

**BROOD YEAR REPORT
DWORSHAK NATIONAL FISH HATCHERY
SPRING CHINOOK SALMON
BROOD YEAR 2007
LIFE CYCLE COMPLETED IN 2012**

PREPARED BY

**John Hook, Carrie Bretz, Ray N. Jones, and Chris Peery
Idaho Fishery Resource Office**

and

**Marilyn Blair
Idaho Fish Health Center**

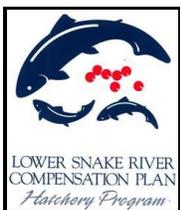
**Dworshak Fisheries Complex
U.S. Fish and Wildlife Service
276 Dworshak Complex Drive
Orofino, Idaho 83544**

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**



October 2014

TABLE OF CONTENTS

TABLE OF CONTENTS.....	2
LIST OF TABLES.....	4
LIST OF FIGURES.....	5
BROOD YEAR 2007 OVERVIEW.....	6
ACKNOWLEDGMENTS.....	7
INTRODUCTION.....	8
Program Goal.....	8
Site Description.....	8
2007 ADULT SPRING CHINOOK SALMON RETURN TO DWORSHAK NFH.....	9
Pre-Season Assessment.....	9
Total Rack Return.....	10
Ladder Operations and Adult Inventories.....	10
Age Composition of Rack Return to Dworshak NFH.....	11
Adult Marking.....	12
Adult Holding and Mortality.....	12
Spawning.....	12
Fish Health Treatments and Data Collection.....	13
Adult Out-Planting.....	14
EGG PRODUCTION AND INCUBATION.....	14
Green Eggs Taken.....	14
Early Incubation.....	14
Eggs Culled for Bacterial Kidney Disease.....	14
Eye-Up.....	15
Egg Transfers and Final Incubation.....	15
Transfer from Incubation to Raceways.....	16
JUVENILE REARING.....	16
Growth and Mortality.....	16
Fish Health Monitoring.....	17
Marking and Tagging.....	17
<i>Coded-Wire Tags and Adipose Fin Clips</i>	17
<i>PIT tags</i>	18
SMOLT RELEASES.....	18
Fish Health Pre-release exam.....	20
SMOLT EMIGRATION.....	20
Travel Time.....	20
River Flows.....	20
Estimated Smolt Survival.....	20
ADULT RETURNS.....	24
Ocean and Lower Columbia River below Bonneville Dam.....	24
Columbia River from Bonneville Dam to McNary Dam.....	24
Columbia Above McNary Dam and Snake River Below Lower Granite Dam.....	24
Strays in the Columbia River.....	25
Lower Snake River from the Mouth to Lower Granite Dam.....	25
Lower Snake and Clearwater River above Lower Granite Dam.....	25
Rack Return to Dworshak NFH.....	25

Idaho Sport Fisheries	25
Idaho Tribal Fisheries	27
Escapement	27
Strays.....	27
Minimal Estimate of Adult Return to Lower Granite Dam	27
Smolt to Adult Return Rate (SAR)	28
Fish Health Information on Adult Rack Returns	28
SPECIAL STUDIES	29
Comparative Survival Study	29
REFERENCES	30

LIST OF TABLES

Table 1. Pre-season prediction and actual adult returns of Dworshak NFH stock to the Clearwater River for BY07.	10
Table 2. Actual rack return of adult spring Chinook salmon to Dworshak NFH.	10
Table 3. Number of spring Chinook salmo on each inventory date	11
Table 4. Age composition of spring Chinook salmon adults returning to Dworshak NFH.....	12
Table 5. Percent mortality of adult spring Chinook salmon during holding and spawning at Dworshak NFH	13
Table 6. Number of male and female spring Chinook salmon spawned during each egg take for BY07 at Dworshak NFH.....	13
Table 7. Summary of egg take and eye-up for Dworshak NFH BY07 spring Chinook salmon ..	15
Table 8. Summary of monthly growth and mortality of BY07 spring Chinook salmon	16
Table 9. Coded-wire tag release information for BY07 spring Chinook salmon released from Dworshak NFH in 2009.....	18
Table 10. Cumulative survival estimates of BY07 spring Chinook smolts.....	21
Table 11. Summary of BY 2007 adult Dworshak NFH spring Chinook salmon collected in various fisheries in the Columbia and Lower Snake Rivers.	26
Table 12. Summary of adult returns to Dworshak NFH for BY07 spring Chinook salmon.	27

LIST OF FIGURES

- Figure 1. Location of Dworshak National Fish Hatchery (NFH) at the confluence of the North Fork and main stem Clearwater River, Idaho. 9
- Figure 2. Mean daily inflow into Lower Granite Reservoir during March – April 2009, compared to the 10 year average. Vertical line indicates the date smolts were released. 19
- Figure 3. Mean daily stream discharge of the Clearwater River at the Orofino Bridge, 2009, compared to the 10-Year Average. Vertical line indicates the date smolts were released. 19
- Figure 4. Major dams of the Columbia River, the lower Snake River, and Clearwater River systems. .. 23

BROOD YEAR 2007 OVERVIEW

Life Stage	Number
2007 Rack Return	2,110
Number of Females Spawned	502
Total Eggs Enumerated¹	1,455,383
Average Eggs per Female	4,256
Eyed Eggs	1,396,225
Smolts Released	1,014,748
In-River Smolt Survival²	69.2%
Adult Returns to the Hatchery³	834
Adults Harvested in Idaho⁴	448
Adult Return to Clearwater River	5,757
Adults Collected at Other Locations⁵	400
Total Adult Return to Columbia River	6,157

¹ Number based on only the number of live and dead eggs enumerated.

² Survival to Lower Granite Dam.

³ 1-Ocean, 2-Ocean, and 3-Ocean returns in 2010, 2011, and 2012 to the hatchery rack.

⁴ Tribal and Sport fisheries combined.

⁵ 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

Hook, J, C. Bretz, R.N. Jones, C. Peery, N. Wiese, and M. Blair. 2014. Brood year report, Dworshak National Fish Hatchery spring Chinook salmon brood year 2007, life cycle completed in 2012. Technical fisheries report by Dworshak Fisheries Complex, U.S. Fish and Wildlife Service, Ahsahka, ID. 30p.

ACKNOWLEDGMENTS

The Complex would like to acknowledge and extend great 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 2007 (BY07) spring Chinook salmon (SCS) reared at Dworshak National Fish Hatchery (NFH) which completed its life cycle in 2012. 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 the Columbia River and 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.

Program Goal

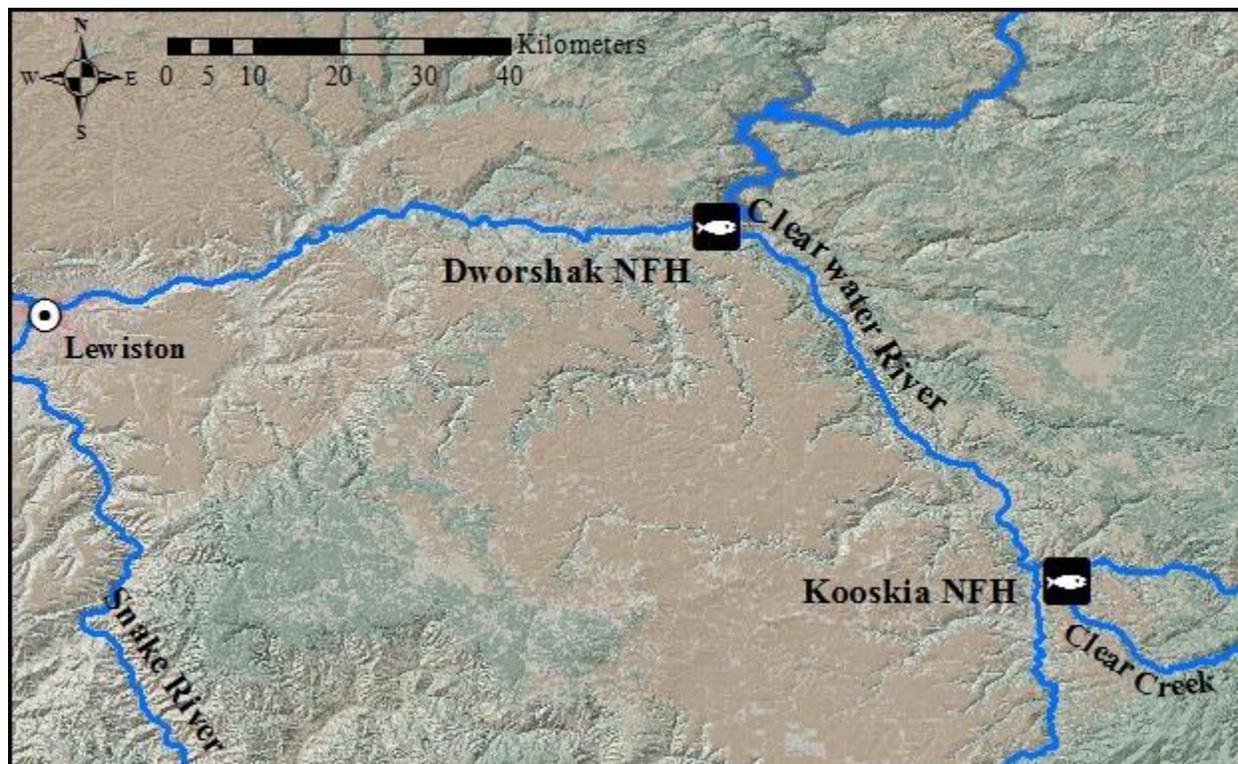
The spring Chinook salmon production program at Dworshak NFH was started in 1982 as part of the Lower Snake River Compensation Plan (LSRCP) and was originally designed to rear 1.4 million smolts to a size of 20 fish per pound (FPP) for direct release from the hatchery into the Clearwater River (U.S. Army Corps of Engineers 1981). This level of production was designed to meet a mitigation goal of 45,675 adults: 36,540 available for harvest in the lower Columbia and Snake Rivers and 9,135 adults past Lower Granite Dam (U.S. Army Corp of Engineers 1975; Herrig 1990). Over the years, several changes have been made to the facility and the production program. For BY07, 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 the 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. In 2011, Dworshak NFH increased the capacity for incubation to 1,856 trays. Protocol calls for one female's eggs per tray giving the hatchery the capacity to incubate nearly 6.8 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 have been 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. During rearing of BY07 spring

Chinook salmon, all the raceways were supplied with single pass ambient river water from the North Fork Clearwater River at a rate of about 500 gallons per minute (GPM).

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



2007 ADULT SPRING CHINOOK SALMON RETURN TO DWORSHAK NFH

The 2007 brood year was formed from the progeny of the adults that return as brood stock to Dworshak National Fish Hatchery during the 2007 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 in excess to brood stock needs.

Pre-Season Assessment

The Idaho Fishery Resource Office (FRO) used a regression equation based on the 1-Ocean (Jack) returns in the previous year to predict the return of 2-Ocean adults to the Clearwater River the following year. In 2006, the 1-Ocean return to Dworshak NFH was originally estimated to be 79 fish (Idaho Fishery Resource Office 2007, Table 9). Using the regression model, we predicted a return of 1,107 2-Ocean adults for 2007 and a total adult return of 1,641 returning to the Clearwater River for the 2007 season (Idaho Fishery Resource Office 2006, Table 11). This number was much lower than the actual return. **Table 1** lists the predicted return, made in 2006, and the estimated returns of all three age classes of adults that returned in 2007 (Idaho Fishery

Resource Office 2012, Table 11). Our prediction for the 1-Ocean return was much lower than the actual return, 194 vs. 767. The regression used for making our prediction gave a relatively good estimate for 2-Ocean returns, 1,107 predicted vs. 1,035 actual. Our prediction for the 3-Ocean returns was lower than the actual return, 340 predicted vs. 762 actual. Although our total prediction was lower 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 out-planting. 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 BY07.

Ocean Age ¹	2006 Prediction for 2007	Actual 2007 Return
1 - Ocean	194	767
2 - Ocean	1,107	1,035
3 - Ocean	340	762
Total	1,641	2,564

¹ 1-Ocean are BY04, 2-Ocean are BY03, and 3-Ocean are BY02.

Total Rack Return

The total rack return is the number of adults that were collected at the hatchery and is not an accounting of the total return to the river. The 2007 adult spring Chinook salmon collected at Dworshak NFH was 2,110 adults (**Table 2**).

Table 2. Number of adult spring Chinook salmon collected at Dworshak NFH by ocean age in 2007 (Idaho Fishery Resource Office 2012, Table 11).

Ocean Age	Smolts Released	2007 Rack Return
1 - Ocean	1,007,738 (2006)	702
2 - Ocean	1,072,359 (2005)	809
3 - Ocean	1,078,923 (2004)	599
Total		2,110

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 hold 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 Dworshak fish ladder was opened June 5, 2007, and closed September 4, 2007 for a total of 91 days (Dworshak National Fish Hatchery 2007). **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 6/27/07 to 9/12/07, including trap mortalities (2007 Salmon News, Idaho FRO Files).

Inventory Date	1-Ocean	2-Ocean	3-Ocean	Total
June 27	360	241	143	744
July 9	137	223	164	524
July 24	69	96	89	254
August 15	77	190	164	431
August 21	26	23	23	72
August 28	14	16	7	37
September 4	10	13	7	30
September 12	5	3	1	9
Trap mortality	4	4	1	9
Total	702	809	599	2,110

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:

- 1 - Ocean (Jacks) < 57 cm
- 2 - Ocean = 57 to 81 cm
- 3 - Ocean > 81 cm.

Adult spring Chinook salmon that return to Dworshak NFH are predominately 2-Ocean fish, those that spend two years in salt water before returning to freshwater to spawn. Based on size, the age composition for the 2007 return was 33% 1-Ocean, 39% 2-Ocean, and 28% 3-Ocean, respectively. The five year mean percent returns in the rack for 1-Ocean, 2-Ocean, and 3-Ocean adults are 16%, 51%, and 33%, respectively, for all years from 2003 to 2007. In 2007, the 1 and 3-Ocean age classes were relatively larger than in recent years (**Table 4**).

Table 4. Age composition of spring Chinook salmon adults returning to Dworshak NFH, 2003-2007.

Year	1-Ocean	%	2-Ocean	%	3-Ocean	%	Unmeasured	Total Return
2003	580	17	478	14	2,364	69	0	3,422
2004	142	6	2,077	88	137	6	0	2,356
2005	74	8	686	78	122	14	0	882
2006	62	5	1,136	84	156	11	0	1,354
2007	702	33	809	39	599	28	0	2,110
Mean¹	312	16	1,037	51	676	33	0	2,025

¹ 5-yr mean.

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 are marked with a left opercle V-notch while Kooskia salmon are notched on the right opercle.

Adult Holding and Mortality

During the period of holding prior to spawning, formalin treatments were administered under veterinary prescription to adults to retard fungus infection. 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.

Adult mortality is reported for two separate periods: holding mortality that occurs prior to the start of spawning (pre-spawn mortality) and holding mortality that occurs after the start of spawning (spawning mortality). From June 5 to August 13, 24 adult spring Chinook salmon (1.1% of rack return) died. From August 14 through August 29, an additional 57 adults died (2.7 % of rack return). The mortality rate of BY07 spring Chinook salmon adults during holding was lower than the 5-year average, and was the second year in a row with total adult mortality below 4% (**Table 5**).

Spawning

Details on the methods and procedures during spawning are provided in the Spawning Report for BY07 (Dworshak National Fish Hatchery 2007). Spawning was started on August 14, about the same time of year as in 2006. Five egg takes were made with the last ripe females for the Dworshak NFH program spawned on August 30 (**Table 6**).

Table 5. Percent mortality of adult spring Chinook salmon during holding (pre-spawning) and during spawning at Dworshak NFH, 2002-2007 (Dworshak National Fish Hatchery 2007).

Brood Year	Pre-Spawning Mortality	Mortality During Spawning	Total
2002	4.9%	7.1%	12.0%
2003	4.9%	2.7%	7.6%
2004 ¹	1.5%	7.2%	8.8%
2005	3.1%	4.1%	7.1%
2006	1.3%	1.6%	2.9%
Five-Year Avg	3.6%	6.7%	10.3%
2007	1.1%	2.7%	3.8%

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

Table 6. Number of male and female spring Chinook salmon spawned during each egg take for BY07 at Dworshak NFH (Dworshak National Fish Hatchery 2007). Jacks are incorporated into the number of males spawned.

Egg Take Date	Males Spawned	Females Spawned
8/14/07	67	103
8/15/07	39	44
8/21/07	101	130
8/29/07	133	171
8/30/07	52	54
Total	392	502

Fish Health Treatments and Data Collection

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.

During the spawning process, 171 of 210 (81.4%) adults tested positive for Infectious Hematopoietic Necrosis Virus (IHNV). Ovarian fluid samples were 3 pooled and spleens were 5 pooled. All spleen tissues were sampled from males. The positive results for IHNV by take are presented below:

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*) using Enzyme-Linked Immunosorbent Assay (ELISA). The results are presented below:

Not Detected - 403

Low - 37

Medium - 1

High- 1

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

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. No excess adults were out-planted in 2007.

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 2007). Egg take and survival is summarized in **Table 7**.

Green Eggs Taken

Eggs are enumerated once they have reached the eye-up stage. The number of green eggs taken initially is estimated using an average of 3,750 eggs per female. A total of 502 females were spawned, giving an initial estimate of 1,882,500 green eggs.

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 ELISA tests. Water flow through the incubators was maintained at approximately four gallons per minute (Dworshak National Fish Hatchery 2007).

Eggs Culled for Bacterial Kidney Disease

Kidney samples were taken from all females to test for BKD. For BY07, an estimated 42,560¹ eggs from 10 females that tested above 0.193 ELISA O.D. level for BKD were culled from production (Dworshak National Fish Hatchery 2007).

¹ Number of eggs culled are based on average female fecundity.

Eye-Up

At eye-up eggs were shocked, dead eggs were removed, and eggs were enumerated by a mechanized egg picker. A total of 58,758 dead eggs were counted. The total number of eyed eggs enumerated was 1,396,225, producing an average of 4,256 total eggs per female.

Table 7. Summary of egg take and eye-up for Dworshak NFH BY07 spring Chinook salmon (Dworshak National Fish Hatchery 2007, Table 2).

Take	Spawn Date 2007	# of Male ¹	# of Female	Female culled BKD ²	Tray Culled Dead	Trays Culled Extra	Dead Eggs Enum	Eyed Eggs Enum	Eggs for Research	Total Eggs	Eggs/Female	Percent Enum Eye-up
1	14-Aug	67	103	3	4	0	16,698	420,752	400	437,850	4,561	96.2
2	15-Aug	39	44	1	1	0	6,614	181,624	0	188,238	4,482	96.5
3	21-Aug	101	130	2	6	0	21,238	496,289	0	517,527	4,242	95.9
4A*	29-Aug	104	134	4	5	125	0	0	0	0	N/A	N/A
4B	29-Aug	29	37	0	3	0	6,355	127,560	0	133,915	3,939	95.3
5	30-Aug	52	54	0	6	0	7,853	170,000	0	177,853	3,705	95.6
Tot/Ave		392	502	10	25	125	58,758	1,396,225	400	1,455,383	4,256	96.0

1 Includes 17 jacks spawned during the season

2 BKD culling above 0.193 ELISA testing for all Takes

*Take 4A enumerated last due to incubation temperature and egg development. During August spawning Dworshak staff was informed to take extra eggs to help make up for possible deficit at IDFG and the NPTH. During enumeration in November both agencies were contacted about excess eggs at Dworshak but both responded they did not need any more SCS eggs this season. Percent enumerated eye-up does not include eggs/females culled before enumeration

Source: BY07 SCS Egg Enumeration and % Survival of Eggs Summary SC2007 EggEnum.xls

IFHC BKD ELISA testing results BY07 SCS

Egg Transfers and Final Incubation

Dworshak eggs were incubated in A, B, and C-banks. Chilled water temperature averaged 39°F for eggs in A and B, the water temperature (non-chilled) in C bank averaged 41.5°F throughout the initial incubation cycle.

Upon eye-up, the eggs were shocked and enumerated using an electronic egg picker and counter (Van Gaalen Model-100). The initial incubation temperature was 39°F but was reduced to 37°F during the winter.

The use of chilled water all winter at Dworshak slows the rate of development in the eggs to target size of 18–20 fish per pound (fpp) at release in the spring. This delay in egg development effectively reduces the length of the Chinook feeding program from 17 months to 14 months. With this shortened feeding program, the fast/feed regime is greatly reduced or eliminated for spring Chinook reared at Dworshak.

Transfer from Incubation to Raceways

All the eggs had hatched by the end of January 2008 and remained in incubation trays until the release of BY06 smolts. BY07 fry were moved from the incubator trays to A-bank raceways (RW's) from April 17-18. There were 1,089,286 fry ponded at that time and these fish were started on feed within a few days after ponding. At the end of the month, there were 1,089,286 BY07 feeding fry averaging 812 fpp and 41 mm (1.6 inches) total length.

JUVENILE REARING

The following data and information was summarized from the hatchery production records at Dworshak NFH, the 2008 and 2009 Annual Reports for Dworshak NFH (Dworshak National Fish Hatchery 2009; Dworshak National Fish Hatchery 2010), the Dworshak NFH monthly production narratives, and the Dworshak NFH monthly inventory summaries (MIS).

Growth and Mortality

Growth for BY07 Chinook salmon was normal and as programmed, reaching the targeted size at release by March 2009. A record of monthly growth and mortality, from the end of April 2008 until the time of release in March 2009, is listed in **Table 8**.

Table 8. Summary of monthly growth and mortality of BY07 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)
4/08	1,089,286	1,340	812.9	41	-	1.2	41.2
5/08	1,080,942	2,116	510.8	47	7	0.8	42.6
6/08	1,076,397	4,996	215.5	63	16	0.4	44.8
7/08	1,073,799	10,168	105.6	80	17	0.2	47.3
8/08	1,030,519	14,935	69.0	93	12	0.2	47.3
9/08	1,030,003	20,921	49.2	104	11	0.1	48.0
10/08	1,029,587	27,719	37.1	114	10	0.04	48.7
11/08	1,028,934	33,246	30.9	121	7	0.06	47.8
12/08	1,027,687	38,464	26.7	127	6	0.12	45.0
1/09	1,025,418	41,006	25.0	130	3	0.22	41.7
2/09	1,021,991	42,582	24.0	132	2	0.33	40.5
3/09	1,014,748	47,941	21.1	137	5	0.47	40.5

Fish Health Monitoring

Beginning in November 2008, 10 fish per month were sampled for BKD by ELISA.

Results:

9-11-08 – Not Detected: 10

10-17-08 – Not Detected: 10

11-6-08 – Not Detected: 10

12-12-08 – Not Detected: 10

1-14-09 – Not Detected: 10

2-26-09 – Not Detected: 10

September 2008– Low levels of the parasites *Trichodina* and *Gyrodactylus* were detected on the skin. Gills were slightly swollen with debris and low levels of gas bubble disease. Some small areas of bacteria were seen on the gills as well. Recommendations were to clean ponds and to continue to watch for flashing, going off feed, and an increase in mortalities. No treatment was thought needed at the time.

October 2008– Very low levels *Trichodina* seen on the skin. Gills were slightly swollen with very low levels of egg cysts from the blood fluke parasite *Sanguinicola* also on the gills. Ponds were noted as much cleaner than previously.

November 2008– Moderate levels of the parasites *Epitheliocystis* and low levels of *Chilodenella* were seen on the skin. Gills were slightly swollen with low levels of *Sanguinicola*. Recommendation was made to treat all ponds that were flashing with a formalin bath treatment at 167 ppm for 1 hour each, treatments were conducted on November 12.

December 2008–Fish were seen to be flashing in several more ponds. Moderate levels of *Chilodenella* and *Epitheliocystis* were detected along with low levels of the parasites *Epistylis* and *Ambiphyra* on the skin. Gills were slightly swollen. No bacteria were detected in bacterial cultures from kidneys. Recommendations were to treat each flashing pond with 167 ppm 1 hour formalin bath treatment. Formalin baths were given to all raceways on December 17.

January 2009–Low levels *Epistylis*, *Epitheliocystis*, and *Ambiphyra* on the skin. Gills were swollen and slightly pale. No bacteria were seen by kidney imprints and no Erythrocytic Inclusion Body Syndrome (EIBS) was seen by blood smears.

February 2009– Several fish were noted with fungus on tails at end of pond. Low levels *Epistylis* and *Epitheliocystis* seen on the skin. Gills were very swollen. Eight of ten fish had hemorrhages in internal fat. No bacteria were seen by kidney imprints or cultures. Virus was not detected.

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 Fisheries Program Office, Vancouver, in August 2008. A total of

136,218 (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 9**). 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 250 fish from each tag code group in March 2009, prior to release. The retention rate at Dworshak NFH was 99%.

Table 9. Coded-wire tagged BY07 spring Chinook salmon released from Dworshak NFH in 2009.

Tag Code	Number of Tags ¹	Number of Fish Released ²	Mark Rate ³	Purpose
053572	67,690	505,040	0.13	Contribution, Raceways B23 and B24
053573	65,226	509,708	0.13	Contribution, Raceways A8 and A9

¹ The number reported is adjusted for mortality and tag loss.

² Number of Fish Released is the total number of tagged and untagged fish that the tag group represents.

³ Mark Rate is the number of tags divided by the number of fish released that the tag code represents.

PIT tags

A total of 51,609 PIT-tagged smolts were released from Dworshak NFH as part of the Comparative Survival Study conducted by the Fish Passage Center in January. See **SPECIAL STUDIES** section for details of the aforementioned study.

SMOLT RELEASES

In March 2009, the Idaho FRO began monitoring flows and river conditions in the main stem Clearwater River and at Lower Granite Dam (**Figures 2 and 3**) to aid in determining the optimum time for smolt releases. By March 23, the mean daily inflow of the Snake River into Lower Granite Reservoir and the mean daily flow of the main stem Clearwater River at the Orofino Bridge were very near the 10-year average (Idaho FRO data files). The forecast at that time was for conditions to remain stable for the next week.

Given the above forecast, Dworshak NFH released 1,014,748 spring Chinook salmon smolts during two separate early evening releases into the North Fork Clearwater River on March 25 and 26, 2009. Mean total length at release was 137 mm. Arrangements were made with the U.S. Army Corps of Engineers to increase flow in the North Fork Clearwater River from 1,200 cfs to 5,000 cfs on those days, to help move the fish into the main stem Clearwater River. Releases were made in the early evening to help avoid predation.

Inflow into Lower Granite Reservoir

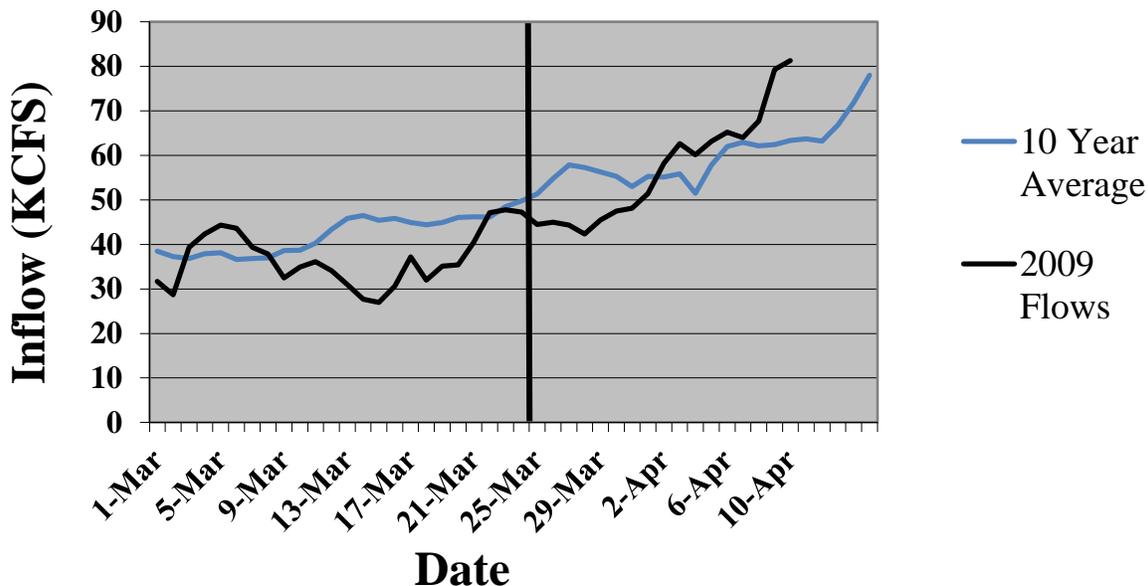


Figure 2. Mean daily inflow into Lower Granite Reservoir during March – April 2009, compared to the 10 year average. Vertical line indicates the date smolts were released.

Clearwater River Mainstem at the Orofino Bridge

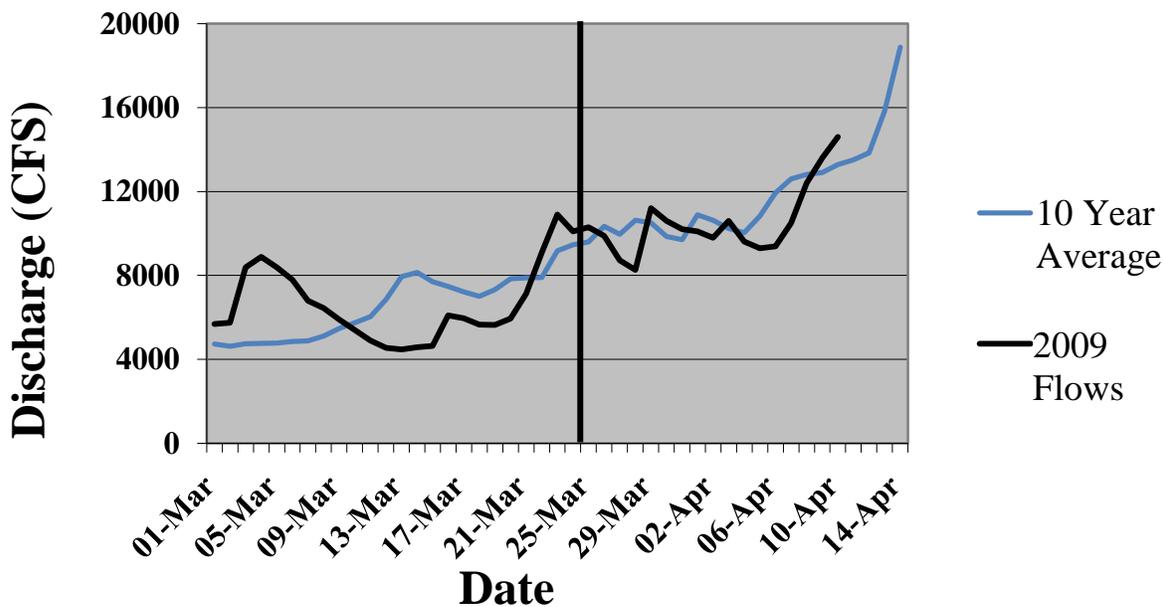


Figure 3. Mean daily stream discharge of the Clearwater River at the Orofino Bridge, 2009, compared to the 10-Year Average. Vertical line indicates the date smolts were released.

Fish Health Pre-release exam

Sixty fish were collected on 3-18-09 for pre-release examination for fish health and smolt readiness for emigration. The results are presented below:

ELISA test results for *R. salmoninarum*:

Not detected – 58

Low – 2

Medium – 0

High -- 0

Viral assays - negative

Bacterial assays - negative

Hematocrits - 20 samples, all in normal range

Observations for smoltification included light parr marks

SMOLT EMIGRATION

The performance of spring Chinook salmon smolts was monitored and evaluated using PIT tags after they were released from the hatchery. Because the smolts are tagged as part of the Comparative Survival Study, the tags are assigned to Separation by Code with 70% of the tags assigned to ‘monitor mode’ and 30% assigned to ‘return to river’. Smolt emigration estimates are based on the cumulative survival of both transported and return to river fish. 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 4**). PIT tags provide information on travel time and survival during emigration.

Travel Time

The migration time for BY07 Chinook salmon to Lower Granite Dam ranged from 5.5 days to 89.2 days with a mean travel time of 41.9 days (n= 8,867). Ten percent arrived at Lower Granite Dam within 25.4 days; 50% and 90% arrived within 43.5 days and 54.4 days, respectively. Smolts that migrated through the hydropower system arrived at Bonneville Dam on average 56.7 days after release.

River Flows

Flows in the Lower Snake River were greater than the 10-year average during nearly the entire emigration period (**Figure 6**). Inflow into Lower Granite Reservoir spiked at 139,900 cubic feet per second (cfs) on April 23, and remained above 75,000 cfs for the rest of the emigration period, peaking at 169,000 on June 1.

Estimated Smolt Survival

Survival probabilities through the Federal Columbia River Power System (FCRPS) were calculated using SURvival under Proportional Hazards (SURPH) 3.5.2 (Lady *et al.* 2013) (**Table 10**).

Table 10. Cumulative survival estimates of BY07 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	0.693	0.0070
Lower Granite Dam – Little Goose Dam	0.994	0.0186
Little Goose Dam – Lower Monumental Dam	0.979	0.0313
Lower Monumental Dam – McNary Dam	0.798	0.0267
McNary Dam – John Day Dam	0.792	0.0479
John Day Dam – Bonneville Dam	0.931	0.1029
Overall	0.427	0.0248

River reach survival for spring Chinook smolts ranged from 0.693 (SE= 0.0070) to 0.994 (SE= 0.0186). The lowest survival occurred between Dworshak NFH and Lower Granite Dam; lower than any previous 5 brood years. The highest survival occurred between Lower Granite Dam and Little Goose Dam. Overall survival to Bonneville Dam was 0.427 (SE=0.0248), lower than the 6 year average (**Figure 7**).

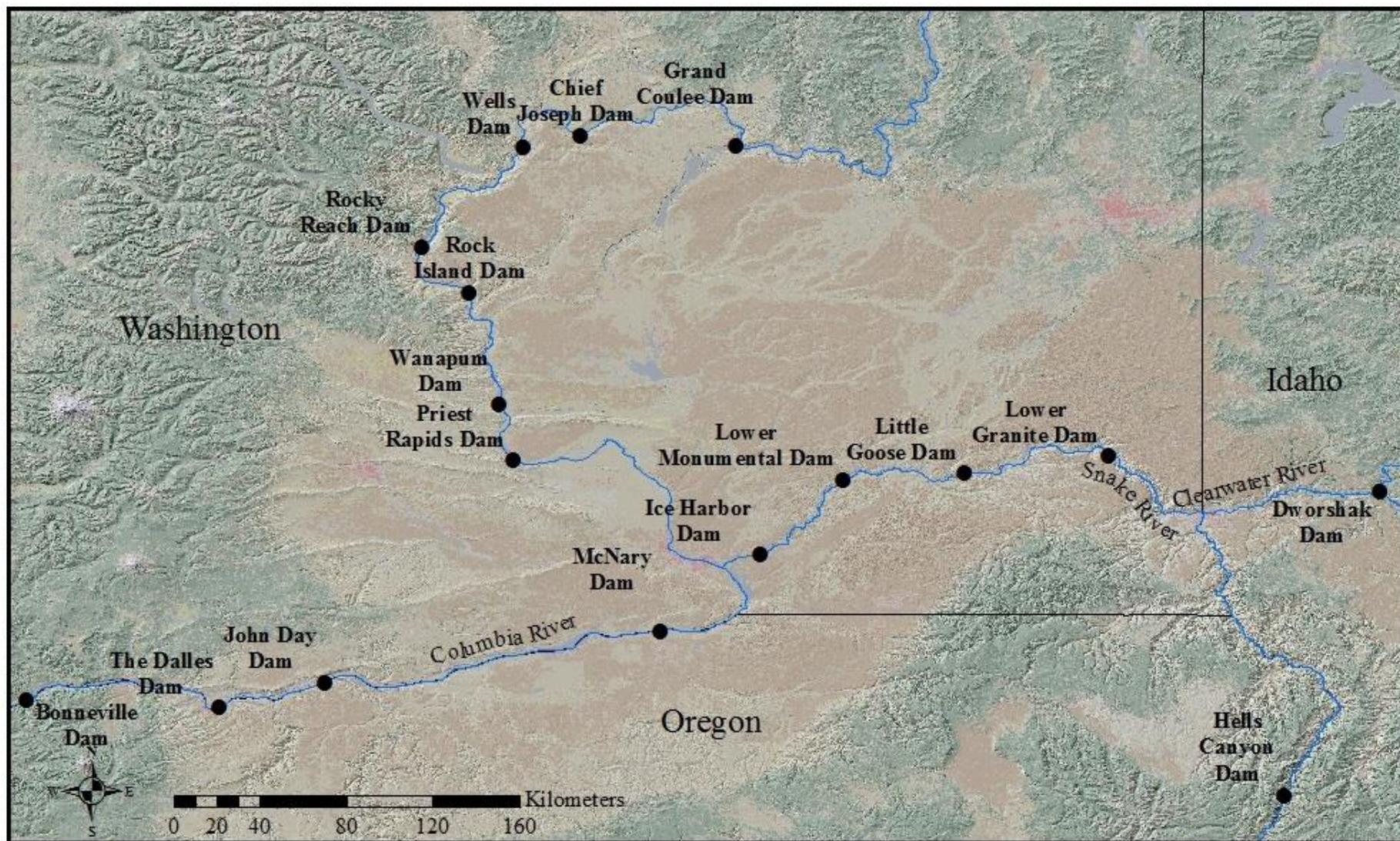


Figure 4. Major dams of the Columbia River, the lower Snake River, and the Clearwater River systems. Emigrating spring Chinook salmon smolts released from Dworshak NFH are interrogated for PIT tags at Lower Granite Dam, Little Goose Dam, Lower Monumental Dam, McNary Dam, John Day Dam, and Bonneville Dam.

Figure 5. Cumulative PIT tag detections for BY07 Dworshak NFH spring Chinook smolts at juvenile bypass facilities in the Lower Snake and Columbia rivers.

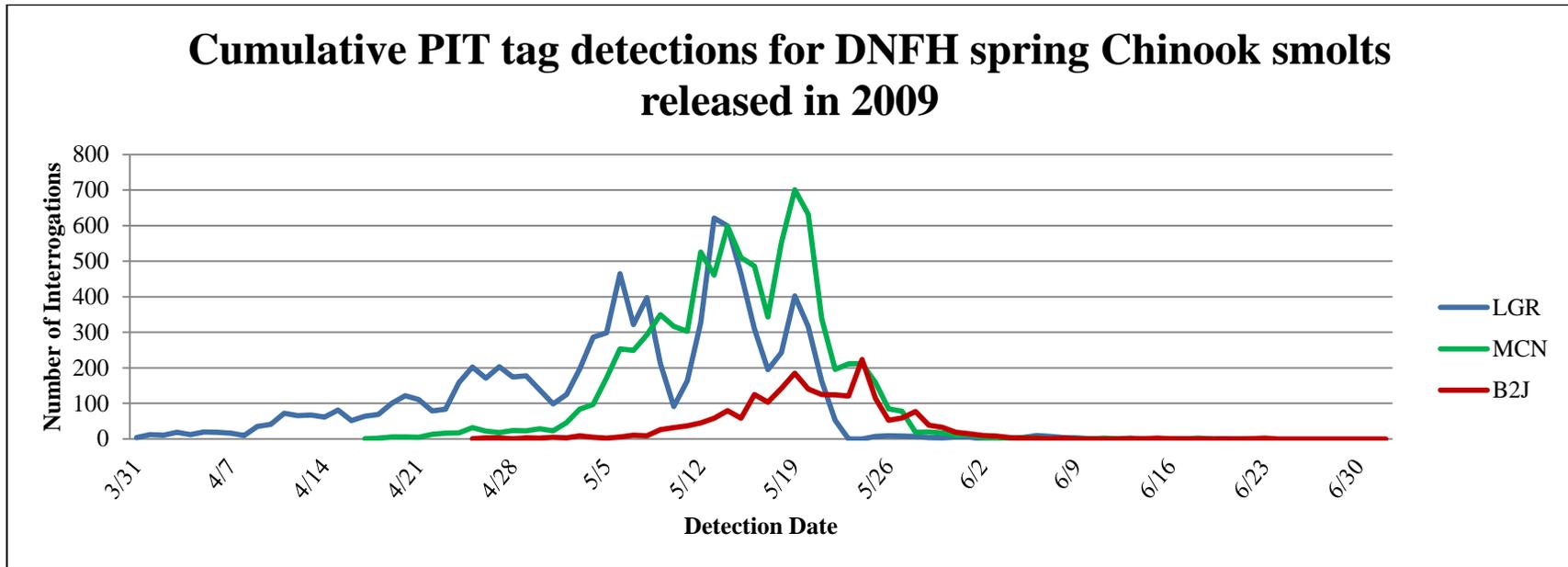


Figure 6. Mean daily inflow to Lower Granite Reservoir from March 1 through June 30, 2009, and the 10 year average during spring Chinook salmon emigration after release from Dworshak NFH.

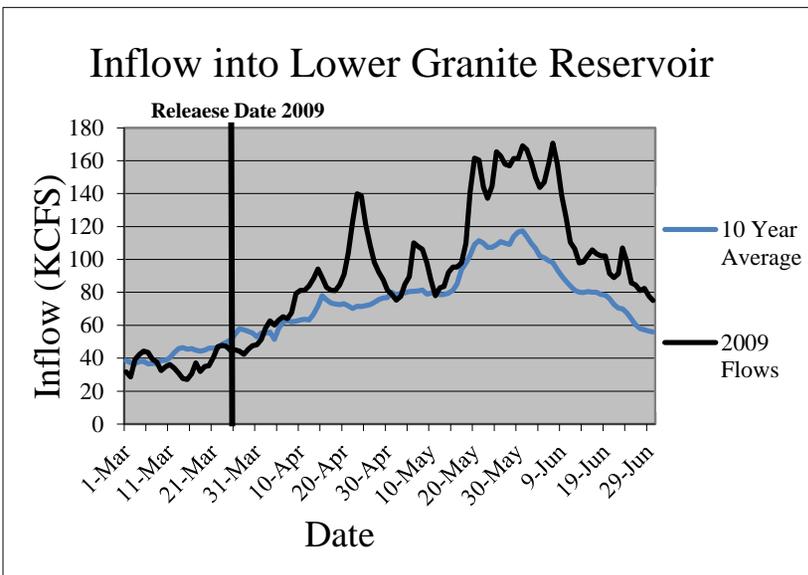
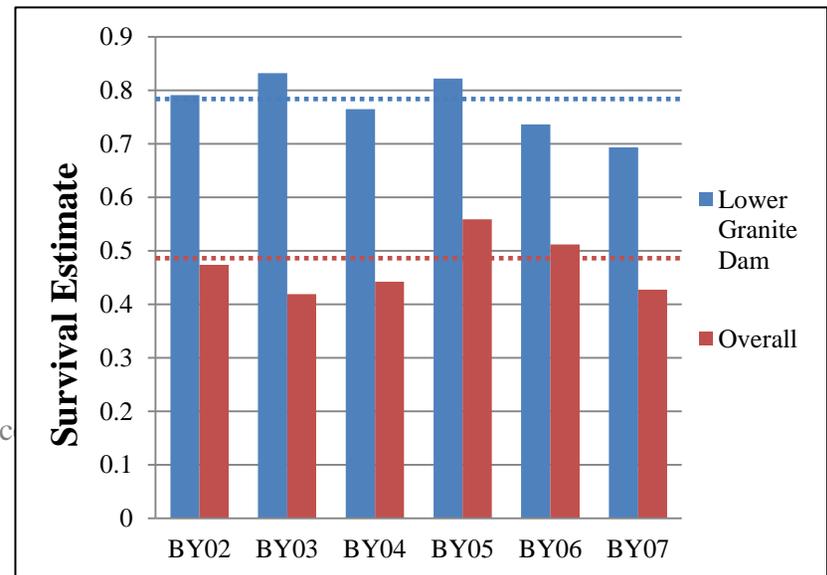


Figure 7. Mean survival estimates to Lower Granite Dam and overall survival estimate through the Federal Columbia River Power System, BY02-BY07. Dashed lines indicate mean survival.



ADULT RETURNS

Estimating the numbers of Dworshak NFH origin adult spring Chinook salmon that return from the ocean for a single brood year is challenging. BY07 adults, released as smolts in 2009, returned as 1-Ocean adults in 2010, 2-Ocean adults in 2011, and 3-Ocean adults in 2012. Adult Chinook salmon that enter the Columbia River are subject to extensive harvest pressure during their upstream migration. Also, those fish that escape to the Clearwater River each year originate from 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.

Estimates of the numbers of adult salmon that are harvested (commercial, sport, and Tribal) or are collected in other fishery programs are based on CWT 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 had 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. 2012). Estimates for various fisheries are provided below.

Ocean and Lower Columbia River below Bonneville Dam

Very few adults are reported harvest in the ocean and 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 2010 to 2012, an estimated 302 Dworshak NFH BY2007 adults were harvested below Bonneville Dam, 233 in sport fisheries and 69 in non-tribal commercial net fisheries (**Table 11**). No ocean harvest was reported for Dworshak NFH BY2007 adults.

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 sport harvest occurs there also. From 2010 to 2012 an estimated 119 Dworshak NFH BY2007 adults were reported harvested in Tribal fisheries (Table 11).

Columbia Above McNary Dam and Snake River Below Lower Granite Dam

Both sport and Tribal harvests occur in this area historically, although Dworshak NFH has contributed very few spring Chinook salmon to these fisheries historically. For 2010, 2011, and 2012, no Dworshak NFH Chinook were reported harvested in sport fisheries in these sections (Table 11).

Strays in the Columbia River

For purposes of adult return accounting, strays are defined as fish that are collected or are captured at any hatchery rack or tributary weir outside the main Columbia River that is not part of the normal adult migration corridor. Salmon harvested in areas outside the normal migration corridor are not considered strays because they may have resumed migration if not harvested. For BY2007, 15 adult strays were collected below McNary Dam and 28 were collected above the mouth of the Snake River (Table 11).

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 BY2007 adults reported harvested in this section (Table 11).

Lower Snake and Clearwater River above Lower Granite Dam

An estimate of fish that returned to the Clearwater River was made based on the Dworshak NFH rack returns, the Nez Perce Tribal subsistence harvests, and the sports harvests that occurred in 2010, 2011, and 2012, and an estimate of escapement. 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. 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

The total adult return to the hatchery rack was 834 fish. The number in each Ocean Age Class is presented in **Table 12**.

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 BY07 spring Chinook salmon occurred in 2010 (1-Ocean fish), in 2011 (2-Ocean fish) and in 2012 (3-Ocean fish). Based on IDFG reports, a total estimated harvest of 1,228 BY07 Dworshak NFH origin adult salmon were taken in the sport harvest. A summary of the number harvested by Ocean Age Class is provided in Table 12.

Table 11. Summary of BY 2007 adult Dworshak NFH spring Chinook salmon collected in various fisheries in the Columbia River and Lower Snake River, below Lower Granite Dam.

Ocean Age	Return Year	Ocean	Columbia River								Snake River ²		
			Below Bonneville Dam			Bonneville to McNary			Above McNary ¹	Strays	Below Lower Granite	Above Lower Granite	Strays
			Zone 1-5 Sport	Zone 1-5 Tribal	Zones 1-5 non-tribal Net	Zone 6 Sport	Zone 6 Tribs	Zone 6 Tribal					
1	2010	0	0	0	17	0	0	0	0	0	0	0	0
2	2011	0	122	0	52	0	0	119	0	53	0	0	0
3	2012	0	111	0	0	0	0	0	0	0	0	0	0
Totals		0	233	0	69	0	0	119	0	43	0	0	0

¹ From McNary Dam to the mouth of the Snake River.

² Excluding the Clearwater

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 adults collected in the trap at Dworshak NFH. Using this method, the total estimated Tribal harvest was 448 BY07 Dworshak NFH adults (Table 12).

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 a mark-recapture method (Peery *et al.* 2012). Escapement is estimated by subtracting the rack return and the total harvest from the estimated adult return to Lower Granite Dam. We estimated that the BY07 escapements for the 2010, 2011, and 2012 returns were 236, 1,398, and 1,613, respectively (Table 12).

Strays

Fifty BY07 Dworshak NFH adults were identified as strays above Lower Granite Dam, all in the Clearwater River basin (Table 12).

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 BY07 is 5,757 (**Table 12**). 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 BY07, the estimated minimum total is 5,757 (834 rack return, 1,676 harvested, and 3,247 escapement).

Table 12. Summary of adult returns to Clearwater River for BY07 spring Chinook salmon.

Return Year	Ocean Age	Rack Return	Sport Harvest	Tribal Harvest	Escapement	Strays	Total
2010	1	142	37	12	236	0	427
2011	2	574	973	361	1,348	50	3,306
2012	3	118	218	75	1,613	0	2,024
Total		834	1,228	448	3,197	50	5,757

Smolt to Adult Return Rate (SAR)

The smolt to adult return rate (SAR) is calculated by dividing the number of adults that return to Lower Granite Dam by the number of smolts released and is used as an indicator of program performance. For BY2007, the SAR was 0.567% (5,757 adults to Lower Granite Dam/1,014,748 smolts released). The SARs for the previous five years are listed below. The SAR for BY 2007 is considerably less than the previous BY, but is higher than the previous 5-year average of 0.410%.

BY 2006 – 0.905%

BY 2005 – 0.403%

BY 2004 – 0.330%

BY 2003 – 0.146%

BY 2002 – 0.269%

Fish Health Information on Adult Rack Returns

I-Ocean Adults (2010 Return) - A total of six out of 212 (two females and four makes; 2.8%) adults tested were found to be positive for IHNV (Infectious Hematopoietic Necrosis Virus). Ovarian fluid and spleen samples were tested individually. All spleen tissues were sampled from males.

Positive results for IHNV by take:

Take 1: 2/72 ovarians, 0/15 male spleens

Take 2: 0/72 ovarians, 0/15 male spleens

Take 3: 0/8 ovarians, 4/30 male spleens

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

Results:

Not Detected - 250

Low - 90

Medium - 3

High- 2

Spring Chinook salmon adults were examined for the parasite *Ceratomyxa Shasta*. Wet mounts from scrapes of the walls of the intestines were examined and found to be positive.

II-Ocean Adults (2011 Return)- Eighty-one of 472 (17.2%) adults tested positive for IHNV. Ovarian fluid and spleen samples were tested individually. All spleen tissues were sampled from males.

Positive result for IHNV by take:

Take 1: 4/43 ovarians, 3/34 male spleens

Take 2: 6/132 ovarians, 14/17 male spleens

Take 3: 5/119 ovarians, 4/9 male spleens

Take 4: 45/118 ovarians

All female adults were tested for BKD using ELISA.

Results:

Not Detected - 189

Low - 205

Medium - 19

High- 4

Spring Chinook salmon adults were examined for the parasite *Ceratomyxa Shasta*. Wet mounts from scrapes of the walls of the intestines were examined and found to be positive. Spring Chinook salmon were examined for the parasite *Myxobolus cerebralis* (Whirling Disease) by pepsin trypsin digest. A total of 35 fish were sampled by head wedges taken from takes 1-2 and were found to be negative.

III-Ocean Adults (2012 Return) - Sixteen of 212 (7.5%) adults tested positive for IHNV. Ovarian fluid and spleen samples were tested individually. All spleen tissues were sampled from males.

Results positive for IHNV by take:

Take 1: 5/50 ovarians, 3/19 male spleens

Take 2: 7/101 ovarians, 1/7 male spleens

Take 3: 0/35 male spleens, 5 pooled.

All female adults were tested for BKD by ELISA.

Results:

Not Detected - 168

Low - 311

Medium - 24

High- 0

One adult fish was positive for the bacteria *Aeromonas salmonicida*, causative agent for Furunculosis, from take 2, as determined from bacterial cultures. Spring Chinook salmon adults were also positive for the parasite *Ceratomyxa shasta* by examination of wet mounts from scrapes of the walls of the intestines. SCS were negative for the parasite *Myxobolus cerebralis* (Whirling Disease) by pepsin trypsin digest. A total of 60 fish were sampled by 20 head wedges taken from each of takes 1-3.

SPECIAL STUDIES

Comparative Survival Study

The Dworshak Fishery Complex has been cooperating with the Fish Passage Center in a Comparative Survival Study (CSS) 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. Dworshak NFH released 50,835 PIT-tagged BY07 spring Chinook salmon smolts in 2009 as part of the CSS. 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 CSS can be found at <http://fpc.org>.

REFERENCES

- Dworshak National Fish Hatchery. 2007. Spawning Report. Brood Year 2007 Spring Chinook Salmon. Dworshak National Fisheries Complex, U.S. Fish and Wildlife Service, Ahsahka, Idaho. 9 pp.
- Dworshak National Fish Hatchery. 2009. Annual Report for Dworshak National Fish Hatchery, Fiscal Year 2008. Dworshak Fisheries Complex, U.S. Fish and Wildlife Service, Ahsahka, Idaho. 47p.
- Dworshak National Fish Hatchery. 2010. Annual Report for Dworshak National Fish Hatchery, Fiscal Year 2009. 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. 2006. Adult spring Chinook salmon returns to Dworshak and Kooskia National Fish Hatcheries in 2005 and prognosis for 2006. Appendix A. Dworshak Fisheries Complex, U.S. Fish and Wildlife Service, Ahsahka, Idaho. 14p.
- Idaho Fishery Resource Office. 2007. Adult spring Chinook salmon returns to Dworshak and Kooskia National Fish Hatcheries in 2006 and prognosis for 2007. Appendix A. Dworshak Fisheries Complex, U.S. Fish and Wildlife Service, Ahsahka, Idaho. 14p.
- Idaho Fishery Resource Office. 2012. An historical record of the adult spring Chinook salmon returns to Dworshak and Kooskia National Fish Hatcheries, through 2011. Technical fisheries report by the Idaho Fishery Resource Office, Dworshak Fisheries Complex, U.S. Fish and Wildlife Service, Orofino, ID. 28 pp.
- 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. Bretz, and H.L. Burge. 2012. Estimating Total Adult Returns of Dworshak National Fish Hatchery Spring Chinook Salmon by Brood Year - Brood Years 1980-2004. Technical Fisheries Report. Idaho Fishery Resource Office, Dworshak Fisheries Complex, U.S. Fish and Wildlife Service, Orofino, Idaho. 10p.
- 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., P. Westhagen, and J.R. Skalski. 2013. SURvival under Proportion Hazards version 3.5.2. School of Aquatic and Fishery Sciences. University of Washington. Available at <http://www.cbr.washington.edu/analysis/apps/surph>
- Peery, C, Jones, R., Bretz, C., and Cassinelli, J. 2012. 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.