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Study Title: Salmon Coded-Wire Tagging in PWS

Study Number: 8

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Lead Agency: Alaska Department of Fish and Game

Cooperating Agencies: PWS Aquaculture Corporation
Valdez Fisheries Development Association

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	DATE
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INTRODUCTION

Salmon stocks in oil impacted areas of Prince William Sound (PWS) were exposed to crude oil from the Exxon Valdez spill. Some stocks may have been damaged by this exposure. Salmon populations throughout the Sound are harvested in a mixed stock fishery that is dominated by hatchery fish and wild stocks from unaffected areas. Recognizing that the commercial harvest is the leading cause of mortality to salmon stocks, successful restoration of injured salmon resources depends upon stock specific management of the commercial fishery to be able to reduce exploitation of oil impacted stocks. To implement and evaluate stock specific restoration efforts requires the ability to determine the exploitation rates of individual stocks of fish within the mixed stock fishery. Through the application of coded-wire tags in 1991, this study will contribute the technical support needed to provide estimates of survival and production (catch and escapement) for hatchery and wild stocks in oiled and unoled areas. This can be accomplished by quantifying fry outmigration, the adult component of the catch, and the escapement to natal streams and hatcheries.

Wild stock returns of pink salmon in PWS have ranged from 10 to 15 million fish in recent years. Chum salmon returns have ranged from 800 thousand to 1,500,000. Additionally, returns of pink salmon to four PWS hatcheries now average more than 20 million fish and hatchery chum salmon returns in excess of 1.4 million fish are expected.

Catch and escapement data for wild pink salmon in PWS have been collected since 1961. In 1985, hatchery production became a significant part of the total salmon return. Consequently, pink salmon fry tagging was initiated at three area hatcheries in 1986 to estimate the survival of those stocks and their contribution to the 1987 catch. Similar estimates were made for a fourth facility based on tagging in 1987 and recoveries in 1988. Natural Resources Damage Assessment (NRDA) Fish/Shellfish Study 3 estimated catch and survival rates of pink salmon released from these four PWS hatcheries based on tags applied in 1988 and 1989 and recoveries of tags in the commercial fishery, cost recovery harvest and hatchery spawners in 1989 and 1990. Tags were also applied to chum, sockeye, coho, and chinook salmon releases from PWS area hatcheries and to smolts from two wild stocks of sockeye salmon in 1989. A similar multi-species tagging program was conducted again in 1990; however, tags were also applied to smolts from one additional wild stock of sockeye salmon and fry from six wild stocks of pink salmon including three from oiled areas and three from unoled areas. Tagging in 1991 will include all the same hatchery and wild stocks.

OBJECTIVES

1. Mark hatchery salmon of known origin and oil exposure history for recovery as adults to estimate catch and survival rates.

2. Mark wild pink salmon from three streams with contaminated estuaries and three streams with uncontaminated estuaries to estimate survival using outmigration, catch and escapement (using stream weirs).
3. Mark salmon of known origin and oil exposure history for recovery by researchers studying early marine migration, growth, and survival (F/S Study 4).
4. Mark wild sockeye salmon from two watersheds with contaminated estuaries and one watershed with an uncontaminated estuary to estimate survival using outmigration, catch and escapement (using stream weirs).
5. Continue to identify relevant injuries for which methods of restoring lost use, populations, and habitat must be developed.

METHODS

A subsample of fry or smolt from all hatcheries releasing salmon into PWS will be tagged with a coded wire tag (Figure 1; Appendix A). Wild stock pink fry and sockeye smolt from both oiled and non-oiled areas of the Sound will also be tagged (Figure 1; Appendix B). Tags will be applied at rates which will insure that, given a realistic recovery effort, sufficient numbers can be recovered in the commercial fishery, hatchery cost recovery harvests, and hatchery brood stock collections (Appendices) to allow researchers to estimate the contribution of each tag release group by district, week, and processor stratum. Release groups represent differences in release timing or treatment (i.e. fed vs. unfed fry).

Tag application will be similar among all hatcheries and among all wild stock systems. Fry or smolt will be randomly selected as they emerge from incubators or raceways in hatcheries or outmigrate from streams. Selected fry will be anesthetized in a 1 ppm solution of MS-222, adipose fin clipped, and tagged. A random sample of 20 fish per clipper will be graded for fin clip quality each day. The proportion of bad clips in the sample will be used to discount the daily release of tagged fish. Clipped fish will be tagged and passed through a quality control device to test for tag retention. Fish repeatedly rejected will be killed to minimize the number of untagged but clipped fish in the release. Fish that retain tags will be held for 24 hours to determine short term mortality. A sample of tagged fish from each tagger will be taken each day and graded for tag placement according to criteria developed by Peltz and Miller (1988). Prior to release, a 200 fish sample from a day's tagging effort will be randomly sampled to estimate overnight tag retention. The proportion of lost tags in the sample will be used to estimate tag retention in the daily release. A written description of the tagging will be developed which will include a detailed description of each tag lot, the

number of fish tagged, the total number of fish in the release lot, the average size of the fish at release, a profile of the exposure history of the release lot to the oil spill, and all information required by the ADF&G Coded-Wire Tag Laboratory which coordinates tagging in Alaska.

Release and tagging procedures are similar for pink and chum salmon. Both species are tagged with half length tags. At the Prince William Sound Aquaculture Corporation (PWSAC) hatcheries, tagged fry are released directly into large saltwater rearing pens with untagged fish of the same release group. At the Valdez Fisheries Development Association (VFDA) Solomon Gulch Hatchery tagged fry are placed in small enclosures within larger saltwater rearing pens for at least three days to allow them to recover from tagging before being mixed with unmarked fry from the same release group. At PWSAC hatcheries, unmarked fry entering large pens are counted with Northwest Marine Technology counters. At VFDA, unmarked fry in each pen are estimated from counts of eggs in incubators minus egg mortalities. At all facilities, mortalities in the large pens are estimated visually prior to release. Mortality rates based on visual estimates will be applied equally to tagged and untagged fish. The total numbers of fish in group t with valid tags at the time of release (R_t) are estimated as

$$R_t = (T_t - M_t) - (T_t - M_t)L_t,$$

where T_t = total number of fish tagged from group t ,
 M_t = overnight mortality among fish tagged from treatment group t ,
 L_t = overnight tag loss among fish tagged in treatment group t .

The VFDA estimate includes a term for short term mortality of tagged fish from treatment group t during saltwater rearing (S_t). The number of tagged fish released becomes

$$R_t = (T_t - M_t - S_t) - (T_t - M_t - S_t)L_t.$$

Hatcheries release fry when plankton monitoring indices indicate peak zooplankton abundance.

Four hatcheries released 615 million pink fry in 1990. Each of 32 release groups were tagged at a rate of approximately one tag per 580 fish released (1 in 500). The tag rate was held constant across release groups to prevent confusion of differential tag mortality with variation in survival between release groups (Peltz and Geiger, 1988; Geiger and Sharr, 1989). Release sizes and tagging rates will be approximately the same in 1991 but the number of release groups will increase (Appendix A).

In 1989, chum salmon were tagged at the rate of approximately one tag per 60 fish released at the Solomon Gulch Hatchery near Valdez. Tagging of Solomon Gulch chum salmon releases continued at the same level of effort at Solomon Gulch in 1990 and the WHN hatchery release of 20.6 million chum salmon fry was also tagged at a rate of approximately one tag per 480 fish released. The 1.6 million chum fry scheduled for release at Solomon Gulch in 1991 will be in two treatment groups each to be tagged at a rate of approximately 1 in 80. The scheduled 78 million chum fry release from WHN Hatchery will in four treatment groups, each tagged at a rate of approximately 1 in 500 (Appendix A).

Wild pink salmon were tagged from six stocks examined in F/S Study 2 in 1990; three from oil contaminated streams and three from streams which were not contaminated. Winged fyke nets are used to capture fry as they outmigrate after emergence. Where conditions allow, two fyke nets will be operated so that fry from upstream spawning areas will be captured and tagged separately from those spawned in intertidal zones. Trapped fry were manually enumerated in 1990. Manual enumeration will continue in 1991 but electronic fry counters will also be tested. A portion of the daily outmigration are anesthetized and tagged with half length tags. The anesthesia and associated trauma require that the tagged fish be held separate from their untagged cohorts, until they appear to have fully recovered from the effects of tagging. The extent to which the survival and behavior of the tagged fish can be extrapolated to other groups of salmon will be assessed at the time of recovery. Approximately 40,000 fry were tagged for each stock at tagging rates ranging from 1 in 4 to 1 in 17 fish released. Tagging will continue for these same stocks and at similar levels in 1991.

Because they have similar freshwater rearing requirements, tagging procedures for hatchery stocks of sockeye, coho and chinook salmon smolt are similar. Full length tags are used for all three species. At each hatchery, a sample of smolt are captured from rearing appliances with nets in approximate proportion to the number of fish in the appliance. They are anesthetized, their adipose fin excised, and then tagged. A sample of fish from each day's tag production is retained to estimate short-term tag loss and tag induced mortality. Following tagging, the tagged fish are returned to mix with untagged cohorts. All mortalities during the first week after tagging will be examined and the tag status noted.

Smolt in the 2.6 million fish release of sockeye salmon from the Main Bay Hatchery were tagged at a rate of 1 in 21 in 1990. The projected 2.6 million sockeye salmon smolt release from Main Bay in 1991 will be divided into 8 treatment groups which will each be tagged at a rate of approximately 1 in 22 (Appendix A). The majority of 2.3 million coho smolt scheduled for release from the WHN Hatchery in 1991 will be two groups to be released at the hatchery site. The remainder of the smolt will be apportioned between two groups destined for remote release sites. The two large releases at the hatchery site will be tagged with separate

tag lots at a rate of approximately 1 in 40. The remote releases will be tagged separately at much higher rates. The scheduled 1991 release of 1.6 million coho smolt from Solomon Gulch Hatchery will occur in two groups which will be tagged with separate codes at a rate of approximately 1 in 80. The majority of the small release of chinook salmon smolt from WHN Hatchery will be tagged at a rate of 1 in 20 and released at the hatchery site. A small remote release at Cordova will be tagged at more than double that rate.

Wild stocks of sockeye salmon are tagged during the volitional smolt outmigration. Smolt are captured in traps as they migrate to saltwater, anesthetized, and tagged. Full length tags are used for two of the wild stocks but half length tags are used for the small smolt from Coghill Lake. The anesthesia and associated trauma require that the tagged fish be held separate from their untagged cohorts until they appeared to have fully recovered from the effects of tagging. As in the wild pink salmon tagging, the extent to which the survival and behavior of the tagged fish can be extrapolated to other groups of salmon will be assessed at the time of recovery. Wild sockeye salmon smolt were tagged at Eshamy and Coghill Lakes in 1989 and at Eshamy and Jackpot Lakes in 1990. Tagging of sockeye salmon will continue all three streams in 1991. Approximately 30,000 smolt are scheduled to be tagged from each of the three stocks but the actual number tagged and the tagging rates will be dependent upon the size and rate of outmigration.

DATA ANALYSIS

Data analysis will take place over many years as tagged salmon continue to return as adults. Salmon fry tagged in 1991 will return as adults as soon as 1992. The analysis of 1989 through 1991's tag return data is funded as part of the 1991 NRDA study plan.

Tag recoveries are expected from releases at all four pink salmon hatcheries in 1990. Recoveries are expected this year for chum salmon released from Main Bay Hatchery in 1986, Main Bay and Solomon Gulch Hatcheries in 1987, and Solomon Gulch in 1989. Tagged sockeye salmon will be recovered from the 1988 and 1989 Main Bay facility releases, and the Eshamy wild stock tagged in 1989. Tagged coho salmon will be recovered from 1990 releases at Wallace H. Noeremberg (WHN) and Solomon Gulch Hatcheries.

The recovery samples are from a stratified sample (Cochran 1977), by district and discrete time segments. The recovery will be further stratified by processor as described in Peltz and Geiger (1988). For each time and area specific stratum, 15% of the pink salmon catch and a minimum of 20% of other salmon species catches will be scanned for fish with a missing adipose fin. Catch sampling will be done in four fish processing facilities in Cordova, one facility in Seward, and three facilities in Valdez. When feasible, sampling will occur at facilities in Kodiak, Kenai, Anchorage, and Whittier and on large floating processors. All

deliveries by fish tenders to these facilities will be monitored by radio and by daily contact with processing plant dispatchers to ensure that the catch deliveries being sampled are district specific.

Although the recovery of tags is not currently funded through the restoration program, the following information on tag recovery methods is provided for informational purposes. In addition to catch sampling at the processing facilities, approximately 15% of the fish in the hatchery terminal harvest areas will be scanned for fish missing adipose fins. There will be a brood stock tag recovery effort at each of the three hatchery facilities where tags were initially applied. A minimum of 50% of the daily brood stock requirements of each facility will be scanned for fish with missing adipose fins.

Tags from wild stocks of sockeye salmon and pink salmon will be recovered coincidentally with recoveries of hatchery stocks in the commercial catch, terminal harvest, and brood stock sampling programs. Tags will also be recovered in the escapements of each tagged wild stock. At each of these streams crews will enumerate the daily escapement through a weir. At sockeye salmon weirs, a portion of the escapement passed through the weir each day will be scanned for missing adipose fins. At pink salmon weirs, daily foot surveys of each stream will be conducted to enumerate fresh carcasses and scan them for missing adipose fins. Carcasses enumerated each day will be marked to prevent duplicate counting on subsequent days and heads will be collected from all carcasses with adipose fin clips.

In the catch, terminal harvest, brood stock, and natural system surveys, the total number of fish scanned and the total number of fish with missing adipose fin will be recorded. The heads will be removed from fish with missing adipose fins. Each head will be tagged with uniquely numbered strap tags. Recovered heads will be assembled and pre-processed in the Cordova area office. Heads will then be sent to the FRED Division Coded-Wire Tag Laboratory in Juneau for decoding and data posting.

A statewide coded-wire tag lab is located in Juneau and operated by FRED Division of ADF&G. Coded-wire tag sampling forms will be checked for accuracy and completeness. Sampling and biological data will first be entered onto the laboratory's data base. Next, the heads will be processed. This involves removing and decoding the tags, and entering the tag code and the code assigned in the recovery survey into the database. Samples will be processed within five working days of receipt.

The first step in the coded-wire tag analysis will be to estimate the harvest of salmon from each tag lot, in units of adult salmon. Adult salmon from these tagged lots will be recovered in the common property fishery, the hatchery cost recovery fishery, and the adult brood stock. For the hatchery stock, a modification of the methods described in an ADF&G technical report by Clark and Bernard (1987)

will be used. The specific methods, estimators, and confidence interval estimators are described in ADF&G technical reports on two previous studies of pink salmon in PWS: Peltz and Geiger (1988), and Geiger and Sharr (1989). Additional references on methods of tagging pink salmon in PWS can be found in Peltz and Miller (1988). In the case of the wild stocks, the methods and estimators and necessary assumptions are described by Geiger (1988).

The contribution of a particular tag lot, to a particular fishery stratum, is estimated multiplying by the number of tags recovered in the structured recovery survey, by both the inverse of the proportion of the catch sampled (the inverse sampling rate), and by the inverse of the proportion of the tag lot that was actually tagged (the inverse tag rate). The escapement (brood stock) of each tag lot is estimated using methods unique to the particular situation. After the contribution to each fishery is estimated for the tag lot, the survival is estimated by summing the estimated harvest of the tag lot in each fishery, and the estimated escapement (brood stock), and dividing by the estimated number of fish represented by the tag code.

Total catches stratified by week, district, and processor were obtained from summaries of fish sales receipts (fish tickets) issued to each fisherman. The total hatchery contribution to the commercial and hatchery cost recovery harvest is the sum of the estimates of contributions in all week, district, and processor strata:

$$\hat{C}_t = \sum_i X_{ti} (N_i / S_i) p_t^{-1}$$

where:

- \hat{C}_t = catch of group t fish,
- X_{ti} = number of group t tags recovered in i th strata,
- N_i = number of fish caught in i th strata,
- S_i = number of fish sampled in i th strata,
- p_t = proportion of group t tagged.

For sampled strata, we used a variance approximation which ignores covariance between release groups (Geiger 1988):

$$V(\hat{C}_t) = \sum_i X_{ti} (N_i / S_i p_t)^2 [1 - (N_i / S_i p_t)^{-1}].$$

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

SCHEDULES AND PLANNING

Appendix A lists the 1991 tagging goals for all hatchery fish and Appendix B lists the goals for wild fish. Tagging at some locations will begin as soon as March 1, 1991 and will be complete by June 1, 1991 at all locations. Finalized tagging and release data will be available on July 1, 1991.

Summary Table

March 1	Tagging begins at PWSAC and VFDA.
April 1	Tagging begins at pink salmon camps.
May 1	Tagging begins at sockeye salmon camps.
June 1	Tagging complete at all hatcheries.
June 15	Tagging of wild salmon complete. Finalized tagging data due from PWSAC and VFDA. Adult sockeye weirs erected at Eshamy and Jackpot for tag recovery.
July 1	Finalized tagging data sent to Tag Lab.
September 10.	Adult sockeye weirs removed.
November 1	Prepare Preliminary Restoration Status Report.
November 15	Submit order for coded wire tags and equipment for 1992.
December 15	Prepare project operational plans for 1992.

DATA ARCHIVAL

This restoration tagging study is a continuation of a damage assessment coded wire tag study. The objectives of the tag application portion of these studies does not generally require the handling of hydrocarbon samples or samples that require chain of custody procedures. The tag application portion primarily generates data that is treated as confidential by all parties involved with the tag applications. Field notes and data records are kept and copies of reports and forms that contain results are stored in the Cordova office of ADF&G.

MANAGEMENT PLAN

PWS Area FRED Biologist: All aspects of tag application to hatchery reared fry as well as cooperative responsibilities for overall tag application and recovery study design. Assisted by two Fisheries Biologists I's.

Commercial Fisheries Division Tagging Project Leader: All aspects of tag application to wild stock salmon as well as cooperative responsibilities for overall tag application and study design. Assisted by two Fisheries Biologist I's and 24 Technicians.

LOGISTICS

Field camps for this project were established in 1989 and 1990 (figure 1). Equipment was purchased as part of the NRDA study in 1989. Leases and permits have been secured from the proper authorities and arrangements have been made to initiate field activities in mid-March. Field work will continue into September for some components of the project. Personnel in the tagging

program have two years experience at operating these same remote field camps and have been preparing for the field season since December.

BUDGET: ADF&G

Salaries	\$425.0
Travel	2.5
Contracts	205.5
Supplies	63.0
Equipment	109.0
Total	\$805.0

PERSONNEL QUALIFICATIONS

Mark Willette, the Prince William Sound Area FRED Biologist is also Principal Investigator for NRDA F/S Study 4 studying the early marine life history of salmon in Prince William Sound. Mr. Willette's experience includes five years of ongoing fisheries research in Norton Sound with the University of Alaska at Fairbanks.

Daniel Sharp, the wild salmon Tagging Project Leader has worked for ADF&G since 1982 and has extensive experience in remote field camp operations and coded wire tagging. Mr. Sharp has been involved with the NRDA coded wire tagging project from it's beginning.

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Appendix A. Coded-wire tagging goals for hatchery releases of salmon in PWS, 1991.

Hatchery	Species	Projected Release	Valid Tag Goal	Number Tags to Order	Total Release /Marked Ratio Goal	Number of Tag Codes	Tag Length
Armin F. Koernig	Pink	116,000,000	193,000	218,000	600	16	Half
Cannery Creek	Pink	140,000,000	234,000	261,000	600	14	Half
Solomon Gulch	Pink	140,000,000	233,000	252,000	600	10	Half
Wally Noerenberg	Pink	225,000,000	375,000	422,000	600	18	Half
GRAND TOTAL	Pink	621,000,000	1,035,000	1,153,000	600	58	Half
Solomon Gulch	Chum	1,600,000	20,000	20,000	80	2	Half
Wally Noerenberg	Chum	78,000,000	156,000	173,000	500	4	Half
GRAND TOTAL	Chum	79,600,000	176,000	193,000	450	6	Half
Solomon Gulch	Coho	1,000,000	30,000	30,000	33	2	Full
		20,000	10,000	10,000	2	1	Full
Wally Noerenberg	Coho	2,300,000	73,500	73,500	40	2	Full
Whittier	Coho	100,000	10,000	20,000	10	1	Full
Cordova	Coho	50,000	10,000	10,000	5	1	Full
GRAND TOTAL	Coho	3,470,000	133,500	143,500	26	7	Full
Main Bay	Sockeye	3,575,000	125,000	125,000	29	8	Full
GRAND TOTAL	Sockeye	3,575,000	125,000	125,000	29	8	Full
Wally Noerenberg	King	600,000	30,000	30,000	20	1	Full
Cordova	King	60,000	10,000	10,000	6	1	Full
GRAND TOTAL	King	660,000	40,000	40,000	17	2	Full
GRAND TOTAL	All	708,305,000	1,509,500	1,654,500	470	81	Both

Appendix B. Coded-wire tagging goals for wild stocks of salmon in PWS, 1991.

System	Treatment	Species	Projected Outmigration	Valid Tag Goal	Total Release /Marked Ratio	Number of Tag Codes	Tag Length
Upper Herring B.	Oiled	Pink	210,000	40,500	5	4	Half
Hayden Ck.	Oiled	Pink	360,000	40,500	9	3	Half
Loomis Ck.	Oiled	Pink	210,000	40,500	5	3	Half
Cathead Ck.	Clean	Pink	150,000	40,500	5	3	Half
O'Brien Ck.	Clean	Pink	300,000	40,500	7	3	Half
Totemoff Ck.	Clean	Pink	720,000	40,500	18	3	Half
GRAND TOTAL	All	Pink	1,950,000	243,000	8	18	Half
Coghill	Clean	Sockeye	600,000	27,000	22	2	Half
Eshamy	Oiled	Sockeye	600,000	27,000	22	2	Full
Jackpot	Oiled	Sockeye	600,000	27,000	22	2	Full
GRAND TOTAL	All	Sockeye	1,800,000	81,000	22	6	Both
GRAND TOTAL	All	All	3,750,000	323,000	30	24	Both