AFF1/LSR-94-14

LOWER SNAKE RIVER COMPENSATION PLAN LYONS FERRY HATCHERY EVALUATION PROGRAM

FALL CHINOOK SALMON 1993 ANNUAL REPORT

LOWER SNAKE RIVER
COMPENSATION PLAN
Hatchery Program

Washington Department of Fish and Wildlife Hatcheries Program

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by

Glen Mendel
Joseph Bumgarner
Deborah Milks
Lance Ross
Jerry Dedloff
Robert Bugert

Hatcheries Program
Washington Department of Fish and Wildlife
600 N. Capitol Way
Olympia, Washington 98501-9960

to

U.S. Fish and Wildlife Service
Lower Snake River Compensation Plan Office
4696 Overland Road, Room 560
Boise, Idaho 83702

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ABSTRACT

This report provides a synopsis of activities from 1 April 1993 to 31 March 1994 by the Washington Department of Fish and Wildlife's Lower Snake River Hatchery Evaluation Program. This work was completed with Fiscal Year 1993 funds provided by the U.S. Fish and Wildlife Service under the Lower Snake River Compensation Plan (LSRCP). In this report we describe the fall chinook salmon program at Lyons Ferry Fish Hatchery (FH), and related natural production in the Snake River. We have also incorporated in this report information regarding salmon trapping at the dams. This information has been in a separate trapping report in past years.

Fall chinook salmon broodstock at Lyons Ferry FH in 1991 was estimated during collection to consist of 1,220 adults and jacks. Fish were obtained from three sources, voluntary returns to the hatchery ladder, and fish trapped and transported to Lyons Ferry FH from both Ice Harbor and Lower Granite dams. We obtained 127 adults and jacks from trapping operations at Ice Harbor Dam, 222 salmon from Lower Granite Dam, and 714 adults and 157 jacks through rack returns. Broodstock collection at Lyons Ferry FH and Ice Harbor Dam accounted for 27.8 and 31.8% of the total fall chinook salmon escapement above Ice Harbor Dam. Another 7.1% of escapement was collected at Lower Granite Dam. Only adipose clipped salmon were collected at Ice Harbor, but coded-wire tagged (CWT) and blank wire tagged (BWT) salmon were collected at Lower Granite Dam.

Analysis of CWT recoveries from salmon spawned at Lyons Ferry FH indicated a substantial stray rate of fall chinook salmon stocks into the Snake River in 1993 from outside the basin, as in past years. Broodstock collected at Ice Harbor Dam had a 32.9% incidence of strays (expanded by mark rate) from the Umatilla River. Most strays were from the Umatilla River. Umatilla strays comprised 45.4% of the fall chinook salmon collected at Lower Granite Dam, and 8.6% of salmon that voluntarily returned to Lyons Ferry FH. Stray fall chinook salmon from Bonneville Dam comprised 2.7% of the fish that passed Ice Harbor Dam, 0.3% at Lower Granite Dam, and 1% of the fish that voluntarily returned at Lyons Ferry FH.

Fall chinook salmon were spawned at Lyons Ferry FH from 19 October to 7 December. Peak of spawning was 21 November. We read the CWTs of all marked fish prior to spawning. Matings consisted of single female/single male lots (with a backup male). Only salmon verified to be of Lyons Ferry FH origin were used for broodstock. All 1989 brood fish from Lyons Ferry, marked (CWT) strays, and unmarked fish were spawned together as "strays". The eggtake from all fish was 2,181,879. Progeny from all stray and unmarked salmon were transferred to Klickitat FH (1,684,100 "eyed" eggs).

We determined fertilization rates from fresh and cryopreserved semen from stray fall chinook salmon. Semen held in a refrigerator for one week produced significantly lower fertilization rates than fresh semen, although fertilization rates exceeded 90% for both the test and control groups. In the second set of tests we found that semen "extender" may reduce the value of the backup male after 30 seconds, if semen from the first male does not successfully fertilize the eggs. Tests where extender was added to the eggs 30 seconds prior to the addition of semen had mean fertilization rates (9.3%) significantly lower than all other test groups. We also found the timing of the addition of sperm "activator" had no significant difference on fertilization rates. Tests with cryopreserved semen as the first addition to the eggs produced fertilization rates that ranged from 27.6-80%. Results from these series of tests generally exceed fertilization rates we have previously obtained with cryopreserved semen. We will continue to test and refine our techniques for holding semen for one to two weeks, or for much longer periods. These techniques may provide us with management options to maintain population size and maximize genetic contribution for endangered fall chinook salmon.

Lyons Ferry FH released 414,997 yearling (1991 brood) fall chinook salmon directly from the hatchery on 12 April 1993. Another 345,021 yearling salmon were barged downstream of Ice Harbor and released on 19 April. All fish were adipose clipped (marked) and had CWT. Approximately half the fish also had a red elastomer tag in the clear tissue behind the left eye. Additionally, 206,775 subyearling (1992 brood) salmon were released directly from the hatchery on 24 June, 1993 as part of a WDFW/tribal agreement.

Cooperative spawning ground surveys upstream of Lower Granite Dam continued in 1993. We estimate that the adult per redd ratio upstream of the dam is 5.3, if redds observed in addition to aerial surveys are included. However, this ratio may be reduced further by the inclusion of fall back of adults at Lower Granite Dam.

We monitored fall chinook salmon spawning in the Tucannon and Palouse rivers. We observed 28 redds (1.4 redds/km below Fletcher's Dam) in the lower Tucannon River in 1993. We recovered 16 carcasses, two of which had BWT and one was RV clipped. We are unable to account for approximately 845 salmon between Ice Harbor Dam and Lower Granite Dam. This estimate includes fish entering Lyons Ferry FH and spawning in the Tucannon River.

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SECTION 1: INTRODUCTION

1.1: Program Objectives

Congress authorized the Lower Snake River Fish and Wildlife Compensation Plan (LSRCP) in 1976. As a result of that plan, Lyons Ferry Fish Hatchery (FH) was designed, constructed, and has been in operation since 1984. A partial objective of this hatchery is to compensate for the loss of 18,300 adult fall chinook salmon, Snake River stock (Corps of Engineers 1975). An evaluation program was initiated in 1984 to monitor the success of Lyons Ferry FH in meeting the LSRCP compensation goals and to identify any production adjustments required to accomplish those goals.

The Washington Department of Fish and Wildlife (WDFW)[1] has identified two broad-based goals in its evaluation program: 1) monitor hatchery practices at Lyons Ferry FH to ensure quality smolt releases, high downstream migrant survival, and sufficient contribution to fisheries with escapement to meet the LSRCP compensation goals, and 2) gather genetic information which will help maintain the integrity of Snake River Basin fall chinook salmon stocks (WDF 1994). Evaluation program objectives are outlined in Appendix A.

This report partially summarizes results and activities performed by the WDFW's LSRCP Fall Chinook Salmon Evaluation Program for the period 1 April 1993 through 31 March 1994. Additional summarization and results of detailed data analyses of 1993 data will be reported in subsequent annual reports. This report also includes a description of the 1993 fall chinook salmon trapping activities at lower Snake River dams which have been described in separate reports in past years.

1.2: Description of Facilities

Lyons Ferry FH is located at the confluence of the Palouse and Snake Rivers at river kilometer (RK) 90 (Lower Monumental Pool, Figure 1). Design capacity for the fall chinook salmon program was 101,800 pounds (9,162,000 subyearling smolts at 90 fish per pound). The current production plan for Lyons Ferry FH is to release up to 800,000 yearlings at 10 fish per pound (fpp), with the rest of capacity as subyearlings at 80-120 fpp. Lyons Ferry has a single pass well water system through the incubators, four adult holding ponds, and 28 raceways. Salmon[2] are hatched and reared at Lyons Ferry FH and have been released either on-station or barged downstream of Ice Harbor Dam. Broodstock are derived from various sources (Section 2).

[1] All references to either the Departments of Fisheries or Wildlife are listed as WDFW: the agencies merged in March 1994.

[2] The term salmon in this report refers to fall chinook salmon.

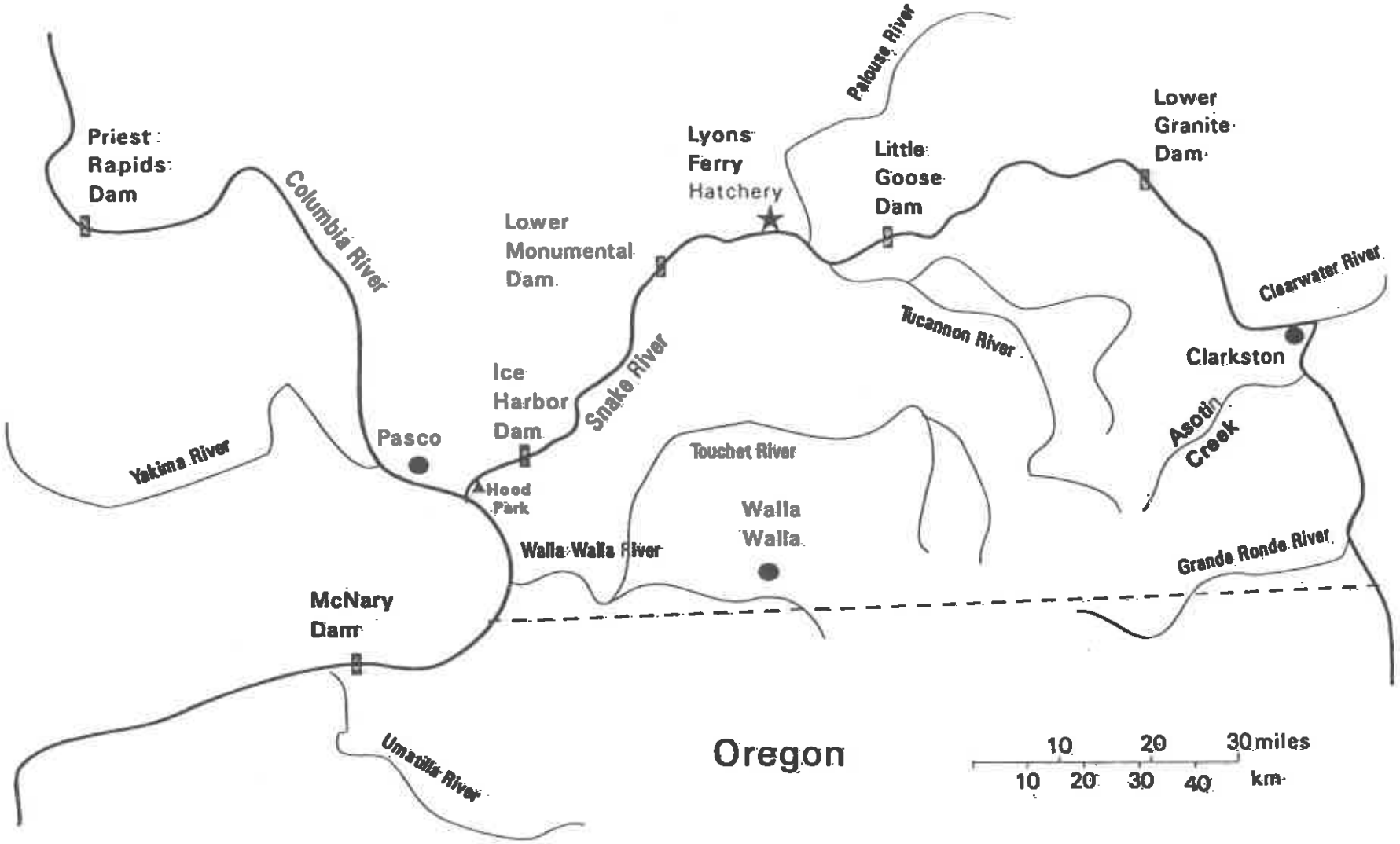

Figure 1. Lower Snake River Basin, showing the location of Lyons Ferry Fish Hatchery and major tributaries in the area.

SECTION 2: BROODSTOCK COLLECTION AND MANAGEMENT

2.1: Broodstock Collection

Lyons Ferry FH has been developing its broodstock since the facility became operational in 1984. Salmon were obtained from two primary sources prior to 1991: 1) returns to the Lyons Ferry FH ladder, and 2) adults trapped at Ice Harbor Dam and transported to Lyons Ferry FH (Bugert and Hopley 1991). From its inception through 1990, Lyons Ferry FH broodstock collection from these two sources has averaged 37% of total escapement to the project area; past Ice Harbor Dam (Bugert et al. 1991). During the period 1984-1986, "eyed" eggs were transported from Kalama Falls FH to Lyons Ferry FH as part of the Snake River Egg Bank Program. Broodstock collection from 1984-1990 and during the eggbank program (1977-1984) have been summarized previously (Bugert and Hopley 1989, Bugert et al. 1991). The first year of adult (≥3 years old) returns from Lyons Ferry FH production was 1986.

From 1991-1993, fall chinook salmon broodstock were obtained from voluntary returns to the hatchery, trapping at Ice Harbor, as well as trapping at Lower Granite Dam (Table 1). National Marine Fisheries Service (NMFS) and WDFW personnel trapped adult and jack fall chinook salmon at these two dams to obtain stray rate information and broodstock for Lyons Ferry FH. In 1993 WDFW continued to honor a request by NMFS to transport all marked (adipose clipped) hatchery salmon captured at the adult trap at Lower Granite Dam to Lyons Ferry FH (Mendel et al. 1994). This was an attempt to limit the number of known hatchery salmon that could spawn upstream of Lower Granite Dam.

2.1.1: Ice Harbor Trap Operations

A total of 2,805 adults and 332 jacks (30-56 cm fork length) were counted passing Ice Harbor Dam in 1993 (Corps of Engineers, 1994). The fall chinook salmon count was well below the 1988 to 1992 average of 5,743.

Since 1984, all salmon trapped at Ice Harbor Dam have been trucked to Lyons Ferry FH. An average of 28.5% of adults counted at Ice Harbor Dam were collected for broodstock from 1984-1990 (Table 1). However, the current percentage of the fall chinook salmon run trapped at Ice Harbor Dam (average of about 6%) has decreased since 1990 because only adipose-clipped salmon were trapped in 1991-1993.

Table 1. Contribution of fall chinook salmon returns to Lyons Ferry Fish Hatchery (FH) from Ice Harbor Dam, Kalama Falls FH, Lyons Ferry FH ladder, and from Lower Granite Dam. Total counts at Ice Harbor Dam are included.

Year	Collection point	Number collected adults	Number collected jacks	Ice Harbor Dam count[a] adults	Ice Harbor Dam count[a] jacks
1984	Lyons Ferry FH	0	0	1,410	642
	Ice Harbor Dam	663	97		
	Kalama Falls FH	220	10		
1985	Lyons Ferry FH	6	4,070[b]	2,046	7,119
	Ice Harbor Dam	589	90		
	Kalama Falls FH	952	0		
1986	Lyons Ferry FH	245	1,125	3,152	2,665
	Ice Harbor Dam	212	23		
	Kalama Falls FH	576	0[c]		
1987	Lyons Ferry FH	1,654	543	6,812	1,619
	Ice Harbor Dam	1,613	47		
1988	Lyons Ferry FH	327	1,053	3,847	2,035
	Ice Harbor Dam	1,076	6		
1989	Lyons Ferry FH	704	670	4,638	1,352
	Ice Harbor Dam	1,179	0		
1990	Lyons Ferry FH	521	602	3,447	1,839
	Ice Harbor Dam	1,092	0		
	Lower Granite Dam	49	0		
1991	Lyons Ferry FH	863	675	4,500	1,526
	Ice Harbor Dam	361	71		
	Lower Granite Dam	37	0		
1992	Lyons Ferry FH	898	176	4,636	894
	Ice Harbor Dam	256	71		
	Lower Granite Dam	178	26		
1993	Lyons Ferry FH	714	157	2,805[d]	332[d]
	Ice Harbor Dam	127[e]	-		
	Lower Granite Dam	218	4		

[a] *Classification of adults and jacks is based upon size at collection (see footnote on page 6 - minijacks not included in this table).*

[b] *The first release from Lyons Ferry FH was in 1985 (1983 brood); first returns of hatchery-reared stock to Lyons Ferry FH were age 2 jacks in 1985.*

[c] *The last year adults returned to Kalama Falls FH was 1986.*

[d] *Excluding salmon counted by video camera or passing during November.*

[e] *Salmon were not classified by size at the time of collection.*

Adult collections: From 7 September through 27 October 1993 we operated an adult trap at the top of the south shore ladder at Ice Harbor Dam. The trap included a floating viewing chamber with pneumatically operated doors and two floating cages. It was in the upper end of the fish ladder upstream of the fish counting window.

This was the fifth year WDFW conducted the trapping operations. The Idaho Cooperative Fish and Wildlife Research Unit (ICFWRU) operated the trap in previous years (Bjornn and Ringe 1989), primarily under the directive of the Snake River Fall Chinook Eggbank Program (Bugert and Hopley 1989). The primary objective of the trapping program was collection of adults for direct contribution to Lyons Ferry FH broodstock. A secondary objective in 1991-1993 was to remove a portion of the stray fall chinook salmon entering the Snake River in an attempt to maintain genetic integrity of the Snake River stock (Mendel et al. 1992). To accomplish this objective only marked salmon were collected at the trap. Their origin was later determined through coded-wire tag (CWT) reading during spawning at Lyons Ferry FH. The third and fourth objectives were to capture and radio tag unmarked (not adipose clipped) salmon and steelhead (as part of a cooperative effort with the ICFWRU), and monitor the run composition in general. Results of our 1993 radio telemetry project will be provided in a separate report (in preparation) to the Bonneville Power Administration (BPA).

We conducted employee training on 7 September and then operated the trap for approximately 7 hours. Full time trapping began on 8 September. We operated the trap 39 days with a cycle of ten days on and four off every two weeks. Our trapping effort in 1993 was substantially reduced from that of 1992 to enable ICFWRU personnel to evaluate steelhead passage at Ice Harbor Dam with, and without, the trap in operation. Our intermittent trapping also was an attempt to reduce delay of salmon passing the dam. The trap was operated only during daylight hours (approximately 06:00 to 1900 hrs) and fish were allowed to pass through the trap when it was not in operation.

We continued to use the additional holding cage and underwater viewing chamber which were added to the trap in 1983. However, one holding cage was usually used to collect steelhead or unmarked salmon to be radio tagged by ICFWRU or WDFW personnel. Consequently, only the remaining holding cage was available for broodstock collection, especially during the first five days of a trapping interval. Both steelhead and salmon were trapped during the first five days of a trapping interval, while only salmon were collected the following five days.

Holding cages containing broodstock were lifted with a boom truck so salmon could be loaded into a tank truck several times a day. The frequency of loading depended on the number of fish and

timing of their entry into the trap. After loading, fish were generally held in the tank truck until sundown and then transported to the hatchery. Fish were held in the truck a maximum of 11 hrs, and a minimum of 1.5 hrs.

Salmon were transported in an aerated, insulated, 5,700 L tank truck. In 1989, we began transporting fish in with unrefrigerated water. This appeared to cause no increased stress to the fish (Ringe and Bugert 1989), and we continued this strategy in 1993. The tank truck was filled with well water from Lyons Ferry FH (about 12°C) and treated with salt (1%) to reduce stress. In previous years we used 1 g Oxytetracycline HCI (Terramycin) per 300 L water in the past, but it was not authorized for aquaculture use in 1993. All trapped salmon were delivered to Lyons Ferry FH. Transport time was 1.5 hrs.

We trapped and transported 127 marked salmon to Lyons Ferry FH in 1993 (Table 1). An additional two unmarked salmon that died during radio tagging were delivered to the hatchery on 24 September. We did not keep separate counts of adult and jack[3] salmon delivered to the hatchery because of past problems with misclassification during collection, and confusion created by differing criteria used by various agencies for classifying jack salmon. This was the third year we collected only marked fish for broodstock, and it is the lowest number of salmon collected since Ice Harbor trapping began in 1977. The peak of trapping occurred in mid-September, as it has the past three years (Table 2). Daily trap counts and estimated numbers of salmon collected as broodstock are presented in Appendix B.

Trapping and loading of unmarked salmon and steelhead for insertion of radio transmitters complicated the trapping effort and may have reduced trapping efficiency. Steelhead and unmarked salmon collected for the radio telemetry study were loaded into tank trucks from the holding pens as often as 4-8 times per day. This may have caused delayed passage of both steelhead and salmon because of disturbance in the fish ladder, particularly during the first five days of each trapping interval.

[3] Throughout this report, jacks collected in trapping operations and returns to the hatchery rack were distinguished by size at the time of collection. The length criterion for jacks collected at the dams was ≤ 56 cm total length in 1993 whereas the criterion at Lyons Ferry FH was ≤ 61 cm fork length. Coded-wire tag or scale analysis has revealed that many of the salmon classified as jacks are adult fish (age 3+) of either sex.

South shore ladder counts: We trapped and collected 6.3% (127) of the salmon (2,007 marked and unmarked adults and jacks) passing over the south shore ladder (WDFW, unpublished data) during the period of trap operation, and 4.0 % of the total fall chinook salmon passing Ice Harbor Dam in 1993 (127 of 3,137 adults and jacks counted at both ladders from 12 August - 31 October). The 1993 trapping rate (4.0%) is below both the 5.5% rate in 1992, as well as the 8.0% trapping rate in 1991. Also, the 1993 rate includes adults and jacks while the rates for the other two years were for adults only. Video counts made in 1993 outside the usual counting periods are not included in these rate comparisons.

Table 2.. Numbers of fall chinook salmon trapped at Ice Harbor Dam and transported to Lyons Ferry Fish Hatchery, duration of trapping, and peak day of trapping.

	Number trapped		Duration of	Peak trapping day	
Year	adults	jacks	trapping	date	adults
1984	663	97	1 Sep - 5 Oct	11 Sep	57
1985	589	90	31 Aug - 30 Sep	9 Sep	68
1986	212	23	4 Sep - 3 Oct	18 Sep	24
1987	1,613	47	2 Sep - 11 Oct	26 Sep	97
1988	1,076	6	3 Sep - 11 Oct	15 Sep	67
1989	1,179	0	2 Sep - 11 Oct	26 Sep	78
1990	1,092	0	4 Sep - 6 Oct	12 Sep	100
1991	361	71	4 Sep - 31 Oct	12 Sep[a]	35
1992	256	71[b]	31 Aug - 31 Oct	14 Sep[a]	30
1993	127[c]	-[c]	7 Sep - 27 Oct	14 Sep[a]	21

[a] *Only adipose clipped salmon were collected for broodstock in 1991-1993.*

[b] *Jacks were classified as <56 cm total length instead of ≤61 cm fork length used in previous years.*

[c] *Fish were not categorized as adults or jacks at the time of collection. This value does not include two unmarked adults that died during radio tagging.*

Trapping efficiency for the period of operation was 28.7% (131 of 457 marked fish at the fish counting window - adults and jacks, adjusted counts). This estimate includes 127 salmon collected for broodstock as well as four fish that were trapped but not collected. It does not include 95 salmon that passed during intervals when trapping was not conducted. In 1993, we collected 20.3% (127) of the total marked salmon estimated to have passed Ice Harbor Dam through the south shore ladder (627), and 15.6% of all marked salmon passing both ladders (816) between 12 August and 31 October. We collected 3.8% (127 of 3,361) of the total (2,805 adults, 332 jacks and 224 minijacks) estimated escapement of fall chinook salmon past Ice Harbor Dam (Corps of Engineers, 1994). In previous years (1984-1991) an average of 16.8% of all salmon (marked and unmarked) counted from 12 August to 31 October were collected (Bugert and Hopley 1991).

Mark rates: Marked adult salmon comprised 18.3% (114) of the total adults observed in the trap (623) between 7 September and 27 October. We used 56 cm total length as the minimum adult size for salmon in our trap as did personnel at the counting windows. We did not stop all salmon to get exact length, and they often came through in groups, so not all fish were classified (our classifications should be considered relative values only). We classified 48 (6.1%) of the salmon (783 - all sizes) passing through the trap as jacks; 17 jacks were marked (35.4%) and 31 were unmarked (Appendix B-Table 1). A total of 19.5% (131 of 671) of the adults and jacks were marked. We classified 112 (14.3%) of the salmon passing through the trap as minijacks (less than 30 cm total length); 95 minijacks were marked (84.8%), and 19 were unmarked. The overall mark rate for trapped salmon (all size categories) was 30.7% (240 of 783); which was slightly higher than the 29.9% observed in 1992, or the 26.7% in 1991.

At our request, fish count personnel kept separate tallies of marked and unmarked salmon (adults and jacks grouped together) observed at both counting windows in the fish ladders at Ice Harbor Dam. Adjusted counts for marked and unmarked salmon for each ladder provide relative values only because not all salmon were classified as marked or unmarked, and because of rounding errors (Appendix B - Table 2). The mark rate at the counting windows at Ice Harbor Dam for the entire period of fall chinook salmon counts (12 August to 31 October) was 26.1% (816 out of 3,129 adult and jack salmon categorized, adjusted counts), which is lower than the 30.1% rate observed in 1992 and the 35.1% in 1991. The 1993 mark rate at the counting station is higher than the mark rate observed at the trap (19.5%). The percentages of marked salmon passing Ice Harbor Dam increased from August through October. The percentage of marked salmon passing the dam in August was 20.2% (49 out of 243). Mark rate in September was 20.4% (426 of 2,090), and in October it was 42.8% (341 of 796; Appendix B). Minijacks were not classified as clipped or unclipped at the counting windows.

Video cameras were used at Ice Harbor Dam to supplement visual fish counts in 1993. Video counts were conducted for 8 hrs each night (8 pm to 4 am) after 16 hr visual count periods from May through October (Corps of Engineers 1994). An additional 181 adult and jack fall chinook salmon (5.8% of total visual counts of 3,137) were counted with video from 12 August through 31 October (52.5%, 95 fish were in the south ladder, WDFW, unpublished data). Approximately 5-8% of the total fall chinook adults and jacks counted each month in the south ladder during the normal fall chinook counting period passed at night after standard 16 hr visual counts were completed (WDFW, unpublished data). Also, 24 hr video counts were conducted in both ladders during November and the first 15 days of December. These counts resulted in 54 adults and 19 jacks passing in November and one adult in December (both ladders combined).

North shore ladder counts: WDFW personnel kept separate counts for adult, jack, and minijack salmon passing each ladder by time of day (but not separated by whether salmon were marked and unmarked per size category). Of 3,137 adult and jack salmon counted from 12 August to 31 October 1993 (2,805 adults and 332 jacks - Corps of Engineers, 1994), 25.7% (806) were counted passing the north ladder. In 1992, 15% of adults and jacks passed the north ladder and approximately 9% passed through this ladder in 1991 (Mendel et al. 1994b).

Most of the marked salmon passed the north shore ladder from 7-30 September 1993 (Appendix B). Overall, a higher percentage (26.9%) of marked fall chinook salmon were counted in the south ladder in 1993 than in the north ladder (23.5%). This is contrary to our observations in 1991 and 1992.

River conditions: In general, water temperatures during trapping operations were slightly cooler than during 1992. The water temperature of the Snake River during the trapping period at Ice Harbor Dam reached a high of 20°C in late August and mid September, and decreased to 18.3°C by the end of September (Corps of Engineers, 1994). Experimental cold water releases from Dworshak Dam in August and September may have contributed to cooler temperatures observed at Ice Harbor Dam. By the end of October water temperature at Ice Harbor Dam was 15°C. Mean visibility in 1993 (7.1 and 6.0 feet secchi disk for September and October, respectively) was much higher than in 1992. Spill and total discharge were also substantially higher in 1993 than in 1992. Spill occurred in 1993 during August and the first day of September.

2.1.2: Lower Granite trap operations

Adult collections: In cooperation with NMFS personnel, we collected wire tagged fall chinook salmon in 1993 at the one fish ladder (south shore) that exists at Lower Granite Dam. Salmon with CWT, blank-wire tags (BWT), or other metal objects activated the gate and were captured at the adult trap in the south shore ladder. NMFS had requested that WDFW cooperate with them in an effort to keep all marked hatchery fall chinook salmon from passing upstream of Lower Granite Dam. Adult and jack salmon collected at the trap were transported by WDFW personnel to Lyons Ferry FH for use as broodstock. This was the forth year adults were collected at Lower Granite. It was the second year jacks were collected alive for use as broodstock at Lyons Ferry FH, and to obtain stray rate information. Jacks were killed for stray rate information in previous years, but no jacks or minijacks were sacrificed in 1993. Salmon collected as broodstock were anesthetized, given numbered metal jaw tags, and transported in a 1,200 L aerated, non-refrigerated tank truck, with water obtained from Lyons Ferry FH wells or the adult trap at Lower Granite. As with transport from Ice Harbor we added salt to the water in the transport tank to reduce injuries and stress to the fish. We collected salmon seven days per week.

The 1993 count of fall chinook salmon at Lower Granite Dam (18 August to 15 December) was 1,170 adults, 39 jacks, and 55 mini-jacks (< 30 cm; Corps of Engineers, 1994). The adult count is 315 fish more than in 1992, and is higher than the 1991 count of 630 adults.

From 10 August to 19 November, 218 marked adult fall chinook salmon (≥ 56 cm) and 4 jacks were collected at Lower Granite Dam and transported to Lyons Ferry FH as potential broodstock (Appendix C). These fish included 79 adult and three jack salmon that were marked and had CWTs. The remaining 139 adults and one jack salmon were unmarked and had BWTs. Fish with BWTs were mostly returns from the 1989 brood from Lyons Ferry FH. That brood originated from parents with a high composition of strays from the Umatilla River. Ninety-one marked adults were counted at the dam during the counting period, however, one adult with a CWT and three with BWT were captured prior to the established fall chinook counting period (18 August). We collected 86.8% (79 of 91) of the adjusted total of adults with CWTs passing the counting window and 91.2% of the combined marked adults and jacks (79 adults and 4 jacks of 91 adults and zero jacks counted). Collection of marked salmon enabled us to: 1) monitor adult salmon composition at the dam (only previously done in 1990-1992), 2) collect fish for a spawning program designed to remove marked stray salmon, and 3) supplement Lyons Ferry FH eggtake.

At NMFS' request, we collected 140 BWT hatchery fish so they would not enter the spawning population upstream of Lower Granite Dam (Mendel et al. 1994; Appendix C). One of these BWT adults died (on 19 September) during transport to Lyons Ferry FH before spawning began.

Mark rates: WDFW personnel kept separate tallies of marked and unmarked fall chinook salmon adults (≥ 56 cm), jacks (30-<56 cm), and minijacks (<30 cm) counted at Lower Granite Dam (Appendix D; WDFW unpublished data). The mark rate for all sizes of salmon observed at Lower Granite Dam during the period of fall chinook salmon counts (18 August to 15 December) was 10.0% (124 out of 1,244); similar to the 9.8% observed in 1992, but substantially less than in 1991 (15.5%). Mark rates for adults, jacks, and minijacks in 1993 were 7.8% (90 of 1,160), 0% (0 of 37), and 72.9% (35 of 48), respectively (WDFW, unpublished data).

Approximately 13% (139 fish) of the 1,070 unmarked fall chinook salmon adults that passed the counting window at the dam were BWT. Thirty-seven unmarked jacks were counted and one (2.7%) was captured at the trap with a BWT.

River conditions: Water temperatures were much cooler than during 1992. During the trapping period water temperatures at Lower Granite Dam reached a high of 20.6°C in late August and decreased to 16.1°C by 30 September (Corps of Engineers, 1994). Experimental cold water releases from Dworshak Dam in August and September may have contributed to cooler temperatures. Mean visibility in 1993 (4.9 and 5.0 feet - secchi disk for September and October, respectively) was similar to 1992. No spill occurred during the August - December counting period. Total discharge was substantially higher in August, and slightly higher in September and October 1993 than in 1992.

2.1.3: Voluntary returns to Lyons Ferry FH

A total of 714 adults and 157 jacks (marked and unmarked) voluntarily returned to Lyons Ferry FH (27.8% of escapement to Ice Harbor Dam) in 1993. Duration of returns was 90 days, compared to the 1986-1990 average of 81 days. Duration of returns has changed little since 1986, yet the peak of returns has varied (Table 3). Peak days of voluntary returns occurred on 3 and 11 November, 1993 (40 adults and 15 jacks on 3 November, and 42 adults and 13 jacks on 11 November). A total of 654 adults and 136 jacks were processed at Lyons Ferry FH, although apparently a few of these fish inadvertently got mixed with fish trapped at Ice Harbor.

Table 3. Voluntary returns of fall chinook salmon to Lyons Ferry Fish Hatchery, duration of returns, and peak day of returns from 1986 through 1993.

Year	Number of returns adults	jacks [a]	Duration of returns	Peak return day date	adults
1986	245	1,125	5 Sep - 15 Nov	18 Sep	24
1987	1,654	543	13 Sep - 12 Dec	26 Sep	202
1988	327	1,053	9 Sep - 5 Dec	16 Sep	95
1989	704	670	6 Sep - 4 Dec	1 Oct	56
1990	521	602	5 Sep - 14 Nov	7 Nov	57
1991	863	675	13 Sep - 4 Dec	1 Oct	54
1992	898	176	14 Sep - 7 Dec	19 Oct	181
1993	714	157	8 Sep - 7 Dec	11 Nov	42

[a] Jacks were classified by size (≤ 61 cm) at the time of collection using our agency standard.

2.1.4: Broodstock collection summary

During 1993, 1,220 salmon were collected as broodstock from all three sources. Trapping at Ice Harbor Dam contributed 10.4% of broodstock and 71.4% voluntary returned to Lyons Ferry FH. The remaining 18.2% were obtained from Lower Granite Dam. Numbers of broodstock collected are based on estimates at the time of collection. Broodstock were collected in 1993 according to our 1992 Broodstock Collection and Spawning Protocol (Mendel et al. 1994).

Broodstock collection from all three sources was 38.9% of total estimated escapement (1,220 of 3,137) of adults and jacks past Ice Harbor Dam in 1993 (Table 1). The Ice Harbor trap collected 4.0% (127 fish) of the total fall chinook escapement to the project area in 1993, and the NMFS upstream migrant trap at Lower Granite Dam collected another 7.1% (222 fish).

We were able to account for 1,158 salmon during spawning operations at Lyons Ferry FH. The difference between estimated escapement and what was processed (62 fish) is primarily from misclassification of salmon and steelhead during trapping and sorting with our partially automated sorting system. A small number of fish processed at the hatchery were not correctly identified according to the point of collection (volunteered or trapped). These problems have occurred nearly every year, but our procedures are continually revised to improve accounting during spawning.

2.2: Stray Fish

We have collected stock composition data for marked hatchery salmon from Ice Harbor, Lyons Ferry, and Lower Granite for the past several years. The stock composition is based on CWTs and BWTs recovered from salmon processed during spawning at Lyons Ferry FH. We have gathered information on adult and jack stock composition at Lower Granite Dam from 1990-1993, and composition of jacks alone from 1985 to 1988 (Bugert et al. 1991).

Marked salmon from Lyons Ferry FH and Umatilla FH comprised the most numerous hatchery stocks at all three collection locations again in 1993 (Tables 4, 5, 6). Expansions for each CWT code from Lyons Ferry FH were based on the number of all fish released on approximately the same dates (Appendix E). This expansion method accounts for fish from Lyons Ferry FH that were branded, or were otherwise untagged, that may not be included with the experimental tag groups in the Pacific States Marine Fisheries Commission (PSMFC) database. All other CWTs were expanded using data available in the PSMFC database. All expansions were based solely on mark rate and do not include sample rate. Recovered fish with a BWT in the snout (1989 brood Lyons Ferry origin) or in the right shoulder (Umatilla R. releases) were added to the number of salmon estimated in the CWT expansions (Tables 5 and 6). Based on these expansions we find that just over 61% of the fall chinook salmon collected at Ice Harbor Dam were of Lyons Ferry origin in 1993, similar to 1992 (70%). However, in 1990 and 1991 this stock comprised about half of the fish collected at Ice Harbor Dam (Mendel et al. 1992b). Likewise, voluntary returns to Lyons Ferry FH in 1993 and 1992 were comprised primarily of Lyons Ferry origin salmon (90.2% and 90.7%, respectively). The percentage of fish returning to Lyons Ferry FH that were of Lyons Ferry origin had increased for several years, but now has leveled off at 90-91%. The percentage of salmon collected at Lower Granite Dam that were of Umatilla FH origin dramatically increased in 1993 (45.5%) compared to the past few years (8.6% in 1992, 25.0% in 1991, 22.9% in 1990). Additionally, salmon of Lyons Ferry origin comprised only 53.8% of the fish trapped at the dam in 1993. This is in contrast to the nearly constant rates (72% in 1992, 74% in 1991 and 75% in 1990) of Lyons Ferry origin fish at Lower Granite Dam over the past few years, even with variable run sizes.

If we base CWT expansions for salmon from Lyons Ferry FH solely on data reported to PSMFC (Appendix F) and exclude BWTs, then the number of recoveries are substantially reduced for Lower Granite and voluntary returns. Although both expansion methods described are based solely on mark rates, sample rates can be applied to fish collected at the dams, but not to voluntary returns to Lyons Ferry FH because of selective removal at Ice Harbor Dam.

All salmon released from Lyons Ferry FH were tagged with wire tags (CWT and adipose clipped, or BWT and unclipped), beginning with the 1989 brood. These marks provide fishery managers the capability to identify and potentially prevent these fish from entering the Snake River above Lower Granite Dam. We recovered 134 fish with BWTs from the 1989 Lyons Ferry brood at Lower Granite Dam in 1993. Another fish had a BWT in the right shoulder (Umatilla River) and four other salmon had no wire was detected at the hatchery. Additionally, 80 fish with BWTs were collected as voluntary returns to Lyons Ferry FH. We also documented seven fish with CWTs that were not marked (five from Lyons Ferry, one from Umatilla and one from Bonneville). Expanded return or run composition estimates based on CWTs alone would substantially underestimate salmon of Lyons Ferry origin returning to Lyons Ferry FH or Lower Granite Dam.

LaVoy (1994) used the 1993 CWT recovery data to estimate run composition to Lower Granite Dam and to spawning grounds upstream of the dam. His estimate includes trapping efficiency at the dam while our escapement estimates later in this report do not. He estimated total escapement past Lower Granite Dam to be 952 adult (1,170 counted - 218 collected) and 35 jack (39-4) fall chinook salmon in 1993. LaVoy (1994) estimated 742 adult and 35 jack salmon that passed Lower Granite Dam were of natural origin. Hatchery fish that passed the dam consisted of 43 adult salmon of Lyons Ferry origin (17 were 1989 brood) and 167 adult salmon originating from Umatilla FH.

Table 4. Stock composition (from CWT) of fall chinook salmon trapped at Ice Harbor and transported to Lyons Ferry FH, 1993.

Origin	Number of tags recovered	Expanded contribution [a]	Percent of expanded
Lyons Ferry	102	138	61.3
Umatilla	20	74	32.9
Bonneville	6	6	2.7
Other [b]	2	7	3.1
Lost [c]	1	--	--
Totals	131	225	100.0

[a] *Expansion based on mark rate.*

[b] *One recovery from Columbia River release, R-2, (7/56/54) and one recovery from Trinity River Spring chinook (6/56/39).*

[c] *Plus eight fish with adipose clips and no CWTs, and one fish with CWT (63-46-55) but not marked.*

Table 5. Stock composition (from CWT and BWT) of fall chinook salmon collected as **voluntary** returns to Lyons Ferry FH in 1993.

Origin	Number of tags recovered	Expanded contribution [a]	Percent of expanded
Lyons Ferry	383[b]	460[b]	90.2
Umatilla	12[c]	44[c]	8.6
Bonneville	5	5	1.0
Other [d]	1	1	0.2
Lost [e]	5	--	--
Totals	406	510	100.0

[a] *Expansion based on mark rate.*
[b] *Includes 80 BWTs from snouts (1989 brood Lyons Ferry).*
[c] *Includes one fish with a BWT in the right shoulder; another 25 fish with no wire had right ventral fin clips (one of these fish may have incorrectly been attributed to collection at Ice Harbor Dam during spawning).*
[d] *One recovery from Columbia River, R-2, release (7/50/34).*
[e] *Plus 11 fish with adipose clips and no CWTs and five fish with CWTs but not marked (one with 23-25-57, two with 63-2-35, one with 63-47-5, and one with 63-55-50).*

Table 6. Stock composition (from CWT and BWT) of fall chinook salmon trapped at **Lower Granite** Dam and trucked to Lyons Ferry FH in 1993.

Origin	Number of tags recovered	Expanded contribution [a]	Percent of expanded
Lyons Ferry	182[b]	203[b]	54.0
Umatilla	27[c]	171[c]	45.4
Bonneville	1	1	0.3
Other [d]	1	1	0.3
Lost [e]	2	--	--
Totals	213	376	100.0

[a] *Expansion based on mark rate.*
[b] *Includes 134 BWTs from snouts (1989 brood Lyons Ferry).*
[c] *Includes one fish with a BWT in the right shoulder.*
[d] *One recovery of Rogue R. spring chinook (7/53/16); not expanded because no others known in Columbia/Snake rivers in 1993.*
[e] *One additional fish with adipose clip and no CWT and one fish with CWT (7-47-58) that was not marked.*

SECTION 3: HATCHERY OPERATIONS

3.1: Spawning and Eggtake

3.1.1: Spawning operations

Salmon collected at Ice Harbor and Lower Granite dams were held separately from voluntary returns to Lyons Ferry FH. Fish collected at Lower Granite Dam were given a numbered jaw tag when trapped, enabling us to identify their origin and date of collection.

Salmon voluntarily returning to Lyons Ferry FH were directed into a pond several times each week. We did not attempt to mark these fish for identification of entry date into the hatchery because in previous years we did not find that stray rate differed substantially by week of collection (Bugert et al. 1991, Mendel et al. 1992b).

Ripe fish were killed and set aside during spawning operations. CWTs were removed from marked fish and read to determine the fish's origin prior to fertilization of the eggs. Fish were spawned in two distinct groups: Lyons Ferry origin fish verified through CWT analysis, and all others. This latter category included all unmarked fish, strays identified by CWT, and all 1989 brood (BWT and CWT) salmon from Lyons Ferry FH. Only known Lyons Ferry origin fish (from CWT) were mated together (excluding the 1989 brood) and retained for subsequent Snake River releases. All fish were mated as single male/single female pairs (with a back up male 15-30 seconds later). Fertilized eggs from known Lyons Ferry fish were incubated in separate trays for each female, and separately from those eggs known to be from stray or unmarked fish. Chilled water was used for eggs of Lyons Ferry origin so all egg takes would hatch on approximately the same date.

Spawning occurred from 19 October through 7 December, 1993 (Table 7). The peak of spawning was 21 November, when 621,272 eggs were taken. This peak date is consistent with previous years, and coincides with apparent peaks on the spawning grounds. The total egg take at Lyons Ferry FH (after picking) was 2,181,879; initial mortality was 6.7% (Table 8). Under authority of an interagency and tribal agreement, progeny of stray, unmarked and 1989 brood Lyons Ferry broodstock were transported to Klickitat FH (1,684,100 "eyed" eggs) for hatching, rearing and release there. The remaining 351,818 eyed eggs were retained for Lyons Ferry FH production.

Table 7. Collection and spawning summary for fall chinook salmon broodstock at Lyons Ferry Salmon Hatchery, 1993.

Week ending	Arrivals[a] adult	jack	Mortality M	F	J	Spawned M	F[b]	J[c]	Eggtake[d]
4 Sep	21								
11 Sep	43								
18 Sep	132								
25 Sep	113	1	1	2					
2 Oct	106	3	1	1					
9 Oct	86	10	1	2					
16 Oct	135	28	1						
23 Oct	61	12	2	5		1	12	36	47,703
30 Oct	70	14		1		11[e]	75	10	328,835
6 Nov	106	50	6	8	1	76	147	25	621,272
13 Nov	81	21	12	7	3	126	145	41	546,540
20 Nov	75	15	21	6	3	87	103	30	417,008
27 Nov	27	2	7	2	4	40	42	6	168,200
4 Dec	2	1	8		2	11	11	1	37,491
12 Dec	7		5	2		3	5	0	14,830
Totals[f]	1,065	157	65	36	13	355	540	149	2,181,879

[a] *Escapement is estimated during collection. Numbers include one trap mortality at Lower Granite Dam and two salmon that died during radio tagging at Ice Harbor Dam that normally would not have been transported and to Lyons Ferry FH. Most males were live spawned.*

[b] *Includes seven females that were not ripe or had spawned (in pond) when killed; three females that were not ripe on 26 October, one spawned out on 2 November, one on 9 November, one unaccounted for on 16 November, and one unripe female on 7 December.*

[c] *Includes spawned jacks on 19 October (1 jack), 26 October (1), 2 November (10), 9 November (14), 16 November (2), and 23 November (5), as well as surplused jacks.*

[d] *Corrected total eggtake after shocking was 2,181,879 eggs. This includes eggs from stray females used for fertilization experiment at Lyons Ferry FH.*

[e] *Includes one male not ripe when killed.*

[f] *The number of salmon that were accounted for during processing at Lyons Ferry FH was 996 adults and 162 jacks (1,158 total). We later found that 13 spawned males and 2 males that died prior to spawning were ≤ 61 cm and should have been counted as jacks. One female was also smaller than 61 cm.*

Table 8. Duration and peak of spawning, eggtake, and percent egg mortality at Lyons Ferry Fish Hatchery since it began operation.

Year	Spawning duration	Peak of spawning	Eggtake	Percent egg loss
1984	8 Nov - 5 Dec	21 Nov	1,567,823	21.58
1985	2 Nov - 14 Dec	7 Nov	1,414,342	3.99
1986	22 Oct - 17 Dec	19 Nov	592,061	3.98
1987	20 Oct - 14 Dec	17 Nov	5,957,976	3.82
1988	18 Oct - 6 Dec	12 Nov	2,926,748	3.41
1989	21 Oct - 16 Dec	11 Nov	3,518,107	5.75
1990	20 Oct - 8 Dec	6 Nov	3,512,571	8.28
1991	15 Oct - 10 Dec	12 Nov	2,994,676 [a]	8.30
1992	20 Oct - 8 Dec	21 Nov	2,265,557 [a]	5.96[b]
1993	19 Oct - 7 Dec	2 Nov	2,181,879	6.69[c]

[a] *Plus 9,000 eggs from stray females given to WSU.*

[b] *Combined loss from both known Lyons Ferry and stray/other fish; known Lyons Ferry was 5.06%, and stray/other was 9.29%.*

[c] *Combined loss from both known Lyons Ferry and stray/other fish; known Lyons Ferry was 9.6%, and stray/other was 6.1%.*

3.1.2: Sperm cryopreservation evaluation

In 1993 we conducted experiments to obtain fertilization rates from two different methods of holding semen at Lyons Ferry FH. Experiment One tested the difference in fertilization rates obtained using fresh and one week old, refrigerated semen (delayed fertilization). The second experiment tested for differences in fertilization rates obtained by varying the timing of the addition of the second straw of cryopreserved semen (with extender) timing of the addition of sperm activator. We collected and used gametes from stray fall chinook salmon for all experiments. Mean fertilization rates were determined by counting live and dead eggs associated with all tests at the "eyed" stage on 28 December.

All data were normalized by applying a modification of the Freeman and Tukey arcsin transformation (Zar 1984). Student's t tests were used to test for differences between group mean fertilization rates for Experiment One. Analysis of Variance and Tukey's multiple range tests were applied to the results of Experiment Two. All statistical tests were evaluated with an alpha level of 0.05.

Experiment One - Delayed fertilization

The poor fertilization rates we obtained with cryopreserved semen in 1991 and 1992 caused us to question the use of this technique for federally listed chinook salmon stocks. For fish stocks at critically low population levels the use of cryopreservation for increasing genetic contribution and diversity has to be balanced with its effects on total population size. Often at the beginning or end of a spawning season we see few males or females ready to spawn at the same time. It is difficult logistically to mate these fish within the constraints of maintaining identified matings groups (eg. strays, and Lyons Ferry origin fish) while maximizing genetic contributions from all fish. We desire alternatives to cryopreservation that would provide us an appropriate "ripe" male when a female is ready to spawn. We decided that if we could hold semen short-term (one or two weeks) and obtain better fertilization rates than those with cryopreserved semen, this would help achieve our management goals of maintaining high genetic contribution and maximum population levels.

The objective of Experiment One was to compare general effects on fertilization rates and sperm motility for semen held for one week in the refrigerator with semen used shortly after collection (fresh).

On 30 November 1993 we conducted fertilization experiments using semen from stray fall chinook salmon collected on 23 November (refrigerated one week) and 30 November (fresh semen) at Lyons Ferry FH. All eggs used in the experiments were collected on the second week. We attempted to keep the egg handling and incubation processes after fertilization as similar as possible as those used in routine hatchery operations at Lyons Ferry FH. Eggs from three stray females were combined (pooled) and divided into 32 lots (only eight lots were used in Experiment One). Each lot was placed in an individual incubation tray. Semen from eight unmarked, unknown origin males was collected for the experiments. Fertilization procedures did not include backup males, as is normally required in our spawning protocol. We pooled the semen before addition to the eggs to minimize the effects of individual males.

Our experiment had two different study groups, four replicates per group. All experiments included pooled eggs from three females.

Fresh semen vs refrigerated semen (held one week)

Group 1. (control) fresh semen, pooled (from four males) then combined with pooled eggs and ovarian fluid (from three females).

Group 2. Semen held one week in a refrigerator (four males) then pooled (three males) and combined with pooled eggs and ovarian fluid (from three females). (Note different males in Groups 1 and 2).

Procedures: On 23 November 1993, four stray fall chinook males were collected (Group 2). Semen from each male was placed in separate plastic bags, sperm motilities were generally estimated (visual estimate of percentage of sperm moving with 100x magnification), and then the bags were oxygenated and refrigerated. The bags were held in a refrigerator at 3.3° C for one week. Sperm motilities were reexamined prior to pooling the samples a week later. A poor quality sample (motility near zero) was discarded after being held one week (male # 369). Semen from the remaining three males were pooled for the refrigerated group (see Appendix G for sperm motilities).

Eggs from three stray females were collected on 30 November and pooled, then separated into 32 lots (eight lots of about 400 eggs each were used in this experiment). Ovarian fluid remained on the eggs at fertilization to duplicate methods used at the hatchery. Also, semen from four males (Group 1; fresh) were collected and their sperm motilities were determined prior to pooling the semen.

Semen was added to the eggs (1 ml of pooled semen per lot of eggs) and stirred by hand. The rest of the egg handling procedures were the same as used by the hatchery (i.e. the egg lots were drained and placed in a 1:100 concentration of iodophor and water for one hour for "water hardening"), and placed in incubator trays. Four reps of each group (fresh vs. refrigerated one week) were evaluated.

Results: Semen held in the refrigerator produced significantly lower fertilization rates ($t=8.02$, $p \leq 0.0015$) than fresh semen, although mean fertilization rates for both groups exceeded 90% (Table 9). This experiment produced mean fertilization rates much higher than we usually obtain with cryopreserved semen.

Conclusions: We had several constraints that limited our ability to conduct these experiments: 1) we did not have divided incubation trays available so each egg lot was placed in a separate tray, 2) we had not devised a plan that would enable us

to collect both eggs and semen during two separate weeks and conduct the experiments without conflicting with our normal spawning duties. Therefore, semen from different males were used during the two week study.

Due to small sample sizes and the fact that we used different males for the comparison of fresh and refrigerated semen samples, we feel it is necessary to duplicate this experiment next year. We are not able to eliminate the possibility that the differences observed were caused by the use of different males in each group. Hopefully we can replicate the experiment next year using the same males in both groups and obtain fertilization rates that are as high as we observed in these tests. If so, holding semen refrigerated for up to a week may be a reasonable management option in the future to improve genetic diversity and maintain fish production for maintenance or enhancements of listed salmon stocks.

Table 9. Fertilization rates of fresh semen and semen held refrigerated for one week (all tests were with 1 ml of semen/lot of eggs). Eggs were counted at the "eyed" stage to determine if they were live or dead.

Semen Treatment	Egg Lot Number	Males Used	Live Eggs	Total Eggs	Percent Fertilization
Fresh	1	P4 [a]	402	404	99.5
	2	P4	388	393	98.7
	3	P4	354	360	98.3
	4	P4	401	401	100.0
				mean	99.14
				std	0.75
Refrigerated [b]	5	P3	381	410	92.9
	6	P3	386	425	90.8
	7	P3	338	374	90.4
	8	P3	350	385	90.9
				mean	91.26
				std	1.14

[a] P4 denotes semen from four stray fall chinook salmon were pooled.
P3 denotes semen from three salmon were pooled (different males than in P4).

[b] The refrigerator was 3.3°C at Lyons Ferry FH.

Experiment Two - Cryopreserved semen tests

We conducted additional fertilization experiments in 1993 at Lyons Ferry FH using cryopreserved semen. Our goals for these experiments were to refine our cryopreservation techniques, determine the effectiveness of the second male (backup male) used in the WDFW spawning protocol, evaluate the 30 second delay between the addition of males during fertilization, and compare the effectiveness of adding the cryopresered sperm "activator" solution after the first or second straw of semen is added to the eggs.

We wanted to compare the 30 second delay between the addition of semen from the primary male and the backup male with a shorter delay of 10 seconds. We were concerned that the egg's micropyle may close or become clogged over time, and using the 10 second delay might increase fertilization rates when using cryopreserved semen (Joseph Cloud, UI, personnel communication[4]). In 1992 almost all cryogenics experiments included the addition of sperm activator (mixture to activate cryopreserved sperm) after the semen from the second (backup) male was placed on the eggs. The addition of activator solution immediately after adding the first straw of thawed semen to the eggs is believed to increase fertilization rates (Paul Wheeler, WSU, personal communication[5]). We wanted to compare fertilization rates when activator is added immediately after semen from the first male with the rates from addition of activator after the second male.

Procedures: On 23 November we began cryopreserving pooled semen from stray fall chinook salmon collected at the hatchery. Semen from five unmarked, unknown origin males was collected for the experiments from voluntary returns to the hatchery. Eggs collected on 30 November from the three stray females used in Experiment One were also used here (24 of the 32 lots, 400 eggs each). Ovarian fluid remained on the eggs during fertilization. We attempted to keep the egg handling and incubation processes as similar as possible after fertilization to those used in routine hatchery operations at Lyons Ferry FH.

Our experiment had eight different study groups, and three replicates per group. Tests B and C included addition of activator immediately after the first straw was added to the eggs.

General cryopreservation procedures were as described in Mendel et al. (1993). Sperm motility was visually estimated for fresh semen from each male prior to being pooled or frozen.

[4] Joseph Cloud, Dept. of Zoology, U of I, Moscow, ID
[5] Paul Wheeler, Dept. of Zoology, WSU, Pullman, WA

We kept the semen and cryogenic extender (dextrose, hen's egg, and DMSO to keep the sperm cells alive during freezing) cool. We put 3 ml of extender in a vial and added 1 ml of pooled semen. We mixed the ingredients individually and froze the straws one at a time by placing them on dry ice, then into liquid nitrogen. This process was continued until all straws were frozen. Each straw was frozen for one week prior to use for fertilization tests.

For Tests B and C the first straw of semen was added to the eggs, and activator solution (enough to cover the eggs) was added immediately as the straw's contents were being mixed with the eggs. The delay between the addition of the first and second straw varied depending on test performed (Test B: 30 second delay, Test C: 10 second delay). For Test D, the same procedures were applied, except the activator was added after the addition of the second straw of semen in group 10. The rest of the egg handling procedures were the same as those mentioned in Experiment One.

Test B: <u>Effectiveness of backup male using 30 second delay</u>

Group 3. Added one straw (4 ml) of semen with extender, then 30 second delay; added one straw containing extender only (3 ml).

Group 4. Added one straw (3 ml) extender only; 30 second delay, then added one straw containing semen with extender.

Group 5. Added one straw (4 ml) of semen plus extender; 30 second delay, added one straw containing semen with extender.

Test C: <u>Effectiveness of backup male using 10 second delay</u>

Group 6. Added one straw (4 ml) of semen with extender, then 10 second delay; added one straw containing extender only (3 ml).

Group 7. Added one straw (3 ml) extender only; 10 second delay, then added one straw containing semen with extender.

Group 8. Added one straw (4 ml) of semen with extender; 10 second delay, added one straw containing semen with extender.

Test D: Comparison of addition of activator immediately vs after backup male

Group 9. Added one straw (4 ml) of semen with extender, added activator immediately; 30 second delay then added backup straw (4 ml) of semen with extender.

Group 10. Added one straw (4 ml) of semen with extender; 30 second delay, added backup straw (4 ml) of semen with extender, then added activator.

Results: Results of tests comparing different time intervals for the addition of the semen or extender indicate that extender may block fertilization after 30 seconds if semen from the first male has not fertilized the eggs (Group 4). However, that does not appear to be the case within 10 seconds. Mean fertilization rates between Groups 4 and 7 were significantly different, and Group 4 produced significantly lower fertilization rates than all other groups. We found no significant difference between Groups 3 and 5, but both of these groups were significantly different than the mean fertilization rate in Group 4. No significant differences were detected among the three groups with 10 second delays between the additions of semen (Table 10). Also, we did not detect significant differences between Groups 3 and 6, but significant differences existed between Groups 5 and 8; all with similar sequences of semen and extender, but different time intervals. Finally, we did not detect a significant difference associated with the timing of the addition of sperm activator (Groups 9 and 10).

Although fertilization rates were variable, fertilization rates tended to decrease from Group 3 to Group 10. Group 5 mean fertilization rates were significantly different than Groups 7, 8, and 10. All these tests were run sequentially so eggs used in Test 3 were held a shorter period than eggs held for Test 4, etc. We do not know if the delay of several hours from egg take to fertilization in Test 10 has contributed to the possible trend towards reduced fertilization rates. This series of tests should be replicated with less elapsed time for all tests to be completed, as well as having the order of the tests randomized.

Table 10. Results of fertilization tests using frozen semen at Lyons Ferry FH to compare the effects of different time intervals for the addition of semen from the backup male, or the addition of sperm activator, November 1993.

Treatment	Egg lot	Primary straw	Secondary straw	Live eggs	Total eggs	Percent fertilization
Test B - 30 Sec Delay Between Straws						
semen then	9	P5 [a]	extender [b]	218	381	57.2
extender	10	P5	extender	218	412	52.9
(Group 3)	11	P5	extender	182	398	45.7
					mean	51.95
					std	5.80
extender	12	extender	P5	67	413	16.2
then semen	13	extender	P5	15	368	4.1
(Group 4)	14	extender	P5	31	403	7.7
					mean	9.33
					std	6.24
semen then	15	P5	P5	347	434	80.0
semen	16	P5	P5	192	406	47.3
(Group 5)	17	P5	P5	298	426	70.0
					mean	65.73
					std	16.74
Test C - 10 Sec Delay Between Straws						
semen then	18	P5	extender	220	429	51.3
extender	19	P5	extender	140	390	35.9
(Group 6)	20	P5	extender	200	449	44.5
					mean	43.91
					std	7.71
extender	21	extender	P5	117	441	26.5
then semen	22	extender	P5	156	450	34.7
(Group 7)	23	extender	P5	185	448	41.3
					mean	34.16
					std	7.39
semen then	24	P5	P5	138	428	32.2
semen	25	P5	P5	216	485	44.5
(Group 8)	26	P5	P5	156	461	33.8
					mean	36.87
					std	6.69

Table 10. (cont)

Treatment	Egg lot	Primary straw	Secondary straw	Live eggs	Total eggs	Percent fertilization
Test D - Activator Timing						
activator	27	P5	P5	115	307	37.5
after 1st	28	P5	P5	164	422	38.9
straw	29	P5	P5	226	417	54.2
(Group 9)					mean	43.50
					std	9.28
activator	30	P5	P5	136	381	35.7
after 2nd	31	P5	P5	170	435	39.1
straw	32	P5	P5	114	413	27.6
(Group 10)					mean	34.13
					std	5.90

[a] P5 denotes five stray fall chinook salmon were pooled together.

[b] Each straw contained 3 ml of frozen extender. No semen was present in these straws.

Conclusions: Tests with cryopreserved semen as the first addition to the eggs (Groups 3, 5, 6, 8, 9, 10) produced fertilization rates that ranged from 27.6 to 80%. Results from these series of tests are generally higher fertilization rates than we have previously obtained with cryopreserved semen, and they give us much encouragement. We will continue to refine and test our techniques in an effort to improve fertilization rates. However, because cryopreserved semen is yielding such low fertilization rates at this time, we feel it is prudent to continue to experiment with other techniques that might be more useful for hatchery management practices. In 1994 we plan to repeat the experiment of holding semen in the refrigerator (Experiment One) and we will also attempt to hold eggs in the refrigerator and determine fertilization rates after one or two weeks.

3.2: Incubation and Rearing

The 1992 brood eggtake was 2,274,557, of which 901,232 eyed-eggs were determined to be Snake River stock, and therefore retained. Cumulative loss after ponding was 24,130 fish. Another 206,775 fish were adipose clipped and tagged with CWT and released as subyearlings in June 1993 (Appendix H). On 31 March 1993, 604,266 fish (50,355 lbs) remained at Lyons Ferry FH.

Total feed conversion rate was 1.3. Additional information regarding this brood year will be included in the 1994 annual report.

The final 1993 brood eggtake was 2,181,879 eggs, of which 1,792,700 were from stray, unknown, or 1989 brood Lyons Ferry origin fall chinook parents and 389,179 eggs were known Lyons Ferry FH origin broodstock. Egg loss was 108,600 from the stray/unknown origin fish (includes 1989 brood fish) and 37,361 eggs from known Lyons Ferry FH origin. A substantial portion (54.8%) of the eggtake was shipped to Klickitat Hatchery because they were from parents of stray, unknown or 1989 brood Lyons Ferry FH origin. Lyons Ferry FH retained all eyed eggs (351,818) of known Lyons Ferry origin broodstock (verified with CWT). Eggs from one 1989 brood Lyons Ferry female was mistakenly fertilized with a known Lyons Ferry male and included with fertilized eggs retained for Lyons Ferry production. Fry loss prior to ponding was 10,555 (3.0%). Total fry ponded were 341,263 (357 lbs).

3.3: Disease Incidence and Prophylaxis

The 1993 broodstock were given flush treatments of formalin 1:7,000) as prophylaxis for Saprolegnia sp. (fungus). Females were injected once with Erythromycin 200 (20 mg/kg of fish) to reduce infection levels of Renibacterium salmoninarum (causative agent of Bacterial Kidney Disease, BKD). Eggs were segregated based on the incidence of BKD in the parents (using ELISA techniques) but no group had a high incidence. Generally this brood has had no fish health problems during the report period.

The 1992 broodstock and their progeny were treated the same as the 1993 broodstock and progeny. This brood had no disease problems.

3.4: Smolt Releases

The fall chinook salmon production goal for Lyons Ferry FH has been to rear 800,000 yearlings for a mid-April release at 10 fpp (80,000 lbs), with roughly half the fish to be transported downstream of Ice Harbor Dam, and half to be released directly from the hatchery. If more eggs were available, they would be reared and released as subyearlings in early June, either on-station or transported downstream by barge. Subyearlings would be transported if Snake River flows and available spills are low. This strategy places the fish in the highest survival potential (Bugert et al. 1991) in an effort to increase the number of returning adult fall chinook salmon to the Snake River. However, this strategy was modified in 1993. In June 1993, WDFW personnel released subyearling fall chinook salmon (1992 brood) directly

into the Snake River from Lyons Ferry FH. This subyearling release was part of a WDFW/tribal agreement. The remaining fall chinook (1992 brood) were released on-station as yearlings in April 1994. Our release strategy may be modified in the near future to accommodate outplanting fall chinook smolts upstream of Lower Granite Dam. However we intend to emphasize yearling releases from Lyons Ferry FH as a means to increase the run size of adult fall chinook salmon into the Snake River as quickly as possible.

3.4.1: 1991 brood

We marked (adipose clip and CWT) the entire 1991 brood prior to release (see Appendix H) to identify salmon known to originate from Lyons Ferry FH upon their return as adults. Approximately one half of the yearling releases were externally marked with a red elastomer tag in the clear tissue behind the left eye. The other half of the fish were to have been marked with a BWT in the left cheek, but they were marked only with adipose clip and CWT. We plan to continue with the use of the elastomer mark for the 1995 release. The rationale for use of this external mark is to enable us to determine origin of returning adults quickly and accurately without killing the fish to extract a CWT.

The 1991 brood yearlings were released in April 1993. On 12 April, 414,997 fish were released on-station, and another 345,021 fish were barged below Ice Harbor Dam on 19 April and released. Hatchery records indicate the average size of this brood was 10-11 fish per pound (fpp).

We sampled all four ponds of fish released directly into the Snake River from Lyons Ferry FH, and from five raceways of the fish that were barged below Ice Harbor Dam. We found mean fork lengths of fish were significantly different (ANOVA, $p<0.05$) among the ponds of fish released directly from the hatchery. The mean length of fish in pond 30 (mean=145.98, SD=16.6, n=65) was much smaller than the mean fish lengths in the other ponds (mean=155.8, SD=16.38, n=391; Figure 3). However, we sampled only 65 fish in pond 30, so it may not have adequately represented the population in the pond. Similarly, mean lengths differed significantly (ANOVA, $p<0.05$) among the five raceways sampled for the barge release group. Fish too small for elastomer tagging had been grouped together in raceways 25, 26, 27 for later tagging. These fish were substantially smaller (mean=129.11 mm, SD=16.79, n=100,) than fish in the other raceways (Figure 4). Also, fish lengths in raceway 17 were not normally distributed and had a higher standard deviation (19.9) than in the other raceways. We believe this may not have been a representative sample. Combined mean fork length from raceways 20, 23 and 28 was 159.5 mm (SD=16.45, n=292; Figure 5).

Mean weight from the only pond of fish we weighed that were released directly to the river was 45.8 g (SD=11.0, n=65). The mean weight of barged fish (raceways 20, 23, 28) was 44.9 g (SD=13.7, n=292).

3.4.2: 1992 brood

On 24 June 1993, 206,775 fish (3,390 lbs) from three raceways were released as subyearlings. The remaining 1992 brood (603,050 fish, 54,823 lbs) were released in April 1994. All released fish were marked (adipose clipped, CWT, and elastomer tagged - see Appendix H). We expanded use of the elastomer tag instead of continuing with the BWT as an externally identifiable tag because the portable wand detectors used to find the BWTs were unreliable.

Mean lengths for the subyearlings were larger in raceway 17 than in raceways 15 or 16. Fish averaged 91.5 mm fork length (SD=9.74, n=100) in raceway 17. Fish length in the other two raceways averaged 86.5 mm (SD=7.67, n=200). Comparisons of mean weights were similar to those of lengths. Combined mean weight for fish in ponds 15 and 16 was 7.23 g (SD=2.015, n=200). Mean weight for fish in pond 17 was 8.99 g (SD=3.013), n=100).

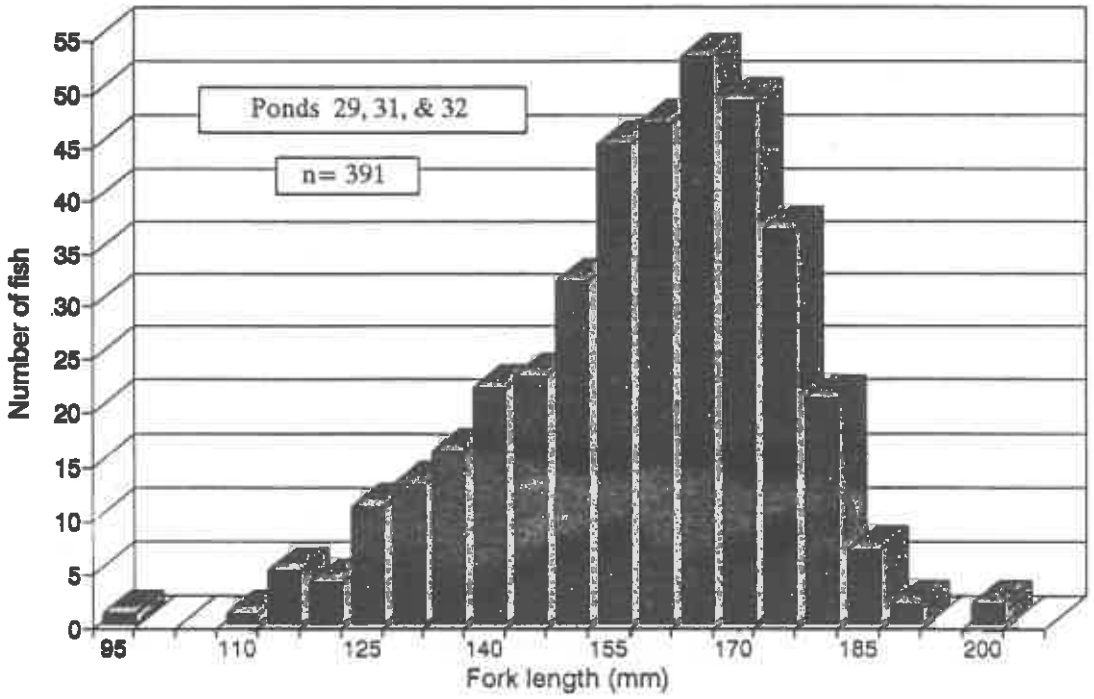

Figure 2. Length frequency distribution of yearling fall chinook salmon (1991 brood year) released directly into the Snake River at Lyons Ferry FH on 12 April 1993.

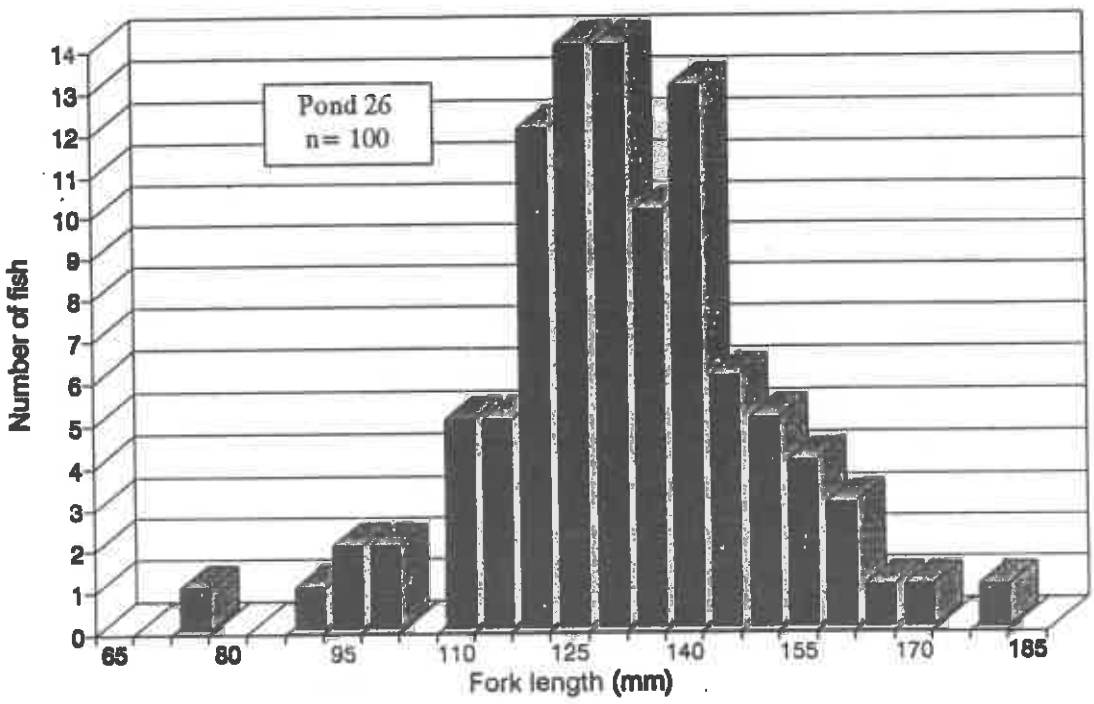

Figure 4. Length frequency distribution of undersized yearling fall chinook salmon (1991 brood year) transported by barge and released downstream of Ice Harbor Dam on 19 April 1993.

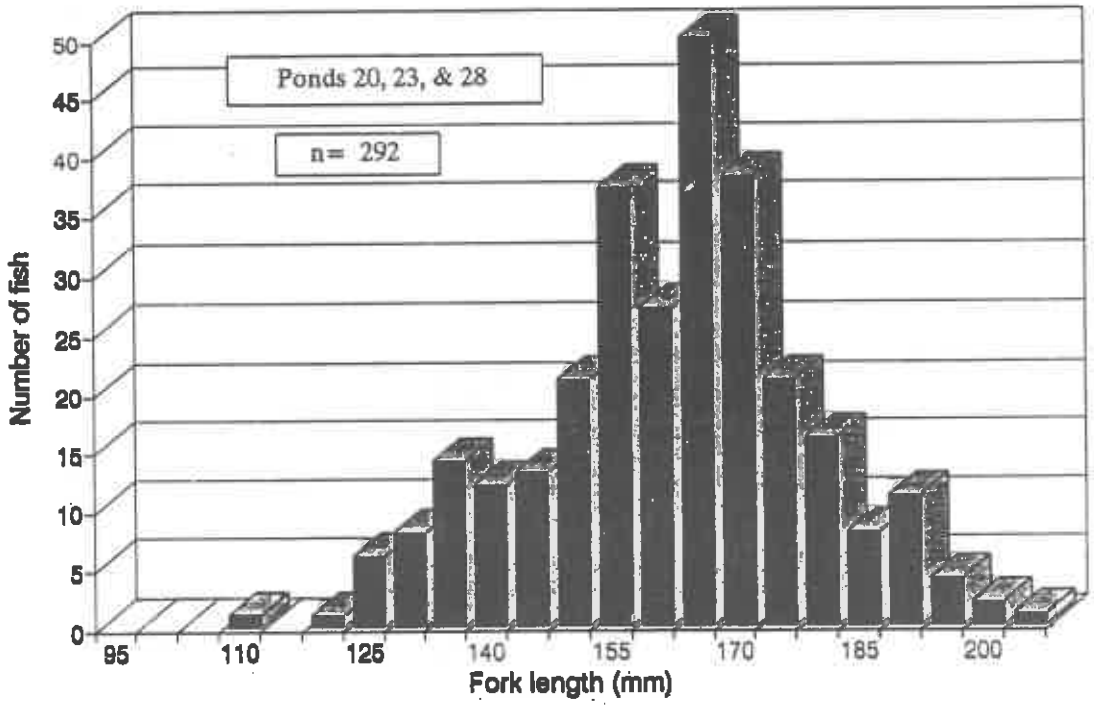

Figure 5. Length frequency distribution of yearling fall chinook salmon (1991 brood year) transported by barge and released downstream of Ice Harbor Dam on 19 April 1993.

SECTION 4: NATURAL PRODUCTION

4.1: Above Lower Granite Dam

4.1.1: Spawning surveys

The U.S. Fish and Wildlife Service (USFWS), Idaho Power Company (IPC), Nez Perce Tribe and the Bureau of Land Management cooperatively funded fall chinook salmon spawning surveys on the Snake River and its tributaries above Lower Granite Dam. These surveys were conducted by the USFWS and IPC and are a continuation of multiple agency cooperative surveys begun several years ago (Mendel et al. 1994).

Fifty-nine redds were observed in the Snake River during weekly helicopter flights between Asotin, Washington, and Hells Canyon Dam in 1993 (Garcia et al. 1994). An additional 68 redds were observed by underwater camera or directly from a boat. Snake River tributaries contained 92 redds (36 in Clearwater, 3 in Salmon, 49 in Grande Ronde and 4 in the Imnaha rivers).

Adjusted total spawning escapement above Lower Granite Dam was 952 adult and 35 jack fall chinook salmon (1,170 - 218 adults, and 39 - 4 jacks). Therefore, we estimate that salmon escapement upstream of Lower Granite Dam included 742 natural origin and 428 hatchery origin adults, 35 natural origin jacks and no hatchery jacks (based on our corrections to counts and wild proportions reported in LaVoy 1994).

The total redds (151) counted from the air in the Snake River and tributaries during 1993 results in a ratio of 7.7 adults per observed redd above Lower Granite Dam. This is lower than in previous years (8.7 in 1992, 14.0 in 1991, 7.4 in 1990, 10.2 in 1989, and 7.8 in 1988). However, sampling effort and methods were not equal for all years. Also, in 1993 an additional 68 redds were observed by underwater camera or from a boat upstream of Lower Granite Dam. Thus, the adult per redd ratio should be reduced to 5.3. Adult per redd ratios above Lower Granite Dam should be reduced further by accounting for fish that did not remain upstream of the dam to spawn (Mendel et al. 1993).

4.1.2: Carcass recovery

Personnel from WDFW, assisted by the USFWS, recovered 36 fall chinook salmon carcasses from the upper Snake River Basin (upstream of Lower Granite Dam) in 1993 (Blankenship, personnel communication)[6]. Ten of these carcasses were recovered from the Clearwater River, plus five from Dworshak Hatchery. Twelve of the carcasses were recovered from the Snake River. The most upstream carcass (RK 382) was recovered less than 18 RK below Hells Canyon Dam. Eight carcasses were recovered from the Grande Ronde River and one carcass was recovered from the lower Imnaha River. Two carcasses were determined to be yearling migrants based on scale patterns. Electrophoresis results may be available from these carcasses in the future with an estimate of the likely origin of each fish (Blankenship personal communication).

4.2: Below Lower Granite Dam

The Tucannon River was surveyed on foot about once a week from 27 October to 8 December 1993. Surveys encompassed the river from the its mouth upstream to Highway 12 (RK 22.0) during most weeks. A survey on 18 and 22 November included the river from Marengo Bridge (RK 39.9) downstream to Highway 12. Survey conditions were fair to good during all survey dates.

Twenty-eight redds, 14 live salmon and 14 carcasses were observed in the Tucannon River during spawning surveys in 1993 (Table 11). Seven redds, and three live salmon were located upstream of Fletcher's Dam (RK 9.6), upstream of Starbuck, in 1993. This is the second year fall chinook salmon have been observed upstream of the dam, which was identified as a passage impediment before 1992 (Mendel et al. 1992). The dam was modified in 1992 to improve salmon passage (Mendel et al. 1994). Spawning ground density was 1.4 redds/mile (2.2 redds/km) downstream of Fletcher's Dam in 1993, compared with 3.8 redds/mile in 1992, 8.8 redds/mile in 1991, 6.6 in 1990, 5.2 in 1989, 2.8 in 1988, 1.7 in 1987 (Mendel et al. 1994, Bugert et al. 1991).

We found 14 carcasses (7 females, 7 males) in the lower Tucannon River. Two additional carcasses (one male and one female) were found during radio tracking activities. Four carcasses were unmarked and radio tagged (two of which were BWT - 1989 brood Lyons Ferry) and one fish was RV clipped (presumably from the Umatilla River). No other marks or tags were identified.

[6] Lee Blankenship, WDFW, Fish Management, Olympia WA

Table 11. Dates, locations surveyed, numbers of redds, and carcasses found during Tucannon River fall chinook salmon spawning surveys in 1993.

Survey date	River kilometer[a]	Redds	Live salmon		Carcasses	
			females	males	females	males
27 Oct	22.0 - 17.7	0				
	17.7 - 9.6	1				
	9.6 - 7.1	0			1	
	7.1 - 3.5	1				
	3.5 - 0.0	0				
4/5 Nov	22.0 - 17.7	0				
	17.7 - 9.6	3	2			
	9.6 - 7.1	2				1
	7.1 - 3.5	0				1
	3.5 - 0.0	0				
10 Nov	22.0 - 17.7	0				
	17.7 - 9.6	0				
	9.6 - 7.1	1	2			
	7.1 - 3.5	1				
	3.5 - 0.0	2				1[b]
17 Nov	20.1 - 17.7	0				
	17.7 - 9.6	2	1			
	9.6 - 7.1	4				
	7.1 - 3.5	1			1[c]	3
	3.5 - 0.0	4	2	1		
18/22 Nov	39.9 - 22.0	0				
24 Nov	22.0 - 17.7	0				
	17.7 - 9.6	1				
	9.6 - 7.1	2	3		1[c]	
	7.1 - 3.5	1				
	3.5 - 0.0	0			1	
30 Nov	7.1 - 3.5	1	1		2	
	3.5 - 0.0	0				1
1 Dec	22.0 - 17.7	0				
	17.7 - 9.6	0				
	9.6 - 7.1	0				
8 Dec	22.0 - 17.1	0				
	17.7 - 9.6	0				
	9.6 - 7.1	0	1			
	7.1 - 3.5	1	1		1	
	3.5 - 0.0	0				
Totals		28	13	1	7[d]	7[d]

[a] River landmarks were as follows: Marengo (RK 39.9) to Highway 12 Bridge (RK 22.0), Kessel's Bridge (RK 17.7) to Fletcher's Dam (9.6), Starbuck Bridge (RK 7.1) to the mouth (RK 0.0).

[b] Right ventral clip.

[c] Blank wire tagged (BWT) and radio tagged.

[d] Additional carcasses of one male and one female with radio tags were found between RK 7.1 and 9.6, but not during spawning surveys.

We surveyed the Palouse River from slackwater to Palouse Falls on 12 and 22 November. No redds, one live salmon and one unmarked female carcass that had not spawned were found. Survey conditions were fair. One redd and two live salmon were seen here in 1992. No redds or adults were observed here in 1991. One redd and three adults were seen here in 1990, and two redds and four adults in 1989 (Mendel et al. 1994).

4.3: Fish Losses Upstream of Ice Harbor Dam

Approximately 27% of fall chinook salmon escapement upstream of Ice Harbor Dam are not accounted for with our standard summation methods (Table 12). This estimated loss is substantially below the 56% that could not be accounted for in 1992. Total salmon accounted for include the differences between the Ice Harbor Dam counts and counts or estimates up to Lower Granite Dam. Possible disposition of these missing fish includes fall back at Ice Harbor Dam, mortality, or spawning in tailraces of the lower Snake River dams. A preliminary count of 12 redds and four redds were observed in 1993 below Lower Granite and Little Goose dams, respectively (Garcia 1994). Also, we have been able to document fall back of fall chinook salmon at Ice Harbor Dam with radio telemetry (Mendel et al. 1993), but improved fall back estimates are needed to account for all salmon passing Ice Harbor.

Table 12. Fall chinook salmon (adults and jacks) accounted for upstream of Ice Harbor Dam, 1993.

	Number of salmon
Counted at Ice Harbor Dam	3,137
Collected at Ice Harbor Dam	- 127
Voluntary returns to Lyons Ferry FH	- 871
Spawning escapement to [a] Tucannon and Palouse rivers	- 85
Counted at Lower Granite Dam	-1,209
Total not accounted for	845

[a] Twenty-eight redds with an estimated 3 adults per redd, plus one adult in the Palouse River.

SECTION 5: CLOSING COMMENTS

We need a reliable sampling method to monitor fish sizes that will assist us with accurately comparing fish size and growth among raceways. We will continue to evaluate sampling methods and fish size for juvenile salmon reared at Lyons Ferry FH. We are not satisfied that current agency hatchery monitoring protocols can provide accurate data for maintenance of fish at the same average size and coefficient of variation in different raceways or ponds. Mark groups should have the same mean size, variance, and fish density to reduce confounding factors for us to evaluate the possible differences in treatment effects (eg. survival rates for different release locations).

Our external tagging program is being revised. We have not been able to consistently detect BWTs in fall chinook salmon. Portable tag detector wands have been very unreliable. They have too limited a range to detect a BWT or CWT in a large salmon with the tag buried deep in the head or elsewhere in the body. Also, often they have given false detections. However, we believe the elastomer tag may have substantial potential for use as an external mark that is detectable on returning adult salmon. We have discontinued use of the BWT and we will continue to evaluate the use of the elastomer mark.

We intend to modify our trapping efforts at the dams. We will no longer trap salmon at Ice Harbor Dam. We have observed a delay of salmon passage at the dam caused by the trapping operations. Also, in recent years few fish have been trapped at a substantial effort and cost. We believe that eliminating trapping at Ice Harbor Dam will reduce the number of stray salmon processed at Lyons Ferry FH because strays that just "dip" into the Snake River, and then return to the Columbia River, will not be transported to Lyons Ferry FH. However, we believe trapping should continue at Lower Granite Dam for at least the next few years for removal of marked, non-Snake River origin salmon. Also, trapping is the only means available to obtain an estimate of the composition of the salmon run passing Lower Granite Dam.

We will count eggs of known Lyons Ferry origin salmon to improve our fecundity estimates at the hatchery. Presently we do not have fecundity estimates by age group or fish size, nor do we have estimates of variability for fecundity. Additionally, we wish to obtain egg size estimates to determine if egg size changes over time.

Our delayed fertilization tests have produced encouraging results. We will expand testing of holding semen in the refrigerator and begin experiments with holding eggs for up to two weeks. Additional testing with cryopreserved semen will also be conducted in 1994.

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APPENDIX A

Washington Department of Fisheries' objectives for the LSRCP Hatchery Evaluation Program. These objectives are interrelated in scope, and are not set in priority.

1) Document juvenile fish output for Lyons Ferry and Tucannon FH. Records will be compiled and summarized by numbers of fish produced at each facility and categorized by stock, size, weight, and planting location. Fish condition and survival rates to planting will be noted.

2) Maintain records of adult returns to the Snake River Basin for each rearing program, categorized by stock and brood year. Data are collected at hatchery racks and spawning grounds by program staff, and compared with escapement to other hatcheries and streams throughout the Columbia River Basin.

3) Document contributions of each rearing program to the various fisheries through coded-wire tag returns. Pacific Coast states, Federal, and Canadian agencies cooperate in returning tags and catch data to the agency of origin. We will attempt to tag sufficient fish to represent each rearing program, and to avoid duplication with contribution studies from other hatcheries.

4) Document downstream movement to Fish Passage Center and National Marine Fisheries Service sampling points on the Snake River and/or lower Columbia River for each rearing program. Program staff will retrieve and summarize data for the Lyons Ferry/Tucannon facilities. Survival rate comparisons for each rearing program will be made. We will use these data to modify hatchery releases to improve downstream migrant survival.

5) Quantify genetic variables that might be subject to alteration under hatchery production strategies. We plan to identify and quantify as many genetic variables as possible in all available Snake River chinook salmon populations. Similar data for other populations which may overlap with Snake River chinook salmon in the lower Columbia River are being developed. These data include qualitative loci analysis through electrophoresis, and quantitative analysis of such factors as meristics, adult and juvenile body morphometry, adult size, run timing, and disease susceptibility.

6) Maintain genetic integrity of indigenous Snake River salmon stocks. Utilization and maintenance of native stocks is an important goal of the LSRCP. We plan to protect these stocks through two strategies: a) identify stray adults at Lyons Ferry and Tucannon FH for removal from the broodstock, and b) mark sufficient smolts prior to release for their proper identification upon return.

7) Determine the success of any off-station enhancement projects, and determine the impact of hatchery fish on wild stock. Our emphasis will be to evaluate changes in natural production in response to hatchery enhancement, and to develop escapement goals based upon optimum natural and hatchery production. We will study interactions at both the juvenile and adult life stages. We may use information obtained from Objective 5 to develop genetic marks (qualitative or quantitative) which could provide techniques for evaluating interactions of wild and hatchery fish in the Tucannon River system.

8) Evaluate and provide management recommendations for major hatchery operational practices, including:

> **A. Optimum size and time-of-release strategies will be determined for both spring and fall chinook salmon.** Existing size, time and return data for other Columbia River Basin programs will be reviewed to determine the release strategies which would have the most likelihood of success. Continual refinement may be necessary in some cases.
>
> **B. Selection and maintenance of broodstock will be done in conformance with LSRCP goals.** Criteria will be developed to program genetic management as determined by Objectives 5 and 6, and in accordance with tribal agreements.
>
> **C. Loading densities, feeding regimes, disease investigations, or other special treatments** on experimental hatchery practices often require mark-release-return groups to facilitate evaluation. Program staff will develop the experimental designs, direct the marking, and analyze the results.

9) Evaluate and provide management recommendations for Snake River salmon distribution programs basin-wide. As Lyons Ferry FH and Tucannon FH goals are reached, eggtake needs to supplement natural production in other streams will be specified. We will set priorities for off-site distribution, based upon current escapement levels, habitat quality, and agreements with co-managing agencies and tribes. Evaluation and improvement of the distribution plan will be an on-going process.

10) Coordinate research and management programs with hatchery capabilities. Advance notice to the hatcheries for specific study groups of marking programs will allow a more efficient use of hatchery facilities and reduce handling and stress on the fish. Research and management programs will be reviewed to determine if the hatcheries will have the capabilities to meet program goals.

Appendix B

Table 1. Numbers of marked (adipose clipped) and unmarked adult, jack, and minijack fall chinook salmon counted and collected at the trap in the south shore fish ladder at Ice Harbor Dam, 1993.[a]

	Number of adult salmon				Number of jack salmon				Number of minijack salmon		
Date	Marked	Unmarked	Total	Hauled	Marked	Unmarked	Total	Hauled	Marked	Unmarked	Total
07-Sep	4	12	16	2	0	1	1	0	0	0	0
08-Sep	2	6	8	2	0	0	0	0	0	1	1
09-Sep	3	17	20	3	0	0	0	0	0	1	1
10-Sep	6	24	30	6	0	2	2	0	0	1	1
11-Sep	5	34	39	5	0	2	2	0	2	0	0
12-Sep	9	27	36	9	1	1	2	1	0	0	0
13-Sep	14	51	65	14	1	4	5	1	0	0	0
14-Sep	19	64	83	19	2	2	4	2	0	0	0
15-Sep	6	31	37	6	1	2	3	1	0	0	0
16-Sep	No trapping										
17-Sep	No trapping										
18-Sep	No trapping										
19-Sep	No trapping										
20-Sep	0	6	6	0	0	2	2	0	0	0	0
21-Sep	1	12	13	1	1	0	1	1	2	0	2
22-Sep	4	22	26	4	0	0	0	0	0	0	0
23-Sep	3	10	13	3	0	0	0	0	1	0	1
24-Sep	4	30	34	4	0	0	0	0	0	0	0
25-Sep	7	13	20	7	0	0	0	0	0	1	1
26-Sep	1	13	14	1	2	1	3	2	0	1	1
27-Sep	0	7	7	0	0	0	0	0	0	0	0
28-Sep	6	32	38	6	3	4	7	3	3	1	4
29-Sep	0	12	12	0	1	0	1	1	0	1	1
30-Sep	No trapping										
subtotal	94	423	517	92	12	21	33	12	8	7	13
01-Oct	No trapping										
02-Oct	No trapping										
03-Oct	No trapping										
04-Oct	2	9	11	2	0	1	1	0	5	1	6
05-Oct	1	3	4	1	0	0	0	0	4	0	4
06-Oct	1	12	13	1	1	0	1	1	2	0	2
07-Oct	2	6	8	2	0	0	0	0	2	0	2
08-Oct	3	3	6	2	1	3	4	0	2	1	3
09-Oct	2	3	5	2	0	1	1	0	0	0	0
10-Oct	2	5	7	2	0	0	0	0	5	0	5
11-Oct	0	9	9	0	0	1	1	0	12	0	12
12-Oct	2	4	6	2	0	0	0	0	10	2	12
13-Oct	0	3	3	0	0	2	2	0	5	2	7
14-Oct	No trapping										
15-Oct	No trapping										
16-Oct	No trapping										
17-Oct	No trapping										
18-Oct	2	5	7	2	1	0	1	1	6	3	9
19-Oct	1	2	3	1	1	0	1	1	5	2	7
20-Oct	1	3	4	1	1	0	1	1	3	0	3
21-Oct	0	3	3	0	0	0	0	0	2	1	3
22-Oct	0	3	3	0	0	0	0	0	7	0	7
23-Oct	0	0	0	0	0	0	0	0	1	0	1
24-Oct	1	6	7	1	0	0	0	0	2	0	2
25-Oct	0	5	5	0	0	0	0	0	7	0	7
26-Oct	0	1	1	0	0	1	1	0	6	0	6
27-Oct	0	1	1	0	0	1	1	0	1	0	1
28-Oct	No trapping										
29-Oct	No trapping										
30-Oct	No trapping										

Appendix B, Table 1. (continued).

Date	Number of adult salmon				Number of jack salmon				Number of Minijack salmon		
	Marked	Unmarked	Total	Hauled	Marked	Unmarked	Total	Hauled	Marked	Unmarked	Total
31-Oct	No trapping										
subtotal	20	86	106	19	5	10	15	4	87	12	99
total	114	509	623	111	17	31	48	16	95	19	112

[a] *WDFW personnel at the trap classified salmon < 30 cm total length as minijacks, salmon 30-<56 cm as jacks, and salmon ≥ 56 cm as adults.*

Appendix B, Table 2. Ice Harbor Dam counts at the fish counting window of marked (adipose clipped) and unmarked fall chinook salmon (adults and jacks), with daily and total counts for the period 12 August to 31 October 1993.

Date	North ladder Adjusted counts[a] marked	unmarked	Daily counts[b]	South ladder Adjusted counts[a] marked	unmarked	Daily counts[b]	Daily total[c]
August							
12	1	5	8	1	4	2	10
13	1	2	4	1	5	6	10
14	0	6	6	4	11	14	20
15	2	1	4	1	5	6	10
16	2	1	4	0	2	2	6
17	1	2	4	1	2	4	8
18	1	1	2	0	2	2	4
19	1	2	4	2	6	8	12
20	0	4	4	2	2	5	9
21	0	1	1	0	8	8	9
22	0	7	7	0	8	8	15
23	0	4	4	0	7	7	11
24	1	5	6	2	6	8	14
25	0	0	0	1	6	7	7
26	0	4	4	4	5	8	12
27	0	2	2	6	14	20	22
28	1	6	7	0	11	11	18
29	1	1	2	1	5	6	8
30	0	0	0	2	10	12	12
31	1	2	4	8	19	28	32
	13	56	77	36	138	172	249
September							
01	1	10	11	4	16	19	30
02	0	4	4	1	18	19	23
03	0	1	1	2	13	16	17
04	0	1	1	6	26	32	33
05	1	2	3	2	16	18	21
06	0	5	5	6	17	23	28
07	1	12	13	1	26	28	41
08	1	10	11	2	20	23	34
09	2	13	16	5	29	34	50
10	5	7	12	24	65	89	101
11	2	14	17	16	90	105	122
12	8	22	30	23	68	91	121
13	5	12	17	24	97	121	138
14	4	12	16	34	102	136	152
15	5	12	17	8	52	60	77
16	4	20	24	6	43	49	73
17	10	22	31	4	19	23	54
18	5	23	28	11	40	50	78
19	5	22	26	8	36	45	71
20	7	6	13	5	23	27	40
21	7	22	29	14	44	59	88
22	5	25	30	11	58	69	99
23	6	25	31	12	40	51	82
24	12	23	35	22	64	85	120
25	6	19	25	7	48	56	81
26	2	19	22	11	35	46	68
27	10	34	43	5	22	26	69

Appendix B, Table 2 (continued).

Date	North ladder Adjusted counts[a] marked	unmarked	Daily counts[b]	South ladder Adjusted counts[a] marked	unmarked	Daily counts[b]	Daily total[c]
28	1	10	11	17	55	72	83
29	4	16	19	6	17	22	41
30	4	23	26	6	19	26	52
	123	446	567	303	1,218	1,520	2,087
October							
01	4	4	7	17	19	36	43
02	1	8	10	14	18	33	43
03	2	5	7	11	18	28	35
04	1	4	5	14	32	47	52
05	4	8	12	17	17	33	45
06	5	7	12	16	38	54	66
07	1	4	5	5	23	27	32
08	4	5	8	12	17	29	37
09	0	10	10	8	6	14	24
10	1	0	1	13	19	32	33
11	2	1	4	13	18	32	36
12	0	5	5	12	13	25	30
13	2	2	5	12	7	19	24
14	2	5	7	11	6	17	24
15	2	2	4	6	5	11	15
16	0	5	5	6	7	14	19
17	1	6	7	6	8	15	22
18	2	2	5	7	7	15	20
19	6	2	8	5	13	18	26
20	1	2	3	5	5	9	12
21	0	0	0	2	8	11	11
22	1	1	2	16	5	20	22
23	4	4	7	8	7	15	22
24	1	1	2	13	19	32	34
25	1	0	1	12	4	16	17
26	1	4	5	5	0	4	9
27	0	4	5	4	5	8	13
28	2	1	4	7	2	10	14
29	0	1	1	5	1	6	7
30	2	1	3	4	2	6	9
31	0	1	2	2	1	3	5
	53	105	162	288	350	639	801
Total	189	607	806	627	1,706	2,331	3,137[f]

[a] Adjusted counts = raw total x 1.2, to account for 10 minutes of each hour not counted. Counting hours were 0400 to 2000 hrs PST.

[b] Daily counts are adjusted counts (adults and jacks) of fall chinook salmon without classifying fish as marked or unmarked. These counts should be considered more accurate for daily total fish passage than the counts of marked and unmarked salmon (Data sums correctly down columns but not across rows because of rounding errors).

[c] The daily total is the daily count of fall chinook salmon (adults and jacks) from annual dam counts report (Corps of Engineers 1994).

[f] Plus 224 minijacks, for a season total of fall chinook salmon of 3,361 fall chinook salmon (2,805 adults and 332 jacks).

Appendix C. Dates of observation at the counting window and numbers of marked (adipose clipped and coded-wire tagged) and unmarked (unclipped, blank wire tagged - BWT) adult and jack fall chinook salmon trapped at Lower Granite Dam and transported to Lyons Ferry Fish Hatchery in 1993

	Adults			Jacks			Adults		minijacks	
	Adipose clipped			Adipose clipped			BWT - unclipped		Adipose clipped	
Date	observed	trapped	hauled	observed	trapped	hauled	trapped	hauled	trapped	hauled
10-Aug [b]							1	1		
12-Aug [b]		1	1				1	1		
14-Aug [b]									1[a]	
17-Aug [b]							1	1		
18-Aug										
19-Aug	5									
20-Aug	1	1	1							
21-Aug	1								1	
22-Aug		1	1				1	1		
23-Aug										
24-Aug									1	
25-Aug							1	1	1	
26-Aug										
27-Aug	1						2	2		
28-Aug		1	1				1	1	1	
29-Aug	1						1	1		
30-Aug							2	2		
31-Aug		1	1				1	1		
subtotal	---	---	---	---	---	---	---	---	---	---
	9	5	5	0	0	0	12	12	5	0
01-Sep										
02-Sep							3	3		
03-Sep	1						1	1		
04-Sep	1	1	1							
05-Sep	1									
06-Sep	1	1	1				2	2	1	
07-Sep										
08-Sep	2						2	2	1	
09-Sep		2	2				4	4		
10-Sep	1						3	3		
11-Sep		1	1				3	3		
12-Sep		1	1				3	3		
13-Sep	2	1	1				4	4		
14-Sep	2	1	1				2	2		
15-Sep	2						3	3		
16-Sep	4	1	1				5	5		
17-Sep	4	3	3				16	16		
18-Sep		1	1				6	6		
19-Sep [c]	4	4	4				7	7		
20-Sep	7	3	3							
21-Sep	5	4	4				1	1		
22-Sep							4	4		
23-Sep	6	3	3				1	1		
24-Sep	2	2	2				2	2		
25-Sep		1	1				5	5		
26-Sep	4	2	2				5	5		
27-Sep	2	3	3				4	4		
28-Sep	2	3	3				3	3		
29-Sep							4	4		
30-Sep	1	2	2				6	6		
subtotal	---	---	---	---	---	---	---	---	---	---
	54	40	40	0	0	0	99	99	2	0
01-Oct	2	2	2				2	2		
02-Oct							2	2		
03-Oct	5	3	3				2	2		
04-Oct	7	6	6		1[a]	1	3	3		

Appendix C, continued.

	Adults			Jacks			Adults		Jacks	
	Adipose clipped			Adipose clipped			BWT - unclipped			
Date	observed	trapped	hauled	observed	trapped	hauled	trapped	hauled	trapped	hauled
05-Oct										
06-Oct	2	1	1				1	1		
07-Oct	1	2	2				2	2		
08-Oct							1	1		
09-Oct		1	1				1	1		
10-Oct	1	1	1				1	1		
11-Oct		1	1							
12-Oct					1	1	1	1		
13-Oct				-1	1	1				
14-Oct	1	1	1							
15-Oct										
16-Oct							1	1		
17-Oct										
18-Oct					1	1	1	1		
19-Oct	1						1	1		
20-Oct	1									
21-Oct	1	1	1				1	1		
22-Oct		1	1							
23-Oct		1	1				1	1		
24-Oct										
25-Oct	1									
26-Oct		2	2							
27-Oct										
28-Oct		1	1							
29-Oct	1									
30-Oct		1	1							
31-Oct										
subtotal	---	---	---	---	---	---	---	---	---	
	24	25	25	-1	4	4	21	21	0	0
01-Nov										
02-Nov										
03-Nov							3	3		
04-Nov										
05-Nov										
06-Nov	1	2	1							
07-Nov		1	1				1	1		
08-Nov	1		1							
09-Nov							1	1		
10-Nov		1	1							
11-Nov	1	1	1				1	1		
12-Nov	1	2	2							
13-Nov		2	2							
14-Nov										
15-Nov							1	1		
16-Nov										
17-Nov										
18-Nov										
19-Nov										
20-Nov	trap closed - cold weather									
subtotal	---	---	---	---	---	---	---	---	---	---
	4	9	9	0	0	0	7	7	0	0
Season Totals	91	79	79	-1	4	4	139	139	7	0

[a] Salmon were observed at the bottom of the ladder and collected midway, hence numbers collected may differ from numbers observed on a given date. Salmon are classified as fall chinook at the counting station from 18 August to 15 December. No marked salmon arrived at the counting window or trap after 30 November.
[b] These fish collected prior to the 18 August start of fall chinook salmon counts.
[c] Had red visual tag behind the left eye.
[d] One of these adult BWT salmon died during transport to Lyons Ferry FH.
[e] One fish not adipose clipped, but with BWT.

Appendix D. Lower Granite Dam counts of marked (adipose clipped) and unmarked fall chinook salmon adults and jacks, and minijacks during the period 18 August to 15 December 1993 [a] (WDFW, unpublished data).

Date	Adjusted totals [b]						Daily counts [c]	
	Adult mark	Jack mark	Mini mark	Adult unmark	Jack unmark	Mini unmark	Adults	Jacks
18-Aug				11			11	
19-Aug	5		4	29			34	
20-Aug	1			12			13	
21-Aug	1		5	13			14	
22-Aug				8			8	
23-Aug				4			4	
24-Aug			1	5			5	
25-Aug			1	7			7	
26-Aug				6			6	
27-Aug	1		2	8			10	
28-Aug				2			2	
29-Aug	1			6			7	
30-Aug				6			6	
31-Aug				5			5	
subtotal	9	0	13	122	0	0	132	0
01-Sep			2	6			10	
02-Sep				10			10	
03-Sep	1		2	6			7	
04-Sep	1			11			12	
05-Sep	1			8	1		10	1
06-Sep	1		4	22			23	
07-Sep				10			10	
08-Sep	2			11			13	
09-Sep				14			14	
10-Sep	1			12	1		13	1
11-Sep				10			10	
12-Sep	2			23	1		25	1
13-Sep	2			20			23	
14-Sep	2		1	29			31	
15-Sep	4			11			14	
16-Sep	4			52			55	
17-Sep				47			47	
18-Sep				53	1		53	1
19-Sep	4			47	2		50	2
20-Sep	7		1	40	6		47	6
21-Sep	5			30			35	
22-Sep			1	26	5		24	5
23-Sep	6		1	18		4	24	
24-Sep	2		1	31	1	1	34	1
25-Sep			2	24	1		24	1
26-Sep	4			18	1		22	1
27-Sep	2		2	12			16	
28-Sep	2			18		4	20	
29-Sep				12	1		13	1
30-Sep	1			23	1	1	26	1
subtotal	54	0	17	654	22	10	714	22
01-Oct	2			36	1		38	1
02-Oct				31			31	
03-Oct	5		1	12	1	1	17	2
04-Oct	7			26	2		34	4
05-Oct				10	1		10	1
06-Oct	2			18	2		20	2
07-Oct	1			17	4		18	4

Appendix D, continued.

Date	Adjusted totals [b] Adult mark	Jack mark	Mini mark	Adult unmark	Jack unmark	Mini unmark	Daily counts [c] Adults	Jacks
08-Oct				10			10	
09-Oct				13			13	
10-Oct	1			7			8	
11-Oct				12	1		12	1
12-Oct			1	11			11	
13-Oct		-1			1			
14-Oct	1			4			5	
15-Oct				6			6	
16-Oct				4	1	1	4	1
17-Oct				2			2	
18-Oct				4			4	
19-Oct	1			1			2	
20-Oct	1		1	1			2	
21-Oct	1		1	6			7	
22-Oct				2			2	
23-Oct				4			4	
24-Oct			1	1	1		1	1
25-Oct	1			2			4	
26-Oct				7			7	
27-Oct				4			4	
28-Oct								
29-Oct	1			1			2	
30-Oct				4			4	
31-Oct				1			1	
subtotal	24	-1	5	257	15	2	283	17
01-Nov				6			6	
02-Nov				2			2	
03-Nov				2			2	
04-Nov				4			4	
05-Nov				4			4	
06-Nov	1						1	
07-Nov				2			2	
08-Nov	1						1	
09-Nov				2			2	
10-Nov				2			2	
11-Nov	1			2			4	
12-Nov	1			1			2	
13-Nov								
14-Nov				1			1	
15-Nov				2			2	
16-Nov				2			2	
17-Nov				2			2	
18-Nov				1		1	1	
19-Nov								
20-Nov								
21-Nov								
22-Nov				1			1	
23-Nov	-1						-1	
24-Nov								
25-Nov				1			1	
26-Nov								

Appendix D, continued.

Date	Adjusted totals [b]						Daily counts [a]	
	Adult mark	Jack mark	Mini mark	Adult unmark	Jack unmark	Mini unmark	Adults	Jacks
27-Nov								
28-Nov								
29-Nov								
30-Nov								
	---	---	---	---	---	---	---	---
subtotal	3	0	0	37	0	1	41	0
December	---	---	---	---	---	---	---	---
subtotal	0	0	0	0	0	0	0	0
Season total [c]	90	-1	35	1,070	37	13	1,170	39

[a] Length criterion used by WDFW is: adults, 56 cm total length or larger; jacks, 30 cm to less than 56 cm; minijacks include only chinook salmon less than 30 cm total length.

[b] Raw total x 1.2 = adjusted total, to account for 10 minutes of each hour not counted. Counting hours were from 0400 to 2000 hrs, except in November and December (1-15), when counts were from 0800 to 1600 hrs PST (WDFW, unpublished data).

[c] Rounding errors: Total for the season was 1,170 including 39 jacks and 55 minijacks (Corps of Engineers, 1994).

APPENDIX E

Coded-wire tag recoveries at Lyons Ferry FH in 1993 (and expansions according to our data to include all fish released from Lyons Ferry FH) . Vol=voluntary return to the hatchery, IH=hauled from Ice Harbor Dam, LG=hauled from L. Granite.

Table 1. Recoveries of Lyons Ferry origin CWTs at Lyons Ferry Hatchery in 1993 (slightly different than reported to PSMFC)

TAG CODES FOUND									NUMBER	NUMBER		EXPANSION	EXPANDED RECOVERY			
VOL	IH	LG	TOTAL	AGENCY	DATA 1	DATA 2	RELEASE SOURCE	BROOD YEAR	TAGGED (T)	AD-ONLY (A)	UNTAGGED (U)	RATE ((T+A+U)/T)	VOL	IH	LG	TOTAL
		1	1	63	2	28	Lyons Ferry	88	113,285	2,076	472,494	5.19	0	0	5	5
28	15	5	48	63	2	31	Lyons Ferry	88	58,988	458	18,708	1.32	37	20	7	64
31	10	5	46	63	2	32	Lyons Ferry	88	58,989	458	18,708	1.32	41	13	7	61
19	7	2	28	63	2	35	Lyons Ferry	88	55,922	496	83,264	2.50	47	17	5	69
19	12	7	38	63	2	37	Lyons Ferry	88	56,597	502	83,264	2.48	47	30	17	94
3			3	63	37	31	Lyons Ferry	91	9,196	197	0	1.02	3	0	0	3
1			1	63	40	12	Lyons Ferry	90	23,954	113	0	1.00	1	0	0	1
	1		1	63	40	13	Lyons Ferry	90	21,137	268	0	1.01	0	1	0	1
15	1	2	18	63	41	18	Lyons Ferry	90	218,110	1,515	0	1.01	15	1	2	18
17	5		22	63	41	20	Lyons Ferry	90	202,674	2,566	0	1.01	17	5	0	22
24	12	3	39	63	41	43	Lyons Ferry	90	111,784	562	0	1.01	24	12	3	39
15	8	2	25	63	41	60	Lyons Ferry	90	110,748	1,345	0	1.01	15	8	2	25
5			5	63	42	9	Lyons Ferry	90	104,820	792	0	1.01	5	0	0	5
11	2		13	63	42	10	Lyons Ferry	90	98,374	560	0	1.01	11	2	0	13
1			1	63	46	18	Lyons Ferry	91	82,796	1,647	0	1.02	1	0	0	1
6			6	63	46	31	Lyons Ferry	91	51,408	415	0	1.01	6	0	0	6
7	1	1	9	63	46	55	Lyons Ferry	91	52,093	104	0	1.00	7	1	1	9
9	1		10	63	46	56	Lyons Ferry	91	49,656	2,449	0	1.05	9	1	0	10
4	1		5	63	46	57	Lyons Ferry	91	53,595	541	0	1.01	4	1	0	5
3			3	63	46	58	Lyons Ferry	91	51,663	312	0	1.01	3	0	0	3
10			10	63	46	59	Lyons Ferry	91	51,371	624	0	1.01	10	0	0	10
4	1		5	63	46	60	Lyons Ferry	91	51,887	104	0	1.00	4	1	0	5
4			4	63	46	61	Lyons Ferry	91	51,370	206	0	1.00	4	0	0	4
8	1		9	63	46	62	Lyons Ferry	91	51,410	310	0	1.01	8	1	0	9
7			7	63	46	63	Lyons Ferry	91	50,892	828	0	1.02	7	0	0	7
6	4		10	63	47	3	Lyons Ferry	91	38,460	139	0	1.00	6	4	0	10
7	3		10	63	47	5	Lyons Ferry	91	38,170	386	0	1.01	7	3	0	10
2	1		3	63	47	6	Lyons Ferry	91	33,994	907	0	1.03	2	1	0	3
4	1		5	63	47	9	Lyons Ferry	91	31,901	987	0	1.03	4	1	0	5
	1		1	63	47	50	Lyons Ferry	87	59,608	299	0	1.01	0	1	0	1
1			1	63	52	4	Lyons Ferry	88	116,935	3,121	214,739	2.86	3	0	0	3

Appendix E: Table 2. continued.

VOL	IH	LG	TOTAL	TAG CODES FOUND AGENCY	DATA 1	DATA 2	RELEASE SOURCE	BROOD YEAR	NUMBER TAGGED (T)	NUMBER AD-ONLY (A)	UNTAGGED (U)	EXPANSION RATE ((T+A+U)/T)	EXPANDED RECOVERY VOL	IH	LG	TOTAL
6	5	12	23	63	55	44	Lyons Ferry	89	123,640	3,662	0	1.03	6	5	12	24
6	3	4	13	63	55	47	Lyons Ferry	89	123,233	3,601	0	1.03	6	3	4	13
9	4	2	15	63	55	49	Lyons Ferry	89	118,104	4,716	0	1.04	9	4	2	16
11	2	2	15	63	55	50	Lyons Ferry	89	119,941	4,787	0	1.04	11	2	2	16
303	102	48	453										380	138	69	587

APPENDIX F

Coded-wire tag recoveries (and expansions according to data reported to Pacific States Marine Fisheries Commission) at Lyons Ferry FH in 1993. Vol = voluntary return to the hatchery, IH = hauled from Ice Harbor Dam, LG = hauled from Lower Granite Dam.

Table 1.. Recoveries of stray CWTs at Lyons Ferry Hatchery in 1993 (data matches PSMFC data).

	TAG CODES FOUND								NUMBER	NUMBER		EXPANSION	EXPANDED RECOVERY			
VOL	IH	LG	TOTAL	AGENCY	DATA 1	DATA 2	RELEASE LOCATION	BROOD YEAR	TAGGED (T)	AD-ONLY (A)	UNTAGGED (U)	RATE ((T+A+U)/T)	VOL	IH	LG	TOTAL
	1		1	6	56	39	Trinity R. spring	89	102,555	6,792	239,567	3.40	0	3	0	3
	1		1	7	0	16	Umatilla River	90	48,301	1,431	49,493	2.05	0	2	0	2
	1		1	7	46	46	Umatilla River	88	52,228	897	744,779	15.28	0	15	0	15
	1	1	2	7	46	47	Umatilla River	88	49,771	3,354	744,788	16.03	0	16	16	32
	1	1	2	7	46	48	Umatilla River	88	52,244	881	744,778	15.27	0	15	15	31
1	1	1	3	7	47	54	Umatilla River	88	25,028	1,589	0	1.06	1	1	1	3
1			1	7	47	57	Umatilla River	88	25,438	0	0	1.00	1	0	0	1
	2	1	3	7	47	58	Umatilla River	88	26,790	281	0	1.01	0	2	1	3
1			1	7	50	34	Columbia R. R-2	88	50,127	252	0	1.01	1	0	0	1
1			1	7	52	25	Umatilla River	90	52,252	269	1,290,790	25.71	26	0	0	26
		4	4	7	52	26	Umatilla River	90	51,728	667	1,290,647	25.96	0	0	104	104
		1	1	7	53	16	Rogue R. spring	90	10,272	0	267,177	27.01	0	0	27	27
	1		1	7	53	22	Umatilla River	89	23,413	534	1,525	1.09	0	1	0	1
	1		1	7	53	26	Umatilla River	89	21,929	546	1,249	1.08	0	1	0	1
2	3	7	12	7	54	3	Umatilla River	89	52,612	914	77,575	2.49	5	7	17	30
2	1	3	6	7	54	4	Umatilla River	89	53,160	401	77,539	2.47	5	2	7	15
	3	1	4	7	54	5	Umatilla River	89	53,248	254	77,597	2.46	0	7	2	10
1	1		2	7	54	49	Umatilla River	90	48,481	1,620	49,861	2.06	2	2	0	4
2		2	4	7	54	50	Umatilla River	90	51,814	128	384	1.01	2	0	2	4
		1	1	7	54	51	Umatilla River	90	52,444	0	262	1.00	0	0	1	1
	1		1	7	55	60	Umatilla River	90	25,720	0	142	1.01	0	1	0	1
		3	3	7	55	62	Umatilla River	90	22,309	986	0	1.04	0	0	3	3
	1	1	2	7	55	63	Umatilla River	90	26,173	246	62	1.01	0	1	1	2
	1		1	7	56	1	Umatilla River	90	24,762	1,697	126	1.07	0	1	0	1
1			1	7	56	2	Umatilla River	90	25,476	1,067	63	1.04	1	0	0	1
	1		1	7	56	54	Columbia R. R-2	90	96,358	4,236	324,350	4.41	0	4	0	4
1			1	23	24	51	Bonneville Bypass	89	29,693	2,286	0	1.08	1	0	0	1
	1		1	23	24	53	Bonneville Bypass	89	30,275	2,331	0	1.08	0	1	0	1

Appendix F: Table 1. continued.

TAG CODES FOUND												EXPANDED RECOVERY			
VOL	IH	LG	TOTAL	AGENCY	DATA 1	DATA 2	RELEASE LOCATION	BROOD YEAR	NUMBER TAGGED (T)	NUMBER AD-ONLY (A)	UNTAGGED (U)	EXPANSION RATE	VOL	IH	LG	TOTAL
	2		2	23	24	56	Bonneville Bypass	89	29,753	2,291	0	1.08	0	2	0	2
1		1	2	23	24	60	Bonneville Bypass	89	29,705	2,287	0	1.08	1	0	1	2
1			1	23	25	57	Bonneville Bypass	89	29,823	2,560	0	1.09	1	0	0	1
1	1		2	23	26	30	Bonneville Bypass	89	29,862	2,558	0	1.09	1	1	0	2
1			1	23	26	31	Bonneville Bypass	89	30,886	656	0	1.02	1	0	0	1
	1		1	23	31	26	Bonneville Bypass	89	29,637	476	0	1.02	0	1	0	1
	1		1	23	31	61	Bonneville Bypass	87	30,120	0	0	1.00	0	1	0	1
17	28	28	73										49	87	198	334

Appendix F: Table 2. Recoveries of Lyons Ferry origin CWTs at Lyons Ferry Hatchery in 1993 (data matches PSMFC data).

TAG CODES FOUND									NUMBER	NUMBER		EXPANSION	EXPANDED RECOVERY			
VOL	IH	LG	TOTAL	AGENCY	DATA 1	DATA 2	RELEASE SOURCE	BROOD YEAR	TAGGED (T)	AD-ONLY (A)	UNTAGGED (U)	RATE ((T+A+U)/T)	VOL	IH	LG	TOTAL
		1	1	63	2	28	Lyons Ferry	88	113,285	2,076	18,244	1.18	0	0	1	1
28	15	5	48	63	2	31	Lyons Ferry	88	58,988	458	18,708	1.32	37	20	7	64
31	10	5	46	63	2	32	Lyons Ferry	88	58,989	458	18,708	1.32	41	13	7	61
19	7	2	28	63	2	35	Lyons Ferry	88	55,922	496	83,264	2.50	47	17	5	69
19	12	7	38	63	2	37	Lyons Ferry	88	56,597	502	83,264	2.48	47	30	17	94
3			3	63	37	31	Lyons Ferry	91	9,196	197	0	1.02	3	0	0	3
1			1	63	40	12	Lyons Ferry	90	23,954	113	0	1.00	1	0	0	1
	1		1	63	40	13	Lyons Ferry	90	21,137	268	0	1.01	0	1	0	1
15	1	2	18	63	41	18	Lyons Ferry	90	218,110	1,515	0	1.01	15	1	2	18
17	5		22	63	41	20	Lyons Ferry	90	202,674	2,566	0	1.01	17	5	0	22
24	12	3	39	63	41	43	Lyons Ferry	90	111,784	562	0	1.01	24	12	3	39
15	8	2	25	63	41	60	Lyons Ferry	90	110,748	1,345	0	1.01	15	8	2	25
5			5	63	42	9	Lyons Ferry	90	104,820	792	0	1.01	5	0	0	5
11	2		13	63	42	10	Lyons Ferry	90	98,374	560	0	1.01	11	2	0	13
1			1	63	46	18	Lyons Ferry	91	82,796	1,647	0	1.02	1	0	0	1
6			6	63	46	31	Lyons Ferry	91	51,408	415	0	1.01	6	0	0	6
7	1	1	9	63	46	55	Lyons Ferry	91	52,093	104	0	1.00	7	1	1	9
9	1		10	63	46	56	Lyons Ferry	91	49,656	2,449	0	1.05	9	1	0	10
4	1		5	63	46	57	Lyons Ferry	91	53,595	541	0	1.01	4	1	0	5
3			3	63	46	58	Lyons Ferry	91	51,663	312	0	1.01	3	0	0	3
10			10	63	46	59	Lyons Ferry	91	51,371	624	0	1.01	10	0	0	10
4	1		5	63	46	60	Lyons Ferry	91	51,887	104	0	1.00	4	1	0	5
4			4	63	46	61	Lyons Ferry	91	51,370	206	0	1.00	4	0	0	4
8	1		9	63	46	62	Lyons Ferry	91	51,410	310	0	1.01	8	1	0	9
7			7	63	46	63	Lyons Ferry	91	50,892	828	0	1.02	7	0	0	7
6	4		10	63	47	3	Lyons Ferry	91	38,460	139	0	1.00	6	4	0	10
7	3		10	63	47	5	Lyons Ferry	91	38,170	386	0	1.01	7	3	0	10
2	1		3	63	47	6	Lyons Ferry	91	33,994	907	0	1.03	2	1	0	3
4	1		5	63	47	9	Lyons Ferry	91	31,901	987	0	1.03	4	1	0	5
	1		1	63	47	50	Lyons Ferry	87	59,608	299	0	1.01	0	1	0	1
1			1	63	52	4	Lyons Ferry	88	116,935	3,121	21,208	1.21	1	0	0	1

Appendix F: Table 2. continued.

TAG CODES FOUND												EXPANDED RECOVERY			
VOL	IH	LG	TOTAL	AGENCY	DATA 1	DATA 2	RELEASE SOURCE	BROOD YEAR	NUMBER TAGGED (T)	NUMBER AD-ONLY (A)	UNTAGGED (U)	EXPANSION RATE ((T+A+U)/T)	VOL	IH	LG	TOTAL
6	5	12	23	63	55	44	Lyons Ferry	89	123,640	3,662	0	1.03	6	5	12	24
6	3	4	13	63	55	47	Lyons Ferry	89	123,233	3,601	0	1.03	6	3	4	13
9	4	2	15	63	55	49	Lyons Ferry	89	118,104	4,716	0	1.04	9	4	2	16
11	2	2	15	63	55	50	Lyons Ferry	89	119,941	4,787	0	1.04	11	2	2	16
303	102	48	453										378	138	65	581

APPENDIX G

Motility of males used in fertilization experiments, November 1993.

Date Collected	Fish Number	Motility (%) 23 Nov.	Motility (%) 30 Nov.	Comments/Use
11/23/93	3	95	--	frozen
11/23/93	1	70	--	frozen
11/23/93	2	70	--	frozen
11/23/93	346	95	--	frozen
11/23/93	369	90	5	jack [a], frozen
11/23/93	366	90	70	refrigerated
11/23/93	361	85	70	jack, refrigerated
11/23/93	0	95	90	refrigerated
11/30/93	S4	--	90	fresh
11/30/93	S3	--	95	fresh
11/30/93	S1	--	90	fresh
11/30/93	S2	--	95	fresh

[a] Some semen from this jack was frozen for 11/30 and the remainder was held in the refrigerator. After one week in the refrigerator some droplets of blood were noted inside the bag. The sample did not appear bloody when it was collected. This semen was not used to fertilize any eggs for the refrigerated group because of poor motility after one week.

APPENDIX H

Lyons Ferry fall chinook salmon releases and number tagged (coded-wire tagged) or untagged by release year and type since its inception (1985).

Release year Age (brood yr)	Release type[a]	Date[b]	Number CWT	CWT code[c]	Adipose only marked	Number untagged	lbs	fish/ lb
1985								
yearling (83)	direct	4/17	250,831	21/52	1,769	235,125	48,773	10
			83,611	32/18	589	78,375	16,468	10
			334,442		2,358	313,500	65,241	
subyearling (84)	direct	6/6	78,064	32/27	235	100,900	2,354	76[d]
			78,504	32/28	236	101,400	2,369	76[d]
			78,417	32/26	236	101,400	2,367	76[d]
			234,985		707	303,700	7,090	
1986								
yearling (84)	direct	4/2&3	258,355	28/41	1,821	181,500	55,210	8
		4/4&8				40,274[e]	5,035	8
						181,500	22,688	8
			258,355		1,821	403,274	82,933	
subyearling (85)	direct	6/10	49,325	36/38	468		859	58
			49,325	36/39	468		859	58
			49,325	36/40	468		859	58
			49,325	36/41	468		859	58
			49,325	36/42	468		859	58
						81,003[e]	1,157	70
						1,212,200	13,933	87
			246,625		2,340	1,293,203	19,385	
subyearling (85)	barge	6/13	49,112	36/33	366		900	55
			49,112	36/34	366		900	55
			49,112	36/35	366		900	55
			49,112	36/36	367		900	55
			49,112	36/37	366		900	55
			245,560		1,831		4,500	
1987								
yearling (85)	direct	4/14	152,479	41/56	1,075		25,592	6
						39,906[f]	4,425	9
						36,300	3,862	9
						653[g]	69	9
			152,479		1,075	78,859	33,948	
yearling (85)	barge	4/16	156,036	41/59	470		22,682	7
subyearling (86)	direct	6/1	126,076	42/59	2,836		2,686	48
			125,570	42/61	2,824		2,675	48
						80,484[h]	1,059	76
			251,646		5,660	80,484	6,420	
subyearling (86)	barge	6/2	128,283	44/01	1,034		1,821	71
			127,715	42/62	1,030		1,836	71
						78,200	745	105
			255,998		2,064	78,200	4,402	
1988								
yearling (86)	direct	4/14	58,970	44/13	237	64,369	15,447	8
			58,735	44/11	236	64,112	15,385	8
						39,952[i]	4,994	8
			117,705		473	168,433	35,826	
yearling (86)	barge	4/19	60,523	44/07	213		7,592	8
			60,281	44/08	212		7,562	8
			120,804		425		15,154	

Appendix H. continued.

Release year Age (brood yr)	Release type[a]	Date[b]	Number CWT	CWT code[c]	Adipose only marked	Number untagged	lbs	fish/ lb
subyearling (87)	direct	6/1	124,345	52/14	374	839,682	18,196	53
			124,394	52/16	374	840,018	18,202	53
						79,961[i]	1,509	53
			248,739		748	1,759,661	37,907	
subyearling (87)	barge	6/8	122,850	52/11	2,125	21,246	2,759	53
			122,899	52/13	2,125	21,254	2,760	53
						271,500	3,879	70
						886,300	8,953	99
						1,114,000	8,984	124
			245,749		4,250	2,314,300	27,335	
1989								
yearling (87)	direct	4/14	57,594	47/56	58	69,249	12,690	10
			57,756	47/52	58	69,443	12,725	10
						39,044[j]	3,904	10
			115,350		116	177,736	29,319	
yearling (87)	barge	4/20	59,609	47/55	299		5,991	10
			59,608	47/50	299		5,991	10
			119,217		598		11,982	
subyearling (88)	direct	6/8	113,285	02/28	2,076	18,244	1,485	90
			113,193	02/26	2,075	18,244	1,483	90
						828,485	8,663	96[k]
						39,991[l]	580	69
						40,025[l]	580	69
			226,478		4,151	944,989	12,791	
subyearling (88)	barge	6/14	117,168	52/07	3,128	21,207	1,887	75
			116,935	52/04	3,121	21,208	1,884	75
						173,595	2,755	63
						125,091	1,061	118
						88,378	982	90
			234,103		6,249	429,479	8,569	
1990								
yearling (88)	direct	4/16	56,597	02/37	502	83,264	15,596	9
			55,922	02/35	496	83,264	15,520	9
			112,519		998	166,528	31,116	
yearling (88)	barge	4/17	58,988	02/31	458	18,708	7,105	11
			58,989	02/32	458	18,708	7,105	11
			117,977		916	37,416	14,210	
subyearling (89)	direct	6/6	123,233	55/47	3,601		2,306	55
			123,640	55/44	3,662		2,315	55
		6/6				79,676[m]	1,035	77
		6/6				303,255[n]	4,332	70
		6/18				793,349[n]	10,868	73
		6/25				604,205[n]	8,757	69
		7/2				534,174[n]	7,524	71
		7/2				768,312[n]	10,821	71
		7/12				227,413[n]	2,707	84
			246,873		7,263	3,310,384	50,665	
subyearling (89)	barge	6/8	118,104	55/49	4,716		1,981	62
			119,941	55/50	4,787		2,012	62
			238,045		9,503		3,993	

Appendix H. continued.

Release year / Age (brood yr)	Release type[A]	Date[B]	Number CWT	CWT code[C]	Adipose only marked	Number untagged	lbs	fish/ lb
1991								
subyearling (90)	barge	6/2	111,784	41/43	562		2,293	49
			110,748	41/60	1,345		2,288	49
			222,532		1,907		4,581	
1992								
yearling (90)	direct	4/15	104,820[D]	42/09	792[D]		13,201	8
						5,125[F]	641	8
						5,207[G,I]	651	8
			4,386[I]	43/20			548	8
			218,110[J]	41/18	1,515[J]		27,453	8
			23,954[K]	40/12	113[K]		3,008	8
			351,270		2,420	10,332	45,502	
yearling (90)	barge	4/17	98,374[L]	42/10	560[L]		10,993	9
			202,674[M]	41/20	2,566[M]		22,804	9
			21,137[N]	40/13	268[N]		2,378	9
			322,185		3,394		36,175	
1993								
yearling (91)	direct	4/12	51,663[V]	46/58	312[V]		4,725	11
			51,371	46/59	624		4,727	11
			51,370[W]	46/61	206[W]		4,689	11
			51,887	46/60	104		4,726	11
			51,408	46/31	415		4,711	11
			52,093[X]	46/55	104[X]		4,745	11
			50,892	46/63	828		4,702	11
			51,410[X2]	46/62	310[X2]		4,702	11
			412,094		2,903		37,727	
yearling (91)	barge	4/19	9,196[Y]	37/31	197[Y]		1,044	9
			82,796	46/18	1,647		4,691	18
			31,901	47/09	987		3,289	10
			33,994[Z]	47/06	907[Z]		3,490	10
			49,656[Z1]	46/56	2,449[Z1]		5,211	10
			53,595	46/57	541		4,921	11
			38,460[Z2]	47/03	139[Z2]		3,509	11
			38,170	47/05	386		3,505	11
			337,768		7,253		29,660	
subyearling (92)	direct	6/24	203,177	50/12	3,598		3,390	61
1994								
yearling (92)	direct	4/18	53,276[A]	52/24	53	168	4,863	11
			49,248[A]	49/20	49	155	4,496	11
			51,702[B]	49/18	312		4,729	11
			51,702[B]	49/17	312		4,729	11
			51,258[C]	49/15	273		4,685	11
			51,168[C]	49/12	273		4,676	11
			308,354		1,272	323	28,178	
		4/19	50,481[D]	47/63	1,831	104	4,765	11
			51,160[E]	47/60	726		4,717	11
			51,091[F]	52/29	1,149		4,749	11
			51,260[O]	52/27	413	104	4,707	11
			51,316[Q]	47/58		206	4,684	11
			33,736[H]	52/63	135		3,074	11
			289,044		4,254	414	26,696	

Appendix H. continued.

[a] Barged fish were released immediately downstream of Ice Harbor Dam.
[b] Release date (month/day).
[c] All tag codes start with agency code 63.
[d] Mean length of marked (67 fpp) and unmarked fish (85 fpp) differed.
[e] Freeze branded (RA-7k-1 in April 1986) and branded RA-T-3 in June.
[f] Freeze branded LA 7N-1.
[g] PIT tagged (Passive Integrated Transponder) by NMFS for migration timing.
[h] Freeze branded LA S-1.
[i] Freeze branded RA 7S-1 for April release and RD R-1 for June.
[j] Freeze branded LD 7U-1 (13,033), LA 7U-1 (13,017) and LA 7U-3 (12,994).
[k] The average of six groups of different sized fish.
[l] Freeze branded LAU-1 (39,991) and branded LAU-3 (40,025).
[m] Freeze branded RA U-1 (39,813) and RA U-3 (39,863) and all BWT in the snout.
[n] All with blank wire tags (BWT) in the snout.
[o] 50.4% have red filament tags behind left eye and 49.6% have BWT in left cheek.
[o1] BWT in left cheek.
[p] All with red filament tags behind left eye (VT).
[q] 49.4% have VT behind left eye and 50.6% have BWT in left cheek.
[r] 49.7% have VT behind left eye and 50.3% have BWT in left cheek.
[s] 49.6% have VT behind left eye and 50.4% have BWT in left cheek.
[t] 51.7% have VT behind left eye and 48.3% have BWT in left cheek.
[u] 49.8% have VT behind left eye and 50.2% have BWT in left cheek.
[v] 90.4% retained red elastomer tag behind left eye.
[w] 91% retained red elastomer behind left eye.
[x] 88.4% retained red elastomer behind left eye.
[x2] 96% retained red elastomer behind left eye.
[y] high density ELISA (BKD) group.
[z] 94.2% retained red elastomer behind left eye.
[z1] 95% retained red elastomer behind left eye.
[z2] 90.3% retained red elastomer behind left eye.
[A] 97.5% retained red elastomer behind left eye.
[B] 96.0% retained red elastomer behind left eye.
[C] 96.8% retained red elastomer behind left eye.
[D] 93.0% retained yellow elastomer behind left eye.
[E] 96.2% retained yellow elastomer behind left eye.
[F] 95.2% retained yellow elastomer behind left eye.
[G] 94.4% retained yellow elastomer behind left eye.
[H] 96.1% retained yellow elastomer behind left eye.