

**BROOD YEAR REPORT  
DWORSHAK NATIONAL FISH HATCHERY  
SPRING CHINOOK SALMON  
BROOD YEAR 2004  
LIFE CYCLE COMPLETED IN 2009**

**PREPARED BY**

**Ray N. Jones, Carrie Bretz, and Luke Gauthier  
Idaho Fishery Resource Office**

**Thomas Trock  
Dworshak National Fish Hatchery**

**Marilyn Blair  
Idaho Fish Health Center**

**Dworshak Fisheries Complex  
U.S. Fish and Wildlife Service  
276 Dworshak Complex Drive  
Orofino, Idaho 83544**

**PREPARED FOR**

**Complex Manager  
Dworshak Fisheries Complex  
U.S. Fish and Wildlife Service  
276 Dworshak Complex Drive  
Orofino, Idaho 83544**

**and**

**The Lower Snake River Compensation Plan Office  
U.S. Fish and Wildlife Service  
1387 South Vinnell Way, Suite 343  
Boise, Idaho 83709**

**June 2011**

## BROOD YEAR 2004 OVERVIEW

Life Stage	Number
<b>2004 Rack Return</b>	<b>2,356</b>
<b>Number of Females Spawned</b>	<b>437</b>
<b>Total Eggs Enumerated<sup>1</sup></b>	<b>1,376,360</b>
<b>Average Eggs per Female</b>	<b>3,813</b>
<b>Eyed Eggs</b>	<b>1,221,685</b>
<b>Smolts Released</b>	<b>1,007,738</b>
<b>In-River Smolt Survival<sup>2</sup></b>	<b>85.1%</b>
<b>Adult Returns to the Hatchery<sup>3</sup></b>	<b>2,148</b>
<b>Adults Harvested in Idaho<sup>4</sup></b>	<b>1,072</b>
<b>Adult Return to Clearwater River</b>	<b>3,322<sup>5</sup></b>
<b>Adults Collected at Other Locations<sup>6</sup></b>	<b>1,786</b>
<b>Total Adult Return to Columbia River</b>	<b>5,108</b>

<sup>1</sup> Number based on the number of culled eggs and enumerated eyed eggs.

<sup>2</sup> Survival to Lower Granite Dam.

<sup>3</sup> I-Ocean, II-Ocean, and III-Ocean returns in 2007, 2008, and 2009 to the hatchery rack.

<sup>4</sup> Tribal and Sport fisheries combined.

<sup>5</sup> Does not include 22 strays above Lower Granite Dam

<sup>6</sup> Estimated adults recovered at various other hatchery racks, dams, fish traps, etc. down river of Lower Granite Dam based on expanded coded-wire tag recoveries.

## **DISCLAIMER**

Data in this report is as complete and accurate as possible at the time of printing. However, because of the life history complexity of spring Chinook salmon and the mixed stock fisheries in the Columbia, Snake, and Clearwater rivers, data is provisional and subject to future revision and corrections, especially in regards to the adult returns. All questions about the validity or precision of information in this report should be directed to the Idaho Fishery Resource Office, Dworshak Fisheries Complex, U.S. Fish and Wildlife Service, (208)-476-7242.

## **Citation for this report**

Jones, R.N., C. Bretz, L. Gauthier, T. Trock, and M. Blair. 2011. Brood year report, Dworshak National Fish Hatchery spring Chinook salmon brood year 2004, life cycle completed in 2009. Technical fisheries report by Dworshak Fisheries Complex, U.S. Fish and Wildlife Service, Ahsahka, ID. 27p.

## **Acknowledgments**

The Complex would like to acknowledge and extend much appreciation to all the other Administrative, Production, Maintenance, and Fish Health staff members at Dworshak Fisheries Complex who accomplish all the fundamental work of producing spring Chinook salmon at Dworshak National Fish Hatchery on an annual basis. From the time that adults are collected and spawned until the smolts are released almost two years later, the Production staff logs an incredible number of hours feeding, cleaning, and monitoring over a million fish on a daily basis. During that time, the Maintenance staff keeps a very complicated infrastructure of rearing containers, pumps, piping, electrical systems, and other equipment operational. The Fish Health staff provides continual testing and monitoring of infectious diseases and parasites. The Administrative Staff works behind the scenes to insure efficient and timely processing of all the necessary paper work required to keep everything operational. Your names might not be on the cover, but you are the people that are really responsible for all that the Complex accomplishes.

## INTRODUCTION

This report provides data for Brood Year (BY) 2004 spring Chinook salmon (SCS) at Dworshak National Fish Hatchery (NFH) which completed its life cycle in 2009. Data are summarized on the adults that were spawned to create the brood year, egg production, nursery rearing, juvenile rearing, smolt releases, fish health, smolt emigration to the ocean, adult contribution to fisheries, adult returns to the hatchery, and estimated total adult return to Lower Granite Dam. Evaluation projects and other research studies involving this brood year are only briefly described in this report and the reader is referred to the specific project reports for details. This Brood Year Report is one of several products called for in the Region One, U.S. Fish and Wildlife Service, Fisheries Vision Action Plan and is intended to provide a broad overview of stock performance and is a compilation of data from various other reports generated by the Dworshak Fisheries Complex.

The reporting of production data for Brood Year 2004 spring Chinook salmon for Dworshak NFH is complicated because of the adult holding, spawning, incubation, and nursery rearing of the spring Chinook salmon from Kooskia NFH. Although the two programs were kept separate as much as possible, these data were not always reported separately for the two stocks and summaries provided in various production and activity reports for Brood Year 2004 were occasionally combined. In those sections where data for the two stocks are combined, it will be pointed out. Otherwise, data is for Dworshak NFH stock and production data for BY2004 Kooskia NFH spring Chinook salmon will be found in the applicable reports for that hatchery.

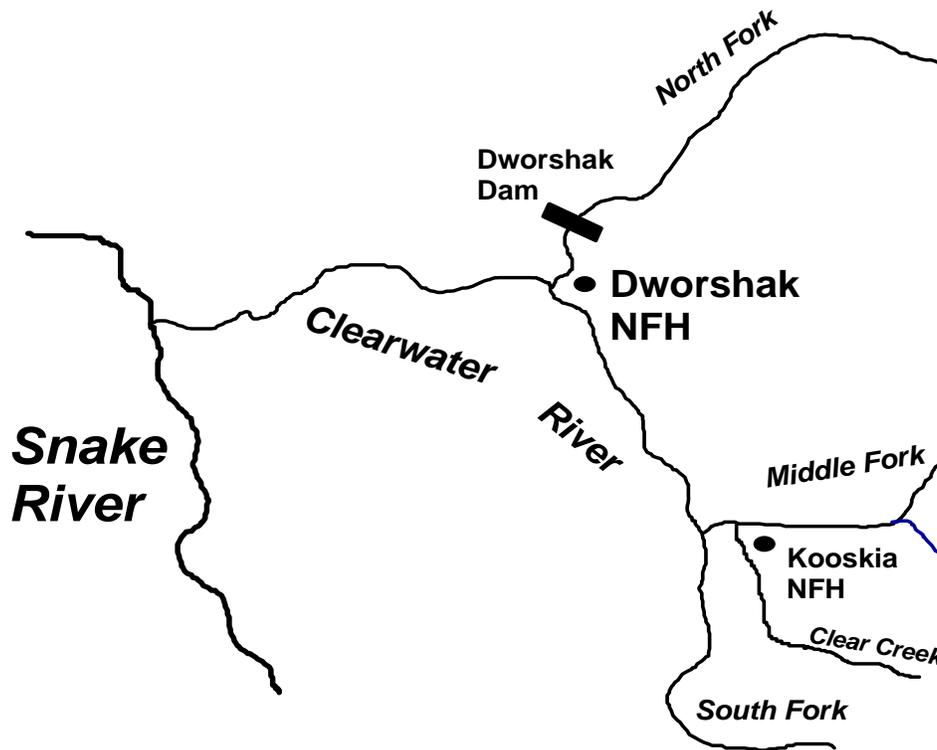
### Program Goal

The spring Chinook salmon production program at Dworshak NFH was started in 1982 as part of the Lower Snake River Compensation Plan (LSRCP) and was originally designed to rear 1.4 million smolts to a size of 20 fish per pound (FPP) for direct release from the hatchery into the Clearwater River (U.S. Army Corps of Engineers 1981). This level of production was designed to meet the mitigation goal of 9,135 adults returning to Lower Granite Dam from the ocean (Herrig 1990). Over the years, several changes have been made to the facility and the production program. For Brood Year 2004, the smolt release target was 1,050,000 smolts reared to a size of between 18 to 20 FPP. The reduction in the number of smolts to be released was based on a change in rearing density as a result of an evaluation by Jones and Miller (1996) and the criteria developed by Integrated Hatchery Operation Team (IHOT).

### Site Description

Dworshak NFH is located at the confluence of the North Fork and the main stem of the Clearwater River near Ahsahka, Idaho (**Figure 1**). Adults enter the hatchery by a ladder located in the North Fork Clearwater River. Adults pass an electronic counter and enter an adult trap until they can be inventoried. Fish are mechanically crowded out of this pond, into a transfer channel and into the spawning room where they can be measured and sorted. From the spawning room, adults can be transferred to one of three long term adult holding ponds until they are

spawned or out-planted. The adult holding ponds are about 8,400 cubic feet in volume and can accommodate about 600-800 adult fish each. Fertilized eggs are incubated in Heath incubation trays. Dworshak NFH has 870 trays. Protocol calls for one female's eggs per tray giving the hatchery the capacity to incubate nearly 3.0 million spring Chinook salmon eggs. In previous years, fry were transferred to inside nursery tanks after hatching. Dworshak NFH has 64 concrete tanks and 64 fiberglass nursery tanks that hold about 667 and 643 gallons of water, respectively. The source of water for both the incubation and nursery rooms is Dworshak Reservoir. However, starting with BY98, fry were transferred directly into the outside rearing raceways, eliminating nursery rearing, in order to lessen the impact on the summer steelhead rearing program. Final rearing occurs in outside raceways. Dworshak NFH has 30 8' X 80' concrete raceways in two separate "banks" (A and B) for juvenile Chinook rearing. Each bank has 15 raceways. All the raceways are supplied with single pass ambient river water from the North Fork Clearwater River.



**Figure 1.** Dworshak National Fish Hatchery (NFH) is located at the confluence of the North Fork and main stem Clearwater River, Idaho.

## 2004 ADULT SPRING CHINOOK SALMON RETURN TO DWORSHAK NFH

The brood year is formed from the progeny of the adults that return as brood stock to Dworshak National Fish Hatchery during the 2004 return year. This section provides information on the pre-season predictions compared to the actual returns (total returns to the Clearwater River), the ladder operations and inventory of adults, the age composition of the run, adult holding and mortality, spawning, and handling of adults that were excess to brood stock needs.

### Pre-Season Assessment

The Idaho Fishery Resource Office (FRO) used a regression equation based on the I-Ocean (Jack) returns in the previous year to forecast or predict the return of II-Ocean adults to the Clearwater River the following year. In 2003, the I-Ocean return to Dworshak NFH was 847 fish providing a prediction of 12,064 adults returning to the Clearwater River for the 2004 season (Idaho Fishery Resource Office 2004, Table 11). This number was much higher than the actual return. **Table 1** lists the predicted return, made in 2003, and the expanded actual returns of all three age classes of adults in 2004 (Idaho Fishery Resource Office 2011, Appendix Table 5). Our prediction for the I-Salt return was slightly less than the actual return, 195 vs. 223. The regression used for making our prediction gave a very high estimate for II-Salt returns, 11,696 predicted vs. 5,891 actual. Our prediction for the III-Salt returns was slightly lower than the actual return, 173 vs. 269. Although our total prediction was much higher than the actual return, it was still useful for management planning purposes such as anticipating potential harvest opportunity, collecting sufficient brood stock, and planning for adult outplanting. We coordinated ladder operations to maximize the fishing opportunities and to minimize brood stock handling and holding.

**Table 1.** Pre-season prediction and actual adult returns of Dworshak NFH stock to the Clearwater River, by ocean age, for BY2004 (Idaho Fishery Resource Office 2011, Appendix Table 5<sup>1</sup>).

Ocean Age <sup>1</sup>	2003 Prediction for 2004	Actual 2004 Return
I - Ocean	195	223
II - Ocean	11,696	5,891
III - Ocean	173	269
<b>Total</b>	<b>12,064</b>	<b>6,383<sup>2</sup></b>

<sup>1</sup> I-Ocean are BY2001, II-Ocean are BY2000, and III-Ocean are BY1999.

<sup>2</sup> Total return updated with more recent estimates of sport and Tribal harvest, compared to data reported in the 2004 Annual Report (Idaho Fishery Resource Office 2005).

## Total Rack Return

The total rack return is the number of adults that return to the hatchery and is not an accounting of the total return to the river. The 2004 adult spring Chinook salmon return to Dworshak NFH was 2,356 adults (**Table 2**).

**Table 2.** Actual rack return of adult spring Chinook salmon to Dworshak NFH by ocean age (Idaho Fishery Resource Office 2005, Tables 4 and 6).

Ocean Age	Smolts Released	2004 Rack Return
I - Ocean	1,033,982 (2003)	142
II - Ocean	1,000,561 (2002)	2,077
III - Ocean	333,120 (2001)	137
Unmeasured		0
<b>Total</b>		<b>2,356</b>

## Ladder Operations and Adult Inventories

Ladder operations at Dworshak NFH vary annually based on run strength and fishery management objectives. Once the ladder is opened, a fish counter monitors the number of adults entering the trap. The trap can optimally handle a maximum of about 900 adults. Once per week or on a regular basis the trap is emptied and the adults are inventoried and transferred to one of three adult holding ponds.

The hatchery ladder was operated intermittently from May 27 to September 7, 2004, being opened and closed four times during that period (Dworshak National Fish Hatchery 2004, Table 1). **Table 3** lists the inventory dates and the numbers of adults collected during that time period by age.

**Table 3.** Number of spring Chinook salmon, by age class, on each inventory date from 6/23/04 to 9/14/04, including trap mortalities (2004 Salmon News, Idaho FRO Files).

Inventory Date	I-Ocean	II-Ocean	III-Ocean	Total
June 23	37	370	22	429
June 30	17	109	8	134
July 13	28	251	24	303
July 21	15	224	15	254
August 3	4	402	29	435
August 19	15	312	17	344
August 25	16	295	18	329
August 31	6	69	2	77
September 7	0	10	1	11
September 14	3	24	0	27
Trap Mortals	1	11	1	13
<b>Total</b>	<b>142</b>	<b>2,077</b>	<b>137</b>	<b>2,356</b>

#### Age Composition of Rack Return to Dworshak NFH

Age composition of spring Chinook salmon returning to the hatchery is based on fork length categories. These length categories were derived from known age/length/sex data from coded-wire tag (CWT) recovery databases. Ocean age categories are listed below:

- I - Ocean (Jacks) < 56 cm
- II - Ocean = 57 to 81 cm
- III - Ocean > 81 cm.

Adult spring Chinook salmon that return to Dworshak NFH are predominately II-Ocean fish, those that spend two years in salt water before returning to freshwater to spawn. The age composition for the 2004 return was 6% I-Ocean, 88% II-Ocean, and 6% III-Ocean, respectively. The five year mean percent returns in the rack for I-Ocean, II-Ocean, and III-Ocean adults are 22%, 53%, and 25%, respectively, for all years from 1999 to 2003 (**Table 4**).

When comparing the percentages of the 2004 to the five-year mean, there is a higher percentage of II-Ocean adults and a lower percentage of I-Ocean and III-Ocean adults. The return in 2004 was similar in structure to that of the 5-year mean, with II-Ocean adults comprising most of the return (**Table 4**).

**Table 4.** Number and percent of adult spring Chinook salmon that returned to Dworshak NFH since 1999, by ocean age (Idaho Fishery Resource Office 2005, Table 4).

Return Year	I-Ocean		II-Ocean		III-Ocean		Total Return
1999	670	84%	78	10%	52	6%	800
2000	221	7%	2,827	90%	104	3%	3,202
2001	36	1%	3,235	80%	747	19%	4,018
2002	62	3%	1,480	69%	615	28%	2,157
2003	580	17%	478	14%	2,364	69%	3,422
Mean	314	22%	1,620	53%	776	25%	2,719
2004	<b>142</b>	<b>6%</b>	<b>2,077</b>	<b>88%</b>	<b>137</b>	<b>6%</b>	<b>2,356</b>

### Adult Marking

Because of space and water temperature limitations at Kooskia NFH, all the spring Chinook salmon collected for brood stock at that hatchery are transferred to Dworshak NFH for holding and spawning. To ensure separation of stocks, all the Dworshak NFH adult spring Chinook salmon were marked with a left opercul V-notch and the adults from Kooskia NFH were marked with a right opercul V-notch.

### Adult Holding and Mortality

Formalin treatments were administered during adult holding to retard fungus infection. Treatments consisted of dripping 200 mg/l into each pond over the course of an hour three times weekly.

Despite efforts to the contrary, adult mortalities occurred. Adult mortality is reported for two separate periods: pre-spawning (holding mortality) and mortality during spawning.

*Pre-Spawning Mortality* - From June 7 to August 16, a total of 36 adult spring Chinook salmon (1.5% of rack return) died: 23 females, 10 males, and 3 jacks.

*Mortality During Spawning* - From August 18 through September 16, an additional 170 adults died (7.2 % of rack return), 97 males and 73 females. Of the 97 males, 13 were jacks.

Compared to previous brood years, the mortality rate of BY04 spring Chinook salmon adults during holding was the lowest in recorded history. Mortality after the first day of spawning was higher than the 5-year average (**Table 5**).

**NOTE:** On June 30, 134 adults that were in holding pond 9, waiting to be inventoried, died when water from System 3 that was being chemically treated, leaked into the pond. In the 2004 spawning report (Dworshak National Fish Hatchery 2004), these fish were included in the Mortality During Spawning category. In this report, we list them separately and recalculated the mortality during holding.

**Table 5.** Percent mortality of adult spring Chinook salmon during holding (pre-spawning) and during spawning at Dworshak NFH, 2000-2004 (Dworshak National Fish Hatchery 2004, Table 9).

Brood Year	Pre-Spawning Mortality	Mortality During Spawning <sup>1</sup>	Total
2000	5.3%	3.0%	8.3%
2001	4.2%	2.6%	6.8%
2002	4.9%	7.1%	12.0%
2003	4.9%	2.7%	7.6%
<b>2004</b>	<b>1.5%</b>	<b>7.2%</b>	<b>8.8%</b>
<b>Five-Year Average</b>	<b>4.2%</b>	<b>4.5%</b>	<b>8.7%</b>

<sup>1</sup> Does not include 134 adults that died in Pond 9 on June 30, prior to being inventoried.

## Spawning

Details on the methods and procedures during spawning are provided in the Spawning Report for Brood Year 2004 (Dworshak National Fish Hatchery 2004). Spawning was started on August 18, about the same time as in 2003. Five egg takes were made with the last ripe females for the Dworshak NFH program taken on August 31. A summary of the number of males and females spawned each week is presented in **Table 6**.

**Table 6.** Number of male and female spring Chinook salmon spawned during each egg take for Brood Year 2004 at Dworshak NFH (Dworshak National Fish Hatchery 2004). Jacks are incorporated into the number of males spawned.

Egg Take Date	Males Spawned	Females Spawned
8/18/04	141	165
8/19/04	37	45
8/24/04	82	90
8/25/04	64	75
8/31/04	52	62
<b>Total</b>	<b>376</b>	<b>437</b>

## Adult Out-Planting

In years where the return of adults exceeds the brood stock needs of the program, excess adults that enter the ladder have been transported to various streams within the Clearwater River and released to spawn naturally. These activities are coordinated with the Idaho Department of Fish

and Game and the Nez Perce Tribe. The 2004 rack returns to Dworshak were greater than was needed to meet brood stock needs. Arrangements were made with the Nez Perce Tribal Fisheries Department to transport excess adults to various tributaries throughout the Clearwater River basin for supplementation purposes. A total of 979 fish were out-planted from Dworshak NFH and 29 from Kooskia NFH (**Table 7**).

**Table 7.** Numbers of adult spring Chinook salmon transported from Dworshak NFH to various locations in the Clearwater River to supplement natural production in 2004 (Idaho Fishery Resource Office 2005, Table 12).

Date	Location	Adults	Jacks	Total	Comments
August 8	Lower Selway	371	29	400	154 males; 217 females; 29 jacks
September 3	Lower Selway	261	21	282	114 males; 147 females; 21 jacks
September 16	Lower Selway	306 <sup>1</sup>	20	326	145 males; 161 females; 20 jacks
	<b>Totals</b>	938	70	1,008	

<sup>1</sup> Twenty-nine were Kooskia NFH stock.

## EGG PRODUCTION AND INCUBATION

Data on early incubation, eye-up, and final incubation and hatching is found in the Dworshak NFH spawning report (Dworshak National Fish Hatchery 2004).

### Green Eggs Taken

Eggs are not enumerated until after eye-up. The number of green eggs taken initially is estimated using an average of 3,500 eggs per female. A total of 437 females were spawned, giving an initial estimate of 1,529,500 green eggs (Dworshak National Fish Hatchery 2004).

### Early Incubation

All eggs were incubated in Heath trays. Eggs from each female were incubated separately to segregate and track offspring by the Bacterial Kidney Disease (BKD) status (low/medium/high) of the female parent based on Enzyme-Linked Immunosorbant Assay (ELISA) tests (see **FISH HEALTH** section for detail). Water flow through the incubators was maintained at about 5 gal/m. Water temperatures averaged 42°F using the water chillers (Dworshak National Fish Hatchery 2004).

### Eggs Culled for BKD

Kidney samples were taken from all females to test for BKD. For brood year 2004, eggs from 49 females, that tested high ( $\geq 0.199$  ODU) for BKD, were culled from production (Dworshak National Fish Hatchery 2004).

## Eye-Up

At eye-up eggs were shocked, dead eggs were removed, and eggs were enumerated by a mechanized egg picker. A total of 154,675 dead eggs were counted. The total number of eyed eggs enumerated was 1,221,685, producing an average of 3,813 eggs per female (**Table 8**).

**Table 8.** Summary of egg take and eye-up for Dworshak NFH BY2004 spring Chinook salmon (Dworshak National Fish Hatchery 2004, Table 2).

Take	Spawn Date 2004	No of Male <sup>1</sup>	Total No. of Females	Female culled BKD <sup>2</sup>	Female culled dead tray	Extra Females Culled <sup>3</sup>	Dead Eggs Enum	Eyed Eggs Enum	Eggs for Research	Total Eggs	Eggs/Female	Percent Enum Eye-up <sup>4</sup>
1	08/18	141	165	8	3	0	85,961	498,900	0	584,861	3,798	85.3
2	08/19	37	45	1	7	0	41,412	101,622	0	143,034	3,866	71.0
3	08/24	82	90	2	2	15	15,565	254,833	0	270,398	3,808	94.2
4	08/25	64	75	24	0	0	4,923	197,000	0	201,923	3,959	97.6
5	08/31	52	62	14	0	0	6,814	169,330	0	176,144	3,670	96.1
<b>Tot/Ave</b>		<b>376</b>	<b>437</b>	<b>49</b>	<b>12</b>	<b>15</b>	<b>154,675</b>	<b>1,221,685</b>	<b>0</b>	<b>1,376,360</b>	<b>3,813</b>	<b>88.8</b>

1 Includes 17 jacks spawned during the season.

2 BKD culling at minimal level above 0.199 ELISA testing for all Takes

3 Wrong water temperature turned on stack at beginning of incubation during Take 3

4 Formalin treatment timer malfunction - 1<sup>st</sup> formalin treatment of season on Takes 1-2 prolonged 30 minutes additional treatment

Percent enumerated eye-up does not include eggs/females culled before enumeration

Source: BY04 SCS Egg Enumeration and % Survival of Eggs Summary SC2004 EggEnum.wk4

IFHC BKD ELISA testing results BY04 SCS

## Egg Transfers and Final Incubation

In order to delay the time of hatching and reach the desired release size without resorting to a feed reduction program, Dworshak NFH's spring Chinook salmon eggs were incubated at 38°F. However, at that time, Dworshak NFH only had the capacity to chill enough water for about one-half of the production and the other half was transferred to Kooskia NFH in October and November, 2004. The water temperature available at Kooskia NFH was about 39°F. Details are provided in the spawning report for 2004 (Dworshak National Fish Hatchery 2004). **Table 9** lists the date, take, and number of eggs transferred to Kooskia NFH.

**Table 9.** Date and number of BY2004 spring Chinook salmon eggs transferred to Kooskia NFH for final incubation and early rearing as part of the Dworshak NFH production program (Dworshak National Fish Hatchery 2004, Table 4).

Date of Transfer	Number of Eggs
October 21 (Take 4)	197,000
October 28 (Take 5)	169,330
November 12 (Take 3)	230,000
<b>Total</b>	<b>596,330</b>

### **Tanking**

Eggs at Dworshak NFH began hatching in December 2004. Hatching was completed by the end of January 2005. Eggs at Kooskia NFH hatched about two weeks earlier due to warmer water temperatures in Clear Creek. Fry at Dworshak NFH were left in incubation trays at temperatures between 36-38°F. After hatching, the fry at Kooskia NFH were transferred to nursery tanks for early rearing.

## **JUVENILE REARING**

The following data and information was summarized from the hatchery production records at Kooskia NFH, the 2006 and 2007 Annual Reports for Dworshak NFH, the Dworshak NFH monthly production narratives, and the Dworshak NFH monthly inventory summaries (MIS).

### **Transfers and Handling**

From April 20-25, 2005, there were 531,500 BY2004 fry transferred from Dworshak incubators to A-bank raceways. These fish began feeding within a day of the transfer. On May 18-19, 2005, there were 550,000 BY2004 fry transferred from Kooskia NFH to Dworshak NFH A-bank raceways. These fish were approximately 250 fish per pound at transfer.

### **Growth and Mortality**

Growth was normal and as programmed, reaching the targeted size at release by March 2006. A record of monthly growth and mortality, from the end of April 2004 until the time of release in March 2006, is listed in **Table 10**.

### **Marking and Tagging**

*Coded-Wire Tags and Adipose Fin Clips-* Adipose fin clipping and coded wire tagging was conducted by the U.S. Fish and Wildlife Service, Columbia River Office, Vancouver, between August 8 and 9, 2005. A total of 136,326 (total number tagged) spring Chinook salmon fingerlings were coded-wired tagged to evaluate the contribution of Dworshak NFH to commercial, sport and tribal fisheries in the lower Snake and Columbia rivers as well as in the ocean (**Table 11**). All the spring Chinook salmon smolts on station were adipose fin clipped to

identify them as hatchery fish. Coded-wire tag retention rates were determined by sampling 500 fish from each tag code group in March 2006, prior to release. Tag code 051188 had a retention rate of 99.0% and tag code 050798 had a retention rate of 99.6%.

**Table 10.** Summary of monthly growth and mortality of Brood Year 2004 spring Chinook salmon during outside raceway rearing at Dworshak NFH. Compiled from monthly production narratives and monthly inventory summaries.

Date (End of Month)	Number	Weight (lbs)	FPP (Fish per Pound)	Mean Length (mm)	Mean Growth (mm)	Mortality (%)	Mean Water Temp (°F)
4/05	517,920	305	1698.1	32	-	2.6	42.4
5/05	1,059,487 <sup>1</sup>	3,200	331.1	55	23	1.3	44.0
6/05	1,050,440	4,493	233.8	62	7	0.8	45.6
7/05	1,046,344	5,972	175.2	68	6	0.4	45.3
8/05	1,017,713	9,775	104.1	81	13	0.2	46.4
9/05	1,016,480	15,168	67.0	93	13	0.1	46.4
10/05	1,015,461	21,689	46.8	105	12	0.1	45.6
11/05	1,014,781	27,722	36.6	114	9	0.1	47.1
12/05	1,014,279	32,792	30.9	121	7	0.1	44.7
1/06	1,013,857	40,063	25.3	129	8	0.1	42.4
2/06	1,010,185	46,428	21.8	136	7	0.1	40.9
3/06	1,007,738	54,402	18.5	143	7	0.1	41.1

<sup>1</sup> 550,000 fry were transferred from Kooskia NFH to Dworshak NFH May 18-19, 2005.

**Table 11.** Coded-wire tag release information for Brood Year 2004 spring Chinook salmon released from Dworshak NFH in 2006.

Hatchery	Tag Code	Number of Tags	Number of Unmarked Fish	Mark Rate	Purpose
DNFH	051188	66,852 <sup>1</sup>	433,260	0.13	Contribution, Raceways A1 and A2
	050798	67,532	440,094	0.15	Contribution, Raceways B16 and B17

<sup>1</sup> The number reported is adjusted for mortality and tag loss.

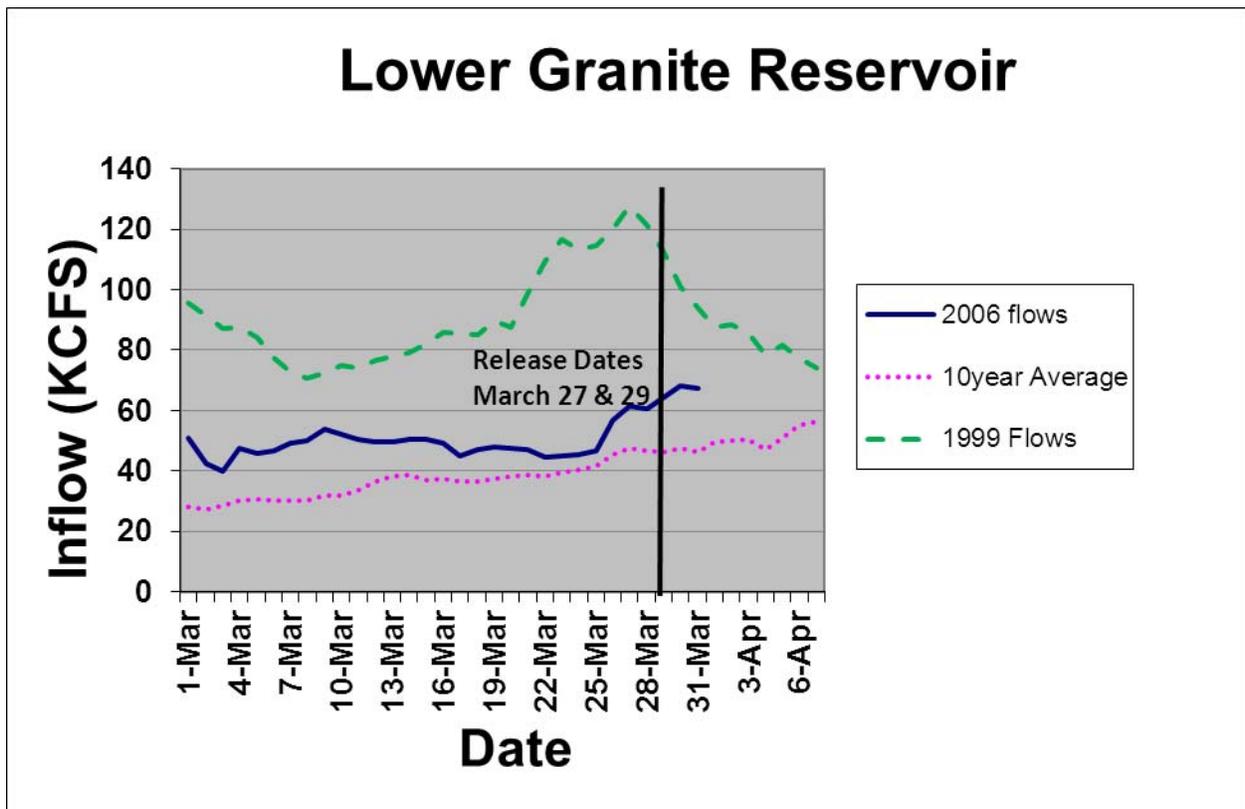
*PIT tags* - PIT tagging of BY2004 spring Chinook smolts was conducted by the Columbia River Fisheries Office (CRFRO) between January 3 and 11, 2006. A total of 51,956 spring Chinook salmon were PIT tagged to monitor travel time and estimate survival to Lower Granite Dam after release. These fish were part of the Comparative Survival Study (CSS). One-thousand smolts were PIT-tagged by the CRFRO for the Comparative Delayed Mortality Study. An additional 44,450 spring Chinook smolts were PIT-tagged by Biomark between February 7 and 10, 2006 as

part of the Disease Susceptibility Study (DSS). See **SPECIAL STUDIES** section for details of the aforementioned studies.

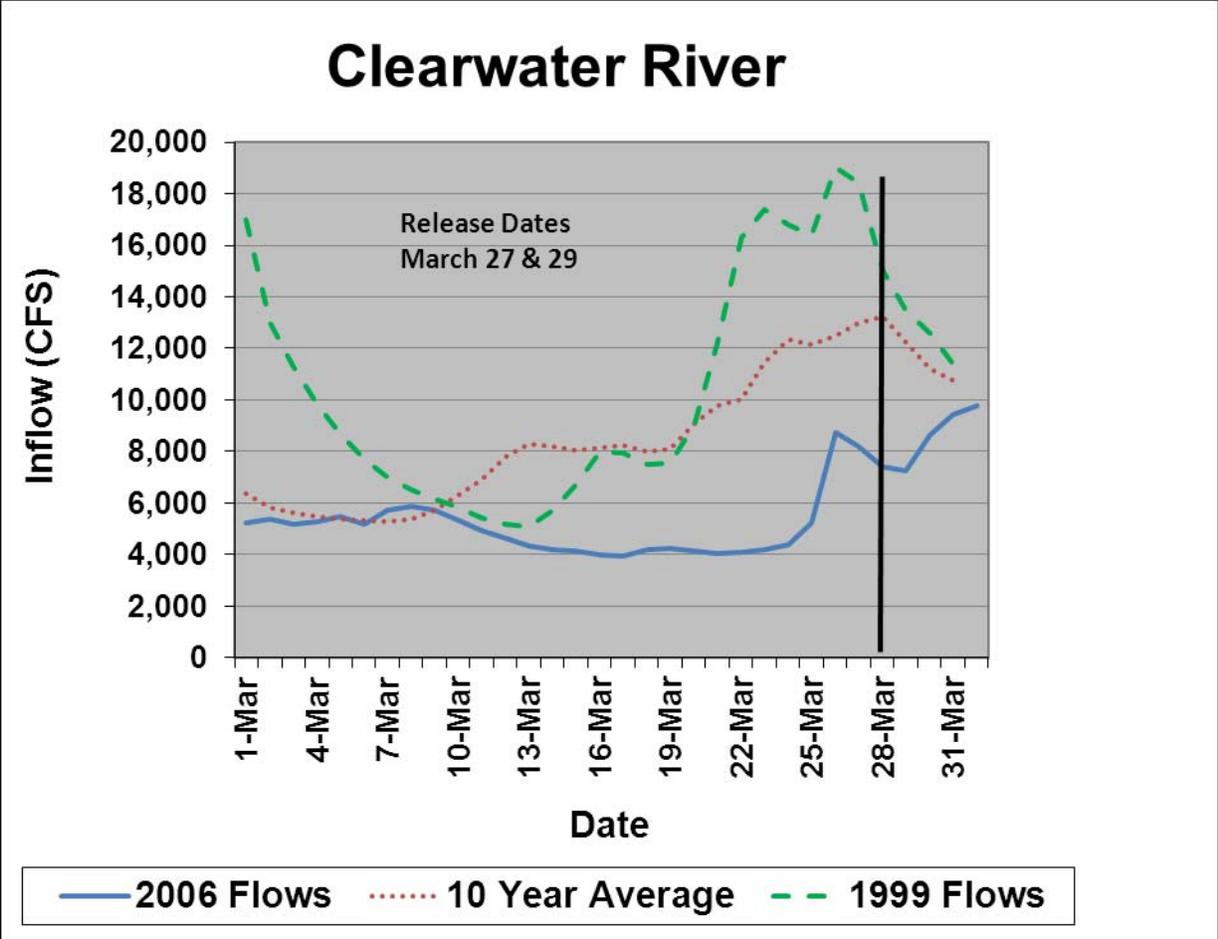
**NOTE:** For consistency among brood years, only the Comparative Survival Study PIT tags were used for analysis of smolt emigration, survival and adult returns.

### SMOLTS RELEASES

Idaho FRO began monitoring stream flows in the Clearwater River at the beginning of March, 2006 to coordinate spring Chinook salmon smolt releases with increases in the hydrograph. Mean daily flows into Lower Granite Reservoir remained above and followed the 10 year average until several days prior to release, when flows increased slightly (**Figure 3**). Mean daily flow in the Clearwater River followed the 10-year average during the first half of March and then remained above the 10-year average until release (**Figure 4**). Releases were made during the afternoon and early evening of March 27 and 29. A total of 1,007,738 smolts were released into the North Fork of the Clearwater River. The smolts averaged 18.5 fish per pound and 143 mm (5.7 inches) total length.



**Figure 3.** Mean daily flow in Lower Granite Reservoir during March 2006, compared to the 10 year average and the high flows in 1999. Vertical line indicates the dates smolts were released.



**Figure 4.** Mean daily stream discharge of the Clearwater River at the Orofino bridge, 2006, compared to the 10-Year Average and during 1999. Vertical line indicates the dates smolts were released.

## FISH HEALTH

### Brood Year 2004 Adult Brood Stock

Holding - During the period of holding prior to spawning, formalin treatments were administered under veterinary prescription to adults to retard fungus infection. All the Dworshak NFH stock was held in Holding Pond Two. Formalin treatments were administered as bath treatments for one hour per day, 3 days per week at a concentration of 1:6,000.

Pre-Spawning - Beginning at 3 weeks prior to spawning, all adult females which returned before start of spawning were injected with the antibiotic Erythromycin under veterinary prescription to decrease levels of *Renibacterium salmoninarum* (Bacterial Kidney Disease) in the eggs. Each female injected received a dosage of 20 mg/kg of body weight.

#### Spawning -

113/213 (53.05%) adults tested positive for IHNV (Infectious Hematopoietic Necrosis Virus). Ovarian fluid samples were 3 pooled and spleens 5 pooled. All spleen tissues were sampled from males.

Results positive for IHNV by take:

Take 1: 12/36 ovarians, 0/9 male spleens

Take 2: 9/18 ovarians

Take 3: 71/95 ovarians, 5/24 male spleens

Take 5: 3/3 ovarians, 13/28 male spleens

All female adults were tested for Bacterial Kidney Disease (*Renibacterium salmoninarum*) by ELISA (Enzyme-Linked Immunosorbent Assay)

Results:

Not Detected - 404

Low - 22

Medium - 6

High- 7

SCS adults were also positive for the parasite *Ceratomyxa shasta* by examination of wet mounts from scrapes of the walls of the intestines.

### Brood Year 2004 Juveniles

#### Production Monitoring –

Beginning in November, 10 fish per month were sampled for BKD by ELISA.

Results:

11-29-05 – Not Detected: 10

12-21-05 – Not Detected: 10

1-30-06 – Not Detected: 10

2-24-06 – Not Detected: 10

August – Fish examined for slight increase in mortality during marking. Most moribund fish were pumpkin-seed shaped or had other genetic deformities. No *R. salmoninarum* (BKD) seen in kidney imprints. No treatment necessary.

October – Moderate levels of the parasite *Epitheliocystis*, and very light levels of *Ambiphyra* seen. Good fat and food levels. No treatment necessary.

December – Low levels of parasites *Epitheliocystis* and *Epistylis* seen on the skin. Low levels of the blood fluke *Sanguinicola* noted on the gills. Fish appeared healthy at this time.

January - Low levels of external parasites *Epistylis* and *Ambiphyra* were found on the skin of Dworshak SCS. Fish appeared healthy at this time.

February – Low levels of external parasites *Epistylis* and *Epitheliocystis* were detected on the skin. Gills were slightly swollen. Ponds were noted to appear dirty and in need of cleaning.

Pre-release exam - 58 fish (kidneys 2-pooled)

ELISA Results: Not detected – 58

Low - 0

Medium - 0

High - 0

Viral assays - negative

Bacterial assays - negative

Hematocrits - 20 samples, all in normal range

## **Adult Returns**

### I-Ocean Adults (2007 Return)

171/210 (81.43%) adults tested positive for IHNV (Infectious Hematopoietic Necrosis Virus). Ovarian fluid samples were 3 pooled and spleens 5 pooled. All spleen tissues were sampled from males.

Results positive for IHNV by take:

Take 1: 33/36 ovarians, 10/30 male spleens

Take 4: 108/114 ovarians, 20/30 male spleens

All female adults were tested for Bacterial Kidney Disease (*Renibacterium salmoninarum*) by

ELISA (Enzyme-Linked Immunosorbent Assay)

Results:

Not Detected - 467  
Low - 28  
Medium - 4  
High- 7

SCS adults were also positive for the parasite *Ceratomyxa shasta* by examination of wet mounts from scrapes of the walls of the intestines.

### II-Ocean Adults (2008 Return)

37/213 (17.4%) adults tested positive for IHNV (Infectious Hematopoietic Necrosis Virus). Ovarian fluid samples were 3 pooled and spleens 5 pooled. All spleen tissues were sampled from males.

Results positive for IHNV by take:

Take 1: 9/38 ovarians, 10/36 male spleens  
Take 2: 0/87 ovarians, 0/25 male spleens  
Take 3: 18/27 ovarians, 13/28 male spleens

All female adults were tested for Bacterial Kidney Disease (*Renibacterium salmoninarum*) by ELISA (Enzyme-Linked Immunosorbent Assay)

Results:

Not Detected - 320  
Low - 55  
Medium - 6  
High- 4

SCS adults were also positive for the parasite *Ceratomyxa shasta* by examination of wet mounts from scrapes of the walls of the intestines.

### III-Ocean Adults (2009 Return)

61/210 (29.05%) adults tested positive for IHNV (Infectious Hematopoietic Necrosis Virus). Ovarian fluid samples were 3 pooled and spleens 5 pooled. All spleen tissues were sampled from males.

Results positive for IHNV by take:

Take 1: 30/77 ovarians, 5/40 male spleens  
Take 3: 21/73 ovarians, 5/20 male spleens

All female adults were tested for Bacterial Kidney Disease (*Renibacterium salmoninarum*) by ELISA (Enzyme-Linked Immunosorbent Assay)

Results:

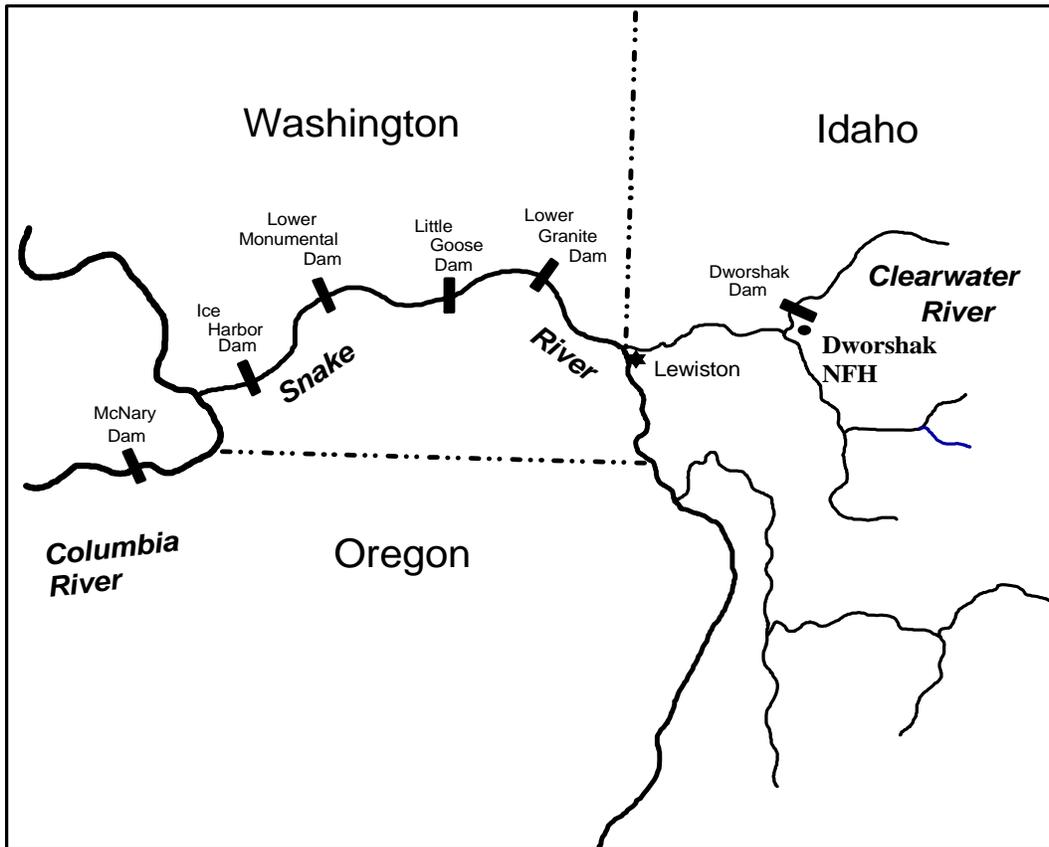
Not Detected - 327  
Low - 45

Medium - 2  
High- 0

SCS adults were also positive for the parasite *Ceratomyxa shasta* by examination of wet mounts from scrapes of the walls of the intestines.

### SMOLT EMIGRATION

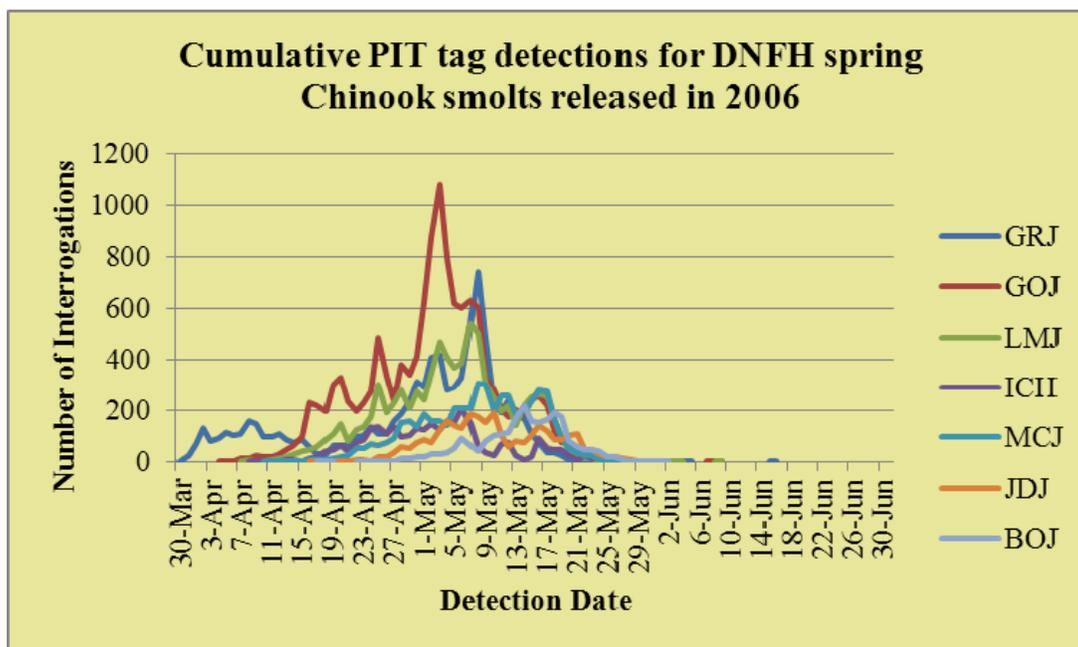
The performance of spring Chinook salmon smolts was monitored and evaluated using PIT tags after they were released from the hatchery. The tags were interrogated at Lower Granite, Little Goose, and Lower Monumental dams on the Lower Snake River and at McNary, John Day and Bonneville dams on the lower Columbia River (**Figure 5**). PIT tags provide information on travel time and survival during emigration. A total of 97,244 PIT-tagged spring Chinook salmon smolts were released in 2006 as part of two separate studies evaluating the effects of transportation on survival. The goal of both studies is to evaluate adult returns and determine whether transportation affords a survival advantage during spring emigration to the ocean; however, each addresses different aspects of survival. (See **SPECIAL STUDIES** section for details)



**Figure 5.** Dams on the lower Snake and Columbia rivers that have PIT tag interrogation facilities for monitoring smolt emigration and adult returns. John Day and Bonneville dams are not shown.

## Travel Time

Travel time for BY2004 spring Chinook smolts released from Dworshak NFH through the Federal Columbia River Power System was monitored using PIT tag interrogations at the juvenile bypass facilities (Figure 6).

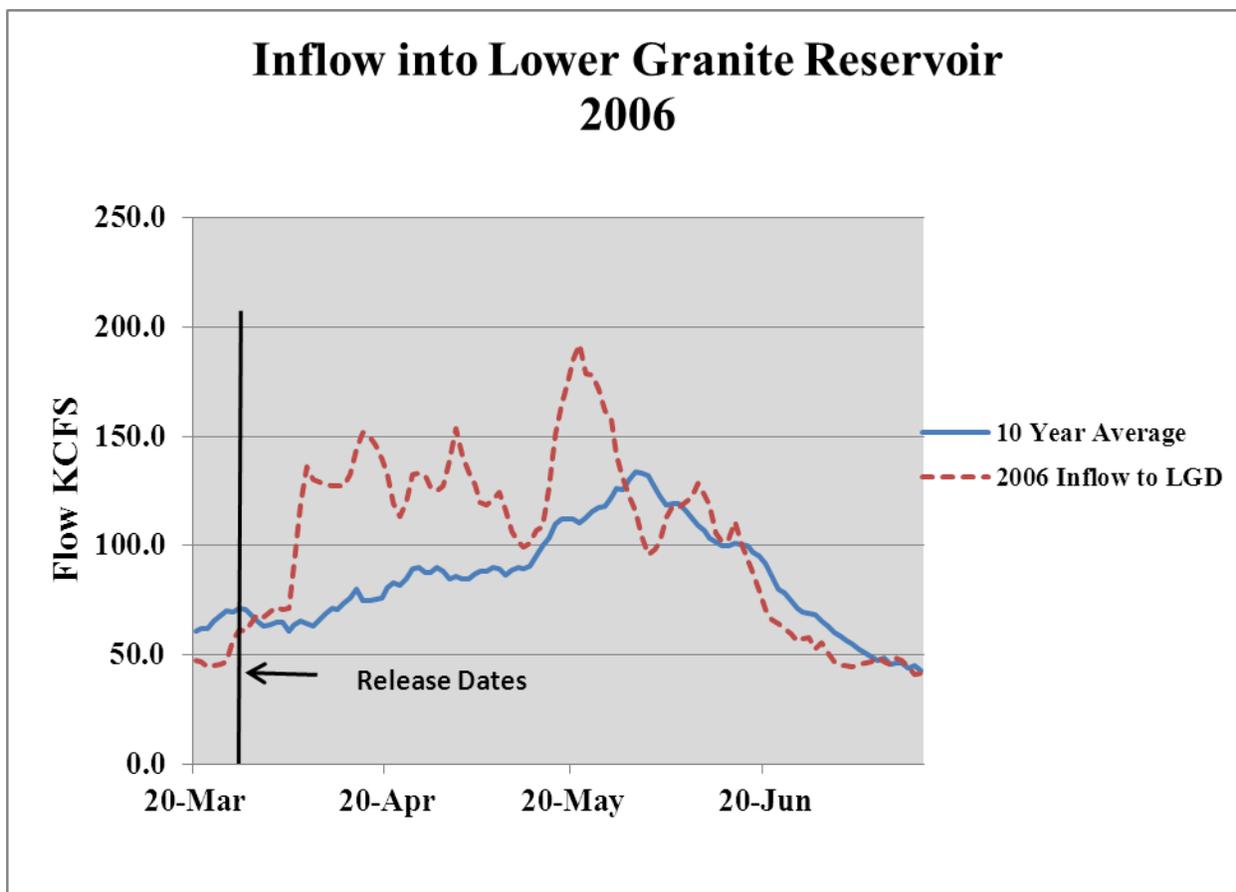


**Figure 6.** Cumulative PIT tag detections for BY04 Dworshak NFH spring Chinook smolts at juvenile bypass facilities in the Lower Snake and Columbia rivers.

The migration time of BY2004 smolts released from Dworshak NFH to Lower Granite Dam ranged from 3.3 days to 79.0 days with a harmonic mean travel time of 32.2 (SE=12.576) days. Ten percent arrived at Lower Granite Dam within 11.2 days; 50% and 90% arrived within 35.4 days and 44.3 days, respectively. Smolts that migrated through the hydro system arrived at Bonneville Dam on average 47.4 days after release.

## River Flows

Flows in the Lower Snake River were higher than the 10-year average for most of the time right after release until the end of May and then followed the 10-year average during the remaining time of the smolts emigration period through mid-July (Figure 7). Inflow into Lower Granite Reservoir never exceeded 90,000 cubic feet per second (cfs). Flows remained at or below 40,000 cfs from the time of release until late April. Flows increased steadily peaking at near 90,000 cfs near mid-May. By early June, flows again decreased to less than 40,000 cfs and remained there for the rest of the period of emigration.



**Figure 7.** Mean daily inflow to Lower Granite Reservoir from March 28 through July 12, 2006 during spring Chinook salmon emigration after release from Dworshak NFH. The 10 year average is shown for perspective.

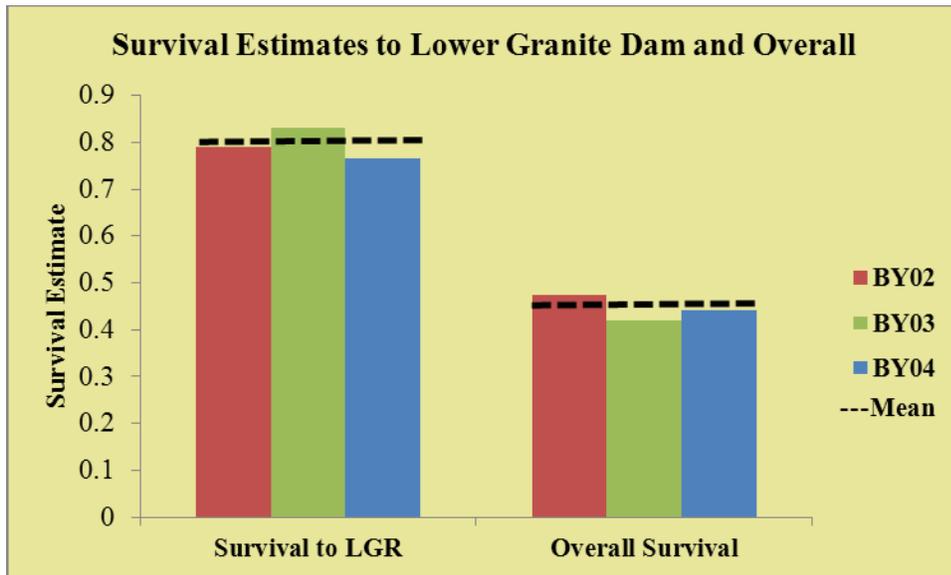
### Estimated Smolt Survival

Survival probabilities through the Federal Columbia River Power System (FCRPS) were calculated using SURvival under Proportional Hazards 2.1 (SURPH) (Lady *et al.* 2001) (**Table 12**).

**Table 12.** Cumulative survival estimates of BY2004 spring Chinook smolts released from Dworshak NFH as they pass juvenile bypass facilities in the Lower Snake and Columbia rivers.

River Reach	Survival Estimate	Standard Error
Release (NF Clearwater) – Lower Granite Dam	0.765	0.0120
Lower Granite Dam – Little Goose Dam	0.812	0.0164
Little Goose Dam – Lower Monumental Dam	0.938	0.0184
Lower Monumental Dam – McNary Dam	0.891	0.0276
McNary Dam – John Day Dam	0.964	0.0588
John Day Dam – Bonneville Dam	0.882	0.1827
Overall	0.442	0.0881

River reach survival for spring Chinook smolts ranged from 0.77 (SE= 0.0120) to 0.94 (SE= 0.0184). The lowest survival occurred between Dworshak NFH and Lower Granite Dam and the highest survival occurred between McNary and John Day dams. Overall survival to Bonneville Dam was 0.44 (SE=0.00881); lower than BY2002, but higher than BY2003 (**Figure 8**).



**Figure 8.** Mean survival estimates to Lower Granite Dam and overall survival estimate through the Federal Columbia River Power System, BY2002-BY2004.

### ADULT RETURNS

Estimating the numbers of Dworshak NFH origin adult spring Chinook salmon that return from the ocean for a single brood year is quite complicated and challenging for several reasons. First, the adult returns entering the mouth of the Columbia River from the ocean are composed of mixed stocks from various state, Tribal, and federal fishery programs and are harvested in the Ocean, the Columbia, Snake, and Clearwater rivers. The adults that enter the Clearwater River each year originate from smolt release programs at Dworshak NFH, Kooskia NFH, Idaho Department of Fish and Game (IDFG) facilities at Powell, Red River, and Crooked River, and Nez Perce Tribal Hatchery program releases in Lolo Creek, Newsome Creek, and the Selway River. The challenge is further complicated because the adults return over three successive years at different ages after spending one to three years in the ocean (Jones *et al.* 2011a). Thus, Brood Year 2004 adults, released as smolts in 2006, return as I-Ocean adults in 2007, II-Ocean adults in 2008, and III-Ocean adults in 2009.

Except for the actual rack return to Dworshak NFH, estimates of the numbers of adults that are harvested (commercial, sport, and Tribal) or are collected in other fishery programs, are based on coded-wire tag information. Coded-wire tags are used to help identify Dworshak NFH adult salmon in the mixed stock fisheries of the Columbia, Snake, and Clearwater rivers. The coded-wire tag data is obtained from the Regional Mark Information System maintained by the Pacific States Marine Fisheries Commission. The number of coded-wire tags collected in a sample is

first expanded by the sampling rate to provide an estimate of the total number of tags that would have been collected if the sampling rate would have been 100%. The total number of adults harvested or collected in various sections of the Columbia and Snake Rivers is then estimated by dividing the total number of tags collected by the tagging rate (Jones *et al.* 2011b). Estimates for various fisheries are provided below.

### **Ocean and Lower Columbia River Below Bonneville Dam**

Very few adults are harvested in the ocean and the lower Columbia River below Bonneville Dam, although in years when returns are high, some are reported from various Oregon and Washington sport and commercial fisheries. From 2007 to 2009, an estimated 1,216 Dworshak NFH BY2004 adults were harvested below Bonneville Dam, 903 in sport fisheries and 312 in non-tribal commercial net fisheries.

### **Columbia River from Bonneville Dam to McNary Dam**

The Columbia River from Bonneville Dam to McNary Dam is the section designated for Tribal Treaty commercial, ceremonial, and subsistence harvest, although Oregon and Washington sports harvest occurs there also. From 2007 to 2009, an estimated 563 Dworshak NFH BY04 adults were reported harvested in Zone 6, 15 in sport fisheries and 548 Tribal fisheries.

### **Strays Below and Above McNary Dam**

For purposes of adult return accounting, strays are defined as fish that are collected or harvested in any fishery or are captured at any hatchery rack or tributary weir outside the normal adult migration corridor. Historically, there have been very few strays of Dworshak NFH adults outside the Clearwater River, although some do occur. Over the years, Dworshak NFH adults have stayed out of the normal migration corridor and have been collected at various hatcheries, fish weirs, fish ladders, or harvested in tributary sport and Tribal fisheries. From 2007 to 2009, 7 BY2004 Dworshak NFH adult strays were collected in the Columbia River above McNary Dam.

### **Lower Snake River from the Mouth to Lower Granite Dam**

Very few Dworshak NFH adults are reportedly harvested from the mouth of the Snake River up to Lower Granite Dam and those that are have historically been caught in sport fisheries reported by Washington. There were no BY2004 adults reported harvested or otherwise collected in this section from 2007 to 2009.

### **Lower Snake and Clearwater River above Lower Granite Dam**

It is challenging to account for the all the Dworshak NFH origin adults that return to the project area above Lower Granite Dam because of the mixed stock fishery, accounting for adults among the various harvest programs, and accounting for the contribution of the various age classes returning over three years. For BY2004, an estimate was made based on the Dworshak NFH rack returns, the Nez Perce Tribal subsistence harvests, and the sports harvests that occurred in 2007, 2008, and 2009. Because of data limitations, escapement could only be estimated for the III-Ocean age class that returned in 2009. Escapement is composed of those fish that do not

return to a project area or weir, or are not captured in the sport or Tribal harvests, and escape to the natural environment where they may attempt to spawn. For BY2004, the estimate of escapement was limited so the estimate of the total return of spring Chinook salmon to the Clearwater River was a very conservative number that is biased low. Assessment of the rack return, sport and Tribal harvest, escapement, and the total return to Lower Granite Dam are provided below.

#### Rack Return to Dworshak NFH

Brood Year 2004 spring Chinook salmon smolts released in 2006 returned as adults in 2007 (I-Ocean), 2008 (II-Ocean), and 2009 (III-Ocean). The total adult return to the hatchery rack was 2,148 fish (**Table 14**).

#### Idaho Tribal Fisheries

The Nez Perce Tribal Department of Fisheries Resource Management is responsible for reporting harvest data in the Tribal fishery. Harvest occurs primarily in the North Fork of the Clearwater River near the ladder at Dworshak NFH. Data on the age composition of the harvest is generally not available. For that reason, in years when it is not available from harvest sampling, it is assumed that the age composition of the harvest is similar to the age composition of the rack return to Dworshak NFH. The total estimated Tribal harvest was 226 and is reported by estimated age class each year in **Table 14**.

#### Idaho Sport Fisheries

The Idaho Department of Fish and Game (IDFG) is responsible for collecting and reporting information on sport harvest. Estimates of the numbers of adults and jacks harvested in the sport fishery are based on expanded numbers of coded-wire tags collected during sport fish harvest surveys by the IDFG. These tags are expanded by tagging and sample rates, across multiple creel survey river sections (J. Cassinelli, IDFG personal communication).

Sport harvest of BY2004 spring Chinook salmon occurred in 2007 (I-Ocean fish), in 2008 (II-Ocean fish) and in 2009 (III-Ocean fish). IDFG reported a total estimated harvest of 846 Dworshak NFH origin adult salmon in 2008. Although there were sports harvests in 2007 and 2009, no Dworshak NFH origin fish were reported caught. A summary of the number harvested by Ocean Age Class is provided in **Table 14**.

#### Escapement

Currently, escapement is estimated through a process of elimination. The Idaho FRO and IDFG have recently cooperated in developing a method to use adult PIT tag returns at Lower Granite Dam to estimate the total adult return of Dworshak NFH spring Chinook salmon to Lower Granite Dam using expansion factors (Peery *et al.* 2011). Escapement is estimated by subtracting the rack return and the total harvest from the estimated adult return to Lower Granite Dam. Adequate PIT-tag data was available only for adults returning in 2009, so the III-Ocean

age class for BY2004 was the only age group that an estimate of escapement could be made. We estimated that the BY2004 escapement for the 2009 adult return was 102 (Idaho Fishery Resource Office 2011, Table 11).

Minimal Estimate of Adult Return to Lower Granite Dam

Based on the rack return, the estimated sport and Tribal harvests, and partial escapement, the minimum estimated adult return to Lower Granite Dam for BY2004 is 3,322 (**Table 14**). The estimated number of adult spring Chinook salmon returning above Lower Granite Dam is calculated by combining the number of adults returning to the hatchery rack with the estimated numbers harvested in Tribal and sport fisheries, and the estimated escapement. For BY2004, the estimated minimum total is 3,322 (2,148 rack return and 1,072 harvested, 102 escapement) giving a smolt to adult return rate, for accountable fish, of 0.330 % (Idaho Fishery Resource Office 2011, Appendix Table 5). The escapement was estimated only for the III-Ocean age class in the 2009 return year. Data are not available to make calculations for 2007 and 2008 return years.

**Table 14.** Summary of adult returns to Dworshak NFH for Brood Year 2004 spring Chinook salmon (Idaho Fishery Resource Office 2011). A total of 1,007,738 smolts were released from Dworshak NFH in 2006.

Return Year	Ocean Age	Rack Return <sup>1</sup>	Sport Harvest <sup>2</sup>	Tribal Harvest <sup>3</sup>	Escapement	Total
2007	I	702	0	65	NA	<b>767</b>
2008	II	1,201	846	125	NA	<b>2,172</b>
2009	III	245	0	36	102	<b>383</b>
<b>Total</b>		<b>2,148</b>	<b>846</b>	<b>226</b>	<b>102</b>	<b>3,322<sup>4</sup></b>

<sup>1</sup> Idaho Fishery Resource Office 2011, Appendix Table 3.

<sup>2</sup> Idaho Fishery Resource Office 2011, Appendix Table 7.

<sup>3</sup> Idaho Fishery Resource Office 2011, Appendix Table 8.

<sup>4</sup> Does not include 22 strays above Lower Granite Dam, identified in the RMIS coded-wire tag database

Strays

A total of 22 BY2004 Dworshak NFH adults were identified as strays in the Snake River and its tributaries above Lower Granite Dam. The estimated strays are not included in the above analysis in order to maintain consistency in the reported data between the 2009 Annual Report and this report. Strays are not accounted for in the annual reports because the coded-wire tag data needed for making the estimate is not available at that time.

## SPECIAL STUDIES

### Comparative Survival Study

The Dworshak Fishery Complex has been cooperating with the Fish Passage Center in a Comparative Survival Study of hatchery PIT-tagged spring Chinook salmon since 1997. This study examines the migration time and survival of hatchery spring Chinook salmon emigrating through the Lower Snake River compared to those that are transported. A pilot study was started in 1997. Dworshak NFH released 51,904 PIT-tagged BY2004 spring Chinook salmon smolts in 2006 as part of the Comparative Survival Study. The goal of the project is to evaluate adult returns and determine whether transportation provides any survival advantage over in-river emigration. Results of the Comparative Survival Study can be found at <http://fpc.org>.

### Disease Susceptibility Study

The Disease Susceptibility Study, a cooperative study among the U.S. Army Corps of Engineers (Derek Fryer), University of California, Davis (Frank Loge) and the National Oceanic and Atmospheric Administration, was conducted using Dworshak NFH spring Chinook smolts for a single release year, 2006. Forty-four thousand three hundred and fifty four PIT tagged smolts were released from Dworshak NFH along with the CSS study group. This study sought to estimate the degree of disease susceptibility in transported, bypassed and in-river migrating juvenile salmon. Results of this study were reported in Dietrich *et. al* (2008).

### Comparative Delayed Mortality Study

The USGS provided additional PIT tags to compare two potential mechanisms of delayed mortality of transported or by-passed juvenile salmonids, increased vulnerability to disease and size-selective predation. Nine hundred and ninety-six PIT tagged BY2004 spring Chinook smolts were released from Dworshak NFH in conjunction with the CSS and DSS study groups. In the final report, the authors concluded that, “*Collectively, our results indicated that transport by barge was stressful, activated many stress-responsive and immune function genes, and resulted in some unexplained changes in pathogen profiles of fish (e.g., an increase in IHNV in barged fish). We conclude that the hypothesis of stress-mediated, disease-related delayed mortality, particularly for barged fish, warrants further attention.*” (Mesa *et. al* 2008).

## REFERENCES

- Dietrich, J., D. Boylen, B. Fleenor, J. Groff, G. Hutchinson, J. Osborn, S. Strickland, D. Thompson, A. Van Gaest, T. Collier, M. Arkoosh, F. Loge. 2008. Estimate of Hydrosystem Delayed Mortality Associated with Barge and In-River Outmigration Life-History Strategies of Snake River Spring/Summer Chinook Salmon. US Army Corps of Engineers, Walla Walla District, Study Code BPS-00-10.
- Dworshak National Fish Hatchery. 2004. Spawning Report. Brood Year 2004 Spring Chinook Salmon. Dworshak National Fisheries Complex, U.S. Fish and Wildlife Service, Ahsahka, Idaho. 13p.
- Dworshak National Fish Hatchery. 2006. Annual Report for Dworshak National Fish Hatchery, Fiscal Year 2005. Dworshak Fisheries Complex, U.S. Fish and Wildlife Service, Ahsahka, Idaho. 47p.
- Dworshak National Fish Hatchery. 2007. Annual Report for Dworshak National Fish Hatchery, Fiscal Year 2006. Dworshak Fisheries Complex, U.S. Fish and Wildlife Service, Ahsahka, Idaho. 44p.
- Herrig, D.M. 1990. A review of the Lower Snake River Compensation Plan Hatchery Program. Report AFF1/LSR-90-06, Lower Snake River Compensation Plan Office, U.S. Fish and Wildlife Service, Boise, Idaho. 47 p.
- Idaho Fishery Resource Office. 2004. Adult spring chinook salmon returns to Dworshak Fisheries Complex in 2003 and prognosis for 2004. Annual Report, Fiscal Year 2003, Appendix A. Dworshak Fisheries Complex, U.S. Fish and Wildlife Service, , Ahsahka, Idaho. 15p.
- Idaho Fishery Resource Office. 2005. Adult spring chinook salmon returns to Dworshak and Kooskia National Fish Hatcheries in 2004 and prognosis for 2005. Appendix A. Dworshak Fisheries Complex, U.S. Fish and Wildlife Service, Ahsahka, Idaho. 14p.
- Idaho Fishery Resource Office. 2011. 2010 Annual Report of Hatchery Evaluation Activities for Spring Chinook Salmon at Dworshak and Kooskia National Fish Hatcheries. Idaho Fishery Resource Office, Dworshak Fisheries Complex, U.S. Fish and Wildlife Service. 31p.
- Jones, R.N., C. Peery, C. Bretz, and H. Burge. (2011a - in progress). Analysis of Spring Chinook Salmon Adult Returns to Dworshak National Fish Hatchery - The Challenges for Monitoring and Evaluation. Idaho Fishery Resource Office, Dworshak Fisheries Complex, U.S. Fish and Wildlife Service, Ahsahka, Idaho.
- Jones, R.N., C. Peery, C. Bretz, and H. Burge (2011b – in progress). Using Coded-Wire Tags in the Evaluation of Spring Chinook Salmon and Summer Steelhead Adult Returns to Dworshak Fisheries Complex. Idaho Fishery Resource Office, Dworshak Fisheries

Complex, U.S. Fish and Wildlife Service, Ahsahka, Idaho.

Jones, R.N. and W.H. Miller. 1996. An evaluation of rearing density in relation to post-release smolt survival and adult returns of spring Chinook salmon at Dworshak National Fish Hatchery. Idaho Fishery Resource Office, U.S. Fish and Wildlife Service, Ahsahka, Idaho. 37 p.

Lady, J. Westhagen P., and Skalski, J.R. SURPH 2.2b User's Manual. University of Washington, Seattle, Washington. 8pp.

Mesa, M., M.H. Averbeck, A.G. Maule, D.G. Elliott, and A.L. Miracle. 2008. Mechanisms of delayed mortality in juvenile salmonids outmigrating in the Columbia River basin. Draft Final Report FY2008 to the U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington. Submitted by U.S. Geological Survey, Western Fisheries Research Center, Columbia River Research Laboratory, Cook, Washington. 82p.

Peery, C, Jones, R., Bretz, C., and Cassinelli, J. 2011. Methodology for Calculating PIT tag Expansion Factors for Estimating the Return of Dworshak NFH Adult Spring Chinook Salmon (*Oncorhynchus tshawytscha*) to the Clearwater River. Idaho Fisheries Resource Office, Dworshak Fisheries Complex, U.S. Fish and Wildlife Service, Ahsahka, Idaho.

U.S. Army Corps of Engineers. 1981. Lower Snake River Fish and Wildlife Compensation Plan. Design Memorandum, No. 9: Dworshak National Fish Hatchery Expansion-Spring Chinook rearing. U.S. Army Engineers, Walla Walla District, Walla Walla, Washington.