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LYONS FERRY FALL CHINOOK SALMON HATCHERY EVALUATION PROGRAM

LOWER SNAKE RIVER
COMPENSATION PLAN
Hatchery Program

Washington Department of Fisheries

1991 Evaluation Report

AFF 1/LSR-92-12

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LYONS FERRY FALL CHINOOK SALMON HATCHERY PROGRAM

1991 EVALUATION REPORT

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ABSTRACT

This report provides a synopsis of activities from 1 April 1991 to 31 March 1992 by the Washington Department of Fisheries' Lower Snake River Hatchery Evaluation Program. This work was completed with Fiscal Year 1991 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. The LSRCP goal for adult returns of salmon from this hatchery is 18,300 Lyons Ferry origin fall chinook salmon back to the project area (past Ice Harbor Dam).

Fall chinook salmon broodstock at Lyons Ferry FH in 1991 was estimated during collection to consist of 1261 adults (age 3+) and 746 jacks. Fish were obtained from three sources, voluntary returns to the FH ladder, and fish trapped and transported to Lyons Ferry FH from both Ice Harbor and Lower Granite dams. We obtained 361 adults and 71 jacks from trapping operations at Ice Harbor Dam, 37 adults from Lower Granite Dam, and 863 adults and 675 jacks through rack returns. Additionally, roughly half of the CWT jacks (19 jacks plus three adults collected as jacks), and 94 BWT jacks were collected at Lower Granite Dam to determine stray rates. Broodstock collection at Lyons Ferry FH and Ice Harbor Dam accounted for 32.7% of the total fall chinook salmon escapement above Ice Harbor Dam. Another 0.6% of escapement was collected at Lower Granite Dam. Only coded-wire tagged (CWT), or blank wire tagged (BWT), salmon were collected at the dams.

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 1991 from outside the basin, as in 1990. Broodstock collected at Ice Harbor Dam had a 32% incidence of strays from the Umatilla River. Umatilla strays comprised 25% of the fall chinook salmon collected at Lower Granite Dam, and 16% of salmon that voluntarily returned to Lyons Ferry FH. Stray fall chinook salmon from Bonneville Dam comprised 15% of the fish that passed Ice Harbor Dam, 1% at Lower Granite Dam, and 2% of the fish that voluntarily returned at Lyons Ferry FH.

Broodstock at Lyons Ferry FH in 1991 was dominated by age 3, 4, and 5 year old fish. Age composition for Lyons Ferry origin salmon in 1991 was 6% age 2, 31% age 3, 32% age 4, 28% age 5, and 3% age 6. Sex ratio was 0.74 female/male. Most large fish in the broodstock were strays.

Fall chinook salmon were spawned at Lyons Ferry FH from 15 October to 10 December. Peak of spawning was 12 November. We read the CWT 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. The resultant eggtake was 2,994,676 (plus 9,000 eggs to WSU). Progeny from all stray and unmarked salmon were transferred to Klickitat FH (1,917,215 eyed eggs).

We were involved in a cooperative study of salmon sperm cryopreservation techniques with Washington State University (WSU) researchers. Test results suggest that cryopreserved semen should be stored long-term in liquid nitrogen (-196 °C), and that fertilization rates declined substantially for semen stored long-term in an ultralow freezer (-80 °C). We also used cryopreserved semen for fertilization of eggs from four Lyons Ferry origin females because of a shortage of ripe males in 1991. However, mean egg loss was 94.4%. We intend to conduct further experiments next year in an effort to improve our techniques, and enable us to successfully incorporate cryopreservation of semen into hatchery operations.

Lyons Ferry FH barged 224,439 subyearling (1990 brood) fall chinook salmon for release below Ice Harbor on 2 June 1991. All fish were adipose clipped and CWT.

We collected several samples for fall chinook salmon stock profile determination in 1991. Genetic sampling included 100 fish each from Lyons Ferry origin broodstock, unknown origin voluntary returns to Lyons Ferry FH, and mid Columbia fall chinook salmon from Priest Rapids FH. We also measured morphometric (67 fish) and meristic (50 fish) characteristics of juvenile salmon at Lyons Ferry FH. Analysis of these data will be reported in subsequent reports.

We were involved in a cooperative effort to monitor natural spawning in all streams upriver of Lower Granite Dam that are believed to be used by fall chinook salmon adults. Spawning ground counts in the Clearwater, Grande Ronde, Imnaha, and mainstem Snake rivers in 1991 totaled 4, 0, 4, and 32 redds, respectively. Although thirty-two redds were observed during index surveys (similar dates as in 1990) of the Snake River, 42 redds were observed during weekly counts in 1991. After broodstock collections at Lower Granite Dam, 274 adults passed the dam, providing an adult/redd ratio of about 18. This is the highest adult/redd ratio we have observed since we began redd counts in 1988.

We monitored fall chinook salmon spawning below Lower Granite Dam as well. We observed a minimum of 50 redds (5.5 redds/km) in the lower Tucannon River in 1991. We recovered 20 carcasses, four of which were marked. All four marked fish were strays; three from the Umatilla River Basin, and one from the Bonneville Dam Bypass Study. We are unable to account for approximately 2,500 adult salmon between Ice Harbor Dam and Lower Granite Dam. This estimate includes fish entering Lyons Ferry FH and spawning in the Tucannon River.

We provide eight recommendations to improve management of fall chinook salmon in the Snake River basin.

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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 is currently operating. A partial objective of this hatchery is to compensate for the loss of 18,300 adult fall chinook salmon, Snake River stock (USACE 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 objectives.

The Washington Department of Fisheries (WDF) 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 1992). A specific list of the evaluation program's objectives is outlined in Appendix A.

In June 1991, the National Marine Fisheries Service (NMFS) concluded that Snake River fall chinook salmon face a high risk of extinction if factors affecting the population remain unchanged (Waples et al. 1991). Specific factors include, but are not limited to: 1) spatial and temporal abundance in relation to historical records, 2) possible threats to genetic integrity, and 3) natural and anthropogenic factors that affect survival and abundance, both short-term and long-term. The stochastic model developed by NMFS predicted a high likelihood of extinction if present conditions continue. This conclusion was prompted by a review of the status of this stock for inclusion as "threatened" or "endangered" under the U.S. Endangered Species Act (ESA) of 1973, as amended (U.S.C. 1531 et seq.). On 22 April 1992, NMFS listed Snake River fall chinook salmon as threatened.

This report briefly summarizes activities performed by the Washington Department of Fisheries' (WDF) LSRCP Fall Chinook Salmon Evaluation Program for the period 1 April 1991 through 31 March 1992. We will continue to evaluate these data and we expect to present additional results of the 1991 data in subsequent annual reports. Separate reports describe the 1991 fall chinook salmon trapping activities at lower Snake River dams (Mendel et al. 1992a) and our fall chinook salmon Radio Telemetry Study (Mendel et al. 1992b). Results of activities associated with the WDF Spring Chinook Salmon Evaluation Program for the 1991 Fiscal Year contract period were published separately (Bugert et al. 1992).

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 is 101,800 pounds (9,162,000 subyearling smolts at 90 fish per pound). Lyons Ferry FH has a single pass wellwater system through the incubators, two adult holding ponds, and 28 raceways. Salmon[1] are hatched and reared at Lyons Ferry FH and either released on-station or barged downstream of Ice Harbor Dam and released. Broodstock are derived from various sources (Section 2). The first year of adult (3+ year old) returns to the hatchery was 1986.

SECTION 2: BROODSTOCK MANAGEMENT

2.1: Broodstock Collection

Lyons Ferry FH has been building its broodstock since the facility became operational in 1984. Salmon are obtained from two primary sources: 1) returns to the Lyons Ferry FH ladder, and 2) adults trapped at Ice Harbor Dam for transport 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). In 1991, broodstock collection from these two sources was 32.7% of total estimated escapement (1,970 of 6,026) to the project area (Table 1). An ancillary source of broodstock in 1990 and 1991 was the NMFS upstream migrant trap at Lower Granite Dam (Section 2.1.3), which collected another 0.6% of the total fall chinook escapement to the project area in 1991. Numbers of broodstock collected are based on estimates at the time of collection.

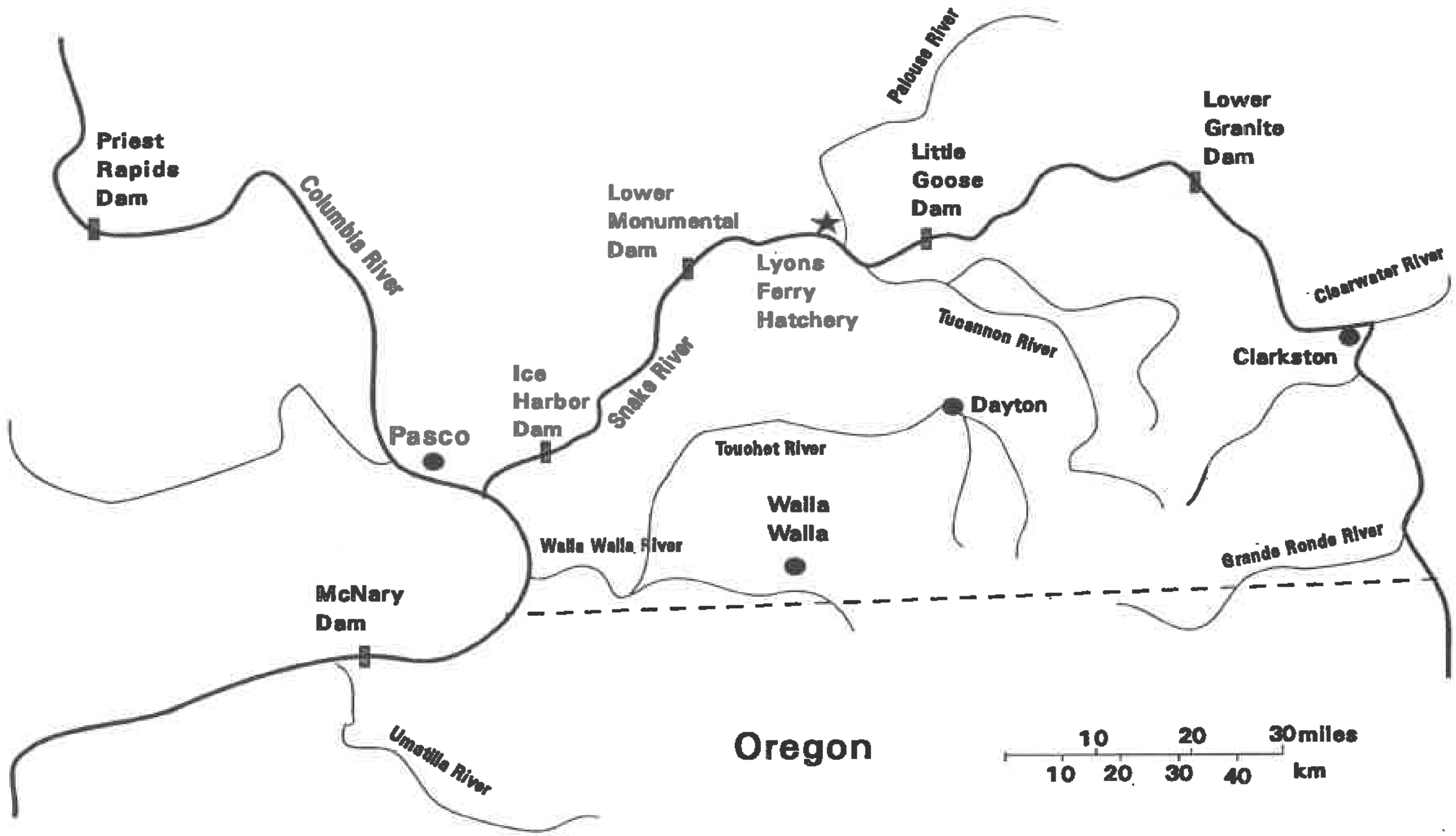

Figure 1. Lower Snake River Basin, showing the location of Lyons Ferry Fish Hatchery and major tributaries in the area.

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). During 1991, 28.6% of adult broodstock were obtained from Ice Harbor Dam and 68.4% were collected as voluntary returns to Lyons Ferry FH (based on estimates at the time of collection). The remaining broodstock were obtained from Lower Granite Dam (3.0%).

2.1.1: Voluntary returns to Lyons Ferry Fish Hatchery

In general, numbers of fall chinook salmon returning to the Lyons Ferry FH ladder vary yearly with run size at Ice Harbor Dam (Figure 2). A total of 863 adults and 675 jacks[1] voluntarily returned to Lyons Ferry FH in 1991. Duration of returns was 83 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 2). A strong peak of voluntary returns did not occur in 1991, but instead broodstock collection had several minor peaks.

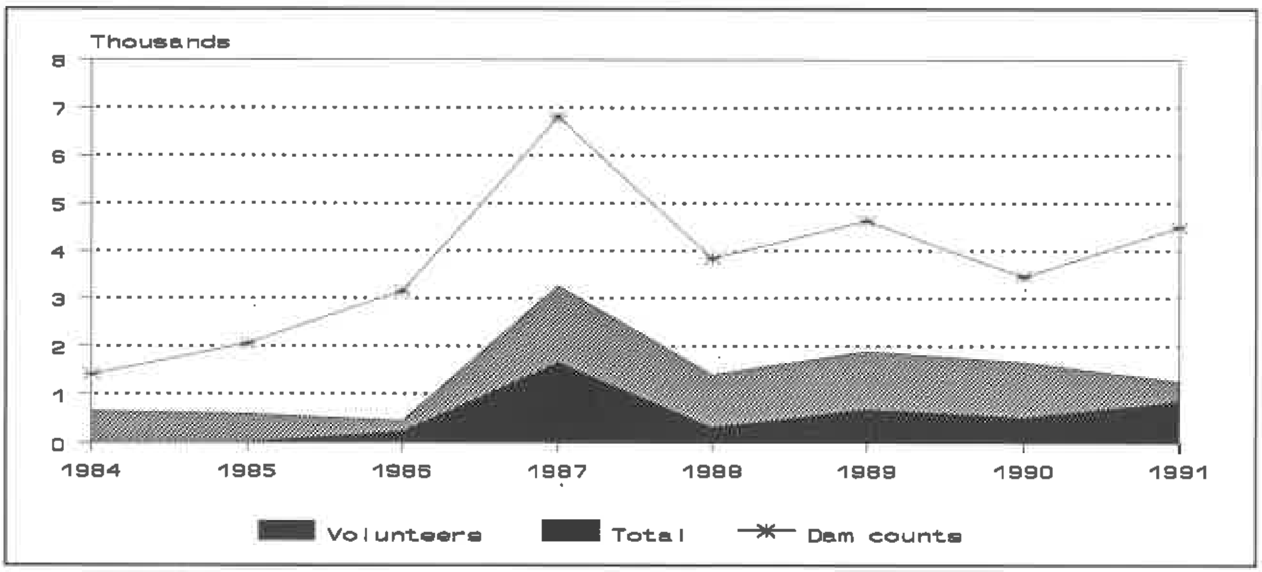

Figure 2. Adult fall chinook salmon counts at Ice Harbor Dam compared with voluntary returns to Lyons Ferry FH, and total broodstock collected from both Ice Harbor Dam (trapped) and Lyons Ferry FH, 1984-1991.

[1] 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 Ice Harbor and Lower Granite dams, and Lyons Ferry FH was larger than 61 cm total length in 1991. Coded-wire tags or scale analysis has revealed that many of these salmon are adult fish (age 3+) of either sex.

2.1.2: Ice Harbor Dam trapping

Since 1984, all salmon trapped at Ice Harbor Dam have been trucked to Lyons Ferry FH (Table 3). An average of 28.5% of adults counted at Ice Harbor Dam have been taken for broodstock from 1984-1990. However, only adipose-clipped salmon were trapped in 1991. A total of 361 adults and 71 jacks were trapped and hauled to Lyons Ferry FH, representing 7.2% of the total run of fall chinook salmon adults passing Ice Harbor Dam in 1991 (Table 1). Actual trap efficiency for the period of operation was 25.2%. Fish were collected from the south shore fish ladder where 91.3% (5,652 of 6,192) of all fall chinook salmon were counted in 1991 (Mendel et al. 1992a).

2.1.3: Lower Granite Dam trapping

Adult collections At our request, NMFS personnel collected marked (coded-wire tagged) salmon adults at the trap in the south shore fish ladder at Lower Granite Dam. Trapping occurred from 16 September to 7 November 1991. The trap was closed prior to 10 September because of high water temperatures. Adults were given a numbered jaw tag and transported in a 1,200 L aerated non-refrigerated tank truck to Lyons Ferry FH. A total of 37 adults were collected in 1991, which is 39.4% of the marked salmon that passed the counting window during the fall chinook salmon passage period (18 August to 15 December; Mendel et al. 1992a). An additional three adult salmon were collected as jacks (<61 cm) for determination of stray rates. Collection of adult salmon enabled us to: 1) monitor adult salmon composition at the dam (only previously done in 1990), 2) collect fish for a spawning program designed to remove marked stray salmon, and 3) supplement Lyons Ferry FH eggtake.

The 1991 coded-wire tag (CWT) recovery data were used to estimate run composition in the Snake River spawning grounds above Lower Granite Dam (LaVoy 1992). He estimated 49.9% of the run of adults (630) to Lower Granite Dam were of hatchery origin. This included the 40 adults removed at the trap for broodstock collection, or during sampling of jacks. Therefore, the total number of hatchery origin adult fall chinook salmon passed above Lower Granite Dam was estimated to be 274.

Table 1. Contribution of 1984-1991 fall chinook salmon returns to Lyons Ferry Fish Hatchery (FH) from Ice Harbor Dam, Kalama Falls FH, to the Lyons Ferry FH ladder, and from Lower Granite Dam. Values are compared to the total counts at Ice Harbor Dam (minijacks of ≤ 30 cm total length are not included here).

Year	Collection point	Number collected adults	Number collected jacks	Ice Harbor Dam count adults	Ice Harbor Dam count jacks [a]
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 [d]		
	Lower Granite Dam	37	0		

[a] Classification of adults and jacks is based upon size at collection.
[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] The actual number of salmon accounted for at Lyons Ferry FH was 404 adults and 18 jacks, plus one adult from Lower Granite Dam that lost its jaw tag and couldn't be identified (423 total).

Table 2. Voluntary returns of fall chinook salmon to Lyons Ferry Fish Hatchery, duration of returns, and peak day of returns from 1986 through 1991.

Year	Number of returns adults	jacks	Duration of returns	Peak return day date	number
1986	245	1,125	5 Sep - 15 Nov	18 Sep	24
1987	1,645	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 [a]	54

[a] Other minor peak returns of 51, 111, and 49 salmon occurred on 16 and 22 October, and on 6 November 1991. The peak on 22 October was a collection following a weekend when the trap was not checked.

Table 3. Numbers of fall chinook salmon trapped at Ice Harbor Dam and hauled to Lyons Ferry Fish Hatchery, duration of trapping, and peak day of trapping from 1984 through 1991.

Year	Number trapped adults	jacks	Duration of trapping	Peak trapping day date	number
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	35[a]

[a] Only adipose clipped salmon were collected as broodstock in 1991. We estimated 361 adults and 71 jacks were delivered to Lyons Ferry FH during the trapping period. The actual number of fish accounted for at Lyons Ferry FH (pond mortalities and spawned fish) was 404 adults and 18 jacks (422 total - excludes one adult fish from Lower Granite Dam that lost its jaw tag).

Jack collections The objective of jack collections was to determine composition of stray salmon to the Snake River above Lower Granite Dam (Section 2.2). At our request, NMFS personnel trapped roughly half the marked (CWT) jacks from 10 September to 30 November 1991. Nineteen marked jacks were collected and processed from the 43 marked fish counted at the trap (Mendel et al. 1992a). This value does not include three fish that were collected as jacks that would have been classified as adults by fish counters at the dams; between 57-61 cm total length. Marked jacks have been sampled at Lower Granite Dam since 1985, except in 1989.

Jacks with blank-wire tags (BWT), were collected at the dam to remove them from the spawning population above Lower Granite Dam. These fish originated from the 1989 brood that had a high stray rate at Lyons Ferry FH. Ninety-four jacks with BWT were collected, and 61 were passed upstream. Four other jacks with BWT were captured and jaw tagged at the juvenile bypass facility during the fall of 1991 while passing downstream of the dam. These jacks were later recaptured at the adult trap. Only 85 jacks with BWT were accounted for during processing at Lyons Ferry FH. We assume this disparity is a result of sensitivity differences in the tools used to detect magnetic wire-tags in fish.

All sampled jacks that were adipose clipped were of Lyons Ferry FH origin, except one from the Umatilla River (CWT 7-54-5). This one recovery at Lower Granite Dam expands to six jacks from the Umatilla River of the 397 total jacks (adjusted count) over Lower Granite Dam in 1991.

2.2: Stray Fish

Procedures In 1991, Lyons Ferry broodstock were collected at three locations: 1) Ice Harbor Dam, where adipose-clipped salmon were trapped 2) Lower Granite Dam, where wire-tagged salmon were trapped, and 3) Lyons Ferry FH, where marked and unmarked fish voluntarily returned. We have information on adult and jack stock composition at Lower Granite Dam from 1990 and 1991 samples, and composition of jacks alone from 1985 to 1988 (Bugert et al. 1991).

Results Adult stock composition was similar between 1990 and 1991, even with a relatively large difference in run size at Lower Granite Dam. Based upon CWT expansions, Lyons Ferry origin salmon accounted for about half of the fall chinook salmon collected at Ice Harbor Dam, both in 1990 (49%), and 1991 (52%). Likewise, Lyons Ferry salmon comprised the bulk of voluntary returns to the hatchery (76% in 1990 and 82% in 1991), and those collected for broodstock at Lower Granite Dam (75% in 1990 and 74% in 1991).

Umatilla FH strays comprised the second most numerous stock at all three locations in both years, and remained relatively consistent:

Ice Harbor Dam: 30% in 1990 and 32% in 1991,
Lower Granite Dam: 23% in 1990 and 25% in 1991, and
Lyons Ferry FH volunteers: 14% in 1990 and 16% in 1991.

A large percentage of fall chinook salmon with CWT from Bonneville (Bonneville Dam bypass study, and direct Bonneville FH releases) were trapped at Ice Harbor Dam (Table 4), with lower percentages in Lyons Ferry volunteers and Lower Granite Dam collections (Tables 5 and 6). By comparison, fall chinook salmon released from other locations accounted for 2% or less in the Lyons Ferry FH broodstock in 1990 (Bugert et al. 1991). Refer to Appendix B for a summary of CWT recoveries of by collection site in 1991.

LaVoy (1992) estimated that 84% of the voluntary returns to Lyons Ferry FH were of Lyons Ferry origin by using a different expansion technique, which accounted for tagged fish removed for broodstock at Ice Harbor Dam. He also estimated that 80.6% of the adults and jacks counted at Ice Harbor Dam were of Snake River origin, and that 48.8% of those fish were of Lyons Ferry origin. Umatilla origin salmon contributed 12.4% to the Ice Harbor Dam counts of adult fall chinook salmon.

Discussion Information recently gathered by LaVoy (1992), and Blankenship (1992) provide additional evidence that hatchery fish comprise a large portion of fall chinook salmon escapement to the Snake River above Lower Granite Dam. LaVoy (1992) estimated that about half the adults counted at Lower Granite Dam were of hatchery origin. From WDF attempts to collect fish for electrophoresis, Blankenship (1992) found at least three of 21 salmon collected (14.3%) were hatchery fish (based on tags from Lyons Ferry and Bonneville hatcheries, and yearling scale patterns). Estimates from previous recoveries indicate a 78% hatchery composition for the run over Lower Granite Dam (Bugert et al. 1991).

No data exists on relative reproductive success of hatchery and natural fall chinook salmon in the Snake River and tributaries, and limited data are available on stock composition on the spawning grounds. The data that are available cannot be regarded as conclusive evidence of random mixing of hatchery and natural salmon over the entire range of spawning habitat because fish were collected from only limited portions of the spawning area (in the Snake River between the confluences of Asotin Creek and Grande Ronde River). We are currently gathering additional data to address these concerns with a cooperative study using radio telemetry, redd mapping, and carcass recovery (Bonneville Power Administration, Project 82-046). Results for the 1991 radio telemetry study portion are available in a separate report (Mendel et al. 1992b).

Beginning with the 1989 brood, all salmon released from Lyons Ferry FH are marked with wire tags (CWT and adipose clipped, or BWT and unclipped). Marks provide fishery managers the capability to identify and potentially prevent these fish from entering the Snake River above Lower Granite Dam.

Table 4. Stock composition of fall chinook salmon trapped at Ice Harbor Dam and transported to Lyons Ferry FH in 1991. Data are based upon coded-wire tag recoveries for salmon ages 3 to 6.

Origin	Number of tags recovered	Expanded contribution [a]	Percent of expanded
Lyons Ferry	233	368	51.8
Umatilla	54	227	32.0
Bonneville	102	108	15.2
Yakima	1	4	0.6
Other [b]	3	4	0.4
Lost [c]	30	--	--
Totals	423	711	100.0

[a] Expansion based on mark rate.
[b] Two recoveries from Drano Lake release, one recovery from Columbia River release, R-5.
[c] Includes lost or unreadable CWT.

Table 5. Stock composition of fall chinook salmon collected as voluntary returns to Lyons Ferry FH in 1991. Data are based upon coded-wire tag recoveries for salmon age 3 to 6.

Origin	Number of tags recovered	Expanded contribution [a]	Percent of expanded
Lyons Ferry	399	754	82.1
Umatilla	21	148	16.1
Bonneville	16	16	1.7
Lost [b]	20	--	--
Totals	456	918	99.9

[a] Expansion based on mark rate.
[b] Includes lost or unreadable CWT.

Table 6. Stock composition of fall chinook salmon trapped at Lower Granite Dam and trucked to Lyons Ferry FH in 1991. Data are based on coded-wire tag recoveries for salmon age 3 to 6.

Origin	Number of tags recovered	Expanded contribution [a]	Percent of expanded
Lyons Ferry	23	80	74.1
Umatilla	11	27	25.0
Bonneville	1	1	0.9
Lost [b]	1	--	--
Totals	36	108	100.0

[a] Expansion based on mark rate.
[b] Includes lost or unreadable CWT.

SECTION 3: ADULT RETURN RATES

Lyons Ferry FH began releases in 1985, using four strategies: 1) yearlings released on-station, 2) yearlings barged downstream of Ice Harbor Dam, 3) subyearlings released on-station, and 4) subyearlings barged downstream of Ice Harbor Dam. Each yearling release group was marked with a minimum of 150,000 CWT, subyearling releases had at least 220,000 CWT (Appendix D).

3.1: Returns to Lower Snake River

Representatives of release groups from the 1985 through 1989 broods returned to Lyons Ferry FH in 1991. The 1988 and 1989 year classes comprised the majority of the returns, with nearly equal recoveries. LaVoy (1992) estimated 2,370 Snake River hatchery origin fall chinook salmon returned to the project area in 1991 (based on the percentage of salmon of hatchery origin).

3.2: Spawning Grounds

Coded-wire tags were recovered from four marked salmon on Tucannon River spawning grounds (four of 20 carcasses recovered), and three marked salmon of 21 carcasses on Snake River spawning grounds (Blankenship 1992, and Section 6). Tucannon River recoveries consisted entirely of fish with origins from outside the Snake River Basin (CWT 07-40-38, and 07-40-39, both Minthorn Creek, 1988 releases, Umatilla River; CWT 07-40-37, Bonnifer acclimation, 1988 release, Meacham Creek; and CWT 23-22-15, Bonneville Bypass Study, 1987 release). Mainstem Snake River recoveries from Lyons Ferry FH origin were 1986 brood subyearling transport releases (63-42-62, 63-44-01) and one Bonneville Bypass Study release, 1986 brood (Blankenship 1992).

3.3: Fishery Contribution

Recovery data for most 1991 fisheries were not available by the time this report was submitted. Analysis of most data for previous years can be found in Bugert et al. (1991). We are currently updating fishery contribution data and will present a more complete analysis of these data in subsequent reports.

Hawkins and Hymer (1991) summarized the harvest of Snake River origin chinook salmon from the Columbia River for 1986-1990. Harvest estimates of Snake River origin salmon have generally been between 2,019 and 3,674 fish, except in 1987 (8,837 salmon). Exploitation rates of Snake River origin fall chinook salmon in the Columbia River range from 25-53% (s=10.9, n=5 years), with a mean of 35.5%. A preliminary[1] estimate for

[1] Joe Hymer, Washington Department of Fisheries, P.O. Box 999, Battle Ground, WA 98604.

1991 Columbia River harvest of Snake River origin fall chinook salmon is 2,222. The jack fishery continued in 1991, based upon regulations established in 1989. No creel surveys were conducted in 1991, and no CWT were recovered or submitted in this fishery.

SECTION 4: HATCHERY OPERATIONS

4.1: Spawning and Eggtake

4.1.1: Spawning operations

Salmon collected at Ice Harbor and Lower Granite dams were held separately at Lyons Ferry FH from voluntary returns of adults and jacks. Fish collected from 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 given uniquely colored tags (electrical wire ties) around the caudal peduncle to designate the week of arrival at the hatchery (Ross and Hopper 1992). Our intention was to apply the stray rate derived from fish with CWT that arrived at the hatchery in any particular week to those fish without CWT that arrived the same week. We assumed that the incidence of stray fish varied by week of arrival. Progeny of some unmarked (no CWT) fish might then be included in the Lyons Ferry FH program if the stray rates for some weeks were deemed to be below an acceptable level.

Ripe fish were killed and set aside during spawning operations. Marked fish had the CWT removed and read to determine the fish's origin prior to fertilization of the eggs. Fish were spawned together in three distinct groups: Lyons Ferry origin (CWT) fish, strays (CWT), and unmarked fish. Only known Lyons Ferry origin fish were mated together, by single male/single female matings. Marked fish found to be strays were spawned together, and the tag color was noted to determine week and location collected. Fish without CWT were mated together by color of external tags, hence fish of the same week and location of collection were mated together, if possible. Fertilized eggs from known Lyons Ferry fish were incubated separately from those known to be progeny of stray or unmarked fish.

Stray rates of fish voluntarily returning to Lyons Ferry FH remained unacceptably high throughout the period of broodstock collection at the hatchery. Therefore, we did not include gametes from unmarked broodstock in our Lyons Ferry FH production. Only progeny of Lyons Ferry origin (CWT) adults were retained for program use. Progeny of stray or unmarked broodstock were transported out of the Snake River Basin as eyed eggs.

Duration of 1991 fall chinook salmon spawning was from 15 October through 10 December (Table 7). Peak of spawning was 12 November, when an estimated 777,476 eggs were taken. This peak date is consistent with previous years, and apparent peaks on the spawning grounds. The total egg take at Lyons Ferry FH (after picking) was 2,994,676 (plus an estimated 9,000 eggs sent to WSU), with an initial mortality rate of 8.3% (Table 8).

Table 7. Collection and spawning summary for 1991 fall chinook salmon broodstock at Lyons Ferry Salmon Hatchery. [a]

	Arrivals		Mortality			Spawned			
Week	adult	jack	M	F	J	M	F [b]	J	Eggtake [c]
7 Sep	8	0		1					
14 Sep	151	3		2					
21 Sep	156	31	2						
28 Sep	203	98	1						
5 Oct	151	120		1	1				
12 Oct	65	76	1						
19 Oct	116	110		1		1	6	46	30,745
26 Oct	102	92	2	13		9	37	28	161,951
2 Nov	46	74	4	5	5	28	96	60	427,313
9 Nov	125	104	7	2	11	49 [d]	172	95	753,449
16 Nov	63	22	17	2	12	113	196	83	777,476
23 Nov	40	12	38	7	52	75	117	121	437,184
30 Nov	29	4	44	1	17	73	80	31	256,445
7 Dec	6	0	41	1	9	48	34	22	126,275
14 Dec			8			17	6		23,838
Totals	1,261	746	165	36	107	413	744	486	2,994,676

a Numbers include trapping mortalities and salmon that died in transport to the hatchery. Most males were live spawned. Escapement is estimated at collection and revised after the spawning season.

b Includes 12 females that were not ripe when killed and one female that had nonviable eggs.

c Corrected total eggtake after shocking was 2,994,676 eggs, plus 9,000 eggs that were sent to Washington State University.

d One male was not ripe.

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

[a] plus 9,000 eggs given to WSU.

4.1.2: Sperm cryopreservation and evaluation

We collected semen from known Lyons Ferry origin males during the 1991 eggtake to develop a sperm bank for use in future years. This semen is to be used to fertilize ripe eggs when we have a shortage of known Lyons Ferry origin males. This will also enable us to retain genetic characteristics present in the existing population of fall chinook salmon at Lyons Ferry FH.

Semen was collected from 37 known Lyons Ferry origin salmon for freezing (Appendix D). Cryoextender (Wheeler and Thorgaard 1991) was mixed with semen at a ratio of 3:1. The 4 ml mixture was then pulled into straws and both ends of the straws were sealed. Straws were put on dry ice, then placed in a liquid nitrogen tank. A detailed description of cryogenics techniques is presented in Bugert et al. (1992).

Evaluation of preservation techniques In 1990, WSU[1] researchers and WDF initiated a cooperative two-year experiment with salmon semen preservation using various storage durations and equipment (Bugert et al. 1991). Semen from five stray males, and eggs from two stray females, were collected at Lyons Ferry FH and used for this study. An unfrozen semen sample (control) from each male was oxygenated and held overnight in a refrigerator and tested for fertility the following day. Eggs from the stray females were also held overnight in a refrigerator prior to the experiment. Four straws of semen from each male were frozen the same day they were collected; two were placed in liquid nitrogen (-196 °C) and two in an ultra-low (-80 °C) freezer. For each

[1] Paul Wheeler, Department of Genetics and Cell Biology, Washington State University, Pullman, WA 99164.

male, one straw in each storage unit was for short-term storage (1 day), and the other was for long-term storage (53 weeks). One male had only enough semen for three straws, so the 53 week storage test in the ultra-low was aborted for this fish.

The eggs were pooled, then divided into 15 lots the following day. Each male fertilized three lots of eggs; 1 ml or straw of semen each for two short-term freezing treatments, and one fresh control.

Fertility was determined after nine days of incubation. During this time the eggs were dipped in formalin at the rate of 1.6 ml/L (or 1:625 dilution) for 15 minutes. Treatments were done every three days, or as needed. After the nine day period, the eggs are fixed with 1.5% acetic acid in 0.9% saline. The eggs were then counted and fertility was determined by the proportion of embryos observed. Relative percent fertility was determined by comparing the success of cryopreserved semen fertilizing eggs to that of unfrozen semen (controls).

In 1991, the experiment was repeated to evaluate long-term storage (53 weeks) using the remaining semen frozen in 1990. Eggs from two stray females were collected at Lyons Ferry FH. The eggs were pooled and divided into nine lots.

Test results indicate that retention of semen in an ultra-low freezer is not sufficient for long term cryopreservation. After one day of storage mean fertility was 33.3% (n=5, s=9.6), decreasing to 0.8% (n=4, s=0.6) after 53 weeks (Table 9). Fertility relative to that of unfrozen sperm also deteriorated over time. Short-term storage had a mean relative fertility of 59.4% (n=5, s=23.8) while long-term storage yielded 1.4% (n=4, s=1.1) relative fertility.

Semen stored in liquid nitrogen for one day had a mean fertility of 40.9% (n=5, s=10.0) with a mean relative fertility of 77.3% (n=5, s=24.1; Table 9). Test results indicate fertility slightly increased with increased storage time, but not appreciably. Mean fertility of sperm stored 53 weeks yielded a mean fertility of 49.0% (n=5, s=14.0) and a mean relative fertility of 90.8% (n=5, s=24.8).

We noted that fertility of controls was substantially below fertility rates we normally obtain at the hatchery. We are unsure of the cause of the low fertility rates for the controls.

Based on the results of these tests, we suggest that an ultra-low freezer should not be used for storage of cryogenically preserved semen. Long term storage of semen is best accomplished with the use of liquid nitrogen.

Table 9. Comparison of fertilization rates between unfrozen fall chinook salmon semen (control) and cryogenically preserved semen stored in either an ultra-low freezer (-80 °C) or liquid nitrogen tank (-196 °C), for short (1 day) or long duration (53 weeks).

Treatment	Male no.	Number of eggs fertilized	Number of eggs unfertilized	Percent fertility actual	Percent fertility relative [a]
Unfrozen control	1	393	254	60.7	--
	2	311	310	50.1	--
	3	358	283	55.9	--
	4	285	333	46.1	--
	5	374	263	58.7	--
	mean	344.2	288.6	54.30	
Ultra-low freezer (1 day)	1	122	528	18.8	31.0
	2	166	455	26.7	53.3
	3	238	420	36.2	64.8
	4	280	354	44.2	95.9
	5	205	460	30.8	52.5
	mean	202.2	443.4	31.34	59.50
Ultra-low freezer (53 weeks)[c]	1	5	440	1.1	1.8
	2	*[b]	*	*	*
	3	6	409	1.5	2.7
	4	1	492	0.2	0.4
	5	2	463	0.4	0.7
	mean	3.5	451.0	0.80	1.40
Liquid nitrogen (1 day)	1	148	491	23.2	38.4
	2	302	364	45.3	90.4
	3	293	344	46.0	82.3
	4	291	330	46.9	101.7
	5	281	370	43.2	73.6
	mean	263.0	379.8	40.92	77.28
Liquid nitrogen (53 weeks)[c]	1	151	267	36.1	59.5
	2	146	237	38.1	76.1
	3	217	223	49.3	88.2
	4	221	220	50.1	108.7
	5	306	123	71.3	121.5
	mean	208.2	214.0	49.00	90.80

[a] Fertility relative to control.

[b] Denotes straws of semen unavailable for use at time of testing.

[c] Eggs from different females than for controls or short term tests in 1990.

Matings using cryogenically preserved semen On 12 November, we had a shortage of known Lyons Ferry origin males for spawning at the hatchery. Semen frozen on 6 November (one day after collection) from four known Lyons Ferry origin males was used to fertilize four known Lyons Ferry origin females. Gametes were crossed by using one male for each female.

Five straws of cryopreserved semen were used for each female. Five straws were thawed simultaneously and added to the eggs, along with cryogenic activating solution, and mixed thoroughly (Bugert et al. 1991, Appendix D). Eggs were picked to remove mortalities on 12 December and egg loss averaged 94.4% (n=4, s=5.9; Table 10). We do not know if the high egg loss was a result of problems with mixing of the cryogenic extender, the freezing of semen, or the thawing procedure. In 1992, we plan to run several tests at Lyons Ferry FH with semen and eggs from stray salmon to evaluate and refine our techniques. Results from these tests will be available in subsequent reports.

Table 10. Known Lyons Ferry origin fall chinook salmon matings from thawed and reactivated cryopreserved semen used on 12 November, 1991. [a]

Male data			Female data		Egg data		
Fish no.	Brood year	Percent motile [b]	Fish no.	Brood year	Total eggs	Dead eggs	Percent loss
143	1986	85	423	1987	3,514	3,010	85.7
164	1987	79	419	1987	3,555	3,427	96.4
154	1986	86	424	1986	4,798	4,692	97.8
203	1986	90	420	1985	5,689	5,564	97.8

[a] Semen from these males was frozen on 6 November, one day after collection.

[b] Percent motility was visually estimated.

4.1.3: Egg transfer

Under authority of an interagency and tribal agreement, Lyons Ferry FH staff transported progeny of stray and unmarked adults to Klickitat FH (1,917,215 eyed eggs) for release there. Anothr 9,000 eggs were sent to Washington State University (WSU) for a cryogenics experiment (Section 4.1.2).

4.2: Incubation and Rearing

The total corrected 1991 brood eggtake was 3,003,879 eggs, of which 1,926,215 were shipped off station (Section 4.1.3). Egg loss totaled 249,150 eggs. Lyons Ferry FH retained all eyed eggs (828,514) of known Lyons Ferry origin broodstock (verified through CWT). Fry loss prior to ponding was 20,829. Total fry ponded equalled 807,685 (702 lbs).

The sole water supply to Lyons Ferry FH was damaged on 28 May, resulting in a loss of 49,200 L/min of water. During 2-4 June all salmon were transferred to the WDF Eastbank FH, on the Columbia River, while the water supply intake was repaired. The 1990 brood were graded, adipose clipped, and coded-wire tagged while at Eastbank FH. Fish were returned to Lyons Ferry FH from 12-16 August, and were then blank wire tagged in the left cheek (346,577 fish), or tagged with externally visible pigmented filaments in clear skin near the left eye (347,814).

At the end of the report period (31 March 1992) the 1990 brood at Lyons Ferry FH consisted of 689,938 fish weighing 75,580 lbs. Cumulative loss after ponding was 29,573 fish. Total feed used for the 1990 brood was 35,886 kg, resulting in an overall conversion rate of 1.19. These fish were scheduled for release in April 1992. On 31 March 1992, 791,555 subyearling (1991 brood) fish were on-hand (1,673 lbs). Cumulative loss in the ponds for the report period was 4,920 fish. Feed used was 405 kg with an overall conversion of 0.98.

Monthly and overall mortality rates from egg to smolt are available for 1984-89 broods (Bugert et al. 1991). However, a portion of the 1990 brood was sent to Klickitat FH after they were determined to be progeny of salmon that originated outside the Snake River Basin. We were unable to determine mortality rates for progeny of parents known to have originated from Lyons Ferry FH because of the unexpected stray rates and subsequent requirements to ship eggs and fry to Klickitat FH.

4.3: Disease Incidence and Prophylaxis

The 1991 broodstock were given flush treatments of Formalin 1:7,000) as prophylaxis for *Saprolegnia* sp. (fungus). Females were injected once with Erythromycin 200 to reduce infection levels of *Renibacterium salmoninarum* (causative agent of Bacterial Kidney Disease, BKD). Eggs and juveniles (1991 brood) were segregated based on the incidence of BKD in the parents (using ELISA techniques). Generally this brood had no fish health problems during the report period.

The 1990 brood salmon were given a 21 day Gallimycin feeding at 2% of body weight/day during March-April 1991. The gut parasite Hexamita salmonis was detected in smaller fish in early April but eventually several ponds of fish required treatment (once in April and once in May) with 3% epsom salts in the feed for three days. After transfer to Eastbank FH (2-4 June) the smaller fish were graded out in order to give them smaller feed, increased feeding rate and another Epsom salt treatment. A group of very small fish that were not healthy enough for tagging due to a low grade infection of bacterial gill disease and Hexamitis were sorted out prior to CWT tagging at Eastbank FH. These very small fish were given a 20 ppm Diquat flush treatment to remove the bacteria. The remainder of the fish were split into separate release groups and differentially tagged (CWT). Following the transfer back to Lyons Ferry FH (12-16 August), all fish received another treatment of 3% epsom salt and their second treatment of Gallimycin at 2% body weight in the feed. Gallimycin toxicity developed during this second treatment and the treatment was cut short (stopped after 14 days rather than the usual 21-day treatment). Fin erosion was observed so salt blocks were added to each pond prior to blank wire and visible tagging to improve osmoregulatory conditions and general health.

4.4: Smolt Releases

The fall chinook salmon production goals for Lyons Ferry FH is 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 planted on-station. If more eggs are available, they are to be released as subyearlings in early June, either on-station or transported by barge. The subyearlings are transported if Snake River flows and available spill are low. This strategy places the fish in the highest survival potential (Bugert et al. 1991). However, this strategy may be modified in the future to accommodate outplanting fall chinook smolts upstream of Lower Granite Dam.

No yearlings (1989 brood) were released during the study period because of the high incidence of strays in the parents. In response to the high stray rate, progeny from stray parents were blank wire tagged (BWT) and released from Lyons Ferry FH as subyearlings in June and July 1990 (Bugert et al. 1991).

The 1990 eggtake was 3,512,571, of which 1,035,000 were determined to be Snake River stock, and therefore retained. Of these, 224,439 fish were released as subyearlings in 1991; the remainder were designated for yearling release in April 1992. The June 1991 Snake River flows (measured at Lower Granite Dam) were 59-61% of the previous ten-year average, consequently, subyearlings were transported by barge immediately downstream of Ice Harbor Dam on 2 June 1991 (tag codes 63/41/43 and 63/41/60). Average size of these smolts (49 fpp) was larger than previous subyearling releases (50-120 fpp). Mean fork length of these fish at release was 94.0 mm (Figure 3); total subyearling poundage production was 4,580. Overall feed conversion rate of the subyearlings was 1.13.

To identify salmon known to originate from Lyons Ferry FH upon their return as adults, we marked (adipose clip and CWT; codes 63/41/43 and 63/41/60) the entire subyearling release. The remaining 1990 brood, retained for yearling release, received additional tags (BWT or visible tags) in the left cheek. These marks will enable us to externally identify these fish upon return. This technique was not feasible for the subyearling releases because the fish were too small at the time of tagging.

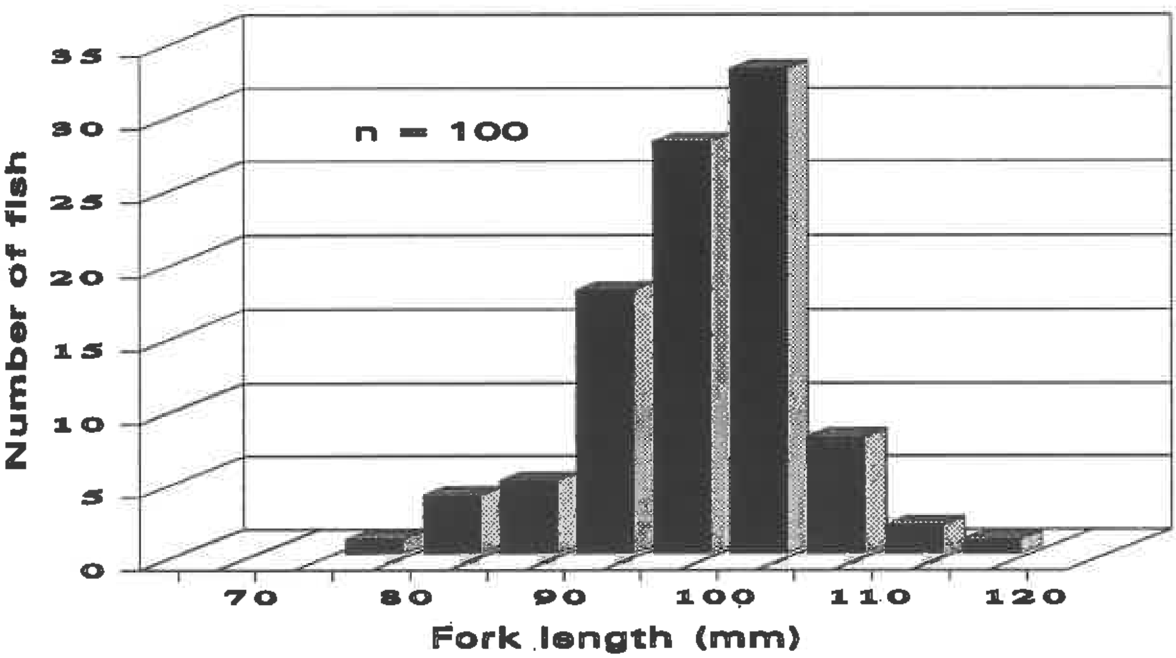

Figure 3. Length frequency distribution of subyearling fall chinook salmon (1990 brood year) transported downstream of Ice Harbor Dam in June 1991.

SECTION 5: STOCK PROFILE EVALUATION

5.1: Population Structure

5.1.1: Age and sex structure

Salmon were sampled for age and lengths during spawning (15 October to 10 December). A total of 1,959 samples were taken (98% of total), of which 654 were known Lyons Ferry origin (Figure 4). Dominant age classes in 1991 were ages 3, 4 and 5 (Table 11, Figure 5). Dominant ages vary yearly depending upon year class strength. Most large fish sampled at Lyons Ferry FH in 1991 originated from outside the Snake River Basin (Figure 5). One stray fish was older than any salmon of known Lyons Ferry FH origin (seven year old fish from a yearling release in the Umatilla River; CWT 7/33/27).

Average age class breakdown since Lyons Ferry FH began broodstock collections in 1984 is 24% age 2, 29% age 3, 35% age 4, 11% age 5, and 1% age 6 (Table 11). In 1991, females of known Lyons Ferry FH origin were predominately age 4 and 5, but males were mainly age 3 (Table 12). Roler (1992) provides age information for voluntary returns to Lyons Ferry FH in 1991.

Average length of known Lyons Ferry origin females sampled at the hatchery in 1991 was slightly larger than males through age 4. Average fork lengths of age 5 and 6 males were larger than females (Table 13).

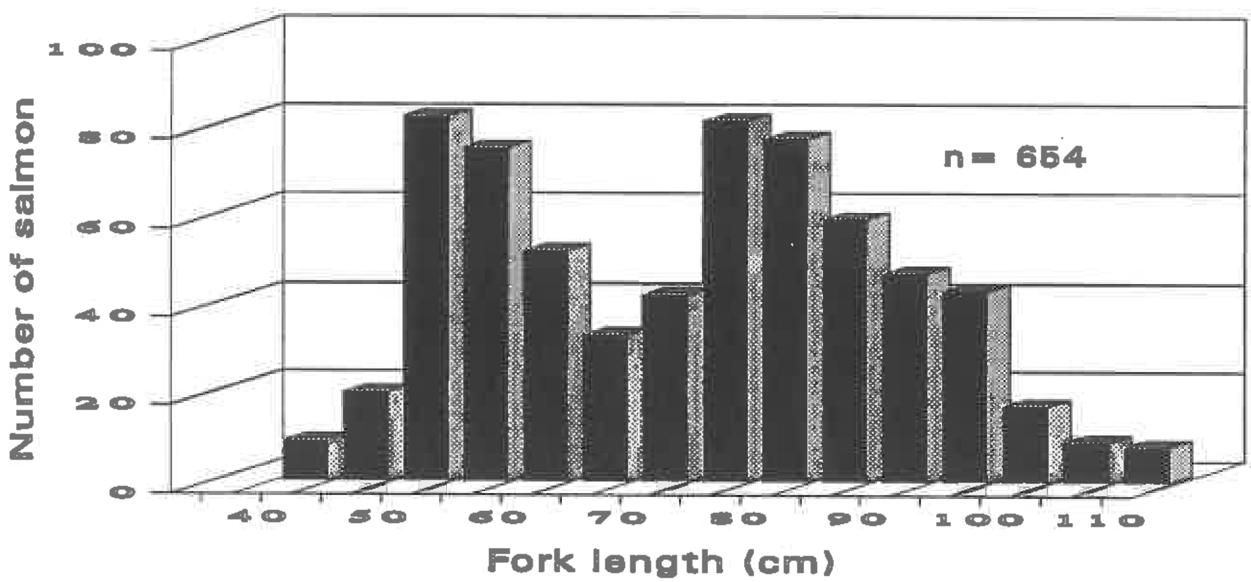

Figure 4. Length frequency distribution of known Lyons Ferry origin (CWT) fall chinook salmon broodstock sampled at the hatchery in 1991.

Table 11. Age composition (and percent of total) for fall chinook salmon broodstock at Lyons Ferry FH, 1984-1991. [a]

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Total
1984	-	278 (37)	401 (54)	67 (9)	-	746 (100)
1985	4,147 (87)	71 (2)	442 (9)	95 (2)	-	4,755 (100)
1986	157 (10)	1,344 (83)	63 (4)	41 (3)	-	1,605 (100)
1987	563 (15)	453 (12)	2,823 (72)	18 (1)	-	3,857 (100)
1988	781 (32)	444 (18)	647 (26)	583 (24)	-	2,455 (100)
1989	277 (11)	982 (39)	957 (39)	248 (10)	18 (1)	2,482 (100)
1990	2 (1)	9 (2)	265 (72)	90 (24)	3 (1)	369 (100) [b]
1991	36 (6)	206 (31)	208 (32)	185 (28)	19 (3)	654 (100) [b]

[a] Numbers include voluntary returns to the hatchery and fish trapped Ice Harbor and Lower Granite dams.
[b] Based on recoveries of Lyons Ferry FH origin salmon with coded wire tags.

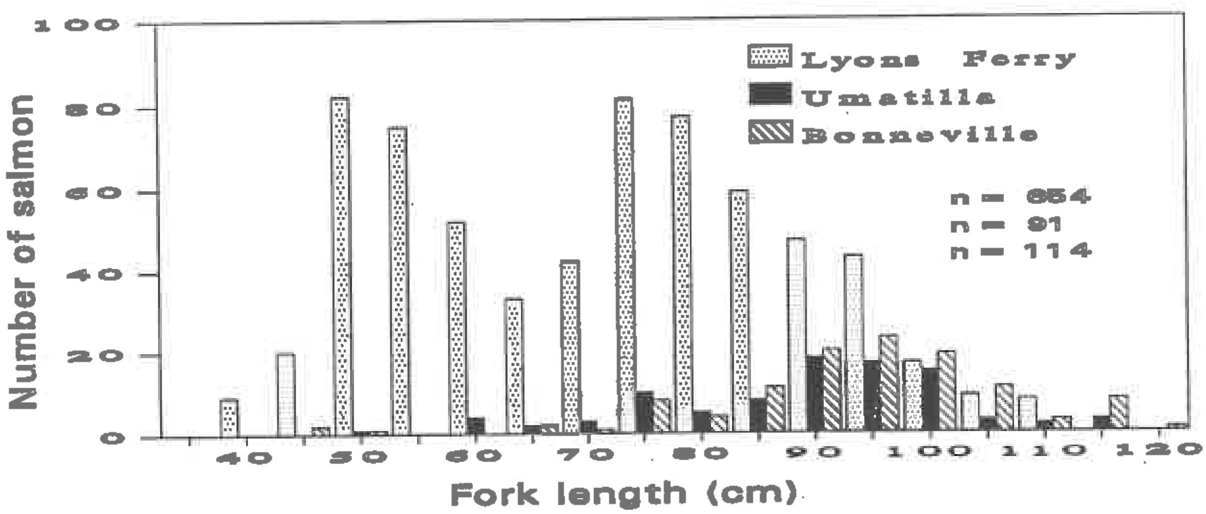

Figure 5. Lengths of adult salmon sampled at Lyons Ferry FH in 1991, and compared by origin.

The sex ratio of known Lyons Ferry origin salmon was 0.74 female:1.00 male (269:385, Table 12). An additional 286 jacks with BWT were recovered at Lyons Ferry FH and Lower Granite Dam (including 65 bypassed at the trap at the dam). The 1990 ratio was 0.54:1.00 (341:629), the 1989 ratio was 0.57:1.00 (900:1,5820); the 1988 ratio was 0.44:1.00 (749:1,706). The 1988 and 1989 values include stray fish, since they were not culled in those years. Sex ratios vary yearly depending upon jack returns. Composition of age 2 and 3 returns to Lyons Ferry FH from 1984 to 1991 has averaged 55.3% of total broodstock (range: 27%-93%).

Table 12. Age composition by sex of known Lyons Ferry origin fall chinook salmon (based on CWT) sampled at Lyons Ferry Fish Hatchery, 1991 (values do not include returns with BWT)[a].

	Age					
Sex	2	3	4	5	6	Total
Male	36	201	74	65	9	385
Female	0	5	134	120	10	269
Total	36	206	208	184	19	654

[a] 136 jacks with BWT volunteered into Lyons Ferry FH, plus 85 jacks with BWT were collected at Lower Granite Dam and another 65 BWT jacks were passed upstream at the dam.

Table 13. Sex, mean fork length (cm), and age (based upon coded-wire tags) of known Lyons Ferry origin fall chinook salmon sampled at the hatchery, 1991.

	Mean length (n, s) at given age				
Sex	2	3	4	5	6
Male	46 (36, 3.9)	53.0 (201, 6.4)	72.3 (74, 10.9)	92.1 (64, 12.3)[a]	92.1 (9, 5.3)
Female	- -	68.4 (5, 6.1)	73.4 (134, 5.3)	83.3 (120, 7.4)	91.2 (10, 7.0)

[a] Fork length is unavailable for one of the 65 males with CWT.

5.1.2: Fecundity and egg size

Average fecundity and egg size for fall chinook salmon in 1991 was 4,025 eggs/female and 1,488 eggs/pound, respectively. We have no estimate of fecundity for known 1991 Lyons Ferry origin females. Fecundity was determined by dividing the total number of eggs taken by the number of females spawned.

5.2: Stock Profile Sampling

In 1991, we collected samples from several groups of adult salmon for electrophoresis: 100 Lyons Ferry FH broodstock at random, 100 known Lyons Ferry origin broodstock, and 100 mid-Columbia fall chinook salmon from Priest Rapids FH. Analysis of these samples will be reported in subsequent reports.

We measured morphometric (67 fish) and meristic (50 fish) characteristics of juvenile salmon (1990 brood) at Lyons Ferry FH in June 1991. These measurements will be added to our baseline database. Analysis of these data will be reported in subsequent reports.

SECTION 6: NATURAL PRODUCTION

6.1: Streams Above Lower Granite Dam

In October, November and December 1991, WDF, U.S. Fish and Wildlife Service (USFWS), Idaho Power Company (IPC), Oregon Department of Fish and Wildlife (ODFW), and the Nez Perce Tribe (NPT) jointly conducted fall chinook salmon spawning surveys on the Snake River and its tributaries above Lower Granite Dam. Streams were surveyed with a Hiller 12E, or 12E4, helicopter.

6.1.1: Spawning surveys

In 1991 the mainstem Snake River was surveyed for salmon redds on 11 and 26 November, and again on 9 December. These index flights were conducted on approximately the same dates as survey flights in 1990 (12 and 26 November and 11 December). Spawning index flights of the Snake River were scheduled to include the segment of the Snake River between Asotin and Hells Canyon Dam. Poor weather limited the 11 November flight to that portion of the Snake River from Asotin to RK 367 (above Pittsburg Landing at the alum bed), and the 9 December flight was limited to below Pittsburg Landing (RK 347.5). A total of 32 redds were observed in the Snake River during these index flights (Table 14). Fourteen redds and eight fish were observed during the first index flight, 17 new redds and one fish during the second, and one new redd and no fish were seen the last flight. Results of these index counts are similar to those in 1990 (15 redds and 11 fish on 12 November, 17 new redds and six fish on 26 November, and five redds and no fish on 11 December), but less than during other years (Table 15).

Conditions were fair to good during spawning survey flights in 1991. However, turbid water from the Grande Ronde River severely limited visibility in the Snake River below the mouth of the Grande Ronde during the 9 December flight. Discharge below Hells Canyon Dam was constant after 4 November (Table 16).

Table 14. Date, location, and number of fall chinook salmon redds and adults observed during spawning index flights of the Snake River in 1991 (survey dates were 11 November, 26 November, and 9 December).

River kilometer	Proximal landmark	Number of redds	Number of adults	Survey number
240.5	Tenmile range	1	0	1
261.3	Captain John Cr	14	9	1,2
268.1	Lower Lewis rapids	3	0	2
284.4	WA/OR State line			
306.8	Eureka Cr	3	0	1,2
319.9	Robinson Gulch	4	0	2
332.3	High range	1	0	1
330.3	Copper Cr	3	0	2,3
386.8	Rock Bar	3	0	2
	Totals	32	9	

Table 15. Numbers of fall chinook salmon redds and adults seen in the mainstem Snake River from 1986 to 1991, with a comparison of visibility and discharge during the surveys.

	Number of			Visibility	Discharge
Year	surveys	redds	adults	(feet)	(kcfs)
1986	1	7 [a]	0	- -	- -
1987	2	66	13	9-10 [b]	13.8-15.8
1988	2	57	19	9-10	11.6-15.6
1989	2	58	27	- -	9.1-11.7
1990	3	37	17	8-11	9.0-10.8
1991	3 [c]	32	9	- -	9.6- 9.6

[a] Flows from Hells Canyon Dam were not lowered for the 1986 survey, which hindered visibility.
[b] Visibility readings (measured with a Secchi disk) are taken downstream of the Grande Ronde River; data were not collected in 1986, 1989 and 1991.
[c] Data for index flights only.

Table 16. Snake River discharge and turbidity during the period of fall chinook salmon spawning ground surveys, 1991 (from Phil Groves, Idaho Power Company.).

Survey date	Discharge (cfs) mean	maximum	minimum	Turbidity (NTU)	Location (River km.)
14 Oct	11,696	12,600	10,120	- -	- -
21 Oct	9,820	10,101	9,673	- -	- -
28 Oct	9,347	9,347	9,347	- -	- -
4 Nov	9,347	9,347	9,347	- -	- -
11 Nov	9,564	9,564	9,564	- -	- -
18 Nov	9,564	9,564	9,564	- -	- -
20 Nov	9,564	9,564	9,564	3.5	249.4
				3.9	270.3
				5.0	273.5
				11.7	302.5
				2.3	305.7
25 Nov	9,564	9,564	9,564	1.8	273.5
				2.2	302.5
				1.4	305.7
2 Dec	9,564	9,564	9,564	- -	- -
3 Dec	9,564	9,564	9,564	2.3	249.4
				8.8	270.3
				1.3	273.5
				1.3	302.5
				1.3	305.7
				1.4	320.2
9 Dec	9,564	9,564	9,564	- -	- -

Additionally, weekly aerial spawning surveys were conducted from 14 October to 9 December; except on 21 October when high winds forced cancellation of the flight above the Grande Ronde River. A total of 42 redds and 21 fish were observed during all weekly flights. Spawning was initiated at least by 28 October, but not before 14 October. The last new redd was located on 9 December. The peak of spawning apparently occurred between 11-18 November (Table 17).

Five of the 42 redds observed during weekly flights were not verified as redds when checked from a boat or from shore. Many other redds or test digs that had been listed as questionable from the air were believed to be caused by boats (jet or propeller wash and boat groundings) when inspected from a boat. However, questionable redds would not have been counted in aerial surveys even without closer inspection. At Captain John Creek (RK 261.3) and Rock Bar (RK 386.8) additional redds were counted by personnel from the USFWS or IPC from boats or by diving.

Apparently, the disparity between aerial and surface or subsurface counts appears to be mostly a result of problems accounting for redds in large cleared areas where there are clusters of redds, or superimposition of redds.

Table 17. Results of weekly spawning survey flights of the Snake River between Asotin and Hells Canyon Dam, including the lower Imnaha River, 1991.

Survey date	Snake River Redds	Snake River Fish	Snake River Carcasses	Imnaha River Redds	Imnaha River Fish
14 Oct	0	0	0	0	0
21 Oct [a]	0	0	0	--	--
28 Oct	1	1	0	0	0
4 Nov	9	6	0	1	0
11 Nov	7 [b]	8	0	0	0
18 Nov	11	5	0	0	0
26 Nov	8 [b]	1	0	0	0
2 Dec	5	0	1	1	0
9 Dec	1	0	0	5	0
Totals	42	21	1	7	0

[a] October 21 flight was terminated at mouth of Grande Ronde because of poor weather.

[b] Three redds counted from aerial surveys on 11 November and two redds counted on 26 November were not verified from a boat.

The Clearwater River was surveyed from its mouth to Kamiah (RK 107.8) on 20 November and from the mouth to Orofino (RK 71.8) on 12 December. Water was low and relatively clear (Table 18). Only one redd and one adult salmon were seen on 20 November and three redds on 12 December 1991[1]. Four redds were also observed during spawning surveys in 1990.

Asotin Creek was surveyed on foot from the mouth to Cloverland Bridge (4.8 km) on 26 November 1991. No redds or adults were seen. We saw no spawning activity in this reach in 1990, 1989, or 1988. Alpowa Creek was also surveyed on foot from the mouth to Banner Ranch (1.5 km) on 26 November 1991. No redds or fish were seen here in 1991, 1990, 1989, or 1988.

[1] Bill Arnsberg, Nez Perce Tribe, P.O. Box 365, Lapwai, ID 83540.

Table 18. Fall chinook salmon redd aerial survey dates, survey conditions, and number of redds and fish observed on the lower mainstem Clearwater River, Idaho, 1988-1991 (modified from Arnsberg, NPT).

Survey date	Weather conditions	Visibility (m)	Discharge (cfs)	Redds observed	Fish observed
12/1/88	clear, cold	- -	4,920	21	3
11/19/89	clear, sunny	3.0	5,560	8	0
12/2/89	clear, sunny	3.0	6,550	2	1
11/16/90	- -	2.0	- -	1	0
12/3/90	- -	4.3	13,540	3	0
11/20/91	ptl. clear,	3.0	10,520	1	1
12/17/91	clear, sunny	3.8	4,137	3	0

The Grande Ronde River was surveyed with a helicopter from its mouth to the Wenaha River (61 km) on 14 October, 28 October, and 11 November. Water levels were low and visibility was fair to good. Survey flights scheduled later were canceled because of turbid water and poor visibility. No redds or adult salmon were observed during any of the flights on the Grande Ronde River in 1991. One redd was observed in 1990, none in 1989, one in 1988, seven in 1987, and none in 1986.

The Imnaha River was surveyed the same dates as the Snake River (Table 17). Flights were limited to the lower 1-3.5 km, except on 9 December when the flight extended upstream to Cow Creek (RK 6.6). Seven redds were counted during these flights. Two redds were seen in the lower 3.2 km during early flights. On 9 December one redd was seen in the lower 3.2 km and four redds were seen below the bridge near Cow Creek. However, ground checks by USFWS and ODFW personnel determined that three cleared areas counted during aerial surveys were not redds (one in the lower river during the early season, and two near Cow Creek). Therefore, four redds (three found on 9 December and one on 11 November) are believed to have been dug in the lower Imnaha River in 1991.

Discussion The 1991 count of fall chinook salmon at Lower Granite Dam (18 August to 15 December) was 630 adults, 397 jacks, and 125 mini-jacks (< 30 cm; USACE, 1992). The adult count was down slightly from the 1987 to 1990 average of 669 adults (951 in 1987, 627 in 1988, 706 in 1989, 391 in 1990). Mark rate (adipose clipped) was 15.5% of the adults counted. National Marine Fisheries Service personnel trapped 40 marked (CWT) adults and 113 jacks (94 BWT with no adipose clip from 1989 brood Lyons Ferry, and 19 CWT jacks) at Lower Granite Dam for WDF broodstock and stray rate monitoring needs. Therefore, adjusted total spawning escapement above Lower Granite Dam was 274 hatchery origin adults (49.9% of 630 less 40 trapped) and 316 natural origin adults, plus 284 jacks (modified from LaVoy 1992 and based on corrected final fish counts).

The total redd count above Lower Granite Dam (from index counts) in 1991 was 32, resulting in a ratio of about 18.4 adults per observed redd, compared to 7.4 in 1990, 10.2 in 1989, and 7.8 in 1988.

6.1.2: Carcass recovery

Personnel from a joint WDF project, assisted by the USFWS, recovered 21 fall chinook salmon carcasses from the mainstem Snake River above Asotin Creek in 1991 (Blankenship 1992). Seventeen carcasses were recovered near Captain John Creek (RK 261.3). Five of the 21 carcasses were marked fish; three were radio tagged fish (two tagged at Lower Granite Dam, one of which had an adipose clip and a CWT from the Bonneville Dam Bypass Study), and two fish contained CWT from Lyons Ferry FH. All three CWT were from 1986 brood year subyearling releases. All fish were aged from scales as subyearling out-migrants, except for two fish recovered at RK 420.4 which were aged as yearling outmigrants. Results of electrophoretic analysis (19 fish sampled) will be provided in a separate report.

6.2: Below Lower Granite Dam

6.2.1: Spawning surveys

The Tucannon River was surveyed on foot about once a week from 15 November to 4 December 1991. Surveys were from the mouth to the irrigation diversion dam (RK 9.2) upstream of Starbuck, except the 25 November and 4 December surveys, which extended upstream to Krouse's Bridge (RK 20.9). Survey conditions were fair to good except on 4 December when the river was high and turbid. We did not survey downstream of the town of Starbuck during the last survey because of poor survey conditions. We were unable to survey later because river conditions remained poor for several weeks.

Fifty redds were observed, all downstream of the irrigation diversion dam, which has been documented as a passage impediment for the past five years (Table 19). Many redds may have been missed because of the high, turbid water during the last spawning survey in December. Spawning ground density was 8.8 redds/mile (5.5 redds/km) in 1991 compared with 6.6 in 1990, 5.2 in 1989, 2.8 in 1988, 1.7 in 1987 (Bugert et al. 1991).

Table 19. Date, location surveyed, and numbers of redds and carcasses seen during Tucannon River fall chinook salmon spawning surveys in 1991.

Survey date	River kilometer	New redds	Carcasses recovered Females	Males	Jacks
15 Nov	9.2 - 4.0	16	0	0	0
	4.0 - 0.0	1	0	0	0
20 Nov	9.2 - 4.0	14	1	2	0
	4.0 - 0.0	12	2	1	1
25 Nov	20.9 - 9.2	0	0	0	0
	9.2 - 4.0	5	2	5	0
	4.0 - 0.0	1	2	1	0
4 Dec	20.9 - 9.2	0	0	0	0
	9.2 - 6.4	1 [a]	0	3	0
Totals		50	7	12	1

[a] Partial count, survey terminated because of poor visibility.

We found 20 carcasses (12 female, 7 male, 1 jack) in the lower Tucannon River. Four marked (CWT) carcasses were found and all four were from outside the Snake River Basin (Section 3.2). Three carcasses contained jaw tags, two of which also contained radio tags from our tagging at Ice Harbor Dam. One salmon contained a jaw tag attached by University of Idaho personnel at the juvenile bypass facility at Lower Granite Dam where this fish was captured going downstream. Several other radio tagged salmon entered the Tucannon River to spawn after having fallen back through Lower Granite Dam (Mendel et al. 1992b).

We surveyed the Palouse River from slackwater to Palouse Falls on 22 November. No redds or fish were observed. Survey conditions were poor because the water was muddy. One redd and three adults were seen here in 1990, and two redds and four adults in 1989.

The final 1991 fall chinook salmon count at Ice Harbor Dam (12 August to 31 October) was 4,500 adults and 1,526 jacks (30 to 56 cm fork length; USACE, 1992). The adult count was down 4% from the 1987 to 1990 average of 4,693. In 1991 we collected approximately 361 adults and 71 jacks from Ice Harbor for broodstock at Lyons Ferry FH. Another 863 adults and 675 jacks voluntarily returned to the hatchery. At Lower Granite Dam 630 adults and 397 jacks were counted (of which we collected 40 adults and 113 jacks). Approximately 150 fish could be accounted for spawning in the Tucannon River (50 redds counted at 3 adults/

redd). Therefore, approximately 2,500 adults and 380 jacks cannot be accounted for. These values are the differences between the Ice Harbor Dam counts and the sum of the following: 1) Lower Granite Dam counts, 2) Lyons Ferry FH voluntary returns, and 3) estimated escapement to the Tucannon and Palouse rivers. Possible disposition of these missing fish include fall back at Ice Harbor Dam, mortality, or spawning in tailraces of the lower Snake River dams. We are currently attempting to account for these fish with a radio telemetry study (Mendel et al. 1992b).

SECTION 7: RECOMMENDATIONS

The following recommendations are to be considered as supplements to those provided in the 1989 and 1990 annual reports.

1) In recent years, the practice of marking fish prior to release from hatcheries has shifted from research purposes to broodstock management programs. An increasing proportion of marks used include wire placement, either coded or blank, yet fin clipping is still widely used. We speculate that these efforts may be counterproductive however, because of the potential for reduced survival after marking. Loss of fish may occur through decreased swimming performance from fin loss, disease transmission from mass tagging machines, or reduced sensory abilities as a result of wire placement. A concerted effort is needed to: 1) determine the effects of marking on survival, and 2) develop a benign, economical mark.

2) Fishery managers in the Snake River have become increasingly reliant upon magnetic-wire detectors to recognize Lyons Ferry origin salmon at the dams and at the hatchery. We found there are differences in the sensitivity of various detection tools, which may lead to incorrect classification of a salmon's origin. Widespread application of this technology should be used with caution.

3) Searches for water sources in the middle Snake River should begin soon, if the option for acclimation and release of Lyons Ferry FH smolts upstream of Lower Granite Dam is to be included in the long-term management plan for Snake River fall chinook salmon.

4) The incubation water chiller installed at Lyons Ferry FH in October 1991 has provided multiple benefits to the spring chinook program: more uniform time period for ponding fry from multiple eggtakes, capability for higher feed ration, and reduced pond loadings at acclimation. Increased water chiller capacity is required to supplement the current chiller, which would provide similar benefits to the fall chinook salmon program.

5) If it becomes apparent that a coordinated interagency plan for trapping marked salmon in the Snake River will not be developed and functioning by 1993, Lyons Ferry FH should secure authorization to modify the outdated structure currently used to trap adipose-clipped fall chinook salmon at Ice Harbor Dam. The current trap is cumbersome and increases holding time, delay, and resultant stress on salmon.

6) In 1992 through 1994, adults returning to the Snake River and Lyons Ferry FH will contain high percentages of the 1989 brood. Roughly 3,000,000 of this brood were marked and released as subyearlings, after it was determined that they were the progeny of a large number of stray mid-Columbia stock salmon. It is likely that three thousand or more of these salmon will return as adults. These fish are currently not intended for use for Snake River production because of assumed genetic differences between these fish and Snake River fall chinook salmon (defined as a Evolutionarily Significant Unit to be protected under the Endangered Species Act).

The genetic relationship between "known" Snake River stock, verified through Lyons Ferry coded-wire tags, and the 1989 brood salmon released from Lyons Ferry is not adequately determined. The genetic similarities between these two groups should be quantified, and an appropriate level of risk established, for proper management of this brood.

7) Based upon the relatively large number of blank-wire tagged minijacks (1989 brood) that returned to the Snake River in 1991, it appears these salmon survived reasonably well, despite the poor release and outmigrant conditions they encountered: 1) wire tagging during parr/smolt transformation, one to five days prior to release, 2) high dissolved gas levels (up to 109% of saturation) and high water temperatures (up to 18.3 ^{o}C) in the river. A delayed release of subyearling smolts from Lyons Ferry FH may not reduce their potential for survival appreciably, and yet may benefit natural smolt outmigrants, by triggering a later spill at Lower Monumental and Ice Harbor Dams (Connor et al. 1992).

8) Composition of the adult salmon run into the Tucannon River should be monitored carefully to determine the use of this stream by stray spawners. If stray rates remain high it may be preferable to limit fall chinook salmon spawning to downstream of the Starbuck irrigation diversion dam (Fletcher's Dam).

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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

Recoveries of coded-wire tags at Lyons Ferry FH, 1991. Expansions are based on cwt rates. Apparent addition errors are due to rounding to the nearest whole number following expansion (VOL = volunteers to the hatchery, IH = Ice Harbor Dam, LGR = Lower Granite Dam, BY = brood year).

Table 1. Stray coded-wire tags recovered at Lyons Ferry FH, 1991.

VOL	IH	LGR	TOTAL	TAGCODE	SOURCE	BY	EXPANDED RECOVERY RATE	VOL	IH	LGR	TOTAL
	1		1	B5/01/04	DRANO LK	86	1.13		1	1	
	1		1	B5/01/06	DRANO LK	86	1.07		1	1	
	1		1	B5/03/15	SS PENS	85	1.04		1	1	
	1		1	5/19/16	LWS-YAKIMA	86	4.05		44		
	1		1	7/50/34	COL RIVER	88	1.01		1	1	
1			1	7/54/06	COL RIVER	89	1.07	1	1		
1			1	7/47/21R2	TANNER CR	86	1.56	2	2		
1	1		2	7/47/32R2	TANNER CR	86	1.47	1	13		
2	2		4	7/39/12	UM-0	86	12.20	24	24		49
1	1		2	7/39/13	UM-0	86	12.20	12	12		24
	3		3	7/39/14	UM-0	86	12.20		37		37
1	1		2	7/46/46	UM-IRRIGON	88	15.28	15	15	31	
2	1		3	7/46/47	UM-IRRIGON	88	16.03	3	2	16	48
2	2	1	5	7/46/48	UM-IRRIGON	88	15.27	31	31	15	76
1			1	7/47/54	UM-IRRIGON	88	1.06	1	1		
1			1	7/47/63	UM-IRRIGON	88	1.01	1	1		
2	4		6	7/50/07R5	UM-IRRIGON	87	9.52	19	38		57
	2	2	4	7/45/36	UMATILLA	87	1.09		2	2	4
1	2	1	4	7/45/37	UMATILLA	87	1.09	1	2	1	4
1		1	2	7/45/38	UMATILLA	87	1.09	1		1	2
1	1		2	7/45/39	UMATILLA	87	1.09	1	1		2
	1		1	7/45/41	UMATILLA	87	1.09		1		1
1			1	7/38/30	UM/BONNHAT	85	2.03	2			2
	1		1	7/38/32	UM/BONNHAT	85	2.03		2		2
1			1	7/33/27	UM/MEA-YR	84	2.34	2			2
	2		2	7/38/29	UM/MEA-YR	85	2.03		4		4
	9	1	10	7/40/36	UM/MEA-YR	86	1.28		11	1	13
	8	2	10	7/40/37	UM/MEA-YR	86	1.28		10	3	13
3	9	1	13	7/40/38	UM/MEA-YR	86	1.24	4	11	1	16
1	5	2	8	7/40/39	UM/MEA-YR	86	1.24	1	6	2	10
	1		1	23/21/09	NMFS-BON	86	1.12		1		1
	1		1	23/21/10	NMFS-BON	86	1.08		1		1
	1		1	23/21/13	NMFS-BON	86	1.10		1		1
	1		1	23/21/14	NMFS-BON	86	1.12		1		1
	2		2	23/21/16	NMFS-BON	86	1.09		2		2
	1		1	23/21/18	NMFS-BON	86	1.10		1		1
		1	1	23/21/20	NMFS-BON	86	1.08			1	1
	2		2	23/21/21	NMFS-BON	86	1.09		2		2

Appendix B, Table 1, continued.

							EXPANDED RECOVERY				
VOL	IH	LGR	TOTAL	TAGCODE	SOURCE	BY	RATE	VOL	IH	LGR	TOTAL
	1		1	23/21/22	NMFS-BON	86	1.12		1		1
	1		1	23/21/24	NMFS-BON	86	1.12		1		1
	1		1	23/21/25	NMFS-BON	86	1.08		1		1
	1		1	23/21/26	NMFS-BON	86	1.09		1		1
	1		1	23/21/32	NMFS-BON	86	1.09		1		1
	1		1	23/21/33	NMFS-BON	86	1.10		1		1
	1		1	23/21/35	NMFS-BON	86	1.08		1		1
	1		1	23/21/36	NMFS-BON	86	1.09		1		1
	1		1	23/21/39	NMFS-BON	86	1.12		1		1
	2		2	23/21/40	NMFS-BON	86	1.08		2		2
	4		4	23/21/43	NMFS-BON	86	1.10		4		4
1			1	23/21/45	NMFS-BON	86	1.08	1			1
	2		2	23/21/46	NMFS-BON	86	1.09		2		2
	2		2	23/21/47	NMFS-BON	86	1.10		2		2
	4		4	23/21/50	NMFS-BON	86	1.08		4		4
1			1	23/21/51	NMFS-BON	86	1.09	1			1
	4		4	23/21/53	NMFS-BON	86	1.10		4		4
	1		1	23/21/54	NMFS-BON	86	1.12		1		1
	1		1	23/21/55	NMFS-BON	86	1.08		1		1
	1		1	23/21/56	NMFS-BON	86	1.09		1		1
	2		2	23/21/57	NMFS-BON	86	1.08		2		2
	3		3	23/21/58	NMFS-BON	86	1.10		3		3
	2		2	23/21/60	NMFS-BON	86	1.08		2		2
	1		1	23/21/62	NMFS-BON	86	1.12		1		1
	3		3	23/22/02	NMFS-BON	86	1.08		3		3
	1		1	23/22/04	NMFS-BON	86	1.10		1		1
	1		1	23/22/05	NMFS-BON	86	1.10		1		1
	2		2	23/22/06	NMFS-BON	86	1.12		2		2
	2		2	23/22/07	NMFS-BON	86	1.08		2		2
	2		2	23/22/09	NMFS-BON	86	1.09		2		2
	2		2	23/22/10	NMFS-BON	86	1.10		2		2
	2		2	23/22/11	NMFS-BON	86	1.12		2		2
	1		1	23/22/12	NMFS-BON	86	1.08		1		1
	1		1	23/22/13	NMFS-BON	86	1.09		1		1
	1		1	23/22/14	NMFS-BON	86	1.08		1		1
	1		1	23/22/15	NMFS-BON	86	1.10		1		1
	1		1	23/22/16	NMFS-BON	86	1.12		1		1
	2		2	23/22/18	NMFS-BON	86	1.09		2		2
	1		1	23/22/23	NMFS-BON	86	1.09		1		1
	1		1	23/22/24	NMFS-BON	86	1.10		1		1
	3		3	23/22/25	NMFS-BON	86	1.10		3		3
	1		1	23/25/03	NMFS-BON	87	1.01		1		1
1	1		2	23/25/07	NMFS-BON	87	1.02	1	1		2
	1		1	23/25/13	NMFS-BON	87	1.03		1		1
	1		1	23/25/14	NMFS-BON	87	1.02		1		1
	1		1	23/25/19	NMFS-BON	87	1.01		1		1
	2		2	23/25/21	NMFS-BON	87	1.01		2		2

Appendix B, Table 1, continued.

							EXPANDED RECOVERY				
VOL	IH	LGR	TOTAL	TAGCODE	SOURCE	BY	RATE	VOL	IH	LGR	TOTAL
	1		1	23/25/22	NMFS-BON	87	1.03		1		1
1			1	23/25/33	NMFS-BON	89	1.06	1			1
1			1	23/25/34	NMFS-BON	89	1.03	1			1
	1		1	23/25/42	NMFS-BON	87	1.03		1		1
1			1	23/25/51	NMFS-BON	89	1.06	1			1
	1		1	23/25/56	NMFS-BON	87	1.02		1		1
	1		1	23/25/61	NMFS-BON	87	1.01		1		1
2			2	23/25/63	NMFS-BON	87	1.03	2			2
	1		1	23/26/01R3	NMFS-BON	87	1.02		1		1
	1		1	23/26/13R3	NMFS-BON	87	1.02		1		1
	1		1	23/26/16R3	NMFS-BON	87	1.01		1		1
	1		1	23/26/28R3	NMFS-BON	87	1.03		1		1
	1		1	23/26/42R3	NMFS-BON	87	1.02		1		1
	1		1	23/26/47R3	NMFS-BON	87	1.01		1		1
3			3	23/26/50R3	NMFS-BON	87	1.02	3			3
	1		1	23/26/52R3	NMFS-BON	87	1.02		1		1
1	1		2	23/26/56R3	NMFS-BON	88	1.03	1	1		2
1			1	23/28/07R3	NMFS-BON	88	1.02	1			1
	1		1	23/28/28R3	NMFS-BON	88	1.02		1		1
	1		1	23/31/08R3	NMFS-BON	88	1.01		1		1
	1		1	23/31/22R3	NMFS-BON	88	1.01		1		1
	1		1	23/31/41R3	NMFS-BON	88	1.02		1		1
	1		1	23/31/52R3	NMFS-BON	88	1.02		1		1
	1		1	23/31/62R3	NMFS-BON	88	1.01		1		1
	1		1	23/32/07R3	NMFS-BON	88	1.00		1		1
37	160	12	209		= TOTALS =			166	342	28	536

Appendix B, continued.

Table 2. Lyons Ferry origin coded-wire tags recovered at Lyons Ferry FH in 1991.

							EXPANDED RECOVERY				
VOL	IH	LGR	TOTAL	TAGCODE	SOURCE	BY	RATE	VOL	IH	LGR	TOTAL
2	1	1	4	63/02/26R6	LF-OS	88	5.19	10	5	5	21
1	1	1	3	63/02/28R6	LF-OS	88	5.19	5	5	5	16
42	6		48	63/02/31R6	LF-YRT	88	1.33	56	8		64
36	5		41	63/02/32R6	LF-YRT	88	1.33	48	7		54
41	5		46	63/02/35R6	LF-YRS	88	2.49	102	12		115
52	6		58	63/02/37R6	LF-YRS	88	2.49	129	15		144
				63/36/33	LF-OT	85	1.01				
				63/36/34	LF-OT	85	1.01				
				63/36/35	LF-OT	85	1.01				
				63/36/36	LF-OT	85	1.01				
				63/36/37	LF-OT	85	1.01				
1			1	63/36/38	LF-OS	85	6.25	6			6
				63/36/39	LF-OS	85	6.25				
				63/36/40	LF-OS	85	6.25				
				63/36/41	LF-OS	85	6.25				
	1		1	63/36/42	LF-OS	85	6.25		6		6
3	7		10	63/41/56R3	LF-YRS	85	1.51	5	11		15
3	4		7	63/41/59R3	LF-YRT	85	1.009	3	4		7
2	3	2	7	63/42/59R6	LF-OS	86	1.34	3	4	3	9
3	7		10	63/42/61R6	LF-OS	86	1.34	4	9		13
6	10	1	17	63/42/62R6	LF-OT	86	1.31	8	13	1	22
5	12		17	63/44/01R6	LF-OT	86	1.31	7	16		22
12	16		28	63/44/07R6	LF-YRT	86	1.009	12	16		28
12	16		28	63/44/08R6	LF-YRT	86	1.009	12	16		28
13	22	2	37	63/44/11R6	LF-YRS	86	2.44	32	54	5	90
21	14	6	41	63/44/13R6	LF-YRS	86	2.44	51	34	15	100
37	40	1	78	63/47/50R6	LF-YRT	87	1.009	37	40	1	78
13	7	2	22	63/47/52R6	LF-YRS	87	2.54	33	18	5	56
39	37		76	63/47/55R6	LF-YRT	87	1.009	39	37		76
11	3	3	17	63/47/56R6	LF-YRS	87	2.54	28	8	8	43
4			4	63/52/04R6	LF-OT	88	2.86	11			11
2			2	63/52/07R6	LF-OT	88	2.86	6			6
3			3	63/52/11R6	LF-OT	87	10.43	31			31
2			2	63/52/13R6	LF-OT	87	10.43	21			21
1	1	2	4	63/52/14R6	LF-OS	87	8.08	8	8	16	32
2	2	2	6	63/52/16R6	LF-OS	87	8.08	16	16	16	48
5	3		8	63/55/44R6	LF-OS	89	1.03	5	3		8
6	1		7	63/55/47R6	LF-OS	89	1.03	6	1		7
9	1		109	63/55/49R6	LF-OT	89	1.04	9	1		10
10	1		11	63/55/50R6	LF-OT	89	1.04	10	1		11
399	232	23	654		= Totals =			754	368	80	1202

APPENDIX C

Lyons Ferry fall chinook salmon releases and proportion marked (coded-wire tag) compared by release year and type.

Release year Age (brood yr)	Release type	Number marked	Number unmarked	Mark rate	Total released
1985					
yearling (83)	on-station	334,442	315,858	0.5143	650,300
subyearling (84)	on-station	234,985	304,407	0.4356	539,392
1986					
yearling (84)	on-station	258,355	223,595	0.5361	481,950
subyearling (85)	on-station	246,625	1,295,543	0.1599	1,542,168
subyearling (85)	transport	245,561	1,831	0.9926	247,392
1987					
yearling (85)	on-station	152,479	77,934	0.6618	230,413
yearling (85)	transport	156,036	470	0.9970	156,506
subyearling (86)	on-station	251,646	86,139	0.7450	337,785
subyearling (86)	transport	255,998	80,264	0.7613	336,262
1988					
yearling (86)	on-station	117,705	168,906	0.4107	286,611
yearling (86)	transport	120,804	425	0.9965	121,229
subyearling (87)	on-station	248,739	1,760,409	0.1238	2,009,148
subyearling (87)	transport	245,749	2,318,550	0.0958	2,564,299
1989					
yearling (87)	on-station	115,350	177,852	0.3934	293,202
yearling (87)	transport	119,217	598	0.9950	119,815
subyearling (88)	on-station	226,478	869,124	0.2067	1,095,602
subyearling (88)	transport	234,103	435,728	0.3495	669,831
1990					
yearling (88)	on-station	112,519	167,526	0.4018	280,045
yearling (88)	transport	117,977	38,332	0.7548	156,309
subyearling (89)	on-station	249,873	2,546,335[a]	0.0894	2,796,208
subyearling (89)	transport	238,045	9,503	0.9616	247,548
1991					
subyearling (90)	transport	222,532	1,907	0.9915	224,439
1992					
yearling (90)	on-station	361,602	2,420	0.9934	364,022
yearling (90)	transport	322,185	3,394	0.9896	325,579

[a] All 1989 brood subyearlings released on-station were marked; those listed as unmarked had a blank-wire tag and no adipose clip.

APPENDIX D

Inventory of known Lyons Ferry origin fall chinook salmon collected and used for cryogenic preservation in 1991.

Brood year	Date collected	Fish no.	Electro no. [a]	Fork ln-cm	CWT code [b]	% motile	No. frozen	No. used [c]
1985	11-05-91	195	--	97	63-41-59R3	85	5 [d]	--
1986	11-05-91	211	--	107	63-42-59R6	65	5	--
	11-26-91	625	--	61	63-44-08R1	65	4	--
	12-03-91	801	--	94	63-44-13R2	80	5	--
	11-05-91	143	91FB40	99	63-42-59R6	85	5	5
	11-05-91	198	--	106	63-44-01R5	85	5	--
	11-05-91	205	--	100	63-44-11R6	85	10 [d]	--
	11-05-91	154	--	109	63-42-62R1	86	5	5
	11-05-91	153	--	101	63-42-61R2	87	5	--
	11-05-91	203	--	95	63-42-61R5	90	10	5
	12-03-91	835	--	99	63-44-11R3	90	10	--
	12-03-91	805	--	92	63-44-08R1	95	10	--
	11-19-91	464	--	94	63-44-13R6	97	10	--
	11-26-91	630	--	92	63-44-07R2	98	5	--
	11-26-91	567	--	95	63-44-07R3	98	2	--
1987	11-26-91	609	--	77	63-47-56R3	70	5	--
	11-19-91	480	91FB98	86	63-47-55R6	75	5	--
	12-03-91	807	--	76	63-47-50R4	78	5	--
	11-05-91	164	--	86	63-47-50R2	79	5	5
	12-03-91	832	--	64	63-47-55R3	80	5	--
	11-19-91	456	91FB95	77	63-47-56R6	85	5	--
	11-19-91	465	91FB94	81	63-52-16R5	85	15	--
	11-26-91	601	--	83	63-47-56R4	90	5	--
	12-03-91	843	--	72	63-47-50R3	95	10	--
	12-03-91	822	--	67	63-47-55R5	95	10	--
	11-26-91	624	--	86	63-47-55R5	95	3	--
	12-03-91	834	--	73	63-47-50R5	99	10	--
	11-19-91	481	91FB93	85	63-47-55R1	99	10	--
1988	12-03-91	823	--	58	63-02-35R6	65	5	--
	11-19-91	484	91FB96	57	63-02-37R4	75	5	--
	11-26-91	603	--	57	63-02-32R1	80	3	--
	12-03-91	836	--	55	63-02-35R5	80	5	--
	11-26-91	627	--	53	63-02-32R3	90	5	--
	11-19-91	461	--	62	63-02-37R1	90	5	--
	11-26-91	619	--	60	63-02-37R3	90	4	--
	11-26-91	645	--	52	63-02-37R4	90	1	--
	11-26-91	646	--	59	63-02-32R4	95	1	--

[a] Sample number for electrophoresis analysis of adult fish.

[b] CWT = coded wire tag abbreviation.

[c] All straws were used on 12 November.

[d] Semen samples became slushy prior to adding cryoextender. Semen sample was thawed and motility taken prior to freezing. Samples are probably bad and will be removed from inventory this fall.