CENWW-OD-EL HOLDREN February, 2017

MEMORANDUM THRU:
Marty Mendiola, Operations Project Manager, Lower Granite Dam

FOR Chief, Operations Division
ATTN: John Bailey / Ann Setter

SUBJECT: Submission of 2016 Juvenile Fish Collection and Bypass Report, Lower Granite Dam Juvenile Fish Facility.

1. Enclosed find the 2016 Juvenile Fish Collection and Bypass Report for Lower Granite Dam as requested.

2. If you have any questions contact Elizabeth Holdren at Lower Granite Dam, (509) 843-2263.

ELIZABETH A. HOLDREN
Supervisory Fisheries Biologist, Lower Granite Dam

Enclosure

2016 Juvenile Fish Collection and Bypass Report
Lower Granite Dam Juvenile Fish Facility

Prepared by

Elizabeth Holdren

U.S. Army Corps of Engineers

and

Shawn Rapp Anchor QEA

February, 2016

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TRANSPORT OPERATIONS - LOWER GRANITE DAM

Introduction

The 2016 collection season at Lower Granite was characterized by below average flow and spill conditions, above average temperatures, and low debris. ESBSs (Extra-Length Bar Screens) were installed March 21 through March 23. The bypass system and juvenile collection facility were watered up in secondary bypass mode at 1300 hours March 21. The JFF (Juvenile Fish Facility) was operated in secondary bypass until collection for transport began at 0700 hours May 1. Daily twenty-four hour sampling for fish condition monitoring occurred from March 26 until collection for transport began May 1. Early season transport of Snake River yearling anadromous salmonids as part of the ongoing study to compare in-river verses transported SARs (Smolt Adult Return Ratios) did not occur during the 2016 season. Six agencies conducted nine research projects and handled a total of 458,051 smolts at the Lower Granite juvenile collection facility this season in addition to smolt monitoring, GBT sampling, and kelt collection for Nez Perce Tribe reconditioning program.

Collection for transport began at 0700 hours on May 1 and ended at 0700 hours on October 31. The facility was operated in secondary bypass mode October 31 through November 17. Total smolt collection for 2016 season was 8,454,280 fish compared to 2,703,675 collected in 2015. Of the 8,454,280 fish collected in the 2016 season, 22,529 were trucked, 3,379,603 were barged, and 5,048,063 were bypassed.

Pacific States Marine Fisheries Commission (PSMFC)/Anchor QEA technicians examined 960 fish for gas bubble trauma (GBT) between April 7 and June 9. Smolts examined prior to May 1 were bypassed to the river and smolts examined after that date were transported. There were no symptoms of GBT observed during the 2016 season.

The passive integrated transponder (PIT) tag system detected 185,368 PIT-tagged fish coming through the JFF during the 2016 season. Of the PIT tagged fish detected 135,659 were diverted to the river, 47,290 were diverted to the raceways for transport, 1,325 were diverted to the sample holding tank, and 1,094 failed to be detected moving to bypass, raceways, or the sample.

This season's total collection by species group included: 3,405,400 clipped yearling Chinook, 1,104,727 unclipped yearling Chinook, 262,101 clipped subyearling Chinook, 512,157 unclipped subyearling Chinook, 2,385,586 clipped steelhead, 600,528 unclipped steelhead, 28,700 clipped sockeye, 4,665 unclipped sockeye, and 150,416 Coho.

Historically Snake River Basin hatchery salmonids were distinguished from wild salmonids by clipped adipose fins (occasionally pectoral or ventral fins). Before 1998, Idaho Fish and Game (IDFG) was the only agency that released sizeable numbers of unclipped hatchery fish. Starting in 1998, increasing numbers of unclipped hatchery fish were released by state, federal, tribal, or other agencies (FPC). Thus salmonids collected, sampled, bypassed, and transported from Lower Granite facilities are designated as clipped/unclipped not hatchery/wild. Snake River Basin Coho were reintroduced by the tribes and are all of hatchery progeny.

Corps of Engineers personnel included: Project Supervisory Fisheries Biologist Elizabeth Holdren, Assistant Biologist Robert Horal, Lead Biological Technician Stephen Hampton, Biological Technicians: Bob Traufer, Dan Caldwell, Geno Sprofera, Henry Kei, Kyle Fronte, Joshua Turner, David Philips, and Interns Tyler Janasz, Kevin Ross, and Joshua Moore. Truck driver / maintenance personnel: Raymond Cooper, Chuck Krasselt, Jeremy Krewer, Tomas Dickinson. Representing Pacific States Marine Fisheries Commission (PSMFC) were biologists Allan Martin and Jenna Davis, Anchor QEA was represented by biologists Shawn Rapp and Paul Burke, and Washington Department of Fish and Wildlife (WDF&W) biologist Charles Morrill. PSMFC technicians Bill Fitzgerald, Praxy McIntyre, Jennifer Warner, and Julie Graves-LaForge conducted fish sampling, and were responsible for the numerous quality control and data keeping tasks.

Facility Modifications

The following modifications were made to the JFF prior to or during the 2016 fish collection season:

1. Juvenile bypass upgrade Phase 1a is ongoing.
2. Refurbished the sample diversion slide gates per PSMFC guidelines.
3. Modified Mule ATV to ESBS inspection vehicle including installation of upgraded underwater camera, electronic equipment, monitor, and hoist system with new cable.
4. Replaced downstream raceway tailscreen guides and filled expansion joint voids.
5. Repaired/replaced potable water supply at barge loading dock used by tug companies.
6. Replaced juvenile sample anesthesia tank chiller recirculation pump in wet lab.
7. Replaced deteriorating fish evacuation/loading lines from lab.
8. Modified upstream and downstream gantry crowders to prevent lamprey and smolt stranding.
9. Installed new brushes on upstream raceway crowder and operating controls.
10. Replaced facility primary pneumatic system broken air lines.
11. Replaced sample slide gate pneumatic seals.
12. Installed new chain on barge loading boom.
13. Rehabbed/repaired gatewell dipping basket including new gasket material.
14. Completed plunger and cylinder installation on 8000 series barges (replaced barge hold plungers, shafts, cylinders, and hoses).
15. Completed compressor and generator upgrade and installation on 8000 and 4000 series barges.
16. Replaced all pneumatic hoses for exit release systems on all barges.
17. Repositions barge engine clutches handles from vertical to horizontal.
18. Extended barge hold latch keys.
19. Installed new fish evacuation plungers and compressors in 2000 series barges.
20. Replaced non-compliant winch cables and replaced all weathered mooring lines on 8000 and 4000 series barges.

River Conditions

During the 2016 season, the average daily flow exceeded 100 kcfs on 18 days. The highest daily average flow for the season was 128.0 kcfs April 25. The lowest daily average flow for the season occurred on September 26 with a flow of 13.0 kcfs. The average flow for the season was 48.5 kcfs. Spill occurred for 152 days from April 3 through midnight on August 31, with a maximum daily average spill of 45.3 kcfs April 25, a minimum daily spill of 8.4 kcfs August 23, and a seasonal average of 18.6 kcfs. The RSW was put into operation when Court ordered spill began April 3. The RSW was taken out of service June 29 to improve tailrace conditions for adult passage. River temperature averaged 60.5° F for the season and ranged from 46.6° F April 1 to 68.0° F June 30. A comparison of daily powerhouse flow and spill is shown in Figure 1. Average monthly flow and spill for the 2012-2016 collection seasons are provided in Table 1.

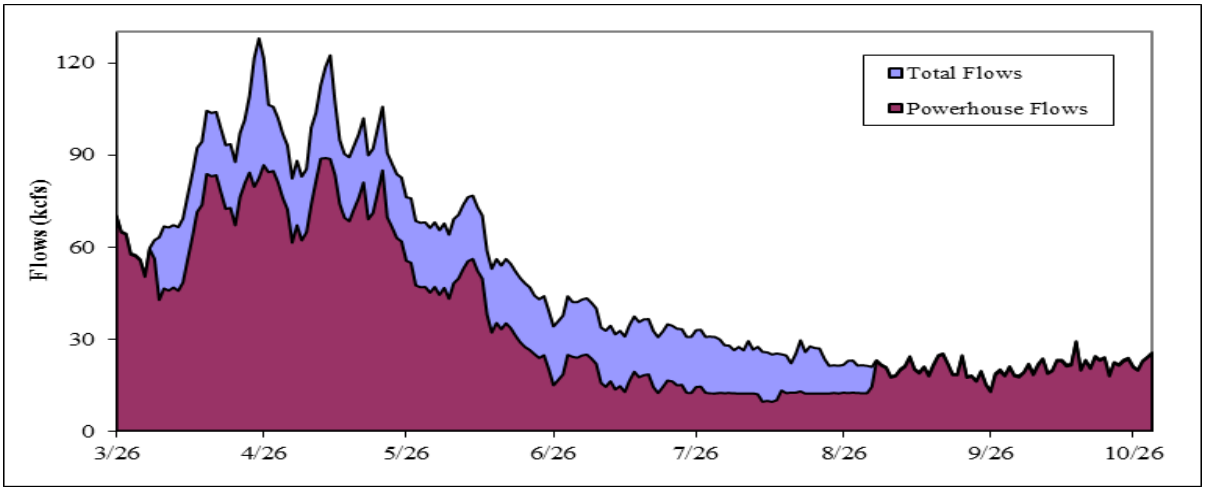

Figure 1. Daily average total flow and powerhouse flow at LWG, 2016.

Table 1. Comparison of average monthly river flow and spill at LWG, 2012-2016.

Flow (kcfs)	**2012**	**2013**	**2014**	**2015**	**2016**	**2012-15 Ave.**
April[1]	114.50	52.58	73.67	52.11	85.12	73.22
May	107.14	82.19	104.08	60.89	90.79	88.58
June	90.31	56.31	88.09	43.08	55.58	69.45
July	46.49	33.31	46.64	28.47	34.41	38.73
August	27.28	22.08	26.06	21.72	24.96	24.28
September	22.82	20.42	21.54	19.26	20.06	21.01
October	19.36	23.30	18.86	16.36	22.06	19.47
Spill (kcfs)						
April[1]	29.91	15.56	16.79	15.34	17.23	19.40
May	29.53	21.45	31.10	20.30	21.53	25.59
June	32.38	19.71	23.22	19.60	19.88	23.73
July	21.42	16.71	18.77	12.22	17.73	17.28
August	14.33	11.52	14.19	8.75	12.46	12.20
September	0.27	1.99	0.47	0.15	0.20	0.72
October	0.00	0.00	0.00	0.00	0.00	0.00

Fish Collection

Migration and Collection

Pre-transport secondary bypass occurred from March 21 through March 26. Daily collection for condition sampling began March 26 and continued until transportation began at 0700 hours on May 1. Collection for transport continued until 0700 hours on October 31. An estimated 8,454,280 juvenile salmonids were collected during the 2016 season compared to 2,703,657 in 2015. This is the highest number of fish collected at Lower Granite in the last five years (Table 2). Within each species group, the number collected and percent of the total collection was: 3,405,400 clipped yearling Chinook (40.3%), 1,104,727 unclipped yearling Chinook (13.1%), 262,101 clipped subyearling Chinook (3.1%), 512,157 unclipped subyearling Chinook (6.1%), 2,385,586 clipped steelhead (28.2%), 600,528 unclipped steelhead (7.1%), 28,700 clipped sockeye/kokanee (0.3%), 4,665 unclipped sockeye/kokanee (0.1%), and 150,416 Coho (1.8%). Daily collection and bypass numbers are provided in Appendix Table 1.

Table 2. Annual collection, bypass, transportation and mortality at LWG, 2012-2016.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
Collection										
2012	1,731,454	962,141	256,860	430,048	1,746,004	607,404	552	30,289	47,678	5,812,430
2013	1,362,720	502,542	173,989	319,566	1,058,688	386,214	27,395	15,377	48,078	3,894,569
2014	2,431,937	1,010,410	242,870	415,002	1,856,040	548,219	18,902	112,122	52,724	6,688,226
2015	902,798	247,380	188,552	500,858	674,434	152,383	8,350	2,572	26,330	2,703,657
2016	3,405,400	1,104,727	262,101	512,157	2,385,586	600,528	28,700	4,665	150,416	8,454,280
Bypass										
2012	1,024,069	678,689	57	17,163	1,119,949	283,526	0	1,430	8,165	3,133,048
2013	184,931	123,327	12,212	1,485	303,992	52,616	0	54	210	678,827
2014	895,654	605,721	3,013	8,991	920,228	156,884	0	59,640	3,722	2,653,853
2015	512,884	163,586	0	8,366	407,393	55,764	0	160	3,499	1,151,652
2016	2,263,433	842,120	596	31,941	1,564,652	311,329	258	655	33,079	5,048,063
Truck										
2012	2	109	145	14,349	6	35	0	207	29	14,882
2013	0	130	456	40,474	3	16	0	112	1	41,192
2014	5	4	486	20,690	0	2	2	64	2	21,255
2015	28	9	145	22,184	28	16	0	7	15	22,432
2016	13	107	784	21,607	2	3	0	11	2	22,529
Barge										
2012	706,147	282,894	255,814	396,998	625,847	323,764	552	28,535	39,447	2,659,998
2013	1,176,085	378,497	161,004	276,789	754,419	333,510	27,386	15,188	47,807	3,170,685
2014	1,535,098	404,342	238,763	383,774	935,573	391,283	18,889	51,966	48,991	4,008,679
2015	389,616	83,675	188,023	468,810	266,752	96,530	8,091	2,392	22,805	1,526,694
2016	1,140,972	262,241	260,025	457,228	820,839	289,171	27,868	3,981	117,278	3,379,603
Total Transport										
2012	706,149	283,003	255,959	411,347	625,853	323,799	552	28,742	39,476	2,674,880
2013	1,176,085	378,627	161,460	317,263	754,422	333,526	27,386	15,300	47,808	3,211,877
2014	1,535,103	404,346	239,249	404,464	935,573	391,285	18,891	52,030	48,993	4,029,934
2015	389,644	83,684	188,168	490,994	266,780	96,546	8,091	2,399	22,820	1,549,126
2016	1,140,985	262,348	260,809	478,835	820,841	289,174	27,868	3,992	117,280	3,402,132
2016 Mortalities										
Facility	982	259	696	1,381	93	25	574	18	57	4,085
NMFS	163	54	297	266	20	2	253	4	10	1,069
Res/Sac	381	41	196	6	58	10	5	0	0	697

[1] Includes Res/Sac fish and NOAA

By the end of May, 91.9% of the total yearly collection had arrived. The percent of total collection arriving by the end of June and the end of July was 98.8% and 99.6%, respectively. The remaining 0.4% of juvenile salmonids was collected during August, September, and October. During this time period 4.2% of the season subyearling Chinook was collected. The peak daily collection total and date for each species group were: clipped yearling Chinook 208,800 (April 26), unclipped yearling Chinook 99,046 (April 15), clipped subyearling Chinook 18,100 (June 10), unclipped subyearling Chinook 25,900 (June 10), clipped steelhead 197,000 (April 24), unclipped steelhead 52,000 (April 26), clipped sockeye 4,600 (May 20), unclipped sockeye 400 (May 9, 10, 11, 16, 17, 22, and 24), and Coho 21,200 (May 9). Total daily collection in 2016 peaked at 492,000 (April 26). Daily collection of all species combined versus total flow is shown in Figure 2. Peak collection date and daily collection total by species group are listed in Table 3.

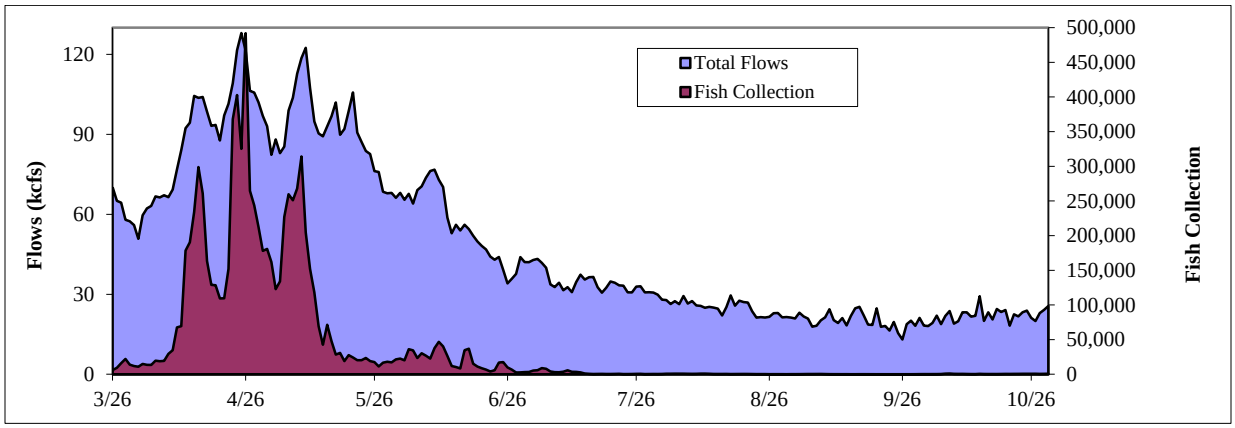

Figure 2. Fish collection and daily average flows at LWG, 2016.

Table 3. Annual peak collection days at LWG, 2012-2016.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
2012	26-Apr	26-Apr	4-Jun	5-Jun	26-Apr	26-Apr	9-May	18-May	18-May	26-Apr
	135,000	69,400	15,000	20,800	119,000	37,400	200	5,200	6,300	362,200
2013	8-May	13-May	9-Jun	9-Jun	13-May	13-May	16-May	17-May	14-May	13-May
	129,641	37,800	20,100	16,225	89,200	42,400	13,000	4,600	9,400	244,000
2014	6-May	24-Apr	3-Jun	3-Jun	27-Apr	8-May	18-May	5-May	19-May	6-May
	287,000	48,000	12,900	18,600	126,200	31,000	8,900	10,800	5,600	438,800
2015	25-Apr	25-Apr	5-Jun	5-Jun	26-Apr	7-May	19-May	9-May	7-May	26-Apr
	66,400	28,200	24,900	44,100	64,200	10,200	1,750	400	2,600	150,800
2016	26-Apr	15-Apr	10-Jun	10-Jun	24-Apr	26-Apr	20-May	9-May	9-May	26-Apr
	208,800	99,046	18,100	25,900	197,000	52,000	4,600	400	21,200	492,000

Adult Fallbacks

A total of 7,091 adult salmonids fell back through the juvenile bypass system and were bypassed from the separator between March 26 and October 31, 2016 (Table 4). The total includes: 1,318 adult Chinook salmon, 896 jack Chinook salmon, 2,118 clipped steelhead, 2,728 unclipped steelhead, 15 sockeye, and 16 Coho. Steelhead kelts are included in the total though they are not technically fallbacks. Fallbacks that went through the separator bars entered the raceways and were transported, were sent to the sample system, or bypassed to the river. These fish were not counted by the separator technician. The 2016 season had the second highest number of fallbacks in the last five years. Total season adult salmonid fallbacks does not include 724 late season fallbacks released between 0700 hours October 31 to 0930 hours November 17. These fallbacks included 376 adult Chinook, 204 jack Chinook, 143 steelhead, and 1 Coho. Mortalities during this time period included 1 adult Chinook, 1 jack Chinook, and 1 steelhead. Daily adult fallbacks and fallback mortalities can be found in Appendix Table 4.

Table 4. Annual totals of adult salmonids released from the separator at LWG (March 26-October 31), 2012-2016.

	Adult Chinook		Jack Chinook		Steelhead		Sockeye	Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip			Totals
2012	581	383	716	496	1,683	2,256	3	6	6,124
2013	1,160	963	1,058	768	1,242	1,058	5	11	6,265
2014	951	992	455	393	2,662	2,546	26	79	8,104
2015	558	483	290	201	1,180	1,472	16	5	4,205
2016	534	784	328	568	2,118	2,728	15	16	7,091
12-15 avg.	813	705	630	464	1,692	1,833	13	25	6,175

Steelhead were the most common adult salmonids species removed from the separator in 2016. April and May accounted for 74.5% of adult steelhead removed from the separator. The remaining 25.5% of steelhead fallbacks were predominantly removed from the separator in September and October. The total number of steelhead fallbacks removed from the separator include out migrating kelts. The majority of Chinook adults and jacks were removed from the separator during September and October (fall Chinook). Sockeye fallbacks were highest in July and Coho fallbacks were highest in October (Table 5).

Table 5. Monthly totals of adult salmonids released from the separator at LWG (March 26-October 31), 2016.

	Adult Chinook		Jack Chinook		Steelhead		Sockeye	Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip			Totals
April[1]	0	3	0	0	1,104	1,447	0	1	2,555
May	49	16	2	1	398	660	0	0	1,126
June	23	12	2	3	11	55	0	0	106
July	23	7	5	4	8	16	13	0	76
August	11	17	3	1	81	87	2	0	202
September	158	221	87	150	305	243	0	2	1,166
October	270	508	229	409	211	220	0	13	1,860
Totals	534	784	328	568	2,118	2,728	15	16	7,091

[1] Includes March 26-31

Adult salmonid condition was classified as good, fair, poor, or dead prior to being released from the separator (Table 6). Overall 91.0% of fallback condition was classified as good to fair. Condition ratings of adult salmonids examined were as follows: 5,190 good (73.2%), 1262 fair (17.8%), 533 poor (7.5%), and 106 mortalities (1.5%). Adult salmonid mortalities included: 3 unclipped Chinook, 71 clipped steelhead, and 32 unclipped steelhead. Adult Chinook had a higher percentage of good/fair fish (97.4%) than steelhead (87.6%).

Table 6. Condition of adult salmonids released from the separator at LWG (March 26-October 31), 2016.

	Adult Chinook		Jack Chinook		Steelhead		Sockeye	Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip			Totals
Good	483	695	321	554	1,230	1,877	15	15	5,190
Fair	38	68	3	13	534	605	0	1	1,262
Poor	13	18	4	1	283	214	0	0	533
Dead	0	3	0	0	71	32	0	0	106
Total	534	784	328	568	2,118	2,728	15	16	7,091

Sampling

Consistent with the 2016 Fish Operations Plan (FOP) Appendix B and guidance provided by the Technical Management Team (TMT), the juvenile fish transportation program allows for a variable start date, based on expected river flows. During years when the spring seasonal average river flow in the Snake River is expected to equal or exceed 65 kcfs, transport operations will begin on staggered start dates between April 21 and May 1 at Lower Granite, Little Goose, and Lower Monumental Dams. Prior to a dam's transport start date, all fish collected will be bypassed to the river. In years when the spring seasonal average river flow is expected to be below 65 kcfs, transport operations at Lower Granite Dam will start on April 1. This year TMT put out a system operational request (SOR) for transportation collection at Lower Granite, Little Goose, and Lower Monumental to begin at 0700 hours May 1. All fish sampled prior to transport were bypassed to the river with the exception of research fish.

Sampling is diverting and segregating groups of fish in a consistent fashion so that data collected from those segregated groups will accurately represent the sum total of the fish being collected in real time. Sampling is not the act of evaluating those groups. Lower Granite fish sampling began at 0700 hours March 26 and ended at 0700 hours October 31. A total of 220 daily samples were processed this season. The sample rate was set at 5% on March 26 and fluctuated throughout the season based on guidelines provided by the Fish Passage Center (FPC) according to daily fish numbers and to accommodate research needs. During 2016 the smolt monitoring staff sampled 85,493 smolts or 1.0% of the total collection compared to 52,359 smolts (1.9%) in 2015. This is the lowest percent of juvenile salmonids sampled in the last five years (Table 7).

Table 7. Annual percentage of smolts sampled at LWG, 2012-2016.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
2012	0.8	0.9	3.8	10.4	0.8	0.9	1.4	2.1	1.2	1.7
2013	1.1	1.3	5.8	15.4	1.3	1.2	0.6	1.6	0.8	2.6
2014	0.6	0.8	2.9	8.5	0.6	0.6	0.8	1.1	0.5	1.2
2015	0.9	1.0	2.1	5.9	0.9	1.1	1.7	1.8	1.2	1.9
2016	0.6	0.6	2.2	6.9	0.6	0.6	1.2	1.0	0.6	1.0
12-15 Ave.	0.8	1.0	3.6	9.6	0.8	0.9	0.8	1.3	0.9	1.7

The sample rate was raised above FPC guidelines June 6 to collect an additional 300 subyearling Chinook needed for USGS/USFWS PIT tag detection efficiency evaluation. The total number of smolts sampled in 2016 by species and percent of each species in the total number sampled included: 18,866 clipped yearling Chinook salmon (22.1%), 6,888 unclipped yearling Chinook (8.1%), 5,876 clipped subyearling Chinook salmon (6.9%), 35,502 unclipped subyearling Chinook salmon (41.5%), 13,424 clipped steelhead (15.7%), 3,686 unclipped steelhead (4.3%), 350 clipped sockeye salmon (0.4%), 48 unclipped sockeye salmon/kokanee (<0.1%), and 853 Coho salmon (1.0%) (Table 8).

Table 8. Weekly sample totals at LWG, 2016.

Week	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
Ending	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
31-Mar	922	633	0	64	101	38	0	0	5	1,763
7-Apr	873	511	0	39	552	231	0	1	3	2,210
14-Apr	2,002	1,402	0	35	1,095	429	0	0	7	4,970
21-Apr	2,195	1,404	0	61	1,963	358	0	1	15	5,997
28-Apr	5,208	991	0	33	4,266	637	0	1	104	11,240
5-May	3,468	579	0	29	1,537	315	0	2	153	6,083
12-May	3,857	820	0	19	2,056	702	2	8	374	7,838
19-May	174	174	0	38	763	398	31	5	58	1,641
26-May	106	150	171	185	509	286	223	11	58	1,699
2-Jun	38	79	814	1,014	285	157	94	4	59	2,544
9-Jun	8	27	1,131	1,388	130	85	0	0	9	2,778
16-Jun	2	20	697	1,218	26	20	0	0	2	1,985
23-Jun	0	8	439	907	9	1	0	0	1	1,365
30-Jun	0	4	364	1,096	7	3	0	0	0	1,474
7-Jul	0	0	270	1,070	6	3	0	0	1	1,350
14-Jul	0	2	122	1,021	7	1	0	0	0	1,153
21-Jul	0	1	182	1,027	38	3	0	0	0	1,251
28-Jul	0	1	208	1,238	33	6	0	0	1	1,487
4-Aug	0	2	284	1,629	14	2	0	0	1	1,932
11-Aug	0	2	348	2,326	7	0	0	0	0	2,683
18-Aug	0	0	177	1,850	6	0	0	0	0	2,033
25-Aug	0	1	107	2,002	4	1	0	0	0	2,115
1-Sep	0	0	31	731	1	0	0	0	1	764
8-Sep	0	0	115	2,051	1	1	0	0	0	2,168
15-Sep	1	1	21	547	1	0	0	1	0	572
22-Sep	1	0	6	282	2	2	0	1	0	294
29-Sep	5	0	6	121	0	0	0	1	0	133
6-Oct	0	8	62	2,128	2	0	0	4	0	2,204
13-Oct	2	6	119	3,462	2	1	0	3	1	3,596
20-Oct	3	6	90	2,725	0	1	0	2	0	2,827
27-Oct	1	30	84	3,784	0	3	0	3	0	3,905
31-Oct	0	26	28	1,382	1	2	0	0	0	1,439
Total	18,866	6,888	5,876	35,502	13,424	3,686	350	48	853	85,493

Transportation

An estimated 3,402,132 juvenile salmonids (40.2% of fish collected) were transported from Lower Granite Dam in 2016. The number of fish and the percentage of collection that was transported of each species group included: 1,140,985 clipped yearling Chinook (33.5%), 262,348 unclipped yearling Chinook (23.7%), 260,809 clipped subyearling Chinook (99.5%), 478,835 unclipped subyearling Chinook (93.5%), 820,841 clipped steelhead (34.4%), 289,174 unclipped steelhead (48.2%), 27,868 clipped sockeye (97.1%), 3,992 unclipped sockeye/kokanee (85.6%) and 117,280 Coho (78.0%). National Marine Fisheries Service (NMFS) study to compare SAR's of transported versus in-river yearling Chinook transport did not occur in 2016. Daily truck and barge transportation numbers are provided in Appendix Table 2.

Collection for barge transport occurred May 2 through August 15. Every day barging operations occurred May 2 through May 25. Every-other-day barging occurred May 26 through August 15. Lower Granite transported an estimated 98.8% of the total juvenile fish collection (May 2-August 15) by barge. The number of fish barged and the percent barged of the total transport collection season (May 2-October 31) for each species group included: 1,140,972 clipped yearling Chinook salmon (33.5%), 262,241 unclipped yearling Chinook salmon (23.7%), 260,025 clipped subyearling Chinook salmon (99.2%), 457,228 unclipped subyearling Chinook salmon (89.3%), 820,839 clipped steelhead (34.4%), 289,171 unclipped steelhead (48.2%), 27,868 clipped sockeye salmon (97.1%), 3,981 unclipped sockeye salmon/kokanee (85.3%), and 117,278 Coho salmon (78.0%). Point Four oxygen monitoring systems were used on 4000 and 8000 series barges this season. YSI portable oxygen monitoring units continue to be kept on barges as backup systems. Fish evacuation plungers were replaced on 8000 and 200 series barges during the 2014-2016 maintenance seasons. Plunger installation on 4000 series was completed during the maintenance season. Generators and air compressors and generators were upgraded on six of the eight barges 2015-2016 maintenance season. Compressor and generator upgrades installed on 8107 and 8108 during the maintenance season.

There was no early season trucking from Lower Granite this season. Juvenile fish were trucked by midi-tanker or semi-truck from August 16 through October 31. All truck trips were made with the 300 gallon pickup mounted tank with the exception of October 8, 26, 28, and 30 when fish pounds exceeded the midi-truck tanks capacity and the 3500 gallon semi-truck trailer was used. The COE transported 22,529 smolts by truck which is 0.3% of the total juvenile collection. The number of smolts trucked by species included: 13 clipped yearling Chinook, 107 unclipped yearling Chinook, 784 clipped subyearling Chinook, 21,607 unclipped subyearling Chinook, 2 clipped steelhead, 3 unclipped steelhead, 11 unclipped sockeye/kokanee, and 2 Coho. Water temperatures and oxygen levels were monitored to ensure acceptable levels. When needed raw river water or raw river water ice is added to the midi-tanker to keep the water temperature at an acceptable level for the trip to Bonneville. This was not required in 2016. Very little tempering was required at the release site.

Bypass

The collection facility operated in secondary bypass mode March 21 through May 1 and October 31 through November 17. Juvenile bypass was estimated at 5,048,063 smolts or 59.7% of the total 2016 season facility collection with 5,012,032 of these being bypassed between March 26

and May 1. During the May 2 through October 31 collection for transport season 36,031 smolts were bypassed. The total number bypassed during collection and percent of each species collection included 2,263,433 clipped yearling Chinook (66.5%), 842,120 unclipped yearling Chinook salmon (76.2%), 596 clipped subyearling Chinook salmon (0.2%), 31,941 unclipped subyearling Chinook salmon (6.2%), 1,564,652 clipped steelhead (65.6%), 311,329 unclipped steelhead (51.8%), 258 clipped sockeye salmon (0.9%), 655 unclipped sockeye salmon/kokanee (14.0%), and 33,079 coho salmon (22.0%). Facility bypass estimates include all fish bypassed to the tailrace during secondary bypass operation, collection for transport, GBT prior to collection, and fish collected and provided for research needs. Fish provided for research needs are recoded as bypassed including research mortalities. There were 697 research mortalities reported during 2016 included 381 unclipped yearling Chinook salmon, 41 unclipped yearling Chinook salmon, 196 clipped subyearling Chinook salmon, 6 unclipped subyearling Chinook salmon, 58 clipped steelhead, 10 unclipped steelhead, and 5 clipped sockeye salmon. An additional 1,069 mortalities were removed from the east raceways that hold NMFS transport research fish including 163 clipped yearling Chinook salmon, 54 unclipped yearling Chinook salmon, 297 clipped subyearling Chinook salmon, 266 unclipped subyearling Chinook salmon, 20 clipped steelhead, 2 unclipped steelhead, 253 clipped sockeye salmon, 4 unclipped sockeye salmon/kokanee, and 10 coho salmon. East raceway mortalities are included in Lower Granite facility mortality when raceways were also used for standard transport collection in addition to NMFS studies. This does not include fish bypassed by the PIT tag diversion system. Juvenile salmonids were bypassed rather than transported for the following purposes this season.

1. Secondary bypass occurred from March 21 through May 1. Sampling occurred March 26 through May 1 for fish condition monitoring (COE). Fish sampled during this period are included in the facility bypass total.
2. GBT inspections during the period of April 7 through May 1 accounted for a total of 402 fish bypassed. Within each species group the number bypassed was: 175 clipped yearling Chinook salmon, 70 unclipped yearling Chinook salmon, 133 clipped steelhead, and 24 unclipped steelhead.
3. As part of research projects 130,919 fish were collected and bypassed (See; Research Section). There were 1069 fish mortalities removed from the east raceways used exclusively for research that were recorded as bypassed. These fish are included in the bypass numbers of this report.
4. The PTAGIS database revealed that 185,368 PIT-tagged fish of different species groups were bypassed through the PIT tag system. These fish are not included in the facility bypass total.

According to the PTAGIS database, 185,368 PIT-tagged fish were detected at LWG in 2016. Of these, 135,659 (73.2%) were bypassed to the LWG tailrace through the PIT-tag diversion system, 47,290 (25.5%) were diverted to the raceways to be transported, 1,325 (0.7%) were diverted to the sample tank, and 1,094 (0.6%) were not detected at any of the bypass, raceway, or sample exit monitors, and their disposition was unknown. Before May 1, all PIT-tagged fish were bypassed to the river.

Incidental Species

Non-target fish species that were too large to pass through the separator bars were recorded and

bypassed through the adult release flume at the separator. Those small enough to pass through the separator bars were either sampled and bypassed, or held in raceways and transported with juvenile salmonids. Sample fish from each incidental species were counted and their total numbers were calculated using the sample rate. These numbers were then added with separator counts of the same group to estimate the total collection for each species. An estimated 89,569 non-salmonid incidental fish were collected at the fish facility during the March 26 to October 31 passage period (Table 9). This is about twice as many incidental species collected than 2015 season (44,554). Pacific lamprey macrophthalmia were the most abundant incidental species with an estimated 27,521 collected compared to 785 in 2015. Siberian prawns were the second most abundant incidental species with an estimated 25,848 collected compared to 20,979 in 2015. Siberian prawns were euthanized rather than released to the LWG tailrace per Washington Department of Fish and Wildlife (WDFW) instructions until August 15 when WDFW directed euthanized Siberian prawns be disposed of in landfills instead of the river. Sand rollers were the third most abundant incidental species with 10,599 collected compared to 4,516 in 2015. Peamouth were the fourth most abundant incidental species with 5,467 collected compared to 3,965 collected in 2015.

Table 9. Estimated collection of incidental fish species at LWG, 2016.

Common Name	*Scientific Name*	Separator	Expanded Sample	Total Collection[1]
American Shad (Adult)	*Alosa sapidissima*	1,275	1,054	2,329
American Shad (Juvenile)	*A. sapidissima*		1,576	1,576
Banded Killifish	*Fundulus diaphanus*		4	4
Bass, Largemouth	*Micropterus salmoides*			
Bass, Smallmouth	*M. dolomieui*	8	4,811	4,819
Bullhead (misc.)	*Amierus sp.*		61	61
Catfish, Channel	*Ictalurus punctatus*	32	237	269
Catfish, Flathead	*Pylodictis olivaris*			
Chiselmouth	*Acrocheilus alutaceus*	2	200	202
Common Carp	*Cyprinus carpio*	22	355	377
Crappie (misc)	*Pomoxis sp.*	29	2,130	2,159
Dace, Longnose	*Rhinichthys cataractae*		6	6
Dace, Speckled	*R. osculus*			
Kokanee	*Oncorhynchus nerka*		51	51
Northern Pikeminnow	*Ptychocheilus oregonensis*	3	8	11
Pacific Lamprey (Adult)	*Entosphenus tridentatus*	7	17	24
Pacific Lamprey (Ammocoete)	*E. tridentatus*		3,581	3,581
Pacific Lamprey (Macrophthalmia)	*E. tridentatus*		27,521	27,521
Peamouth	*Mylocheilus caurinus*	3	5,464	5,467
Redside Shiner	*Richardsonius balteatus*			
Sand Roller	*Percopsis transmontana*		10,599	10,599
Sculpin	*Cottus sp.*		55	55
Siberian Prawn	*Exopalaemon modestus*		25,848	25,848
Sucker (misc.)	*Catostomus sp.*	619	821	1,440
Sunfish (misc.)	*Lepomis sp.*		2,582	2,582
Trout, Bull	*Salvelinus Malma*	1	3	4
Trout, Cutthroat	*Oncorhynchus clarkii*			
Trout, Rainbow	*O. mykiss*		126	126
Walleye	*Stizostedion vitreum*	3		3
Warmouth	*Lepomis gulosis*		55	55
White Sturgeon	*Acipenser transmontanus*	1		1
Whitefish	*Prosopium sp.*	5	389	394
Yellow Perch	*Perca flavescens*	4	1	5
Total		2,014	87,555	89,569

[1]Separator count plus expanded sample count equals estimated total facility collect.

Fish Condition

Descaling

Standard descaling criteria identifies a fish with 20% or greater scale loss on one side of its body. If scale loss is less than 20% on one side the fish body it is not considered descaled. PSMFC smolt monitoring personnel collected descaling data from all live sample fish (full sample) rather than just a portion (subsample).

The descaling rate for all fish sampled in 2016 was 1.4% which is lower than the 2012-2015 average of 2.3%. The annual descaling rate by species group was: clipped yearling Chinook 0.9%, unclipped yearling Chinook 0.5%, clipped subyearling Chinook 1.0%, unclipped subyearling Chinook 2.0%, clipped steelhead 1.1%, unclipped steelhead 1.3%, clipped sockeye/kokanee 1.2%, unclipped sockeye/kokanee 2.2%, and Coho 1.1%. Annual descaling rates are summarized in Table 10.

Table 10. Annual full-sample descaling rates (>20%) by species at LWG, 2012-2016.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
2012	2.8	0.8	1.9	2.9	3.0	2.2	0.0	5.4	1.1	2.6
2013	3.1	1.6	2.0	3.0	2.6	2.5	1.9	7.4	2.7	2.7
2014	0.9	0.6	0.7	1.8	1.3	1.2	0.0	2.6	1.0	1.3
2015	1.6	1.2	0.7	2.6	2.2	3.3	5.1	0.0	0.9	2.2
2016	0.9	0.5	1.0	2.0	1.1	1.3	1.2	2.2	1.1	1.4
12-15 Ave.	2.2	1.0	1.5	2.6	2.3	2.2	2.2	3.9	1.4	2.3

The highest weekly descaling rate for all species combined was 5.4% for the week ending October 6. The lowest descaling rates were 0.14% the week June 30 followed by 0.29% the week of June 9, and 0.35% the week of July 14 (Table 11). As has been observed in the past, descaling rates increased as sample size decreased in late August, September, and October. Increased water temperatures low river flows are factors that influence increased descaling in late summer. Increased descaling during October are likely due to the pulse in debris in the juvenile collection facility when forebay elevation is raised to 736-737 feet (msl). Clipped sockeye collected at the juvenile fish facility in late May and early June exhibited descaling, caudal fin rot, and fungus. IDFG pathology examined the fish and determined these maladies were due to hatchery related fish transport and release conditions not Lower Granite operation. This probably led to higher descaling rates on clipped sockeye observed this season. Daily descaling rates are provided in Appendix, Table 3.

Table 11. Weekly descaling rates in percent for fish sampled at LWG, 2016.

Week Ending	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	Total
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	
31-Mar	0.76%	0.32%	--	--	0.99%	0.00%	--	--	0.00%	0.59%
7-Apr	0.12%	0.59%	--	--	0.54%	0.43%	--	0.00%	0.00%	0.37%
14-Apr	0.65%	0.29%	--	--	0.46%	0.70%	--	--	0.00%	0.51%
21-Apr	0.91%	0.57%	--	--	0.77%	0.56%	--	0.00%	0.00%	0.76%
28-Apr	0.85%	0.61%	--	--	0.59%	0.79%	--	0.00%	0.00%	0.72%
5-May	0.78%	0.35%	--	0.00%	0.91%	0.96%	--	0.00%	1.31%	0.80%
12-May	1.54%	0.37%	--	0.00%	1.95%	2.28%	0.00%	0.00%	0.53%	1.54%
19-May	0.00%	1.72%	--	3.70%	2.62%	1.26%	0.00%	0.00%	5.17%	1.96%
26-May	4.72%	0.00%	0.00%	0.60%	2.17%	2.46%	1.36%	0.00%	0.00%	1.61%
2-Jun	0.00%	0.00%	0.37%	0.31%	3.51%	2.55%	1.25%	0.00%	0.00%	0.84%
9-Jun	0.00%	0.00%	0.18%	0.07%	0.77%	3.53%	--	--	11.11%	0.29%
16-Jun	0.00%	0.00%	0.58%	0.58%	0.00%	0.00%	--	--	0.00%	0.56%
23-Jun	--	0.00%	0.00%	0.45%	0.00%	0.00%	--	--	100.00%	0.37%
30-Jun	--	0.00%	0.28%	0.09%	0.00%	0.00%	--	--	--	0.14%
7-Jul	--	--	1.87%	0.47%	16.67%	0.00%	--	--	0.00%	0.82%
14-Jul	--	0.00%	0.83%	0.30%	0.00%	0.00%	--	--	--	0.35%
21-Jul	--	0.00%	1.67%	0.79%	2.70%	0.00%	--	--	--	0.97%
28-Jul	--	0.00%	2.45%	1.14%	12.12%	0.00%	--	--	0.00%	1.56%
4-Aug	--	0.00%	3.58%	2.97%	7.14%	0.00%	--	--	0.00%	3.08%
11-Aug	--	0.00%	0.29%	1.26%	14.29%	--	--	--	--	1.17%
18-Aug	--	--	2.87%	1.53%	0.00%	--	--	--	--	1.64%
25-Aug	--	0.00%	0.95%	1.99%	0.00%	0.00%	--	--	--	1.93%
1-Sep	--	--	0.00%	3.22%	0.00%	--	--	--	0.00%	3.08%
8-Sep	--	--	2.68%	3.12%	0.00%	0.00%	--	--	--	3.10%
15-Sep	0.00%	0.00%	0.00%	4.31%	0.00%	--	--	--	--	4.12%
22-Sep	0.00%	--	0.00%	2.52%	0.00%	0.00%	--	0.00%	--	2.41%
29-Sep	0.00%	--	0.00%	5.00%	--	--	--	0.00%	--	4.55%
6-Oct	--	0.00%	3.23%	5.49%	0.00%	--	--	0.00%	--	5.39%
13-Oct	50.00%	0.00%	3.39%	2.14%	0.00%	0.00%	--	0.00%	0.00%	2.20%
20-Oct	0.00%	0.00%	6.67%	2.48%	--	0.00%	--	0.00%	--	2.60%
27-Oct	0.00%	0.00%	4.76%	2.53%	--	0.00%	--	33.33%	--	2.58%
31-Oct	--	0.00%	0.00%	3.37%	0.00%	0.00%	--	--	--	3.23%
# Descaled	177	31	60	709	153	49	4	1	9	1,193
# Sampled	18,794	6,863	5,820	34,715	13,393	3,680	334	45	852	84,496
% Descaled	0.94%	0.45%	1.03%	2.04%	1.14%	1.33%	1.20%	2.22%	1.06%	1.41%

Injuries and Disease

Injury data was gathered from a sub sample of 100 of the dominant species and not more than 100 each of the non-dominant species. There were 26,201 fish examined for injury and disease in 2016. The body injuries associated with dam passage that were recorded this season included a generic body injury category and a generic fin injury category. Head injuries that were associated with dam passage include generic head injuries, eye injuries, operculum injuries and "pop" or bulging eye. Fish were also examined for external symptoms of fungus, columnaris, bacterial kidney disease, and parasites.

Body injuries were observed on 17.7% of the smolts examined in the detailed subsample. Blood pooling is defined as the vasodilatation of the capillaries in fins (also referred to as fin pinkness). It seems to be a symptom of anesthetic use during higher water temperatures and is mostly found on subyearling Chinook. Fin hemorrhaging is the discharge of blood outside the body and is a sign of trauma. Of the smolts examined from the sample that had body injuries, the most common symptom observed in 2016 was blood pooling (37.3%) followed by general fin injury (29.6%), and discolored fin (26.5%). Unclipped subyearling Chinook exhibited the highest percent of body injuries at 25.1% (3,066 of 12,239 fish examined) followed by clipped subyearling Chinook at 20.2% (482 of 2,389 fish examined).

Head injuries were recorded on 0.4% of the smolts examined in the detailed subsample. Clipped yearling Chinook salmon had the highest incidence of head injury at 0.72% (25 of 3,449 examined), followed by clipped steelhead at 0.70% (25 of 3,553 examined). Eye hemorrhage comprised the majority of observed head injuries at 31.6%, followed by injury to the operculum at 28.1%, and general head injuries at 17.5%.

Injuries associated with predators include wounds inflicted by other fish, birds, and lamprey. Predator wounds were observed on 1.0% of the smolts examined. Predator marks caused by birds, characterized by a distinct V-shaped descaling pattern on both sides of a fish were the most common predator mark at 61.6% compared to 31.4% caused by fish and 7.1% caused by lamprey. Predator marks were highest on clipped sockeye at 3.5% (9 of 258 fish examined), clipped steelhead at 2.0% (70 of 3,553 fish examined), and unclipped steelhead at 1.3% (21 of 1,609 fish examined).

External symptoms of disease were observed on 5.8% of the smolts examined in the detailed subsample compared to 3.6% in 2015, 3.4% in 2014, 4.2% in 2013, and 4.4% in 2012. Symptoms of disease were most common on clipped sockeye (20.5%). Of the fish afflicted Columnaris comprised the majority of disease symptoms (39.9%), followed by fin hemorrhages (38.4%), and fungus (10.8%).

Fungus was found on 0.6% of all fish examined and on all species and rearing types. Fungus was the primary disease afflicting clipped sockeye. The occurrence of fungus is generally seen early in the season while the water is still relatively cold. Smolt Monitoring Program and Corps biological staff observed clipped sockeye salmon arriving in poor condition at the fish facility. Idaho Department of Fish and Game (IDFG) pathologist took samples from fish at Lower Granite and determined the poor condition of clipped sockeye salmon was due to hatchery release conditions and not related to dam passage.

Columnaris is caused by the bacterium *Flavobacterium columnare* that becomes more virulent when water temperatures exceed 60º F. Therefore summer and subyearling Chinook migrants are more susceptible to infection. Columnaris can be recognized by the presence of yellowish lesions on the belly, damage to the gills, pelvic fins, snout, and caudal fins. SMP at Lower Granite only classify fish as being infected with columnaris if there is some tissue loss on the snout or body (fish with only red mouth edges are not classified as infected). Columnaris was identified at Lower Granite in 1996 and symptoms in sample fish have been recorded since 1999. Typically the first incidence of columnaris is observed in July after the majority of subyearling

Chinook have passed the project. Symptoms of columnaris were first observed July 18 with the highest rate of infection occurring in September. The 2016 columnaris infection rate for subyearling Chinook was 2.2% (905 of 40,433) compared to 0.8% (276 of 32,815) in 2015, 1.8% (736 of 41,386) in 2014, 1.4% (796 of 58,510) in 2013, and 2.1% (1,119 of 53,799) in 2012.

Mortality

Facility mortality includes fish removed from the barges or trucks before departure, sample mortalities, recovery tank mortalities, separator mortalities and raceway mortalities, not including the east raceways when used by NMFS for research. Mortalities removed from east raceways used exclusively for NMFS transportation and survival studies were included in bypassed fish and not considered facility mortalities during 2016. Annual facility mortality for all groups combined was 0.05% in 2016 and totaled 4,085 fish (Table 12). All species group mortality rates were lower than those observed for the 2012-2015 average except for clipped subyearling Chinook, clipped sockeye, and unclipped sockeye. Within each species group, the number of facility mortalities and percent of those collected in that group was: 982 clipped yearling Chinook (0.03%), 259 unclipped yearling Chinook (0.02%), 696 clipped subyearling Chinook (0.27%), 1,381 unclipped subyearling Chinook (0.27%), 93 clipped steelhead (<0.01%), 25 unclipped steelhead (< 0.01%), 574 clipped sockeye (2.00%), 18 unclipped sockeye/kokanee (0.39%), and 57 coho (0.04%). IDFG pathologists sampled clipped sockeye May 26 and determine the higher than average mortality rate was due to poor fish condition at release not Lower Granite operations.

Table 12. Annual facility mortality in percent by species group at LWG, 2012-2016.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
2012	0.07	0.04	0.33	0.36	0.01	0.01	0.00	0.39	0.08	0.08
2013	0.12	0.11	0.16	0.26	0.02	0.02	0.03	0.15	0.12	0.10
2014	0.05	0.03	0.25	0.37	0.01	0.01	0.06	0.40	0.02	0.06
2015	0.03	0.04	0.20	0.29	0.04	0.04	3.03	0.47	0.04	0.10
2016	0.03	0.02	0.27	0.27	<0.01	<0.01	2.00	0.39	0.04	0.05
12-15 Ave.	0.07	0.05	0.25	0.32	0.01	0.01	0.49	0.38	0.07	0.08

Weekly facility mortality rates were low during April and May, increased during June and July but did not increase over 1% until the week ending August 18. Mortality rate increased as the sample size decreased, water temperatures increased, and river flows decreased in late August. The week ending September 15 had the maximum weekly mortality rate of 2.45%. Weekly mortality rates decreased to the end of the season (Table 13).

Table 13. Weekly facility mortality in percent by species group at LWG, 2016.

Week Ending	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	Total
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	
31-Mar	0.00%	0.01%	--	0.00%	0.00%	0.00%	--	--	0.00%	0.01%
7-Apr	0.02%	0.01%	--	0.00%	0.00%	0.00%	--	0.00%	0.00%	0.01%
14-Apr	0.00%	0.02%	--	0.63%	0.00%	0.00%	--	--	0.00%	0.01%
21-Apr	0.00%	0.00%	--	0.06%	0.00%	0.00%	--	0.00%	0.00%	0.00%
28-Apr	0.00%	0.00%	--	0.05%	0.00%	0.00%	--	0.00%	0.00%	0.00%
5-May	0.03%	0.03%	--	0.16%	0.00%	0.00%	--	0.75%	0.03%	0.02%
12-May	0.09%	0.08%	--	0.32%	0.01%	0.00%	0.00%	0.31%	0.05%	0.06%
19-May	0.05%	0.07%	--	0.19%	0.00%	0.00%	0.03%	0.56%	0.03%	0.02%
26-May	0.14%	0.06%	0.07%	0.10%	0.01%	0.02%	0.95%	0.18%	0.07%	0.16%
2-Jun	0.00%	0.05%	0.19%	0.14%	0.03%	0.04%	8.21%	0.00%	0.00%	0.43%
9-Jun	0.00%	0.04%	0.24%	0.18%	0.04%	0.02%	--	--	0.00%	0.19%
16-Jun	0.67%	0.00%	0.39%	0.31%	0.22%	0.12%	--	--	0.00%	0.33%
23-Jun	--	0.00%	0.21%	0.22%	0.29%	0.00%	--	--	0.00%	0.22%
30-Jun	--	0.00%	0.20%	0.13%	0.31%	0.00%	--	--	--	0.15%
7-Jul	--	--	0.29%	0.18%	1.45%	0.00%	--	--	0.00%	0.20%
14-Jul	--	0.00%	0.29%	0.20%	0.71%	5.00%	--	--	--	0.22%
21-Jul	--	0.00%	0.64%	0.98%	1.11%	16.67%	--	--	--	0.97%
28-Jul	--	0.00%	0.96%	0.85%	0.00%	0.00%	--	--	50.00%	0.87%
4-Aug	--	0.00%	1.06%	0.43%	0.00%	0.00%	--	--	0.00%	0.52%
11-Aug	--	0.00%	0.57%	0.80%	0.00%	--	--	--	--	0.76%
18-Aug	--	--	1.12%	0.95%	11.11%	--	--	--	--	1.00%
25-Aug	--	0.00%	1.87%	1.90%	0.00%	0.00%	--	--	--	1.89%
1-Sep	--	--	3.23%	2.33%	0.00%	--	--	--	0.00%	2.36%
8-Sep	--	--	2.61%	1.66%	0.00%	0.00%	--	--	--	1.71%
15-Sep	0.00%	0.00%	0.00%	2.38%	0.00%	--	--	100.00%	--	2.45%
22-Sep	0.00%	--	0.00%	1.42%	0.00%	0.00%	--	0.00%	--	1.36%
29-Sep	0.00%	--	0.00%	0.83%	--	--	--	0.00%	--	0.75%
6-Oct	--	0.00%	0.00%	2.40%	0.00%	--	--	25.00%	--	2.36%
13-Oct	0.00%	0.00%	0.84%	1.59%	0.00%	0.00%	--	33.33%	0.00%	1.59%
20-Oct	33.33%	16.67%	0.00%	0.84%	--	0.00%	--	0.00%	--	0.88%
27-Oct	0.00%	0.00%	0.00%	0.73%	--	0.00%	--	0.00%	--	0.70%
31-Oct	--	1.92%	0.00%	0.69%	0.00%	0.00%	--	--	--	0.69%
# morts	982	259	696	1,381	93	25	574	18	57	4,085
# collected	3,405,400	1,104,727	262,101	512,157	2,385,586	600,528	28,700	4,665	150,416	8,454,280
% mortality	0.03%	0.02%	0.27%	0.27%	0.00%	0.00%	2.00%	0.39%	0.04%	0.05%

Sample mortalities include dead fish removed from the sample tank prior to sampling and those from the sorting trough in the sample lab. Annual sample mortality for all groups combined was 0.74% in 2016 (Table 14) and totaled 629 fish. The number of sample mortalities and mortality rate by species group was: 72 clipped yearling Chinook (0.38%), 25 unclipped yearling Chinook (0.36%), 56 clipped subyearling Chinook (0.95%), 419 unclipped subyearling Chinook (1.18%), 31 clipped steelhead (0.23%), 6 unclipped steelhead (0.16%), 16 clipped sockeye/kokanee (4.57%), 3 unclipped sockeye/kokanee (6.25%), and 1 Coho (0.12%). Sample mortality for all groups combined has ranged from a high of 1.05% in 2014 to a low of 0.74% in 2016.

Table 14. Annual sample mortality by species group in percent at LWG, 2010-2016.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
2012	0.91	0.72	1.08	1.00	0.36	0.28	0.00	8.51	0.72	0.89
2013	0.74	0.90	1.88	1.12	0.22	0.22	1.27	6.15	0.81	0.97
2014	0.61	0.68	1.38	1.41	0.40	0.46	0.00	4.06	0.35	1.05
2015	0.40	0.52	0.70	1.13	0.48	0.23	4.17	4.35	0.31	0.86
2016	0.38	0.36	0.95	1.18	0.23	0.16	4.57	6.25	0.12	0.74
12-15 ave	0.69	0.73	1.36	1.15	0.34	0.30	1.74	5.63	0.59	0.95

Barge mortalities are salmonids removed from barge holds after the barges depart LWG. The total number of smolts barged in 2016 included: 3,379,603 fish from LWG, 2,409,707 from LGS, and 2,751,127 fish from LMN. The barge mortality rate of 0.03% (2,608 of 8,539,837) is lower than observed in the last five years (Table 16). Barge mortalities by species group included: 591 clipped yearling Chinook, 198 unclipped yearling Chinook, 596 clipped subyearling Chinook, 343 unclipped subyearling Chinook, 323 clipped steelhead, 134 unclipped steelhead, 338 clipped sockeye, 4 unclipped sockeye/kokanee, 51 Coho, and 30 salmonids that could not be identified to species during release (Table 15). Increased mortality of sockeye was the result of poor fish health related to hatchery transport and release conditions and not related to operations at Lower Granite or downstream collection facilities or barge transport conditions.

Table 15. Total barge mortalities from LWG 2012-2016.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	Unknown	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Others	Total
2012	1,600	364	250	371	327	137	7	22	61	30	3,169
2013	2,410	576	123	149	637	225	24	1	137	0	4,282
2014	1,562	427	217	404	476	159	4	328	100	0	3,677
2015	563	247	719	1462	599	258	84	19	13	1,720	5,684
2016	591	198	596	343	323	134	338	4	51	30	2,608
12-15 ave	1,534	404	327	596	510	195	30	92	78	437	4,203

Lower Granite truck transport fish mortality rate in 2016 was 0.08% (18 of 22,529) which is the lowest truck mortality rate in the last five years (Table 16). The truck mortality number and percent by species included: 3 clipped subyearling Chinook (0.38%) and 15 unclipped subyearling Chinook (0.07%). All trips were made with the 300 gallon pickup truck mounted tank except October 8, 26, and 30 when fish densities exceeded the midi tank capacity and the 3500 gallon semi-truck was used.

Table 16. Annual percent truck mortality at LWG, 2012-2016.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
2012	0.00	0.00	0.00	0.20	0.00	0.00	--	4.35	0.00	0.25
2013	--	0.77	0.00	0.23	0.00	0.00	--	3.57	0.00	0.24
2014	0.00	0.00	0.00	0.18	--	0.00	0.00	1.56	0.00	0.18
2015	0.00	0.00	0.69	0.14	0.00	0.00	--	0.00	0.00	0.14
2016	0.00	0.00	0.38	0.07	0.00	0.00	--	0.00	0.00	0.08
12-15 Ave.	0.00	0.40	0.08	0.19	0.00	0.00	0.00	3.59	0.00	0.21

--no fish trucked

Gas Bubble Trauma Monitoring (PSMFC)

Juvenile salmonids were sampled for GBT from April 7 through June 9 in 2016. PSMFC personnel examined up to 100 clipped and unclipped yearling Chinook and steelhead each week for evidence of bubbles in paired and unpaired fins, and in the eye, as per Fish Passage Center GBT protocols. This season 960 fish were sampled for GBT: 266 clipped yearling Chinook, 83 unclipped yearling Chinook, 455 clipped steelhead, and 156 unclipped steelhead. During GBT sampling 13 PIT-tagged smolts were handled, not examined and returned to the separator including: 3 clipped yearling Chinook, 1 unclipped yearling Chinook, 7 clipped steelhead, and 2 unclipped steelhead. An additional 40 fish were handled and released into the separator including 3 clipped yearling Chinook, 6 clipped subyearling Chinook, 4 unclipped subyearling Chinook, 3 clipped steelhead, 14 clipped sockeye, and 10 Coho. Prior to May 1, smolts examined for GBT were released in the sample recovery tank and bypassed. Smolts examined for GBT after May 1 were returned to the raceways and transported. A total of 402 smolts were bypassed including: 175 clipped yearling Chinook, 70 unclipped yearling Chinook, 133 clipped steelhead, and 24 unclipped steelhead. A total of 558 smolts were transported including: 91 clipped yearling Chinook, 13 unclipped yearling Chinook, 322 clipped steelhead, and 132 unclipped steelhead. No symptoms of GBT were observed this season.

Gatewell Dipping

In 2012 three John Day ESBSs were used to replace LWG damaged fish screens. Gatewell slot sampling was performed by PSMFS and Corps personnel in 2013 and 2015 to compare screen performance and descaling rates in C and B gatewell slots, respectively. There was no difference in descaling rates between John Day and LWG screens. Sampling to evaluate John day screens in A gatewell slots was performed March 28, 29, and 31 with a John Day screen in gatewell slot 3A and a LWG screen in gatewell slot 2A. PSMFC, Anchor QEA, and COE personnel sampled a total of 151 fish from slot 2A and 71 from 3A over the three days. Similar to the results from previous years, the John Day fish screens do not seem to cause an increase in descaling or injuries when used at LWG. Gatewell slot 2A had a descaling rate of 0.66% (1 descaled out of 151 sampled) and gatewell slot 3A had no descaling.

Research

Six agencies participated in nine research projects at LWG juvenile facility that impacted 458,026 which is 5.4% of bypassed and collected smolts combined or 13.5% of the 2016 facility collection for transport. By comparison 451,816 were handled in 2015, 471,305 were handled in 2014, 458,554 in 2013, and 548,206 in 2012. The 458,051 smolts taken from the collection included: 150,152 clipped yearling Chinook, 37,600 unclipped yearling Chinook, 52,921 clipped subyearling Chinook, 60,843 unclipped subyearling Chinook, 115,026 clipped steelhead, 20,356 unclipped steelhead, 12,278 clipped sockeye, 760 unclipped sockeye/kokanee, and 8,115 Coho. In addition, the University of Idaho, Nez Perce Tribe (NPT) and Columbia River Intertribal Fisheries Commission (CRITFC) collected 890 clipped and 1,212 unclipped steelhead kelts from the juvenile facility this season.

National Marine Fisheries Service (NMFS)-Study to Compare the Adult Returns of In-river Migrating versus Barged Juvenile Anadromous Salmonids (Transportation Study)
Corps biological technicians collected smolts in the east raceways for NMFS tagging May 18 to June 10. Raceways flow, fish behavior, and mortalities were monitored by Corps biological techs 24 hours per day. NMFS handled 177,181 smolts in the marking trailers at Lower Granite JFF as part of this transportation study. Of these 9,335 smolts were PIT tagged and transported including 2,069 unclipped yearling Chinook, 3,395 clipped steelhead, and 3,871 unclipped steelhead. There were 167,774 smolts handled that were not selected for tagging. All fish were held overnight in the east raceways prior to transport. There were 72 smolt mortalities reported including 3 clipped yearling Chinook, 1 unclipped yearling Chinook, 38 clipped subyearling Chinook, 12 unclipped subyearling Chinook, 2 clipped steelhead, 1 unclipped steelhead, and 15 unclipped sockeye. There were an additional 1,069 mortalities removed from the east raceways while used exclusively for NMFS research projects this season by Corps personnel during normal raceway inspections. Unclipped yearling Chinook with fork lengths less than 124 mm were targeted. Unclipped steelhead with fin erosion were not PIT tagged. All smolts handled and PIT-tagged for this study were collected in the east raceways and tagged in the NMFS marking trailer adjacent to the east raceways.

National Marine Fisheries Service (NMFS)-Study to Estimate Juvenile Salmonid Reach Survival
Corps biological technicians collected smolts in the east raceways for this in-river survival study April 12 to June 10 in conjunction with the NMFS Transportation Evaluation study. NMFS handled 275,522 smolts as part of this study including 55,075 fish that were PIT-tagged and bypassed, 72,259 not tagged and bypassed, 148,109 not tagged and transported. Tagged fish including 22,318 unclipped yearling Chinook, 17,935 clipped yearling Chinook, and 14,822 unclipped steelhead. There were 20 fish mortalities prior to tagging and 59 post tagging mortalities. Post tagging mortalities included 41 unclipped yearling Chinook, 8 clipped steelhead, and 10 unclipped steelhead. There were 1,069 mortalities removed from the east raceways while used exclusively for NMFS as described above.

National Marine Fisheries Service (NMFS)-Monitoring the Migrations of Wild Snake River Spring/Summer Chinook
This study to monitor the migration behavior and survival of Snake River Basin wild spring/summer Chinook salmon aims to characterize migration timing and estimate individual wild population parr-to-smolt survival to LWG and the influence of environmental factors on

migration patterns. Fish PIT-tagged in natal streams during the summer of 2015 were diverted to the SBC tanks at LWG April 4 to June 9 during 2016. Corps biological technicians monitored tanks for flow, fish behavior, and mortalities. A total of 1,512 fish were impacted by this study. NMFS handled and bypassed 728 targeted unclipped yearling Chinook as part of this study. An additional 699 untagged smolts and 84 non-target PIT-tagged fish were incidentally diverted to the SBC tanks handled and bypassed. There was 1 clipped Chinook mortality.

Idaho Fish and Game (IDFG)-Genetic Stock Identification

The goal of this study is to develop detailed genetic profiles for natural origin salmon and steelhead, develop genetic stock identification (GSI) techniques to estimate stock-specific escapement over LWG, monitor abundance, productivity and distribution of naturally produced adult and juvenile steelhead and salmon and to research and monitor stock-specific life history characteristics. The objective of the study is to enumerate and characterize the natural production of spring/summer Chinook salmon and steelhead above LWG with regards to age composition and genetic stock identification. Lower Granite biological staff and SMP biologists provided IDFG 2,755 smolts for this study March 28 to June 17. Scale samples and fin clips were taken from 1,240 non-fin eroded unclipped steelhead and fin clips only were taken from 1,515 non-coded wire tag (CWT) unclipped yearling Chinook. Fish bypassed prior to transport collection (March 28-May 1) included 657 unclipped steelhead without fin erosion and 1,111 yearling Chinook without CWT bypassed.

University of Idaho/Columbia River Intertribal Fisheries Commission (CRITFC)/Nez Perce Tribe (NPT)-Evaluate Reproductive Success of Natural-Origin, Hatchery-Origin, and Kelt Steelhead in the Columbia River Basin

This project studies steelhead kelt physiology and endocrinology to evaluate strategies for rehabilitating and handling steelhead kelts captured at LWG. Lower Granite biological technicians diverted 2,102 steelhead kelts to the holding tanks from April 1 to June 24. NPT/CRITFC personnel genetic sampled, PIT-tagged, and returned to the tailrace 1,838 steelhead, including 878 clipped and 960 unclipped steelhead. Another 243 steelhead kelts were transported to Dworshak National Fish Hatchery for acclimation and feeding studies, and 21 were mortalities. Mortalities included 11 clipped and 10 unclipped steelhead. One of the 11 clipped steelhead died during sampling.

U.S. Geological Survey (USGS)/U.S. Fish and Wildlife Service (USFWS)- Evaluating Detection Efficiency of Subyearling Chinook Salmon Tagged with 8-, 9-, and 12-mm PIT-tags and released into the Juvenile Bypass System at LWG

Lower Granite biological staff and SMP biologists raised the sample rate above SMP guidelines June 6 to target collection of 300 additional subyearling Chinook to facilitate USGS research requirements to evaluation of 8-, 9-, or 12-mm PIT-tags detection efficiency. Tagged fish were released into the upwell at the south end of the juvenile collection facility. PIT tag detection efficiency of each group was measured as fish volitionally egressed from the separator through facility PIT tag detection systems. USGS personnel PIT-tagged a total 306 subyearling Chinook salmon, including 103 clipped and 193 unclipped. Mortalities included 4 clipped and 6 unclipped subyearling Chinook mortalities.

UW/NMFS Within-season Indicators of Fish Condition Related to Differential Delayed Mortality

Clipped yearling Chinook were collected throughout the season to better understand indices of smoltification, bio-energetic reserves, and length and how these indices can relate to post-hydropower system survival. Fish condition indices can be used to test and refine models of smolt-to-adult return rates and differential delayed mortality including freshwater and marine environments, fish interannual baselines, and seasonal patterns. Sampled fish were provided by Corps, SMP, and NMFS biologists at LWG and was compared to data collected at a midpoint (i.e., Ice Harbor Dam) and at the exit (i.e., Bonneville Dam) of the hydropower system. University of Washington (UW) and/or NMFS personnel sampled 626 fish from April 19 to June 14. Sampled fish included 381 clipped yearling Chinook and 192 clipped subyearling Chinook that were sacrificed for tissue samples. There were 53 clipped subyearling Chinook handled, not sacrificed, and transported.

NMFS and Pacific Northwest National Laboratory Evaluate the Effectiveness of Habitat Restoration Actions in the Lower Columbia River and Estuary

This aimed to characterized interior stocks of Chinook and steelhead at four locations between Bonneville Dam and the Columbia River mouth to evaluate estuary habitat restoration benefits. Fish size, food habitats, and three physiological indicators were used to evaluate stock-specific benefits of fish collected at three upstream dams and below Bonneville. NMFS personnel sacrificed 25 clipped steelhead April 26 and May 10.

USGS Feeding Ontogeny in the Hydrosystem

Diet information was provided by fish sacrificed as part of UW/NMFS Differential Delayed Mortality Study at LWG. All clipped yearling Chinook sacrificed by the UW or NMFS researchers were utilized by USGS researchers. USGS personnel sampled 573 fish including 381 clipped yearling Chinook and 192 clipped subyearling Chinook.

IDFG Evaluation of Hatchery Sockeye Salmon at LWG

When clipped sockeye salmon smolts arrived at LWG, they exhibited fin maladies, similar to fin rot and fungus, and had high mortality rates throughout the fish facility. IDFG pathologist examined juvenile sockeye at Lower Granite May 26 and collected fin and tissue samples from 99 clipped sockeye. IDFG informed the Corps Biologist that the maladies were rearing and/or a release issue and not related to dam operation.

Operation and Maintenance

Turbine Operations

Efforts were made to operate all turbine units within one percent of the peak efficiency from April 1 to October 31. Deviations were infrequent and brief or required by BPA (table 17).

Table 17. Lower Granite turbine unit outages, 2016.

Unit	Date OOS	Reason out of service
All Units	As Listed Under ESBS	ESBS/VBS inspection.
All Units	March 21-23	ESBS installation
All Units	August 8-11	Doble testing
All Units	August 14-15	VBS inspections
All Units	October 30-31	VBS inspections
All Units	Nov 15-17	ESBS removal
Unit 1		
	February 16	Testing
	April 12-December 31	Kaplan blade linkage repair
Unit 2		
	January 14	NERC Testing
	Jan 27-Feb 1	VBS repair/replacement
	March 1	Rake trash
	March 28, 29, 31	Gatewell dipping for John Day ESBS condition testing ~one hour in the morning
	August 29	Governor oil pump failure
	September 8	Setting governor oil pump
	November 22	Shaft alignment testing prior to unit annual maintenance
	Nov 28-Dec 15	Annual maintenance
	Dec 21-31	Blade packing failure
Unit 3		
	January 14	NERC Testing
	March 4	Rake trash
	March 28, 29, 31	Gatewell dipping for John Day ESBS condition testing ~one hour in the morning
	May 11	Contractor hit PMG tripping unit off line
	June 26-29	Repair VBS in slot 3B
	July 11-14	Repair VBS in slot 3A
	Oct 17-Nov 7	Annual Maintenance
Unit 4		
	January 11	NERC testing
	March 4	Rake trash
	April 11	Exciter issues
	May 5-6	ESBS brush failure in slot 4A
	May 23	Brush gear cleaning due to field ground
	July 5-20	Annual Maintenance
	August 28	ESBS screen cleaner issues
Unit 5		
	January 8	NERC testing
	January 20-26	VBS replacement
	March 4	Rake trash
	March 28	Field ground test
	June 15	Heat exchanger cleaner
	Aug 29- Oct 13	Annual maintenance 6 year overhaul
	October 24	ESBS ground alarm on brush in slot 5A
Unit 6		
	January 11	NERC testing
	March 2	Rake Trash
	April 17	Exciter failure
	June 20	Faulty ESBS ground in gatewell 6B
	June 23-30	EAL install and testing
	August 1-26	Annual maintenance
	December 8	Phase 1a collection channel caisson install

	December 14	Phase 1a collection channel caisson install

Debris/Trash Racks

Unit 2 trashracks were raked March 1, units 3, 4, and 5 were raked March 4, and unit 6 was raked March 2. About 30 cubic yards of debris was removed from the forebay and trashracks.

Extended-length Submersible Bar Screens (ESBSs)

ESBSs were inspected and tested on the week of March 14. Screens were installed from March 21 through March 23. Video inspection took place April 25-26, May 22-23, June 27-28, and August 14-15, and October 30-31. No problems with the ESBSs were detected during video inspections. Manufacturer flaws were discovered on ESBS screen cleaner motors installed during the 2014-2015 maintenance season. Faulty components were replaces during 2015-2016 winter maintenance outage. Brush cleaning cycle was set to operate every two hours this season.

Vertical Barrier Screens (VBSs)

VBSs were video inspected in conjunction with ESBSs during the 2016 fish passage season. Detailed inspections were performed during the June ESBS inspection. VBSs in slots 3A and 3B were repaired after small tears were identified during inspection. VBS screen panel mesh has the potential to deteriorate and become brittle over time. Panels for screens that passed underwater camera inspection but showed potential for deterioration in 2015 fish passage season were replaced with new panels during the 2015-2016 winter maintenance season. Mesh screens panels were replaces in gatewell slots of unit 2 and unit 5. VBS screen panels will continue to be replaced during winter maintenance as time permits.

Gatewells

Gatewells were normally less than 1% covered with debris and did not exceed the 50% debris surface coverage criterion. Turbulence in gatewells with ESBSs causes debris to tumble around and exit through the orifices rather than accumulate on the gatewell surfaces. Surface debris was removed from individual gatewells with a hand dipping basket during initial water-up in late March and continued throughout the season. Occasional oil sheens were dealt with by floating oil absorbent pads in the affected gatewells.

Orifices/Collection Channel

During the 2016 season the number of open orifices usually varied from 18 to 21 according to forebay level. With the Lower Granite reservoir at minimum operating pool, water discharge through an orifice is reduced. Orifices were cycled and back-flushed with air remove debris every three hours from March 21 through November 17 when the channel was dewatered. The automated backflush system was not operational this season. Orifice obstructions were not a problem this season. Orifice lights were checked daily. Orifices with burnt out lights were switched to the other orifice in the slot until the bulb was replaced. The south makeup water

valve shaft was out of service from 0710 hours July 7 to 1300 hours July 21 due a gate operator issue. During this time 18-30 orifices were operated and the makeup water valve was fixed at 30% open to maintain channel elevation.

Primary Dewaterer

Lower Granite's primary dewatering structure is an inclined screen just upstream from the porosity control perforated plate for the separator. Debris is removed from the screen with a long handled brush every half hour to once a shift depending on debris level. When the inclined screen becomes severely clogged the facility is put in primary bypass mode to take pressure off the top of the inclined screen. Debris then either floats off or is brushed off. This cleaning procedure takes about 20-30 minutes to complete. During 2016 it was not necessary to go to primary bypass due to debris accumulating on the incline screen. Facility operation remained in secondary bypass through November 17 to eliminate the potential for subyearling Chinook mortalities on the incline screen.

Wet Separator/Distribution and Sampling Systems

Water levels in the separator also varied with the forebay elevation requiring adjustment in the number of orifices operating and adjustments of the 42-inch valve to maintain proper water level. The separator water levels also fluctuated due the south shore makeup water valve being unable to adjust automatically. Separator personnel manually operated orifice valves to maintain collection channel and separator water levels. North and south makeup water valves were repaired/replaced during the 2015-2016 winter maintenance season.

Historical PVC separator bar spacing at Lower Granite allow shad, Chinook jacks, and other adults to be collected into the sample, raceways, and barges for transport. Jack bars designed to keep larger fish out of the collection system were positioned on top of the standard separator bars. Debris accumulation between the two sets of bars has the potential to increase descaling. Separator bars will be modified to address these concerns during the 2016-2017 outage.

Barge Loading Operations

Barge loading operations occurred from May 2 through August 15. Both direct loading and loading from the raceways went smoothly this season.

Truck Loading Operations

Juvenile fish were loaded every other day from August 16 through October 31 either into the midi-truck or the semi-truck with no problems this season.

Recommendations

1. Retain 10 inch knife gates from orifice gallery as spares for raceways after they are removed as part of Phase 1.
2. Replace mesh tailscreens with porosity plates to allow lamprey passage.
3. Replace PVC separator bars with metal bars.
4. Remove all chipped paint and rust from separator interior surfaces and paint.
5. Remove rust and chipped paint from metal pipe surfaces and paint.
6. Cover upstream raceways to provide shade.
7. Improve flow/elevation in the sample recovery truck loading pipe to eliminate fish being stranded in the pipe.
8. Operate the facility secondary bypass at all times when the collection channel is watered up to prevent fish stranding on the incline screen until Phase 1a completion.
9. Continue rebuilding motors on 2000 series barges.
10. Install bumper system to replace cable and tire system on barges.
11. Replace failed sea chest intake seals, pump seals, and bio-balls in aerators on all 8000 barges recirculation system.
12. Paint hulls on 8000 barges.
13. Install ballast material in voids of 4394 and 4382 to eliminate the need to use river water.
14. Purchase a 1000 gallon fish tank and truck, a 3500 gallon tank and semi, and a service truck dedicated to trap and transport truck/barge maintenance.

APPENDIX TABLES

Appendix Table 1. Daily collection and bypass numbers and river conditions at Lower Granite Dam, 2016.

Appendix Table 2. Percent descaling and daily facility mortality numbers at Lower Granite Dam, 2016.

Appendix Table 3. Daily number of fish trucked and barged from Lower Granite Dam, 2016.

Appendix Table 4. Daily number of adult fallbacks and fallback mortality at Lower Granite Dam, 2016.