STATE/FEDERAL NATURAL RESOURCE DAMAGE ASSESSMENT
DRAFT PRELIMINARY STATUS REPORT

Project Title:	**CODED-WIRE TAG STUDIES ON PRINCE WILLIAM SOUND SALMON**
Study ID Number:	**Fish/Shellfish Study Number 3** **Restoration Study Number 8**
Lead Agency:	**State of Alaska, ADF&G**
Cooperating Agency(ies):	**NOAA, UA** **State: DNR**
Principal Investigator(s):	**Samuel Sharr, Comm. Fish. Division** **Mark Willette, FRED Division**
Assisting Personnel:	**Carol Peckham, Dan Sharp,** **Jodi Smith**
Date Submitted:	**November 20, 1991**

This is an interim and not a final Report. It may not have been subjected to scientific peer review or if it has been subjected to scientific peer review it may not have been rewritten or otherwise edited to reflect that peer review. The conclusions and other statements in the report should be viewed as the interim conclusions of the author(s) at the time the report is written. THE CONCLUSIONS IN THIS REPORT MAY HAVE CHANGED SINCE THE REPORT WAS WRITTEN, either as a result of the insight from peer review or the addition of subsequent data.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The study is part of an integrated group of Natural Resources Damage Assessment Fish/Shellfish Studies (NRDA F/S Studies 1,2,3,4, and 28) and Restoration Studies (8 and9), being conducted to quantify damage to wild Pacific salmon from the *MV Exxon Valdez* oil spill and restore damaged stocks to health. To determine how adult returns are affected, accurate appraisals of catch and spawning escapement are needed. NRDA F/S Study 3 is designed to estimate catch contributions and survival rates for both wildstock and hatchery salmon in oiled and unoiled areas of Prince William Sound (PWS). It is also designed to provide tags of known origin for recovery in NRDA F/S Study 4, Early Marine Salmon Injury Assessment. Restoration Study 8 integrates with NRDA F/S Study 3 as the tag application portion of the wildstock analyses and is summarized in this report.

Contribution of wild and hatchery pink salmon (*Oncorhynchus gorbuscha*) to the 1991 PWS commercial, cost recovery, special (discarded and donated pink salmon), and brood stock harvests were estimated from tagged fish released from 6 streams and 4 PWS hatcheries in 1990. Nineteen percent of the pink salmon harvest and 90% of the wildstock pink salmon carcasses in 46 selected streams were scanned for coded-wire tags. Out of 14,409 pink salmon heads sent to the Juneau Tag Lab, 8253 tags were recovered. The preliminary maximum estimate of wildstock contribution to the PWS pink salmon fishery is 6.8 million fish out of a total catch of 38.3 million fish (82% hatchery contribution). Estimated pink salmon survival, unadjusted for tag loss or tagging mortality, for the 6 tagged wildstock streams was 2.2%. Estimated maximum pink salmon survival for all hatcheries combined was 5.1%. The 1989 and 1990 hatchery average survival rates were 4.02% and 7.02%. Adjustment factors used in the hatchery contribution estimates ranged from 1.4 to 1.9.

Approximately 42% of the chum (*O. keta*), sockeye (*O. nerka*), coho (*O. kisutch*), and chinook (*O. tshawytscha*) salmon catch was scanned for tags, and 64, 4872, 1236, and 21 tags were recovered. Marine survival rates for these 4 species will be calculated as the many age classes return. Coho salmon brood stock sampling has just been completed and contribution estimates are incomplete.

Approximately 60,000 wild sockeye salmon in 3 streams and 319,400 wild pink salmon in 6 streams were tagged in 1991. Over 800,000 of the 535 million pink salmon fry and 473,000 hatchery produced chum, coho, sockeye, and chinook salmon released from PWS hatcheries in 1991 were also tagged.

Examination of the wild stock tagging data for differences in survival due to oiling is underway but not yet completed. Analysis of hatchery returns from oiled and unoiled areas is also being addressed.

OBJECTIVES

1. Estimate catch and survival rates of pink, chum, sockeye, coho, and chinook salmon released from five hatcheries in Prince William Sound; two hatcheries are in heavily oiled areas, and three are not.

2. Estimate survival rates of wild pink salmon from three streams with contaminated estuaries and three streams with uncontaminated estuaries using outmigration, catch, and escapement (provided by stream surveys).

3. Estimate survival rates of wild sockeye salmon from two watersheds with contaminated estuaries and one watershed with an uncontaminated estuary using outmigration, catch, and escapement (provided by operating weirs).

4. Provide marked salmon of known origin and oil exposure history for recovery by researchers studying early marine existence and migration of juvenile salmon (NRDA F/S Study 4).

5. Identify relevant injuries for which methods of restoring lost use, populations, and habitat must be developed.

INTRODUCTION

Wild pink salmon returns to Prince William Sound (PWS) have averaged 8 million fish since 1961. Hatchery produced pink salmon have been a significant component of the total return since 1985 and now average over 20 million fish. Hatchery fry have been tagged since 1986 to estimate contributions of wild and hatchery fish to the commercial catch and to estimate survival rates for release groups. Hatchery contribution estimates are necessary to estimate the wildstock catch and production. Estimates of catch and escapement for both wild and hatchery fish are needed to assess effects of oil and possible loss of production.

NRDA F/S Study 3 applies tags to all species of salmon produced at 6 hatcheries (Figure 1). Restoration Study 8 applies tags in wild sockeye salmon in 3 streams, and wild pink salmon in 6 streams (Figure 2). Results of the tagging and recovery are used to examine the relationship between oil exposure and survival rates and to document any loss of production. Pink salmon fry are produced at the Valdez Fisheries Development Association (VFDA) Solomon Gulch Hatchery and at three Prince William Sound Aquaculture Corporation (PWSAC) hatcheries: A.F. Koernig, W.H. Noerenberg, and Cannery Creek. The W.H. Noerenberg and Solomon Gulch hatcheries also produce chum and coho salmon. Chinook salmon are produced at the W.H. Noerenberg hatchery and sockeye salmon are produced at the Main Bay hatchery, which is also operated by PWSAC. The Ft. Richardson hatchery, a Fisheries Rehabilitation, Enhancement Department (FRED) facility, produces coho salmon smolts for release in Whittier and Cordova. Wild sockeye salmon were tagged at Jackpot, Coghill, and Eshamy Rivers. Wild pink salmon were tagged at Herring, Hayden, Loomis, Cathead, O'Brien, and Totemoff Creeks.

Tags were recovered at fish processing plants in Cordova, Valdez, Anchorage, Whittier, Kenai, and Kodiak. Recovery of tags from carcasses occurred at 6 wildstock pink salmon streams which had adult weirs and at 40 other streams surveyed as part of NRDA F/S 1. Broodstock scanning was conducted at all PWS hatcheries. A significant number of tags were recovered, allowing accurate contribution estimates and survival rates for hatchery and wildstock pink salmon in oiled and unoiled areas.

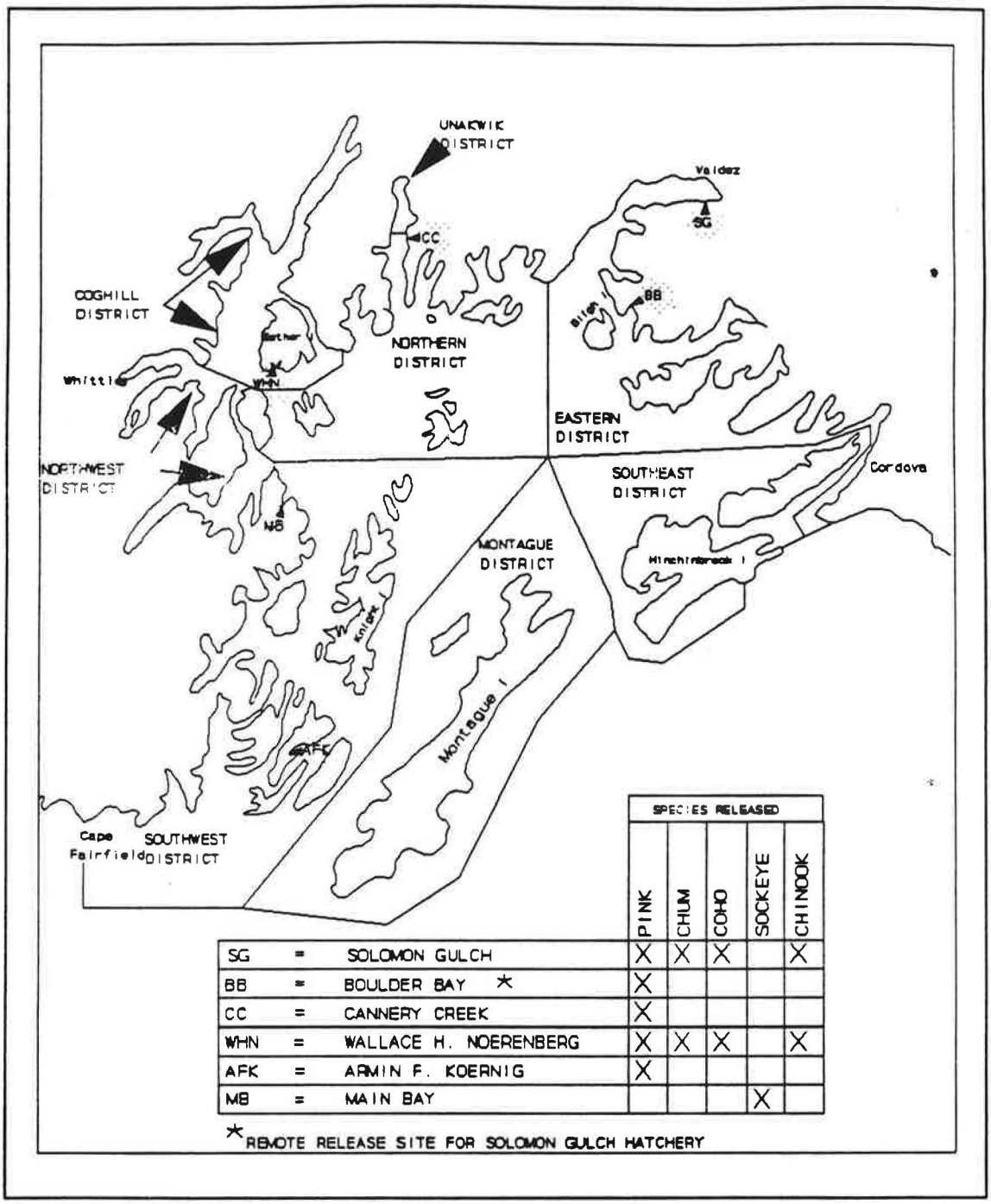


Figure 1. Map of Prince William Sound fishing districts and hatcheries.

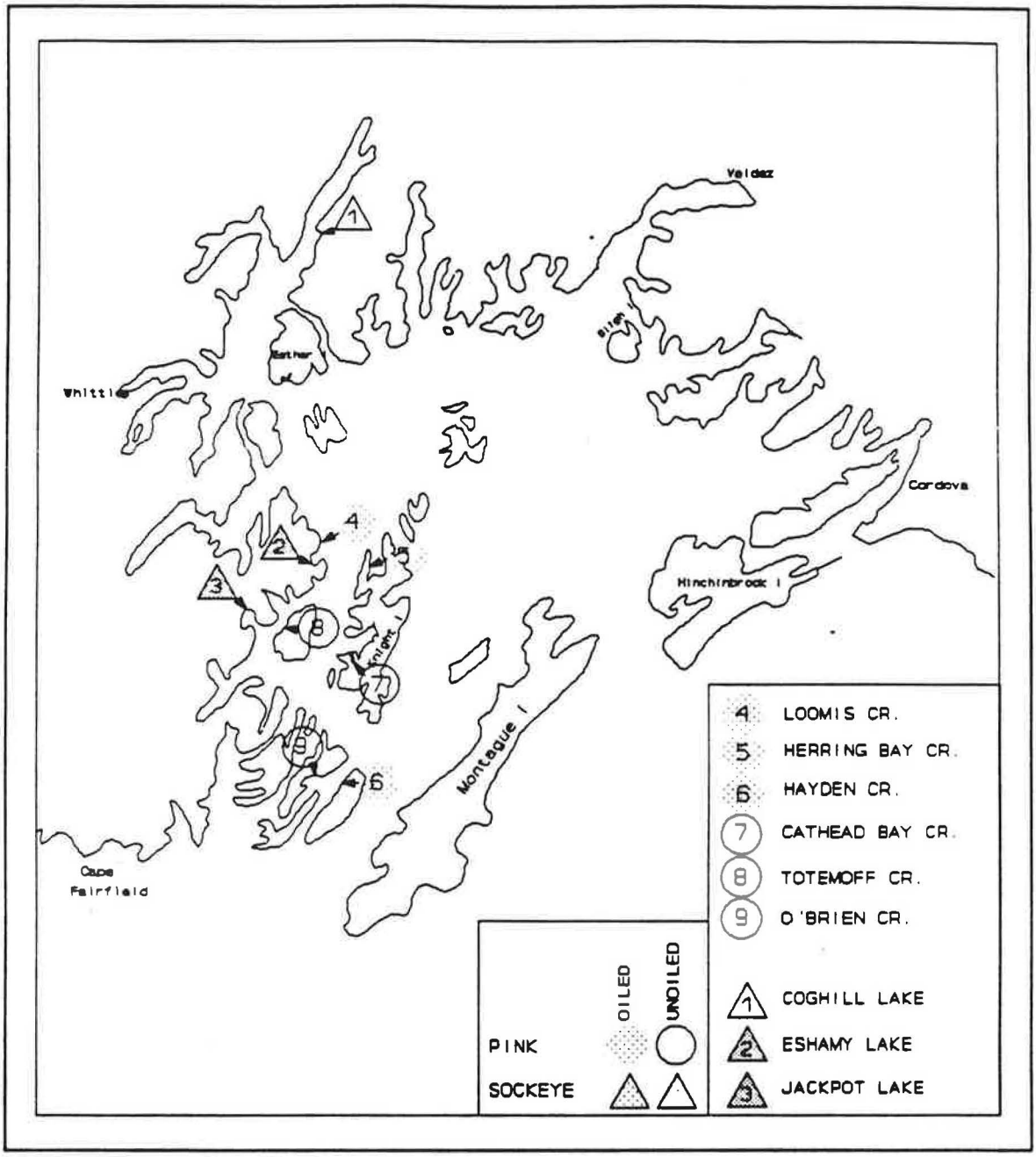


Figure 2. Map of Prince William Sound pink and sockeye salmon weir sites.

METHODS

Tagging

Tag recovery rates vary by district, week, and processor (Peltz and Geiger 1988). Tagging goals are set to ensure tags can be recovered in sufficient numbers to estimate the contribution of each release group to each district, week, and processor stratum. This degree of precision is required to estimate differences in production for oiled and unoiled groups of wild salmon (when NRDA F/S 1, 2, 3, and 28 are synthesized). Hatchery release groups represent differences in fry treatment or timing (i.e., fed vs. unfed, early vs. late fry emergence). Tagging rates were held as constant as possible.

Tagging of Hatchery Stocks

Pink and chum salmon fry to be tagged were randomly selected as they emerged from incubators. Fry were then anesthetized in a 1 ppm solution of MS-222, adipose fin clipped, and tagged. A random sample of 20 clipped fish was graded for clip quality during each tagging shift. The proportion of bad clips was used to discount the daily release of tagged fish. Clipped fish were tagged and passed through a quality control device (QCD) to test for tag retention. Rejected fish were held and retested later in the day. If rejected a second time, they were killed to minimize the number of untagged but clipped fish in the release. Fry which retained tags were held overnight to determine short-term mortality. An overnight tag retention rate was estimated by randomly selecting 200 fish and testing them with the QCD before release into saltwater rearing pens. Tag placement was checked periodically but not quantified.

Methods of handling tagged fry prior to release differed slightly between PWSAC and VFDA facilities. Fry tagged at Solomon Gulch hatchery were held in freshwater incubators until all tagging within a single tag code was completed. They were then moved to saltwater pens. Fry tagged at PWSAC facilities were introduced into saltwater net pens once the initial 24 hour waiting period after tagging had passed. Tagged fry at all facilities were placed in small net pens suspended within the larger salt water rearing pens they represented for at least 3 days. This allowed tagged fry time to recover from tagging and handling before being mixed with their unmarked cohorts. By deducting both the short-term tagging and

saltwater rearing mortalities from the number tagged, the total number of fry with valid tags was estimated for each release group as:

$$T_{vt} = (T_t - M_{ot} - M_{sw})\ (1 - L_{ot})\ C\ ,$$

where

M_{sw} = saltwater rearing mortality,
T_t = total number of group t fish tagged,
M_{ot} = overnight mortality of tagged group t fish,
L_{ot} =overnight tag loss rate of group t fish,
C = good clip rate for group t fish.

Unmarked fry entering the salt water rearing pens were counted with fry counters at PWSAC hatcheries. At Solomon Gulch, the numbers of unmarked fry entering salt water net pens were estimated from counts of eggs loaded into incubators minus egg mortalities. Chum fry at Solomon Gulch Hatchery were transferred to salt water after emergence while those at W.H. Noerenberg Hatchery were reared in fresh water. At all facilities, fry mortalities in the large pens were estimated visually prior to release. Mortality rates determined from visual estimates were applied equally to tagged and untagged fish. The timing of hatchery releases was determined by the goals of the rearing experiment.

Sockeye, coho, and chinook salmon smolts were tagged using nearly identical methods as described for pink salmon fry tagging. The major differences were that full-length tags were used instead of half-length tags and fin clip inspections and discounting for poor clips were unnecessary because of the size of fish being tagged. After tagging, smolts were returned to freshwater before being transferred to either saltwater pens or remote release locations.

Tagging of Wild Stocks

In 1991, coded wire tags were applied to wild pink salmon at the same six streams examined in 1990 as part of NRDA Fish Study 3. Tags were also applied to the same three wild stocks of sockeye salmon examined in 1989 and 1990. Intertidal fry weirs, inclined-plane traps, and smolt weirs were used to capture and enumerate outmigrating juvenile salmon. A portion of the outmigration from each site was marked with an adipose fin clip and a coded wire tag was applied. Length, weight, and age information were collected to characterize the outmigration at each site. At Herring Creek, an upstream weir was operated in conjunction with an intertidal weir to separately enumerate and tag the pink fry production from both stream components.

Intertidal weirs were designed to provide a total enumeration of outmigrating pink salmon fry. Weirs were fished continuously and outmigration counts were summed for each low tide. Fry were counted

using electronic fry counters or by individually tallying fry using thumb counters. Each day, a random sample of fry were set aside for tagging. Of these, approximately 150 to 200 fry were measured and weighed to quantify size differences between creeks and within individual creeks over time. Fry to be tagged were anesthetized in an MS-222 solution, their adipose fin clipped, and injected with a half-length coded wire tag. Tagged fry were held for 24 hours to measure short term tag-loss and mortality rates. Each tagging day, a sample of 20 clipped fry were graded for fin clip quality to determine a good fin clip rate. Tag placement was also checked daily. After tag retention checks, fry were introduced into salt water net pens and held for up to 24 hours prior to release. The total number of fry with valid tags was estimated as:

$$T_{vt} = (T_t - M_{ot})\ (1 - L_{ot})\ C \quad ,$$

where

T_t = total number of fish tagged from group t,
M_{ot} = overnight mortality of tagged group t fish,
L_{ot} = overnight tag loss rate of group t fish,
C= good clip rate.

Tagging at each site was temporally stratified. The number of strata ranged from 3 to 5 depending on the magnitude and duration of the run. Tag codes for each stream were unique.

Smolts from wild stocks of sockeye salmon at Coghill, Eshamy, and Jackpot rivers were enumerated and a random sample were coded wire tagged. Inclined plane traps were used to capture smolt at all locations. A 1.22 m x 1.22 m fyke net was also used at the Eshamy weir. Smolts were anesthetized with an MS-222 solution and their adipose fins were clipped. Smolts were tagged and held for at least 24 hours to determine short term mortality and tag loss rates. The number of valid tags released was calculated the same as for pink salmon fry without discounting for bad fin clips.

1991 Tag Recovery

Commercial and Cost Recovery Harvests

Salmon delivered to sixteen land based processors and two floating processors were sampled for coded wire tags during the 1991 PWS fishery. All five species of salmon were sampled. Catches of salmon were scanned for coded wire tags by visual and tactile methods as the fish were off-loaded from tendering vessels. Each sample was from a specific tender, and the following data were recorded: sampler name, port, harvest type (i.e., commercial or cost recovery catch), catch date, delivery date, processor, tender

or boat name, fishing district(s) where fish were caught, number of fish examined, number of fish with adipose fin clips found, identification numbers for fish heads recovered, and the quality of adipose clip on each recovered fish. District and subdistrict information for each tender load was obtained from tender crews, processor records, and fish tickets. Heads of clipped fish were frozen and sent to the ADF&G Coded-Wire Tag Processing Lab in Juneau along with sample data. The tag lab processed the heads, recording each head's tagcode when a tag was recovered. This information along with the information from the data sheets was entered into the Juneau tag lab database and sent to Cordova on a weekly basis to aid in-season editing and analysis.

Scanning commercial pink salmon catches for coded-wire tags involves visually selecting adipose clipped fish from a mixture of unclipped and clipped fish on a conveyor belt. Samplers select fish on the basis of whether they have a good view of the adipose fin region; negative sampling bias is possible by consistent exclusion of tagged fish. This possible sampling bias was tested by comparing the tag recovery rates of sampled fish to recovery rates in a complete census of the sampled load of fish.

Brood Stock Harvests

A technician was stationed at each of the 5 PWS hatcheries to scan the broodstock during egg take for all five species of salmon. After the salmon were manually spawned, technicians used visual and tactile methods to scan approximately 95% of the fish. When an adipose clipped fish was found, the head was removed and marked with a uniquely numbered cinch tag. Total number of fish scanned and total number of fin-clipped fish found were recorded on a daily basis. Heads and their corresponding data sheets were picked up weekly from each hatchery and returned to Cordova for editing and shipping to the Juneau Tag Lab.

Broodstock scanning is an important part of estimating hatchery contributions. Due to differential mortality between tagged and untagged fish as well as differential tag loss between release groups the tag expansion factor at release may no longer accurately reflect the tag expansion factor in the adult population. Theoretically, brood stock is 100% hatchery fish and representative of returns from each fry and smolt release group (Figure 3). Based on this assumption, tag recovery rates from brood stock can be used to adjust the initial tag expansions for each hatchery. Salmon sold for cost recovery are taken from terminal harvest areas directly in front of the hatcheries. Therefore, these fish are expected to be of primarily hatchery origin. Therefore, a similar analysis to that of the broodstock is performed for the cost recovery harvest.

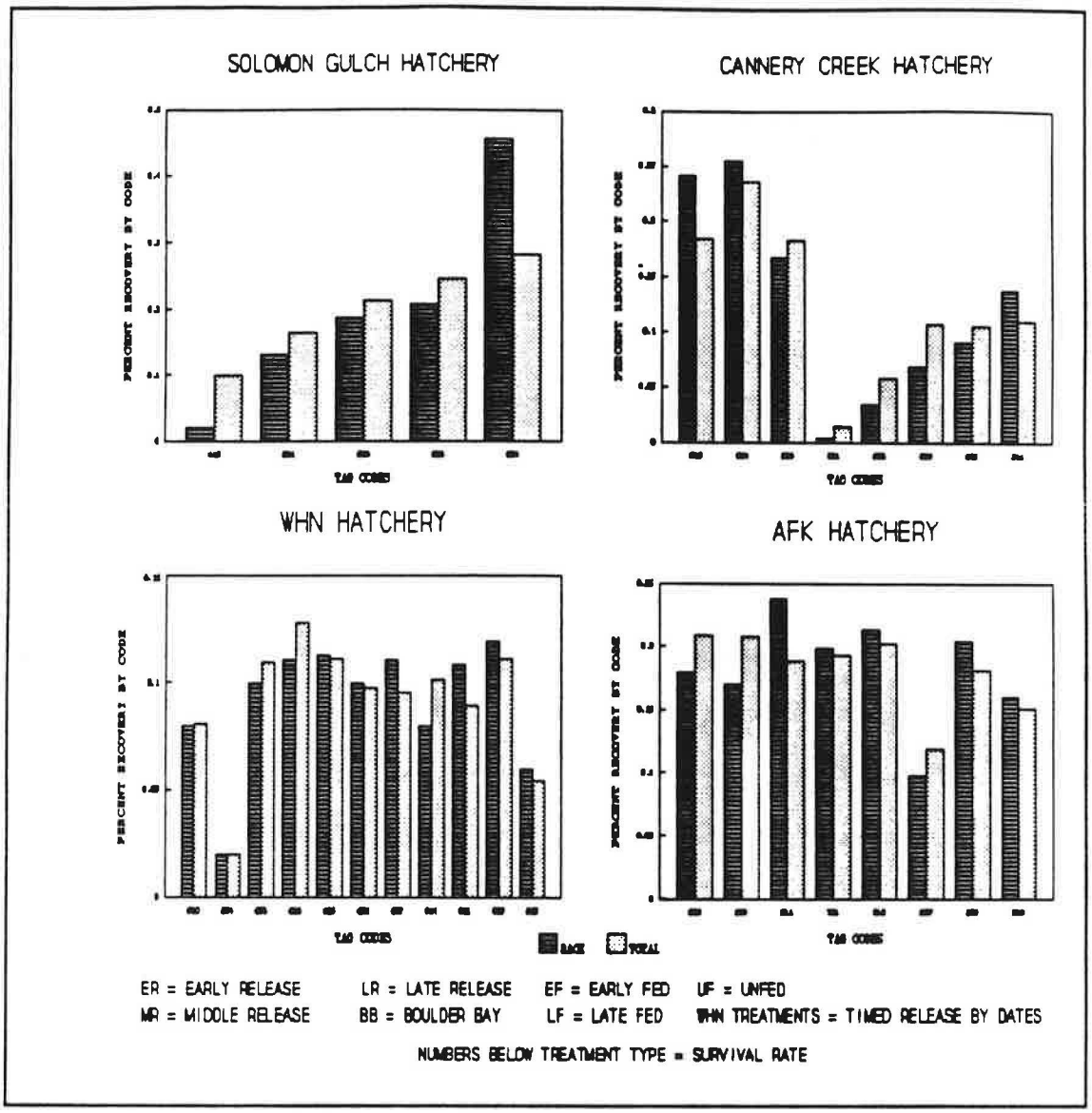


Figure 3. Percent tags recovered in broodstock and total catch, 1991.

Wildstock Streams

Carcasses were scanned for coded-wire tags at the six tagged wildstock streams: Loomis, Cathead, Herring, Totemoff, O'Brien, and Hayden, and at an additional 40 streams surveyed as part of NRDA F/S 1. Only carcasses with a visible adipose region were counted. Heads were removed from the adipose clipped carcasses, soaked in a brine solution, and put into plastic bags. Total number of carcasses and total number of adipose clipped fish were recorded on a daily basis for each stream surveyed. Heads and their corresponding data sheets were picked up on a regular basis and returned to Cordova for editing and shipping to the Juneau tag lab.

Catch and Contribution

The 1986-87 tagging study indicated catch allocations for each hatchery should be stratified by district, week, and processor (Peltz and Geiger 1988). Processors tend to obtain fish from specific sub-areas within each district. In 1988, most fishing effort was restricted to terminal areas (close to the hatcheries) to prevent harvest of wild stocks. With this fishing pattern, it was not found necessary to stratify by processor when calculating the Solomon Gulch Hatchery contribution, presumably because tenders for each processor were in close proximity (Geiger and Sharr 1989). In 1989, fishing effort was again restricted to terminal areas due to the presence of oil in portions of PWS, but processor differences, though small, were found significant, suggesting that contribution estimates should be stratified by processor even when the fishery is conducted in terminal areas. The 1990 hatchery contribution estimates were therefore stratified by district, week and processor. Stratification differences have not yet been analyzed for the 1991 data and hatchery contribution estimates remain stratified by district, week, and processor.

Catches were obtained from summaries of fish sales receipts (fish tickets) issued to fishermen. The total hatchery contribution (C) to each harvest type is the sum over all release groups of theestimated contributions for each release group over all week, district, and processor strata:

$$\hat{C} = \Sigma_t \Sigma_i X_{ti} \left(N_i / S_i p_t \right) ,$$

where

X_{ti}= number of group t tags recovered in ith strata,
N_i= number of fish caught in ith strata,
S_i= number of fish sampled in ith strata,
p_t= proportion of group t tagged.

A variance approximation which ignores covariance between release groups was calculated for sampled strata (Geiger 1988):

$$V(\hat{C}) = \Sigma_t \Sigma_i X_{ti} \left[\left(N_i / S_i p_t\right)^2 - \left(N_i / S_i p_t\right) \right].$$

The average tag recovery rate for all processors in a week and district was used to estimate hatchery contribution in catches delivered to processors not sampled that district and week. Variances associated with unsampled strata are not calculated.

RESULTS

Previous Findings

In 1986, 625,000 of 200.5 million pink salmon fry released (1 out of 320) from 3 of the 4 Prince William Sound pink salmon hatcheries were tagged with half-length coded-wire tags and marked with adipose fin clips (Peltz and Miller 1988). These tags were recovered in 1987 by scanning catches at four processors and scanning the hatchery brood stock. Analysis of the 2,274 tag recoveries suggested the 3 hatcheries contributed approximately 10.2 million pink salmon to the total PWS harvest of 26.1 million pink salmon (Peltz and Geiger 1988). Survival of tagged hatchery stocks was approximately 6.3%.

In 1987, roughly 178,000 of the 60 million pink salmon fry released from Solomon Gulch hatchery were tagged, an average of 337 fish per tag. They were recovered by sampling commercial catches and hatchery brood stock in 1988. Approximately 300,000 pink salmon out of the total PWS commercial pink salmon catch of 11.8 million were attributed to Solomon Gulch returns. The survival rate for the stock was estimated at 0.5%.

Approximately 893,000 of the 521 million pink salmon fry released from all hatcheries in 1988 were tagged, an average of 583 fish per tag. Approximately 8,000 PWS pink salmon heads were sent to Juneau where 4,821 legible tags were removed and decoded. Tag expansions adjusted by tag recovery rates from brood stock collections yielded a maximum estimate of 20.3 million hatchery fish in the total harvest of 21.8 million fish which indicated a wildstock failure. Based on this estimate, survival of pink salmon from all hatcheries combined was 4.1%.

In 1989, over 1 million of the 506.6 million pink salmon fry released from PWS hatcheries were tagged, an average of 480 fish per tag. Approximately 182 thousand of the 3.68 million coho salmon smolts released from Solomon Gulch, Esther, and Ft. Richardson hatcheries, and 100 thousand of the 2.6 million sockeye salmon smolts released from the Main Bay hatchery were tagged. Over 8,500 tags were recovered in the 1990 season. The maximum catch contribution estimate was 36.5 million hatchery pink salmon out of a total catch of 45 million (8.5 million wildstock fish). The average survival rate for hatchery pink salmon stocks was 7.2%.

1991 Tagging

Tagging of Hatchery Stocks

Total releases and number of tagged fish for each stock returning to the PWS fishery in 1991 are shown in Table 1. Tables 2 and 3 summarize tagging of hatchery and wild stocks in 1991. Efforts to maintain a constant tagging rate for hatchery produced pink salmon fry were successful with PWSAC hatcheries having a release to tagged ratio of approximately 600. Solomon Gulch was not as successful and had a lower tag ratio of 544.

Over 800,000 of the 535 million pink salmon released from PWS hatcheries were tagged, as were almost 473 thousand hatchery produced chum, coho, sockeye, and chinook salmon.

Tagging of Wild Stocks

Dates of operation and tagging results for the wild pink salmon fry and sockeye salmon smolt weirs are shown in Table 3. Timing and magnitude of pink salmon fry outmigrations for 1990 and 1991 are shown in Figures 4 and 5. Each pink salmon fry weir was at some time inoperable due to extremely high water or ice flows. Tide series outmigration sounts for times when the weirs were inoperable will be estimated using regression models of outmigrations on surrounding tide series. Over 319,000 wild pink salmon fry and approximately 60,000 wild sockeye salmon smolt were tagged.

1991 Tag Recovery

Twelve percent of the pink salmon common property catch was scanned for coded wire tags. Thirty percent of the cost recovery harvest, 7% of the special harvest and 93% of the pink salmon brood stock were scanned. Forty-two percent of the sockeye, chum, coho, and chinook catches were scanned. An average of 90% of the wildstock pink salmon carcasses at each surveyed stream was examined.Over 15,000 tags were recovered from almost 34,000 heads sent to the Juneau tag lab.

The preliminary unadjusted contribution estimate of the 6 tagged wildstock streams to the PWS pink salmon fishery is 47,077 fish. Survival rates ranged from .24% to 3.40% with an overall average of 2.2%. It appears that fry emigrating at the peak of outmigration timing had the highest survival rates (Table 4). This may be due to lessened effects of predation on larger groups of fry. Survival rates for the oiled streams (2.1%, 2.7%, 2.6%) were fairly consistent, while the survival rates for the unoiled streams

Table 1. Hatchery tagged stocks returning to Prince William Sound in 1991.

Salmon Species	Hatchery	Year of Releas	Valid Tags[a]	Total Release[a]	Tag Ratio
Pink	A.F. Koernig	1990	193	113,844	590
	W.H. Noerenberg	1990	395	235,379	596
	Cannery Cr.	1990	240	143,663	599
	Solomon Gulch	1990	205	122,242	596
Chum	Main Bay	1986	120	5,109	42
	Main Bay	1987	110	76,537	696
	Solomon Gulch	1987	36	3,437	95
	Solomon Gulch	1989	28	2,921	104
Coho	W.H. Noerenberg	1989	101	2,600	26
	W.H. Noerenberg	1990	70	2,460	35
	Solomon Gulch	1989	31	980	32
	Solomon Gulch	1990	34	787	23
	Ft. Richardson	1989	51	100	2
	Ft. Richardson	1990	29	143	5
Sockeye	Main Bay	1988	42	309	7
	Main Bay	1989	100	2,645	26
	Main Bay	1990	141	2,747	19

[a] Thousands of fish.

Table 2. Coded wire tagging results for hatchery stocks released in Prince William Sound, 1991.

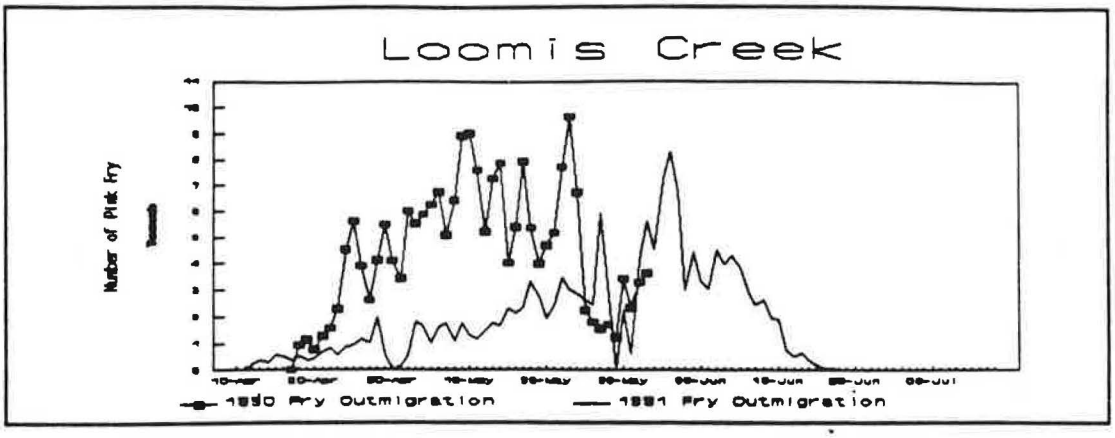
Salmon Species	Hatchery	Valid Tags[a]	Releases[a]	Tag Ratio	Tag Codes
Pink	A.F. Koernig	195	109,131	598	16
	W.H. Noerenberg	371	12,523	583	18
	Cannery Cr.	237	141,514	596	14
	Solomon Gulch	241	131,295	544	10
Chum	W.H. Noerenberg	178	77,949	459	4
	Solomon Gulch	20	1,736	87	2
Coho	W.H. Noerenberg	73	5,142	70	4
	Solomon Gulch	36	1,956	55	3
Sockeye	Main Bay	115	3,726	32	8
Chinook	W.H. Noerenberg	41	411	10	2

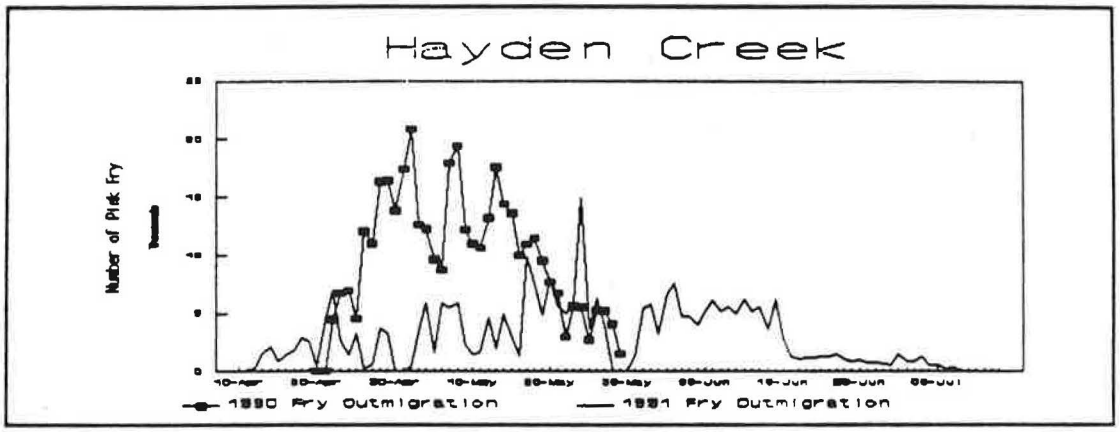
[a] Thousands of fish.

Table 3. Coded wire tagging results and dates of weir operation for wild stocks in Prince William Sound, 1991.

Salmon Species	Treatment	Stream	Date	Valid Tags[a]	Seaward Migration[a]	Tag Ratio
Pink	Control	Cathead Creek	4/18 - 5/25	40	158[b]	4
		O'Brien Creek	4/22 - 5/26	28	298[c]	10
		Totemoff Creek	4/17 - 5/24	43	734[d]	17
Pink	Oil	Hayden Creek	4/23 - 5/28	43	391[e]	9
		Herring Creek	4/13 - 6/3	43	399[d]	9
		Loomis Creek	4/18 - 6/1	45	211[e]	5
Sockeye		Eshamy River	4/4 - 6/25	21	683	33
		Jackpot Creek	4/14 - 6/1	5	20	4
		Coghill River	4/5 - 5/30	0	4	0

[a] Thousands of fish.
[b] Interpolated 5 days data.
[c] Interpolated 1 day data.
[d] Interpolated 3 days data.
[e] Interpolated 4 days data.





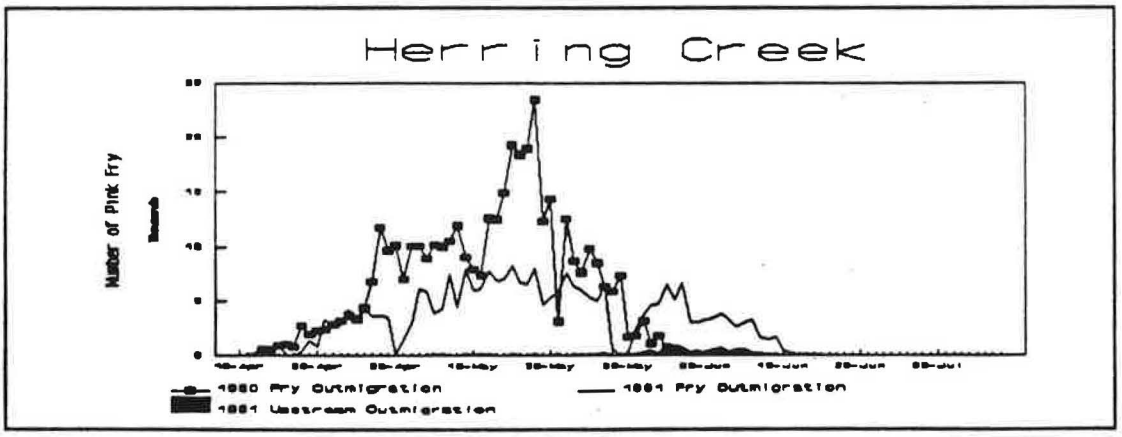
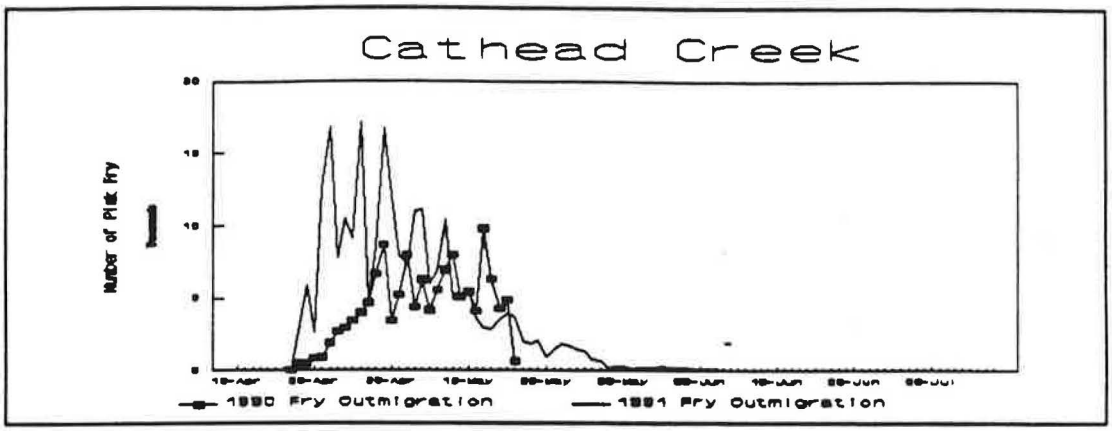
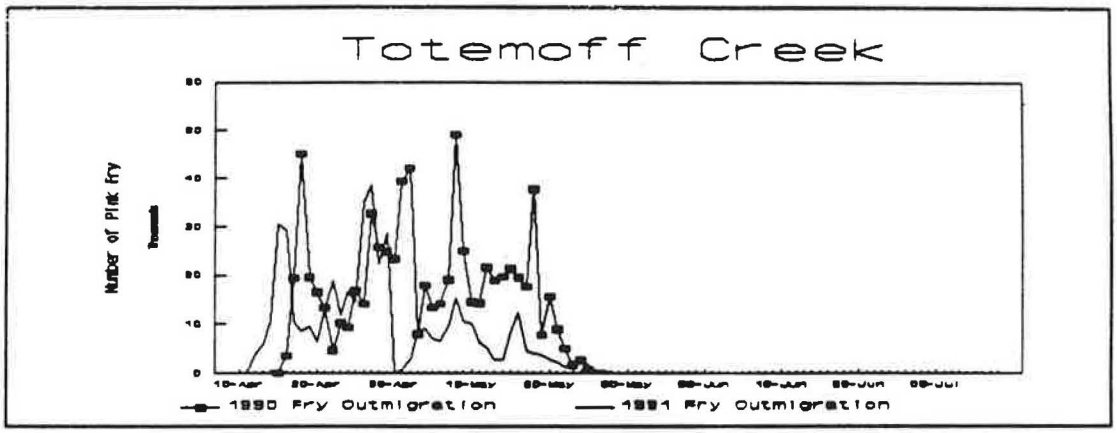


Figure 4. Timing and magnitude of pink salmon fry outmigrations from three oiled streams in Prince William Sound





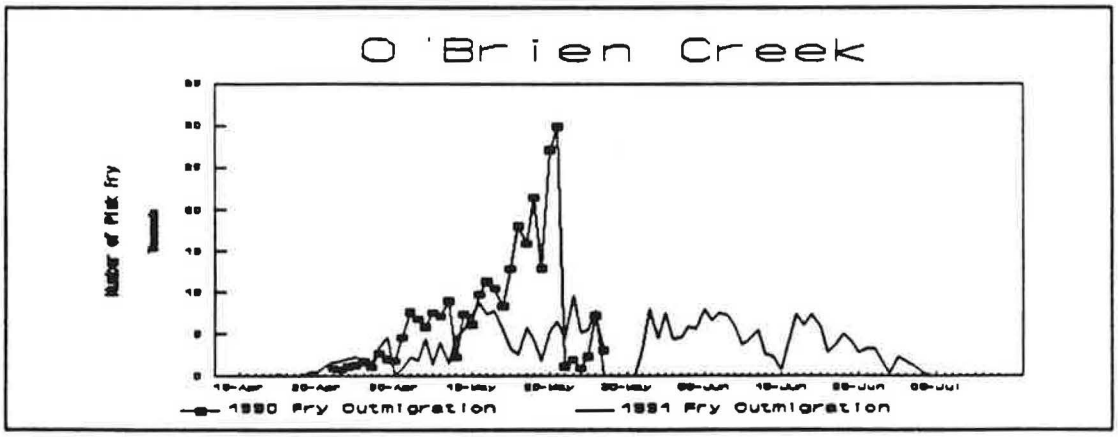


Figure 5. Timing and mignitude of 1990 and 1991 pink salmon fry outmigrations from three unoiled streams in Prince William Sound.

Table 4. Recovery results for tagged wildstock pink salmon, 1991.

	WILDSTOCK STREAM	TAG CODE	TOTAL RELEASED	TOTAL TAGGED	TAG EXPANSION	TOTAL TAGS RECOVERED	TOTAL CONTRIBUTION	SURVIVAL RATE(%)
OILED	HAYDEN	802	275,233	30,574	9.002	154	7,457	2.71
		803	89,804	12,584	7.136	24	467	0.52
	HERRING	715	84,184	27,747	5.622	22	663	0.79
		801	309,229	14,974	11.144	193	10,004	3.24
	LOOMIS	707	130,586	27,132	4.812	219	4,396	3.37
		708	72,729	17,571	4.139	42	869	1.19
UNOILED	O'BRIEN	712	207,366	22,831	9.082	69	3,688	1.78
		711	82,342	5,358	15.368	1	197	0.24
	TOTEMOFF	713	440,358	25,457	17.298	189	10,881	2.47
		714	274,101	17,535	15.631	37	3,409	1.24
	CATHEAD	709	125,326	30,047	4.170	180	4,266	3.40
		710	29,051	9,617	3.020	35	780	2.68

(1.34%, 2.0%,3.3%) varied. There was an apparent failure in the return of one O'Brien tagcode, 711, (one recovery) which influenced the overall O'Brien survival rate (Table 4). Some straying of hatchery and wildstock pinks is indicated by the 1991 tag recovery data (Table 5.). Tagged wildstock pink salmon were recovered in cost recovery and broodstock harvests as well as the common property fishery, and hatchery pinks were recovered in many of the wildstock streams. This suggests possible genetic mixing between and among the wild and hatchery pink salmon.

The preliminary estimate of maximum hatchery contribution to the 1991 catch of 37,037,118 pink salmon is 30,358,793 (6.7 million wild) with Solomon Gulch contributing 18%, W H Noerenburg 38%, A F Koernig 16%, and Cannery Creek 28% (Table 6). Figures 6 and 7 show contribution results stratified by district and week. Total hatchery contribution to each harvest type ranges from 80% (Common Property) to 92% (Broodstock) (Table 7). Pink salmon survival for all hatcheries combined is 5.2% (Figure 8). A. F. Koernig hatchery, located in a heavily oiled area, had the lowest survival rate (4.56%) of the 3 PWSAC hatcheries. Summary results for hatchery releases from 1987 through 1991 are listed in Table 8.

Tag expansion factors for 1990 releases from each hatchery were multiplied by adjustments between 1.38 and 1.92, based on tag recovery rates in cost recovery and brood stock samples. Tagging related mortality and tag loss may lower the incidence of tagged fish in hatchery returns and necessitate increasing tag expansion factors calculated for fry releases. Among adult returns, 100% of the fish in a hatchery broodstock are assumed to have originated from the releases at the hatchery. If no tag loss or tagging related mortality occur, the fraction of tagged fish in the broodstock should closely approximate the fraction observed in fry releases. Observed decreases in the fraction tagged are assumed to be related to tag loss or taggging related mortalities and a tag expansion factor calculated from tagging and release data are adjusted according to the tag rates observed in the broodstock. Tag rates in the broodstock were used to adjust tag expansions for AFK and WHN hatcheries in 1991, but not for Solomon Gulch and Cannery Creek hatcheries. At the latter 2 hatcheries, tag rates were much lower than those observed in fry releases, but were also much lower than those observed in hatchery cost recovery harvest. The low occurrence of tagged fish in these broodstocks relative to rates observed in the cost recvery harvests is puzzling. The problem could be related to sampling error (missed clips during scanning), but this seems unlikely since scanning procedures are uniform for all hatcheries. Low rates of tag occurrence may also be due to wildstock dilution of broodstock. Wild fish in the broodstock may originate from natural spawning regularly observed in streams adjacent to Solomon Gulch and Cannery Creek hatcheries. These streams also provide the hatcheries with water and provide olfactory cues to both hatchery and wild fish returning to these

Table 5. Tags recovered in wildstock streams by hatchery or stream of origin.

	TAG ORIGIN										
RECOVERY	WILDSTOCK STREAM						HATCHERY				TOTAL
STREAM	LOOMIS	TOTEMOFF	O'BRIAN	HAYDEN	HERRING	CATHEAD	AFK	CCH	WHN	SGH	TAGS
LOOMIS	150	2	0	0	14	0	1	1	18	0	186
TOTEMOFF	3	108	0	0	4	8	1	1	6	0	131
O'BRIEN	0	1	26	3	1	3	10	0	5	1	50
HAYDEN	0	0	0	84	1	1	5	1	2	0	94
HERRING	2	0	0	1	54	1	1	0	3	0	62
CATHEAD	0	0	0	0	0	36	1	0	1	0	38
16949	0	0	0	0	2	3	0	0	1	0	6
500	0	0	0	0	1	0	0	0	0	0	1
507	0	1	0	0	0	0	0	0	0	0	1
508	2	3	0	0	20	2	3	0	2	0	32
510	1	4	0	0	1	2	0	2	4	0	14
511	0	1	0	0	3	2	0	1	1	0	8
515	0	0	0	0	1	0	0	0	2	0	3
516	2	1	1	0	2	0	0	0	5	0	11
601	0	1	0	0	2	1	1	0	4	0	9
602	0	1	0	0	1	1	0	1	1	0	5
604	1	11	0	0	1	5	0	0	2	0	20
612	0	1	0	0	0	0	0	0	0	0	1
618	1	0	0	1	3	0	1	0	1	0	7
623	0	3	1	0	0	3	1	1	2	0	11
628	0	0	0	0	1	1	1	2	2	0	7
636	1	0	0	0	0	0	0	0	0	0	1
665	0	0	0	1	3	0	3	0	1	0	8
670	0	0	0	1	0	1	1	0	0	0	3
673	0	0	1	2	0	0	1	1	0	0	5
678	0	0	0	0	0	0	1	0	0	0	1
695	0	0	0	1	2	2	0	1	0	0	6
697	0	0	0	0	0	1	0	0	1	0	2
76	0	0	0	0	0	0	1	0	0	2	3
80	0	1	0	0	0	0	0	1	0	0	2
93	0	0	0	0	0	0	0	0	0	3	3
94	0	1	0	0	0	0	0	0	0	0	1
TOTAL TAGS	163	140	29	94	117	73	33	13	64	6	732

Table 6. Summary of hatchery contributions to the PWS Fishery using tag expansions at release and adjustment factors calculated from the broodstock or cost recovery.

	Contribution	
	Unadjusted	Adjusted
SOLOMON GULCH HATCHERY		
Common Property	2,074,973	2,544,914
Cost Recovery	2,075,455	2,872,737
Special [1]	0	0
Broodstock	146,239	218,852
Total Return	4,296,667	5,636,503
Total Release	122,242,297	
Marine Survival	3.51	4.61
CANNERY CREEK HATCHERY		
Common Property	3,964,731	6,978,131
Cost Recovery	392,141	682,124
Special [1]	430,854	760,306
Broodstock	155,690	299,275
Total Return	4,943,416	8,719,836
Total Release	143,662,511	
Marine Survival	3.44	6.07
W.H. NOERENBERG HATCHERY		
Common Property	5,313,197	8,084,192
Cost Recovery	710,399	1,044,032
Special [1]	1,651,081	2,444,692
Broodstock	294,715	453,103
Total Return	7,969,392	12,056,019
Total Release	235,378,496	
Marine Survival	3.39	5.11
ARMIN F. KOERNIG HATCHERY		
Common Property	2,922,811	4,011,573
Cost Recovery	478,981	645,966
Special [1]	213,865	290,126
Broodstock	181,358	244,589
Total Return	3,797,015	5,192,254
Total Release	113,843,914	
Marine Survival	3.34	4.56

[1] Special includes the pink salmon that were discarded and donated.

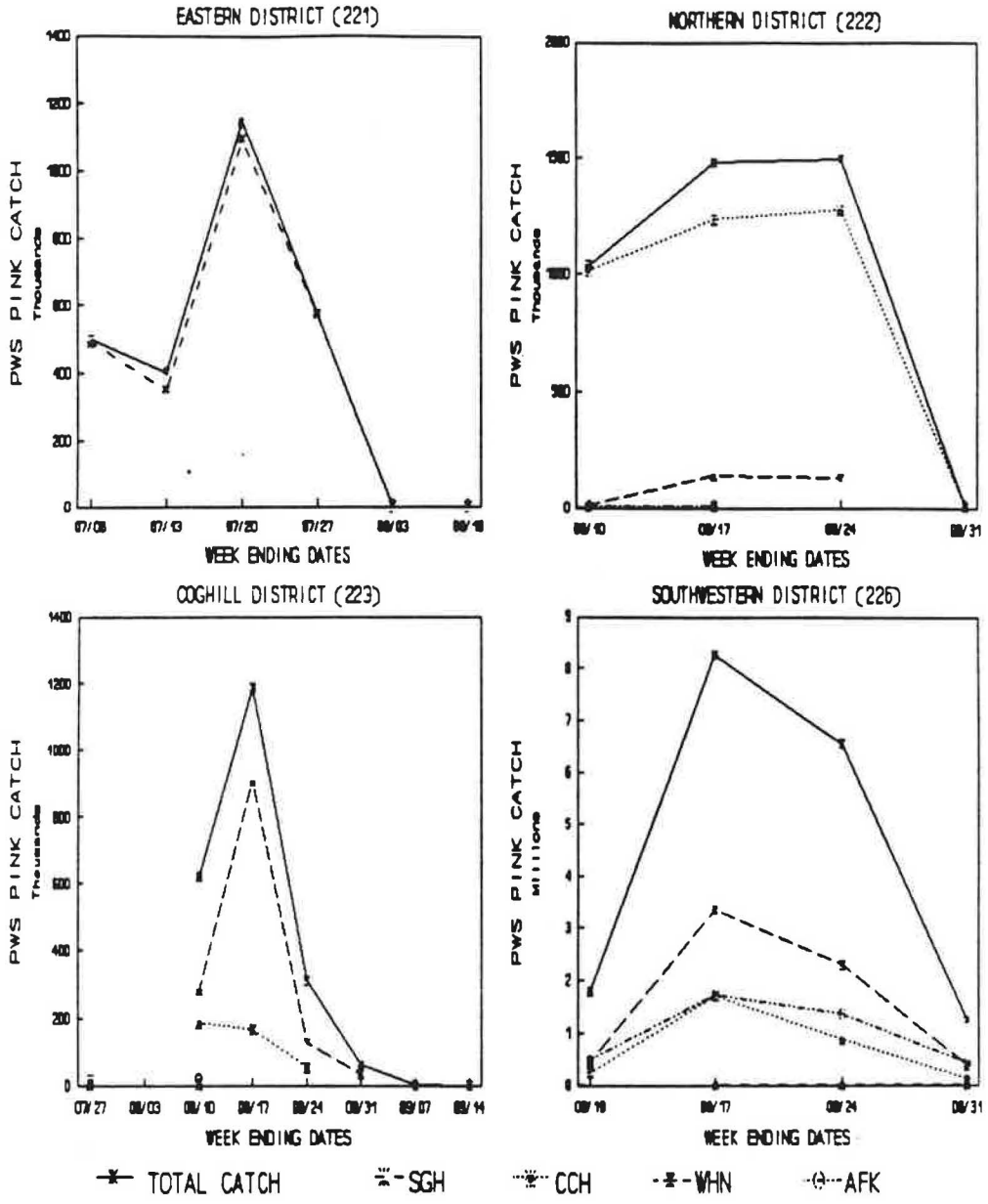


Figure 6. Hatchery contribution to the 1991 PWS pink salmon commercial fishery by district.

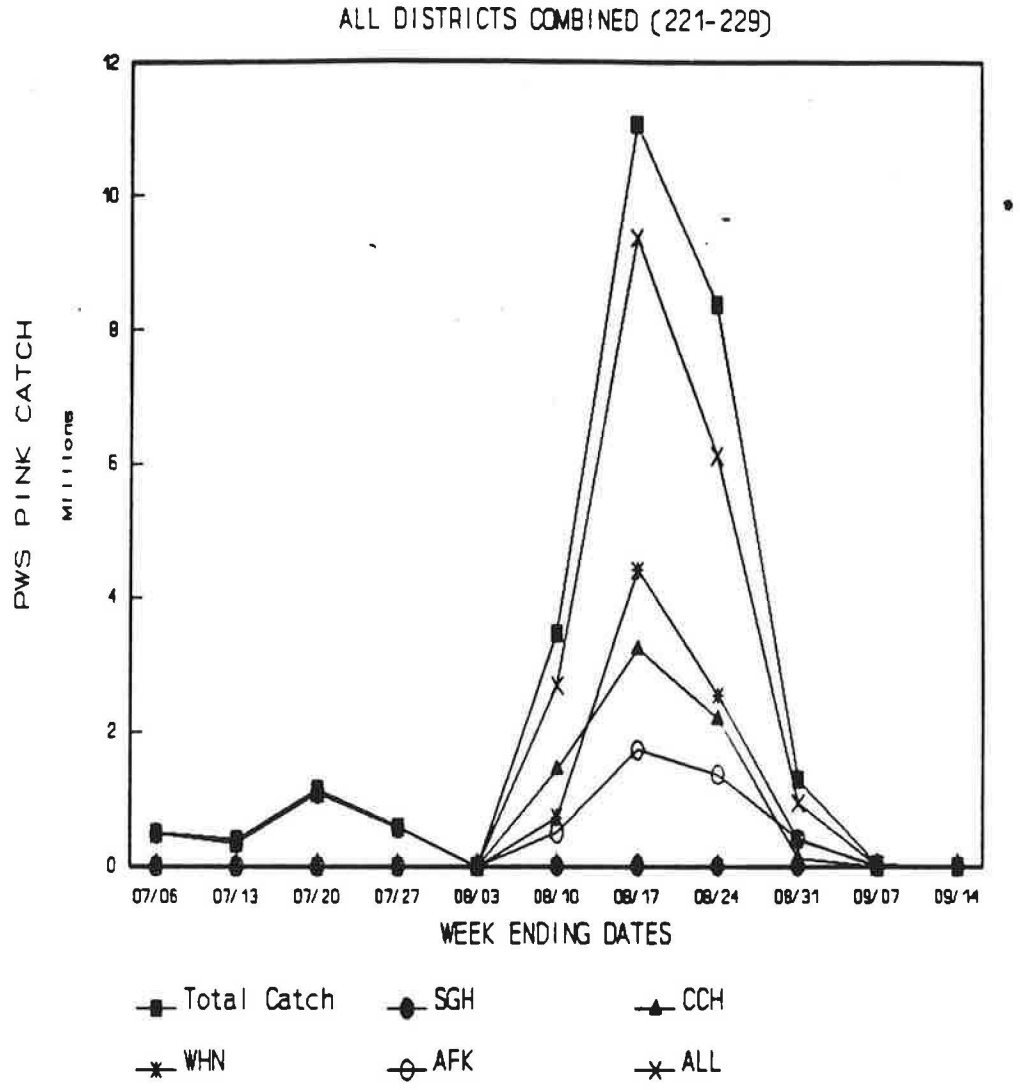


Figure 7. Total hatchery contribution to the 1991 PWS pink salmon commercial fishery for all districts combined.

Table 7. Total hatchery contribution (adjusted and unadjusted) to the Prince William Sound pink salmon fishery by harvest type.

HARVEST TYPE	TOTAL CATCH	CONTRIBUTION (UNADJUSTED)	PERCENT CONTRIBUTION	CONTRIBUTION (ADJUSTED)	PERCENT CONTRIBUTION
COMMON PROPERTY	26,894,679	14,275,712	53.08	21,618,810	80.38
COST RECOVERY	6,094,282	3,656,976	60.01	5,244,859	86.06
*SPECIAL	4,048,157	2,295,800	56.71	3,495,124	86.34
BROODSTOCK	1,317,708	778,002	59.04	1,215,819	92.27
TOTAL	38,354,826	21,006,490	54.77	31,574,612	82.32

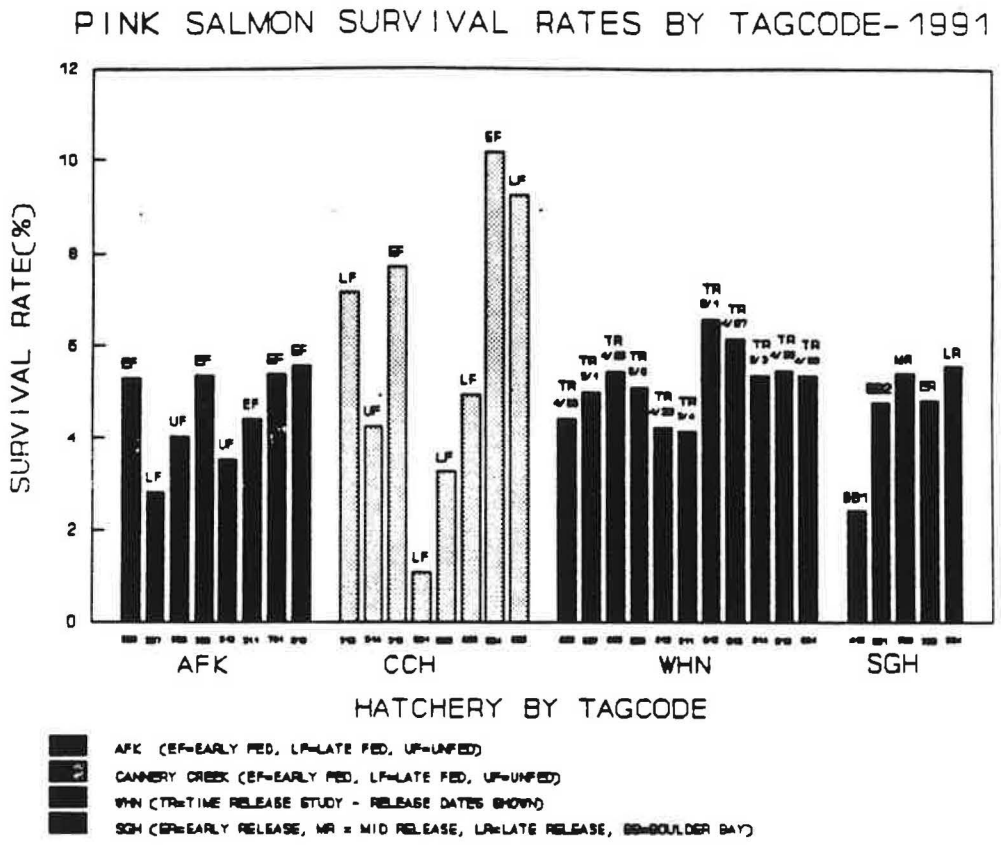


Figure 8. Pink salmon survival rates by hatchery, tagcode, and treatment.

Table 8. Summary of results of coded wire tag studies on pink salmon in Prince William Sound, 1987-1991. Results of 1991 tag recoveries are preliminary.

Hatchery	Year	Releases[a]	Returns[a]	Survival Rate	Adjustment Factor[b]
A. F. Koernig	87	112,528	7,614	6.8	.96
	88				
	89	110,037	2,736	2.5	1.31
	90	160,487	7,159	4.5	1.56
	91	109,131	5,192	4.6	1.38
W. Noerenberg	87	34,437	3,032	8.8	1.18
	88				
	89	195,608	7,092	3.6	1.90
	90	159,714	14,833	9.3	1.26
	91	12,523	12,026	5.1	1.55
Cannery Cr.	87	56,200	2,123	3.8	2.22
	88				
	89	95,571	7,099	7.4	1.87
	90	58,970	3,245	5.5	1.87
	91	141,514	8,720	6.1	1.92
Solomon Gulch	87				
	88	130,827	300	.5	2.35
	89	60,000	3,405	2.6	1.15
	90	128,500	11,278	8.8	1.19
	91	131,295	5,636	4.6	1.50

[a] Thousands of fish.
[b] Adjusted for lost tags.

sites. In any case, tag rates in cost recovery harvest for these two hatcheries were much more consistent with rates observed at the time of fry release and were used to adjust the expansion factors. Given the high probability of at least some occurrence of wild fish in the cost recovery harvests as well, these expansion factor adjustments were probably too large.

STATUS OF INJURY ASSESSMENT

The major objective of this tagging study is to estimate differential survival of fish exposed to oil contaminated waters. Estimates of catch contributions and production from this study in conjunction with escapement (NRDA F/S 1), egg and fry survival (NRDA F/S 2), and early marine survival (NRDA F/S 4) will provide information on the extent of effects on each Pacific salmon life stage. The time frame depends on the life span of each species. Although still preliminary, we now have survival estimates for 1989, 1990, and 1991 hatchery produced pink salmon, as well as 1990 tagged wildstock pink salmon. We also have an extensive escapement database which will be modeled to determine whether differential production occurred between oiled and unoiled streams. (NRDA F/S 28)

Progress on each objective is as follows:

1. Catch and survival rates of pink salmon released from four PWS hatcheries in 1988 were estimated from 1989 recoveries. The overall survival rate for pink salmon was 4.1%. Almost 1.4 million tagged pink, chum, sockeye, and coho salmon were released from five hatcheries in 1989. Over 8,500 of the pink salmon tagged in 1989 were recovered in 1990 providing an overall hatchery survival estimate of 7.2%. Marine survival of the other 4 species will be calculated as they return. Chum and sockeye salmon began returning in significant numbers in 1991, and recovery efforts will need to continue through 1993 to encompass the majority of adult returns from the 1989 release. Approximately 1.6 million tagged pink, chum, sockeye, and coho salmon were released from 5 hatcheries in 1990 along with over 265,000 wild sockeye and pink salmon. In 1991, 8253 pink salmon tags were recovered providing an overall hatchery survival rate of estimate of 5.13%. Chinook salmon tagged in 1990 will begin returning in 1993 and continue through 1995. Sockeye, chum, and coho salmon from the 1990 release will continue to return through 1994. In 1991, approximately 473,000 tagged pink, chum, sockeye, and coho salmon were released from the 5 hatcheries.

2. Six streams (3 oiled and 3 unoiled) were selected for pink salmon fry tagging and estimation of seaward migrants in 1990 using information gathered in NRDA F/S 1 and 2. Over 240,000

wild pink salmon were tagged at the 6 streams. These fish were recovered in the 1991 harvests and escapement surveys (NRDA F/S 1), providing survival rates and production estimates. The preliminary contribution estimate is 47,077 and the average survival rate was 2.2%. In 1991, 319,400 wild pink salmon were tagged at these same six streams.

3. Over 90,000 sockeye salmon smolts were tagged at Eshamy and Coghill Rivers in 1989. These fish will began returning in 1991. In 1990, 25 thousand tags were applied to sockeye salmon smolts in the Jackpot and Eshamy Rivers. Fish from the Coghill River were not tagged due to low smolt abundance. The sockeye salmon tagged in 1990 will begin returning in 1993. In 1991, approximately 60,000 tags were applied to sockeye salmon in the Eshamy, Jackpot, and Coghill Rivers. Weirs operated by ADF&G Commercial Fisheries and OSIAR Divisions are in place to monitor the escapements.

4. Almost 1.4, 1.6 million and 1.3 million Pacific salmon were tagged and released in 1989, 1990, and 1991 providing fish of known origin for NRDA F/S 4 (early marine life history) and this study.

5. The analysis of spatial trends in the recent and historic catch and escapement data suggest that alternative strategies for managing the commercial fleet may be the first and most effective step in restoring full production to PWS in the wake of the Exxon Valdez oil spill. A comprehensive escapement enumeration and stock identification projects, which are designed to improve the accuracy of current management strategies, have been proposed.

LITERATURE CITED

Geiger, H.J. 1988. Parametric bootstrap confidence intervals for estimates of fisheries contribution in salmon marking studies. Proceedings of the international symposium and educational workshop on fish-marking techniques. University of Washington Press, Seattle. In press.

Geiger, H.J., and S. Sharr. 1989. A tag study of pink salmon from the Solomon Gulch Hatchery in the Prince William Sound fishery, 1988. Alaska Department of Fish and Game, Division of Commercial Fisheries. In press.

Peltz, L., and H.J. Geiger. 1988. A study of the effect of hatcheries on the 1987 pink salmon fishery in Prince William Sound, Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries. In press.

Peltz, L., and J. Miller. 1988. Performance of half-length coded-wire tags in a pink salmon hatchery marking program. Proceedings of the international symposium and educational workshop on fish-marking techniques. University of Washington Press, Seattle. In press.