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Performance of the Chinook Salmon Enhancement Program in Willow Creek, Alaska, through 1996

by

Dana E. Sweet

May 1999

Alaska Department of Fish and Game **Division of Sport Fish**

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Spell out acre and ton.

Time and temperature

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

Spell out year, month, and week.

Physics and chemistry

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

General

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

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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by

Dana E. Sweet
Division of Sport Fish, Palmer

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1599

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Dana E. Sweet
Alaska Department of Fish and Game, Division of Sport Fish,
1800 Glenn Hwy., Suite 4, Palmer, AK 99645-6736, USA

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ABSTRACT

The contribution of hatchery-produced chinook salmon *Oncorhynchus tshawytscha* to the Willow Creek sport harvest and escapement has been assessed since 1986 using roving creel surveys, catch sampling, annual mail survey estimates, a weir at Deception Creek (a tributary to Willow Creek), peak spawning escapement aerial surveys and ground postspawning carcass surveys. Goals for the hatchery enhancement program have been set at 4,000 hatchery produced fish available to the harvest and 15,000 angler-days of fishing effort while maintaining the historical spawning escapement and fish quality. The minimum estimated number of hatchery fish available to the fishery ranged from 1,076 to 5,329 chinook salmon from 1989 through 1996. Angler effort during this period ranged from 7,382 to 18,271 angler-days and first reached the 10,000 angler-day goal in 1991. Except for 1994, spawning escapement remained above the 2,600 fish objective from 1989 through 1996. Our current biological data show no significant change in fish size, however, the tendency to return at an earlier age has been indicated.

Key words: chinook salmon, *Oncorhynchus tshawytscha*, Willow Creek, Deception Creek, fish culture, smolt, stocking, creel survey, sport effort, sport catch, sport harvest, escapement counts, population, hatchery contribution, age, sex, length.

INTRODUCTION

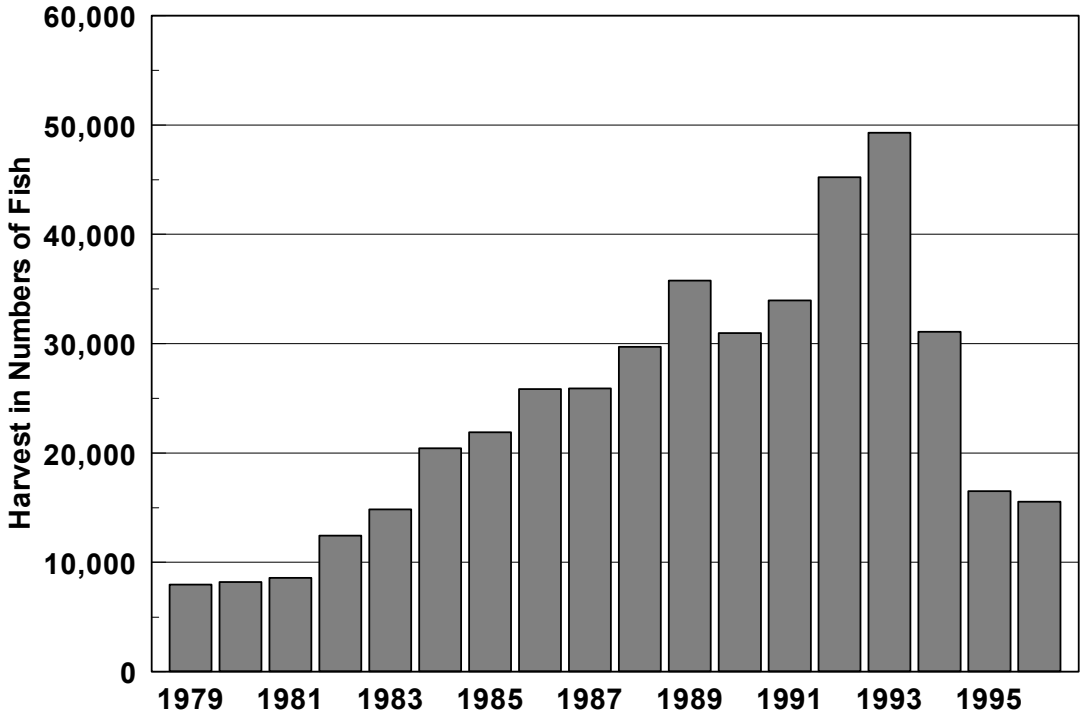
The sport fishery for chinook salmon *Oncorhynchus tshawytscha* in the Northern Cook Inlet (NCI) area (that portion of Cook Inlet north of the West Forelands) was closed periodically during the 1960s and 1970s because of small returns. Increases in the returns of chinook salmon to NCI drainages in the late 1970s allowed reopening of a limited sport fishery in 1979. An intensively managed and growing fishery has existed since that time (Figure 1).

Willow Creek, a tributary of the Susitna River (Figure 2), was designated as a potential recipient for chinook salmon enhancement in the Cook Inlet Regional Salmon Enhancement Plan (CIRPT 1981). Development of a chinook salmon enhancement program at Willow Creek was spurred by construction of a road to the mouth of Willow Creek and establishment of the Willow Creek State Recreation Area in the mid-1980s. A chinook salmon smolt stocking program was initiated at Willow Creek in 1985, with the first significant return of fish in 1989. With the exception of 1987, this stocking program has continued annually. An onsite creel survey has been conducted since 1979 to aid inseason management of the fishery. The creel survey was redesigned in 1988 to evaluate the enhancement program.

Willow Creek has developed into the most heavily utilized road-accessible sport fishery for chinook salmon in NCI (Mills 1980-1994, Howe et al. 1995-1997). Natural chinook salmon production is relatively stable and appears near maximum. Exploitation of this production also appears to be maximized. The initial purpose of the Willow Creek enhancement program was to increase chinook salmon fishing opportunities on a sustained yield basis and presently is to maintain this opportunity by supplementing the existing natural run with hatchery fish.

The goals of the Willow Creek chinook salmon enhancement program are to:

1. Maintain the present quality and quantity of natural chinook salmon production;
2. Produce an additional 6,000 returning chinook salmon of which 4,000 would be available for harvest at Willow Creek on an annual basis by 1994; and
3. Provide a minimum of 15,000 angler-days of chinook salmon fishing opportunity during the period 10 June to 10 July.



Source: Mills 1980-1994, Howe et al. 1995-1997.

Figure 1.-Sport harvest of chinook salmon in Northern Cook Inlet, 1979-1996.

To help measure program performance and achieve project goals, the following objectives were identified:

1. Estimate the age, sex, and length compositions of chinook salmon harvested from Willow Creek;
2. Monitor chinook salmon escapement indices to determine if approximately 2,600 spawn naturally in Willow Creek;
3. Estimate the relative contribution of stocked chinook salmon to the sport harvest, and estimate the relative contribution of stocked chinook salmon to the spawning escapement in Willow Creek;
4. Collect and transport approximately 440,000 fertilized chinook salmon eggs from the Deception Creek weir to the Ft. Richardson hatchery; and
5. Release approximately 200,000 chinook salmon smolts, of which 40,000 will be marked with coded wire tags, into the Willow Creek drainage in order to yield 4,000 returning adults available for harvest.

This report presents fish culture, creel survey, escapement, age, sex, length, and hatchery contribution data collected from the Willow Creek program from 1979 through 1996. Additionally, a compilation of all historic data used to evaluate this enhancement program is presented. Program success is evaluated by comparing historic performance to achievement of stated program goals and objectives. Finally, recommendations for consideration in future program planning are developed.

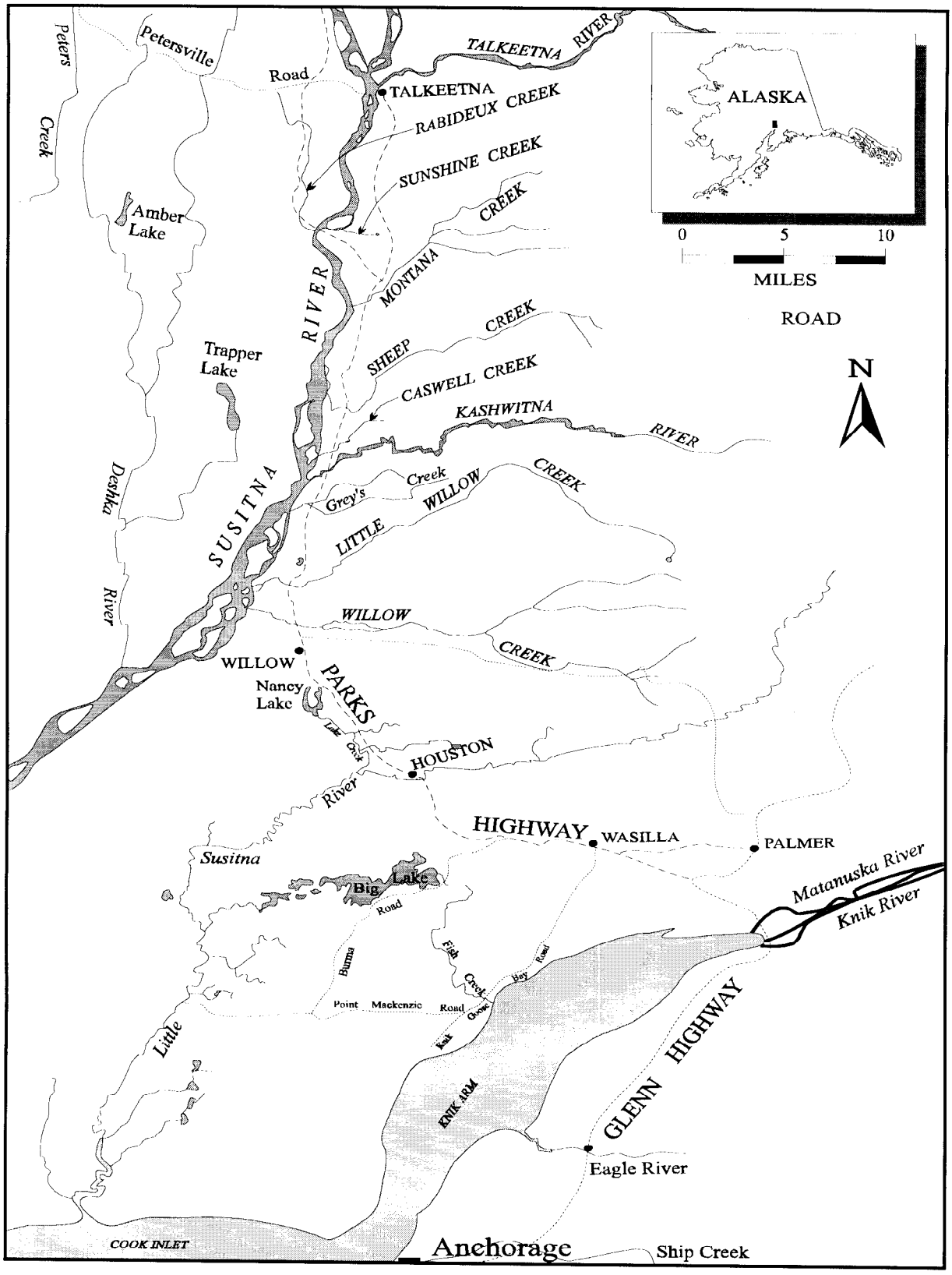


Figure 2.-Map of Northern Cook Inlet and the Susitna River drainage.

METHODS

FISH CULTURE

Chinook salmon smolt were released into Deception Creek at the Deception Creek bridge on the Hatcher Pass Road from 1985 through 1995 with the exception of 1990, when approximately one-third was released into Willow Creek at the Parks Highway bridge. No fish were stocked in 1987. In 1996 all smolt were released into Deception Creek at the Four Mile Road crossing (Figure 3). The annual smolt release has varied from 101,256 to 655,491 fish during all years with the 1992 through 1996 releases near 200,000. The proportion of coded wire tagged (CWT) and adipose finclipped fish through the 1996 release year varied from 0.0490 to 0.2581 (Table 1). Beginning in 1997, 100% of released fish will be tagged. Adipose finclipping and coded wire tagging of smolt followed standard hatchery methodology (ADF&G 1983).

To capture brood stock in 1996, two weirs were installed on Deception Creek during the first week in July (Figure 3). All fish entering the weir complex were detained between the weirs until the egg take was complete. Multiple egg takes occurred during the last 10 days in July. During this period, fish were seined and checked for ripeness. Ripe fish were killed and placed on a clean tarp. Milt from males and eggs from females were combined at a 2:1 male to female ratio in a 5-gallon bucket (six males and three females). Water from Deception Creek was added to the bucket to initiate fertilization. After a 1-minute waiting period, excess milt, coagulated blood, and other debris were rinsed from the fertilized eggs. The clean eggs were put into plastic bags with water and placed in coolers for 45 to 90 minutes to water harden. The water-hardened eggs were packed in ice to keep them cool during shipment to Fort Richardson hatchery where they were incubated.

CATCH AND ESCAPEMENT SAMPLING

Design

Willow Creek was open to fishing for chinook salmon in all waters within a 0.4 km (0.25 mi) radius of the creek's confluence with the Susitna River and upstream to the Parks Highway. Season length has varied since 1979. Increases in the open season have been implemented by regulation and emergency order. Since 1989, this section has been open to fishing daily from January 1 through the third Monday in June after which it opens the following two consecutive weeks during the 3-day periods of 0001 hours Saturday to 2400 hours on Monday.

Willow Creek is road accessible, allowing primary access to the fishery by vehicle and foot. Some anglers access the fishery by boating downstream from the Parks Highway area. The majority of anglers fish within 0.4 km (0.25 mi) of the mouth (Figure 3).

Roving creel surveys (Neuhold and Lu 1957) on Willow Creek were conducted from 1979-1993 to obtain estimates of angler effort, catch, and harvest for chinook salmon. The fishery was sampled using a stratified, multi-stage, roving survey design. However, beginning in 1994, after determining that the Statewide Harvest Survey, Alaska Department of Fish and Game's annual mail survey, was an adequate means to measure harvest and catch, these onsite surveys were abandoned for the purpose of collecting harvest and effort data. A modified creel survey was then conducted to collect biological and hatchery contribution data. Specific methods for creel surveys during 1989 through 1993 can be found in Sweet and Webster (1990), Sweet et al. (1991), Peltz and Sweet (1992 and 1993) and Sweet and Peltz (1994).

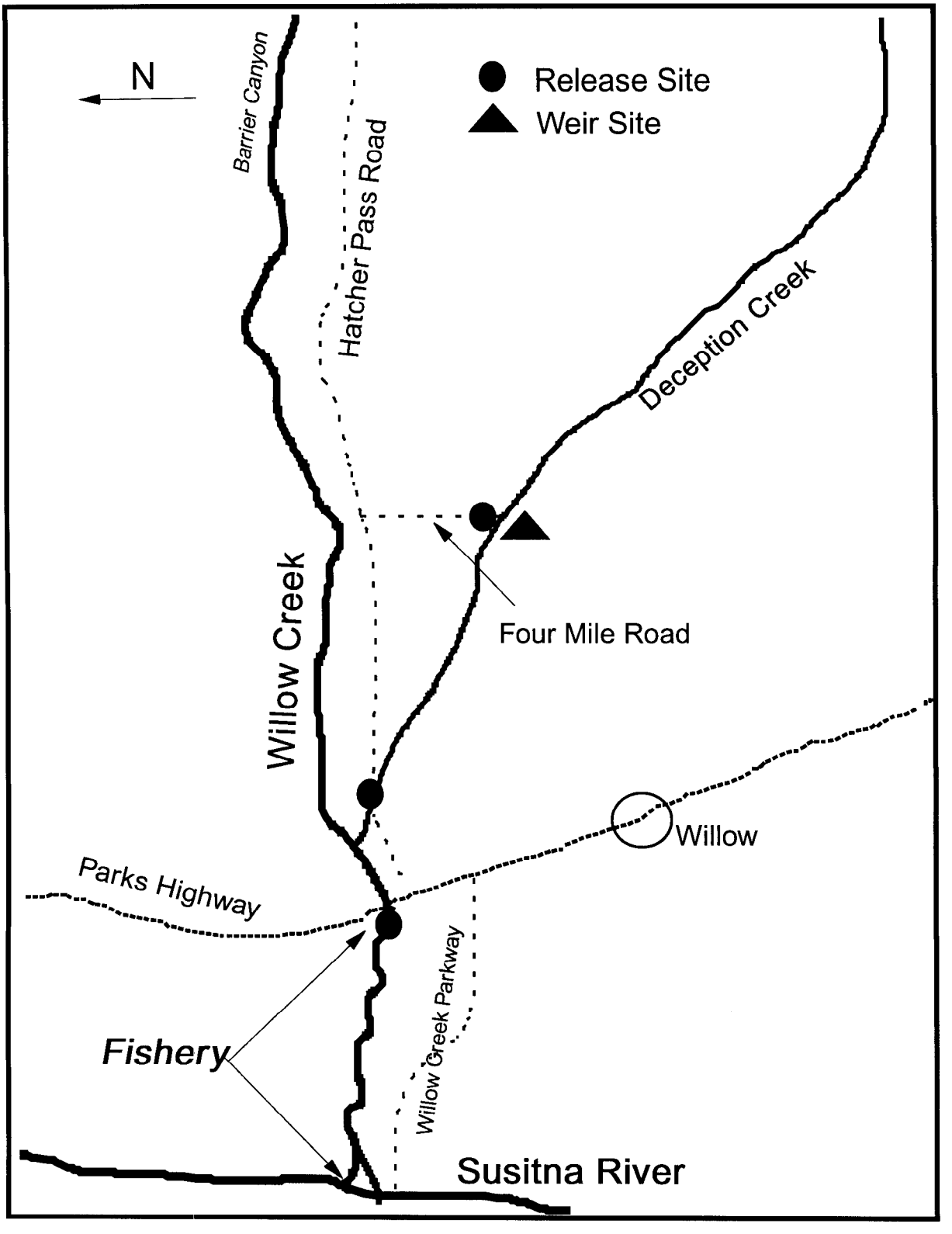


Figure 3.-Map of Willow and Deception creeks showing the location of creel survey areas, carcass survey areas, smolt stocking site, and egg take site, 1996.

Table 1.-Number of chinook salmon smolt stocked into Willow Creek drainage from 1985-1996 with corresponding release and recovery information.

Brood Year	Release Location	Total Smolt Release	Valid CWT[a]	Number Marked[b]	Mean Size (gm)	Release Date	Tag code	Proportion CWT	Total Tags Recov	Min.Est Rtn[c]	Min.Est Survival to Adult[d]	Last RtnYear
1983	Deception	101,256	8,152		18.0	6/13/85	31-16-42	0.0805	3	49	<0.05%	1989
1984	Deception	214,384	11,038		13.8	6/11-12/85	31-16-45	0.0515	26	1,313	0.6%	1989
	Deception	218,743	10,708		14.0	6/20/85	31-16-47	0.0490	29	969	0.4%	1989
	Total	433,127	21,746									
1985	Deception	49,668	9,933		16.7	5/01/86	31-17-33[e]	0.2000	5	60	0.1%	1990
	Deception	127,904	18,400		12.2	5/10/86	31-17-27					
	Deception	147,877			11.4	5/10/86						
	Total	325,449	28,333					0.0667	9	293	0.1%	1990
1987	Deception	201,091	20,936		10.9	7/12/88	31-17-58	0.1041	142	3,306	1.6%	1992
1988	Deception	240,885	19,851		13.0	5/31/89	31-17-60	0.0824	87	2,980	1.2%	1993
1989	Deception	219,362	41,570		14.4	5/24/90	31-17-34	0.1895	129	2,651	1.2%	1994
	Deception	219,432	40,575		13.4	5/24/90	31-18-51	0.1849	123	2,712	1.2%	1994
	Deception	216,697	40,438		13.9	5/24/90	31-18-52	0.1866	147	2,731	1.2%	1994
	Total	655,491	122,765							8,094	1.2%	1994
1990	Deception	168,777			11.2	5/21/91						
	Deception	70,258	31,167		12.3	5/31/91	31-19-33					
	Willow	73,756			12.3	5/28/91						
	Willow	78,878	31,167		12.3	5/30/91	31-19-33					
	Total	391,669	62,334					0.1591	73	2,342	0.6%	1995
1991	Deception	179,724	33,464	44,089	13.5	5/29/92	31-21-03					
	Deception	35,752			14.5	6/09/92						
	Total	215,476	33,464	44,089				0.1553	39	1,139	0.5%	1996
1992	Deception	160,194	39,420	42,782	14.9	6/01/93	31-21-60	0.2460	64	1,220	0.8%[f]	1997
1993	Deception	177,913	45,921	46,289	13.3	5/24-25/94	31-23-17	0.2581	35	750	0.4%[f]	1998
1994	Deception	184,740	46,256	46,807	13.5	5/25/95	31-24-34	0.2504	0	0	0	1999
1995	Deception	186,918	47,145	47,700	14.4	6/12-17/96	31-25-14	0.2522	0	0	0	2000

[a] Estimated number possessing a coded wire tag at the time of release.

[b] Fish that were adipose finclipped and coded wire tagged.

[c] Minimum estimated return to Willow Creek includes estimated CWT recoveries from sport fishery harvest (creel survey), estimated escapement (carcass surveys) and Deception Creek egg take. No estimate is made for interception in commercial fisheries, nontarget sport fisheries or straying from Willow Creek.

[d] Minimum estimated return (estimated from total CWT recoveries) divided by total smolt release times 100.

[e] 31-17-33 are Deshka River chinook mistakenly released in Willow Creek.

[f] Incomplete estimate. All age classes have not yet returned.

During 1994-1996, survey technicians monitored the fishery at the head of the trail leading from the parking lot to the fishing area at the mouth of the creek. Time was spent interviewing exiting anglers, inspecting the observed harvest for adipose finclips, and collecting biological data.

Data Analysis

Biological data forms were visually checked for coding errors and corrected as necessary. Corrected data forms were sent to Research and Technical Services (RTS) for optical scanning. Resultant data files and summary printouts were also checked for errors and corrected as necessary. Corrected data files were sent to RTS for archiving (Appendix B1).

SIZE, SEX, AND AGE COMPOSITIONS

Data Collection

Chinook salmon harvested in the sport fishery were sampled for age, length, and sex information from 1979-1996. Carcasses of postspawned chinook salmon in Willow Creek, from the canyon downstream to the confluence with Deception Creek, were also sampled from 1979-1993 (Figure 3). Length, sex information, and scales were collected from every fish possible. However, during carcass surveys, some fish were badly decomposed which precluded scale collection and accurate measuring.

Sampled fish were measured from the middle of the eye to fork of the tail, to the nearest 5 mm. The sex of those fish selected for age composition was recorded. Three scales were collected on the left side of each fish approximately two rows above the lateral line and on the diagonal row downward from the posterior insertion of the dorsal fin as described in Welander (1940). Scales were mounted on adhesive-coated cards and thermohydraulic impressions were made in cellulose acetate. Age determinations were made by examination of scale impressions using a microfiche reader. Ages were designated using the European method (Koo 1962). Age, sex, and length data were recorded on standard biological mark-sense forms.

Examination of scales during 1989 and 1990 indicated that freshwater growth in scales from hatchery-produced fish was indistinguishable from that of nonhatchery fish when viewed on a microfiche reader (Sweet and Webster 1990, Sweet et al. 1991). Therefore, hatchery-produced and natural fish were combined by saltwater age classes only.

Data Analysis

Estimates of age composition (proportion) by sex for the subsampled chinook salmon were calculated. All data were treated as if the data were obtained by a simple random sampling procedure. The age composition data collected at Willow Creek were assumed to be the result of a proportional sample survey (i.e., equal proportions of the harvest or escapement sampled throughout the survey). Accordingly, the resultant age composition estimates should be unbiased for the entire harvest or escapement of chinook salmon.

The proportion by age and sex of the chinook salmon was estimated as follows:

$$\hat{p}_z = \frac{n_z}{n_a}, \qquad (1)$$

where: $\hat{p}_z$ equals the estimated proportion of the chinook salmon from age and sex category z, n_z equals the number of fish sampled that were classified as age or sex category z, and n_a equals the number of chinook salmon sampled for age and sex determination.

The variance of $\hat{p}_z$ was calculated by:

$$\hat{V}[\hat{p}_z] = \frac{\hat{p}_z(1-\hat{p}_z)}{n_a - 1}. \qquad (2)$$

Estimates of mean length-at-age group of subsampled chinook salmon were also calculated. The procedures outlined by Sokal and Rohlf (1981, Boxes 4.2 and 7.1, pages 56 and 139) were used to obtain the estimates of each mean and its standard error.

CONTRIBUTION OF CODED WIRE TAGGED STOCKS

Data collection

In addition to the age, sex, and length information, chinook salmon harvested at Willow Creek were examined for a missing adipose fin (indicating the presence of a coded wire tag). Daily records were kept of both the number of fish examined and the number of fish observed to have a missing adipose fin (clipped fish). Heads were collected from the clipped fish and sent to the Alaska Department of Fish and Game (ADF&G) Tag Lab in Juneau for decoding.

Carcasses from the chinook salmon escapement in the reaches of Willow Creek and Deception Creek upstream of their confluence were also inspected for adipose finclips to recover associated CWTs and estimate relative hatchery contributions. Data collected included number of carcasses observed, number of fish inspected for adipose finclips, number of clips observed and mideye-to-fork length. Heads from fish with a missing adipose fin were collected and decoded as described above.

No sampling has been conducted to specifically estimate Willow Creek hatchery chinook salmon contributions in nontarget commercial, sport, or subsistence fisheries. However, recoveries have been reported in various fisheries throughout Alaska (Appendix A1).

Data Analysis

Hatchery contributions were estimated for the sport fishery using the procedures outlined by Bernard and Clark (1996). The large-scale approximations defined by Bernard and Clark (1996) for variance estimates were used in all cases.

ESCAPEMENT SURVEYS

Data Collection

Chinook salmon spawning in Willow Creek, including Deception Creek, were counted annually by aerial survey (helicopter). Escapement surveys were conducted during the peak spawning period which was identified through frequent inspections of spawning activity. Escapement data reported were the number of observed fish, both alive and dead.

Raw survey counts of chinook salmon in Willow Creek were not expanded to account for stream life, poor visibility, or missed fish. The actual number of chinook salmon observed was reported as the escapement index and was considered to be a minimum escapement estimate.

Data Analysis

Relative hatchery contributions were estimated for the escapement using procedures from Bernard and Clark (1996). The notation used in the following equations essentially follows that used by Bernard and Clark (1996), with adaptations primarily due to estimating relative rather than absolute contributions. The first step involved estimating the relative contribution in the escapement of each particular tag code:

$$\hat{u}_j = \hat{p}_j \theta_j^{-1}, \qquad (3)$$

where: $\hat{u}_j$ equals the estimated relative contribution of chinook salmon from a coded wire tagged stock identified by the unique tag code j; θ_j is the proportion of the hatchery release which contained a coded wire tag of the unique tag code j; $\hat{p}_j$ was calculated as:

$$\hat{p}_j = \frac{m_j}{\lambda\, n}; \qquad (4)$$

n is number of chinook salmon inspected for missing adipose fins from the sampled escapement; m_j equals the number of coded wire tags dissected out of the salmon heads and decoded as the unique tag code j in the escapement sample; λ is defined as:

$$\lambda = \frac{a'\ t'}{a\ \ t}; \qquad (5)$$

a is the number of salmon with a missing adipose fin which were counted from the sampled fish from the escapement sample; a' equals the number of salmon heads previously marked with a head strap which arrived at the tag lab; t is the number of coded wire tags which were detected in the salmon heads at the tag lab; and t' equals the number of coded wire tags which were removed from the salmon heads and decoded as any tag code.

The variance of $\hat{u}_j$ was estimated by:

$$\hat{V}\left[\hat{u}_j\right] = \hat{V}\left[\hat{p}_j\right]\theta_j^{-2}. \qquad (6)$$

The variance of $\hat{p}_j$ was estimated approximately (adapted from Bernard and Clark 1996) as:

$$\hat{V}\left[\hat{p}_j\right] \approx \frac{\hat{p}_j}{\lambda\, n}, \qquad (7)$$

where all terms are as defined above.

RESULTS

FISH CULTURE

Since the inception of stocking in 1985, the annual smolt release into Willow Creek has varied from 101,256 to 655,491, with the 1992 through 1996 releases averaging 185,048 smolts. The proportion of CWT and adipose finclipped fish varied from 0.0490 to 0.2581 through 1996 (Table 1).

The goal of collecting 440,000 fertilized eggs has been achieved annually.

ANGLER EFFORT

Estimates of angler effort for the Willow Creek chinook salmon fishery are available for 1979-1993 and 1995 from onsite creel surveys. No survey was conducted in 1994 or 1996 (Table 2). During these surveys, effort ranged from 504 to 18,271 angler-days. For years in which effort estimates are available and hatchery fish contributed to the harvest, effort ranged from 5,444-18,271 angler-days.

SIZE, SEX, AND AGE COMPOSITIONS

Age, length and sex data have been collected since 1979 from the Willow Creek chinook salmon harvest. Prior to 1986, sex and size data were reported for all Susitna River fisheries combined; consequently individual data for Willow Creek are not available for that period.

During 1979-1988, years with no significant hatchery contribution, mean age composition was 17% age 1.2, 30% age 1.3, and 53% age 1.4. For the time period 1989-1996, years in which hatchery fish contributed to the population, mean age composition was 19% age 1.2, 29% age 1.3, and 52% age 1.4 (Table 3). Mean length by age class for 1986-1988 was 622 mm for age 1.2, 845 mm for age 1.3, and 957 mm for age 1.4. For 1989-1996 mean length by age class for age 1.2, 1.3 and 1.4 fish was 605 mm, 807 mm and 942 mm, respectively (Table 4). Sex composition by age class for 1986-1988 for ages 1.2, 1.3 and 1.4 was 93% male, 58% male and 34% male, respectively. The 1989-1996 mean sex composition for age 1.2, 1.3 and 1.4 males was 99%, 57% and 37%, respectively (Table 5).

Scales from hatchery-produced fish are indistinguishable from nonhatchery fish

Table 2.-Contribution of hatchery and nonhatchery chinook salmon to the sport harvest and escapement index of Willow Creek and to the Deception Creek escapement index, 1979-1996.

Year	Creel Survey[a]	Season Length WE	Season Length WD	Angler-days[b]	Sport Harvest[c] Non-hatchery	Sport Harvest[c] Hatch[f]	Sport Harvest[c] Total[e]	Sport Harvest[c] % Hatch	Willow Creek Escapement Index[d] Non-hatchery	Willow Creek Escapement Index[d] Hatch[f]	Willow Creek Escapement Index[d] Total	Willow Creek Escapement Index[d] % Hatch	Deception Creek Escapement Index Non-hatchery	Deception Creek Escapement Index Hatch[f]	Deception Creek Escapement Index Total	Deception Creek Escapement Index % Hatch	Total Hatch	Total % Hatch	Total Return
1979	Hwy	8		975	459		459				848				239				
1980	Hwy	8		612	289		289				g				g				
1981	Mouth and Hwy	8		540	585		585				991				366				
1982	Mouth and Hwy	8		504	629		629				592				229				
1983	Mouth and Hwy	8		1,811	534		534				771				121				
1984	Mouth and Hwy	8		1,939	774		774				2,789				675				
1985	Mouth and Hwy	8		2,338	1,063		1,063				1,856				1,044				
1986	Mouth and Hwy	8		2,313	1,017	h	1,017			h	2,059		364	157	521	30.1	157	4.4	3,597
1987	Mouth, Hwy, Susitna Lnd	8	4	3,770	1,987	h	1,987			h	2,768		518	174	692	25.1	174	3.2	5,447
1988	Mouth, Hwy, Susitna Lnd	8	4	5,444	1,994	355	2,349	15.1	2,496	0	2,496	0	537	253	790	32.0	608	10.8	5,635
1989	Mouth, Hwy, Susitna Lnd	8	8	8,685	1,767	1,079	2,846	37.9	4,907	153	5,060	3.0	623	177	800	22.1	1,409	16.2	8,706
1990	Mouth and Hwy	8	10	9,313	2,043	1,194	3,237	36.9	2,315	49	2,365	2.1	420	280	700	40.0	1,523	24.2	6,302
1991	Mouth	10	8	10,461	2,364	844	3,208	26.3	2,006	0	2,006	0.0	515	232	747	31.1	1,076	18.1	5,961

-continued-

Table 2.-Page 2 of 2.

Year	Creel Survey[a]	Season Length WE	Season Length WD	Angler-days[b]	Sport Harvest[c] Non-hatch	Sport Harvest[c] Hatch[f]	Sport Harvest[c] Total[c]	Sport Harvest[c] % Hatch	Willow Creek Escapement Index[d] Non-hatch	Willow Creek Escapement Index[d] Hatch[f]	Willow Creek Escapement Index[d] Total	Willow Creek Escapement Index[d] % Hatch	Deception Creek Escapement Index Non-hatchery	Deception Creek Escapement Index Hatch[f]	Deception Creek Escapement Index Total	Deception Creek Escapement Index % Hatch	Total Hatch	Total % Hatch	Total Return
1992	Mouth	8	11	18,271[i]	4,318	4,566	8,884	51.4	1,457	203	1,660	12.2	423	560	983	57.0	5,329	46.2	11,527
1993	Mouth	8	10	15,298	4,649	3,977	8,626	46.1	1,935	292	2,227	13.1	502	719	1,221	59.0	4,988	41.3	12,074
1994	Mouth	8	9	no survey	3,277	2,703	5,980	45.2	1,430	49	1,479	3.3	388	378	766	49.3	3,130	38.5	8,225
1995	Mouth	8	9	7,382	1,631	1,111	2,742	40.5	2,966	826	3,792	21.8	445	389	834	46.6	2,326	31.6	7,368
1996	Mouth	8	14	no survey	1,277	1,037	2,314	44.8	1,577	199	1,776	11.2	664	557	1,211	46.0	1,793	33.8	5,301

[a] Creel survey sites changed from year to year to accommodate the evolving fishery.

[b] From: Watsjold 1980 and 1981; Bentz 1982 and 1983; Hepler and Bentz 1984, 1985, 1986 and 1987; Hepler et al. 1988 and 1989; Sweet and Webster 1990; Sweet et al. 1991; Peltz and Sweet 1992, 1993; Sweet and Peltz 1994; Whitmore et al. 1996. In years where effort in angler-days was not reported, total estimated effort was divided by the mean length of the angler-day to obtain the number of angler-days.

[c] There was a 300 fish quota in effect 1979-1983.

[d] Escapement index counts are from aerial counts during peak spawning activity.

[e] All harvest estimates are from the SWHS (Mills 1979-1994 and Howe et al. 1995-1997).

[f] All hatchery estimates are from coded wire tag recovery programs associated with the creel and escapement surveys.

[g] No survey.

[h] Small numbers of hatchery fish probably returned but recovery of coded wire tags was not recorded. All production was attributed to nonhatchery fish returns.

[i] Effort in angler days assumed to equal the number of angler-trips estimated during angler catch and harvest distribution analysis.

Table 3.-Estimated yearly age composition of Willow Creek chinook salmon from 1979-1996 based on sport fish harvests with a corresponding estimate of minimum run size.

Year[b]	Sample Size	Age Class by Percent[ab] 1.2[c]	1.3[c]	1.4[c]	Sport Harvest[d]	Escapement Indices	Minimum Run Size
1979	152	10.0	14.0	76.0	459	1,087	1,546
1980	120	29.0	18.0	53.0	289		
1981	155	12.0	36.0	52.0	585	1,357	1,942
1982	308	7.0	18.0	75.0	629	821	1,450
1983	896	30.0	30.0	40.0	634	892	1,526
1984	1,113	13.0	40.0	47.0	774	3,464	4,238
1985	448	14.0	24.0	62.0	1,063	2,900	3,963
1986	143	15.0	38.0	46.0	1,017	2,580	3,597
1987	148	28.0	31.0	41.0	1,987	3,460	5,447
1988	344	16.0	49.0	35.0	2,349	3,286	5,635
1989	362	7.0	19.0	74.0	2,846	5,860	8,706
1990	413	32.0	17.0	51.0	3,237	3,065	6,302
1991	361	10.0	37.0	53.0	3,208	2,753	5,961
1992	664	26.0	33.0	41.0	8,884	2,643	11,527
1993	420	16.4	43.5	39.5	8,626	3,448	12,074
1994	278	10.4	23.7	64.4	5,980	2,245	8,225
1995	251	17.1	23.9	56.6	2,742	4,626	7,368
1996	242	36.4	30.2	31.8	2,314	2,987	5,301
1979-1988							
Mean		17.4	29.8	52.7			
Maximum		30.0	49.0	76.0			
Minimum		7.0	14.0	35.0			
1989-1996							
Mean		19.4	28.4	51.4			
Maximum		36.4	43.5	74.0			
Minimum		7.0	17.0	31.8			

[a] Other age classes exist (1.1, 1.5, 2.2, 2.3, 2.4, 2.5) but never make up more than 5% of the return on a combined basis.

[b] Source of data: Watsjold 1980 and 1981; Bentz 1982 and 1983; Hepler and Bentz 1984, 1985, 1986 and 1987; Hepler et al. 1988 and 1989; Sweet and Webster 1990; Sweet et al. 1991; Peltz and Sweet 1992 and 1993; Sweet and Peltz 1994; Whitmore et al. 1995-1997.

[c] All fish (hatchery and nonhatchery produced) are reported as having one freshwater annulus.

[d] Source of data: SWHS (Mills 1979-1994 and Howe et al. 1995-1997).

Table 4.-Estimated mean lengths by age for chinook salmon in the Willow Creek sport harvest, 1986-1996.

Age Class	1.2						1.3						1.4					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
Year	Sample Size	Length (mm)	Sample Size	Length (mm)	Length (mm)	SE	Sample Size	Length (mm)	Sample Size	Length (mm)	Length (mm)	SE	Sample Size	Length (mm)	Sample Size	Length (mm)	Length (mm)	SE
1986	22	642	0	0	642	3.0	22	841	33	861	853	2.0	17	1027	49	955	974	1.9
1987	35	600	0	0	600	14.0	33	841	13	883	853	13.1	20	961	34	936	945	14.1
1988	61	619	6	690	625	15.0	133	822	95	836	828	6.0	70	975	116	939	953	7.4
1989	36	578	0	0	578	12.0	63	790	27	835	804	9.8	112	952	245	914	926	3.5
1990	173	575	0	0	575	16.0	61	801	23	871	820	19.8	88	983	135	934	953	9.6
1991	56	594	0	0	594	48.0	117	786	66	830	802	14.9	107	980	205	926	945	14.4
1992	224	611	0	0	611	3.1	101	741	87	766	753	4.3	60	944	163	903	914	4.4
1993	76	611	2	595	611	5.2	100	798	87	811	804	3.8	70	966	81	925	944	6.2
1994	29	621	0	0	621	8.2	39	768	27	796	779	7.4	59	953	120	902	919	5.1
1995	42	629	1	680	630	7.1	24	795	36	846	865	6.9	56	979	86	922	944	5.8
1996	88	618	0	0	617	4.9	37	830	36	833	831	7.2	39	1018	38	968	993	8.4
1986-1988																		
Mean		620		690	622			835		860	845			988		943	957	
SE					20.7						14.5						16.0	
90% CI					581-663						817-873						920-974	
1989-1996																		
Mean		605		623	605			789		824	807			972		924	942	
SE					53.7						30.0						22.4	
90% CI					500-710						748-866						898-986	

Source of data: Hepler and Bentz 1987; Hepler et al. 1988 and 1989; Sweet and Webster 1990; Sweet et al. 1991; Peltz and Sweet 1992 and 1993; Whitmore et al. 1994-1997.

Table 5.-Estimated sex composition by age class for sport fish harvests of Willow Creek chinook salmon, 1986-1996.

Age Class	1.2				1.3				1.4			
	Male		Female		Male		Female		Male		Female	
	Sample		Sample		Sample		Sample		Sample		Sample	
Year	Size	%	Size	%	Size	%	Size	%	Size	%	Size	%
1986	22	100.0	0	0.0	22	40.0	33	60.0	17	25.4	50	74.6
1987	37	88.1	5	11.9	35	76.1	11	23.9	22	36.7	38	63.3
1988	53	91.4	5	8.6	97	57.1	73	42.9	48	41.0	69	59.0
1989	27	100.0	0	0.0	47	70.1	20	29.9	85	31.7	183	68.3
1990	134	100.0	0	0.0	48	70.6	20	29.4	82	39.2	127	60.8
1991	35	100.0	0	0.0	83	61.5	52	38.5	60	31.4	131	68.6
1992	224	100.0	0	0.0	102	54.0	87	46.0	60	26.8	164	73.2
1993	76	97.4	2	2.6	100	53.2	88	46.8	70	46.4	81	53.6
1994	29	100.0	0	0	39	59.1	27	40.9	59	33.0	120	67.0
1995	43	97.7	1	2.3	24	40.0	36	60.0	56	39.4	86	60.6
1996	88	100.0	0	0	37	50.7	36	49.3	39	50.6	38	49.4
1986-1988												
Mean		93%		7%		58%		42%		34%		66%
1989-1996												
Mean		99%		1%		57%		43%		37%		63%

Source of data: Hepler and Bentz 1987; Hepler et al. 1988 and 1989; Sweet and Webster 1990; Sweet et al. 1991; Peltz and Sweet 1992 and 1993; Whitmore et al. 1994-1997.

scales; consequently, during years the harvest included hatchery-produced fish, all fish were grouped together by saltwater age and designated as having one freshwater annulus.

CONTRIBUTION OF CODED WIRE TAGGED STOCKS

CWTs were first recovered from the Willow Creek drainage in 1986. Annual CWT recoveries conducted in the Willow Creek sport harvest and escapement and Deception Creek escapement during 1986-1996 ranged from 5 to 315 fish, representing all tag codes released into Willow Creek (Appendix A4).

From 1989–1996, years with significant returns of hatchery fish, minimum estimated return of hatchery fish was 1,076-5,329 chinook salmon annually (Appendix A5). The estimated hatchery contribution to the Willow Creek sport harvest ranged from 26.3% to 51.4% with a mean of 41%. This has resulted in annual contributions of 844 to 4,566 chinook salmon to the sport harvest, averaging 2,064 hatchery fish (Table 2). The 1989-1996 contribution to the Willow Creek escapement above the confluence with Deception Creek ranged from 0%-21.8%, averaging 8.3%. The 1989-1996 contribution to the Deception Creek escapement ranged from 22.1%-59.0%, averaging 43.9% (Table 2). The total estimated annual contribution to the return to Willow Creek ranged from 16.2% to 46.2%, averaging 31.2% (Table 2).

Tag recoveries from the Willow Creek sport harvest during 1991 and 1992 included some Montana and Sheep creek release fish (Appendices A2 and A3). These fish were not included in the Willow Creek hatchery contribution estimate and no hatchery contribution estimate was calculated for the Montana or Sheep creek returns. Tagged

Willow Creek chinook salmon have also been recovered in other sport, commercial, and subsistence fisheries for which no hatchery contribution estimates have been made (Appendix A1).

ESCAPEMENT SURVEYS

Aerial escapement index surveys on Willow Creek during 1979-1996 ranged from 592 to 5,060 chinook salmon. A combination of ground and aerial surveys conducted on the escapement index area of Deception Creek, a tributary to Willow Creek, during 1979-1996 ranged from 121 to 1,221 (Table 2). Total spawning escapement from 1989–1996, obtained by summing the Willow Creek and Deception Creek escapement indices, has remained above the objective of 2,600 fish. The exception was 1994 when the index was 2,245 chinook salmon.

DISCUSSION

The Willow Creek chinook salmon sport fishery has existed annually since 1979 (Table 2). From 1979 to 1996, the fishery has changed from a weekend-only fishery with a harvest quota of 300 fish to a combination weekday and weekend season with harvests reaching 8,800 fish. Fishery monitoring has changed over time to adjust to changes in the fishery. Initially, the fishery took place at the Parks Highway bridge. With the construction of a road to the stream mouth in 1988, the majority of the fishery shifted to the downstream area, within 1/4 mile upstream of the mouth. Consequently, direct comparisons of data among years are in some instances of limited value. It is possible, however, to make the following general observations. Participation and harvests in the fishery grew substantially from 1979 through 1992 (Figure 4). Harvest of nonhatchery fish increased approximately 1,000% from 1979 to 1993 (Figure 5). Large increases in effort occurring in 1983, 1989 and 1992 are most likely related to additional fishing time and improvements in access during these years. The 1992 increase in the harvest of nonhatchery fish is probably a result of the popularity of this fishery relating to the large return of both nonhatchery and hatchery fish during that year. Harvest decreased beginning in 1994 as a result of new sport fishing restrictions imposed to address the overall decline in Susitna River chinook salmon escapement. The contribution of hatchery fish to the harvest reached 50% in 1992 and has remained between 40% and 50% from 1993-1996. In 1992 the contribution of hatchery fish to the escapement increased to 29% and since then has remained below 30% (Figure 6).

FISH CULTURE

Egg takes have been successful in collecting the approximately 400,000 eggs annually necessary for the Willow Creek stocking program and stocking area landlocked lakes. In years prior to 1997, any ripe fish collected at the egg-take site was used as brood stock whether or not it was a known hatchery fish (adipose finclipped). Beginning in 1997 no known released hatchery fish will be used as brood stock. Marking 100% of releases will assure that no eggs will be taken from previously released stocks.

SIZE, SEX, AND AGE COMPOSITIONS

In order to measure maintenance of fish quality, our first program goal, we needed size, age and sex composition data from enhanced returns. Returns from the first three brood years (1983-1985) were too small to provide meaningful information to the database and no eggs were collected in 1986. Returns from the 1987 through 1990 brood years are complete and provide data for comparison to previous years.

As indicated in previous reports, it is possible to use historical age, length, and sex data from sport-harvested chinook salmon from Willow

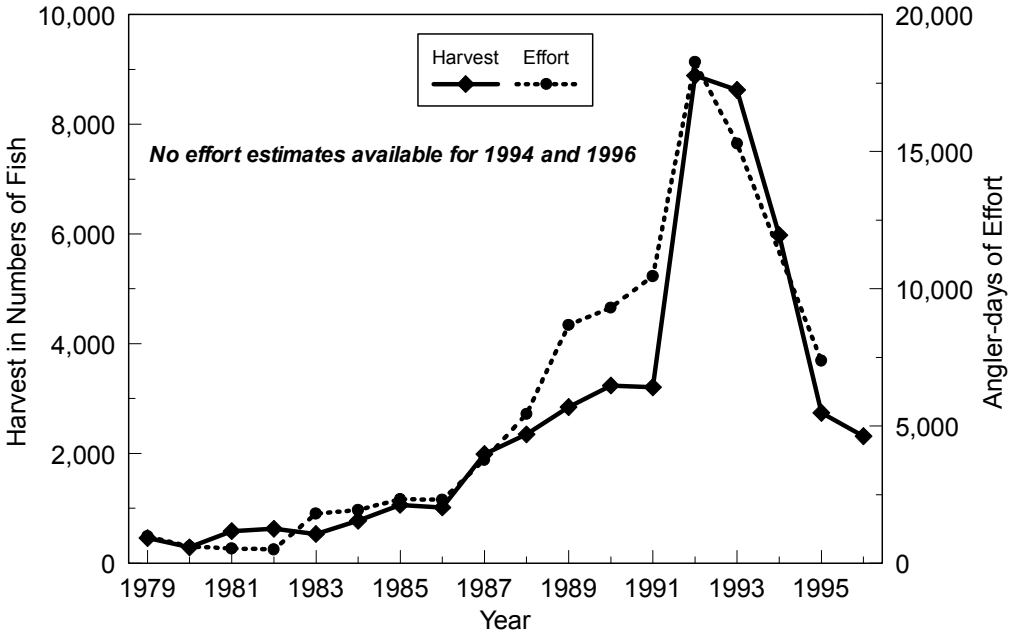


Figure 4.-Numbers of chinook salmon harvested and angler-days of effort expended sport fishing on Willow Creek, 1979-1996.

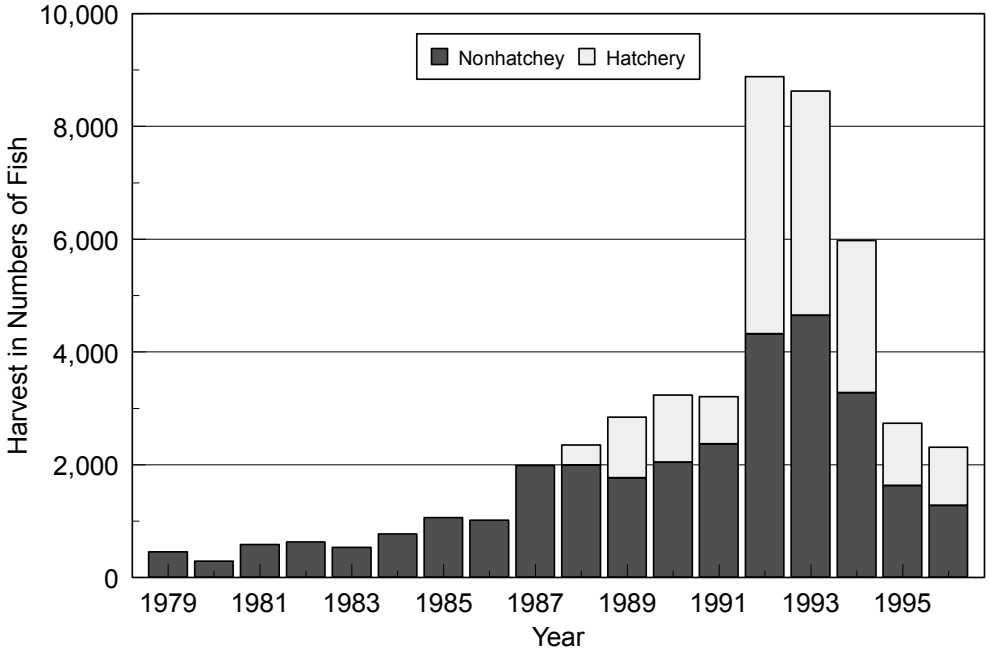


Figure 5.-Harvest of nonhatchery and hatchery chinook salmon in Willow Creek, 1979-1996.

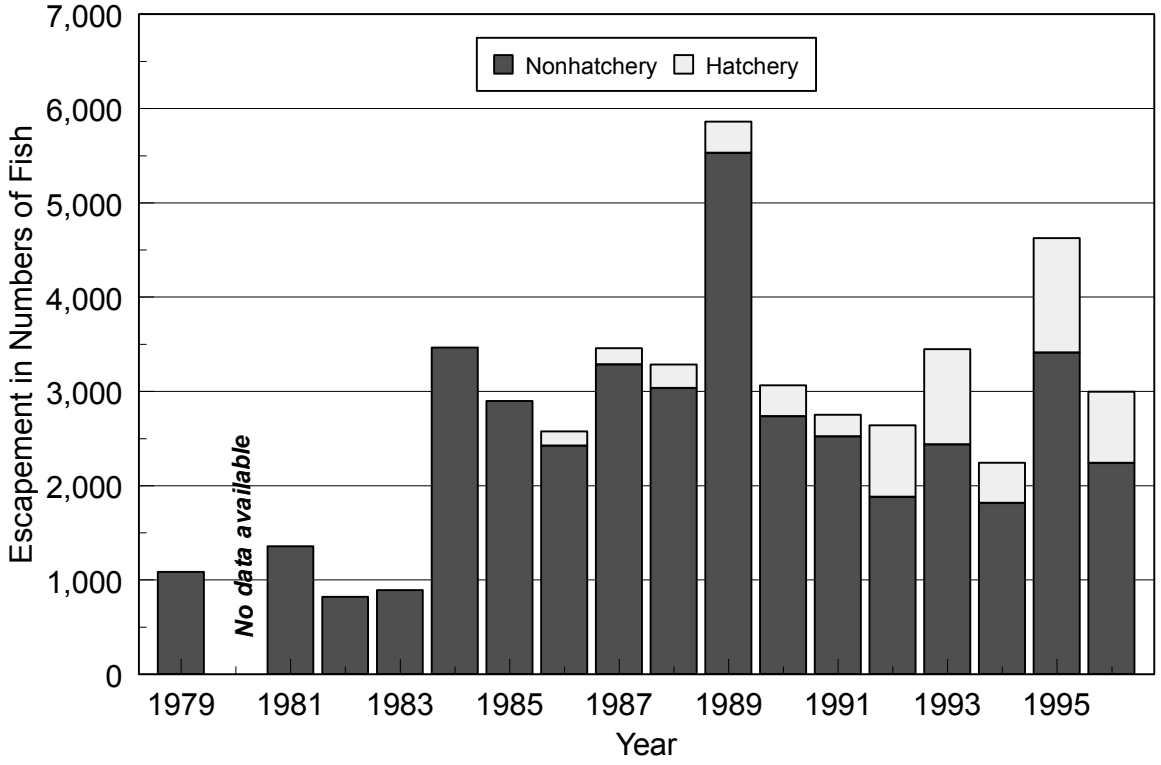


Figure 6.-Numbers of nonhatchery and hatchery chinook salmon in the Willow Creek and Deception Creek escapement index, 1979-1996.

Creek to determine trends in these parameters for the sport-harvested population (Peltz and Sweet 1992 and 1993). Age composition data from the sport harvests have been collected since 1979 (Table 3). If the age composition of the escapement is assumed the same as that of the sport harvest, we can construct a brood table which lists the age composition by brood year rather than year at return. Data collected prior to interaction of hatchery-produced fish (1986) indicate that the majority of fish (60%) return after 4 years residence in the ocean with lesser numbers after 3 (27%) and 2 (13%) years (Table 6, Figure 7). We now have five complete brood year returns, 1986-1990, since significant numbers of hatchery fish have been added. Comparison of the mean return by age class for the 1986-1990 brood years of hatchery and nonhatchery fish reveals a higher percentage of hatchery fish than nonhatchery fish returning after 2 or 3 years ocean residence, 47% of the nonhatchery fish return as 2- and 3-ocean fish whereas 62% of hatchery fish return at this age (Table 6). Males are returning at a younger age since the percentage of 2-ocean fish has increased substantially and is almost exclusively males (jacks). Other researchers (Bilton et al. 1984, and Martin and Wertheimer 1989) have documented a decline in age at return of hatchery releases (particularly males) as the size of the smolt increases. It may be possible to reduce the occurrence of "jacking" in the Willow Creek chinook salmon smolt releases by reducing the size of the smolt released. However, this could cause a reduction in marine survival (Bilton 1984) so this course of action is not

Table 6.-Estimated age at return of Willow Creek chinook salmon by brood year based on sport harvest data collected during the period 1979-1996.

Brood Year[b]	Origin	Estimated Number Returning by Age Class[acd] 1.2	1.3	1.4	Total Return	Estimated Percentage Returning by Age Class[d] 1.2	1.3	1.4	Total Return
1973	Wild			1,175	1,175				
1974	Wild		216	153	369				
1975	Wild	155	52	1,010	1,217	12.7	4.3	83.0	100.0
1976	Wild	84	699	1,088	1,871	4.5	37.4	58.1	100.0
1977	Wild	233	261	610	1,104	21.1	23.6	55.3	100.0
1978	Wild	102	458	1,992	2,552	4.0	17.9	78.1	100.0
1979	Wild	458	1,695	2,457	4,610	9.9	36.8	53.3	100.0
1980	Wild	551	951	1,655	3,157	17.5	30.1	52.4	100.0
1981	Wild	555	1,367	2,233	4,155	13.4	32.9	53.7	100.0
1982	Wild	540	1,689	1,972	4,201	12.8	40.2	47.0	100.0
1983	Wild	1,525	2,761	6,442	10,728	14.2	25.7	60.0	100.0
1984	Wild	902	1,654	3,214	5,459	15.6	28.7	55.7	100.0
1985	Wild	609	1,071	3,159	4,839	12.6	22.1	65.3	100.0
1986	Nonhatchery	870	1,329	3,444	5,642	15.4	23.5	61.0	100.0
1987	Hatchery	1,147	877	1,282	3,306	34.7	26.5	38.8	100.0
	Total	2,017	2,206	4,726	8,948	22.5	24.6	52.8	100.0
1987	Nonhatchery	357	2,016	3,832	6,250	5.7	33.0	61.3	100.0
1988	Hatchery	239	1,743	998	2,980	8.0	58.5	33.5	100.0
	Total	596	3,804	4,830	9,230	6.5	41.2	52.3	100.0
1988	Nonhatchery	864	1,948	2,701	5,512	15.7	35.3	49.0	100.0
1989	Hatchery	2,133	3,365	2,596	8,094	26.4	41.6	32.1	100.0
	Total	2,997	5,313	5,297	13,606	22.0	39.0	38.9	100.0
1989	Nonhatchery	1,135	1,566	3,008	5,709	19.9	27.4	52.7	100.0
1990	Hatchery	797	383	1,162	2,342	34.0	16.4	49.6	100.0
	Total	1,932	1,949	4,170	8,051	24.0	24.2	51.8	100.0
1990	Nonhatchery	721	1,184	1,258	3,163	22.8	37.4	39.8	100.0
1991	Hatchery	134	577	428	1,139	11.8	50.7	37.6	100.0
	Total	855	1,761	1,686	4,302	19.9	40.9	39.2	100.0
1991	Nonhatchery	633	1,008		1,641	38.6	61.4		100.0
1992	Hatchery	627	593		1,220	51.4	48.6		100.0
	Total	1,260	1,601		2,861	44.0	56.0		100.0
1992	Nonhatchery	1,180			1,180	100.0			100.0
1993	Hatchery	750			750	100.0			100.0
	Total	1,930			1,930	100.0			100.0
Brood years 1975 to 1985				Mean %		13	27	60	
Nonhatchery brood years 1986-1990				Mean %		16	31	53	
Hatchery brood years 1987-1991				Mean %		23	39	38	
Total Return by nonhatchery brood years 1986-1990				Mean %		20	34	46	

[a] From: Watsjold 1980 and 1981; Bentz 1982 and 1983; Hepler and Bentz 1984, 1985, 1986 and 1987; Hepler et al. 1988 and 1989; Sweet and Webster 1990; Sweet et al. 1991; Peltz and Sweet 1992, 1993; Sweet and Peltz 1994; Whitmore et al. 1995 and 1996; Whitmore and Sweet 1997.

[b] Nonhatchery fish are all age 1 freshwater and hatchery fish are all age 0. Hatchery fish and nonhatchery fish are grouped by smolt year.

[c] Other age classes exist (1.1, 1.5, 2.2, 2.3, 2.4, 2.5) but do not make up more than 5% of the return on a combined basis.

[d] These data assume the age composition of the Willow Creek escapement and sport harvest are comparable.

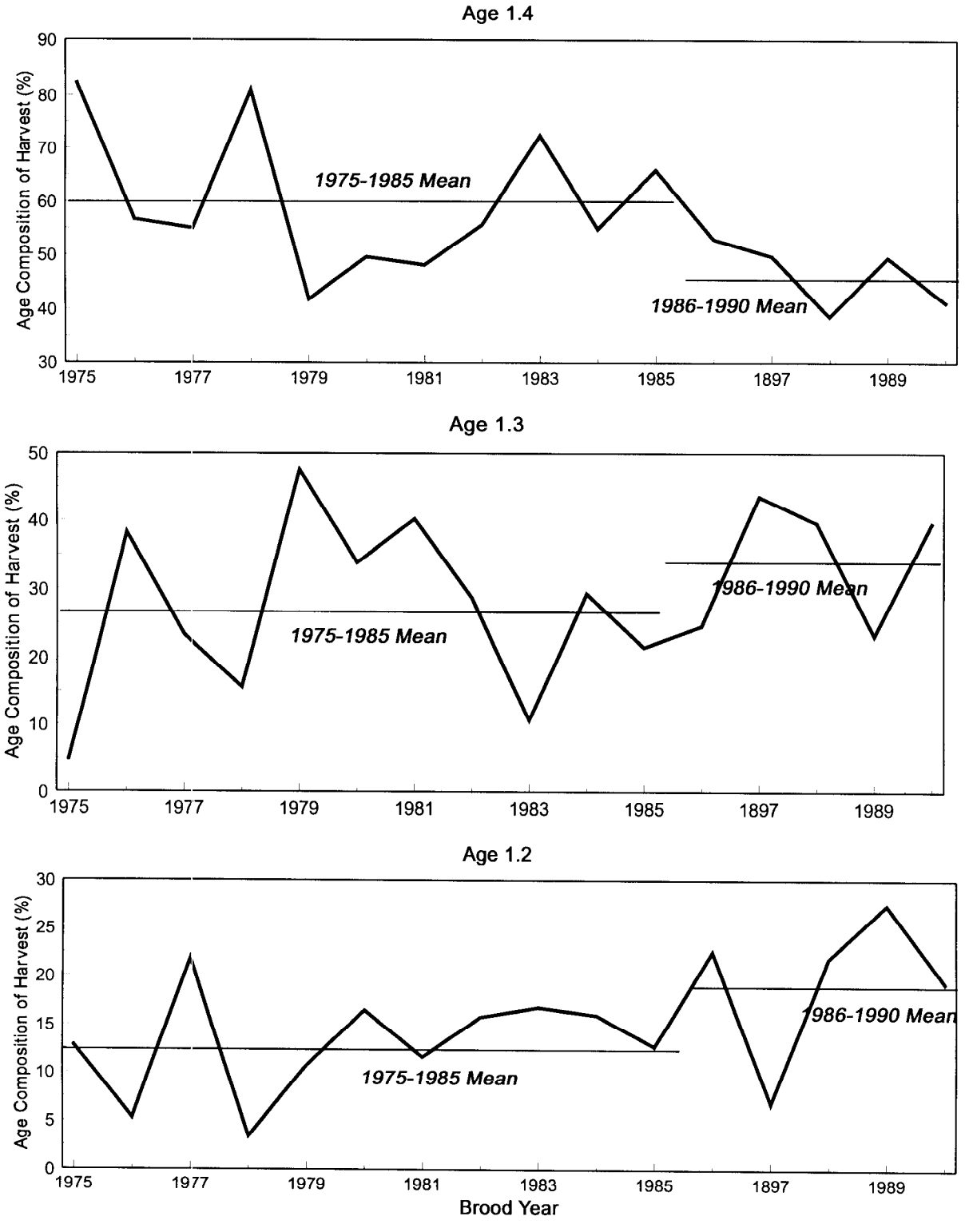


Figure 7.-Willow Creek chinook salmon estimated age composition at return for brood years 1975-1990 based on sport harvest data.

advocated at this time. The age at return should continue to be closely monitored as additional brood years complete their return.

Comparable length (Table 4) and sex (Table 5) data have been collected from the sport harvest since 1986. Sex composition in the harvest varies among age classes. Based on the mean of data collected in 1986-1988 (before hatchery influence), the majority of 2-ocean (93%) and 3-ocean (58%) fish return as males while most 4-ocean (66%) fish return as females. When the 1989-1996 data are combined, the resulting mean percents by age class were similar to the 1986-1988 percents indicating that the addition of hatchery fish has not affected the sex ratio within age classes of the harvest (Table 5, Figure 8).

Based on 1986-1988 means, average length differences among age classes in the sport harvest are obvious with 2-ocean, 3-ocean, and 4-ocean fish averaging 622 mm, 845 mm, and 957 mm, respectively (Table 4). The 1989-1996 mean lengths of 2-ocean and 4-ocean fish lie well within the 90% confidence interval (CI) of the historical mean (1986-1988) indicating no change in length; however, the 1989-1996 mean length of 3-ocean fish falls slightly below the historical mean CI indicating a possible decrease in mean length for that year class (Figure 9). It should be noted, however, that the prehatchery influenced years (1986-1988) have only three seasons' data available which may be too small a sample size to accurately represent the return over time. Scale samples and length measurements should continue to be collected from the sport harvest to monitor any trends in decreasing length and changing sex ratios.

The historic age, length and sex data compiled in Tables 3-5 as well as Figures 7-9 should provide a basis for future comparison.

Another indicator of fishery quality is maintenance of historic harvest timing; however, with the historical changes in the characteristics of this fishery it is difficult to detect changing trends in harvest timing (Sweet and Peltz 1994).

CONTRIBUTION OF CODED WIRE TAGGED STOCKS

Initial performance of hatchery smolt stocking at Willow Creek was well below expectations based on a 2% return, as evidenced by returns from brood years 1983-1985. However, the 1987-1989 brood years with 1.6%, 1.2% and 1.2% minimum survival, respectively, indicated considerable improvement over previous years (Table 1, Figure 10). Returns for the following two brood years (1990 and 1991), however, produced only a 0.6% survival. There are no evident reasons for this decline and the following brood years (1992 and 1993), although not complete, indicate a return to the 1%-1.5% survival rate. If we continue to accomplish a 1%-1.5% return from a 200,000 fish release we can expect 2,000 to 3,000 fish available for harvest leaving us short of our goal of 4,000.

The estimated hatchery contribution to the Willow Creek total return has varied considerably from year to year, ranging from 157 to 5,329 (Table 2). The actual hatchery return by return year (based on a 2% return of the hatchery release calculated by age class composition in Table 6) has fallen below 50% of the projected estimated hatchery return in all years except 1992 and 1993 (Figure 11). Years in which there were returns allowing harvests of hatchery fish near or above our goal of 4,000 fish (1992-1994) were influenced by years (1990 and 1991) with releases two and three times the recommended release of 200,000 smolt. It should be noted that the minimum estimated return is based on aerial escapement counts which have been shown for other systems to equal approximately 50% of the actual number present (Whitmore et al. 1996). With

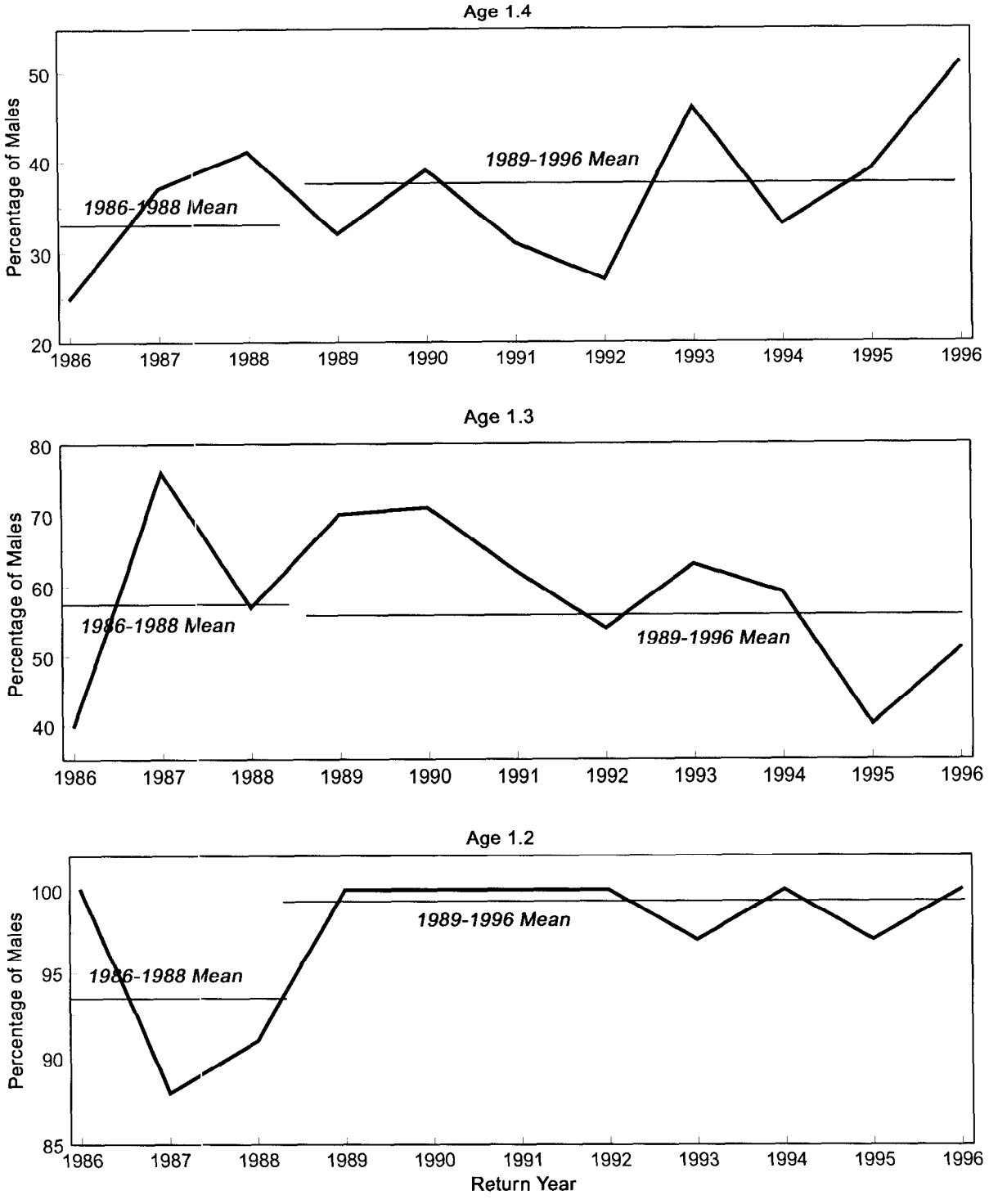


Figure 8.-Willow Creek chinook salmon estimated percentage of males by age class from sport harvests for the period 1986-1996.

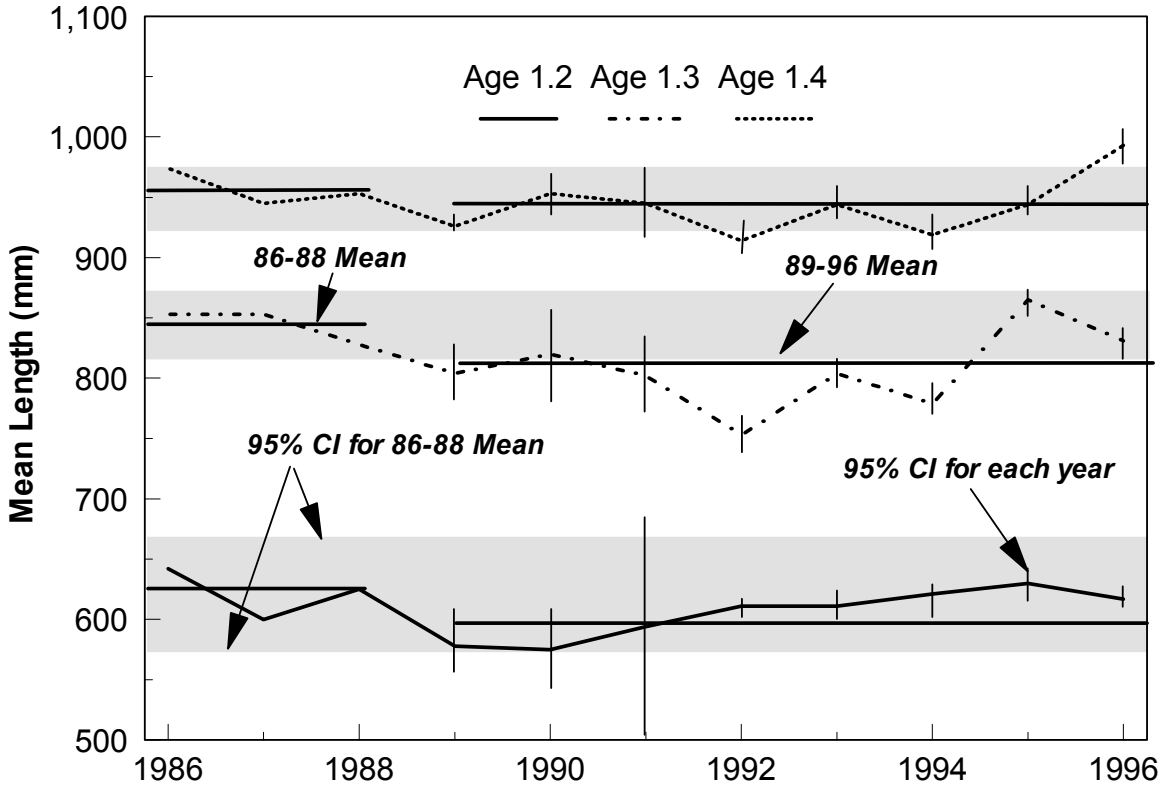


Figure 9.-Willow Creek chinook salmon estimated mean length by age class from sport harvests for the period 1986-1996.

this in mind, the number of returning hatchery fish in the escapement component of the estimate would be approximately double what is indicated in Table 2. Therefore, the actual hatchery return for recent years is considerably greater than indicated by the reported minimum estimated return and brings us close to our 4,000 fish goal.

ESCAPEMENT SURVEYS

The spawning escapement aerial surveys on Willow and Deception creeks serve as functional indices of the spawning population. These surveys are necessary to measure the effectiveness of fisheries management in obtaining the escapement goal. The function of the carcass survey is to estimate the relative hatchery contribution to the mainstem of Willow Creek and Deception Creek.

The first program goal is to maintain the quality and quantity of natural chinook salmon production. The escapement goal for the aerial index for Willow and Deception creeks, set at the onset of this project, is 2,600 naturally spawning fish. This historic quantity of natural chinook salmon production has been maintained every year since the introduction of hatchery fish, except 1994 (Table 2). During 1994 all Susitna River drainage streams fell below escapement goals, suggesting the enhancement program was not the cause of the decreased return to Willow Creek.

Because of genetic concerns, Sport Fish Division tries to ensure that hatchery releases do not outnumber wild production (Larry Peltz, Alaska Department of Fish and Game,

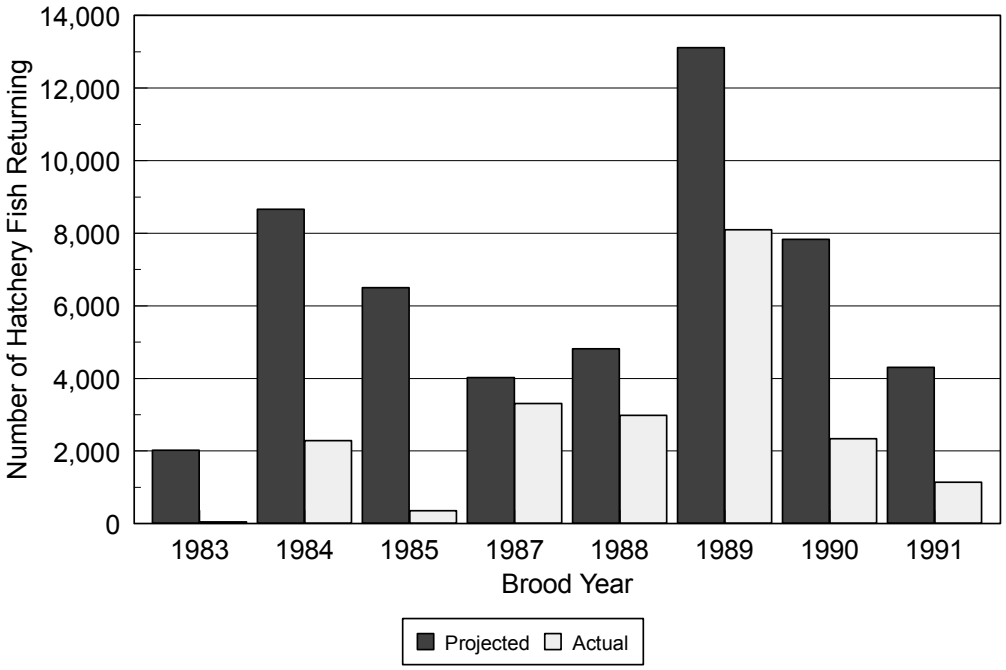


Figure 10.-Willow Creek chinook salmon projected and actual hatchery returns by brood year, 1983-1991.

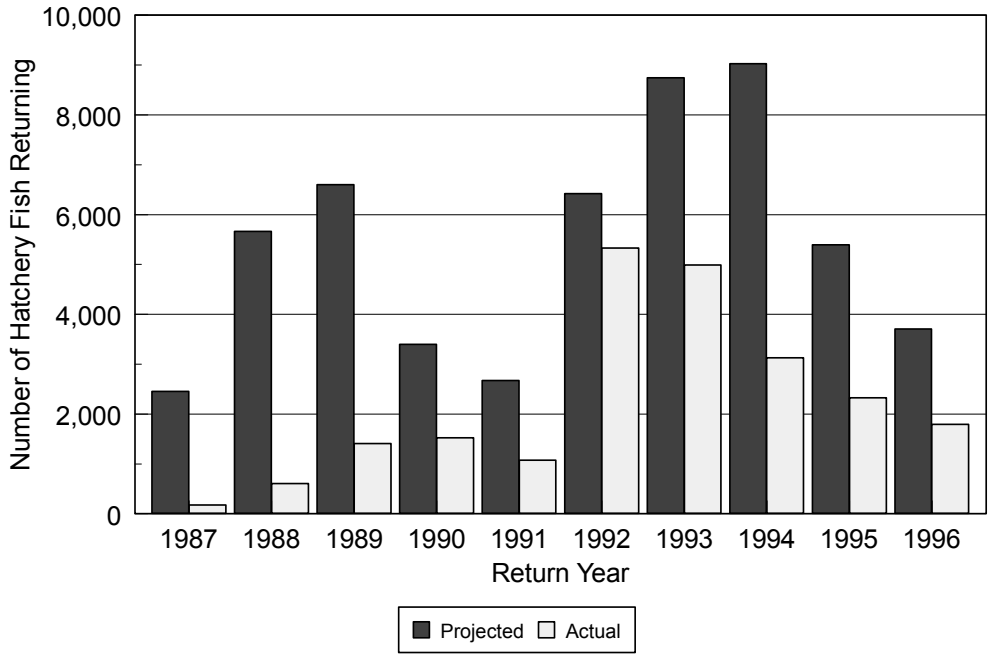


Figure 11.-Willow Creek chinook salmon projected and actual hatchery returns for the period 1987-1996 assuming a 2% return.

Sport Fish Division, Anchorage, personal communication). The Willow Creek hatchery return has remained below 50% of the total return throughout the stocking program in both the harvest and escapement.

FISHING OPPORTUNITY

The last goal of the enhancement program is to provide a minimum of 15,000 angler-days of participation during the period 10 June through 10 July. This time frame was originally set for the purpose of conducting an inseason creel survey which was deemed no longer necessary beginning with the 1994 season. We would like to restate the participation goal, measured in angler-days of effort, as a seasonal goal. Effort is dependent on the abundance of returning fish and the length of the season, neither of which is anticipated to increase much beyond existing levels. A large increase in hatchery returns occurred during 1992-1994, which, combined with a stable annual return of over 4,000 nonhatchery fish and increased access to the fishery, resulted in a corresponding increase in angler effort (Table 2). During these 3 years, the annual combined return of hatchery and nonhatchery chinook salmon was 8,000-12,000 fish. In 1992 we exceeded our effort goal by 3,000 angler-days, in 1993 we attained our goal of 15,000 angler-days, and in 1994, a year in which no inseason effort survey was conducted, an effort level of 10,000 angler-days was approximated. This level of effort, between 10,000 and 18,000 angler-days, should be maintained if returns continue to fall near the 8,000-12,000 fish range. We therefore restate our goal to the following: to maintain the level of participation at 10,000-15,000 angler-days of chinook salmon fishing a year.

NONHATCHERY STOCK CWT PROGRAM

Depressed chinook salmon returns to the Susitna River drainage during the early 1990s raised questions about possible marine interception of these stocks. A program to CWT juvenile chinook salmon within the Willow Creek drainage was found to be feasible and was initiated in 1996 when approximately 46,000 juveniles were tagged and released. This program will continue through 1998. Recoveries will be made in selected Southcentral commercial and recreational fisheries and will be used to estimate the contribution of tagged stocks to the marine harvest. Returns to Willow Creek will be monitored through the present catch sampling program and through a weir to be constructed in the spring of 1999.

CONCLUSIONS AND RECOMMENDATIONS

The goals of this project have undergone changes from the original goals stated in Peltz and Sweet (1992). The basis of these changes are documented in previous reports by Peltz and Sweet (1992 and 1993) and Sweet and Peltz (1994). These reports also established the database for measuring the performance and success of the Willow Creek chinook salmon enhancement program. The developmental phase of this project has been completed, and based on data assimilated to date, the Willow Creek chinook salmon project continues to be successful. However, monitoring certain parameters is still necessary to assure that our continuing assessment is accurate.

The following recommendations are based on data analysis and discussion presented in this report:

1. Continue to obtain age, length, and sex data from sport harvests.
2. Continue to monitor the sport harvest for adipose finclipped fish and collect heads for coded wire tag recovery.

3. Examine carcasses for adipose finclipped fish and collect heads for coded wire tag recovery in escapement surveys to determine the proportion of the Willow Creek spawning escapement that is hatchery fish.
4. Maintain existing databases and include yearly statistics of interest in the Northern Cook Inlet Area Management Report. A periodic progress report should be written to document the future success or failure of the project.
5. Restate the present goal of providing 15,000 angler-days of effort during the period 10 June to 10 July to maintaining 10,000 to 15,000 angler-days of chinook salmon fishing opportunity during the entire season.
6. Beginning in 1997 smolt releases should be 100% marked to insure no hatchery-released fish are used as brood stock.

ACKNOWLEDGMENTS

Thanks to Larry Peltz for his contributions in writing the 1992 and 1993 versions of this report from which some of this report is taken, and to the many technicians who helped collect the data. Appreciation is also given to Research and Technical Services staff who diligently processed all mark-sense data forms and provided electronic data files, Allen Bingham who provided invaluable biometric support, and Margaret Leonard for editing and preparing this report for publication.

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APPENDIX A

Appendix A1.-Tag recoveries from chinook salmon stocked in Willow Creek and recovered in nontarget fisheries, 1986-1996.

Year	Tag Code	Recovery Date	Statistical Area	Recovery Fishery
1986	No Recoveries			
1987	31-16-47	11-Jul-87	331-	Kotzebue Sound subsistence (Sheshalic)
1988	No Recoveries			
1989	31-17-27	14-Jul-89	157-	Southeast troll, outside waters
1990	31-17-58	11-Jun-90	247-	Cook Inlet gillnet
	31-17-60	22-Oct-90	56N-155W	High seas trawl
1991	31-17-58	31-May-91	212-	Copper River gillnet
	31-17-58	20-May-91	244-10	Homer sport
	31-17-58	18-Jun-91	224-30	Crooked Creek
	31-17-60	20-May-91	212-	Copper River gillnet
	31-18-51	16-Jul-91	212-	Copper River gillnet
1992	31-18-52	16-Jun-92	225-	Prince William Sound
	31-18-52	20-Jun-92	212-	Copper River gillnet
	31-18-52	9-Nov-92	113-41	Southeast troll
1993	31-18-51	28-Oct-93	113-41	Southeast troll
	31-18-52	2-Jul-93	113-	Southeast troll
	31-17-34	27-May-93	212-	Copper River gillnet
	31-17-34	12-Jun-93	212-	Copper River gillnet
1994	31-17-34	23-May-94	244-70	Kenai sport fishery
	31-18-51	5-Jun-94	247-41	Anchorage sport
	31-18-52	14-Jun-94	223-40	Cordova gillnet
	31-21-03	14-Jun-94	212-	Valdez gillnet
1995	31-17-34	23-May-95	212-	Cordova gillnet
	31-21-03	11-Jul-95	189-	Yakutat troll
	31-18-51	4-Apr-95	244-70	Ninilchik sport
1996	31-21-60	29-May-96	244-70	Anchor Point sport
	31-21-60	3-Jun-96	247-	Anchorage traditional, set gillnet
	31-21-60	3-Jun-96	247-	Homer traditional, set gillnet
	31-21-60	3-Jun-96	247-	Homer traditional, set gillnet
	31-23-17	3-Jun-96	247-	Homer traditional, set gillnet
	31-24-34	17-Jul-96	223-30	Coghill River, escapement

Appendix A2.-Tag recoveries from chinook salmon stocked in Montana Creek and recovered in nontarget fisheries, 1986-1996.

Year	Tag Code	Recovery Date	Statistical Area	Recovery Fishery
1990	31-17-59	23-Oct-90	55N-155W	High seas trawl
1991	31-17-59	15-Jun-91		Willow Creek, sport
	31-17-59	22-Jun-91		Willow Creek, sport
	31-17-59	29-Jun-91		Willow Creek sport
1992	31-18-31	8-Jun-92	244-20	Homer sport
	31-18-31	13-Jun-92		Willow Creek, sport
	31-17-59	13-Jun-92		Willow Creek, sport
	31-17-59	23-Jun-92		Willow Creek, sport

Appendix A3.-Tag recoveries from chinook salmon stocked in Sheep Creek and recovered in nontarget fisheries, 1986-1996.

Year	Tag Code	Recovery Date	Statistical Area	Recovery Fishery
1992	31-18-36	16-Oct-92	113-41	Southeast troll
	31-18-36	13-Jun-92		Willow Creek, sport
	31-18-36	27-Jun-92		Willow Creek, sport

Appendix A4.-Coded wire tag recoveries of Willow Creek chinook salmon in the Willow Creek creel survey, Willow Creek escapement surveys and Deception Creek escapement (egg take and carcass survey), 1986-1996.

Recovery Year	Brood Year / Tag Code / Recovery Location	1983 31-16-42	1984 31-16-45	1984 31-16-47	1985 31-17-33	1985 31-17-27	1987 31-17-58	1988 31-17-60	1989 31-17-34	1989 31-18-51	1989 31-18-52	1990 31-19-33	1991 31-21-03	1992 31-21-60	1993 31-23-17	1994 31-24-34	Total Tags	Total Fish Inspt
1986	Deception Ck. E.T.[a]	1	2	2	0	0	0	0	0	0	0	0	0	0			5	296
1987	Deception Ck. E.T.[a]	2	6	16	0	0	0	0	0	0	0	0	0	0			24	692
1988	Willow Ck. C.S.[b]	0	2	2	0	0	0	0	0	0	0	0	0	0			4	528
	Deception Ck. E.T.[a]	0	1	3	1	0	0	0	0	0	0	0	0	0			5	358
																Total	9	886
1989	Willow Harvest[b]	0	10	5	0	1	0	0	0	0	0	0	0	0			16	1,005
	Willow Ck. Esc.	0	1	0	0	0	0	0	0	0	0	0	0	0			1	632
	Deception Ck. E.T.[a]	0	3	0	1	1	0	0	0	0	0	0	0	0			5	358
																Total	22	1,995
1990	Willow Harvest[b]	0	1	1	0	5	33	1	0	0	0	0	0	0			41	1,309
	Willow Ck. Esc.	0	0	0	1	0	1	0	0	0	0	0	0	0			2	703
	Deception Ck Esc.[c]	0	0	0	2	2	22	1	0	0	0	0	0	0			27	659
																Total	70	2,671
1991	Willow Harvest[b]	0	0	0	0	0	19	5	0	0	0	0	0	0			24	1,063
	Willow Ck. Esc.	0	0	0	0	0	0	0	0	0	0	0	0	0			0	270
	Deception Ck. Esc.[c]	0	0	0	0	0	10	0	0	0	0	0	0	0			10	309
																Total	34	1,642
1992	Willow Harvest[b]	0	0	0	0	0	48	62	46	49	74	10	0	0			289	4,607
	Willow Ck. Esc.	0	0	0	0	0	2	0	0	0	1	0	0	0			3	202
	Deception Ck. Esc.[c]	0	0	0	0	0	7	4	3	4	4	1	0	0			23	115
																Total	315	4,924
1993	Willow Harvest[b]	0	0	0	0	0	0	6	30	25	17	12	0	0			90	1,443
	Willow Ck. Esc.	0	0	0	0	0	0	3	1	1	1	0	0	0			6	398
	Deception Ck. Esc.[c]	0	0	0	0	0	0	5	10	5	10	3	0	0			33	441
																Total	129	2,282
1994	Willow Harvest[b]	0	0	0	0	0	0	0	22	30	26	11	4	2			95	1,172
	Willow Ck. Esc.	0	0	0	0	0	0	0	1	1	0	0	0	0			2	325
	Deception Ck. Esc.[c]	0	0	0	0	0	0	0	14	8	13	2	0	0			37	414
																Total	134	1,911
1995	Willow Harvest[b]	0	0	0	0	0	0	0	0	0	0	17	11	14			42	606
	Willow Ck. Esc.	0	0	0	0	0	0	0	0	0	0	3	1	2			6	192
	Deception Ck. Esc.[c]	0	0	0	0	0	0	0	2	0	1	13	11	18			45	518
																Total	93	1,316
1996	Willow Harvest[b]	0	0	0	0	0	0	0	0	0	0	0	6	11	16	0	33	389
	Willow Ck. Esc.	0	0	0	0	0	0	0	0	0	0	0	2	1	2	0	5	219
	Deception Ck. Esc.[c]	0	0	0	0	0	0	0	0	0	0	1	2	16	17	0	36	326
																Total	74	934
Total		3	26	29	5	9	142	87	129	123	147	73	39	64	35	0	906	17,549

[a] E. T. = egg take.

[b] CWT collected during a creel survey, SWHS estimate used for harvest.

[c] Deception Creek weir and Deception Creek carcass survey combined.

Appendix A5.-Estimated hatchery return of Willow Creek releases to the Willow Creek sport harvest, Willow Creek escapement survey, and Deception Creek escapement (egg take and carcass survey), 1986-1996.

Recovery Year	Brood Year / Tag Code / Recovery Location	1983 31-16-42	1984 31-16-45	1984 31-16-47	1985 31-17-33	1985 31-17-27	1987 31-17-58	1988 31-17-60	1989 31-17-34	1989 31-18-51	1989 31-18-52	1990 31-19-33	1991 31-21-03	1992 31-21-60	1993 31-23-17	1994 31-24-34	Estimated Minimum Return
1986	Deception Ck. E.T.[a]	21	68	68	0	0	0	0	0	0	0	0	0	0			157
1987	Deception Ck. E.T.[a]	28	28	118	0	0	0	0	0	0	0	0	0	0			174
1988	Willow Ck. C.S.[b]	0	173	182	0	0	0	0	0	0	0	0	0	0			355
	Deception Ck. E.T.[a]	0	55	182	16	0	0	0	0	0	0	0	0	0			253
																Total	608
1989	Willow Harvest[b]	0	673	354	0	52	0	0	0	0	0	0	0	0			1,079
	Willow Ck. Esc.	0	153	0	0	0	0	0	0	0	0	0	0	0			153
	Deception Ck. E.T.[a]	0	128	0	16	33	0	0	0	0	0	0	0	0			177
																Total	1,409
1990	Willow Harvest[b]	0	35	65	0	176	891	27	0	0	0	0	0	0			1,194
	Willow Ck. Esc.	0	0	0	17	0	32	0	0	0	0	0	0	0			49
	Deception Ck. Esc.[c]	0	0	0	11	32	224	13	0	0	0	0	0	0			280
																Total	1,523
1991	Willow Harvest[b]	0	0	0	0	0	645	199	0	0	0	0	0	0			844
	Willow Ck. Esc.	0	0	0	0	0	0	0	0	0	0	0	0	0			0
	Deception Ck. Esc.[c]	0	0	0	0	0	232	0	0	0	0	0	0	0			232
																Total	1,076
1992	Willow Harvest[b]	0	0	0	0	0	913	1,595	502	554	850	152	0	0			4,566
	Willow Ck. Esc.	0	0	0	0	0	158	0	0	0	45	0	0	0			203
	Deception Ck. Esc.[c]	0	0	0	0	0	211	148	49	68	65	19	0	0			560
																Total	5,329
1993	Willow Harvest[b]	0	0	0	0	0	0	587	1,104	1,025	696	565	0	0			3,977
	Willow Ck. Esc.	0	0	0	0	0	0	203	29	31	29	0	0	0			292
	Deception Ck. Esc.[c]	0	0	0	0	0	0	208	183	85	183	61	0	0			720
																Total	4,989
1994	Willow Harvest[b]	0	0	0	0	0	0	0	603	842	723	359	134	42			2,703
	Willow Ck. Esc.	0	0	0	0	0	0	0	24	25	0	0	0	0			49
	Deception Ck. Esc.[c]	0	0	0	0	0	0	0	140	82	132	24	0	0			378
																Total	3,130
1995	Willow Harvest[b]	0	0	0	0	0	0	0	0	0	0	541	304	266			1,111
	Willow Ck. Esc.	0	0	0	0	0	0	0	0	0	0	466	159	201			826
	Deception Ck. Esc.[c]	0	0	0	0	0	0	0	17	0	8	132	114	118			389
																Total	2,326
1996	Willow Harvest[b]	0	0	0	0	0	0	0	0	0	0	0	276	319	442	0	1,037
	Willow Ck. Esc.	0	0	0	0	0	0	0	0	0	0	0	104	33	63	0	200
	Deception Ck. Esc.[c]	0	0	0	0	0	0	0	0	0	0	23	48	241	245	0	557
																Total	1,794
Total		49	1,313	969	60	293	3,306	2,980	2,651	2,712	2,731	2,342	1,139	1,220	750	0	22,515

[a] E. T. = egg take.

[b] CWT collected during a creel survey, SWHS estimate used for harvest.

[c] Deception Creek weir and Deception Creek carcass survey combined.

APPENDIX B

Appendix B1.-Computer data files and analysis programs used for the Willow Creek chinook salmon hatchery enhancement evaluation studies for 1994-1996.

Data Files	
M004DBA4.DTA	Willow Creek, mouth, catch sampling biological data file, 1994.
M004DBA5.DTA	Willow Creek, mouth, catch sampling biological data file, 1995.
M004DBA6.DTA	Willow Creek, mouth, catch sampling biological data file, 1996.
Analysis Programs	
SFXTAB.EXE	RTS program used to cross-tabulate biological data files and produce either "discrete" or "continuous" tables of age, sex, length, and weight data.

Data files are archived with the Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services Unit, 333 Raspberry Road, Anchorage, Alaska 99518-1599. Contact Donna Buchholz (907-267-2369) for copies of the files and descriptions of the file format.