River	Combined Survey Index	Hugh Smith Lake (Weir & M/R)
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***	4,488	1,244
2008	115	55	570	25	1,250	23	420	100	***613***	7,100	***2,524***	925	2,600	360	16,680	1,741
2009	***160***	330	330	340	750	110	1,050	100	1,100	***1,041***	315	1,675	700	225	8,226	2,282
2010	85	102	370	***68***	880	90	570	190	***202***	350	550	350	200	***650***	4,656	2,878
Avg.	148	140	538	111	614	130	489	204	334	1,389	1,184	1,270	551	1,083	8,186	1,377
Goal:																
Point															5,100	850
Lower															4,250	500
Upper															8,500	1,600

Note: Combined survey count is the sum of counts and interpolated values. Interpolated values are shown in shaded bold italic print.

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. *BEG*s 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. 2010) and conducted in the Lost River in 2003 and 2004 (Clark et al. 2005, 2006) in hopes of providing a calibration of the index counts. Mark-recapture estimates were not consistent with index counts (Figure 7; Table 6) and as a result, meaningful expansion factors could not be estimated. Index counts were substantially lower than total escapement in all years 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 somewhat since 2001. The combined escapement index for Yakutat shows peaks in the early to mid-1990s and in 2002 (Figure 7) similar to northern inside stocks (Figure 4). Escapement goals have been attained in most years.

SMOLT PRODUCTION

Recent smolt production estimates are available for 8 years or more for 6 systems, while presmolt estimates in the summer prior to smolt emigration are available for Ford Arm Creek (Table 7). 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). The average number of smolts during the recent 8-year period of low counts (2003–2010) was 4,150 smolts, which was 43% lower than the first 8 years (7,316 smolts in 1980–1987). However, the approximately level trend in smolt production during 2003–2010 period does not suggest further decline, while the migration of 6,053 smolts associated with the 2011 return was slightly above the long-term average and was the largest smolt run since 1999. The decrease 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 the *BEG* (Figure 4, Table 2). Following improvement in 2010, a 2011 migration (2012 return) count of 10,435 smolts (John Joyce, National Marine Fisheries Service (NMFS), personal communication) represents a full rebound from the long declining trend and was second only to 1980 migration of 10,714 smolts. As with the decline, the reason for the dramatic recent rebound is unknown.

The estimated number of smolts migrating from the Berners River declined from an average of 198,398 (range 133,629–326,312) smolts during 1990–2005 to only 124,070 smolts in 2006, 115,845 smolts in 2007, and 89,177 smolts in 2008 (Table 7; Figure 8). The decrease in smolt production, in combination with lower marine survival rates, resulted in a dramatic decrease in adult returns. Shaul et al. (2008) discuss the phenomenon and the fact that the decline coincided with a strong departure from a significant linear relationship ($p<0.01$) between summer/fall precipitation at the Juneau airport and the Berners River smolt migration the following spring for the 14-year period 1989–2002 (Figure 8). They found no indication of physical changes in habitat observed during the period that would likely explain the decrease. However, a similar decline in smolt production from the Chilkat River after the 2004 return year (Table 7) suggests the primary agent in the decline may have operated over a broader area. Berners River smolt production estimates increased from the low of 89,177 smolts for the 2008 return year to a substantially improved 161,112 smolts in 2010 before falling again to 130,795 smolts in 2011.

As with Auke Creek, the pattern of escapements and returns does not point toward a decrease in spawning escapement as the primary factor in the decline in Berners River smolt production. Interestingly, the primary brood year for improved freshwater production in the 2010 return year was 2007, a year with a small adult escapement of 3,915 spawners that was below goal and the lowest escapement count since 1988. Newly emerged fry (<38 mm) from that brood year that were marked for an aging validation study survived to age-1+ smolthood at an extremely high estimated rate of 39.2%, while fry to adult survival was estimated at 5.3%. Both of these estimates are likely low because they do not yet include fish that remained in the system another year and smolted at age 2.

The Chilkat River has shown a similar recent decrease in smolt production. On average, an estimated 1.00 million (range 0.72–1.81 million) smolts produced the 2005–2011 adult returns to the Chilkat River, which was 45% lower than the average of 1.81 million (range 1.19–2.97 million) smolts associated with the prior 5 adult returns in 2000–2004. This decrease between periods was similar to the 41% decline observed for the Berners River.

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 over 3.3 million smolts for the 2008 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 2.1–3.3 million annually starting in 2002 (Table 7). Estimates for the Taku River since 1992 averaged 2.0 million smolts. The reason for the recent upward trend in Taku River smolt estimates, in contrast to those in the Berners and Chilkat rivers, 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 5 years) due to size selectivity in smolt tagging. Stratified estimates that account for this apparent bias were employed for estimates beginning in 2002. A change in the smolt capture method from screw traps to minnow traps after 1996 may also have altered the stock composition of the smolt catch toward later-run mainstem stocks relative to samples from returning adults at Canyon Island, which may also have increased estimates.

Shaul et al. (2005) noted an upward trend in presmolt production in the Ford Arm Creek system and speculated that it may have resulted from increased carcass nutrient input. Estimated mid-summer presmolt abundance in the Ford Arm Creek system trended upward from an average of 62,566 presmolts for returns in the 1980s to 81,934 in the 1990s, and 89,327 during 2000–2010.

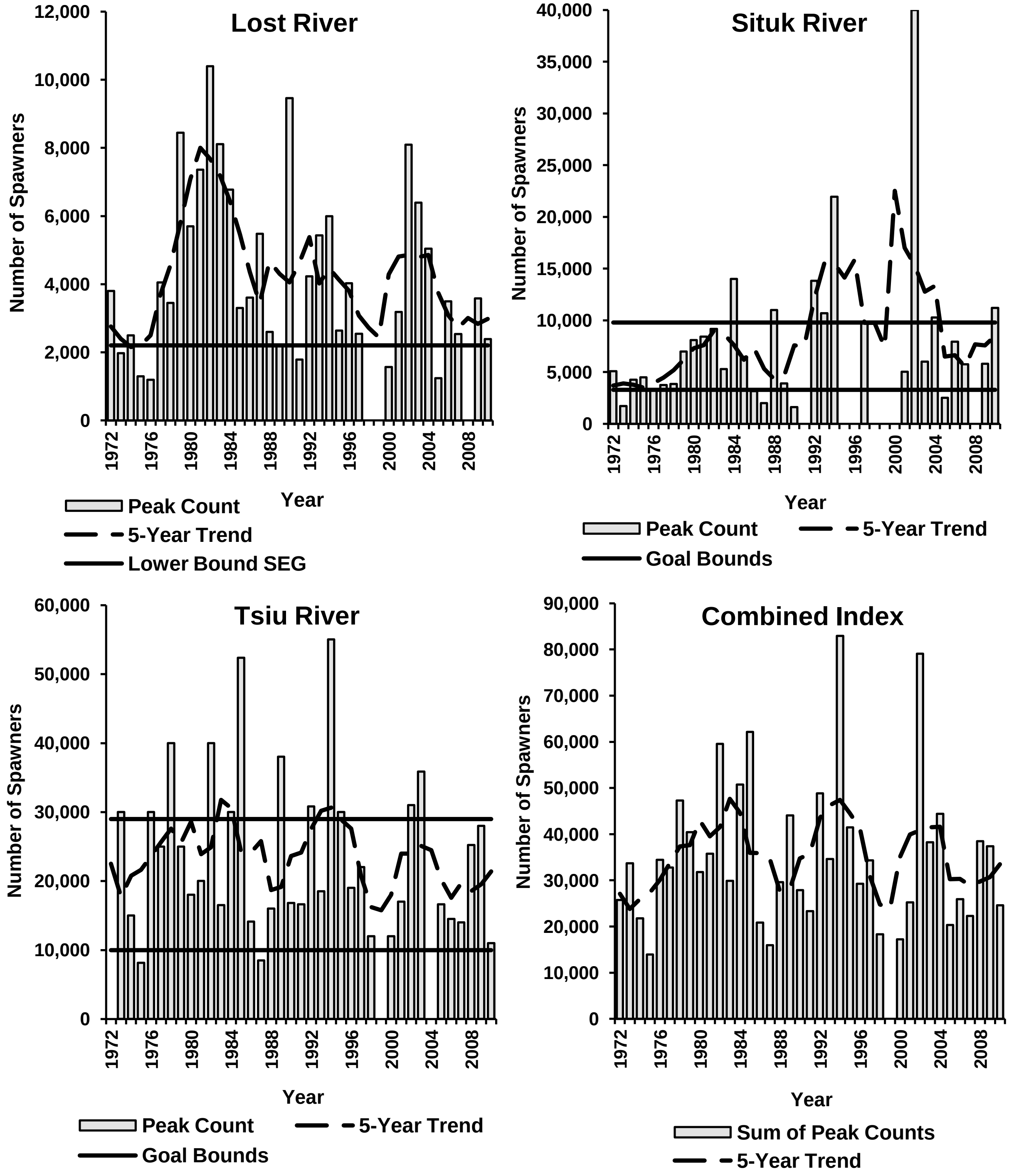


Figure 7.–Peak coho salmon escapement survey counts for 3 systems in the Yakutat area and the combined count for all 3 systems, 1972–2010. Also shown are 5-year symmetrical average trends and escapement goal ranges. The total index includes interpolations for systems without counts in all years, except 1999 (see Escapement Indicators section for a description of the method used).

Table 6.–Yakutat area coho salmon peak escapement survey counts and available total escapement estimates, 1972–2010.

	Lost River		Situk River		Tsiu River	Total
Year	Count	Mark-Recapture	Count	Mark-Recapture	Count	Count[a]
1972	3,800	–	5,100	–	–	25,773
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	23,361
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	41,474
1996	4,030	–		–	19,000	29,261
1997	2,550	–	9,780	–	22,000	34,330
1998	–	–	–	–	12,000	18,330
1999	–	–	–	–	–	–
2000	1,572	–	–	–	12,000	17,244
2001	3,190	–	5,030	–	17,000	25,220
2002	8,093	–	40,000	–	31,000	79,093
2003	6,396	23,685	6,009	–	35,850	38,254
2004	5,047	47,566	10,284	49,582	–	44,396
2005	1,241	–	2,514	33,644	16,600	20,355
2006	3,500	–	7,950	23,169	14,500	25,950
2007	2,542	–	5,763	–	14,000	22,305
2008	–	–	–	–	25,200	38,493
2009	3,581	–	5,814	–	28,000	37,395
2010	2,393	–	11,195	–	11,000	24,588
Average	4,332	35,626	8,046	35,465	23,679	35,399
Goals:						
Lower Bound	2,200		3,300		10,000	
Upper Bound	–		9,800		29,000	

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

Table 7.–Total coho smolt and presmolt production estimates for 7 wild coho salmon-producing systems in Southeast Alaska by age-.1 return year, 1980–2011.

Return Year	Auke Creek Smolts	Berners River Smolts	Chilkat River Smolts	Taku River Smolts	Ford Arm Creek Presmolts	Hugh Smith Lake Smolts	Chuck Creek Smolts
1980	8,789	–	–	–	–	–	–
1981	10,714	–	–	–	–	–	–
1982	6,967	–	–	–	79,059	–	–
1983	6,849	–	–	–	63,686	29,117	–
1984	6,901	–	–	–		53,227	–
1985	6,838	–	–	–	38,509	32,283	–
1986	5,852	–	–	–	45,748	23,572	–
1987	5,617	–	–	–	70,322	21,878	–
1988	7,014	–	–	–	88,983	36,218	–
1989	7,685	–	–	–	51,658	27,904	–
1990	7,011	163,998	–	–	54,851	26,620	–
1991	5,137	141,291	–	–	56,284	33,101	–
1992	5,690	187,688	–	1,080,551	61,728	23,373	–
1993	6,596	326,312	–	1,510,032	57,401	32,657	–
1994	8,647	255,519	–	1,475,874	82,893	48,434	–
1995	7,495	181,503	–	1,525,330	134,640	49,516	–
1996	4,884	194,019	–	986,489	91,605	22,267	–
1997	3,934	133,629	–	759,763	66,772	32,294	–
1998	6,111	139,959	–	853,662	80,517	37,436	–
1999	7,420	252,168	–	1,184,195	132,655	29,875	–
2000	5,233	183,023	1,237,056	1,691,411	62,444	19,902	–
2001	4,969	268,777	1,185,804	1,811,038	102,610	23,327	–
2002	5,980	264,599	2,970,458	2,741,593	102,918	36,487	–
2003	3,616	151,980	1,696,212	2,737,851	77,081	26,841	12,487
2004	3,695	185,125	1,938,322	2,961,344	101,579	22,997	29,302
2005	4,549	144,778	776,934	3,755,274	120,632	39,924	17,507
2006	4,287	124,070	1,807,837	2,149,673	98,470	28,184	10,306
2007	4,515	115,845	875,478	3,152,471	84,017	37,267	15,604
2008	4,053	89,177	893,032	3,344,590	72,315	28,793	17,327
2009	3,815	102,318	716,689	2,803,021	96,180	24,006	15,471
2010	4,667	161,112	871,220	2,270,500	64,349	25,813	22,651
2011	6,053	130,795	1,026,314	1,677,123	85,428	37,862	[a]
Average	5,987	177,168	1,332,946	2,023,589	80,184	31,420	17,582

[a] Project discontinued.

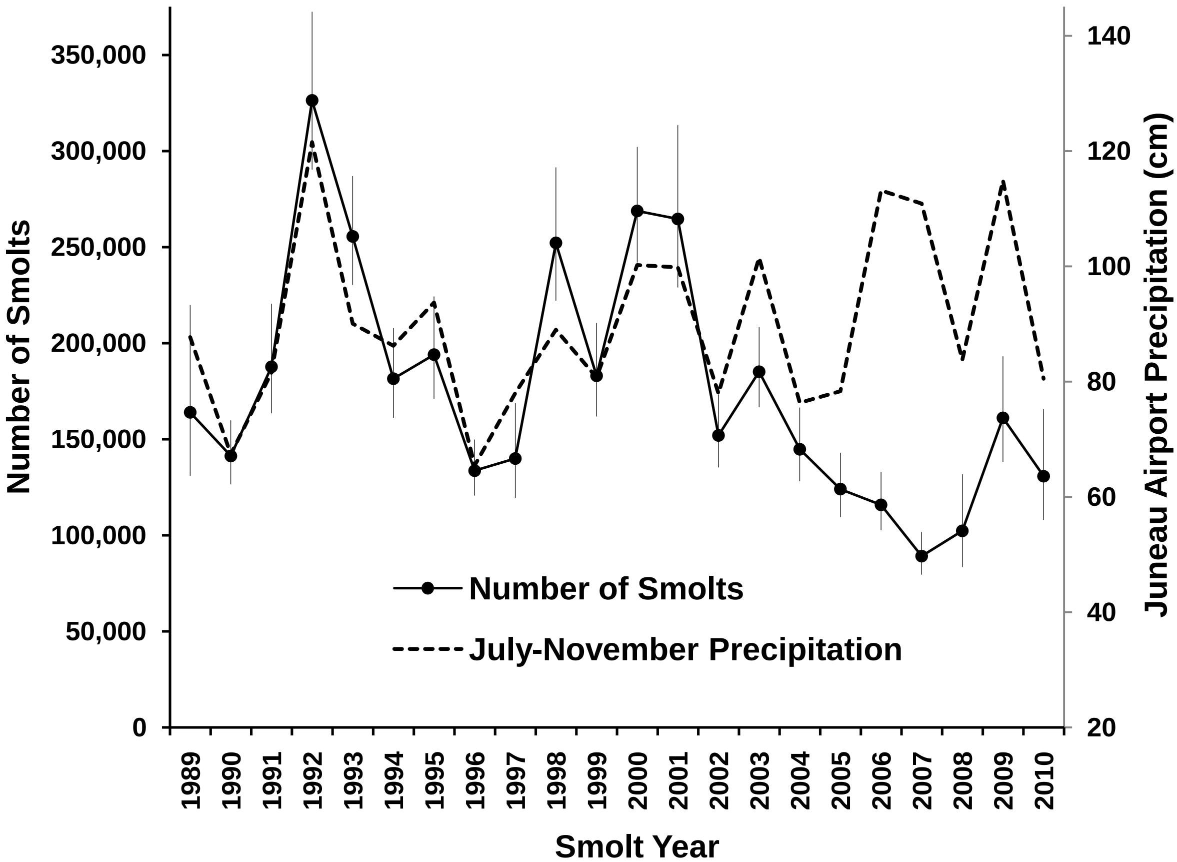


Figure 8.–Berners River coho salmon smolt estimates (with 95% confidence bounds) and total July-November precipitation at the Juneau Airport in the prior year, 1989–2010. The 2010 estimate is very preliminary.

Shaul et al. (*in prep*) examined more closely the relationship between coho salmon production and marine-derived nutrient loading by pink salmon and other species. They found freshwater production of coho salmon in the Ford Arm Creek to be positively correlated with pink salmon escapement in (a) the common brood year for both species, (b) the following brood year, and (c) the average for both years, up to a saturation level at about 116,000 pink salmon (peak count), above which there appeared to be no further response. The relationship, fitted with a logistic hockey stick model, suggests an approximate doubling of coho salmon production as pink salmon escapement increases from zero to a peak survey count of approximately 116,000 spawners. When divided by total stream and lakeshore area of 175,721 m^2, the estimated pink salmon carcass density associated with the nominal saturation point is 1.4 carcasses/m^2. This value is consistent with the growth response by juvenile coho salmon to addition of pink salmon carcasses in an artificial stream channel observed by Wipfli et al. (2003), who found a substantial response in increased mass and length to coho salmon fry exposed to pink salmon carcass densities between 0 and 1 carcass/m^2, with incremental increases sharply diminishing at higher carcass densities up to 4 carcasses/m^2. However, accounting for the contribution by carcasses of all species in Ford Arm Creek (of which pink salmon contributed 76% by mass on average), the number of total pink salmon equivalents associated with the nominal saturation point is approximately 1.8 carcasses/m^2.

Smolt production from Hugh Smith Lake, the southern inside indicator stock, has shown no evident trend over a 29-year period (1984–2011 return years) when production averaged 31,420 smolts (Table 7). There is also no evident trend in the shorter 8-year data series for Chuck Creek on the southern outside coast, where production averaged 17,582 (range 10,306–29,302) smolts for the 2003–2010 adult returns.

MARINE SURVIVAL

Marine survival rates for wild indicator stocks increased in the early 1980s and reached a peak in the early to mid-1990s before declining to more moderate levels from 1995 to 2004 (Figure 9; Table 8). Survival rates then declined, reaching a recent low in northern inside systems (Auke Creek and Berners, Chilkat and Taku rivers) in 2007 at an average of 7.0% (range 4.2–11.9%). Survival rates then rebounded in all 4 systems to an average of 14.6% (range 10.9–17.7%) in 2010. The southern inside indicator stock (Hugh Smith Lake) showed a similar pattern, although it bottomed in 2006 at 6.8% before rebounding consistently in each of the following 4 years to a record 21.0% in 2010. Regionally, the mean-average survival rate for the 6 stocks shown in Table 8 increased from 9.5% in 2005–2007 to 12.8% in 2008–2010.

Outer coastal stocks, represented by Ford Arm Creek and Chuck Creek, have shown somewhat different patterns. Survival of Ford Arm Creek presmolts was close to average in 2007 at 10.3%, but declined to only 7.4% in 2009 and 7.0% in 2010 (Figure 9; Table 8). Chuck Creek marine survival reached a peak of 15.6% in 2009 before falling to a below-average 7.2% in 2010.

Marine survival has been, on average, a more important determinant of adult return compared with smolt production, based on their relative contributions to the combined coefficient of variation squared (CV^2). On average, through 2010, 55% of the variation in the adult return to indicator systems has been attributed to marine survival compared with 45% for freshwater factors, including parent spawning escapement (Figure 10). The estimates ranged from 64% marine and 36% fresh water for Auke Creek to near parity (51% marine and 49% fresh water) for 2 mainland river systems (Berners and Taku rivers). For Ford Arm Creek, the results were similar to the 2 other lake systems (Auke Creek and Hugh Smith Lake), with 62% of variation in adult production attributed to variation in survival from tagging to adulthood compared with 38% attributed to variation in the number of presmolts. However, the survival estimate for that system includes a portion of the freshwater residence period.

Hatchery Survival Rates

Releases of coho salmon from Southeast Alaska hatcheries have increased steadily over the past 3 decades, from fewer than 1 million fish in 1980 to 19.0 million fish in 2009 (Figure 11). However, the aggregate contribution by hatcheries to common property fisheries has not shown a commensurate increase. The estimated troll catch of hatchery coho salmon reached a peak, along with the all-gear catch, in the early 1990s, but has since declined. The 20-year linear trend from 1991 to 2010 decreased by 40% in the troll catch (Figure 11) and 43% in the all-gear commercial catch. Much of the decline can be attributed to an overall decline from peak survival and abundance for both wild and hatchery stocks in the early 1990s as shown in total wild abundance estimates that declined by 15% (Figure 18) and average wild stock survival rates that declined by 35% (Figure 9). However, the hatchery fraction of the aggregate troll catch (Figure 11), as well as in the all-gear commercial catch, show a slight negative slope, despite a tripling of smolts, presmolts, and fingerlings released from 1990 to 2009.

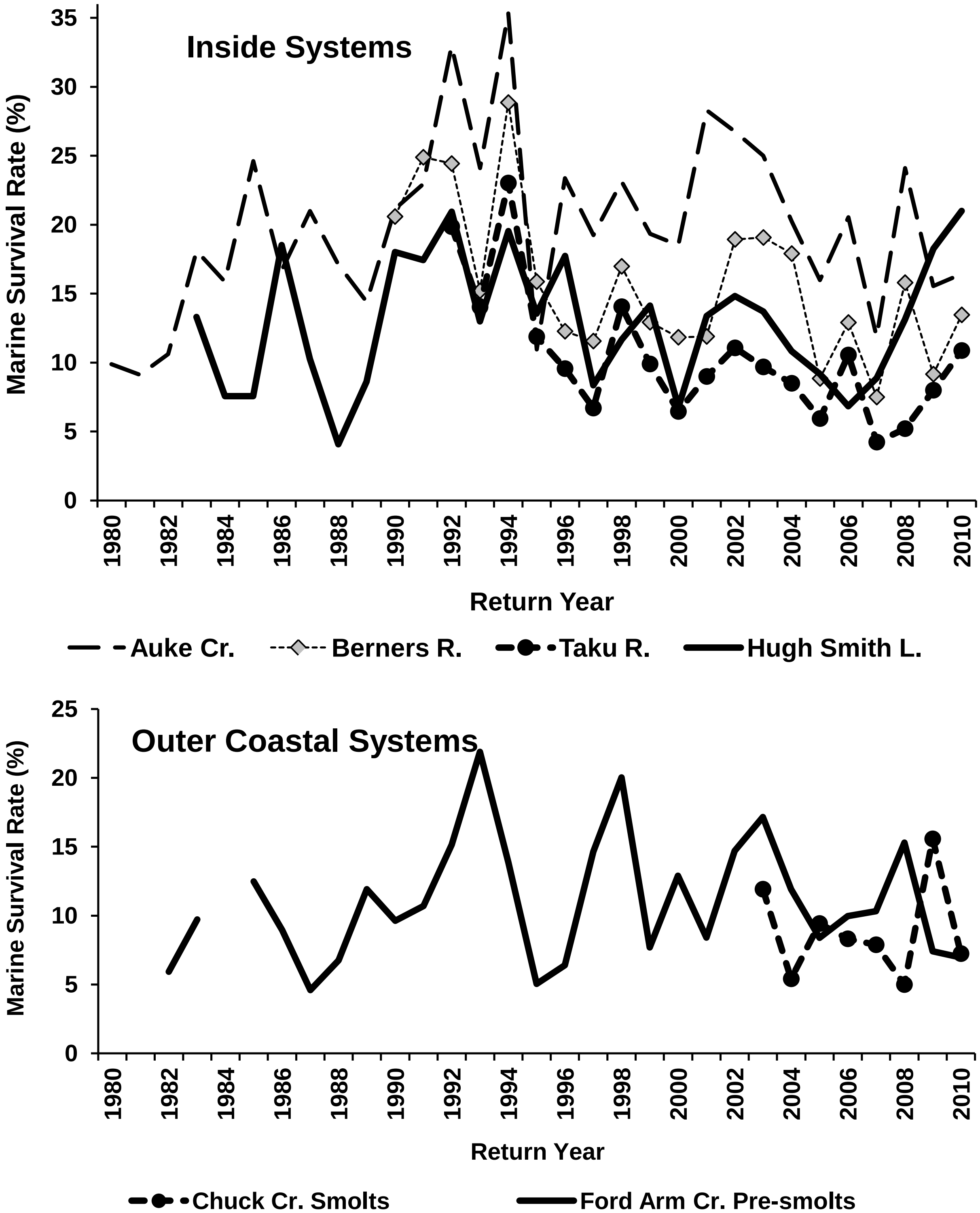


Figure 9.–Estimated marine survival rate for wild coho salmon smolts from 4 systems in inside areas of Southeast Alaska (upper graph) and smolts from one system and presmolts from one system on the outer coast of Southeast Alaska (lower graph), 1980–2010. The estimates for Ford Arm Lake presmolts include approximately 10 months of mortality from July to May.

Table 8.–Estimated survival rate (percent) of coho salmon smolts and presmolts from 7 wild Southeast Alaska indicator stocks from the time of tagging until return to the fisheries, 1980–2010.

Return Year	Auke Creek Smolts	Berners River Smolts	Chilkat River Smolts	Taku River Smolts	Ford Arm Lake Presmolts	Hugh Smith Lake Smolts	Chuck Creek Smolts
1980	9.9	–	–	–	–	–	–
1981	9.1	–	–	–	–	–	–
1982	10.6	–	–	–	5.9	–	–
1983	18.1	–	–	–	9.7	13.3	–
1984	15.9	–	–	–	–	7.6	–
1985	24.6	–	–	–	12.5	7.6	–
1986	16.6	–	–	–	9.0	18.5	–
1987	21.0	–	–	–	4.6	10.3	–
1988	17.1	–	–	–	6.8	4.1	–
1989	14.4	–	–	–	11.9	8.6	–
1990	21.1	20.6	–	–	9.6	18.0	–
1991	23.0	24.9	–	–	10.7	17.4	–
1992	33.0	24.4	–	19.9	15.1	20.9	–
1993	24.1	15.2	–	14.0	21.9	13.0	–
1994	35.3	28.9	–	23.0	13.9	19.5	–
1995	10.9	15.9	–	11.9	5.0	13.5	–
1996	23.4	12.3	–	9.6	6.4	17.7	–
1997	19.2	11.6	–	6.7	14.6	8.3	–
1998	23.1	17.0	–	14.0	20.0	11.7	–
1999	19.3	12.9	–	9.9	7.7	14.1	–
2000	18.5	11.8	10.1	6.5	12.9	6.8	–
2001	28.3	11.9	13.1	9.0	8.4	13.4	–
2002	26.8	18.9	10.7	11.1	14.7	14.8	–
2003	25.0	19.1	12.9	9.7	17.1	13.7	11.9
2004	20.2	17.9	10.3	8.5	11.9	10.8	5.4
2005	16.0	8.8	8.4	5.9	8.4	9.1	9.4
2006	20.5	12.9	8.4	10.5	10.0	6.8	8.3
2007	11.9	7.5	4.3	4.2	10.3	8.9	7.9
2008	24.1	15.8	12.4	5.2	15.3	13.1	5.0
2009	15.5	9.2	11.3	8.0	7.4	18.3	15.6
2010	16.4	13.5	17.7	10.9	7.0	21.0	7.2
Average	19.8	15.8	10.9	10.4	11.0	12.9	8.8

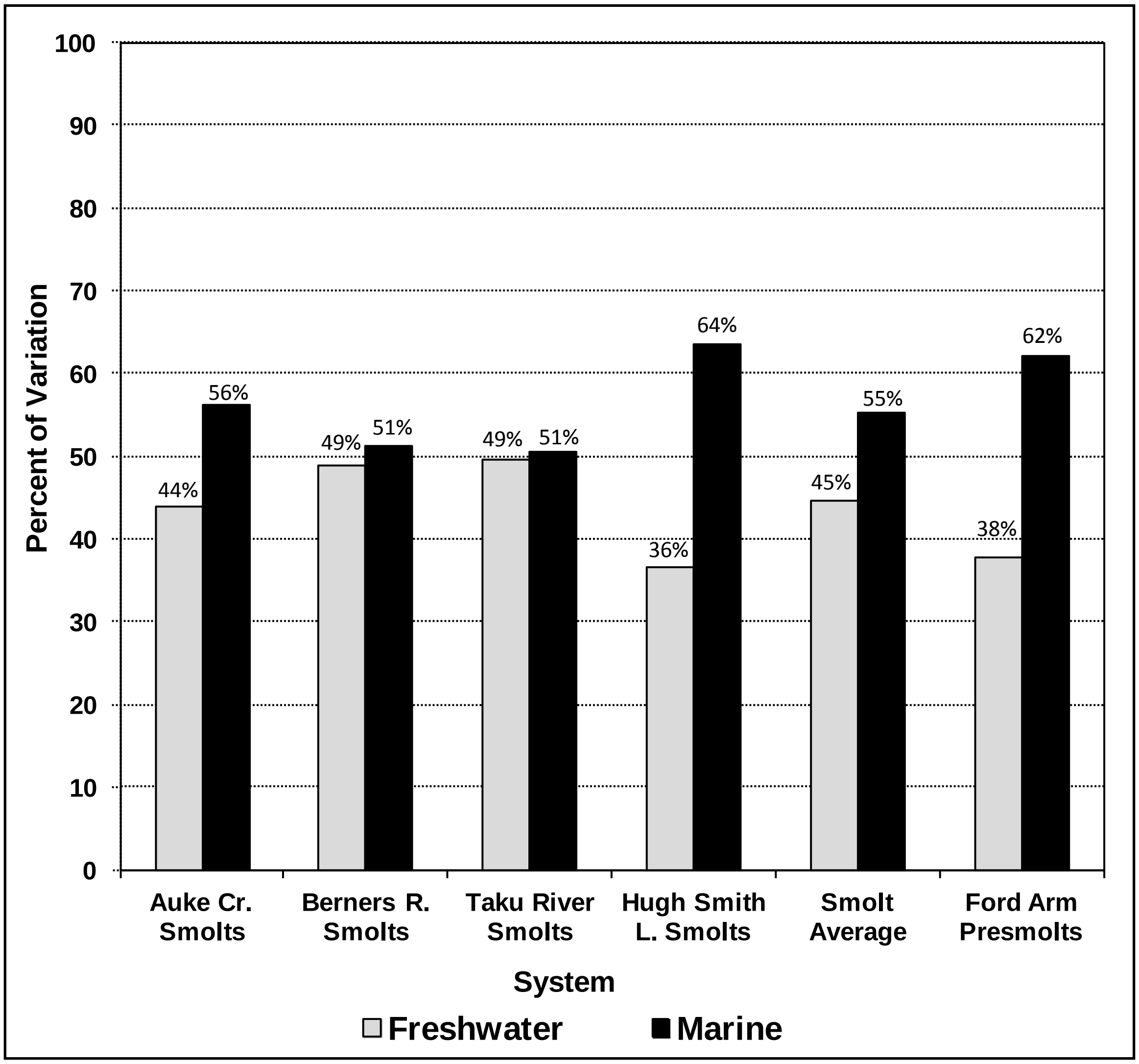


Figure 10.–Percent of variation in total adult run size attributed to freshwater influences (including spawning escapement) and marine survival, 1980–2010. Ford Arm Creek juveniles were marked in mid-July of the year before sea-migration, so survival estimates for that system include the last 10 months of freshwater residence.

The lack of both an absolute and proportionate positive response to increasing hatchery releases indicates that either wild smolt production has increased in proportion to hatchery releases over the period (which is not evident in most of the indicator stocks), or that hatchery smolts have progressively underperformed wild smolts in marine survival over time.

We therefore compared hatchery and wild survival rates over time (Figure 12), focusing only on streams, facilities, and release locations with a substantial history of consistent releases based on wild stock survival estimates in Table 8 and survival rate estimates reported by hatchery operators and compiled by Skannes et al. (2011). Hatchery survival rates have averaged substantially lower, 69% of the rate for wild indicator stocks in northern Southeast and 62% in southern Southeast. Interestingly, hatchery survival rates in both regions began at near-parity with wild indicator survival rates and then declined (Figure 13). Both regions show a slight rebound in the hatchery-to-wild survival ratio in the early-2000s before decreasing again later in the decade.

For northern Southeast, there was a 48% decline in the average hatchery-wild survival ratio from 0.86 in the first 3 years of the time series (1991–1993) to 0.45 in the last 3 years (2008–2010). For southern Southeast, there was a 53% decline in the average hatchery-wild survival ratio from 1.10 in the first 3 years of the time series (1983–1985) to 0.51 in the last 3 years (2008–2010). Although these estimates indicate a relative decrease in survival, the decline in survival of longer-established hatchery stocks in comparison with wild stocks is far from adequate to fully explain the absence of an adult production response to an overall tripling of hatchery releases in the region. Spectacularly poor success by a few major new programs has been a substantial factor in the lack of increase in overall adult production.

We suspect that the decrease in marine survival relative to wild stocks over time is, in part, the result of development of predator fields attracted to large point sources of smolts entering marine waters (Nickelson 2003, Beamish et al. 1992). Development of predator fields affecting marine survival around larger annual point sources of salmon smolts may not be unique to hatcheries in the region. Shaul et al. (2003) noted a strong inverse relationship between total salmon production and average marine survival in both the northern inside area (Auke Creek, Berners River, and Taku River) and in the southern boundary area (Hugh Smith Lake, Lachmach River, and Nass River) based on estimates reported by the Joint Northern Boundary Technical Committee (2002). The broad dispersion of point sources of wild coho salmon smolts in Southeast Alaska, because of the region’s high rainfall, extensive shoreline, and large number of small primary streams, may be a substantial advantage to their marine survival.

Both wild and hatchery survival rates averaged higher in northern Southeast compared with southern Southeast during most period of record, but the trend has increasingly favored southern Southeast since 2004 (Figure 14).

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 9–15 and figures 15–17.

The 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 (Figures 15 and 16; Tables 9, 10, 12, and 13) 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 133,300 fish was the smallest return since 1997 (Figure 16; Table 13). Returns to these inside systems have since rebounded substantially through 2010.

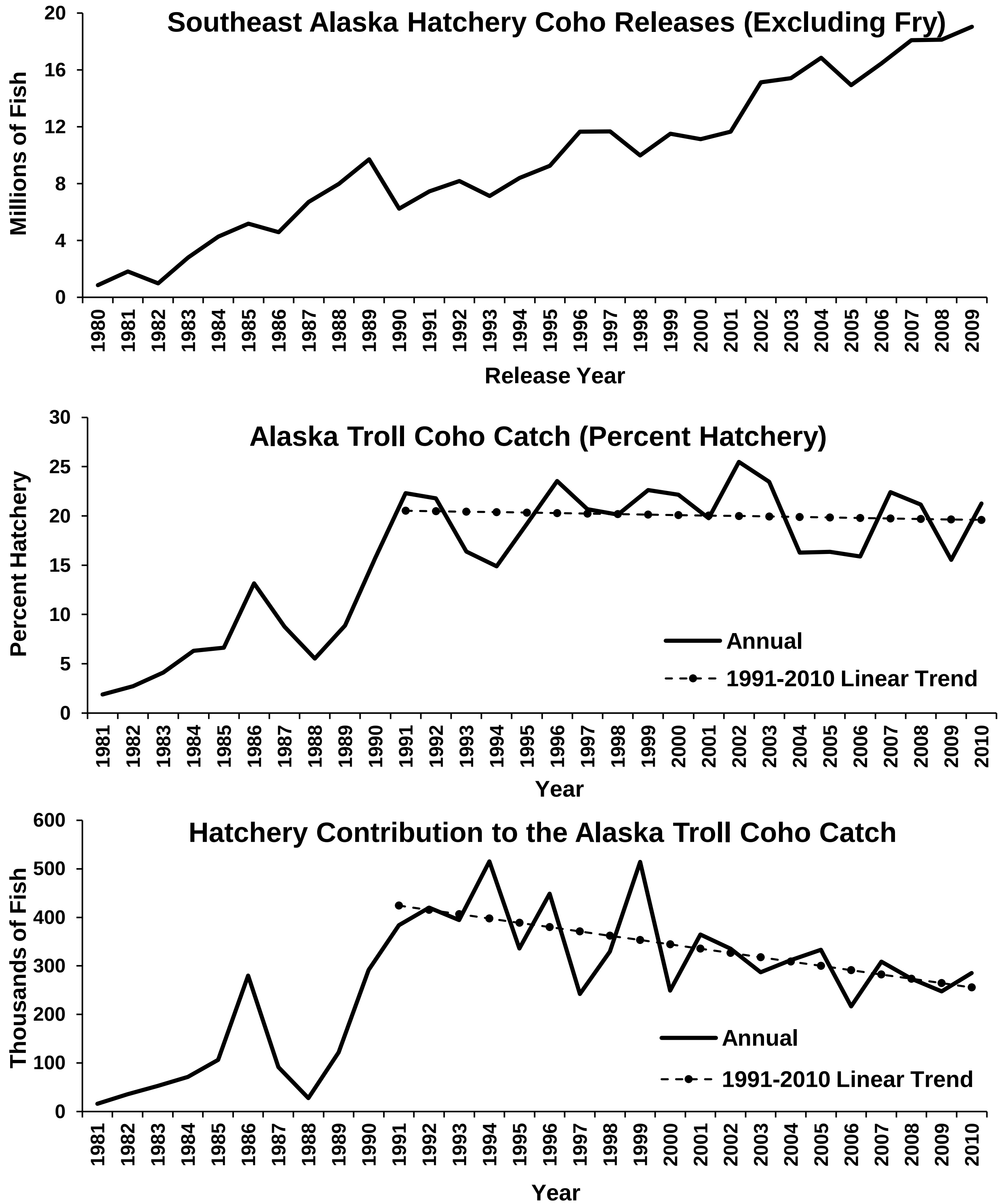


Figure 11.–Releases of coho salmon (excluding fry) from Southeast Alaska hatcheries, the percent of the troll catch comprised of fish of hatchery origin, and the number of hatchery fish contributed to the Alaska troll coho salmon catch, 1981–2010.

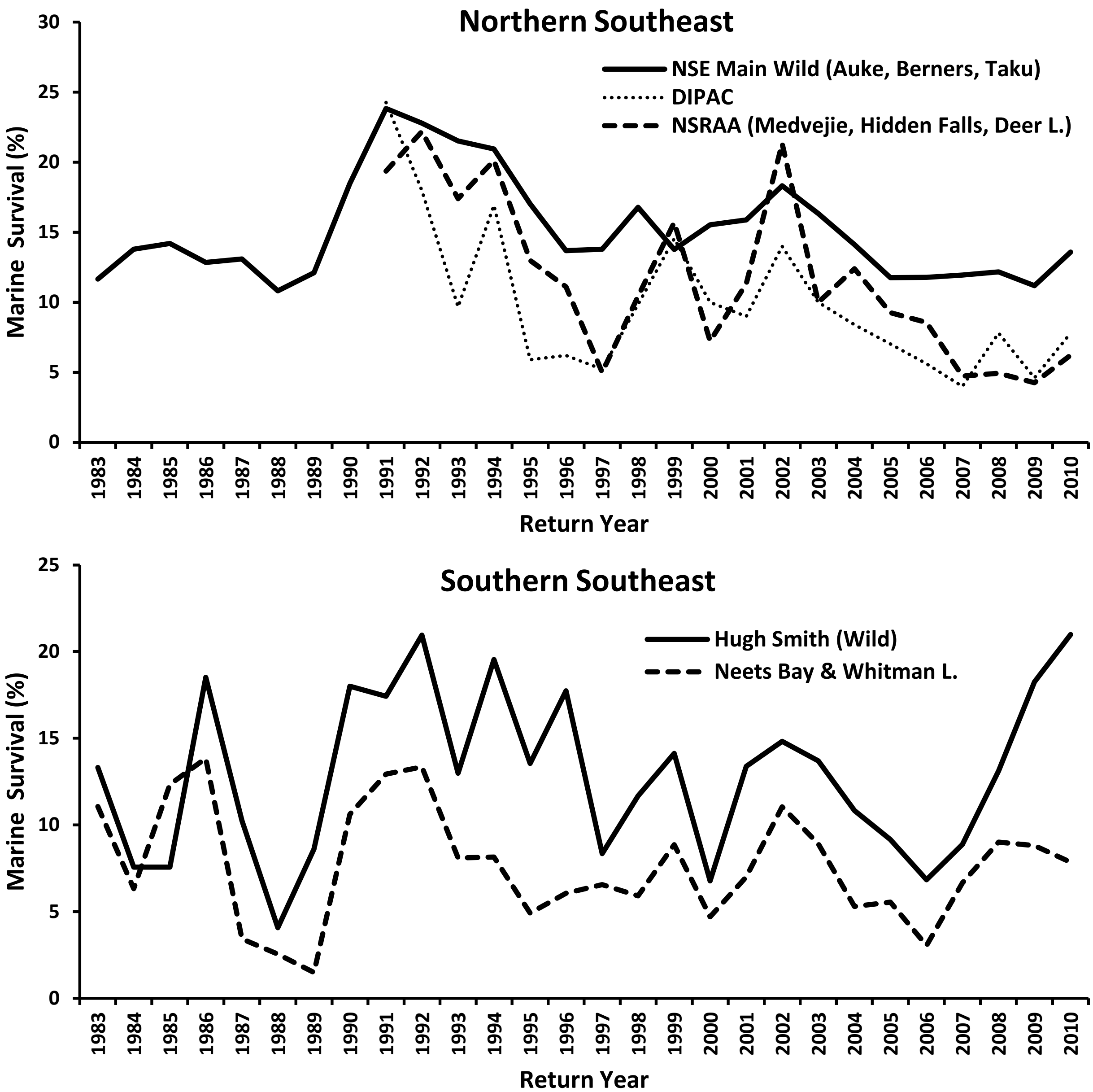


Figure 12.–Average marine survival estimates for long-term, consistent wild and hatchery release locations in northern and southern Southeast, 1983–2010. Statistical interpolations were made for missing estimates for within wild and hatchery groups in each region.

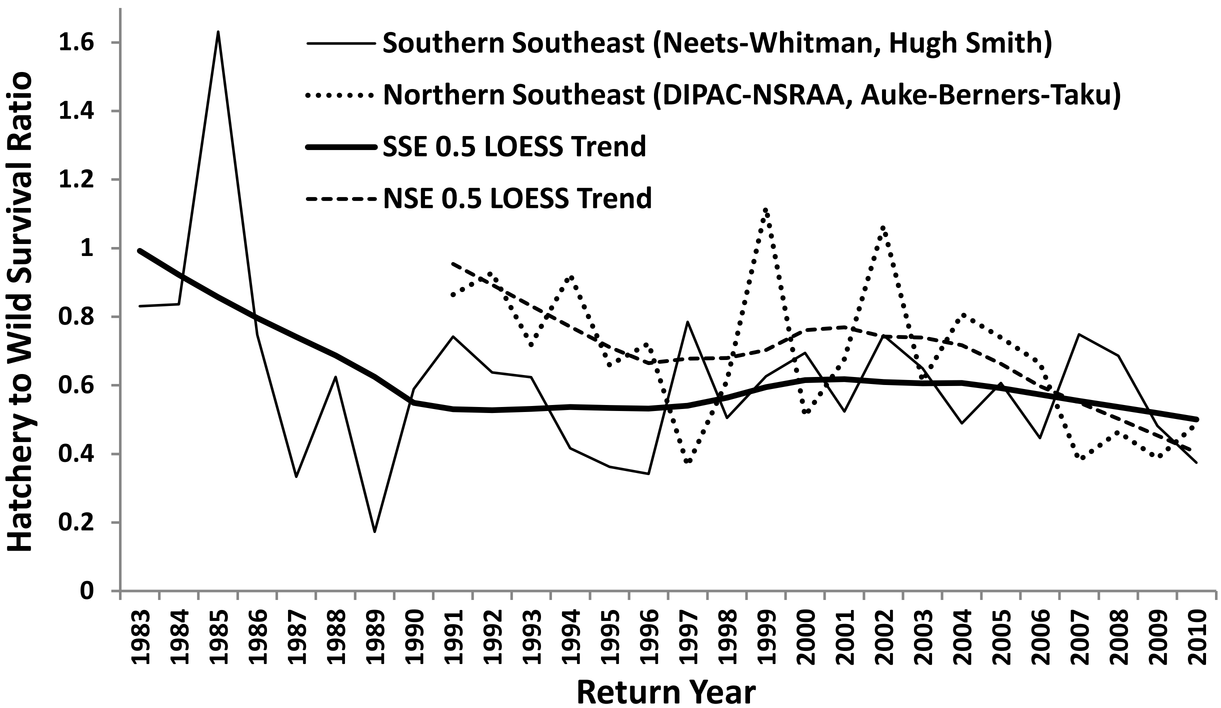


Figure 13.–Ratio of the average hatchery to average wild marine survival rate for long-term wild indicator stocks and hatchery release locations within northern and southern Southeast Alaska with a 0.5 LOESS trend, 1983–2010.

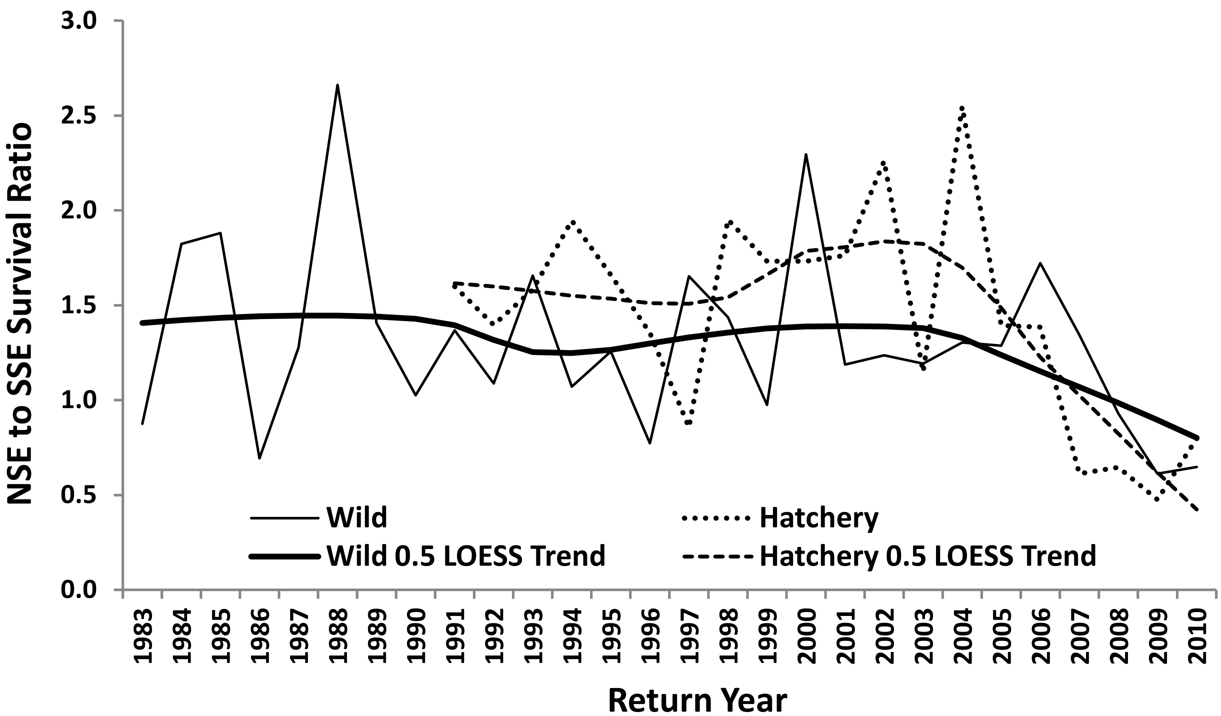


Figure 14.–Ratio of the average marine survival rate in northern Southeast to the average for southern Southeast for long-term wild and hatchery indicator stocks in the 2 regions, with a 0.5 LOESS trend, 1983–2010.

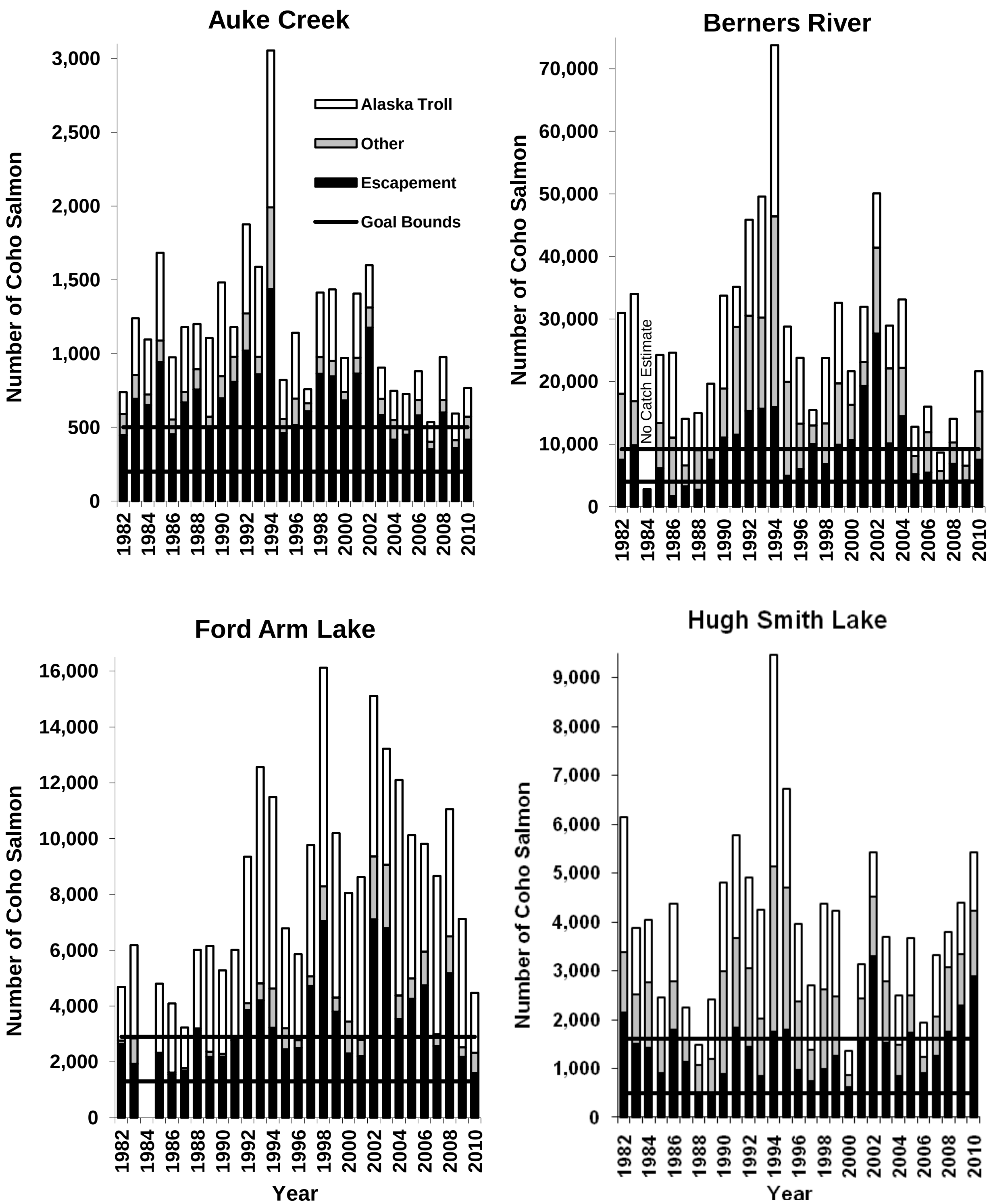


Figure 15.–Total run size, catch, escapement, and biological escapement goal range for 4 wild Southeast Alaska coho salmon indicator stocks, 1982–2010.

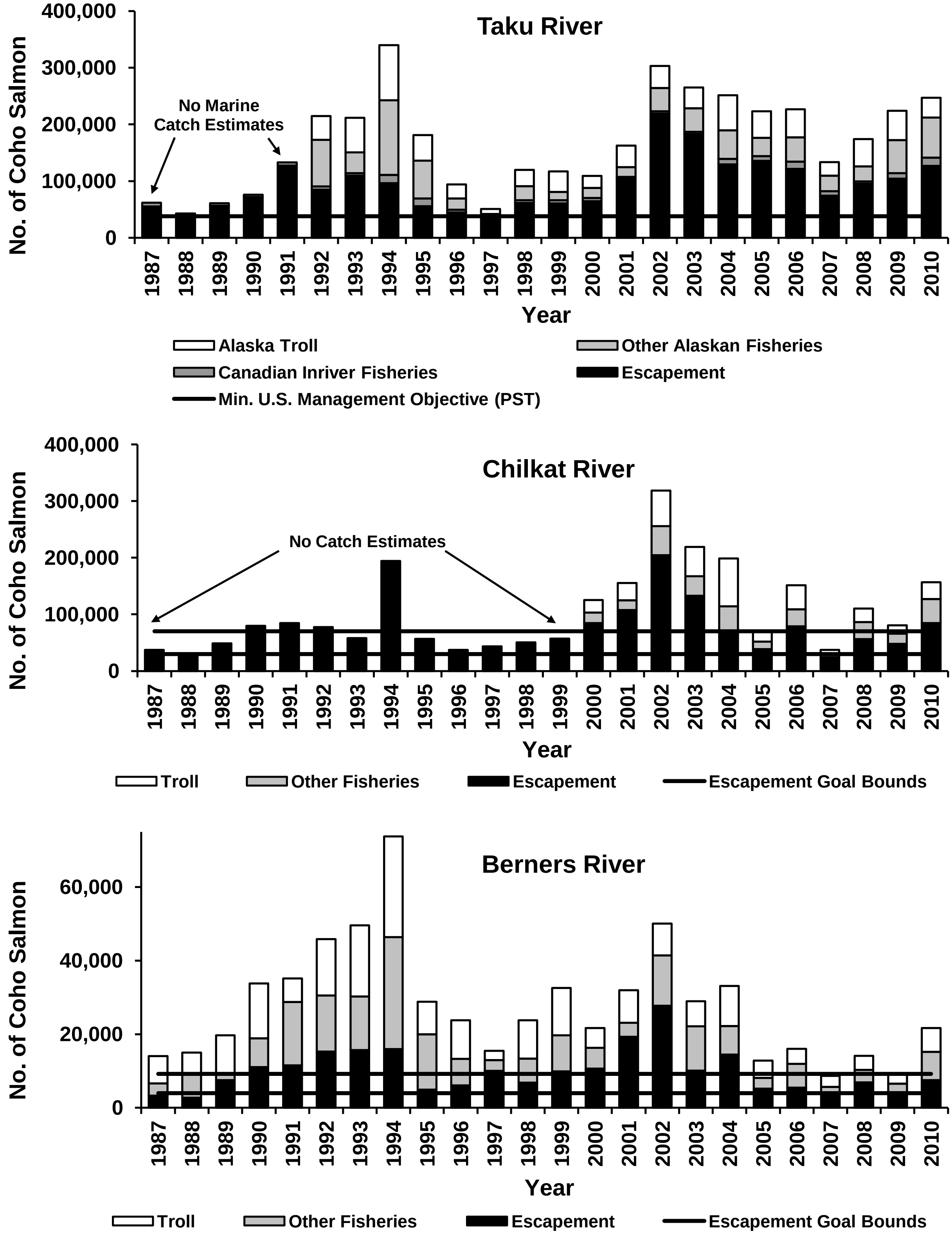


Figure 16.–Total estimated run size, catch, and escapement of coho salmon bound for the Taku River (above Canyon Island) and the Chilkat and Berners rivers, 1987–2010.

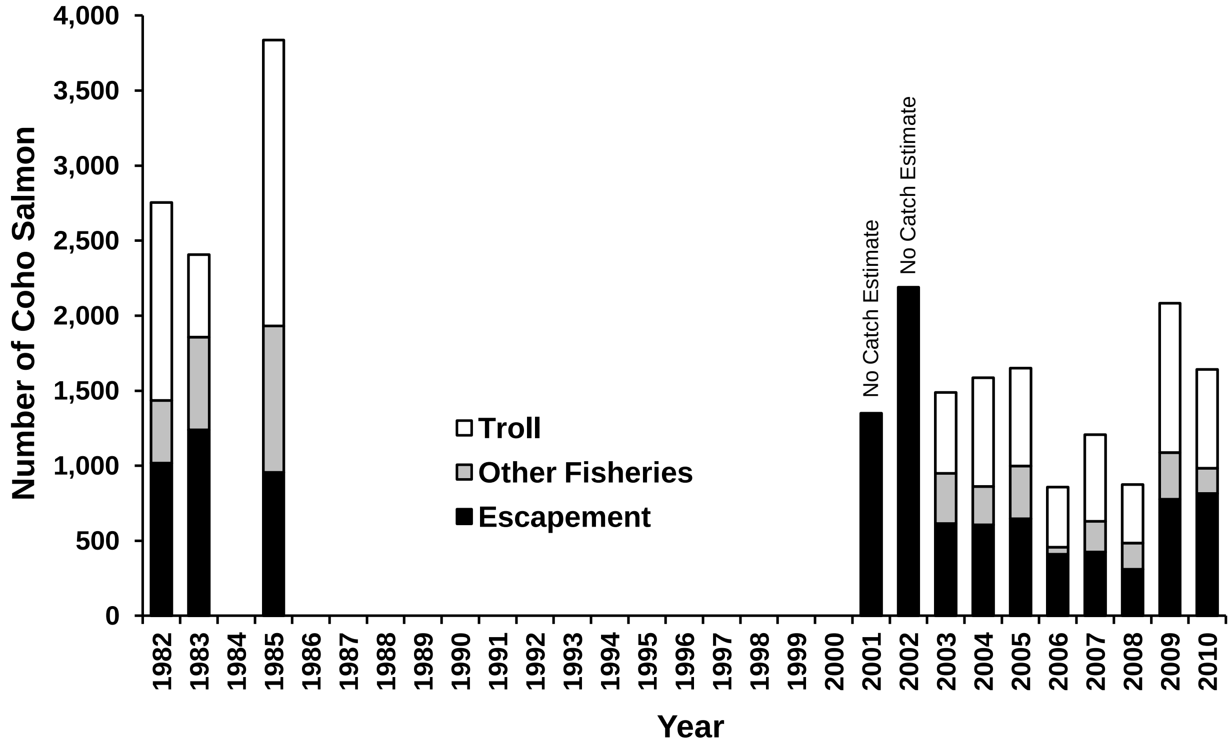


Figure 17.–Total run size, catch, and escapement of adult coho salmon returning to Chuck Creek, 1982–2010.

The return to Ford Arm Creek on the outer coast has been poorly correlated with most inside systems (Shaul et al. 2009). Estimated returns to that system increased dramatically from an average of 5,164 adults in 1982–1991 to 10,027 adults in 1992–2010, with peaks of 16,124 adults in 1998 and 15,118 adults in 2002 (Figure 15; Table 11). However, returns have been lower in most years since 2005, while the 2010 return of only 4,473 adults was the lowest since 1987 and the third lowest return in 28 years.

Recent estimated Chuck Creek returns of 857–2,083 (average 1,423) adults during 2003–2010 were far smaller than 1982–1985 returns, averaging 3,000 (range 2,407–3,837) adults (Figure 17; Table 15). However, escapement counts of 1,350 adults in 2001 and 2,189 adults in 2002 suggest total returns were strong in those years. The Chuck Creek drainage was heavily logged to the creek bank and lakeshore in most areas in the 1970s and 1980s. That activity likely reduced habitat structure in the system, increased solar exposure, and elevated temperatures. There has been substantial regrowth and beaver pond development in recent years. This pattern of widespread disturbance, followed by succession, has likely had a substantial influence on coho salmon returns.

REGIONAL WILD ABUNDANCE

The projected commercial catch of wild coho salmon was established in the 1980s as a proxy for total abundance in determining the need for an early-season troll fishery closure under Alaska regulatory statute (5 AAC 29.110). Specifically, the department may close the coho salmon troll fishery in the Southeastern Alaska-Yakutat Area for up to 7 days, on or after July 25, if the total projected commercial harvest of wild coho salmon is less than 1.1 million fish. When this regulation was established, the commercial harvest of wild fish was considered the best available proxy for aggregate wild coho salmon abundance returning to the region.

However, a weakness in using commercial catch as a proxy for abundance is the assumption of a stable total exploitation rate, while exploitation rates have, in fact, varied substantially. Therefore, a more stable index of total abundance has been developed based on the estimated troll catch of wild coho salmon and an index of the troll exploitation rate using estimates for 3 wild indicator stocks distributed across the region (Auke Creek, Ford Arm Creek, and Hugh Smith Lake). These indicator stock projects were selected because of their precise accounting of escapement, their long-term history of estimates, and their geographic distribution. Auke Creek and Hugh Smith Lake appear to be suitable representatives for major stock aggregates in inside production areas of northern and southern Southeast, respectively. Ford Arm Creek likely represents the more heavily exploited milling-type stock on the outer coast and is consistently heavily exploited by the troll fishery. The Ford Arm Creek stock receives only half weighting (20%) in the index compared with Auke Creek and Hugh Smith Lake (40% each) out of concern that it is not as broadly representative as the other two, and is exploited by the troll fishery at rates that are far above average for indicator stocks in the region. For example, the nearby Nakwasina River stock in Sitka Sound, also on the outer coast, is more migratory and has been exploited by the troll fishery at a far lower rate averaging 26% during 2000–2007 (Shaul et al. 2008), compared with 52% for Ford Arm Creek.

Total wild coho salmon abundance available to the troll fishery (Table 16) was estimated by dividing the estimated wild catch of coho salmon by the Alaska troll fishery by the Alaska troll fishery exploitation rate, based on the above-described weighted average for the three indicator stocks. We also examined the season total (statistical weeks 28–38) mean-average catch-per-boat-day (CPUE) by power trollers in relation to the total wild abundance, as well as wild commercial catch (Figure 18). Since power troll CPUE is a primary inseason indicator used to assess aggregate abundance, it is important to account for its historical relationship.

There was a substantial upward shift in mean-average power troll wild CPUE relative to estimates of aggregate wild coho salmon abundance between 1995 and 1996. Mean-average power troll CPUE has maintained about the same correlation coefficient with abundance between the periods 1982–1995 and 1996–2010 (R^2 = 0.74), but CPUE was about 23% higher relative to abundance during the latter period (Figure 19).

This shift occurred concurrently with increasing price and cost pressures on the fishery in the mid-1990s. Although some power troll vessels departed the fishery between 1995 and 1996 and technological improvements may have contributed to increased effectiveness of a boat-day of effort, we believe from discussions with trollers that reduced willingness to fish in areas and times of lower abundance was a primary factor in the shift. Troll effort in power-troll boat-days concurrently declined sharply from an average of 49,400 boat-days during 1982–1995 to 26,000 boat-days during 1996–2010 (Table 16). The record low of 20,394 boat-days in 2002 occurred in a year of high abundance, but very low salmon prices and low exploitation rates. With improving prices, troll effort has since increased to 31,157 boat-days in 2010, the highest level since 1999.

Meanwhile, the all-gear wild commercial catch has fallen as a fraction of the abundance index from an average of 64% during 1982–1999 to only 50% during 2000–2010, as exploitation rates have declined. The troll exploitation rate used to calculate the index decreased from an average of 39% to 32% between those periods.

Table 9.–Estimated harvest by gear type, escapement, and total run of coho salmon returning to Auke Creek, 1980–2010.

Year	Fishery Sample Size	Number of Fish: Troll	Seine	Drift Gillnet	Sport	Total Catch	Escapement	Total Return
1980	15	117	0	29	24	170	698	868
1981	70	280	0	31	19	330	646	976
1982	45	149	117	24	2	292	447	739
1983	129	385	10	28	122	545	694	1,239
1984	124	372	8	13	51	444	651	1,095
1985	177	594	3	71	73	741	942	1,683
1986	110	421	2	60	37	520	454	974
1987	145	438	2	48	23	511	668	1,179
1988	145	306	12	72	55	445	756	1,201
1989	182	533	7	15	49	604	502	1,106
1990	168	635	15	57	78	785	697	1,482
1991	47	200	8	152	11	371	808	1,179
1992	53	603	10	196	46	855	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	26	299	581	880
2007	47	134	6	30	14	184	352	536
2008	105	292	0	76	9	377	600	977
2009	75	179	0	46	8	233	360	593
2010	86	194	0	134	22	350	417	767
Average		356	18	66	40	479	679	1,158

Table 10.–Estimated harvest by gear type, escapement and total run of coho salmon returning to the Berners River, 1982–2010.

Year	Fishery Sample Size	Number of Fish								
		Troll	Seine	Drift Gillnet	Sport	B.C. Net	Cost Recovery	Total Catch	Escapement	Total Return
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
2008	421	3,790	0	3,386	38	0	0	7,214	6,870	14,084
2009	201	2,807	36	2,037	258	0	0	5,138	4,230	9,368
2010	325	6,472	109	7,264	315	0	0	14,160	7,520	21,680
Average		9,726	211	8,136	216	0	0	18,289	9,112	27,626

Table 11.–Estimated harvest by gear type, escapement, and total run of coho salmon returning to Ford Arm Creek, 1982–2010.

Year	Fishery Sample Size	Number of Fish: Alaska Troll	Seine	Drift Gillnet	Sport	Canadian Troll	Total Catch	Escapement	Total Return
1982	38	1,927	106	0	0	0	2,033	2,655	4,688
1983	93	3,344	912	0	0	0	4,256	1,931	6,187
1984	–	–	–	–	–	–	–	–	–
1985	49	2,482	0	0	0	0	2,482	2,324	4,806
1986	87	2,483	63	0	0	0	2,545	1,552	4,097
1987	71	1,458	81	0	0	0	1,539	1,694	3,233
1988	151	2,816	46	0	0	31	2,893	3,119	6,012
1989	218	3,799	185	0	0	0	3,984	2,176	6,160
1990	174	2,982	100	0	0	0	3,082	2,192	5,274
1991	193	3,203	44	10	0	0	3,257	2,761	6,018
1992	199	5,252	233	0	0	0	5,485	3,866	9,351
1993	349	7,749	434	0	176	0	8,360	4,202	12,562
1994	236	6,856	1,020	0	384	0	8,259	3,227	11,486
1995	82	3,582	759	0	0	0	4,341	2,446	6,787
1996	64	3,083	0	0	281	0	3,364	2,500	5,864
1997	242	4,702	0	0	351	0	5,053	4,718	9,771
1998	320	7,835	435	20	785	0	9,075	7,049	16,124
1999	146	5,893	66	0	436	0	6,395	3,800	10,195
2000	193	4,604	916	14	211	0	5,744	2,304	8,048
2001	131	5,821	115	0	480	0	6,415	2,209	8,624
2002	246	5,751	1,260	0	998	0	8,009	7,109	15,118
2003	225	4,154	504	0	1,770	0	6,429	6,789	13,218
2004	153	7,722	524	0	319	0	8,564	3,539	12,103
2005	81	5,134	60	0	672	0	5,867	4,257	10,124
2006	137	3,866	367	0	844	0	5,078	4,737	9,815
2007	188	5,673	217	7	202	0	6,098	2,567	8,665
2008	231	4,563	1,047	0	277	0	5,887	5,173	11,060
2009	156	4,604	248	0	93	0	4,945	2,181	7,126
2010	96	2,149	582	0	132	0	2,863	1,610	4,473
Average		4,410	369	2	300	1	5,082	3,382	8,464

Table 12.–Estimated harvest by gear type, escapement, and total run of coho salmon returning to Hugh Smith Lake, 1982–2010.

	Fishery	Number of Fish										
Year	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	1,262	175	300	0	74	57	11	186	2,065	1,244	3,309
2008	302	716	244	779	0	33	59	12	192	2,035	1,741	3,776
2009	253	1,049	268	483	0	18	265	0	19	2,102	2,281	4,383
2010	632	1,205	287	692	0	36	218	0	101	2,539	2,878	5,417
Average		1,414	375	522	3	51	199	23	27	2,613	1,406	4,019

Table 13.–Estimated catch and escapement of coho salmon bound for the Taku River above Canyon Island, 1987–2010.

Year	Fishery Sample Size	Number of Fish: Troll	Seine	Gillnet	Marine Sport	Inriver	Total Catch	Escapement	Total Return
1987	–	–	–	–	–	6,519	–	55,457	–
1988	–	–	–	–	–	3,643	–	39,450	–
1989	–	–	–	–	–	4,090	–	56,808	–
1990	–	–	–	–	–	3,788	–	72,196	–
1991	–	–	–	–	–	5,525	–	127,484	–
1992	128	41,736	2,668	76,324	3,337	5,629	129,694	84,853	214,547
1993	121	61,130	2,675	31,440	2,513	4,659	102,417	109,457	211,874
1994	178	97,039	26,352	86,198	19,018	14,786	243,393	96,343	339,736
1995	201	45,041	1,853	56,820	7,857	13,835	125,406	55,710	181,116
1996	136	24,781	220	17,067	2,461	5,119	49,648	44,635	94,283
1997	66	8,822	550	1,490	4,963	2,717	18,542	32,345	50,887
1998	231	28,827	742	19,371	4,428	5,176	58,544	61,382	119,926
1999	252	36,231	2,881	7,507	4,170	5,619	56,408	60,768	117,176
2000	221	21,236	2,132	11,466	4,137	5,478	44,449	64,700	109,149
2001	344	38,326	2,066	11,777	3,094	3,121	58,384	104,394	162,778
2002	397	39,054	3,457	30,894	6,641	3,870	83,916	219,360	303,276
2003	195	36,433	3,646	27,694	10,504	3,776	82,053	183,038	265,091
2004	223	62,002	5,334	30,961	14,107	9,804	122,208	129,327	251,535
2005	90	46,522	4,324	23,546	4,653	8,393	87,438	135,558	222,996
2006	319	49,394	614	37,879	4,621	12,409	104,917	121,778	226,695
2007	150	23,519	6,484	18,795	2,123	8,053	58,974	74,326	133,300
2008	94	47,997	0	25,254	1,530	3,930	78,711	95,360	174,071
2009	300	51,748	4,749	46,838	6,720	9,635	119,690	104,321	224,011
2010	117	34,554	3,988	52,497	14,287	14,666	119,992	126,830	246,822
1992–2010 Average		41,810	3,933	32,306	6,377	7,404	91,831	100,236	192,067
1987–2010 Average		–	–	–	–	6,843	–	93,995	–

Table 14.–Estimated harvest by gear type, escapement, and total run of coho salmon returning to the Chilkat River, 1987–2010.

Year	Fishery Sample Size	Number of Fish: Troll	Seine	Drift Gillnet	Marine Sport	Inriver Sport	Subsistence	Total Catch	Escapement	Total Return
1987	–	–	–	–	–	–	10	–	37,432	–
1988	–	–	–	–	–	–	83	–	29,495	–
1989	–	–	–	–	–	–	60	–	48,833	–
1990	–	–	–	–	–	–	107	–	79,807	–
1991	–	–	–	–	–	–	100	–	84,517	–
1992	–	–	–	–	–	–	217	–	77,588	–
1993	–	–	–	–	–	–	209	–	58,217	–
1994	–	–	–	–	–	–	186	–	194,425	–
1995	–	–	–	–	–	–	334	–	56,737	–
1996	–	–	–	–	–	–	203	–	37,331	–
1997	–	–	–	–	–	–	134	–	43,519	–
1998	–	–	–	–	–	–	178	–	50,758	–
1999	–	–	–	–	–	–	115	–	57,140	–
2000	265	21,911	825	15,580	1,230	819	199	40,564	84,843	125,407
2001	251	30,624	673	13,709	817	2,094	126	48,043	107,697	155,740
2002	329	63,056	812	43,296	2,775	3,480	574	113,993	204,805	318,798
2003	424	51,794	1,268	26,305	3,883	2,489	498	86,237	133,045	219,282
2004	254	84,286	937	35,155	7,982	2,822	455	131,637	67,053	198,690
2005	141	17,646	325	10,590	872	1,203	335	30,971	38,589	69,560
2006	217	42,621	295	26,246	1,297	1,782	355	72,596	79,050	151,646
2007	78	8,078	0	3,986	66	540	107	12,777	24,770	37,547
2008	358	23,875	0	28,727	251	738	390	53,981	56,369	110,350
2009	325	14,911	301	15,179	72	2,059	460	32,982	47,911	80,893
2010	427	29,828	246	37,723	1,807	2,021	322	71,947	84,909	156,856
2000–2010 Average		35,330	517	23,318	1,914	1,822	347	63,248	84,458	147,706
1987–2010 Average		–	–	–	–	–	240	–	74,368	–

Table 15.–Estimated harvest by gear type, escapement, and total run of adult coho salmon returning to Chuck Creek, 1982, 1983, 1985, and 2003−2010, with escapement counts only for 2001 and 2002.

Year	Fishery Sample Size	Number of Fish Alaska Troll	Seine	Drift Gillnet	Sport	B.C. Troll	B.C. Net	B.C. Sport	Total Catch	Escapement	Total Return
1982	28	1,320	418	0	0	0	0	0	1,738	1,017	2,755
1983	11	551	618	0	0	0	0	0	1,169	1,238	2,407
1985	29	1,906	975	0	0	0	0	0	2,881	956	3,837
2001	–	–	–	–	–	–	–	–	–	1,350	–
2002	–	–	–	–	–	–	–	–	–	2,189	–
2003	192	539	252	0	83	0	0	0	874	614	1,488
2004	203	725	179	0	76	0	0	0	980	606	1,586
2005	160	652	232	0	120	0	0	0	1,004	646	1,650
2006	84	401	32	0	8	7	0	0	448	409	857
2007	143	577	116	0	29	10	5	45	782	425	1,207
2008	121	389	146	17	8	5	0	0	565	309	874
2009	311	996	292	3	16	0	0	0	1,307	776	2,083
2010	284	658	110	0	49	4	0	6	827	814	1,641
Average		792	306	2	35	2	0	5	1,143	873	1,853

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 in apparent response to improved prices, particularly in the troll fishery (Figures 20 and 21; Tables 17–23).

The Auke Creek stock has been exploited at a relatively low average rate of 40% (range 20–55%) during 1980 to 2010, owing mainly to lack of intensive net fishing in its migratory pathway during the fall (Figures 20 and 21; Table 17). 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 attributed to seine, gillnet, and sport fisheries. During 2008–2010, this stock was exploited at an average of 41%, very close to the long-term average of 40%. However, the 2010 estimate of 46% was the highest all-gear exploitation rate estimate since 1996 (53%), owing largely to a record drift gillnet exploitation rate of 17%. The troll fishery exploitation rate during 2008–2010 ranged from 25% to 30%.

During 2008–2010, total exploitation rate estimates for the Berners River stock ranged from 51% to 65%, and averaged 57%. 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, ranging from 22% to 34% (Figures 20 and 21; Table 18).

Table 16.–Estimates of wild and hatchery commercial catch and troll catch, troll exploitation rate index, mean-average power troll wild coho CPUE, total troll effort, and total wild coho salmon abundance available in the Alaska troll fishery, in millions of fish, 1982–2010.

	Troll Catch (Millions of Fish)			Alaska Troll Exploitation	Estimated Total Wild	Mean-Avg. Power Troll	Troll Effort (Power Troll	Commercial Catch (Millions of Fish)		
Year	Total	Hatchery	Wild	Rate Index[1]	Abundance	Wild CPUE[2]	Boat-Days)[3]	Total	Hatchery	Wild
1982	1.322	0.036	1.286	34.3%	3.752	47.4	67,039	2.103	0.062	2.041
1983	1.280	0.053	1.227	37.4%	3.280	44.1	50,376	1.943	0.075	1.868
1984	1.134	0.071	1.062	37.0%	2.868	38.7	50,502	1.881	0.121	1.760
1985	1.606	0.107	1.500	38.7%	3.878	42.4	54,905	2.562	0.177	2.385
1986	2.130	0.280	1.850	44.0%	4.200	47.7	61,356	3.259	0.394	2.865
1987	1.042	0.091	0.951	35.6%	2.671	25.6	52,908	1.487	0.112	1.374
1988	0.500	0.028	0.472	30.6%	1.544	21.5	38,866	1.036	0.049	0.987
1989	1.370	0.122	1.248	51.9%	2.408	54.3	48,228	2.182	0.175	2.007
1990	1.851	0.292	1.560	43.5%	3.586	43.9	48,291	2.740	0.413	2.327
1991	1.721	0.384	1.337	32.0%	4.175	48.7	42,598	2.897	0.608	2.289
1992	1.929	0.420	1.509	39.3%	3.845	51.1	45,478	3.424	0.739	2.685
1993	2.408	0.394	2.014	48.7%	4.134	64.5	46,527	3.556	0.544	3.012
1994	3.462	0.515	2.947	44.2%	6.669	89.1	51,912	5.520	0.732	4.788
1995	1.750	0.336	1.414	35.5%	3.987	54.0	32,193	3.130	0.583	2.547
1996	1.907	0.449	1.458	42.2%	3.453	57.0	29,779	2.986	0.626	2.360
1997	1.170	0.242	0.928	34.2%	2.714	39.9	24,974	1.839	0.327	1.512
1998	1.636	0.329	1.307	38.3%	3.413	57.8	26,150	2.751	0.547	2.204
1999	2.273	0.514	1.758	41.7%	4.214	69.0	31,894	3.277	0.724	2.552
2000	1.125	0.249	0.876	35.4%	2.476	43.8	22,557	1.688	0.354	1.334
2001	1.845	0.365	1.481	34.8%	4.254	73.4	23,806	2.945	0.554	2.391
2002	1.315	0.335	0.980	21.4%	4.578	63.7	20,394	2.487	0.605	1.882
2003	1.223	0.287	0.936	25.4%	3.693	55.4	21,549	2.166	0.501	1.665
2004	1.917	0.312	1.605	39.7%	4.040	76.7	26,776	2.858	0.451	2.407
2005	2.038	0.333	1.705	36.1%	4.725	76.3	27,065	2.767	0.450	2.317
2006	1.363	0.217	1.146	31.4%	3.653	55.6	25,862	1.841	0.266	1.575
2007	1.378	0.309	1.069	38.4%	2.788	48.8	26,033	1.911	0.393	1.519
2008	1.293	0.274	1.019	27.8%	3.668	49.0	24,799	2.040	0.396	1.644
2009	1.592	0.247	1.344	34.6%	3.888	67.1	27,021	2.375	0.384	1.991
2010	1.343	0.285	1.058	28.6%	3.695	54.2	31,157	2.286	0.470	1.815
Total	1.618	0.272	1.346	36.6%	3.664	53.8	37,276	2.550	0.408	2.142

[a] Index of the exploitation rate on available wild coho salmon stocks by the Alaska troll fishery based on the following weightings: Auke Creek (40%), Hugh Smith Lake (40%), and Ford Arm Creek (20%).

[b] Average of estimates of wild coho salmon CPUE by power trollers during statistical weeks 28–38.

[c] Total troll effort in boat-days during statistical weeks 28-40, with hand troll effort converted to power troll equivalents.

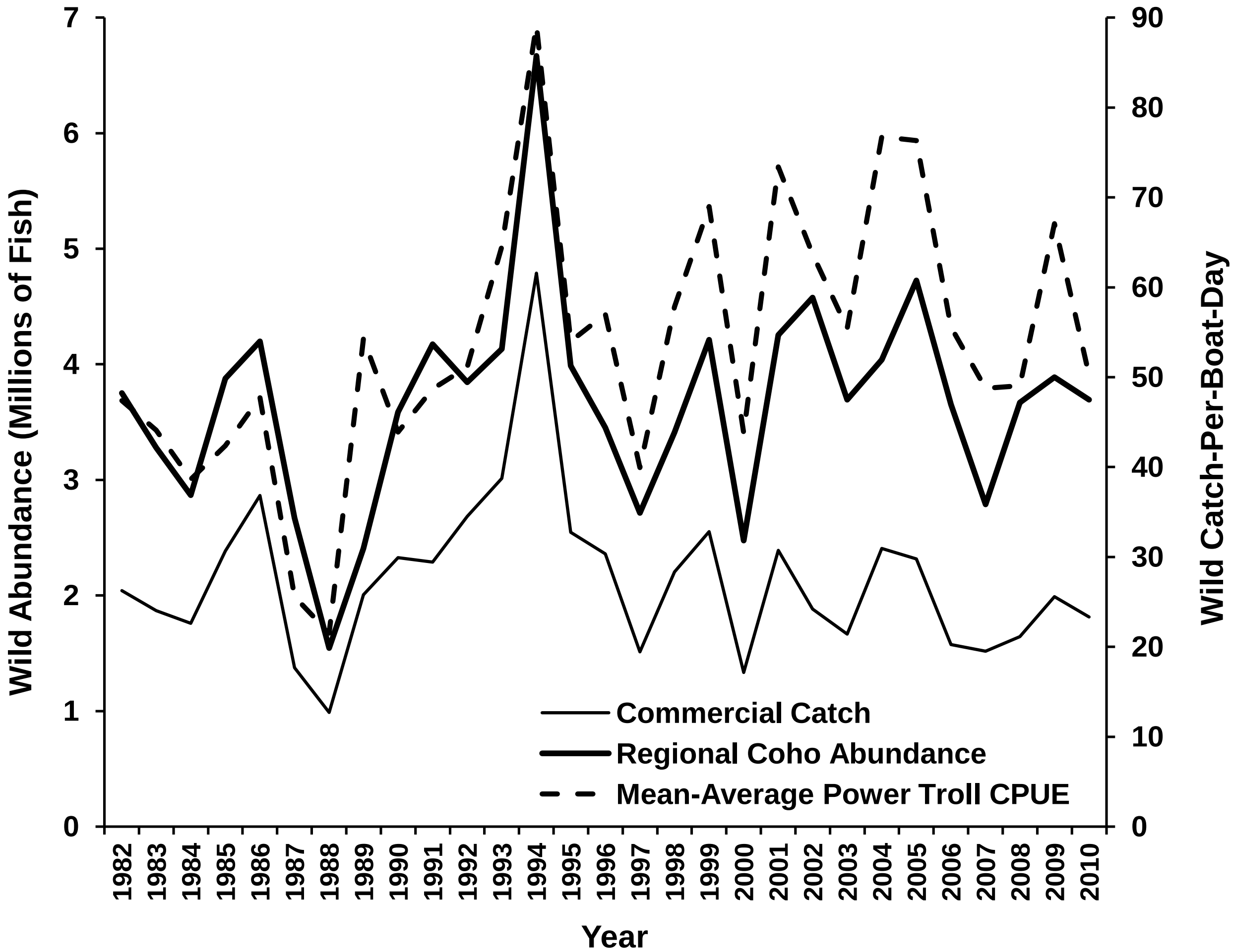


Figure 18.–Estimates of Southeast Alaska wild coho salmon commercial catch, total wild abundance available to the Alaska troll fishery and mean-average power troll wild CPUE in statistical weeks 28–38, 1982–2010.

Exploitation rate estimates for the Taku River run during 1992–2010 ranged from 28% to 72% (average 47%; Table 21). Trollers accounted for 22% (range 13–31%) of the run, on average, while drift gillnetters accounted for 16% (range 3–36%). The drift gillnet exploitation rate ranged from 15% to 36% during 1992–1998 (except for 1997 when the District 111 gillnet fishery was closed early) and declined to only 6–11% in 1999–2003, before increasing again to 11–21% in 2006–2010. Seine, marine sport, and inriver fisheries have accounted for an average of 2%, 3%, and 4% of the run, respectively.

Troll fishery exploitation rate estimates for the Chilkat River stock during 2000–2010 averaged higher than estimates for the Taku River (23% compared with 20%), but displayed a similar pattern, with the highest estimate in 2004 (Tables 21 and 22). Chilkat River fish were also exploited more heavily by the drift gillnet fishery, on average, at rates ranging from 9% to 26% (average 16%) during 2000–2010, compared with 14% (range 7–21%) for the Taku run. Total all-gear exploitation rate estimates for the Chilkat River increased sharply from 31% to 39% in 2000–2003 to a peak of 66% in 2004 before decreasing again to 34–49% in 2005–2010.

The Ford Arm Creek 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 20; Table 19), 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. The Ford Arm stock has also become one of the more heavily fished stocks by the recently expanded 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 of the stock in some years. The seine exploitation rate estimate of 13% in 2010 was the second highest on record and occurred incidentally to an all-time record catch of 2.25 million pink salmon by seine fishery in Khaz Bay.

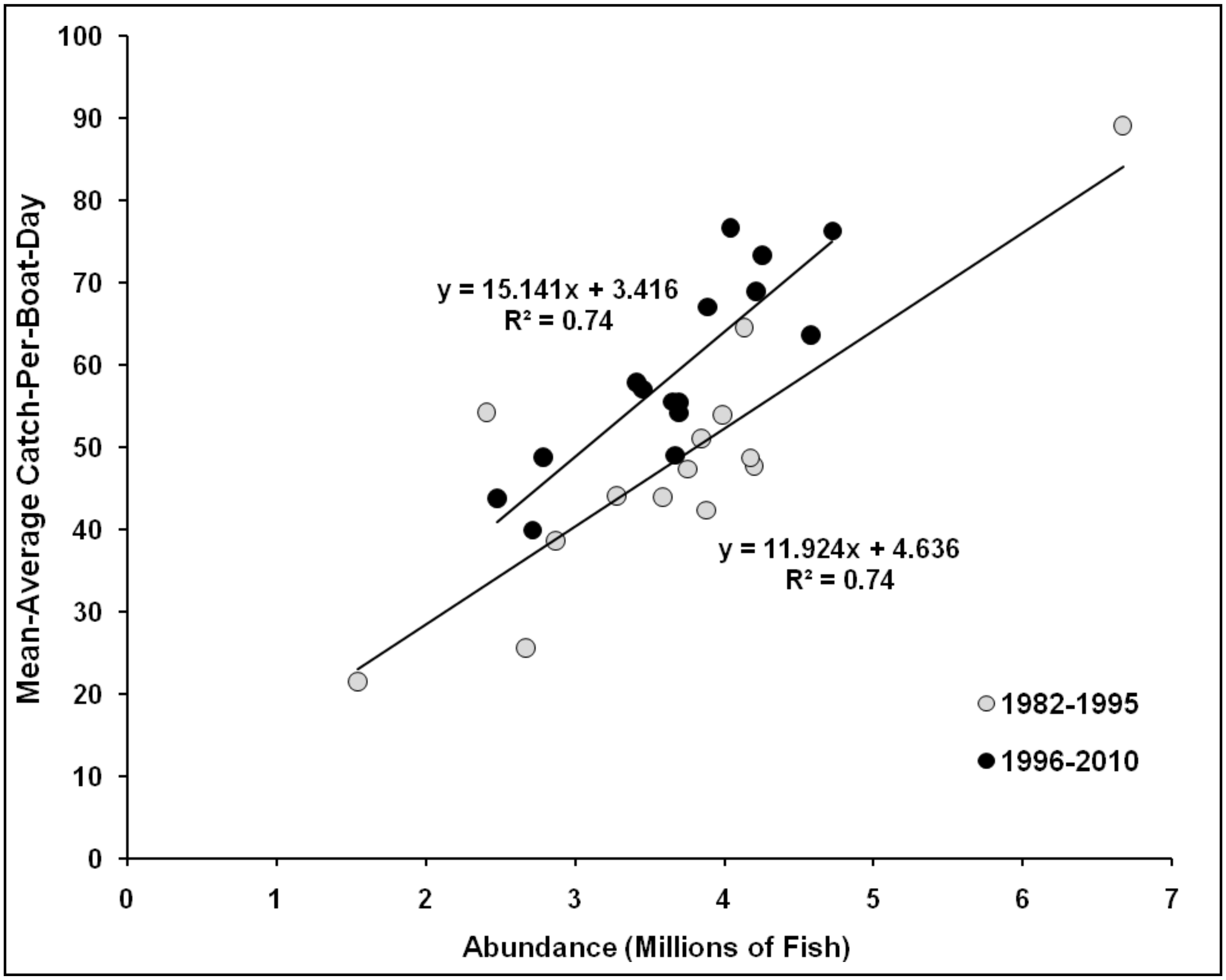


Figure 19.–Linear relationship between estimated region total wild coho salmon abundance and mean-average power troll wild CPUE in statistical weeks 28−38, 1982−1995 and 1996−2010.

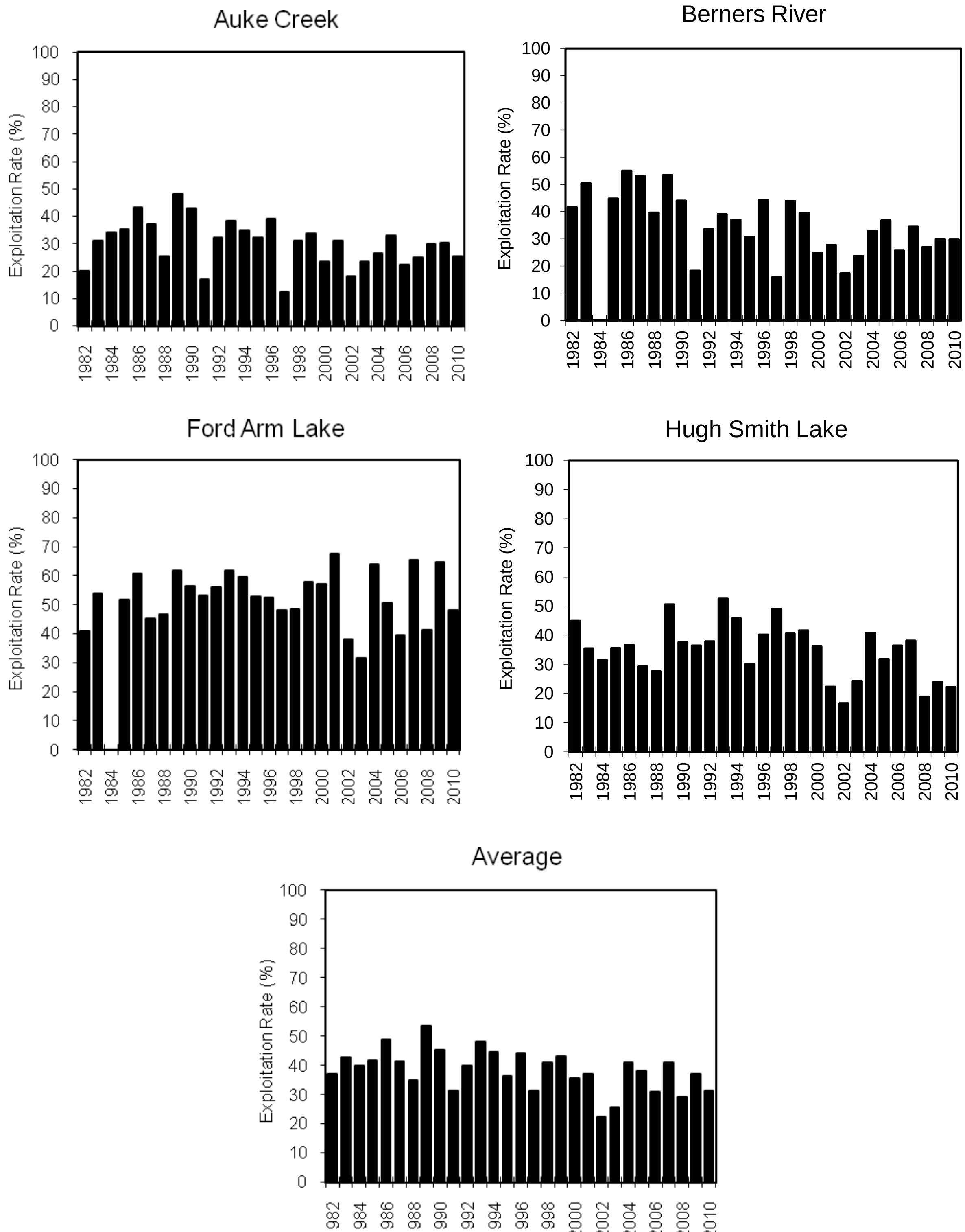


Figure 20.–Estimated exploitation rates by the Alaska troll fishery for 4 coded-wire-tagged Southeast Alaska coho salmon stocks, 1982–2010.

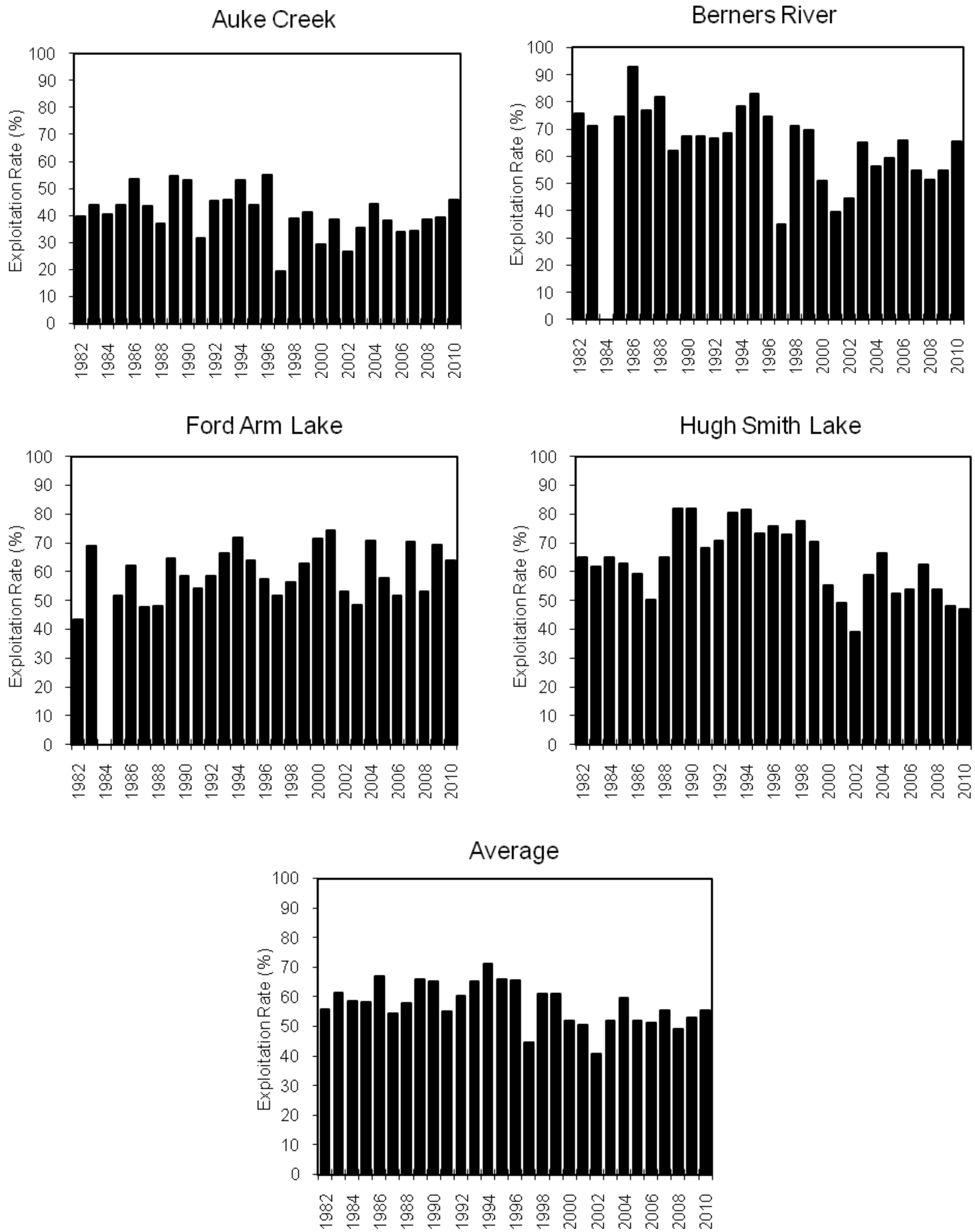


Figure 21.–Estimated total exploitation rates by all fisheries for 4 coded-wire-tagged Southeast Alaska coho salmon stocks, 1982–2010.

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, the Hugh Smith Lake stock was exploited at moderate rates for coho salmon, averaging 61% (Figure 21; Table 20). However, exploitation became markedly more intense during 1989–1999, at an average rate of 76% (range 68–82%) before decreasing sharply to 53% (range 39–66%) during 2000–2010. The recent decrease was distributed across all commercial fisheries, with the Alaska troll exploitation rate decreasing from 42% to 28%, the Alaska seine rate decreasing from 10% to 7%, and the Alaska gillnet rate decreasing from 16% to 12%. The average Alaska sport exploitation rate remained about the same at 2%, while the average exploitation rate on the stock by Canadian fisheries decreased from 6% to 4%. The troll fishery in British Columbia was a substantial factor through the mid-1990s, with an average exploitation rate on the Hugh Smith Lake stock of 7% from 1982 through 1997, after which Canadian exploitation decreased to zero for several years due to severe fishing restrictions on coho salmon. Although the troll fleet in northern British Columbia was substantially reduced in the late-1990s, relaxation of fishery restrictions aimed primarily at conserving upper Skeena coho salmon has increased the Canadian troll exploitation rate on the Hugh Smith Lake stock to 4–6% in 2009 and 2010.

The Chuck Creek stock on the southern outside coast was exploited at an average rate of 60% (range 50–65%) in 2003–2010 compared with 62% (range 49–75%) in 1982, 1983, and 1985 (Table 23). This stock has a relatively localized fishery distribution concentrated in southern outside waters compared with the more migratory Hugh Smith Lake stock and southern inside fall hatchery stocks that are more broadly distributed in the catch as they progress southward during the season. 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 3% during 2003–2010.

A substantial shift in harvest by gear type on the Chuck Creek stock occurred between the early to mid-1980s and the mid to late-2000s, with a reduction by nearly half in the average seine exploitation rate estimate from 22% to 12%. This occurred concurrently with decreases of 34% and 75%, respectively, in the average number of purse seine boat-days fished in Districts 103 and 104. The average number of coho salmon harvested by purse seiners in those districts decreased by 8% in District 103 from 29,200 fish to 26,900 fish and by 57% in District 104 from 146,500 fish to 62,600 fish. The decline in purse seine effort and catch in District 104 has been a substantial factor in the total Southeast Alaska purse seine catch falling below its 19% long-term allocation of the commercial catch, while average catches by trollers and drift gillnetters since 1989 have been above their long-term allocations (Skannes et al. 2011). The reasons for the decline in purse seine catch and effort in District 104 appear to be primarily a combination of restrictions on fishing early in the season under the PST, as well as trends in migration and availability of sockeye salmon and other species in the district that have made it a less attractive fishing location in some recent years relative to other opportunities.

The 10% decline in purse seine exploitation on the Chuck Creek stock was offset, in part, by an increase in average Alaska troll exploitation from 40% in 1982, 1983, and 1985 to 44% in 2003−2010 and by an increase in estimated marine sport exploitation from a trace level to an average of over 3%.

Table 17.–Estimated harvest (by gear type) and escapement as a percent of the total Auke Creek coho salmon run, 1980–2010.

Year	Fishery Sample Size	Percent of Total Return: 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	22.3	0.0	8.8	3.0	34.0	66.0	100.0
2007	47	25.0	1.1	5.6	2.6	34.3	65.7	100.0
2008	105	29.9	0.0	7.8	0.9	38.6	61.4	100.0
2009	75	30.2	0.0	7.8	1.3	39.3	60.7	100.0
2010	86	25.3	0.0	17.5	2.9	45.6	54.4	100.0
Average		29.6	1.4	5.7	3.3	40.0	60.0	100.0

Table 18.–Estimated harvest (by gear type) and escapement as a percent of the total Berners River coho salmon run, 1982–2010.

Year	Fishery Sample Size	Troll	Seine	Drift Gillnet	Sport	B.C. Net	Cost Recovery	Total Catch	Escapement	Total Return
		Percent of Total Return								
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
2008	421	26.9	0.0	24.0	0.3	0.0	0.0	51.2	48.8	100.0
2009	201	30.0	0.4	21.7	2.8	0.0	0.0	54.8	45.2	100.0
2010	325	29.9	0.5	33.5	1.5	0.0	0.0	65.3	34.7	100.0
Average		35.5	0.7	28.1	0.8	0.0	0.0	65.1	34.9	100.0

Table 19.–Estimated harvest (by gear type) and escapement as a percent of the total Ford Arm Creek coho salmon run, 1982–2010.

	Fishery	Percent of Total Return							
	Sample	Alaska		Drift		Canadian	Total		Total
Year	Size	Troll	Seine	Gillnet	Sport	Troll	Catch	Escapement	Return
1982	38	41.1	2.3	0.0	0.0	0.0	43.4	56.6	100.0
1983	93	54.0	14.7	0.0	0.0	0.0	68.8	31.2	100.0
1984	–	–	–	–	–	–	–	–	–
1985	49	51.6	0.0	0.0	0.0	0.0	51.6	48.4	100.0
1986	87	60.6	1.5	0.0	0.0	0.0	62.1	37.9	100.0
1987	71	45.1	2.5	0.0	0.0	0.0	47.6	52.4	100.0
1988	151	46.8	0.8	0.0	0.0	0.5	48.1	51.9	100.0
1989	218	61.7	3.0	0.0	0.0	0.0	64.7	35.3	100.0
1990	174	56.5	1.9	0.0	0.0	0.0	58.4	41.6	100.0
1991	193	53.2	0.7	0.2	0.0	0.0	54.1	45.9	100.0
1992	199	56.2	2.5	0.0	0.0	0.0	58.7	41.3	100.0
1993	349	61.7	3.5	0.0	1.4	0.0	66.5	33.5	100.0
1994	236	59.7	8.9	0.0	3.3	0.0	71.9	28.1	100.0
1995	82	52.8	11.2	0.0	0.0	0.0	64.0	36.0	100.0
1996	64	52.6	0.0	0.0	4.8	0.0	57.4	42.6	100.0
1997	242	48.1	0.0	0.0	3.6	0.0	51.7	48.3	100.0
1998	320	48.6	2.7	0.1	4.9	0.0	56.3	43.7	100.0
1999	146	57.8	0.7	0.0	4.3	0.0	62.7	37.3	100.0
2000	193	57.2	11.4	0.2	2.6	0.0	71.4	28.6	100.0
2001	131	67.5	1.3	0.0	5.6	0.0	74.4	25.6	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	39.4	3.7	0.0	8.6	0.0	51.7	48.3	100.0
2007	188	65.5	2.5	0.1	2.3	0.0	70.4	29.6	100.0
2008	231	41.3	9.5	0.0	2.5	0.0	53.2	46.8	100.0
2009	156	64.6	3.5	0.0	1.3	0.0	69.4	30.6	100.0
2010	96	48.0	13.0	0.0	3.0	0.0	64.0	36.0	100.0
Average		52.7	4.2	0.0	2.8	0.0	59.7	40.3	100.0

Table 20.–Estimated harvest (by gear type) and escapement as a percent of the total Hugh Smith Lake coho salmon run, 1982–2010.

	Fishery	Percent of Total Return										
Year	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
2008	302	19.0	6.5	20.6	0.0	0.9	1.6	0.3	5.1	53.9	46.1	100.0
2009	253	23.9	6.1	11.0	0.0	0.4	6.0	0.0	0.4	48.0	52.0	100.0
2010	632	22.2	5.3	12.8	0.0	0.7	4.0	0.0	1.9	46.9	53.1	100.0
Average		35.0	9.0	12.2	0.1	1.5	4.8	0.6	0.7	63.8	36.2	100.0

Table 21.–Estimated harvest (by gear type) and escapement as a percent of the total Taku River coho salmon run above Canyon Island, 1992–2010.

Year	Fishery Sample Size	Percent of Total Return: Troll	Seine	Marine Gillnet	Sport	Inriver	Total Catch	Escapement	Total Return
1992	128	19.5	1.2	35.6	1.6	2.6	60.5	39.5	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	4.4	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	52.7	47.3	100.0
1997	66	17.3	1.1	2.9	9.8	5.3	36.4	63.6	100.0
1998	231	24.0	0.6	16.2	3.7	4.3	48.8	51.2	100.0
1999	252	30.9	2.5	6.4	3.6	4.8	48.2	51.9	100.0
2000	221	19.5	2.0	10.5	3.8	5.0	40.7	59.3	100.0
2001	344	23.5	1.3	7.2	1.9	1.9	35.9	64.1	100.0
2002	397	12.9	1.1	10.2	2.2	1.3	27.7	72.3	100.0
2003	195	13.7	1.4	10.4	4.0	1.4	31.0	69.0	100.0
2004	223	24.6	2.1	12.3	5.6	3.9	48.6	51.4	100.0
2005	90	20.9	1.9	10.6	2.1	3.8	39.2	60.8	100.0
2006	319	21.8	0.3	16.7	2.1	5.5	46.3	53.7	100.0
2007	150	17.6	4.9	14.1	1.6	6.0	44.3	55.8	100.0
2008	94	27.6	0.0	14.5	0.9	2.3	45.2	54.8	100.0
2009	300	23.1	2.1	20.9	3.0	4.3	53.5	46.6	100.0
2010	117	14.0	1.6	21.3	5.8	5.9	48.6	51.4	100.0
1992–2010 Average		22.1	1.8	15.8	3.4	4.1	47.2	52.8	100.0

Table 22.–Estimated harvest (by gear type) and escapement as a percent of the total Chilkat River coho salmon run, 2000–2010.

Year	Fishery Sample Size	Percent of Total Return: Troll	Seine	Drift Gillnet	Marine Sport	FW Sport	Subsistence	Total Catch	Escapement	Total Return
2000	265	17.5	0.7	12.4	1.0	0.7	0.2	32.3	67.7	100.0
2001	251	19.7	0.4	8.8	0.5	1.3	0.1	30.8	69.2	100.0
2002	329	19.8	0.3	13.6	0.9	1.1	0.2	35.8	64.2	100.0
2003	424	23.6	0.6	12.0	1.8	1.1	0.2	39.3	60.7	100.0
2004	254	42.4	0.5	17.7	4.0	1.4	0.2	66.3	33.7	100.0
2005	141	25.4	0.5	15.2	1.3	1.7	0.5	44.5	55.5	100.0
2006	217	28.1	0.2	17.3	0.9	1.2	0.2	47.9	52.1	100.0
2007	78	21.5	0.0	10.6	0.2	1.4	0.3	34.0	66.0	100.0
2008	358	21.6	0.0	26.0	0.2	0.7	0.4	48.9	51.1	100.0
2009	325	18.4	0.4	18.8	0.1	2.5	0.6	40.8	59.2	100.0
2010	427	19.0	0.2	24.0	1.2	1.3	0.2	45.9	54.1	100.0
Average		23.4	0.3	16.0	1.1	1.3	0.3	42.4	57.6	100.0

Table 23.–Estimated Estimated harvest (by gear type) and escapement as a percent of the total Chuck Creek coho salmon run, 1982, 1983, 1985, and 2003−2010.

Year	Fishery Sample Size	Percent of Total Return: Alaska Troll	Seine	Drift Gillnet	Sport	B.C. Troll	B.C. Net	B.C. Sport	Total Catch	Escapement	Total Return
1982	28	47.9	15.2	0.0	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	0.0	48.6	51.4	100.0
1985	29	49.7	25.4	0.0	0.0	0.0	0.0	0.0	75.1	24.9	100.0
2003	192	36.2	16.9	0.0	5.6	0.0	0.0	0.0	58.7	41.3	100.0
2004	203	45.7	11.3	0.0	4.8	0.0	0.0	0.0	61.8	38.2	100.0
2005	160	39.5	14.1	0.0	7.3	0.0	0.0	0.0	60.8	39.2	100.0
2006	84	46.8	3.7	0.0	0.9	0.8	0.0	0.0	52.3	47.7	100.0
2007	143	47.8	9.6	0.0	2.4	0.8	0.4	3.7	64.8	35.2	100.0
2008	121	44.5	16.7	1.9	0.9	0.6	0.0	0.0	64.6	35.4	100.0
2009	311	47.8	14.0	0.1	0.8	0.0	0.0	0.0	62.7	37.3	100.0
2010	284	40.1	6.7	0.0	3.0	0.2	0.0	0.4	50.4	49.6	100.0
Average		42.6	14.5	0.2	2.3	0.2	0.0	0.4	60.3	39.7	100.0

Length and Weight Trends

Changes in size of returning coho salmon may have an economic effect on the total landed weight of the catch, as well as important reproductive effects. Although Shaul et al. (2007) found no significant trend in the average dressed weight of Southeast Alaska coho salmon, we decided to examine size trends in coho salmon in the region in more detail in light of recent observations and reports by fishermen and sampling personnel of small average size in some years and increasing variability in size. We examined temporal trends in Southeast Alaska of both the dressed weight in kg of troll-caught fish and the mid-eye to fork (MEF) length of males and females sampled in escapements to 4 wild systems.

Troll Fishery Average Weight

In the troll catch, we examined average dressed weight for fish landed in three periods defined by statistical weeks: weeks 27–28 (early July), weeks 32–33 (early to mid-August), and weeks 37–38 (mid-September). Over the period 1970–2010, average weight increased substantially (average 41%; range 33–51%) over the course of the summer troll season between weeks 27–28 and weeks 37-38 (Figure 22; Appendix A1). However, there was substantial variability across the summer season in the inter-annual trend in average weight. Early-season weights have remained most stable, with the exception of a brief period of higher weights during the period 1983–1986. The average for the most recent decade (2.57 kg) is essentially unchanged from the 1970–2000 average (2.56 kg). The same peak in the 0.33 LOESS trend in average weight is also evident in the mid and late-season periods. However, the trend in midseason weights shows a much more marked decline (16.2%) from a peak in 1985 to a low in 2004, and has remained low during the most recent decade, for a 2001–2010 average of 2.82 kg that was 7.0% below the previous historical average of 3.03 kg during 1970–2000. The mid-September average weight shows an intermediate pattern with a decline of 4.6% in mean-average weight in 2001–2010 compared with 1970–2000.

Therefore, average weight during the midseason has shown a disproportionate decrease relative to both the earliest and latest weeks in the summer troll season. There was a shift in the 1990s in the intra-annual pattern of increasing average size of troll-caught coho salmon. In recent years, the dressed weight of troll-caught fish averaged slightly heavier at the beginning of the season, compared with the 1970s through the mid-1990s, but then increased much more slowly before rising to nearly the same mean-average weight of 3.65 kg by the third week of September (Figure 23). During 1997–2010, the mean-average week-to-week increase in dressed weight of landed troll-caught fish from early July to early August fell by more than half to only 2.0% from 4.3% in 1970–1996 (Figure 24). Weekly rates of increase in dressed weight were relatively similar between the periods from mid to late August, averaging 4.7% in 1970–1996 and 4.3% in 1997–2010, while peaking at 6.0% on about August 20 during both periods. However, while the weekly rate of increase quickly declined to nil during September in the earlier period, substantial average weekly gains of 2.3–5.3% continued until the end of the season during 1997–2010. The ratio of the average weekly increase in weight in late weeks compared with earlier weeks indicates that the shift occurred between 1990 and 1998, with the trend being level since 1998 (Figure 25).

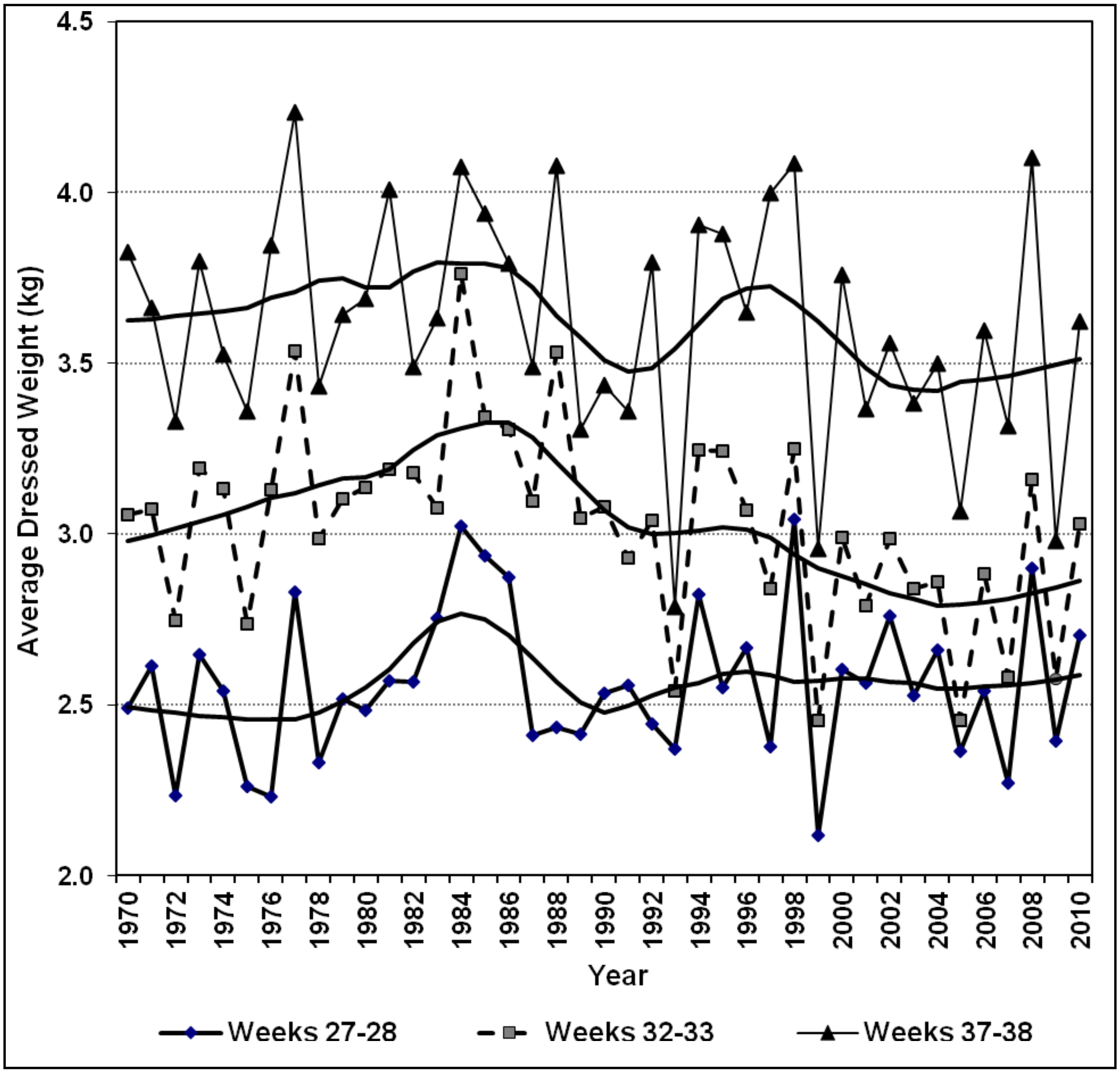


Figure 22.–Mean-average dressed weight of troll caught coho salmon landed during early July (weeks 27–28), early to mid-August (weeks 32–33) and mid-September (weeks 37–38), with 0.33 LOESS trends shown by dark solid lines.

With the exception of age-.0 jacks, coho salmon remain at sea for an average of about 16 months and put on much of their growth during their final summer. Therefore, weekly rates of increase might be presumed to reflect primarily the growth rate of fish foraging on common resources during their final summer at sea. However, this simplistic view has been challenged in recent years as fishermen and samplers have reported increasing variability in size of fish caught and landed, with mostly smaller fish available during the peak of the troll fishery from mid-July to mid-August, but with much larger fish appearing in an increasing proportion in late August and September. The contrast in size and appearance among fish has become so striking in some years, beginning in the late-1990s, that some fishermen and samplers have commented that there appeared to be two different “subspecies” of coho salmon in the catch.

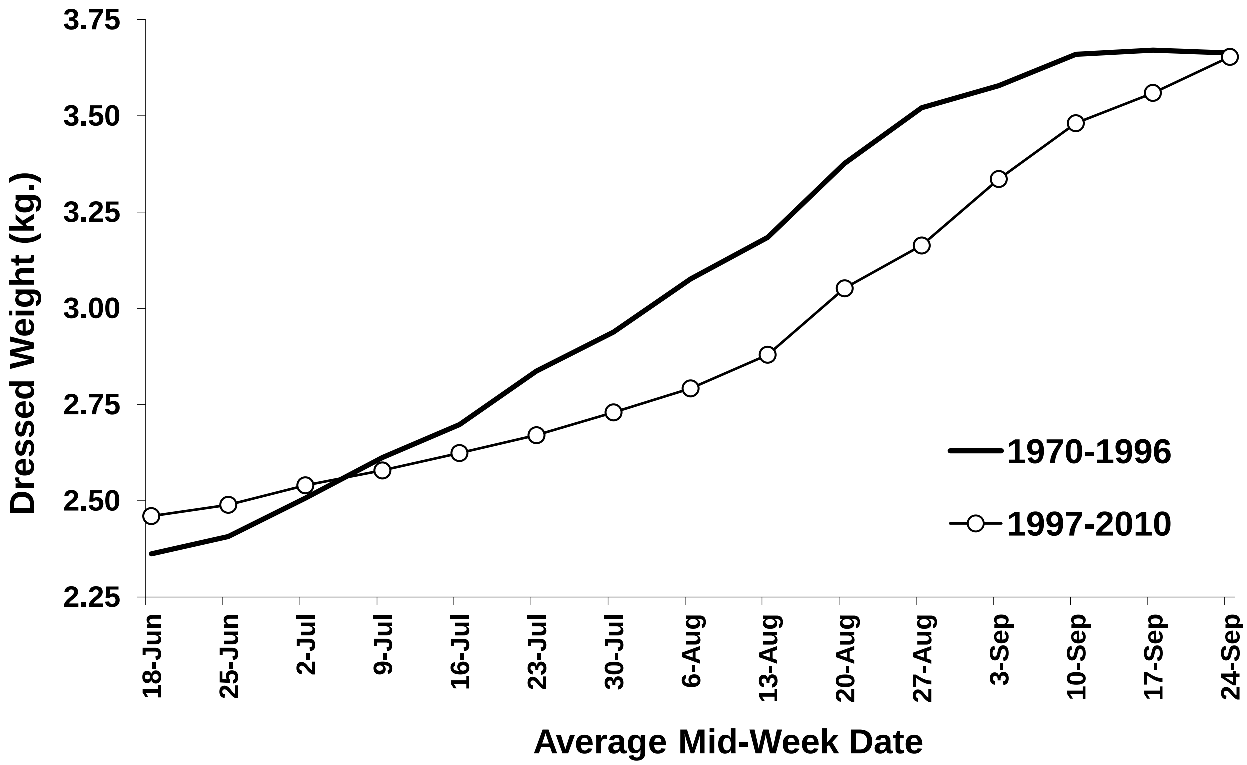


Figure 23.–Mean-Average weekly dressed weight of troll-caught coho salmon by statistical week of landing, 1970–1996 and 1997–2010.

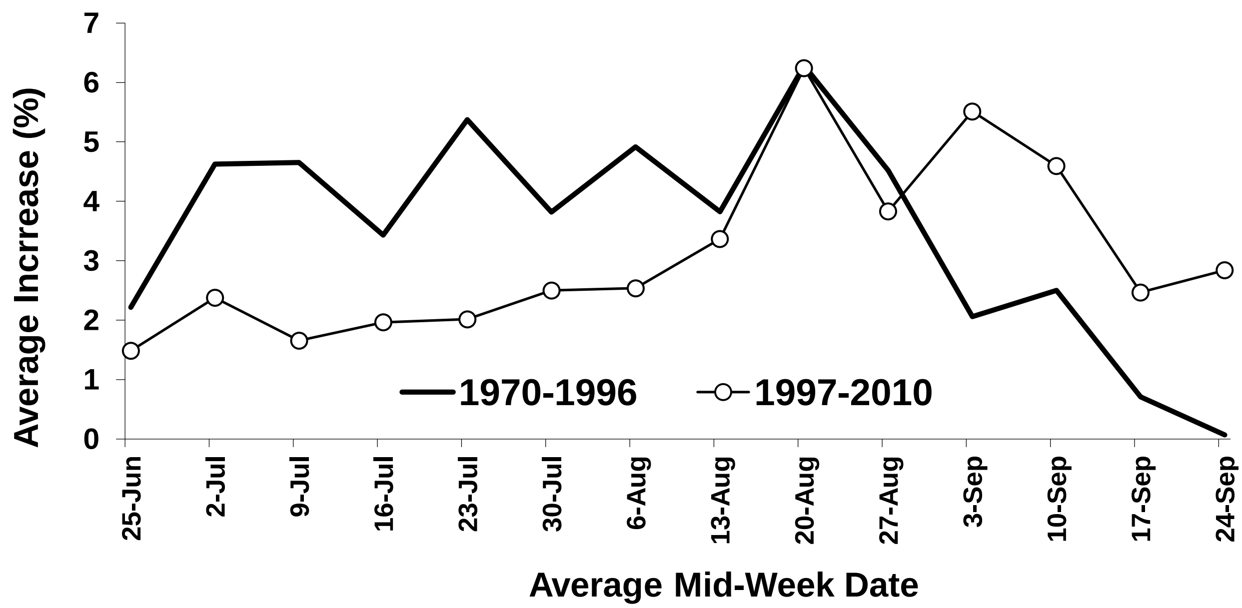


Figure 24.–Mean percent increase in average weekly dressed weight of troll-caught coho salmon by statistical week of landing, 1970–1996 and 1997–2010.

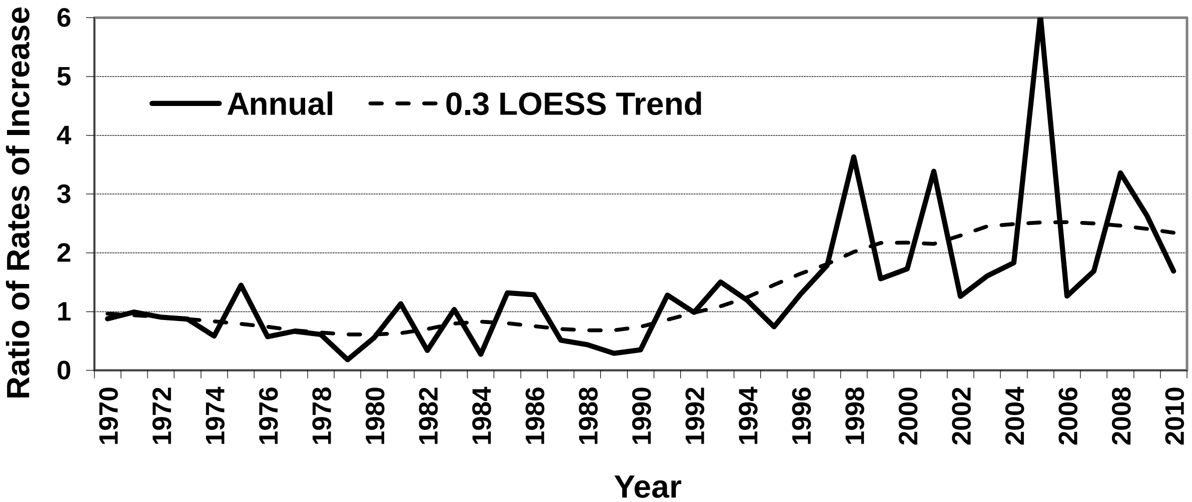


Figure 25.–Ratio of the average weekly increase in mean dressed weight of Southeast Alaska troll-caught coho salmon in statistical weeks 34–38 compared with statistical weeks 28–33.

This led us to speculate that the rapid increase in size late in the season did not reflect an increase in the overall growth rate, but rather divergence in conditions for growth of coho salmon in different areas of the ocean, with the large late-returning fish having spent most of their time in an area of much more productive feeding conditions compared with those that had remained near the coast within range of the troll fishery for most of the season. We suspected that the change reflected differences in the predominant feeding area of fish and/or a major shift in the forage community in coastal waters. It appeared that more migratory fish that gained more of their growth on the high seas were experiencing far better conditions for growth than those that arrived earlier and fed along the coast.

Adult Coho Salmon Length

We examined trends in MEF length of age-.1 adult coho salmon from the 4 long-term wild indicator stocks during 1982–2010 (Figures 26 and 27; Appendices A2 and A3).

Overall, we found declines in average size of both males and females after the early to mid-1980s (Figure 26). This was not unexpected because collection of MEF length data in most wild systems was initiated within or just prior to the early to mid-1980s peak in average dressed weight in the troll fishery (Figure 22). In comparing the earliest 6 years when data were available for all 4 stocks (1982–1988, excluding 1984), with the most recent 6-year period (2005–2010), mean-average MEF length of age-.1 adults declined for both sexes in all systems, ranging from a 2.7% decline for Auke Creek females to 10.3% for Ford Arm Creek males (Table 24). Females showed a lesser decrease in average length in all 4 stocks, ranging from 2.7–4.6% compared with 3.8–10.3% for males. Between the same periods, mean-average dressed weight of coho salmon landed by the troll fishery decreased by 4.8% for the earliest weeks (27–28), 13.5% at midseason (weeks 32–33) and 7.1% in the late-season (weeks 37–38). We found the overall mean-average MEF length for all stocks and both sexes during 1982–2010 to be most closely correlated with the midseason (weeks 32–33) troll dressed weight (R^2 = 0.79), compared with the early season (R^2 = 0.47) or the late-season (R^2 = 0.55).

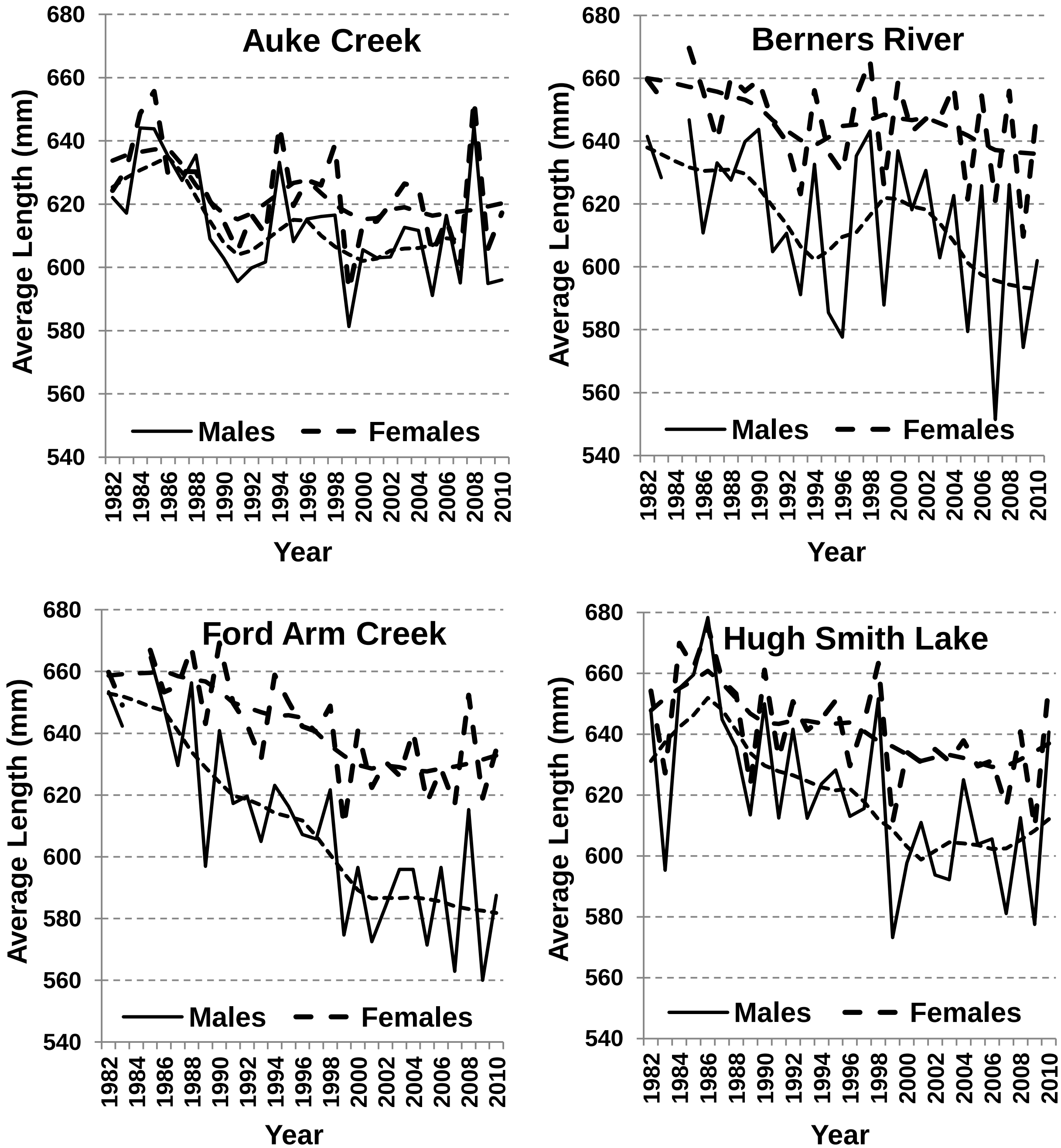


Figure 26.–Annual average mid-eye to fork length and 0.33 LOESS trend for age-.1 male and female coho salmon sampled in Auke Creek, Berners River, Ford Arm Creek, and Hugh Smith Lake, 1982–2010.

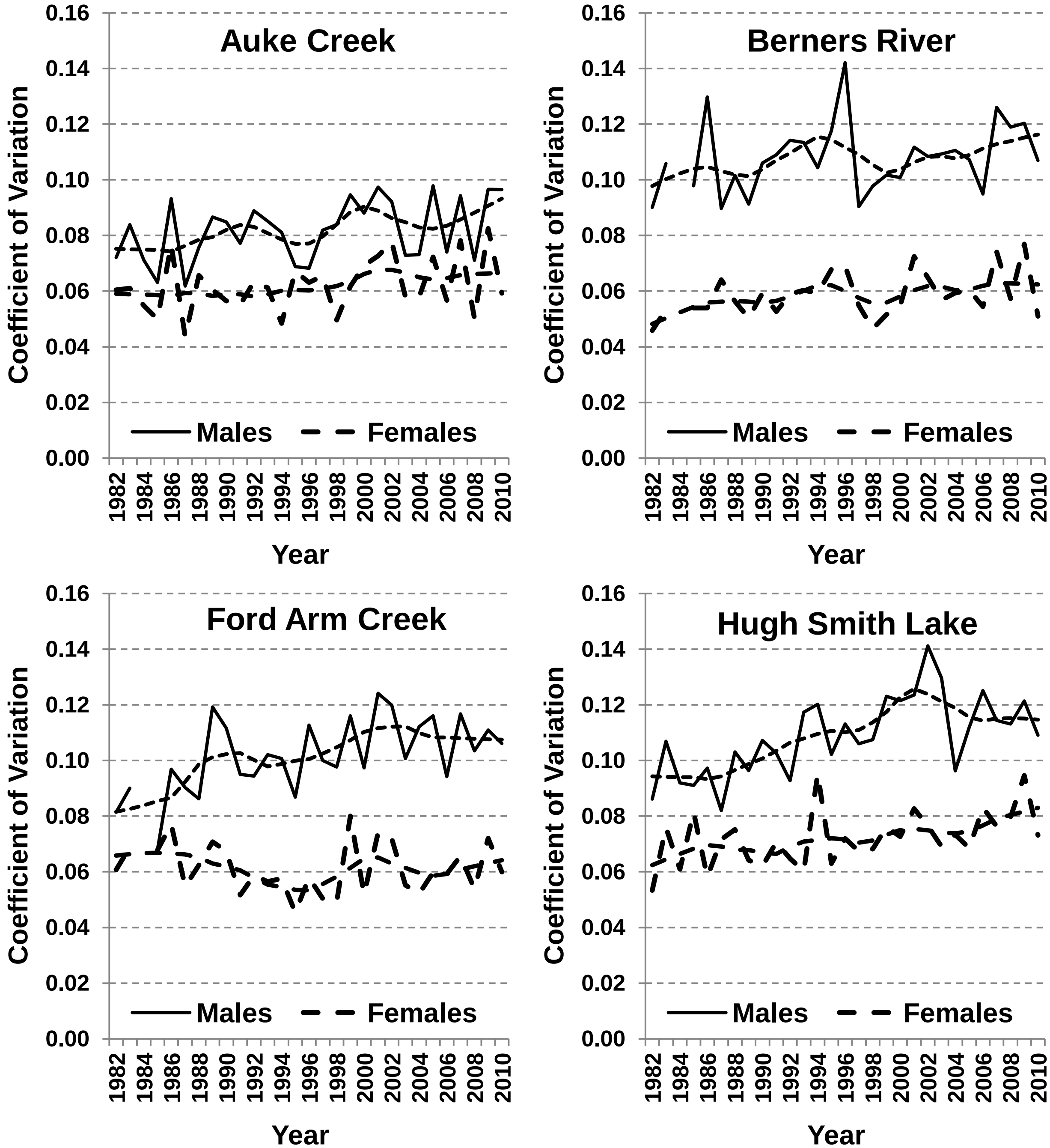


Figure 27.–Coefficient of variation in the mid-eye to fork length and 0.33 LOESS trend for age-.1 male and female coho salmon sampled in Auke Creek, Berners River, Ford Arm Creek, and Hugh Smith Lake, 1982–2010.

On average, we found size of adult males to be substantially more variable in length than females, with the coefficient of variation (CV) of males averaging 1.58 times the CV of females sampled from the same system and year, with averages for individual stocks being 1.32 for Auke Creek, 1.84 for Berners River, 1.66 for Ford Arm Creek, and 1.51 for Hugh Smith Lake.

Auke Creek (least different) and the Berners River (most different) are situated in relatively close proximity and have similar migratory characteristics. However, jacks have comprised an average of 44% (range 20–65%) of the male escapement to Auke Creek by sea-entry year compared with <0.5% for the Berners River, based on the composition of beach seine samples from the upper Berners River system. The high percentage of jacks in Auke Creek compared with the Berners River may be related to substantially larger average size of smolts migrating from Auke Creek. Ford Arm Creek and Hugh Smith Lake are likely intermediate in jack percentages, although precise jack counts or estimates are unavailable for those systems because broader picket spacing allows some jacks to escape uncounted. The mean-average MEF length of 0-ocean Auke Creek jacks during 1982–2010 was 317 mm compared with 614 mm for 1-ocean adult males.

Table 24.–A comparison of average mid-eye to fork length (mm) and associated average coefficient of variation of length for 4 wild coho salmon indicator stocks in Southeast Alaska during the periods 1982–1988 (excluding 1984) and 2005–2010, and the early and late-season mean-average weekly troll coho dressed weight for the same periods.

		1982–1988, excl. 1984		2005–2010		Change	% Change	
Source		Avg. Length	CV	Avg. Length	CV	Avg. Length	Avg. Size[a]	CV
Auke Creek	Males	630	0.0750	606	0.0884	-24	-3.8	17.9
	Females	633	0.0596	616	0.0665	-17	-2.7	11.6
Berners River	Males	631	0.1025	593	0.1124	-38	-6.0	9.7
	Females	657	0.0546	635	0.0624	-21	-3.2	14.3
Ford Arm Lake	Males	649	0.0855	582	0.1079	-67	-10.3	26.3
	Females	659	0.0653	628	0.0617	-31	-4.6	-5.5
Hugh Smith Lake	Males	639	0.0944	604	0.1158	-36	-5.6	22.7
	Females	650	0.0693	631	0.0792	-20	-3.0	14.3
Avg. Troll Weight (kg)	Weeks 27–28	2.66	–	2.53	–	–	-4.8	–
	Weeks 32–33	3.26	–	2.82	–	–	-13.5	–
	Weeks 37–38	3.74	–	3.47	–	–	-7.1	–

[a]Average size is compared based on mid-eye to fork length for the 4 wild indicator stocks and in dressed weight (kg) for troll caught fish.

Auke Creek and Berners River males had nearly the same long-term mean-average length during 1982–2010 (excluding 1984), at 612 mm and 615 mm, respectively. However, Berners River males had a 31% higher average CV among individuals within a year of 0.1078, compared with 0.0823 for Auke Creek males, and were also substantially more variable in annual average length across years, with the CV of 0.0412 for Berners River being 55% higher than the CV of 0.0265 for Auke Creek. Berners River males have responded more to apparent declining growth conditions, going from a mean-average length 3 mm longer than Auke Creek males during 1982–1987 (excluding 1984) to a mean-average length 14 mm shorter than Auke Creek males during 2006–2010.

Over the long term, adult females in the 4 systems have usually been longer than males, by an average of 1.6% for Auke Creek, 3.4% for Hugh Smith Lake, 5.2% for Berners River, and 5.3% for Ford Arm Creek (mean-average 3.9%).

There has been substantial variability in the temporal pattern of average MEF length as shown by the 0.33 LOESS trends in Figure 26. However, males and females from the same system tended to show a similar pattern of change that was more exaggerated in males. The most striking example of the difference between sexes is found at Ford Arm Creek, where males displayed a remarkably steep decline in MEF length through the 1980s and 1990s. Male and female average length was strongly correlated over a 28-year period (R^2 = 0.84), but females averaged within 1% of the same MEF length when males averaged largest (665 mm in 1985), but averaged 10% longer than males in 2007 and 2009 when the average length of males was small (563 mm and 560 mm, respectively).

Coincident with the downward trend in average length, most stocks showed increasing variability in length, with significant ($p<0.05$) increasing linear trends in the CV of MEF length evident in all groups except Ford Arm Creek females and Berners River males (Figure 27 and Appendix A3). Again, the data suggests that males are much more plastic in their growth and size at maturity. However, it also indicates that conditions for growth have generally deteriorated since the early to mid-1980s, with both males and females from Ford Arm Creek showing the greatest decline in mean-average MEF length between the earliest and most recent 6 years of observations from 1982–1988 (excluding 1984) and 2005–2010 (Table 24). The Ford Arm Creek stock shows by far the greatest decline in mean-average length between the periods, decreasing by 10.3% for males and 4.6% for females. In contrast, the Auke Creek stock showed the least change, decreasing by only 3.8% for males and 2.7% for females. The Berners River and Hugh Smith Lake stocks were intermediate with decreases of 5.6–6.0% for males and 3.0–3.2% for females. Oddly, while average variability in MEF length increased the most between the periods for Ford Arm Creek males (+26.3%), it actually decreased for females from the same system (–5.5%). Excluding Auke Creek, where males and females both show a lesser decrease in average length (with males decreasing 38% more than females), adult males in the other 3 systems decreased by an average of double (202%) as much as females.

Relationships with Coho Salmon Abundance

We examined linear relationships between estimated total coho salmon abundance (total troll catch divided by troll exploitation rate index) and average adult length for the 4 indicator stocks and average dressed weight of troll-caught fish by regressing average size against abundance for the entire period (1982–2010) and for even years only and odd years only. None of the relationships were significant, with the highest R^2 value (0.24) and lowest p value (0.072) found for Berners River males in odd years.

Relationships with Pink Salmon Abundance

Beginning in 1999, when average troll-caught coho salmon were very small, concurrently with a record pink salmon catch in Southeast Alaska, we began to suspect that an increasing trend in pink salmon returns was placing greater pressure on food resources used by returning coho salmon. Although their diet in the ocean has limited overlap with coho salmon (Heard 1991; Sandercock 1991), a number of studies have shown highly abundant pink salmon to exhibit competitive dominance over other salmonids in the North Pacific Ocean (Ruggerone and Nielsen 2004). Because the observed decline in average weight was most prominent at midseason, prior to an influx of larger fish that increased average weight, we suspected that competition for forage between the species may have been greatest in coastal waters rather than offshore and high seas waters where large migratory fish appeared to be growing well.

However, regression of early and late troll average weight against the region pink salmon catch suggests somewhat the opposite. Late-August and September troll mean-average coho salmon weights from fish landed in statistical weeks 35–38 shows a significant negative linear relationship with the commercial catch of pink salmon in Southeast Alaska (R^2 = 0.21, p = 0.003) (Figure 28). However, fish landed in earlier statistical weeks (28–32) did not (R^2 = 0.04, p = 0.217). Furthermore, when even and odd years were examined separately, no significant correlation was found between pink salmon catch and coho salmon weight in even years, either early in the season (R^2 = 0.09, p = 0.175) or late in the season (R^2 = 0.00, p = 0.949) (Figures 29 and 30). Although no significant correlation was found between the pink salmon catch in odd years and early coho salmon weight (R^2 = 0.15, p = 0.095), a significant negative correlation was found between the odd year pink salmon catch and late coho salmon weight (R^2 = 0.35, p = 0.006) (Figure 29).

We then examined relationships between the Southeast Alaska pink salmon catch and average MEF length of age-.1 adult coho salmon from the 4 long-term wild indicator stocks for all years, even years and odd years. Although significant ($p<0.05$) negative correlations were found in a few cases in which R^2 values ranged from 0.15 to 0.37, most relationships were not statistically significant (Table 25).

Interestingly, however, coho salmon measured in escapements and caught in the troll fishery averaged larger in even years compared with odd years. During 1981–2010, troll-caught coho salmon averaged significantly larger by an estimated 12% in even years in both the early to midseason period (weeks 28–32; p = 0.000) and during late August and September (weeks 35–38; p = 0.002). The difference is less significant when the years 1970–1980 are included, when both pink and coho salmon were less abundant on average (p = 0.015 for the early-season period and 0.054 for late-season period).

Measured mean-average MEF length was 11–23 mm larger in even years during 1982–2010, with the difference being statistically significant for the average of all stock and sex combinations, with the exception of males and females returning to Auke Creek (Table 26).

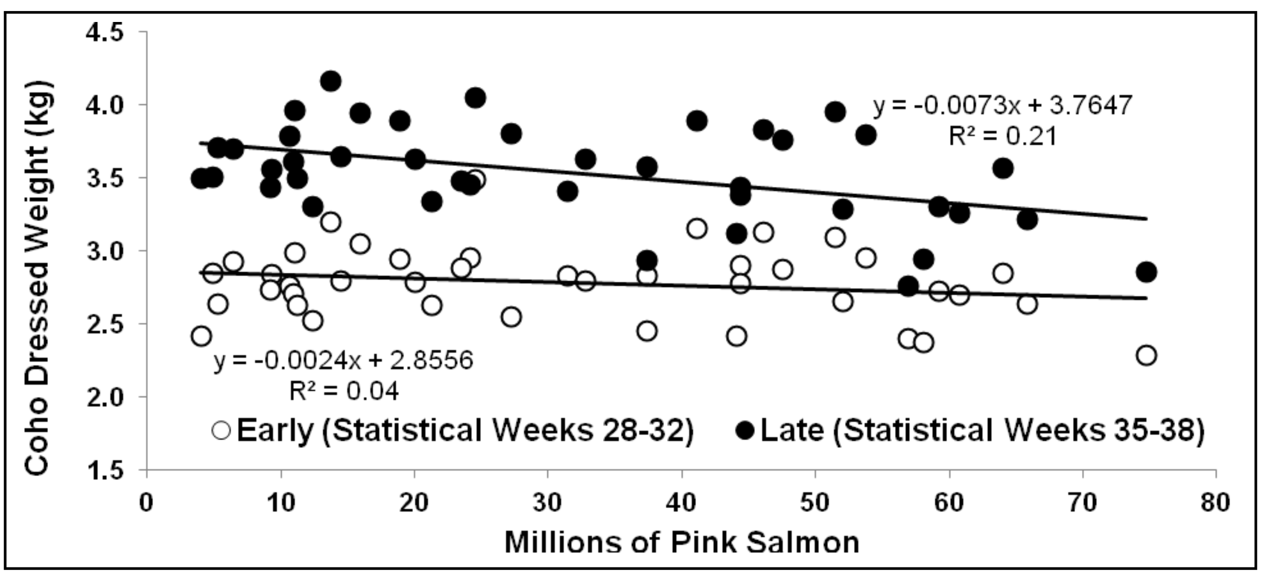


Figure 28.–Linear relationships between the Southeast Alaska pink salmon catch and the dressed weight of troll-caught coho salmon early in the season (early July to early August) and late in the season (late August through mid-September).

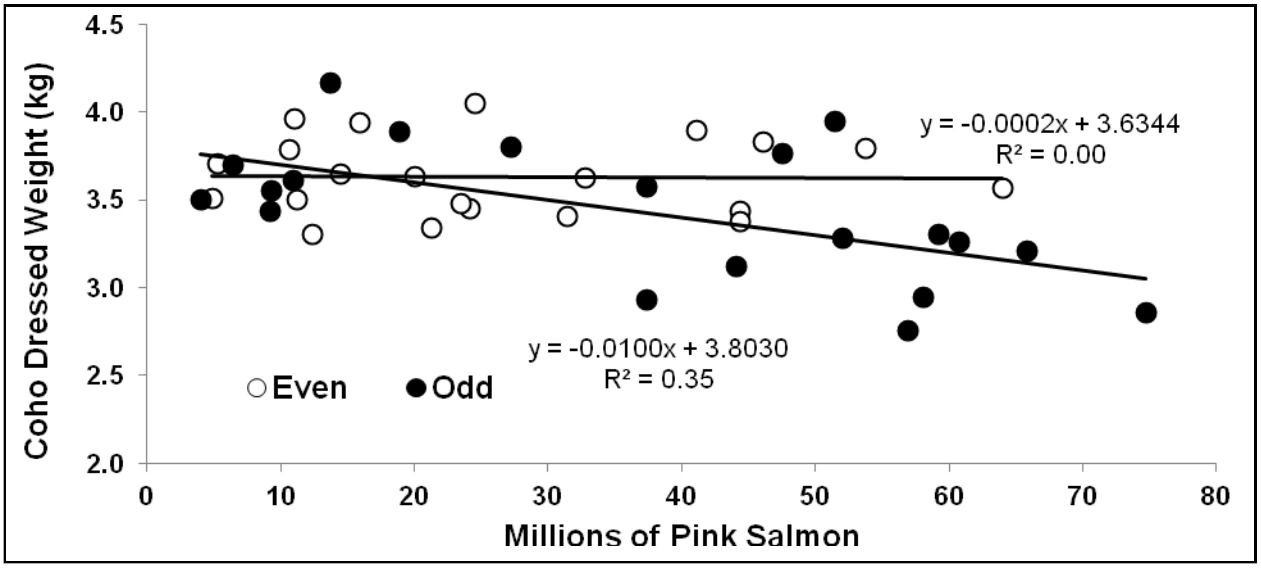


Figure 29.–Linear relationship between the commercial catch of pink salmon in Southeast Alaska and the mean-average dressed weight of troll-caught coho landed from late August through mid-September (statistical weeks 35–38).

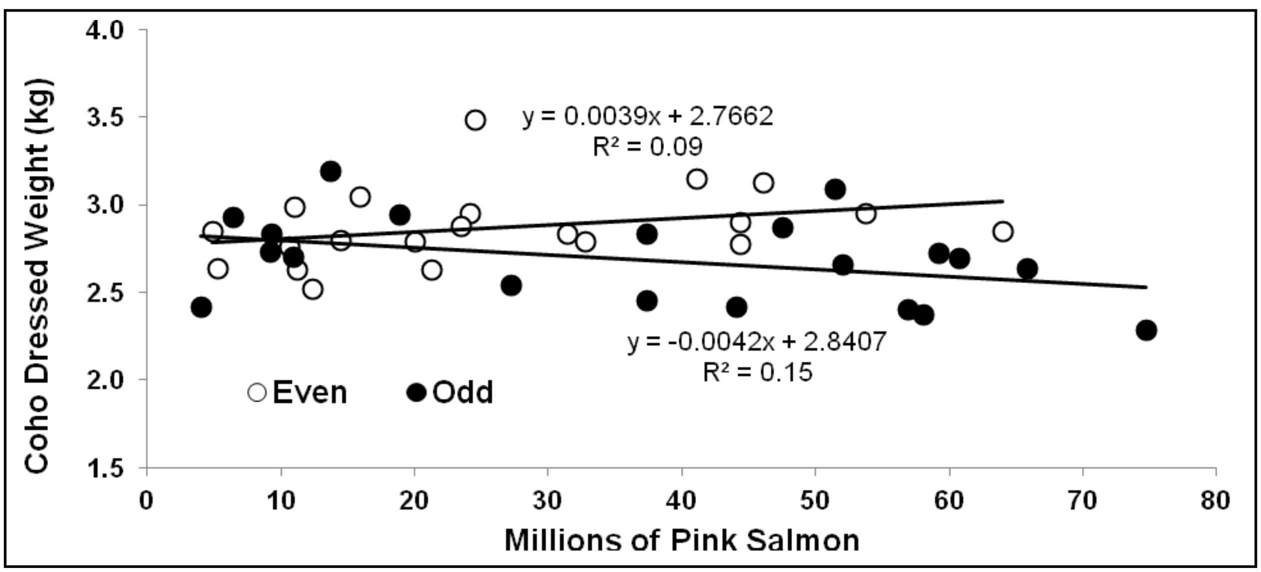


Figure 30.–Linear relationship between the commercial catch of pink salmon in Southeast Alaska and the mean-average dressed weight of troll-caught coho landed from early July through early August (statistical weeks 28–32).

Table 25.–Linear relationships between the commercial catch of pink salmon in Southeast Alaska in all years, even years only, and odd years only and the MEF length of age-.1 adult male and female coho salmon sampled from escapements at 4 Southeast Alaska systems.

Stock (Years)	Sex	Observations	Intercept	Slope	R^2	*p* Value (Slope)[a]
Auke Creek (All Years)	Males	31	629	-0.39	**0.18**	**0.017**
	Females	31	633	-0.25	0.09	0.093
Auke Creek (Even Only)	Males	16	620	-0.07	0.00	0.805
	Females	16	623	0.14	0.03	0.521
Auke Creek (Odd Only)	Males	15	635	-0.57	**0.37**	**0.017**
	Females	15	642	-0.49	**0.27**	**0.048**
Berners River (All Years)	Males	28	638	-0.56	**0.16**	**0.034**
	Females	28	659	-0.31	0.14	0.051
Berners River (Even Only)	Males	14	638	-0.43	0.15	0.172
	Females	14	662	-0.26	0.20	0.107
Berners River (Odd Only)	Males	14	626	-0.41	0.06	0.409
	Females	14	643	-0.09	0.01	0.767
Ford Arm Creek (All Years)	Males	28	630	-0.51	0.10	0.096
	Females	28	656	-0.35	**0.15**	**0.043**
Ford Arm Creek (Even Only)	Males	14	623	-0.16	0.01	0.725
	Females	14	649	-0.05	0.00	0.843
Ford Arm Creek (Odd Only)	Males	14	630	-0.59	0.10	0.267
	Females	14	656	-0.42	0.17	0.144
Hugh Smith Lake (All Years)	Males	29	638	-0.44	0.09	0.110
	Females	29	657	-0.38	**0.16**	**0.029**
Hugh Smith Lake (Even Only)	Males	15	629	0.09	0.00	0.838
	Females	15	651	-0.06	0.00	0.826
Hugh Smith Lake (Odd Only)	Males	14	631	-0.46	0.10	0.276
	Females	14	652	-0.39	0.16	0.153
Average (All Years)	Males	29	634	-0.48	0.13	0.064
	Females	29	651	-0.32	0.14	0.054
Average (Even Only)	Males	15	627	-0.14	0.04	0.635
	Females	15	646	-0.05	0.06	0.574
Average (Odd Only)	Males	14	630	-0.51	0.16	0.242
	Females	14	648	-0.35	0.15	0.278

[a] Cases in which slope is significant are shown in shaded bold.

Table 26.–A comparison of average MEF length of adult coho salmon from selected Southeast Alaska systems in even and odd years.

Stock	Period	Sex	Average Length Even Years	Average Length Odd Years	Difference	t Statistic	t Critical	*P* (T<=t)[a]
Auke Creek	1980–2010	Male	618	609	-9	1.594	2.045	0.122
Auke Creek	1980–2010	Female	627	619	-8	1.459	2.056	0.156
Auke Creek	1982–2010	Male	624	606	-18	1.983	2.052	0.058
Auke Creek	1982–2010	Female	628	617	-11	1.937	2.074	0.064
Berners River	1982–2010, excl. 1984	Male	622	604	-18	2.278	2.179	**0.042**
Berners River	1982–2010, excl. 1984	Female	653	638	-15	2.964	2.179	**0.012**
Ford Arm Creek	1982–2010, excl. 1984	Male	615	598	-17	3.133	2.179	**0.009**
Ford Arm Creek	1982–2010, excl. 1984	Female	647	635	-12	2.930	2.179	**0.013**
Hugh Smith Lake	1982–2010	Male	631	609	-23	2.539	2.052	**0.017**
Hugh Smith Lake	1982–2010	Female	649	633	-16	2.778	2.056	**0.010**
Average	1982–2010, excl. 1984	Male	622	606	-16	2.297	2.074	**0.032**
Average	1982–2010, excl. 1984	Female	644	631	-13	2.726	2.080	**0.013**
Average	1982–2010, excl. 1984	Average	633	618	-15	2.488	2.080	**0.021**

[a] Cases in which average length in even and odd years is significantly different ($p \leq 0.05$) are shown in shaded bold.

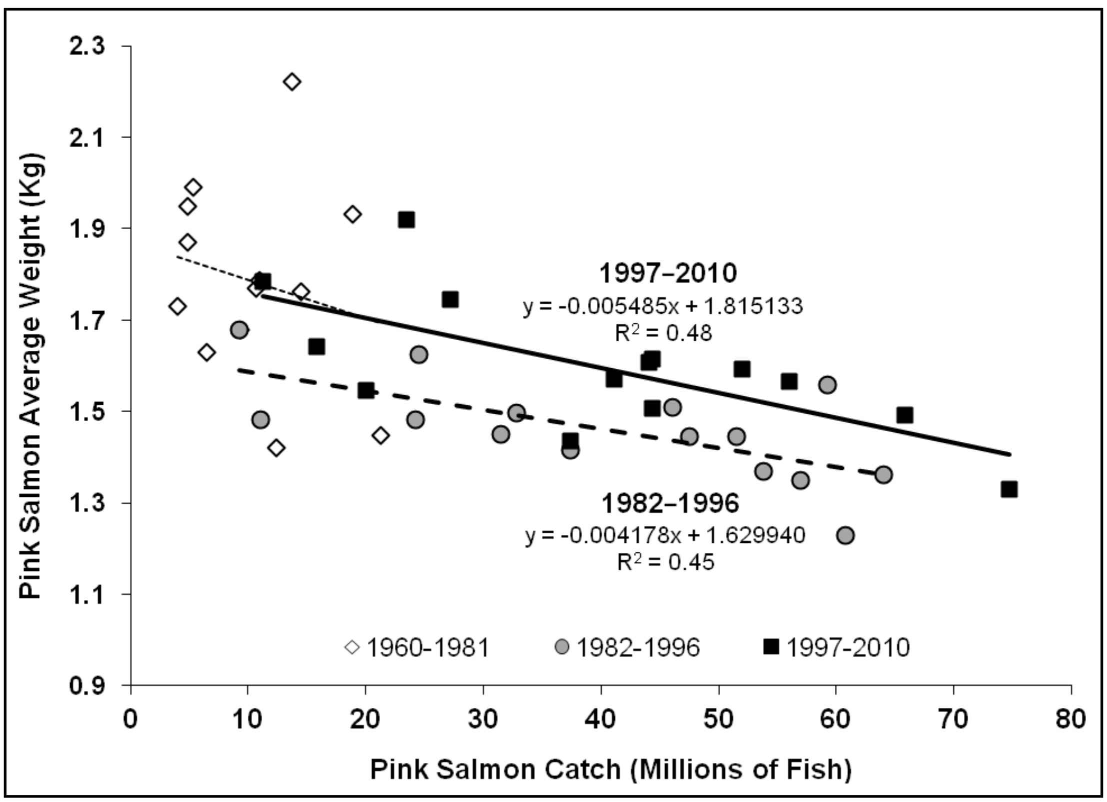


Figure 31.–Linear relationships between the commercial catch of pink salmon by fisheries in Southeast Alaska and the average weight (kg) of the pink salmon catch, 1982–1996 and 1997–2010.

In contrast to coho salmon, pink salmon have returned at historically large size since the mid-1990s, with the 1997–2010 mean-average round weight in the commercial catch of 1.60 kg being 9.0% larger than the 1982–1996 average weight of 1.46 kg (Appendix A1). When adjusted for a negative relationship with commercial catch (highly significant slope, p = 0.006 for both periods), the predicted average weight of pink salmon from a 1982–2010 average commercial catch of 40.3 million fish is 1.59 kg based on the 1982–1996 linear relationship, or 9.4% larger than the prediction of 1.46 kg based on the 1997–2010 relationship (Figure 31). In contrast, the mean-average weight of dressed troll-caught coho salmon decreased between these periods by 2.4% in early July, 10.4% in early to mid-August and 3.3% in mid-September.

Also in contrast to troll-caught coho salmon, the mean-average weight of pink salmon caught in even and odd years was not significantly different during 1982–2010 (p = 0.232), even though average catch was larger in odd years (48.6 million fish) than in even years (32.6 million fish).

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 initiated for the Berners River and Hugh Smith Lake populations in 1996. The preliminary 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 that appear more appropriate to the species than the Ricker model.

The Transboundary Technical Committee of the PSC is currently developing a *BEG* for Taku River coho salmon to replace the current management threshold. In the meantime, goals have been developed for other systems, including the Chilkat River (Ericksen and Fleischman 2006), and aggregates of streams that are surveyed in the Ketchikan and Sitka areas (Shaul and Tydingco 2006). The *BEG* for Hugh Smith Lake was revised from 770 (range 500–1,100) spawners to 850 (range 500–1,600 spawners) based on an analysis by Shaul et al. (2009). In addition, Clark (2005) revised goals for 2 Juneau roadside streams (Montana and Peterson Creeks) and recommended elimination of goals for the other 3 streams (Steep, Jordan, and Switzer Creeks).

Shaul et al. (*in prep*) reviewed the *BEG* of 2,050 (range 1,300–2,900) spawners for Ford Arm Creek based on a variety of conventional spawner-recruit models, including one incorporating pink salmon escapement. Their analyses resulted in estimates similar to the current goal and they concluded that no change is warranted.

Recent spawner-recruit analysis for two of the long-term indicator stocks, Hugh Smith Lake and Ford Arm Creek, indicates a positive relationship between brood year escapement and production over the range of observations, with no evidence of the over-compensation feature prominent in the widely employed Ricker spawner-recruit model. The data series were reasonably well described by the Beverton-Holt Model (Figure 32) which fits both data sets better than alternative models, including the logistic hockey stick and particularly, the Ricker model.

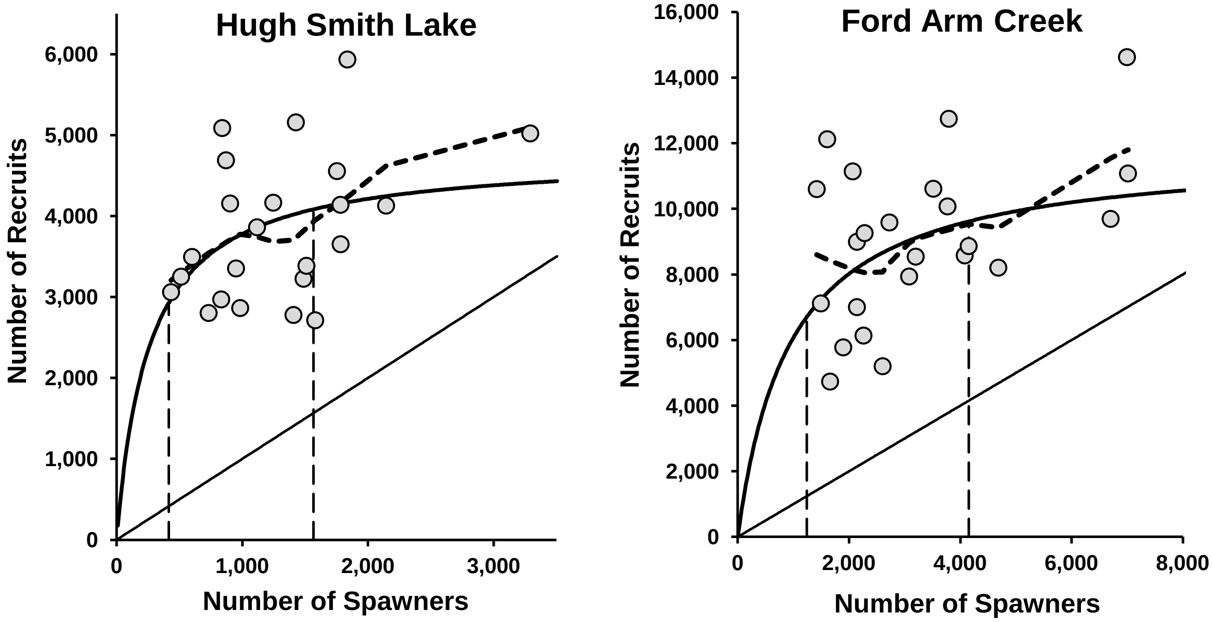


Figure 32.–Beverton-Holt spawner-recruit relationships for Hugh Smith Lake coho salmon (1982–2004 brood years) and Ford Arm Lake coho salmon (1982, 1983, and 1985–2005 brood years) showing a 0.75 LOESS trend (heavy dashed line) and the escapement range estimated to produce 90% or more of maximum sustained yield (light dashed lines).

The results indicate that exploitation rates applied to both stocks under fishery management, in effect since the early 1980s, have achieved a large fraction of potential biological yield. Despite the fact that escapement to Hugh Smith Lake during 1982–2005 was variable and averaged 150% of the Beverton-Holt estimate of E_{MSY} (851 spawners), Shaul et al. (2009) estimated the realized average harvest from the Hugh Smith Lake stock over the period to be 95% of the theoretical maximum potential had it been possible to hold escapement at exactly 851 spawners and catch all remaining adults. A similar analysis for the Ford Arm Creek stock (Shaul et al. *in prep*) suggests that 93–94% of potential yield was achieved from variable escapements during 1982–2005 that averaged 3,410 spawners, or 142% of estimated E_{MSY} of 2,394 spawners. However, an alternative slanted hockey stick spawner-recruit model for Ford Arm Creek incorporating the effects of pink salmon escapement on coho salmon production places estimated E_{MSY} substantially lower at 1,422 spawners and effectiveness in achieving theoretical maximum *MSY* at 79%.

The Beverton-Holt spawner-recruit relationships for the Ford Arm Creek and Hugh Smith Lake stocks (Figure 32) both reflect a positive relationship between escapement and the marine survival-adjusted return over the range of observations, indicating that equilibrium yields within 10% of *MSY* can be obtained over a relatively broad range of escapements from about 0.5 to 1.7 or 1.8 times the estimated level of escapement estimated to produce *MSY* (E_{MSY}). Escapements to these 2 systems during 1982–2010 averaged 1.4 and 1.7 times estimates of E_{MSY}, respectively, while the median escapement was 1.1–1.7 times estimated E_{MSY}.

The Beverton-Holt model appears to provide the best fit for these data sets because it is the only one of the 3 conventional spawner-recruit models that allows for an overall positive relationship between escapement and return, without either a saturation effect (hockey stick model) or over-compensation (Ricker model). The hockey stick model and its variation, the logistic hockey stick

(LHS; Barrowman and Myers 2000), is an appealingly simple model that describes the territorial freshwater life history of coho salmon in streams. At very low levels, smolt production and predicted adult return are directly proportionate to spawning escapement up to a saturation point at which available territories are filled and above which "surplus" fry that fail to establish and defend territory are displaced from the stream, presumably without contributing to adult production. Therefore, the hockey stick model predicts no response in the adult return at escapements above E_{MSY}.

Accounting for Nomads

The displaced fry known as "nomads" (Chapman 1962) enter estuaries and salt water where early observers assumed they perished without contributing to the adult population (Chapman 1966, Crone and Bond 1976). However, a substantial body of evidence, summarized by Koski (2009), indicates that many nomads likely survive and grow in the estuary, returning to overwinter before migrating as smolts the following spring. Documented movement of tagged fish among systems separated by saltwater distances up to 113 km in Lynn Canal and Stephens Passage (Table 27) indicates that presmolts are able to overcome osmoregulatory challenges to achieve much of their growth in marine as well as estuarine waters before returning to fresh water in the fall to overwinter and smolt in the spring.

Table 27.–Inter-system movement of tagged presmolt coho salmon in Lynn Canal and Stephens Passage, Southeast Alaska, showing minimum saltwater distances.

Number Recovered	Tagging Location	Tagging Date(s)	Recovery Location	Recovery Date(s)	Recovery Length (mm)	Distance (km)
1	Berners R.	June 22−30, 1988	Auke Cr.	October 11, 1988	125	56
1	Chilkat R.	April 7−June 2, 1999	Berners R.	May 17, 2000	126	67
1	Chilkat R.	June 1−6, 1999	Berners R.	May 26, 2000	127	67
1	Chilkat R.	May 12−29, 2004	Auke Cr.	September 10, 2004	147	109
1	Chilkat R.	May 14−22, 2001	Jordan Cr.	May 13, 2002	–	113
8	Burro Cr. Hatchery	June 13, 2000	Berners R.	May 11−29, 2001	114−142	90

Of a total of 13 recovered tags, 2 were from fish returning upstream in Auke Creek in September–October (Taylor and Munk 1988; Taylor and Lum 2005), while the other tagged fish were captured in downstream migrant smolt traps in the spring, including 10 fish from the Berners River and 1 fish from Jordan Creek (Lum and Glynn 2007). Minimum saltwater distances traveled ranged from 56–113 km.

A fall upstream migration of large, immature silvery returning nomads resembling smolts has been documented on a few occasions, but may be a common feature in many coho salmon streams in Southeast Alaska. These migrations appear to begin as early as mid-summer and usually peak during the return of spawners in September or October. Harding (1993) counted 1,434 juvenile coho salmon migrating through a weir approximately 300 m above the head of the estuary into Kake Bake Creek on Kupreanof Island between August 18 and November 7, with a mean immigration date of September 25 and a daily peak count on October 17. These fish averaged 83 mm (range 38–235 mm) and most were "bright silver (resembling smolts) in color." Several of the largest immigrants (>200 mm) were dissected and it was confirmed that they were not precocious males. A number of the fish had sea lice (*Caligus* spp.) attached near the anal fin, suggesting recent (<6 days) immigration from marine water. Using baited minnow traps, Shaul et al. (1986) captured several large (120–165 mm fork length) fish described as silver in coloration with black-tipped fins, typical of migrating smolts, in Ford Arm Lake and an adjacent pond on the outer coast of Chichagof Island during August 15–25.

The weir at Auke Creek was modified to capture small immigrants during 4 years (Taylor and Lum 2003, 2004, 2005; Taylor 2006). Counts of immature migrants and the range (and average) of migration dates by year include: 446 fish during July 18–October 30, 2002 (September 14); 310 fish during July 29–October 30, 2003 (September 26); 90 fish during September 10–October 26, 2004 (September 25); and 307 fish during July 7–October 28, 2005 (September 23). These numbers comprised 12.5%, 6.8%, 2.1%, and 6.8% (average 7.0%), respectively, of subsequent spring smolt migrations from the system totaling 3,574 smolts in 2003, 4,581 smolts in 2004, 4,318 smolts in 2005, and 4,532 smolts in 2006 (Taylor and Lum 2004, 2005; Taylor 2006, 2007). These percentages may be conservative because nomads were still migrating within a day before the weir was removed near the end of October each year. The low count in 2004 occurred coincident with a very dry summer and early fall period when stream flows dropped to nil in June and the creek dried up from July until the end of August (Lum and Taylor 2006).

Although a fall migration of returning nomads may be common in Southeast Alaska streams, it has seldom been documented because weirs commonly operated to enumerate returning adult spawners have openings too large to detain small fish. Presumably, most returning nomads overwinter in fresh water and join the spring smolt migration. The strategy allows fish that are surplus to the summer carrying capacity of freshwater habitat to attain a high growth rate on estuarine and marine food resources (Murphy et al. 1984; Tshlapinski 1988) before returning in the fall to stable overwintering habitat found in many Southeast Alaska systems.

Otoliths from 11 of the fish listed in Table 27, including all 10 fish recovered from the Berners River and 1 fish from Jordan Creek (Lum and Glynn 2007), were microprobed along a transect from the primordium to the margin to measure the Sr:Ca ratio, an indicator of exposure to saline water. Features evident in the growth history of the otolith were matched with the microprobe transect to pinpoint transitional movement between habitats. All of the samples showed elevated Sr:Ca ratios for a period after tagging, marking their exposure to estuarine and marine waters of Lynn Canal and Stephens Passage. However, 1 of the 2 wild Chilkat-Berners migrants was of particular interest because it displayed evidence of extended exposure to saline water during 2 periods, comprising 36% and 15%, respectively, of the smolt's total growth history as indicated by the distance from the primordium to the margin of the otolith (Figure 33). A check was evident at emergence, with an apparent winter annulus appearing at the point where the Sr:Ca ratio began to decline in fall 1998, indicating a return to fresh water prior to initial capture and tagging in a section of the Chilkat River 5–26 km upstream from its mouth in spring 1999 (Ericksen 2001). A second marine-rearing period marked by an elevated Sr:Ca ratio is evident as the fish moved 67 km across Lynn Canal before swimming 8 km up the Berners River, where it was captured in May 2000 as a 126 mm migrant from a beaver pond. A second marked smolt, also tagged in the Chilkat River in spring 1999, was recovered from the same pond 9 days later.

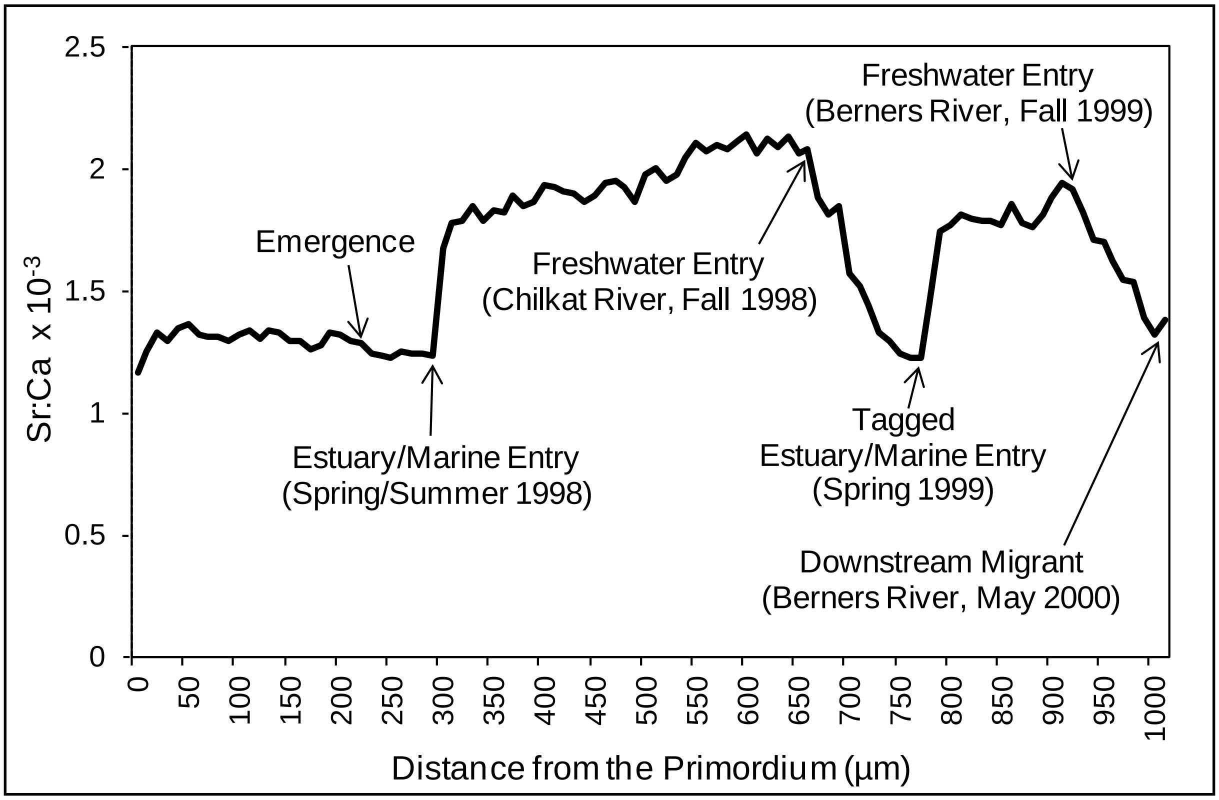


Figure 33.–Changes in the Sr:Ca ratio measured across an otolith from a coho salmon tagged in the Chilkat River between April 7 and June 2, 1999 (Ericksen 2001) and recaptured from the Berners River at a length of 126 mm on May 17, 2000.

Although this wandering nomad overwintered in both the Chilkat and Berners rivers (Figure 33), its natal system and its probable spawning destination remain unknown. Do nomads that overwinter in distant freshwater systems imprint on the streams from which they smolt, or do they return to spawn in their natal streams? Recoveries of tagged fish from these same systems at later life stages may provide a clue. To date, 4 adults have been recovered from the Chilkat River as "strays", of which 3 were tagged as smolts migrating from the Berners River and 1 from Jordan Creek (Alaska Department of Fish and Game, Mark Tag and Age Laboratory database). The migration of these fish between the smolt and returning adult stages in the reverse direction of "straying" presmolts recaptured as smolts (Table 27) suggests that they may not have been strays in the genetic sense, but may have returned to their natal river (the Chilkat) after growing in marine waters, overwintering in distant freshwater habitat, and migrating to the high seas. Such behavior would help to explain the typically substantial fraction of returning adults that are unmarked in systems where 100% of observed smolts have been coded-wire tagged after capture in a carefully installed smolt weir operated throughout the spring migration. For example, the adipose clipped rate for adults returning to Hugh Smith Lake has never exceeded 84% (Shaul et al. 2009), or 89% at Chuck Creek (McCurdy 2010), while the highest adipose clipped rate reported in the adult return to the Lachman River was 72% (Lane et al. 1994).

Slanted Hockey Stick Model

Although estuarine and marine waters present osmoregulatory challenges and increased predation risk, growth, and survival in those environments appears to be far less compensatory than in fresh water (Tschaplinski 1988). The contribution by nomads to the smolt population above the capacity of freshwater habitat could, therefore, be a relatively constant function of the increase in the number of spawners. Depending on the spatial scale of suitable marine habitat, nomads overflowing into estuarine and marine waters could contribute to smolt and adult production in proportion to the number of spawners, even at escapements far above E_{msy}. Successful contribution by nomads to coho salmon smolt and adult populations provides a plausible explaination for significant positive linear slope observed in the spawner-recruit relationships (parent escapement versus smolts x average marine survival) for Hugh Smith Lake (slope = 0.60, p = 0.04) and Ford Arm Creek (slope = 0.68, p = 0.02).

In locations where the nomadic life history strategy is common and successful, it may be appropriate to discard or revise the logistic hockey stick (LHS) model (Barrowman and Myers 2000). A conceptual representation of our proposed modification, the slanted hockey stick (SHS) model is depicted in Figure 34 with the initial slope (α), smoothness parameter (θ), and the secondary slope (representing the nomad contribution within and above in the inflection region), based on average parameter estimates for the populations in Hugh Smith Lake and Ford Arm Creek.

Individual model fits for the 2 stocks (Figure 35) indicate substantially broader 90% of *MSY* ranges around E_{msy} for the SHS model compared with the LHS model, but not as broad as indicated by the Beverton-Holt model (Figure 32). Akaike's information criterion (AIC) values were very similar for the SHS and Beverton-Holt models. We initially fitted spawner-recruit data from both stocks to a modification of the LHS model (Barrowman and Myers 2000, equation 8) by adding a simple constant multiplier to the increase in escapement beginning at estimated E_{msy}. However, the smoothness parameter (θ) for Ford Arm Creek reverted to 0, and the best model fit with the lowest AIC value was a modification of the simple Hockey stick model (Barrowman and Myers 2000, equation 3) that begins at 0 with a constant slope (α). Instead of fixing production at a constant return above E_{msy} (independent of spawning escapement), we substituted a second linear relationship with slope and intercept. Estimates of intrinsic productivity (α) of 8.78 for Hugh Smith Lake and 5.49 for Ford Arm Creek were likely conservative values because there were no observed escapements substantially below estimated E_{msy} with which to define the lower end of the relationship. The slope of the recruitment response above estimated E_{msy} based on the model fits was 0.54 for Hugh Smith Lake and 0.68 for Ford Arm Creek.

For Hugh Smith Lake, the SHS model estimate of E_{msy} is 600 spawners, with a 90% of *MSY* range from 409–1,360 spawners (Figure 35) compared with a Beverton-Holt estimate of E_{msy} = 851 spawners, range 417–1,566 spawners (Figure 32) and an LHS estimate of of E_{msy} = 844 spawners, range 593–1,279 spawners (Shaul et al. 2009). For Ford Arm Creek, the SHS model indicates E_{msy} = 1,422 spawners, with a 90% of *MSY* range from 1,280–3,415 spawners (Figure 35) compared with a Beverton-Holt estimate of E_{msy} = 2,394 spawners, range 1,242–4,153 spawners (Figure 32), and a LHS estimate of E_{msy} = 1,885 spawners, range 1,349–2,857 spawners (Shaul et al. *in prep*).

If we attribute the slope of the SHS relationship above estimated E_{msy} (Figure 35) entirely to nomad production, then the contribution by nomads to adult returns from average brood year escapements of 1,305 spawners at Hugh Smith Lake and 3,275 spawners in Ford Arm Creek is predicted at 12% and 14%, respectively, of combined total production. These theoretical proportionate contributions are similar to the highest minimum count of nomads into Auke Creek as a percent of the smolt migration the following spring (12.5%), and somewhat above the average for all 4 years (7.0%).

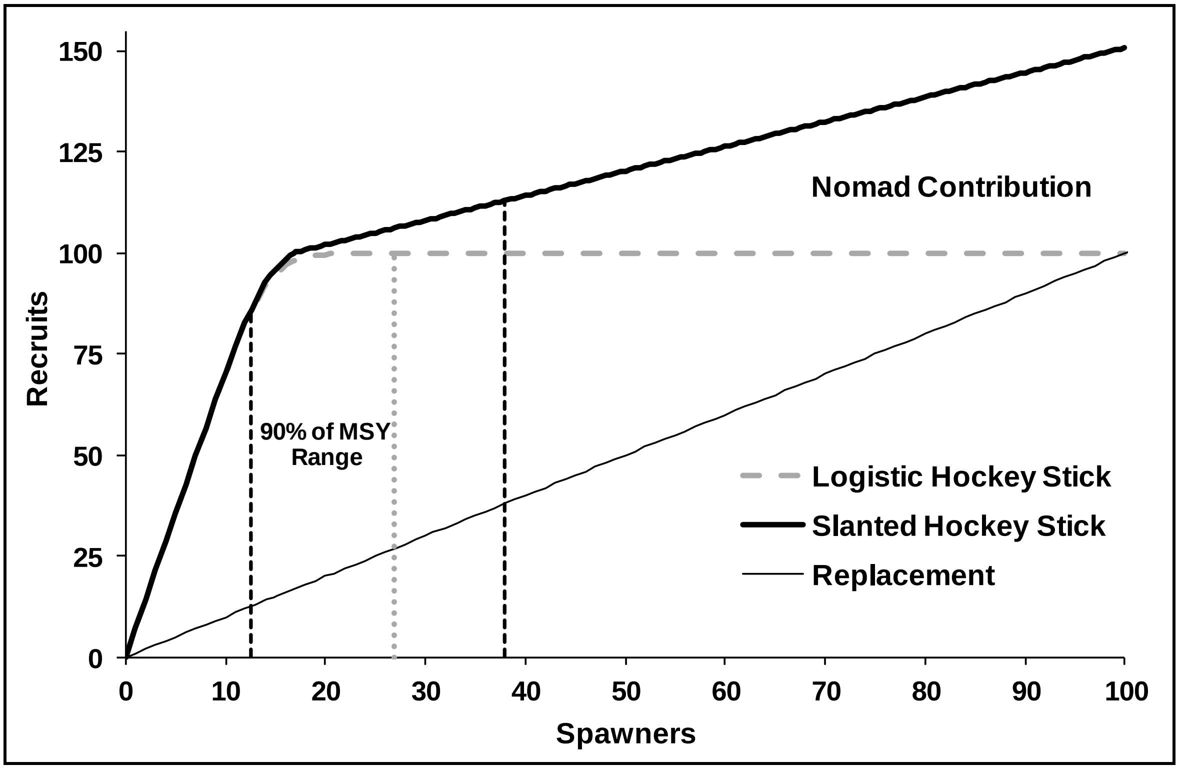


Figure 34.–Conceptual slanted hockey stick (SHS) model based on average spawner-recruit parameters (including α, θ and secondary slope) for the Ford Arm Creek stock and the Hugh Smith Lake stock, compared with the logistic hockey stick (LHS) model. Axis scales are shown as a percent of carrying capacity (K) indicated by the LHS model.

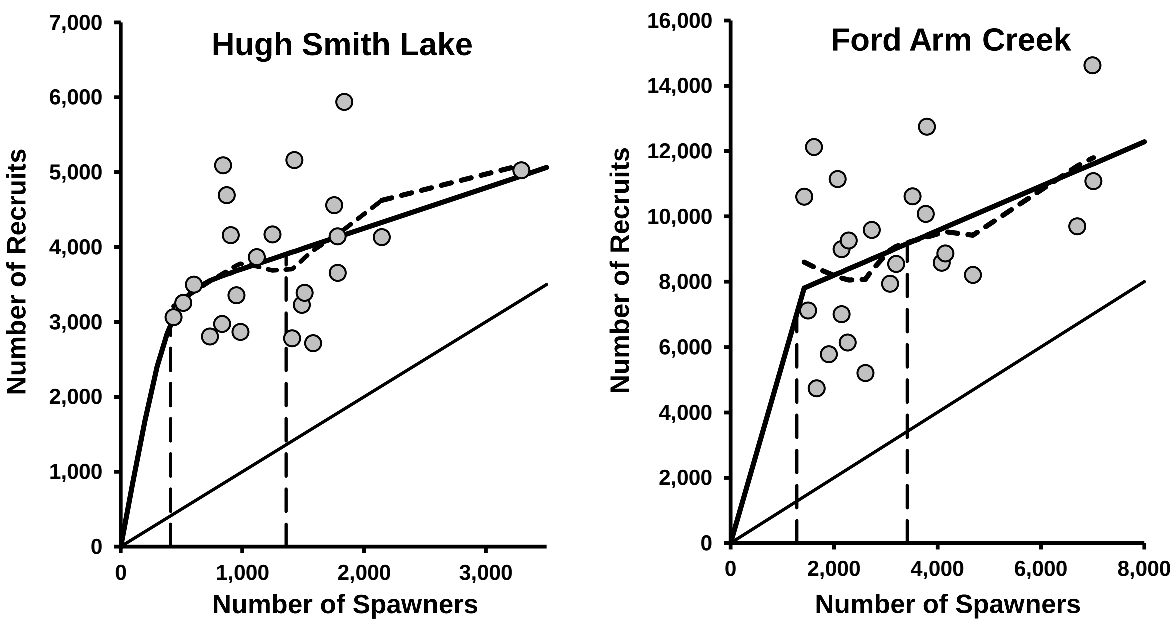


Figure 35.–Slanted hockey stock (SHS) spawner–recruit relationships for Hugh Smith Lake coho salmon (1982–2004 brood years) and Ford Arm Lake coho salmon (1982, 1983, and 1985–2005 brood years) showing a 0.75 LOESS trend (heavy dashed line) and the escapement range estimated to produce 90% or more of maximum sustained yield (light dashed lines).

Clearly, while estuarine and marine-rearing nomads appear to make a substantial contribution to coho salmon production in some systems, and likely have an important effect on the spawner-recruit relationship, they are secondary in importance to production of smolts reared entirely in fresh water. Although their survival may be low on average and highly variable, nomads' use of a different environment for summer growth provides the overall population with benefits of diversification and a potential numerical buffer.

DISCUSSION

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

Shaul et al. (2008) raised concerns about a substantial decline in marine survival during 2005-2007 compared with the 1982–2004 average in most indicator systems. This decline raised the possibility of a change in ocean conditions, possibly a "regime shift", toward a period of conditions less favorable for salmon survival in Southeast Alaska than have been experienced since the early 1980s. Furthermore, a poorly-understood decline in smolt production resulted in exceptionally low total returns to some systems, including the Berners and Chilkat rivers, where escapements fell below goal in 2007.

Average survival of all monitored wild stocks during 2008–2010, however, has shown improvement over the prior 3-year period (2005–2007), with a 40% average relative increase between the periods, with the overall mean-average survival rate across all stocks increasing from 9.5% to 12.8%. The relative increase ranged from 3% for Ford Arm Creek to 111% for Hugh Smith Lake. The recent improvement in average survival provides some assurance that there has not been another fundamental regime shift toward an extended period of poor survival in Southeast Alaska (coincident with higher survival southward along the coast), similar to the period from 1956–1981 (Shaul et al. 2007). However, within Southeast Alaska there has been a recent shift in survival in favor of wild and hatchery stocks in the southern part of the region compared to the north that has persisted for 4 years so far (2007–2010).

For the Berners River, a decline in average freshwater production, from 202,000 smolts in 1990–2004 to 115,800 smolts in 2005–2007, was compounded by a decrease in average smolt survival from 17.5% to 9.7% between the periods, reaching a record low of 7.5% in 2007. The combined result was extremely poor total runs of 8,682 adults in 2007 and 9,368 adults in 2009 that were far below the 1990–2004 average of 35,220 fish and barely justified any harvest, given an escapement goal of 4,000–9,200 spawners. Fortunately, freshwater production bottomed at 89,200 smolts for the 2008 return, coinciding with near-average 15.8% survival, and has partially rebounded to 161,100 smolts for the 2010 return and 130,800 smolts for the 2011 return. Marine survival decreased to 9.2% in 2009, but rebounded again to 13.5% in 2010 which, combined with improved freshwater production, resulted in a total 2010 run estimated at 21,680 adults that was the largest return in 6 years (although below the long-term average of 27,600 adults).

The apparent improvement in smolt production from the Berners River is encouraging given a very low, below-goal escapement of 3,915 spawners in a primary contributing brood year to the smolt migrations in both 2009 (age 1+) and 2010 (age 2+). Such high freshwater survival from low brood year escapement demonstrates a strong density-dependent, compensatory response frequently observed in coho salmon that lends resilience to population shocks.

The larger population in the Chilkat River in upper Lynn Canal has tracked closely with the Berners River population for 11 years with a linear regression R^2 value of 0.88 for the adult returns to the 2 systems. While the period of very poor smolt production in the Berners River does not appear to be explained by dry summer-fall weather, the very similar abundance history between the Berners and Chilkat rivers suggests that the primary factor(s) responsible for the recent decline in adult abundance were not drainage-specific, but operated over a broad area.

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. Preseason 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 have been available for some systems, including Auke Creek and Chuck Creek, while lower quality preseason estimates are available for most other systems using mark-recapture methods based on tagging of smolts and recovery sampling of smolts or jacks. 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. 2009). Preliminary smolt production estimates combined with inseason survival predictions are very useful for forecasting 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 during the season.

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 2006–2010, substantial but moderate, average exploitation rates ranging from 38–64% (mean-average 52%) were achieved from 6 stocks that have very different migratory characteristics and are exposed to very different, but overlapping, complexes of fisheries. The Chuck Creek and Ford Arm Creek stocks on the outer coast were exploited at the highest average rates of 59% and 64%, 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 3 management jurisdictions (state-managed waters, Annette Island Reserve, and northern British Columbia) was exploited at an average rate of 53% (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 58%, 43%, and 48%, respectively, for the same recent 5-year period. The Auke Creek stock, which is less available to gillnet fisheries, had a markedly lower average exploitation rate of 38% for the period.

There has been a long-term decrease in exploitation rates on southern inside stocks, represented by Hugh Smith Lake, that may justify liberalization of current management strategy in order to better achieve available yield from southern inside stocks. The decline in the all-gear exploitation rate from an average of 75% in the 1990s to 50% (range 47–54%) during 2008–2010 has approximately doubled escapement from a given total run size, resulting in escapements well over the *BEG* range in the 3 most recent years. The trend toward a lower all-gear exploitation rate has now continued for the past 12 years, during which it averaged 52%. All fisheries have shown a recent decline in exploitation on the stock, except those in northern B.C., where increased marine sport exploitation appears to have offset a decrease in Canadian troll and net fishery exploitation of the stock. In Southeast Alaska, the average drift gillnet exploitation rate, primarily in the Tree Point fishery, has declined only slightly from 16% in the 1990s to 15% in 2008–2010, while the average purse seine exploitation rate decreased from 10% to 6%. However, the greatest factor was a decrease from 41% to 22% for the Alaska troll fishery. This decline in exploitation is difficult to explain based simply on decreasing troll effort, especially since average troll exploitation rates did not decrease nearly as much for stocks to the north, where they dropped from 55% to 51% for Ford Arm Lake and from 31% to 28% for Auke Creek.

It appears likely that changing ocean conditions have had some effect on the availability of the Hugh Smith Lake stock to the troll fishery because the sharpest decline (from 27% to 12%) in the average troll exploitation rate occurred in the same northern Southeast waters where the Ford Arm Creek and Auke Creek stocks area caught. The Southeast Quadrant showed the least decline, from 8% to 6%, while Southwest Quadrant decreased nearly as much as Northern Southeast, from 6% to 3%. However, the Chuck Creek stock, which is harvested primarily in the Southwest Quadrant, has actually shown a slight increase in average troll exploitation rate from 40% in the early to mid-1980s to 44% in 2003–2010.

Irrespective of the cause, the result has been that the upper bound of the *BEG* of 500–1,600 spawners will be exceeded by 15–20% when the run is average (4,000 fish) and the exploitation rate equal to the 10-year average (53%), whereas even at the lowest run size ever observed (1,346 adults), the lower *BEG* bound will be exceeded by a healthy margin of about 26%.

The analysis of length and weight data suggests that spatial variability in growth conditions has substantially increased across the range inhabited by Southeast Alaska coho salmon in the North Pacific Ocean. Furthermore, the data support the hypothesis that most of the decline can be attributed to a change in the quantity and/or quality of forage in outer coastal waters along the Southeast Alaska coast. Earlier support for that hypothesis came from a change in the temporal pattern of average weekly troll dressed weight over the past 3 decades, combined with anecdotal observations among fishery participants and samplers of the late-season appearance of larger fish that had apparently experienced more favorable growth rates than those that had been caught by trollers in the midpart of the season. The decline in size is most marked in the Ford Arm Creek stock, which is a less migratory “milling” stock available in high abundance at the July 1 opening of the summer troll fishery and exploited by trollers at a high historical average rate of 53%, compared with 30% and 35%, respectively, for the more migratory Auke Creek and Hugh Smith Lake stocks. This provides further evidence that the decline in growth has occurred primarily in local outer coastal waters rather than high seas feeding areas.

Interestingly, an increase of about 9% in the mean-average size of pink salmon between 1982–1996 and 1997–2010 indicates a concurrent improvement in forage conditions for that species. The trend in size of pink salmon bottomed in the early 1990s, with a record low of annual average weight 1.23 kg in 1991, before rebounding and reaching 1.92 kg in 2010, the largest observed weight since 1981. The timing of these changes suggests a likely shift in the marine food web away from prey species favored by coho salmon toward those favored by pink salmon.

The timing of the changes over a period of years, beginning in the early-1990s, points to the most recent recognized ocean "regime shift" in 1989 (Hare and Mantua 2000) as a possible catalyst for the opposing trends in growth of pink and coho salmon.

In recent discussions, several board members of the Alaska Trollers Association (ATA) indicated verbally to us that they have noticed a large amount of krill in the ocean in recent years and a decrease in fish in the stomachs of troll-caught coho salmon. A substantial amount of diet information from salmon landed in the troll fishery was collected annually during 1976–1991 through a logbook program sponsored by ATA, in partnership with ADF&G, NMFS, Sea Grant, and University of Alaska (Wing 1985). That data provides a potentially valuable baseline for comparable future data collection that could help identify and quantify changes in the forage community available to adult salmon in the waters of Southeast Alaska.

It is not surprising that adult female coho salmon have averaged 1.6–5.3% (mean-average 3.9%) larger, while showing substantially less variation in MEF length, indicating less flexibility in size at return, because larger females may have a substantial reproductive advantage in fecundity and the ability to dig nests (van den Berghe and Gross 1984 and 1989). However, female size may also be influenced by conditions in spawning areas including stream flow, depth, and substrate. The fact that Berners River females averaged significantly longer than Auke Creek females in all years ($p<0.001$), by an average of 32 mm in 1982–2010 (excluding 1984), may reflect adaptation based on availability of larger stream spawning habitat in the upper Berners River proper compared with the Auke Creek system, where the small inlet streams where spawning occurs are shallow and have comparatively little average flow.

Adult males and females were most similar in both average MEF length and variability in length in Auke Creek, but were most different in both features in the nearby Berners River. Gross (1985) has shown that competition among male coho salmon may result in disruptive selection favoring larger body size for fighting and smaller size for sneaker or satellite roles. A potential explanation for the substantially greater difference in average size between males and females and greater variation in size of males in the Berners River population within and across years is that, with little competition from 0-ocean jacks, small 1-ocean adult males have more opportunity to successfully occupy subdominant roles during spawning. Greater reproductive flexibility in the absence of jacks allows Berners River adult males to remain competitive as spawners at a variety of sizes and may promote greater flexibility in marine growth rates.

There is no compelling evidence that the decrease in average size of coho salmon since the early 1980s resulted primarily from either intra-species competition or inter-species competition with pink salmon. Furthermore, although evidence around the decline in growth points primarily to waters immediately off the Southeast Alaska coastline, any effect on growth from interaction with pink salmon appears more likely in offshore waters of the North Pacific. Although we found Southeast Alaska pink salmon abundance (as indicated by commercial catch) to be unrelated or at best, poorly correlated with measures of adult coho salmon size, we did find nearly all indicators of adult coho salmon size to be significantly larger in even years than in odd years since the early 1980s. One possible explanation is that coho salmon returning to Southeast Alaska interact more intensively on the high seas with pink salmon stocks from other areas, with stronger odd-year dominance, such as those from southern British Columbia and Washington, or are in some way responding to the pattern of greater overall pink salmon abundance in the northeast Pacific in odd years However, this seems unlikely because southern pink salmon populations that are most strongly odd-year dominant are of substantially lesser average abundance compared with Alaskan stocks (Ruggerone et al. 2010) and show substantial overlap in high-seas feeding areas (Myers et al. 1996). Another possible factor is that coho salmon returning to Southeast Alaska in even years may have greater access to juvenile pink salmon prey from more southern cyclic-dominant systems, because pink salmon entering the northeast Pacific appear to follow the coast for long distances to the northwest (Takagi et al. 1981; Hartt and Dell 1986). Adult coho salmon have been found to be the dominant salmonid predator on juvenile pink salmon during the summer in northern Southeast Alaska, based on data from trawl surveys (Joe Orsi, NMFS, personal communication). It is interesting to note that while Southeast Alaska pink salmon display a negative relationship between size and abundance since the early 1980s, there is no significant difference in average weight between even and odd years as in coho salmon.

Substantial inter-system variability in returns of specific coho salmon stocks (Shaul et al. 2009), combined with the broad distribution of production across many streams, present challenges to management for *MSY*. However, the disadvantage to fishery management resulting from variability among individual populations is offset, to some extent, by population characteristics of the species that provide resilience and flexibility under mixed-stock 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 (as recently evidenced in the Berners River 2007 brood year).

To the extent that higher brood year escapements above *MSY* may produce larger average returns (Figure 32), the fisheries may be slightly more economically 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.

A critical contributing factor to high management effectiveness under conservative exploitation is the estimated response characteristic of the stocks at escapements above E_{MSY}. An apparent overall positive relationship between spawners and returns results in a broad range of escapements across which predicted yield remains within 10% of *MSY*. For both the Hugh Smith Lake and Ford Arm Creek stocks, the estimated yield penalty for allowing escapement to vary and average 42–50% over $E_{MSY,}$ has been less than 10% as indicated by the Beverton-Holt model. The larger average run size partially offsets the yield penalty for exploiting at a below-optimum rate, while providing a potential population buffer for the next generation in the event of poor marine survival. Finally, managing at higher average abundance combined with a lower-than-optimal exploitation rate has the added benefit of improving economic efficiency in harvesting fish. An increase in abundance drives up CPUE, thereby lowering the amount of fishing effort required to achieve a constant level of catch.

One reason recent management has been effective in achieving a large fraction of potential yield lies in the fact that the stocks have been exploited under relatively consistent, substantial rates (averaging 64% for Hugh Smith Lake and 60% for Ford Arm Creek) that, while somewhat conservative, have been generally well-matched to the productivity of the stocks. For comparison, the optimum equilibrium exploitation rate at *MSY*, estimated using the Beverton-Holt model, is 76% for the Hugh Smith Lake stock and 72% for the Ford Arm Creek stock

(Shaul et al. 2009 and *in prep*). Estimates based on the SHS model place it at 82% for both stocks.

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. However, the process of isostatic rebound from a period of extensive glaciations is likely affecting some wetland habitat, particularly near Yakutat (Shaul et al. 2010).

Coho salmon growth and smolt production is also strongly affected by nutrient subsidies provided to streams by spawning salmon, in particular pink salmon. The beneficial effect to coho salmon production of an incremental increase in marine-derived nutrients is particularly important at lower salmon densities, but appears to approach a saturation density at roughly 1 pink salmon or more per m^2 of habitat (Wipfli et al. 2003; Shaul et al. *in prep*).

We have introduced a new spawner-recruit model that is consistent with our developing understanding of coho salmon life history in Southeast Alaska. The SHS model combines the well-documented territorial freshwater life history strategy of the species with emerging information on the presumed non-compensatory life-history strategy of nomads rearing in estuaries and the ocean as fry and presmolts. The SHS model tends to point to a broader *BEG* range compared with the hockey stick model and its variations, including LHS (Barrowman and Myers 2000), although not as broad as indicated by the Beverton-Holt model. Although the Beverton-Holt model also fits our data sets for 2 stocks nearly as well, we find the SHS model to be intuitively more compelling. Like the LHS model, the SHS model also assumes a more conservative linear response at very low escapement levels in the area of the spawner-recruit relationship where the Beverton-Holt and Ricker models often overestimate return-per-spawner (Myers et al. 1994; Barrowman and Myers 2000).

The Ricker model, the most commonly applied spawner-recruit model, provided the poorest statistical fit of all models tested for both the Hugh Smith Lake and Ford Arm Creek populations (Shaul et al. 2009; Shaul et al. *in prep*). Although we find it to be the model least consistent with coho salmon life history, the Ricker model may actually represent a safer option for more problematic data sets subject to substantial statistical and process error, because it tends to produce conservatively high E_{msy} estimates that are less sensitive to the shape of the distribution of paired spawner and recruit estimates. Point estimates of E_{msy} based on the Ricker model were substantially higher for both the Hugh Smith Lake and Ford Arm Creek stocks compared with all the other models tested (Shaul et al. 2009; Shaul et al. *in prep*).

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APPENDIX A

Appendix A1.–Mean-average dressed weight (kg) of coho salmon during 3 periods of the Southeast Alaska summer troll season and the all-gear commercial catch of coho and pink salmon and round weight of commercially-caught pink salmon (kg), 1970–2010.

Year	Coho Average Dressed Weight in kg (stat. weeks)			Number of Coho Salmon (millions)	Pink salmon	
	27–28	32–33	37–38		Catch (millions)	Avg. Wt. (kg)
1970	2.49	3.06	3.83	0.759	10.657	1.77
1971	2.62	3.07	3.66	0.914	9.345	1.68
1972	2.23	2.75	3.33	1.509	12.400	1.42
1973	2.65	3.19	3.80	0.836	6.455	1.63
1974	2.54	3.13	3.53	1.277	4.889	1.87
1975	2.26	2.74	3.36	0.425	4.027	1.73
1976	2.23	3.13	3.84	0.822	5.330	1.99
1977	2.83	3.54	4.23	0.945	13.751	2.22
1978	2.33	2.99	3.43	1.713	21.242	1.45
1979	2.52	3.10	3.64	1.278	10.939	1.79
1980	2.48	3.14	3.69	1.115	14.493	1.76
1981	2.57	3.19	4.01	1.353	18.900	1.93
1982	2.57	3.18	3.49	2.103	24.210	1.48
1983	2.75	3.07	3.63	1.943	37.417	1.42
1984	3.02	3.76	4.07	1.881	24.529	1.62
1985	2.94	3.34	3.94	2.562	51.470	1.44
1986	2.87	3.31	3.79	3.259	46.083	1.51
1987	2.41	3.10	3.49	1.487	9.216	1.68
1988	2.43	3.53	4.08	1.036	11.044	1.48
1989	2.41	3.04	3.31	2.182	59.219	1.56
1990	2.53	3.08	3.43	2.740	31.432	1.45
1991	2.56	2.93	3.36	2.897	60.776	1.23
1992	2.44	3.04	3.80	3.424	32.824	1.50
1993	2.37	2.54	2.79	3.556	56.937	1.35
1994	2.82	3.25	3.90	5.520	53.764	1.37
1995	2.55	3.24	3.88	3.130	47.530	1.44
1996	2.67	3.07	3.65	2.986	63.977	1.36
1997	2.38	2.84	4.00	1.839	27.216	1.74
1998	3.04	3.25	4.08	2.751	41.073	1.57
1999	2.12	2.46	2.96	3.277	74.703	1.33
2000	2.61	2.99	3.76	1.688	20.006	1.55
2001	2.57	2.79	3.36	2.945	65.807	1.49
2002	2.76	2.99	3.56	2.487	44.405	1.51
2003	2.53	2.84	3.38	2.166	52.027	1.59
2004	2.66	2.86	3.50	2.858	44.337	1.62
2005	2.37	2.46	3.07	2.767	58.045	1.56
2006	2.54	2.88	3.60	1.841	11.275	1.78
2007	2.27	2.58	3.32	1.911	44.101	1.61
2008	2.90	3.16	4.10	2.040	15.878	1.64
2009	2.39	2.58	2.98	2.375	37.392	1.44
2010	2.70	3.03	3.62	2.286	23.448	1.92

Appendix A2.–Average and coefficient of variation of mid-eye to fork length ofmale and female adult age-.1 coho salmon returning to Auke Creek and the Berners River, 1980–2010.

Year	Auke Creek (Males)		Auke Creek (Females)		Berners River (Males)		Berners River (Females)	
	Average Length (mm)	Coefficient of Variation	Average Length (mm)	Coefficient of Variation	Average Length (mm)	Coefficient of Variation	Average Length (mm)	Coefficient of Variation
1980	607	0.0888	624	0.0627	–	–	–	–
1981	633	0.0746	631	0.0560	–	–	–	–
1982	622	0.0720	649	0.0604	642	0.0901	660	0.0459
1983	617	0.0838	656	0.0610	628	0.1058	654	0.0533
1984	644	0.0712	629	0.0548	–	–	–	–
1985	644	0.0631	630	0.0499	647	0.0979	670	0.0539
1986	635	0.0932	630	0.0768	611	0.1298	656	0.0539
1987	628	0.0619	621	0.0436	633	0.0896	640	0.0641
1988	636	0.0757	615	0.0656	628	0.1016	660	0.0563
1989	609	0.0866	605	0.0604	640	0.0912	656	0.0503
1990	603	0.0848	617	0.0565	644	0.1060	659	0.0592
1991	595	0.0772	610	0.0551	605	0.1090	646	0.0526
1992	600	0.0889	645	0.0634	611	0.1142	640	0.0590
1993	602	0.0852	620	0.0612	591	0.1134	623	0.0603
1994	633	0.0811	628	0.0484	633	0.1044	656	0.0593
1995	608	0.0688	626	0.0671	585	0.1176	636	0.0678
1996	615	0.0682	639	0.0631	578	0.1421	630	0.0690
1997	616	0.0819	593	0.0654	635	0.0903	655	0.0548
1998	617	0.0839	614	0.0496	643	0.0978	666	0.0465
1999	581	0.0946	615	0.0618	588	0.1017	626	0.0515
2000	606	0.0880	620	0.0692	637	0.1008	659	0.0547
2001	603	0.0973	626	0.0726	618	0.1118	643	0.0725
2002	603	0.0922	625	0.0776	631	0.1084	647	0.0649
2003	613	0.0729	604	0.0580	603	0.1093	647	0.0568
2004	612	0.0732	615	0.0579	623	0.1105	657	0.0594
2005	591	0.0978	601	0.0723	579	0.1073	621	0.0603
2006	616	0.0740	653	0.0566	626	0.0949	654	0.0545
2007	595	0.0943	606	0.0781	551	0.1260	621	0.0742
2008	645	0.0711	617	0.0502	626	0.1189	656	0.0573
2009	595	0.0966	606	0.0825	574	0.1203	610	0.0769
2010	596	0.0964	617	0.0592	602	0.1069	650	0.0509
Average								
1982–1989	629	0.0759	629	0.0591	633	0.1009	656	0.0539
1990–1999	607	0.0815	620	0.0592	611	0.1097	644	0.0580
2000–2010	607	0.0867	617	0.0667	606	0.1104	642	0.0620
All Years	614	0.0819	622	0.0618	615	0.1078	646	0.0586

Appendix A3.–Average and coefficient of variation of mid-eye to fork length ofmale and female adult age-.1 coho salmon returning to Ford Arm Creek and Hugh Smith Lake, 1982–2010.

Year	Ford Arm Creek (Males)		Ford Arm Creek (Females)		Hugh Smith Lake (Males)		Hugh Smith Lake (Females)	
	Average Length (mm)	Coefficient of Variation	Average Length (mm)	Coefficient of Variation	Average Length (mm)	Coefficient of Variation	Average Length (mm)	Coefficient of Variation
1982	653	0.0814	660	0.0608	648	0.0862	654	0.0533
1983	642	0.0901	649	0.0689	595	0.1069	627	0.0759
1984	–	–	–	–	655	0.0920	670	0.0609
1985	665	0.0680	667	0.0678	660	0.0910	662	0.0814
1986	649	0.0968	653	0.0771	678	0.0973	675	0.0582
1987	630	0.0903	655	0.0547	645	0.0820	658	0.0716
1988	656	0.0862	668	0.0624	636	0.1030	653	0.0752
1989	597	0.1193	643	0.0707	613	0.0964	623	0.0641
1990	641	0.1116	669	0.0674	650	0.1072	661	0.0620
1991	617	0.0950	650	0.0516	612	0.1026	632	0.0707
1992	620	0.0944	643	0.0586	642	0.0927	651	0.0648
1993	605	0.1021	631	0.0565	612	0.1173	641	0.0603
1994	623	0.1007	659	0.0576	624	0.1202	645	0.0952
1995	616	0.0869	650	0.0454	628	0.1022	651	0.0630
1996	607	0.1127	642	0.0580	613	0.1131	630	0.0720
1997	606	0.1000	641	0.0503	616	0.1061	644	0.0674
1998	622	0.0977	649	0.0492	652	0.1075	663	0.0682
1999	575	0.1160	610	0.0800	573	0.1231	611	0.0761
2000	597	0.0974	641	0.0518	598	0.1215	634	0.0726
2001	573	0.1242	622	0.0739	611	0.1235	631	0.0827
2002	584	0.1199	631	0.0719	594	0.1412	635	0.0765
2003	596	0.1007	626	0.0552	592	0.1296	631	0.0691
2004	596	0.1122	641	0.0521	625	0.0963	638	0.0734
2005	571	0.1160	618	0.0597	604	0.1119	630	0.0685
2006	597	0.0942	628	0.0593	606	0.1251	631	0.0831
2007	563	0.1167	617	0.0657	581	0.1144	616	0.0764
2008	615	0.1034	652	0.0538	613	0.1131	641	0.0796
2009	560	0.1110	619	0.0720	577	0.1214	609	0.0946
2010	588	0.1061	635	0.0599	641	0.1090	657	0.0731
Average								
1982–1989	642	0.0903	656	0.0661	641	0.0943	653	0.0676
1990–1999	613	0.1017	644	0.0575	622	0.1092	643	0.0700
2000–2010	585	0.1093	630	0.0614	604	0.1188	632	0.0772
All Years	609	0.1018	642	0.0612	620	0.1088	642	0.0721