

**BROOD YEAR REPORT
DWORSHAK NATIONAL FISH HATCHERY
SPRING CHINOOK SALMON
BROOD YEAR 2008
LIFE CYCLE COMPLETED IN 2013**

PREPARED BY

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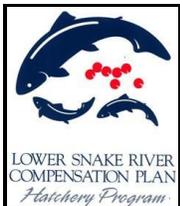
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BROOD YEAR 2008 OVERVIEW

Life Stage	Number
2008 Rack Return	1,857
Number of Females Spawnd	384
Total Eggs Enumerated¹	1,216,845
Average Eggs per Female	4,300
Eyed Eggs	1,193,435
Smolts Released	1,109,195
In-River Smolt Survival²	77.1%
Adult Returns to the Hatchery³	1,617
Adults Harvested in Idaho⁴	4,327
Adult Return to Clearwater River	12,653
Adults Collected at Other Locations⁵	21
Total Adult Return to Columbia River	12,856
SAR	1.16%

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 2011, 2012, and 2013 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.

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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 2008 (BY08) spring Chinook salmon (SCS) reared at Dworshak National Fish Hatchery (NFH) which was completed with the return of the 3-Ocean adults in 2013. 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

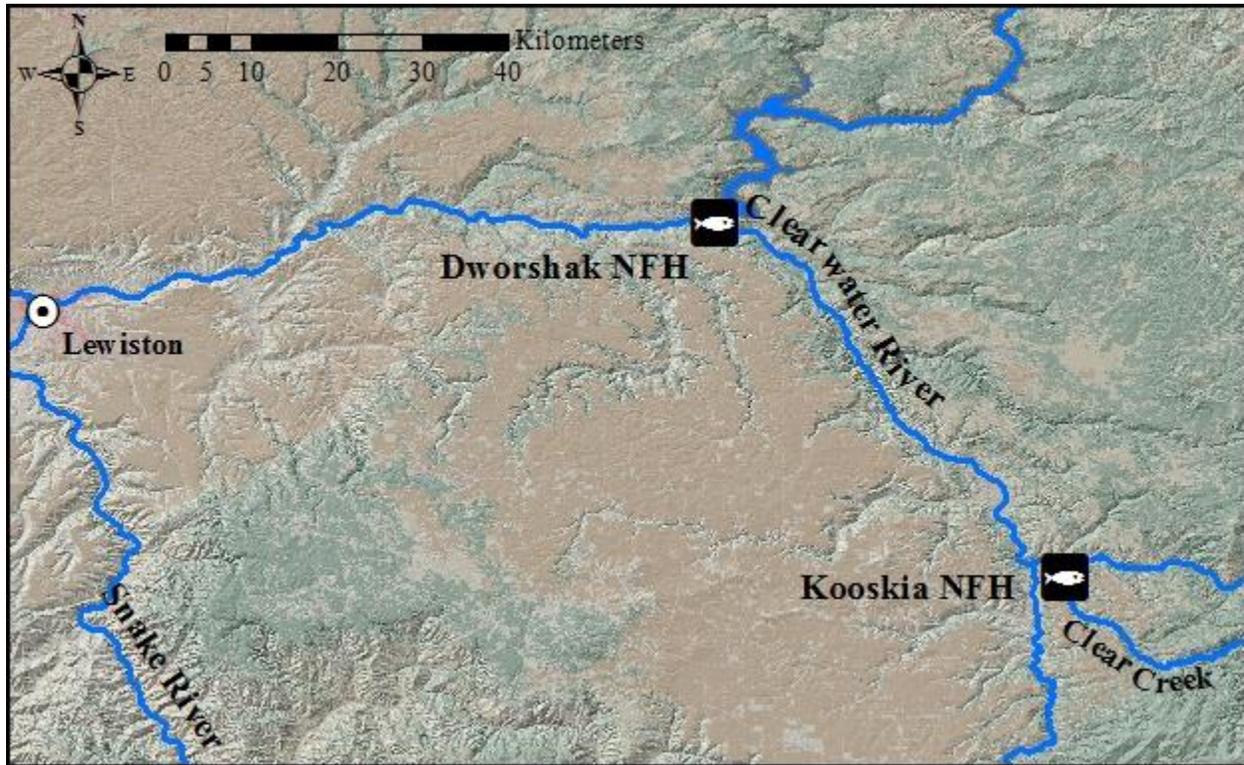
The spring Chinook salmon production program at Dworshak NFH was started in 1982 as part of the Lower Snake River Compensation Plan (LSRCP) and was originally designed to rear 1.4 million smolts to a size of 20 fish per pound (FPP) for direct release from the hatchery into the Clearwater River (U.S. 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 upstream of 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 BY08, 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 up to 952 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 BY08 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.



2008 ADULT SPRING CHINOOK SALMON RETURN TO DWORSHAK NFH

The 2008 brood year was formed from the progeny of the adults that return as brood stock to Dworshak National Fish Hatchery during the 2008 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 2007, the 1-Ocean return to Dworshak NFH was originally estimated to be 767 fish (Idaho Fishery Resource Office 2007, Table 9). Using the regression model, we predicted a return of 6,172 2-Ocean adults for 2008 and a total adult return (2- and 3-Ocean fish) of 6,769 returning to the Clearwater River for the 2007 season (Idaho Fishery Resource Office 2007, Table 11). This number was much lower than the actual return. **Table 1** lists the predicted

return, made in 2007, and the estimated returns of all three age classes of adults that returned in 2008 (Idaho Fishery Resource Office 2012, Table 11). Our prediction for the 1-Ocean return was much lower than the actual return, 174 vs. 506. The regression used for making our prediction overestimated 2-Ocean returns, 6,172 predicted vs. 2,172 actual. Our prediction for the 3-Ocean returns was slightly lower than the actual return, 423 predicted vs. 447 actual. Although our total prediction was 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 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 BY08.

Ocean Age ¹	2007 Prediction for 2008	Actual 2008 Return
1 - Ocean	174	506
2 - Ocean	6,172	2,172
3 - Ocean	423	447
	6,769	3,125

¹ 1-Ocean are BY05, 2-Ocean are BY04, and 3-Ocean are BY03.

Adult Chinook Salmon Collection

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 952 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 adult ladder at Dworshak NFH was opened on June 16 and was operated intermittently through August 12. (Dworshak National Fish Hatchery 2008. During that time, 1,857 adult spring Chinook salmon were collected at 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.

During 2008, adult spring Chinook salmon that return to Dworshak NFH are predominately 2-Ocean fish, those that spend two years rearing in the ocean before returning to freshwater to spawn. Based on size, the age composition for the 2008 return was 17% 1-Ocean, 65% 2-Ocean, and 18% 3-Ocean, respectively. **Table 2** lists the inventory dates and the numbers of adults collected during that time period, by age.

Table 2. Number of spring Chinook salmon, by age class, on each inventory date from 7/02/08 to 9/04/08, including trap mortalities (2008 Salmon News, Idaho FRO Files).

Inventory Date	1-Ocean	2-Ocean	3-Ocean	Total
July 2	16	105	24	145
July 9	80	249	42	371
July 16	80	313	88	481
July 23	69	153	71	293
August 4	54	168	53	275
August 14	15	203	58	276
September 4	0	2	0	2
Trap mortality	5	8	1	14
Total	319	1,201	337	1,857

The five year mean percent returns in the rack for 1-Ocean, 2-Ocean, and 3-Ocean adults were 15%, 69%, and 18%, respectively, for years 2004 to 2008 (**Table 3**).

Table 3. Age composition of spring Chinook salmon adults returning to Dworshak NFH, 2004-2008.

Year	1-Ocean	%	2-Ocean	%	3-Ocean	%	Unmeasured	Total Return
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
<u>2008</u>	<u>319</u>	<u>17</u>	<u>1,201</u>	<u>65</u>	<u>337</u>	<u>18</u>	<u>0</u>	<u>1,857</u>
Mean¹	260	15	1,182	69	270	16	0	1,712

¹ 5-yr mean.

Adult Marking

Because of space and water temperature limitations at Kooskia NFH, 576 spring Chinook salmon collected for brood stock at that hatchery were 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 opercle V-notch while Kooskia salmon were 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 occurred prior to the start of spawning (pre-spawn mortality) and holding mortality that occurred after the start of spawning (spawning mortality). From June 6 to August 12, 26 adult spring Chinook salmon (1.4% of rack return) died. From August 13 through September 2, an additional 70 adults died (3.8 % of rack return). The mortality rate of BY08 spring Chinook salmon adults during holding was lower than the 5-year average (**Table 4**).

Table 4. Percent mortality of adult spring Chinook salmon during holding (pre-spawning) and during spawning at Dworshak NFH, 2003-2008 (Dworshak National Fish Hatchery 2008).

Brood Year	Pre-Spawning Mortality	Mortality During Spawning	Total
2003	4.9%	2.7%	7.6%
2004	1.5%	7.2%	8.8%
2005	3.1%	4.1%	7.1%
2006	1.3%	1.6%	2.9%
2007	1.1%	2.7%	3.8%
2008	1.4%	3.8%	5.2%
Five-Year Avg	2.4%	4.8%	7.2%

Spawning

Details on the methods and procedures during spawning are provided in the Spawning Report for BY08 (Dworshak National Fish Hatchery 2008). Spawning began August 12, about the same time of year as in 2007. Five egg takes were made with the last ripe females for the Dworshak NFH program spawned on August 2 (**Table 5**).

Fish Health Treatments and Data Collection

Holding - During the period of holding prior to spawning, formalin treatments were administered under veterinary extra-label prescription to adults to retard fungus infection. 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 extra-label prescription to decrease levels of *Renibacterium salmoninarum* (Bacterial Kidney Disease) in the adult and the eggs. Each female injected received a dosage of 10 mg/kg of body weight.

Table 5. Number of male and female spring Chinook salmon spawned during each egg take for BY08 at Dworshak NFH (Dworshak National Fish Hatchery 2008). Jacks are incorporated into the number of males spawned.

Egg Take Date	Males Spawned	Females Spawned
8/12/08	34	37
8/19/08	86	86
8/26/08	112	115
8/27/08	67	66
<u>9/2/08</u>	<u>80</u>	<u>80</u>
Total	379	384

Spawning - 37/213 (17.4%) adults tested positive for IHNV (Infectious Hematopoietic Necrosis Virus). Ovarian fluid samples were 3-pooled and spleens were 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

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

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.

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. 243 spring Chinook salmon were out-planted in to the Selway River on July 14, 2008 (Dworshak National Fish Hatchery 2008).

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 2008). Egg take and survival is summarized in **Table 6**.

Green Eggs Taken

Eggs were enumerated once they have reached the eye-up stage. The number of green eggs taken was initially estimated using an average of 3,750 eggs per female. A total of 384 females were spawned, giving an initial estimate of 1,440,000 green eggs.

Early Incubation

All eggs were incubated in Heath trays. Eggs from each female were incubated separately to allow tracking offspring by the BKD status (low/medium/high) of the female parent based on ELISA results from kidney samples taken at time of spawning. Water flow through the incubators was maintained at approximately four gallons per minute (Dworshak National Fish Hatchery 2008). For BY08, an estimated 116,250¹ eggs from 31 females that tested above 0.120 ELISA O.D. level for BKD were culled from production (Dworshak National Fish Hatchery 2008).

Eye-Up

At eye-up, eggs were shocked, dead eggs were removed, and eggs were enumerated by a mechanized egg picker (Van Gaalen Model-100). A total of 23,410 dead eggs were counted and removed. The total number of eyed eggs enumerated was 1,193,435.

Egg Transfers and Final Incubation

Dworshak eggs were incubated in A, B, and C-banks. Chilled water temperature averaged 41.5°F for eggs in A and B, the water temperature (non-chilled) in C bank averaged 44.7°F throughout the initial incubation cycle.

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 2009 and remained in incubation trays until the spring release of BY07 smolts. BY08 fry were moved from the incubator trays to A-bank raceways (RW's) during April 9-17. There were 1,171,098 fry ponded at that time and these fish were started on feed within a few days. At the end of April 2009, there were 1,162,130 BY08 feeding fry averaging 502 fpp and 48 mm (1.9 inches) total length.

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

Table 6. Summary of egg take and eye-up for Dworshak NFH BY07 spring Chinook salmon (Dworshak National Fish Hatchery 2008, Table 2).

Take	Spawn date	Males ¹	Females	Females culled for BKD ²	Trays culled dead	Total eggs enumerated	Eyed eggs enumerated	Percent enumerated ³ eye-up
1	8/12/08	34	37	7	1	111,663	110,000	98.5
2	8/19/08	86	86	2	1	330,253	324,000	98.1
3	8/26/08	112	115	3	2	325,290	320,000	98.4
4	8/27/08	67	66	15	2	194,395	189,435	97.4
5	9/2/08	80	80	4	1	255,244	250,000	97.9
Total/ Mean		379	384	31	7	1,216,845	1,193,435	98.1

¹ Includes 37 jacks spawned during the season

² BKD culling above 0.120 ELISA testing for all takes

JUVENILE REARING

The following data and information was summarized from the hatchery production records at Dworshak NFH, the 2009 and 2010 Annual Reports for Dworshak NFH (Dworshak National Fish Hatchery 2010; Dworshak National Fish Hatchery 2011), the Dworshak NFH monthly production narratives, and the Dworshak NFH monthly inventory summaries (MIS).

Growth and Mortality

Growth for BY08 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 2009 until the time of release in March 2010, is listed in **Table 7**.

Table 7. Summary of monthly growth and mortality of BY08 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)
4/09	1,162,130	2,313	502.4	48	-	0.77	40.5
5/09	1,156,766	5,963	194.0	66	18	0.46	44.3
6/09	1,156,359	11,151	103.6	81	15	0.14	46.3
7/09	1,154,764	16,404	70.3	92	11	0.09	44.8
8/09	1,125,316 ¹	22,140	50.8	102	10	0.07	45.3
9/09	1,124,728	30,670	36.7	114	12	0.05	48.5
10/09	1,123,521	36,893	30.5	122	8	0.11	49.2
11/09	1,222,510	45,459	24.7	130	8	0.09	48.7
12/09	1,121,090	49,643	22.6	134	4	0.13	45.0
1/10	1,119,106	52,570	21.3	137	3	0.18	42.4
2/10	1,114,974	59,485	18.7	143	6	0.37	41.9
3/10	1,109,195	66,051	16.8	148	5	0.34	41.6

¹ The number of BY08 juveniles listed prior to August is based on egg counts in trays brought to ponds in April. After the completion of fin clipping and tagging on August 15, 2009 numbers were adjusted to reflect counts performed while fin clipping.

Fish Health Monitoring

Beginning in September, 10 fish per month were sampled for BKD monitoring by the ELISA test for the last 6 months until release.

Results:

9-30-09 – Not Detected: 8, Low positive: 2 (all samples 2 fish pooled)

10-21-09 – Not Detected: 11

11-18-09 – Not Detected: 10

12-17-09 – Not Detected: 10

1-4-10 – Not Detected: 10

2-24-10 – Not Detected: 10

September – Low levels of the parasites *Epistylis* and *Epitheliocystis* were detected on the skin. Gills were slightly swollen with very low levels of egg cysts from the blood fluke parasite *Sanguinicola*. It was decided that the condition did not warrant treatment.

October – Fish were seen to be flashing in several raceways. High levels *Epitheliocystis* and low

levels Gyrodactylus were seen on the skin. Gills were slightly swollen with low levels of egg cysts from the blood fluke parasite Sanguinicola. Recommendation was made to treat all ponds that were flashing with a formalin bath treatment at 167 ppm for 1 hour each.

November – Light Trichophyra, light Epistylis, and heavy Epitheliocystis were detected on the skin. One fish had an eroded nose. There was moderate debris noted on the gills. Moderate amount of feed was seen on bottom of pond, possibly indicating that fish may have been eating less. Recommendations were to watch to ensure fish were eating and that feed may need to be reduced to ensure ponds were kept clean.

December – Four moribund and 6 healthy fish were examined. Low to moderate levels Ambiphyra were seen on the skin. Fish feed and waste were seen on bottom of pond. Gills of two of the moribund fish had swollen with fused gills. Recommendations were to clean ponds. No treatment at that time.

January – Light flashing was seen in one raceway. Most fish sampled from this raceway were smaller than the general population in that pond. Some fish were jumping at screens at the head end of ponds in some raceways. Low to moderate Ambiphyra and low levels Epitheliocystis were seen on the skin. Gills were pale and swollen with low levels of Sanguinicola. Fish were tested for virus by cell culture but no virus was detected. Recommendations were to treat with 2-3% salt for 15-30 minute bath if jumping became excessive or flashing increased.

February – Low levels Epistylis and Epitheliocystis were seen on the skin. Fish were collected from tail end of RW; they were very thin. Gills were swollen and had low levels of Sanguinicola. No bacteria were seen by kidney imprints or cultures. Virus was not detected. Recommendations were to re-evaluate feed sizes.

Marking and Tagging

Coded-Wire Tags and Adipose Fin Clips

Adipose fin clipping and coded wire tagging were conducted by the U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, in August 2009. A total of 121,263 (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 8**). 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 2010, prior to release. The retention rate at Dworshak NFH was 99%.

PIT tags

A total of 51,423 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.

Table 8. Coded-wire tagged BY08 spring Chinook salmon reared at Dworshak NFH.

Tag Code	Number of Tags ¹	Number of fish without CWT's	Mark Rate ²	Purpose
054686	59,331	498,399	0.11	Contribution, Raceways B20 and B21
054685	59,652	491,813	0.11	Contribution, Raceways A5 and A6

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

² Mark Rate is the number of tags divided by the number of fish released that the tag code represents.

SMOLT RELEASES

In March 2010, the Idaho FRO began monitoring flows and river conditions in the main stem Clearwater River and at Lower Granite Dam (**Figure 2**) to aid in determining the optimum time for smolt releases. By March 15, 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 about half of the 10-year average, the lowest flows observed in the past 20 years. The forecast at that time was for conditions to remain about the same for the next couple of weeks. The Idaho FRO recommended delaying releases until April 14/15, or as long as possible, to provide an opportunity for flows to increase. By the last week in March, flows in the Clearwater and Snake rivers had increased significantly due to rainstorm events but were still below the 10-year average. Even so, the managers decided that circumstances were favorable for a release on March 31, 2010.

Dworshak NFH released a total of 1,109,195 BY08 spring Chinook salmon smolts during the evening of March 31. Mean total length at the time of release was 148 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 that day, to help move the fish into the main stem Clearwater River.

Fish Health Pre-release exam

Sixty fish were collected on 3-18-10 for pre-release examination for fish health and smolt readiness for emigration. The results are presented below:

ELISA Results: Not detected – 56

Low – 4

Medium – 0

High -- 0

Viral assays - negative

Bacterial assays - negative

Hematocrits - 20 samples, all in normal range

Observations for smoltification included light parr marks and very silvered-up.

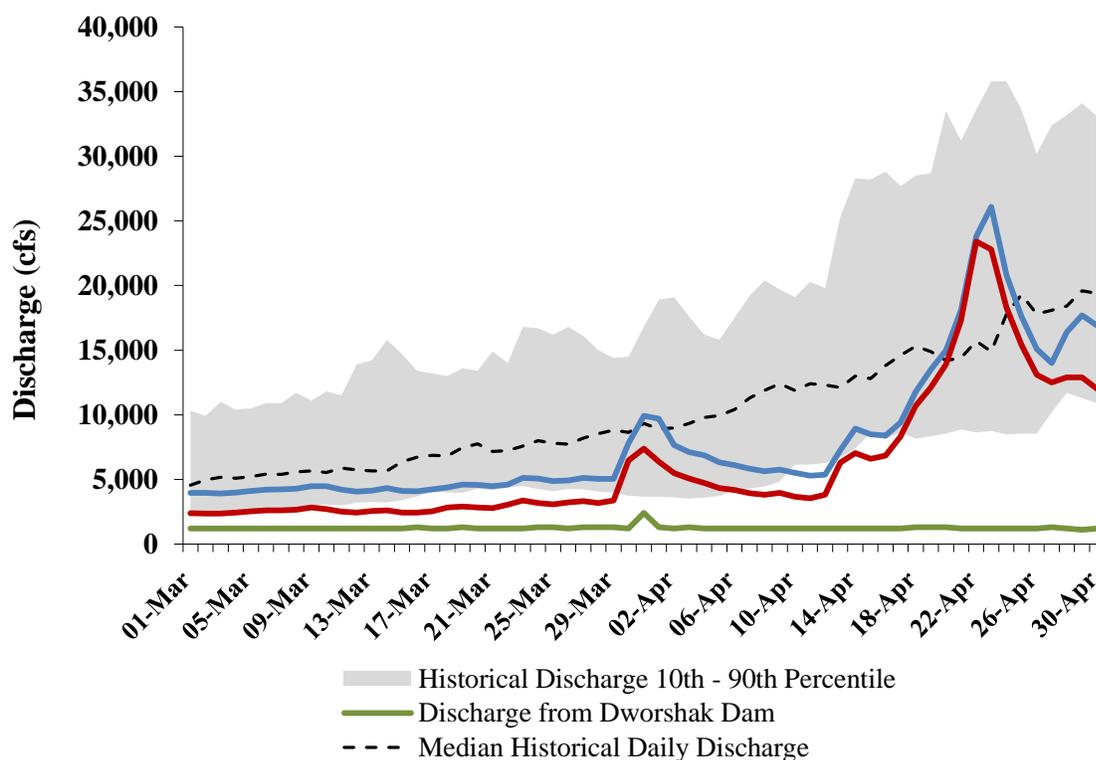


Figure 2. Mean daily inflow into Lower Granite Reservoir and mean daily discharge of the Clearwater River at the Orofino Bridge. Vertical line indicates the March 31, 2010 release of smolts.

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 were 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 (**Figures 3 & 4**). PIT tags provided information on travel time and survival during emigration.

Travel Time

The migration time for BY08 Chinook salmon to Lower Granite Dam ranged from 10 to 66 days with a harmonic mean of 27 days ($n=7,098$). Ten percent arrived at Lower Granite Dam within 22 days; 50% and 90% arrived within 27 days and 374 days, respectively. Smolts that migrated through the hydropower system arrived at Bonneville Dam on average 53 days after release.

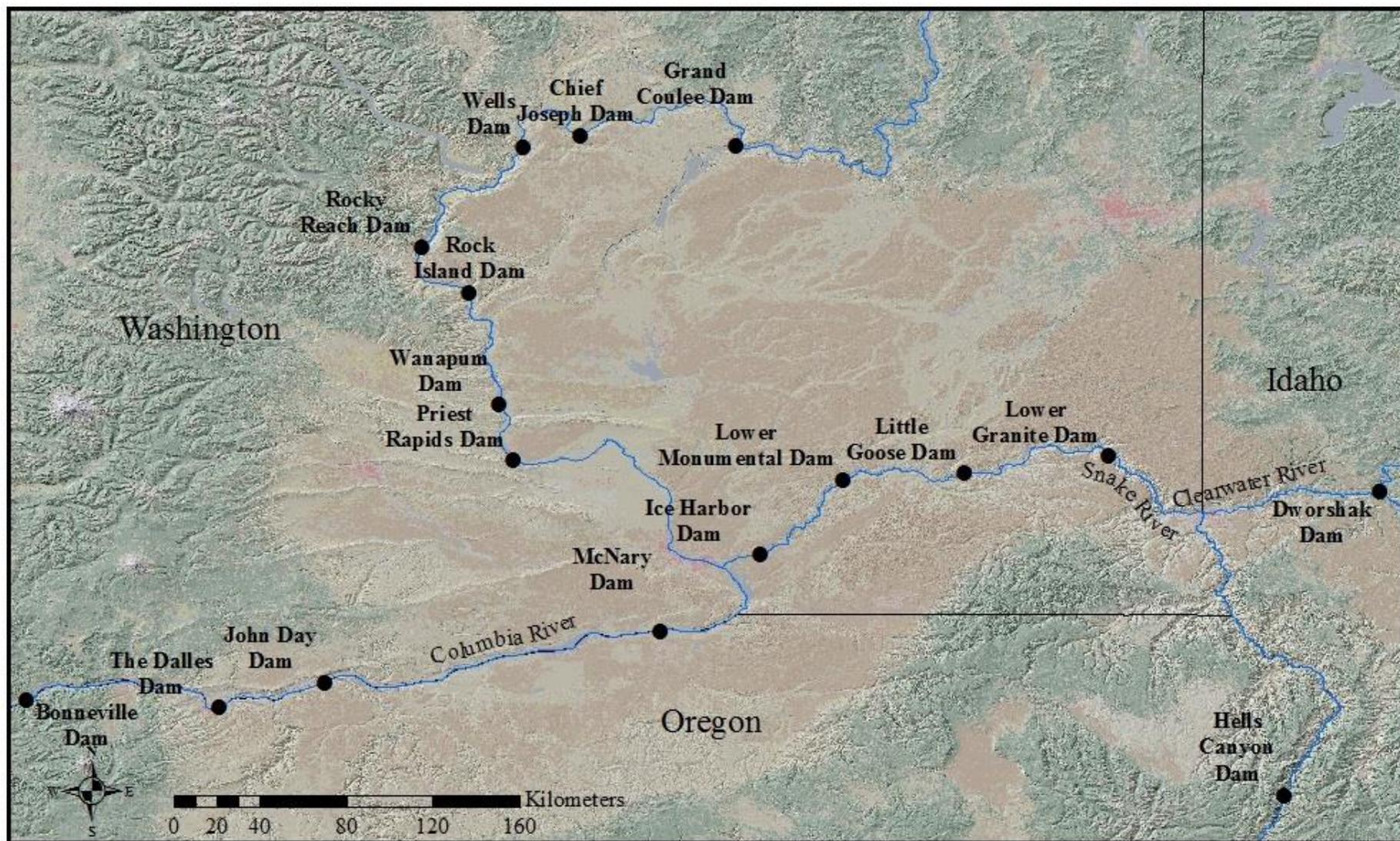


Figure 3. Major dams of the Columbia River, the lower Snake River, and the Clearwater River systems. Emigrating spring Chinook salmon smolts released from Dworshak NFH are interrogated for PIT tags at Lower Granite Dam, Little Goose Dam, Lower Monumental Dam, McNary Dam, John Day Dam, and Bonneville Dam.

Figure 4. Cumulative PIT tag detections for BY08 Dworshak NFH spring Chinook smolts at juvenile bypass facilities in the Snake and Columbia rivers.

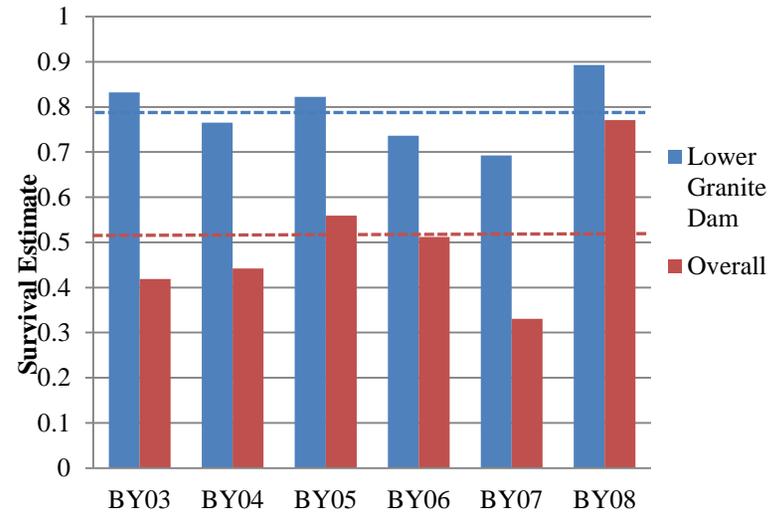
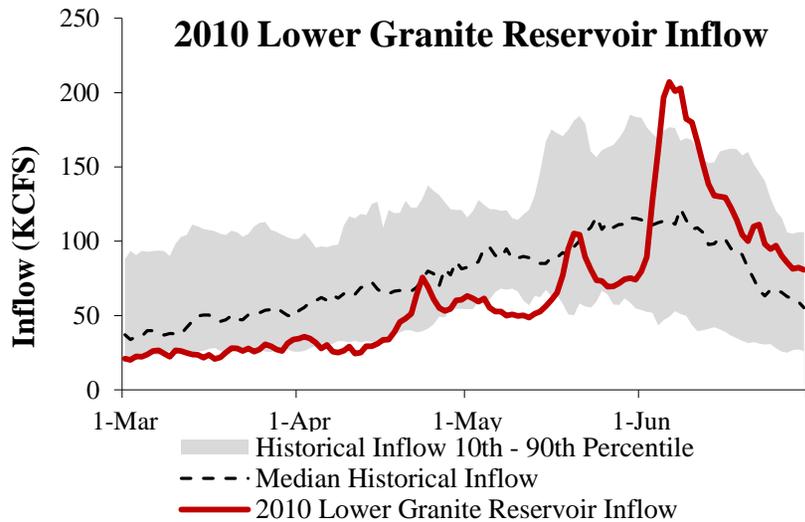
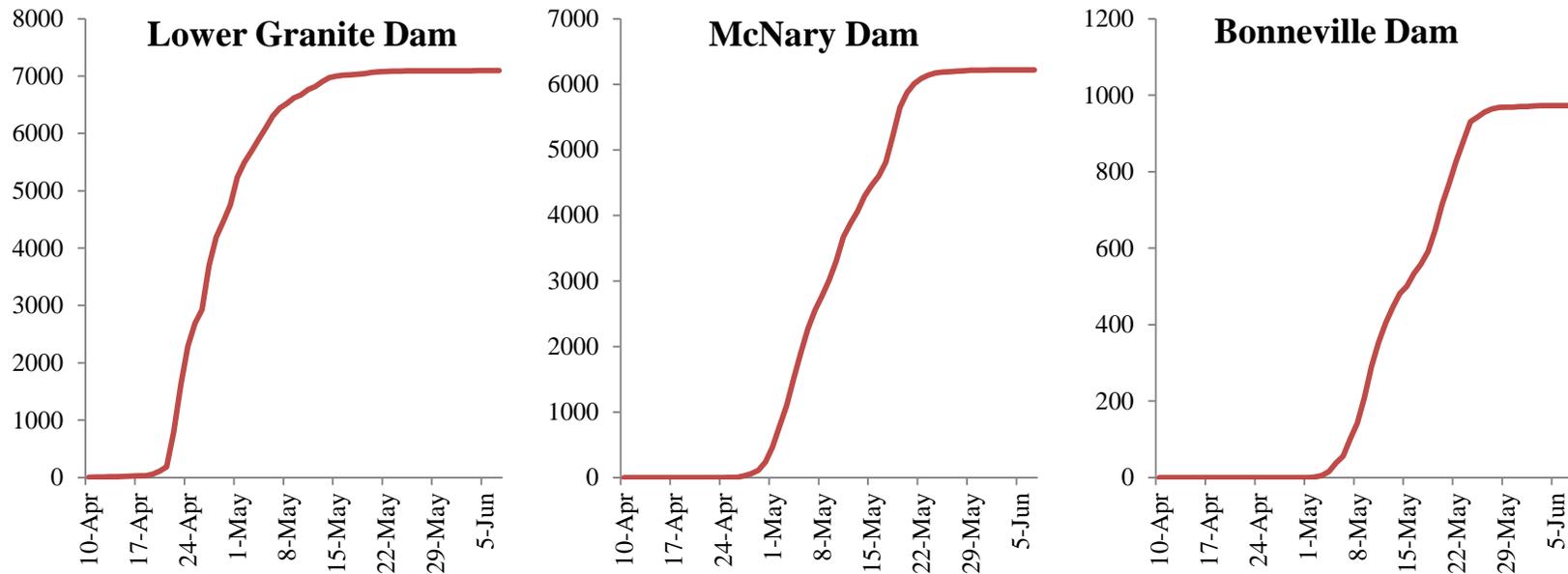


Figure 5. Mean daily inflow to Lower Granite Reservoir from March 1 through June 30, 2010, and the historic 10th – 90th percentile range during spring Chinook salmon emigration after release from DNFH.

Figure 6. Mean survival estimates to Lower Granite Dam and overall survival estimate through the Federal Columbia River Power System, BY03-BY08. Dashed lines indicate mean survival.

River Flows

Flows in the Lower Snake River were greater than the 10-year average during nearly the entire emigration period (**Figure 5**). 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 9**).

Table 9. Cumulative survival estimates of BY08 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	0.893	0.016
Lower Granite Dam – Little Goose Dam	0.9348	0.0256
Little Goose Dam – Lower Monumental Dam	1.0436	0.0602
Lower Monumental Dam – Ice Harbor Dam	0.9215	0.0589
Ice Harbor Dam – McNary Dam	0.9698	0.0363
McNary Dam – John Day Dam	0.9912	0.0465
John Day Dam – Bonneville Dam	0.990	0.0466
Overall	0.771	0.0340

River reach survival for spring Chinook smolts ranged from 0.893 (SE= 0.016) to 0.1.04 (SE= 0.0602). The lowest survival occurred between Dworshak NFH and Lower Granite Dam; lower than any previous 5 brood years. The highest survival occurred between Little Goose Dam and Lower Monumental. Overall survival to Bonneville Dam was 0.771 (SE=0.0340), lower than the 6 year average (**Figure 6**).

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. BY08 adults, released as smolts in 2010, returned as 1-Ocean adults in 2011, 2-Ocean adults in 2012, and 3-Ocean adults in 2013. 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.

Lower River Harvest Estimates

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 fisheries 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 original 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 2013, an estimated 107 Dworshak NFH BY08 adults were harvested below Bonneville Dam, 84 in sport fisheries, 19 in Tribal net fisheries, a four in Columbia River test fisheries (Table 11). No ocean harvest was reported for Dworshak NFH BY08 adults, three 0-Ocean Dworshak NFH Chinook were harvested in ocean 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 sport harvest occurs there also. From 2011 to 2013 an estimated 38 Dworshak NFH BY08 adults were reported harvested in Tribal fisheries (Table 10).

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 2011, 2012, and 2013, an estimated 53 Dworshak NFH Chinook were reported harvested in sport fisheries in these sections (Table 10).

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 an estimated five Dworshak NFH BY2008 adults reported harvested in this section from 2011 to 2013 (Table 10).

Strays in the Columbia River

For purposes of adult return accounting, strays are defined as fish that were collected or were captured at any hatchery rack or tributary weir outside the main Columbia River that was not part of the normal adult migration corridor. Salmon harvested in areas outside the normal migration corridor were not considered strays because they may have resumed migration if not harvested. For BY08, four adult strays were collected below McNary Dam and none were collected above the mouth of the Snake River (Table 10).

Table 10. 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	Below Lower Granite	Above Lower Granite
			Zone 1-5 Sport	Zone 1-5 Tribal	Zones 1-5 non-tribal Net	Zone 6 Sport	Zone 6 Tribs	Zone 6 Tribal				
0	2010	3	0	0	0	0	2	0	0	0	0	
1	2011	0	19	0	1	0	9	0	0	0	5	
2	2012	0	57	19	3	0	6	9	0	53	0	
3	2013	0	8	0	0	8	4	0	0	0	0	
Totals		3	84	19	4	8	21	9	0	53	5	

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

² Excluding the Clearwater

Adult Returns to the Clearwater River

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 2011, 2012, and 2013, 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. Based on these values, the estimated number of adult Dworshak NFH spring Chinook salmon from BY08 that returned to the Clearwater River was 12,635 (**Table 11**). Descriptions of the rack return, sport and Tribal harvest and escapement are provided below.

Table 11. Summary of adult returns to Clearwater River for BY08 spring Chinook salmon.

Return year	Ocean age	Rack Return	Sport harvest	Tribal harvest	Escapement	Strays	Total
2011	1	289	1,316	449	2,434	0	4,488
2012	2	1,171	1,751	757	4,045	0	7,724
<u>2013</u>	3	<u>157</u>	<u>0</u>	<u>54</u>	<u>230</u>	<u>0</u>	<u>441</u>
Total		1,617	3,067	1,260	6,709	0	12,653

Rack Return to Dworshak NFH.—The total adult return to the hatchery rack was 1,617 fish. The number in each Ocean Age Class is presented in **Table 11**.

Idaho Sport Fisheries.—The Idaho Department of Fish and Game (IDFG) is responsible for collecting and reporting information on sport harvest in the state. 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 BY08 spring Chinook salmon occurred in 2011 (1-Ocean fish), in 2012 (2-Ocean fish) and in 2013 (3-Ocean fish). Based on IDFG reports, a total estimated harvest of 3,607 BY08 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 11**.

Idaho Tribal Fisheries.—The Nez Perce Tribal Department of Fisheries Resource Management is responsible for reporting harvest data in the Tribal fishery in the Clearwater River. 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 1,260 BY07 Dworshak NFH adults (**Table 11**).

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 BY08 escapements for the 2011, 2012, and 2013 returns were 2,434, 4,045, and 230, respectively (**Table 11**).

Strays.—No BY08 Dworshak NFH adults were identified as strays above Lower Granite Dam (**Table 11**).

Smolt to Adult Return Rate (SAR)

The smolt to adult return rate (SAR) is calculated by dividing the number of adults that returned to Lower Granite Dam by the number of smolts released and is used as an indicator of program performance. For BY08, the SAR was 1.141% (12,653 adults to Lower Granite Dam/1,109,195 smolts released). The SARs for the previous five years are listed below. The SAR for BY08 is higher than in any of the previous 5 brood years, and much higher than the previous 5-year average of 0.470%.

BY 2007 – 0.567%
 BY 2006 – 0.905%
 BY 2005 – 0.403%
 BY 2004 – 0.330%
 BY 2003 – 0.146%

Fish Health Information on Adult Rack Returns

I-Ocean Adults (2011 Return)

81/472 (17.2%) adults tested positive for IHNV (Infectious Hematopoietic Necrosis Virus). Ovarian fluid and spleen samples were 1 pooled (tested individually). All spleen tissues were sampled from males.

Results positive 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 Bacterial Kidney Disease (*Renibacterium salmoninarum*) by ELISA (Enzyme-Linked Immunosorbent Assay)

Results:

Not Detected - 189

Low - 205

Medium - 19

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.

SCS were negative for the parasite *Myxobolus cerebralis* (Whirling Disease) by pepsin trypsin digest. A total of 60 fish were sampled by head wedges throughout the spawning season.

II-Ocean Adults (2012 Return)

16/212 (7.5%) adults tested positive for IHNV.

Ovarian fluid samples were 3 pooled and spleens were 5 pooled. 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 Bacterial Kidney Disease (*Renibacterium salmoninarum*) by ELISA (Enzyme-Linked Immunosorbent Assay)

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 from bacterial cultures.

SCS 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 head wedges throughout the spawning season.

III-Ocean Adults (2013 Return)

75/210 (35.7%) adults tested positive for IHNV.

Ovarian fluid samples were 3 pooled and spleens were 5 pooled. All spleen tissues were sampled from males.

Results positive for IHNV by take:

Take 1: 18/54 ovarians, 15/30 male spleens

Take 2: 27/96 ovarians, 15/30 male spleens

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

Results:

Not Detected - 230

Low - 254

Medium - 33

High- 2

SCS 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 head wedges throughout the spawning season.

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 51,423 PIT-tagged BY08spring Chinook salmon smolts in 2010 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.