CENWW-OD-EL HOLDREN February, 2020

MEMORANDUM THRU:
Rob Lustig, Operations Project Manager, Lower Granite Dam

FOR Chief, Operations Division
ATTN: Eric Hockersmith / Ann Setter

SUBJECT: Submission of 2019 Juvenile Fish Collection and Bypass Report, Lower Granite Dam Juvenile Fish Facility.

1. Enclosed find the 2019 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

2019 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, 2020

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TRANSPORT OPERATIONS - LOWER GRANITE DAM

Introduction

The 2019 collection season at Lower Granite Dam (LWG) was characterized by above average flow and spill throughout the season. Spring spill volume was managed based on the total dissolved gas (TDG) cap of 120% saturation per the 2019 - 2021 Flex Spill Operation Agreement. Operation under this agreement requires LWG to spill up to the 120% gas cap for 16 hours and 8 hours of Performance Standard spill of 20 kcfs split into two blocks. Spring river flow required involuntary spill above the 20 kcfs during the majority of spring Performance Standard spill operations. Summer spill volume requirements remained at the historical level of 18 kcfs. Water temperatures were below average during the season with the exception of September. Debris levels were high during the spring migration but low the rest of the season. ESBSs (Extended Length Submersible Bar Screens) were installed March 13 through March 20. The primary dewatering structure (PDS) was watered up and placed in emergency bypass on March 11 for juvenile bypass system upgrade commissioning testing. The collection facility was switched to primary bypass operation at 1524 hours March 12. Water and fish were routed to the separator and out the adult release flume to test porosity plate control modifications from 0920 to 1005 hours on March 14. The juvenile collection facility was watered up in secondary bypass to collect a 24-hour condition sample at 0700 hours March 25. Operation of the JFF (Juvenile Fish Facility) in secondary bypass continued until collection for transport began at 0700 hours April 23. Early season transport of Snake River anadromous salmonids as part of the ongoing study to compare in-river verses transported SARs (Smolt Adult Return Ratios) occurred April 4, 11, and 18. Three agencies conducted five research projects and handled a total of 466,556 smolts in the Lower Granite juvenile collection facility wet lab this season in addition to smolt monitoring, gas bubble trauma (GBT) sampling, and kelt collection for Nez Perce Tribe reconditioning program.

Collection for transport began at 0700 hours April 23 and ended at 0708 hours November 1. The facility was operated in primary bypass November 1 through December 18. The total facility smolt collection was 5,164,205 in 2019 fish compared to 6,473,432 in 2018. The 2019 total collection distribution was 2,042,236 bypassed, 3,099,442 barged, and 19,586 trucked.

Pacific States Marine Fisheries Commission (PSMFC) technicians examined 901 fish from the LWG separator for GBT between April 4 and May 30. Smolts examined prior to April 23 were bypassed to the river and smolts examined after April 23 were transported. No fish were observed with symptoms of GBT during the 2019 season.

The passive integrated transponder (PIT) tag system detected 118,836 PIT-tagged fish at the JFF during the 2019 season. Facility PIT tagged fish distribution was 73,884 diverted to the river, 43,304 diverted to raceways for transport, 1,260 diverted to sample holding tank, and 388 failed to be detected in secondary bypass, raceways, or the sample.

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 (such as the Fish Passage Center (FPC)). Salmonids collected, sampled, bypassed, and transported from Lower Granite facilities are designated as clipped or unclipped not hatchery or wild. Snake River Basin coho were reintroduced by the tribes and are all of hatchery origin.

Corps of Engineers personnel included: Project Supervisory Fisheries Biologist Elizabeth Holdren, Assistant Biologist Stephen Hampton/David Miller, Maintenance Lead Jeremy Krewer, Lead Biological Technician Steven Lee; Biological Technicians: Bob Traufer, Tyler Janazs, David Philips, Joshua Moore, Taylor Lance, David Riley, Kenneth McIntyre, and Justin Dorathy; Biological Pathway Intern Addison Kyte; and Maintenance personnel/truck transport drivers: Chuck Krasselt, Jeff Kuhn, and Tyler Potts, David Hernandez Anchor QEA was represented by Biologists Shawn Rapp and Paul Burke. Representing Pacific States Marine Fisheries Commission (PSMFC) were Biologists Allan Martin, Beth Kennedy and Jenna Davis. Washington Department of Fish and Wildlife (WDF&W) was represented by Biologist Charles Morrill. PSMFC technicians Blair Peterson, Max Burner and Praxy McIntyre 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 2019 fish collection season:

1. Juvenile collection channel expansion joints from the orifice gallery to the PDW installed as part of phase 1a were replaced.
2. PDW system screen cleaner shafts and brushes installed as part of 1a were upgraded to resolve wear issues and brush failures.
3. Tied the PDW pneumatic system into the JFF for additional/supplemental facility air supply.
4. Baffles were installed in primary bypass switch gate flush water valves to reduce flow.
5. Designed, installed, and modified porosity unit plates, controls, and customized directional water flow fins balance flow following phase 1a.
6. Replaced porosity control system round perforated plate with narrower oval perforation plate.
7. Refurbished the sample diversion slide gates per PSMFC guidelines.
8. Replaced one fish hold water supply pump in 4000 and two in 8000.
9. Front void structural support repairs in barges 8105, 8107, and 8108.
10. Continued replacing aerators biological balls on fish transport barges.
11. Replaced facility air compressors and some system components.
12. Replaced fuel tanks on both 2000 series barges to maintain EPA compliance.
13. Continued replacing old mesh on raceway supply headbox screens to prevent fry and juvenile lamprey passage.
14. Installed ports in 2 of 8000 series barges and both 2000 series barges for TDG monitor deployment in the barges holds and sea chest to evaluate gas levels in barge holds compared to the river.
15. Installed anodes to prevent corrosion on barge fish hold supply pump to prevent electrolysis.
16. Designed and installed sample dewatering system resulting in a reduction of MS222 usages and disposal needs for EPA permit.
17. Installed flatbed on transport pickup for personnel safety and lowered truck loading pit.

18. PH crew installed temperature gauges on turbine each unit for consistent scroll case temperatures.
19. Designed and built a GBT monitoring station located next to the separator to eliminate safety hazards associated with carrying buckets and fish up/down stairs.
20. Designed and built and anesthetic disposal tanks and system for SMP waste.
21. Installed a drain pipe for NOAA tagging trailer for anesthetic waste.
22. Continued rebuilding ESBSs and installing anodes.

River Conditions

The average daily river flow exceeded 100 kcfs on 63 days during the 2019 season. Total river flows averaged 64.4 kcfs this season. Highest daily average flow for the March 26-November 1 collection season was 183.7 kcfs April 11. Lowest daily average flow for the season was 16.7 kcfs October 23. An emergency debris spill through the RSW occurred March 19. Spill for fish passage occurred for 152 days from April 3 through midnight on August 31. LWG spilled up to the 120% gas cap for 16 hours a day and performance standard spill (20 kcfs) for up to 8 hours per day during the spring spill season (April 3-June 20). The majority of spring performance standard spill exceeded 20 kcfs due to high river flows. Summer spill of 18 kcfs began at 0001 hours on June 21 and ended at 2400 hours on August 31. Spill is distributed according to FPP Table LWG-7 and LWG-8. The seasonal average flow through spillways was 32.2 kcfs with a maximum daily average spill of 75.2 kcfs April 11 and a minimum daily average of 11.7 kcfs August 29. The RSW was closed at 1306 hours August 6 due to total project outflow being less than 30 kcfs and flows forecasted to remain less than 30 kcfs for more than 3 consecutive days. River temperatures collected as part of the daily condition sample averaged 58.6° F for the season and ranged from 44.1° F March 28 to 68.0° F September 11. A comparison of daily powerhouse flow and spill is shown in Figure 1.

Average monthly flow and spill for the 2015-2019 collection seasons are provided in Table 1.

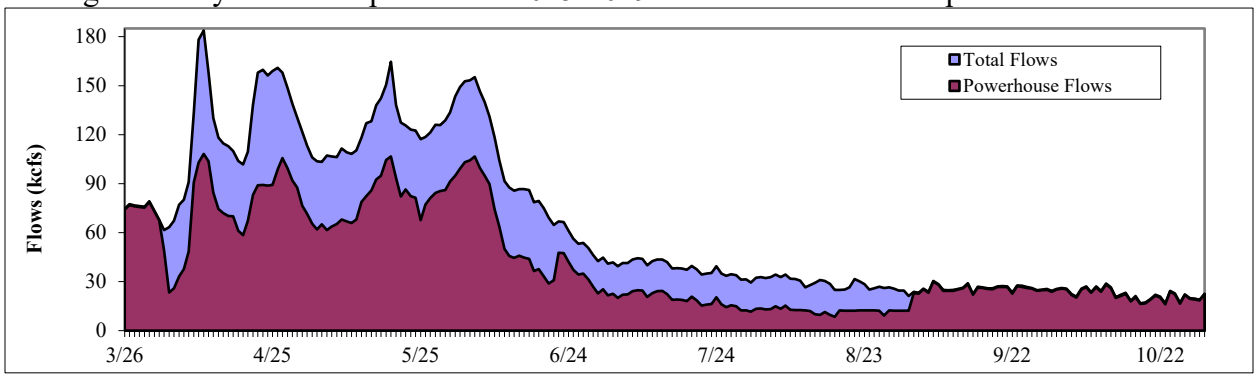

Figure 1. Daily average total flow and powerhouse flow at LWG, 2019.

Table 1. Comparison of average monthly river flow and spill at LWG, 2015-2019.

Flow (kcfs)	2015	2016	2017	2018	2019	2015-18 Ave.
April[1]	52.11	85.12	140.76	88.40	114.00	91.60
May	60.89	90.79	142.82	139.11	122.06	108.40
June	43.08	55.58	131.44	82.92	92.71	78.25
July	28.47	34.41	51.98	38.22	38.54	38.27

August	21.72	24.96	31.31	29.48	28.92	26.87
September	19.26	20.06	26.08	22.97	25.75	22.09
October	16.36	22.06	21.42	18.70	22.13	19.64
Spill (kcfs)						
April[1]	15.34	17.23	64.33	34.98	38.49	32.97
May	20.30	21.53	56.98	42.76	42.73	35.40
June	19.60	19.88	46.24	30.94	35.66	29.16
July	12.22	17.73	18.26	17.48	18.62	16.42
August	8.75	12.46	17.05	16.12	16.18	13.60
September	0.15	0.20	3.74	0.42	0.29	1.13
October	0.00	0.00	3.17	0.00	0.00	0.80

Fish Collection

Migration and Collection

Daily collection for condition sampling began at 0700 hours March 25 and continued until transportation began at 0700 hours on April 23. Collection for transport continued until 0708 hours November 1. An estimated 5,164,205 juvenile salmonids were collected during the 2019 season compared to 6,473,432 in 2018 (Table 2). Within each species group, the number collected, and percent of the total collection was: 1,470,467 clipped (28.5%) and 396,127 unclipped (7.7%) yearling Chinook, 176,608 clipped (3.4%), 263,341 unclipped (5.1%) subyearling Chinook, 2,190,548 clipped (42.4%) and 540,061 unclipped (10.5%) steelhead, 44,450 clipped (0.9%) and 5,207 unclipped (0.1%) sockeye/kokanee, and 77,396 coho (1.5%). Daily collection and bypass numbers are provided in Appendix Table 1.

Table 2. Annual collection, bypass, transportation and mortality at LWG, 2015-2019.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
Collection										
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
2017	1,789,880	572,818	225,787	402,606	1,798,556	530,958	15,750	19,839	74,225	5,430,419
2018	2,342,198	698,954	208,584	329,159	1,877,057	645,906	165,786	22,959	182,829	6,473,432
2019	1,470,467	396,127	176,608	263,341	2,190,548	540,061	44,450	5,207	77,396	5,164,205
Bypass[1]										
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
2017	980,750	401,216	3,517	18,985	1,158,305	221,673	104	15,631	10,915	2,811,096
2018	353,084	257,945	1,075	13,690	599,397	112,054	12	4,483	3,543	1,345,283
2019	453,214	153,562	3,285	41,108	1,160,105	210,169	9	154	20,630	2,042,236
Truck										
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
2017	0	0	0	0	0	0	0	0	0	0
2018	0	7	665	12,387	0	2	0	40	9	13,110
2019	4	258	1,906	17,377	3	2	0	28	8	19,586
Barge										
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
2017	807,461	171,227	220,591	380,436	640,117	309,241	15,613	4,086	63,247	2,612,019
2018	1,988,387	440,782	206,504	302,296	1,277,515	533,803	165,687	18,378	179,217	5,112,569

2019	1,016,004	242,036	171,023	204,217	1,030,304	329,833	44,341	5,005	56,679	3,099,442
Total Transport										
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
2017	807,461	171,227	220,591	380,436	640,117	309,241	15,613	4,086	63,247	2,612,019
2018	1,988,387	440,789	207,169	314,683	1,277,515	533,805	165,687	18,418	179,226	5,125,679
2019	1,016,008	242,294	172,929	221,594	1,030,307	329,835	44,341	5,033	56,687	3,119,028
2019 Mortalities										
Facility	1,245	271	394	639	136	57	100	20	79	2,941
NMFS	194	40	43	32	45	11	9	4	7	385
Res/Sac	0	15	0	0	14	11	0	0	0	40

[1]Includes Res/Sac fish and NMFS raceway mortalities.

By the end of May, 93.7% of the total yearly collection had occurred. The percent of total collection arriving by the end of June and the end of July was 99.1% and 99.6%, respectively. The remaining 0.30% of juvenile salmonids was collected August through October. Daily collection of all species combined versus total flow is shown in Figure 2. Total daily collection in 2019 peaked at 245,802 (April 10). The peak daily collection total and date for each species group for 2015-2019 are listed in Table 3.

Figure 2. Fish collection and daily average flows at LWG, 2019.

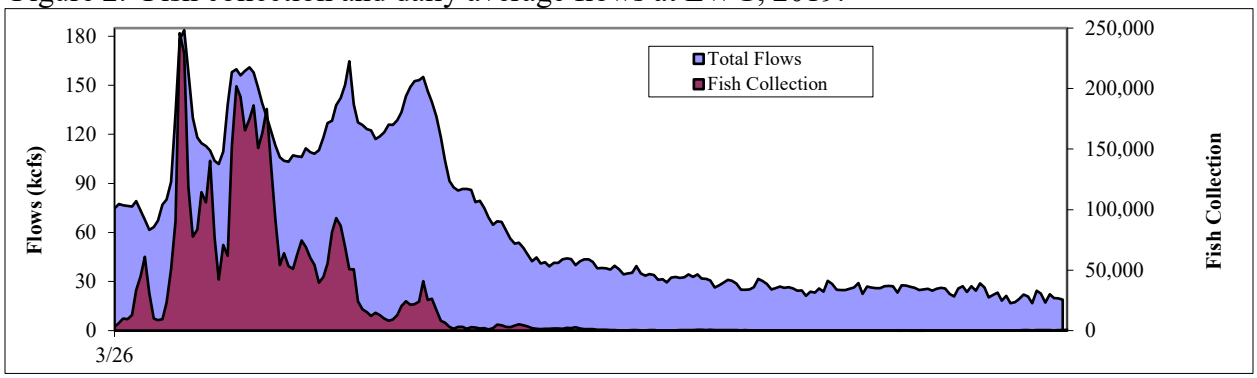

Table 3. Annual peak collection days at LWG, 2015-2019.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
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
2017	2-May	15-Apr	1-Jun	29-May	21-Apr	9-May	11-May	17-Apr	12-May	21-Apr
	114,800	27,400	17,900	26,500	138,642	43,600	2,400	1,800	5,200	224,300
2018	9-May	1-May	29-May	27-May	14-Apr	10-May	17-May	17-May	10-May	10-May
	196,200	33,600	19,400	26,800	93,403	49,400	40,800	1,600	18,800	383,600
2019	30-Apr	30-Apr	5-Jun	5-Jun	10-Apr	27-Apr	18-May	18-May	12-Apr	10-Apr
	76,200	17,600	16,650	18,250	159,600	31,400	13,000	1,000	8,000	245,802

Adult Fallbacks

A total of 2,357 adult salmonids fell back through the juvenile collection facility and were bypassed directly back to the river from the separator between March 25 and November 1 (Table 4). The total number of each species of adult fallbacks are listed in Table 4. 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, sent through the sample system, or were secondary bypassed to the river were not counted by the separator technician. No fallbacks were bypassed through the fish facility before March 25 or after November 1 due to the facility being in primary bypass and/or emergency bypass operation. Daily adult fallbacks and fallback mortalities are in Appendix Table 4.

Table 4. Annual totals of adult salmonids released from the separator at LWG, 2015-2019.

	Adult Chinook		Jack chinook		Steelhead		Sockeye		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Totals
2015	558	483	290	201	1,180	1,472	9	7	5	4,205
2016	534	784	328	568	2,118	2,728	12	3	16	7,091
2017	91	101	19	16	611	820	1	0	0	1,659
2018	297	350	124	252	762	616	4	3	17	2,425
2019	222	293	147	142	814	713	0	7	19	2,357
15-18 avg.	370	430	190	259	1,168	1,409	6	3	10	3,845

Steelhead were the most common adult salmonid species removed from the separator in 2019. April and May accounted for 81.5% of adult steelhead removed from the separator. The remaining 18.5% of steelhead fallbacks were removed from the separator June through October. The total number of steelhead fallbacks removed from the separator include out migrating kelts. The majority of Chinook adults (86.4%) were removed from the separator during September and October (fall Chinook). There were 7 unclipped Sockeye fallbacks removed in July and August with 71.4% removed in August. There were 19 coho fallbacks removed from the separator with 17 (89.5%) removed in October (Table 5).

Table 5. Monthly totals of adult salmonids released from the separator at LWG, 2019.

	Adult Chinook		Jack Chinook		Steelhead		Sockeye		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Totals
April[1]	1	2	0	2	363	216	0	0	0	584
May	6	13	0	0	345	320	0	0	0	684
June	14	10	3	2	18	81	0	0	0	128
July	9	7	3	6	1	1	0	2	0	29
August	5	3	0	2	4	15	0	5	0	34
September	28	53	30	30	39	44	0	0	2	226
October	159	205	111	100	44	36	0	0	17	672
Totals	222	293	147	142	814	713	0	7	19	2,357

[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 93.0% of fallback condition was classified as good to fair. Condition ratings of adult salmonids examined were as follows: 1,877 good (79.6%), 316 fair (13.4%), 140 poor (5.9%), and 24 mortalities (1.0%). Adult salmonid mortalities included: 17 clipped and 7 unclipped steelhead. Adult Chinook had a higher percentage of good/fair fish (98.1%) than steelhead (90.0%). A total of 33 adult lamprey (*Entosphenus tridentatus*),

including 3 from the separator, 3 from the raceways, and 27 from the sample tank, were collected at the fish facility and transported upstream of Lower Granite Dam to the Offield Landing boat ramp. There was 1 adult lamprey mortality in the truck pit loading flume.

Table 6. Condition of adult salmonids released from the separator at LWG, 2019.

	Adult Chinook		Jack chinook		Steelhead		Sockeye		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Totals
Good	202	275	139	136	534	567	0	6	18	1,877
Fair	14	14	7	6	171	102	0	1	1	316
Poor	6	4	1	0	92	37	0	0	0	140
Dead	0	0	0	0	17	7	0	0	0	24
Total	222	293	147	142	814	713	0	7	19	2,357

Sampling

Consistent with the 2019 Fish Operations Plan (FOP), Appendix E of the 2019 Fish Passage Plan, and guidance provided by the Regional Implementation Oversight Group (RIOG) through the Technical Management Team (TMT), the juvenile fish transportation program allows for a variable start date based on fish survival, adult returns, current in-river conditions, and water supply forecasts data. All fish collected that are not needed for research will be bypassed to the river prior to the start of collection for transportation. This year TMT requested transportation collection at Lower Granite, Little Goose, and Lower Monumental to begin at 0700 hours April 23. All fish sampled prior to transport were bypassed to the river with the exception of research fish. Lower Granite collection for fish sampling began at 0700 hours March 25 and ended at 0700 hours November 1. Sampling at Lower Granite Dam 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 and is not the act of evaluating those groups. A total of 221 daily samples were processed this season. The sample rate was set at 10% March 25 and fluctuated from a minimum of 0.5% to a maximum of 100% based on guidelines provided by the Fish Passage Center (FPC), according to daily fish numbers, and to accommodate research needs. The smolt monitoring staff sampled 64,765 smolts or 1.3% of the total facility collection during 2019 compared to 68,111 smolts or (1.1% of the total facility collection) in 2018 (Table 7).

Table 7. Annual percentage of smolts sampled at LWG, 2015-2019.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
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
2017	0.6	0.8	2.0	2.4	0.7	0.8	0.9	0.9	1.0	0.9
2018	0.6	0.7	3.1	7.9	0.6	0.6	0.5	1.1	0.6	1.1
2019	0.6	0.9	4.7	9.1	0.7	0.7	0.6	1.6	1.2	1.3
15-18 Ave.	0.6	0.7	2.4	5.8	0.7	0.7	0.7	1.0	0.7	1.1

The total number of smolts sampled in 2019 by species and percent of each species included: 9,286 clipped (14.3%) and 3,439 unclipped (5.3%) yearling Chinook, 8,292 clipped (12.8%) and 23,931 unclipped (37.0%) subyearling Chinook, 14,702 clipped (22.7%) and 3,881 unclipped (6.0%) steelhead, 255 clipped (0.4%) and 85 unclipped (0.1%) sockeye/kokanee, and 894 coho

(1.4%) (Table 8).

Table 8. Weekly sample totals at LWG, 2018.

Week	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
Ending	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
28-Mar	217	223	0	19	558	98	0	1	1	1,117
4-Apr	919	353	0	120	1,270	358	0	2	35	3,057
11-Apr	1,187	502	0	58	3,025	370	0	3	54	5,199
18-Apr	725	240	0	110	2,109	355	0	0	48	3,587
25-Apr	1,020	274	0	23	2,523	582	0	0	18	4,440
2-May	1,807	423	0	12	2,492	660	0	1	24	5,419
9-May	1,287	223	4	5	434	160	0	0	31	2,144
16-May	1,380	339	70	83	632	365	86	11	80	3,046
23-May	414	168	188	249	448	261	166	16	100	2,010
30-May	202	152	589	757	474	301	3	7	169	2,654
6-Jun	101	140	1,228	1,370	441	222	0	6	201	3,709
13-Jun	15	42	663	654	121	69	0	1	50	1,615
20-Jun	4	19	833	808	87	36	0	0	39	1,826
27-Jun	1	9	1,468	1,340	32	15	0	1	30	2,896
4-Jul	0	8	743	810	14	2	0	0	4	1,581
11-Jul	0	10	518	858	5	0	0	3	3	1,397
18-Jul	1	33	263	857	3	0	0	2	0	1,159
25-Jul	0	55	143	611	6	0	0	1	0	816
1-Aug	2	35	157	543	4	1	0	0	0	742
8-Aug	0	55	441	2,101	3	1	0	0	0	2,601
15-Aug	0	27	178	1,117	1	1	0	0	1	1,325
22-Aug	0	46	195	1,396	2	2	0	0	1	1,642
29-Aug	0	17	109	1,021	2	4	0	1	1	1,155
5-Sep	0	6	71	896	4	1	0	0	0	978
12-Sep	0	7	97	1,156	1	1	0	2	0	1,264
19-Sep	0	1	37	673	0	1	0	1	1	714
26-Sep	0	0	19	246	2	2	0	0	0	269
3-Oct	0	1	31	234	0	5	0	6	0	277
10-Oct	0	3	24	392	2	3	0	2	1	427
17-Oct	0	0	21	327	1	2	0	4	0	355
24-Oct	0	7	82	1,559	4	1	0	4	0	1,657
31-Oct	3	12	94	2,673	1	1	0	8	1	2,793
1-Nov	1	9	26	853	1	1	0	2	1	894
Total	9,286	3,439	8,292	23,931	14,702	3,881	255	85	894	64,765

Transportation

An estimated 3,119,028 juvenile salmonids (60.4% of fish collected) were transported from Lower Granite Dam in 2019 by barge and truck combined. The number of fish and the percentage of collection that was transported of each species group from Lower Granite included 1,016,008 clipped (69.1%) 242,294 unclipped (61.2%) yearling Chinook, 172,929 clipped (97.9%) and 221,594 unclipped (84.1%) subyearling Chinook, 1,030,307 clipped (47.0%) and 329,835 (61.1%) unclipped steelhead, 44,341 clipped (99.8%) and 5,033 unclipped (96.7%) sockeye/kokanee, and 56,687 coho (73.2%). Early season transport occurred April 4, April 11, and April 18 as part of National Marine Fisheries Service (NMFS) study to compare transport and in-river yearling Chinook smolt to adult returns (SARs). Daily barge transportation numbers are provided in Appendix Table 2.

Collection for barge transport occurred April 23 through July 30 from Lower Granite. Every day

barging operations occurred April 24 through May 15. Every other day barging from Lower Granite occurred May 17 through July 30 with the exception of June 26. The facility was in secondary bypass on June 24 and June 25 due to Ice Harbor Dam navigation lock repairs. An estimated 3,099,442 juvenile salmonids (60.0% of fish collected) were transported by barge from Lower Granite Dam in 2019 including 1,016,004 clipped (69.1%) and 242,036 (61.1%) unclipped yearling Chinook, 171,023 clipped (96.8%) and 204,217 unclipped (77.6%) subyearling Chinook, 1,030,304 clipped (47.0%) and 329,833 unclipped (61.1%) steelhead, 44,341 clipped (99.8%) and 5,005 unclipped (96.1%) sockeye/kokanee, and 56,679 coho (73.3%). A total of 7,572,717 smolts were barged from LWG, LGO, and LMN by Lower Granite staff as part of the Walla Walla District trap and transport program.

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. TDG meters were installed in both 2000 and two of the 8000 series barge holds and sea chests. TDG levels in the river were monitored during flex spill operation and TDG levels in barge hold and sea chests were compared to determine degassing benefits of barge aerators.

Juvenile fish were trucked by pickup or semi-truck August 1 through November 1. The majority of truck trips were made with the 300 gallon pickup mounted midi-tank. Lower Granite piggy backed with Little Goose using the 3500 gallon trailer August 5, 7, 9, 11, 13, and 15 due to Little Goose exceeding their midi-tank capacity. The 3500 gallon tank was again used to transport both Lower Granite and Little Goose November 1. Lower Granite transported 19,586 smolts by truck which is 0.4% of the total juvenile collection. Fish collected at Little Goose which were transported with Lower Granite smolts during the August 5-15 semi truck trips included 13,912 smolts. The number of smolts trucked from Lower Granite by species included: 4 clipped and 258 unclipped yearling Chinook, 1,906 clipped and 17,377 unclipped subyearling Chinook, 3 clipped and 2 unclipped steelhead, 28 unclipped sockeye/kokanee, and 8 Coho. The number of smolts trucked from Little Goose with Lower Granite smolts by species included: 2,764 clipped and 11,087 unclipped subyearling Chinook, 48 clipped and 4 unclipped steelhead, 4 clipped sockeye/kokanee, and 5 Coho. Water temperatures and oxygen levels were monitored to ensure acceptable levels. River water or river water ice is added to temper truck transport tanks when needed to ensure temperature are within 1-2ºF of Bonneville tailrace.

Bypass

An estimated 2,042,236 juvenile salmonids were bypassed during the 2019 collection season. The facility was operated in secondary bypass mode March 25 through April 23. Bypassed fish were enumerated during the daily condition sample period from 0716 hours March 25 to 0700 hours April 23 an estimated 2,001,210 smolts or 38.8% of the total 2019 season facility collection were bypassed. During the April 24 through November 1 collection for transport season 40,601 smolts were bypassed. The total number bypassed during the collection season and percent of each species collected included 453,214 clipped (30.8%) and 153,562 unclipped (38.8%) yearling Chinook, 3,285 clipped (1.9%) and 41,108 unclipped (15.6%) subyearling Chinook, 1,160,105 clipped (53.0%) and 210,169 unclipped (38.9%) steelhead, 9 clipped (0.02%) and 154 unclipped (3.0%) sockeye/kokanee, and 20,630 coho (26.7%). Facility bypass estimates include all fish bypassed to the tailrace during secondary bypass operation before

collection for transport, GBT fish prior to April 24, and fish collected and provided for research needs. Fish provided for research needs are recorded as bypassed including research mortalities. There were 40 research mortalities reported during 2019 included 15 unclipped yearling Chinook, 14 clipped and 11 unclipped steelhead. An additional 385 mortalities were removed from the east raceways that held NMFS transport research fish including 194 clipped and 40 unclipped yearling Chinook, 43 clipped and 32 unclipped subyearling Chinook, 45 clipped and 11 unclipped steelhead, 9 clipped and 4 unclipped sockeye/kokanee, and 7 Coho. East raceway mortalities are included in Lower Granite facility mortality when raceways were also used for standard transport collection in addition to NMFS studies. The facility bypassed fish estimate 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 25 through April 23. Sampling occurred March 26 through April 23 for fish condition monitoring (COE). Fish sampled during this period are included in the facility bypass total. The facility was operated in primary bypass from 0700 hours November 1 until the bypass was dewater for winter maintenance at 1045 hours December 18.
2. GBT inspections during the period of April 4 through April 18 accounted for a total of 320 fish bypassed. Within each species group the number bypassed was: 146 clipped and 27 unclipped yearling Chinook, 121 clipped and 20 unclipped steelhead, and 6 coho.
3. As part of research projects 43,850 fish were collected and bypassed (See; Research Section). There were 385 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 73,884 PIT-tagged fish of different species were bypassed through the PIT tag system. These fish are not included in the facility bypass total.

According to the PTAGIS database, 118,836 PIT-tagged fish were detected at LWG in 2019. Of the detected fish 73,884 (62.2%) were bypassed to the LWG tailrace through the PIT-tag diversion system, 43,304 (36.4%) were diverted to the raceways to be transported, 1,260 (1.1%) were diverted to the sample tank, and 388 (0.3%) were not detected at an exit monitor and their disposition was unknown. From March 25 through April 23 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. Incidental fish small enough to pass through the separator bars were either sampled and bypassed back to the river or held in raceways and transported with juvenile salmonids. The number of incidental species counted in the daily sample were expanded based on the sample rate to calculate collection. Incidental fish were added to the expanded collection from the sample to estimate the total collection for each incidental species. An estimated 142,936 non-salmonid incidental were collected at the fish facility during the March 26 to November 1 passage period compared to 127,860 in 2018 (Table 9). Siberian prawns, Smallmouth bass, Chiselmouth, sunfish species, and Walleye had their

highest number collected at the fish facility since 2000. Siberian prawns were the most abundant incidental species in 2019, with an estimated 71,565 collected compared to 43,434 in 2018, the next highest year. Siberian prawns were euthanized per Washington Department of Fish and Wildlife instructions and disposed of in landfills according to the Washington Department of Fish and Wildlife permit requirements. Pacific lamprey macrophthalmia were the second most abundant incidental species, with an estimated 29,448 collected compared to 40,736 in 2018, 5,142 in 2017 and 27,521 in 2016. Smallmouth bass were the third most abundant incidental species with an estimated 7,781 collected compared to 3,625 in 2018. Pacific lamprey ammocoetes were the sixth most abundant incidental species, with an estimated 4,411 collected compared to 10,212 in 2018, 9,520 in 2017 and 3,581 in 2016.

Table 9. Estimated collection of incidental fish species at LWG, 2019.

Common Name	*Scientific Name*	Separator	Expanded Sample	Total Collection[1]
American Shad (Adult)	*Alosa sapidissima*	71	11	82
American Shad (Juvenile)	*A. sapidissima*	0	943	943
Banded Killifish	*Fundulus diaphanus*	0	1	1
Bass, Largemouth	*Micropterus salmoides*	0	2	2
Bass, Smallmouth	*M. dolomieui*	14	7,767	7,781
Bullhead (misc.)	*Amierus sp.*	0	243	243
Catfish, Channel	*Ictalurus punctatus*	34	567	601
Catfish, Flathead	*Pylodictis olivaris*	0	0	0
Chiselmouth	*Acrocheilus alutaceus*	5	1,267	1,272
Common Carp	*Cyprinus carpio*	41	47	88
Crappie (misc)	*Pomoxis sp.*	42	5,876	5,918
Dace, Longnose	*Rhinichthys cataractae*	0	43	43
Dace, Speckled	*R. osculus*	0	0	0
Kokanee[2]	*Oncorhynchus nerka*	0	64	64
Northern Pikeminnow	*Ptychocheilus oregonensis*	0	28	28
Pacific Lamprey (Adult)	*Entosphenus tridentatus*	0	33	33
Pacific Lamprey (Ammocoete)	*E. tridentatus*	0	4,411	4,411
Pacific Lamprey (Macrophthalmia)	*E. tridentatus*	0	29,448	29,448
Peamouth	*Mylocheilus caurinus*	27	3,043	3,070
Redside Shiner	*Richardsonius balteatus*	0	0	0
Sand Roller	*Percopsis transmontana*	4	2,370	2,374
Sculpin	*Cottus sp.*	0	356	356
Siberian Prawn	*Exopalaemon modestus*	0	71,565	71,565
Sucker (misc.)	*Catostomus sp.*	668	6,373	7,041
Sunfish (misc.)	*Lepomis sp.*	0	2,738	2,738
Trout, Bull	*Salvelinus Malma*	1	0	1
Trout, Cutthroat	*Oncorhynchus clarkii*	0	0	0
Trout, Rainbow	*O. mykiss*	719[3]	0[4]	719
Walleye	*Stizostedion vitreum*	13	0	13
Warmouth	*Lepomis gulosis*	0	1	1
White Sturgeon	*Acipenser transmontanus*	14	0	14
Whitefish	*Prosopium sp.*	57	4,023	4,080
Yellow Perch	*Perca flavescens*	5	1	6
Total		1,715	141,221	142,936

[1]Separator count plus expanded sample count equals estimated total facility collection.
[2]Unclipped *Oncorhynchus nerka* not CWT or PIT-tagged and >200mm
[3]Large steelhead smolts that cannot fit through the narrower spaced separator bars.
[4]Steelhead lacking smoltification characteristics and/or fish under 140mm, per FPC guidelines.

Fish Condition

Descaling

The standard descaling criteria is classified as a fish with 20% or greater scale loss on one side of its body. Scale loss less than 20% on one side of a fishes body 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 2019 was 1.0% which is compared to the 2015-2018 average of 1.7% (Table 10). The annual descaling rate by species group was: clipped yearling Chinook 1.2%, unclipped yearling Chinook 0.7%, clipped subyearling Chinook 0.6%, unclipped subyearling Chinook 0.7%, clipped steelhead 1.6%, unclipped steelhead 1.8%, clipped sockeye 1.2%, unclipped sockeye/kokanee 6.0%, and Coho 1.1%.

Table 10. Annual full-sample descaling rates (>20%) by species at LWG, 2015-2019.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
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
2017	1.8	0.8	1.3	1.5	2.7	1.8	5.6	4.7	1.1	1.9
2018	1.3	0.8	0.6	0.8	3.6	2.7	1.0	3.3	1.4	1.5
2019	1.2	0.7	0.6	0.7	1.6	1.8	1.2	6.0	1.1	1.1
15-18 Ave.	1.3	0.7	0.9	1.8	2.4	2.1	1.9	3.4	1.2	1.7

The highest weekly descaling rate for all species combined was 2.1% for the week ending May 23. In most previous years the highest weekly descaling rates were normally observed in late August, September, and October when temperatures increase, flows decrease, and the sample size decreases. Heavy debris load likely contributed to increased descaling rates in May. The lowest descaling rates are generally during June and July when small subyearling Chinook salmon dominate the collection. In 2019 descaling rates were lowest during August and September (Table 11). Clipped sockeye collected at the juvenile fish facility in late May and early June in 2018 and 2019 exhibited caudal fin rot and fungus but not descaling like in previous years. IDFG determined these maladies were due to water hardness differences between the hatchery and release sites, and not Lower Granite operation. Daily descaling rates are provided in Appendix, Table 3.

Table 11. Weekly descaling rates in percent for fish sampled at LWG, 2019.

Week	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
Ending	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
28-Mar	3.23%	0.90%	--	--	0.18%	3.06%	--	0.00%	0.00%	1.18%
4-Apr	0.33%	0.29%	--	--	0.39%	0.56%	--	0.00%	0.00%	0.38%
11-Apr	1.52%	1.20%	--	--	0.63%	1.89%	--	0.00%	0.00%	0.97%
18-Apr	0.97%	0.00%	--	--	1.09%	1.97%	--	--	0.00%	1.07%
25-Apr	1.48%	0.00%	--	--	1.23%	1.89%	--	--	5.56%	1.32%
2-May	1.83%	0.71%	--	--	1.21%	0.91%	--	0.00%	4.17%	1.35%
9-May	1.48%	0.90%	0.00%	0.00%	4.39%	1.26%	--	--	3.23%	2.01%
16-May	0.44%	0.59%	0.00%	0.00%	3.32%	2.74%	2.33%	0.00%	3.75%	1.45%
23-May	0.24%	1.20%	0.00%	0.41%	7.14%	2.30%	0.61%	0.00%	0.00%	2.14%

30-May	1.49%	0.00%	0.86%	0.93%	5.92%	1.99%	0.00%	0.00%	1.78%	1.97%
6-Jun	0.99%	0.71%	0.49%	0.74%	3.63%	3.64%	--	0.00%	0.00%	1.14%
13-Jun	0.00%	0.00%	0.30%	1.71%	4.96%	1.47%	--	0.00%	0.00%	1.25%
20-Jun	0.00%	0.00%	0.97%	1.15%	1.16%	5.56%	--	--	2.56%	1.17%
27-Jun	0.00%	0.00%	0.68%	0.53%	0.00%	0.00%	--	0.00%	0.00%	0.59%
4-Jul	--	0.00%	0.13%	0.37%	7.69%	0.00%	--	--	0.00%	0.32%
11-Jul	--	11.11%	0.39%	0.94%	20.00%	--	--	66.67%	0.00%	1.02%
18-Jul	--	0.00%	1.14%	0.82%	0.00%	--	--	0.00%	--	0.87%
25-Jul	--	1.85%	0.71%	1.49%	0.00%	--	--	100.00%	--	1.49%
1-Aug	0.00%	0.00%	0.00%	1.11%	0.00%	0.00%	--	--	--	0.82%
8-Aug	--	0.00%	1.14%	0.38%	0.00%	0.00%	--	--	--	0.50%
15-Aug	--	0.00%	0.00%	0.45%	100.00%	0.00%	--	--	0.00%	0.45%
22-Aug	--	2.22%	0.00%	0.43%	0.00%	0.00%	--	--	0.00%	0.43%
29-Aug	--	0.00%	0.00%	0.69%	0.00%	0.00%	--	0.00%	0.00%	0.61%
5-Sep	--	0.00%	1.43%	0.22%	0.00%	0.00%	--	--	--	0.31%
12-Sep	--	0.00%	0.00%	0.61%	--	0.00%	--	0.00%	--	0.56%
19-Sep	--	0.00%	0.00%	0.60%	--	0.00%	--	0.00%	--	0.56%
26-Sep	--	--	0.00%	0.82%	0.00%	0.00%	--	--	--	0.75%
3-Oct	--	0.00%	0.00%	0.00%	--	0.00%	--	0.00%	--	0.00%
10-Oct	--	33.33%	0.00%	0.77%	0.00%	0.00%	--	0.00%	0.00%	0.94%
17-Oct	--	--	0.00%	1.23%	0.00%	0.00%	--	0.00%	--	1.13%
24-Oct	--	0.00%	1.22%	0.64%	0.00%	0.00%	--	25.00%	--	0.73%
31-Oct	0.00%	0.00%	1.08%	0.56%	0.00%	0.00%	--	12.50%	0.00%	0.61%
1-Nov	0.00%	0.00%	3.85%	0.70%	0.00%	0.00%	--	0.00%	0.00%	0.78%
# Descaled	113	23	47	157	235	71	3	5	10	664
# Sampled	9,259	3,422	8,248	23,412	14,685	3,874	254	83	892	64,129
% Descaled	1.22%	0.67%	0.57%	0.67%	1.60%	1.83%	1.18%	6.02%	1.12%	1.04%

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 29,742 fish examined for injury and disease and 6,669 fish (22.4 %) were afflicted with an injury or disease symptom in 2019. The overall affliction rate, body injury rate, predator injury rate, head injury rate and disease symptom rates reported are the actual rates observed for 2014 to 2019. In previous years, these rates were reported with the caveat that the actual injury rates are lower than reported due to individual fish having more than one symptom or injury. 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 17.2% 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 2019 was pink fin (39.8%), followed by general fin injury

(31.9%), fin discoloration (24.5%), body injury (2.1%), and body deformities (1.6%). Unclipped subyearling Chinook exhibited the highest percent of body injuries at 25.2% (2,834 of 11,245 examined) followed by clipped subyearling Chinook at 16.0% (574 of 3,595 examined). Head injuries were recorded on 0.4% of the smolts examined in the detailed subsample. Unclipped sockeye/kokanee had the highest incidence of head injury at 2.4% (2 of 83 examined), followed by Coho at 0.7% (6 of 891 examined). Injuries to the operculum comprised the majority of observed head injuries at 38.8%, followed by eye hemorrhage at 24.8%, eye injuries at 15.7%, general head injuries at 15.7%, "pop" eye at 5.0%.

Injuries associated with predators include wounds inflicted by other fish, birds, and lamprey. Predator wounds were observed on 0.6% 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 52.1% compared to 41.6% caused by fish and 6.3% caused by lamprey. Predator marks were highest on clipped sockeye at 1.6% (4 of 254 examined), followed by unclipped steelhead at 1.1% (20 of 1,775 examined), and clipped yearling Chinook at 0.9% (40 of 4,404 examined).

External symptoms of disease were observed on 6.5% of the smolts examined in the detailed subsample compared to 5.9% in 2018, 2.9% in 2017, 5.6% in 2016, and 3.5% in 2015. Symptoms of disease were most common on unclipped subyearling Chinook (11.0%). Of the fish afflicted, fin hemorrhages comprised the majority of disease symptoms (79.0%), followed by columnaris (9.7%), parasites (7.7%), bacterial kidney disease (1.9%) and fungus (1.7%).

Fin hemorrhage was found on 5.2% of all fish examined and on all species and rearing types. Fin hemorrhage was the primary disease afflicting unclipped subyearling Chinook and was observed on 9.2% of unclipped subyearling Chinook examined.

Columnaris is caused by the bacterium *Flavobacterium columnare* that becomes more virulent as water temperatures increase. Summer and subyearling migrants are more susceptible to infection as water temperatures increase during their outmigration. 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 observed on 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. The first symptoms of columnaris this season were observed June 30. The 2019 columnaris infection rate for subyearling Chinook was 0.7% (222 of 31,660) compared to 2015-2018 average of 1.0%.

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 to hold NMFS research fish. Mortalities removed from east raceways when used exclusively for NMFS studies were included in bypassed fish and not considered facility mortalities. Annual facility mortality for all groups combined was 0.06% in 2019 and totaled 2,941 fish (Table 12). All species group mortality rates were lower than those

observed for the 2015-2018 average except for clipped and unclipped yearling Chinook, unclipped steelhead and coho. Within each species group the number of facility mortalities and percent of those collected in that group was: 1,245 clipped (0.08%) and unclipped (0.07%) yearling Chinook, 394 clipped (0.22%) and 639 unclipped (0.24%) subyearling Chinook, 136 clipped (0.01%) and 57 unclipped (0.01%) steelhead, 100 clipped (0.22%) and 20 unclipped (0.38%) sockeye/kokanee, and 79 coho (0.10%).

Table 12. Annual facility mortality in percent by species group at LWG, 2015-2019.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
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
2017	0.09	0.07	0.74	0.79	0.01	0.01	0.21	0.61	0.08	0.13
2018	0.03	0.03	0.16	0.24	0.01	0.01	0.05	0.25	0.03	0.04
2019	0.08	0.07	0.22	0.24	0.01	0.01	0.22	0.38	0.10	0.06
15-18 Ave.	0.04	0.04	0.35	0.39	0.01	0.01	0.43	0.42	0.04	0.07

Weekly facility mortality rates were low during April, increased during May through August as water temperatures increased, river flows decreased, and the sample size decreased and peaked at 1.23% the week ending July 25 (Table 13). During September and October facility mortality rates were lower than previous years and peaked at 1.03% the week ending on September 12.

Table 13. Weekly facility mortality in percent by species group at LWG, 2019.

Week	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
Ending	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
28-Mar	0.00%	0.00%	--	1.39%	0.00%	0.00%	--	0.00%	0.00%	0.03%
4-Apr	0.00%	0.02%	--	0.36%	0.00%	0.01%	--	0.00%	0.00%	0.02%
11-Apr	0.00%	0.00%	--	0.19%	0.00%	0.00%	--	0.00%	0.00%	0.00%
18-Apr	0.00%	0.00%	--	0.09%	0.00%	0.00%	--	--	0.01%	0.00%
25-Apr	0.08%	0.07%	--	0.07%	0.00%	0.01%	--	--	0.03%	0.03%
2-May	0.12%	0.08%	--	0.21%	0.01%	0.01%	--	1.50%	0.06%	0.05%
9-May	0.10%	0.09%	1.25%	0.90%	0.01%	0.01%	--	--	0.06%	0.08%
16-May	0.13%	0.10%	0.69%	0.72%	0.02%	0.02%	0.13%	0.47%	0.15%	0.12%
23-May	0.13%	0.13%	0.12%	0.14%	0.02%	0.02%	0.26%	0.07%	0.15%	0.11%
30-May	0.11%	0.13%	0.08%	0.15%	0.04%	0.02%	0.00%	1.71%	0.12%	0.10%
6-Jun	0.46%	0.20%	0.18%	0.15%	0.10%	0.10%	--	0.33%	0.19%	0.16%
13-Jun	0.73%	0.06%	0.16%	0.11%	0.05%	0.08%	--	1.00%	0.21%	0.13%
20-Jun	0.00%	0.67%	0.52%	0.31%	0.29%	0.00%	--	--	0.00%	0.39%
27-Jun	0.00%	0.00%	0.19%	0.30%	0.00%	0.00%	--	10.00%	0.00%	0.24%
4-Jul	--	0.00%	0.11%	0.22%	0.71%	5.00%	--	--	0.00%	0.18%
11-Jul	--	1.00%	0.52%	0.65%	0.00%	--	--	0.00%	0.00%	0.60%
18-Jul	20.00%	0.57%	0.33%	0.86%	0.00%	--	--	0.00%	--	0.74%
25-Jul	--	3.45%	1.53%	0.97%	0.00%	--	--	0.00%	--	1.23%
1-Aug	0.00%	1.67%	0.38%	0.75%	0.00%	0.00%	--	--	--	0.71%
8-Aug	--	6.06%	0.72%	0.41%	0.00%	0.00%	--	--	--	0.57%
15-Aug	--	2.78%	0.21%	0.35%	0.00%	25.00%	--	--	0.00%	0.41%
22-Aug	--	1.82%	0.00%	0.75%	0.00%	50.00%	--	--	0.00%	0.74%
29-Aug	--	0.00%	0.92%	0.78%	0.00%	0.00%	--	0.00%	100.00%	0.87%

5-Sep	--	0.00%	1.41%	0.33%	0.00%	0.00%	--	--	--	0.41%
12-Sep	--	0.00%	2.06%	0.87%	100.00%	0.00%	--	0.00%	--	1.03%
19-Sep	--	0.00%	2.70%	0.45%	--	0.00%	--	0.00%	100.00%	0.70%
26-Sep	--	--	0.00%	0.41%	0.00%	0.00%	--	--	--	0.37%
3-Oct	--	0.00%	0.00%	0.85%	--	0.00%	--	16.67%	--	1.08%
10-Oct	--	0.00%	0.00%	0.51%	0.00%	0.00%	--	0.00%	0.00%	0.47%
17-Oct	--	--	0.00%	0.31%	0.00%	0.00%	--	25.00%	--	0.56%
24-Oct	--	0.00%	0.00%	0.38%	0.00%	0.00%	--	0.00%	--	0.36%
31-Oct	0.00%	0.00%	1.06%	0.19%	0.00%	0.00%	--	0.00%	0.00%	0.21%
1-Nov	0.00%	0.00%	0.00%	0.23%	0.00%	0.00%	--	0.00%	0.00%	0.22%
# morts	1,245	271	394	639	136	57	100	20	79	2,941
# collected	1,470,467	396,127	176,608	263,341	2,190,548	540,061	44,450	5,207	77,396	5,164,205
% mortality	0.08%	0.07%	0.22%	0.24%	0.01%	0.01%	0.22%	0.38%	0.10%	0.06%

Sample mortalities include fish removed from the sample holding tank prior to being handled in the lab and mortlities removed from the sorting trough in the wet lab. Annual sample mortality for all groups combined was 0.45% in 2019 (Table 14) and totaled 293 fish. This is the lowest sample mortality rate on record since 1996. The number of sample mortalities and mortality rate by species group was: 27 clipped (0.29%) and 17 unclipped (0.49%) yearling Chinook, 44 clipped (0.53%) and 176 unclipped (0.74%) subyearling Chinook, 17 clipped (0.12%) and 7 unclipped (0.18%) steelhead, 1 clipped (0.39%) and 2 unclipped (2.35%) sockeye/kokanee, and 2 Coho (0.22%). All species groups sample mortality rates were lower than the 2015 to 2018 average except for unclipped yearling Chinook. Sample mortality for all groups combined has ranged from a high of 0.86% in 2015 to a low of 0.45% in 2019.

Table 14. Annual sample mortality by species group in percent at LWG, 2015-2019.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
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
2017	0.62	0.56	1.58	1.81	0.29	0.35	1.37	5.00	0.71	0.86
2018	0.32	0.31	0.85	0.87	0.30	0.27	0.72	1.99	0.00	0.58
2019	0.29	0.49	0.53	0.74	0.12	0.18	0.39	2.35	0.22	0.45
15-18 ave	0.42	0.42	1.01	1.15	0.30	0.26	2.03	3.62	0.23	0.74

Barge mortalities are salmonids removed from barge holds after the barges depart LWG. The total number of smolts barged in 2019 included: 3099442 fish from LWG, 2337397 from LGS, and 2135878 fish from LMN. The seasonal barge transport program mortality rate was 0.03% (2,572 of 7,572,717) (Table 16). Barge mortalities by species group included: 1,345 clipped and 302 unclipped yearling Chinook, 55 clipped and 48 unclipped subyearling Chinook, 590 clipped and 211 unclipped steelhead, and 21 clipped sockeye salmon (Table 15).

Table 15. Total annual transport program barge mortalities 2015-2019.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	Unknown	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Others	Total
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

2017	1,729	534	405	693	456	243	33	9	17	0	4,119
2018	2,945	782	270	311	690	283	50	47	15	1	5,394
2019	1,345	302	55	48	590	211	21	0	0	0	2,572
15-18 ave	1,457	440	498	702	517	229	126	20	24	438	4,451

The truck transport fish mortality rate in 2019 was 0.10% (32 of 33,498) (Table 16). Of these 19,586 were collected at LWG and 13,912 were collected at LGS and transported by LG. The majority of truck trips from LWG were made by pickup truck mounted with a 300-gallon tank (midi-tank). Smolts were transported in the 3500 gallon semi-truck from LWG and LGS when the midi-tank capacity was exceeded August 5-15 and November 1. Fish transported from LGS with LWG fish totaled 13,912 smols. A total of 19,586 fish were collected and transported by truck from LWG. Truck mortality number and percent by species included: 3 unclipped (1.16%) yearling Chinook, 9 clipped (0.19%) and 19 unclipped (0.07%) subyearling Chinook, and 1 unclipped (3.6%) sockeye/kokanee.

Table 16. Annual percent truck mortality at LWG, 2015-2019.

	Yearling Chinook		Subyearling Chinook		Steelhead		Sockeye/Kokanee		Coho	
	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	Clipped	No Clip	All	Total
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
2017	--	--	--	--	--	--	--	--	--	--
2018	--	14.30	0.60	0.10	--	0.00	--	17.50	0.00	0.19
2019	0.00	1.16	0.19	0.07	0.00	0.00	--	3.57	0.00	0.10
15-18 Ave.	0.00	0.81	0.50	0.10	0.00	0.00	--	12.10	0.00	0.13

--no fish trucked

Gas Bubble Trauma Monitoring (PSMFC)

Juvenile salmonids were sampled for GBT from April 4 through May 30 in 2019. 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 901 fish were sampled for GBT: 431 clipped and 74 unclipped yearling Chinook and 304 clipped and 92 unclipped steelhead. During GBT sampling 25 PIT-tagged smolts were handled, not examined and returned to the separator including: 14 clipped and 3 unclipped yearling Chinook, 1 clipped subyearling Chinook and 7 clipped steelhead. An additional 80 fish were handled and released into the separator including: 7 clipped and 1 unclipped yearling Chinook, 10 clipped and 29 unclipped subyearling Chinook, 5 clipped steelhead, 5 clipped sockeye, and 23 Coho. Smolts examined for GBT prior to April 23 were released in the sample recovery tank and bypassed. Smolts examined for GBT after April 23 were returned to the raceways and transported. A total of 320 smolts were bypassed including 146 clipped yearling Chinook, 27 unclipped yearling Chinook, 121 clipped steelhead, and 20 unclipped steelhead and 6 coho. A total of 686 smolts were transported including: 306 clipped and 51 unclipped yearling Chinook, 11 clipped and 29 unclipped subyearling Chinook, 195 clipped and 72 unclipped steelhead, 5 clipped sockeye, and 17 coho. There were no fish observed with symptoms of GBT during 2019 while 5 were observed with symptoms in 2018.

Research

Three agencies participated in five research projects at LWG juvenile facility that impacted 466,556 smolts which is 9.0% of the total collection or 15.1% of the 2019 facility collection for transport. The 2015-2018 average was 502,159 smolts handled as part of LWG research projects. The 466,556 smolts taken from the collection included: 117,955 clipped and 18,285 unclipped yearling Chinook, 39,146 clipped and 47,068 unclipped subyearling Chinook, 196,865 clipped and 32,784 unclipped steelhead, 5,230 clipped and 717 unclipped sockeye/kokanee, and 8,506 coho. Corps biological staff collected 739 clipped and 612 unclipped steelhead kelts, 1 adult clipped Chinook and 1 sucker from the LWG juvenile facility for the Nez Perce Tribe (NPT) and Columbia River Inter-Tribal Fisheries Commission (CRITFC) this season.

National Marine Fisheries Service (NMFS)-Study to Compare the Adult Returns of In-river Migrating versus Barged Juvenile Anadromous Salmonids (Transportation Study)

LWG Corps biological technicians collected smolts in the east raceways for NMFS tagging April 3 to June 15. Raceway flows, fish behavior, and mortalities were monitored by Corps biological staff 24 hours per day. Corps biological technicians collected 420,362 smolts for NMFS that were handled in their marking trailers at LWG fish facility as part of the annual transportation study. Of these 28,761 smolts were PIT tagged and transported including 5,999 unclipped yearling Chinook, 8,591 clipped steelhead, and 14,171 unclipped steelhead. There were 391,522 smolts handled that were not selected for tagging. All fish were held overnight in the east raceways prior to transport. There were 79 smolt mortalities reported by NMFS including 38 clipped and 5 unclipped yearling Chinook, 6 clipped and 2 unclipped subyearling Chinook, 21 clipped and 7 unclipped steelhead. There were an additional 385 mortalities removed by Corps biological staff from the east raceways while being used exclusively for holding NMFS research fish. Unclipped yearling Chinook with fork lengths less than 124 mm were targeted. Unclipped steelhead with fin erosion were not PIT tagged.

National Marine Fisheries Service (NMFS)-Study to Estimate Juvenile Salmonid Reach Survival

Corps biological technicians collected smolts in the east raceways for the continuing in-river survival study April 3 to June 15 in conjunction with the NMFS Transportation Evaluation study. NMFS handled 42,124 smolts as part of this study, 42,084 that were PIT-tagged and bypassed including 6,375 unclipped yearling Chinook, 20,487 clipped steelhead, and 15,222 unclipped steelhead. There were 40 post tagging mortalities including 15 unclipped yearling Chinook, 14 clipped steelhead, and 11 unclipped steelhead. There were 385 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, estimate individual wild population parr-to-smolt survival to LWG, and influence of environmental factors on migration patterns. Fish PIT-tagged in natal streams during the summer of 2018 were diverted to the SByC tanks at LWG April 3 to June 10 during 2019. Corps biological technicians monitored tank flow, fish behavior, and tank for mortalities 24 hours/day. A total of 480 fish were impacted by this

study. NMFS handled and bypassed 322 targeted unclipped yearling Chinook and 1 unclipped steelhead as part of this study. An additional 19 untagged smolts and 136 non-target PIT-tagged fish were incidentally diverted to the SBC tanks handled and bypassed and there was 1 unclipped yearling Chinook and 1 unclipped subyearling Chinook mortalities.

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 collected 2,608 fish that were sorted by SMP biologists and provided to IDFG for this study March 26 to June 28. Scale samples and fin clips were taken from 1,387 non-fin eroded unclipped steelhead and fin clips only were taken from 1,221 non-coded wire tag (CWT), unclipped yearling Chinook. Sampled fish for this study were bypassed prior to transport collection (March 26-April 23) and included 507 unclipped steelhead without fin erosion and 404 yearling Chinook without CWT. After April 23 sampled fish for this study were transported.

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

Corps biological staff collected 1,351 steelhead kelts from the Lower Granite juvenile separator from March 26 to June 27. The purpose of the study is to evaluate steelhead kelt physiology and endocrinology for rehabilitating. NPT/CRITFC personnel took genetic samples, PIT-tagged, and returned to the tailrace 1,037 steelhead, including 722 clipped and 315 unclipped steelhead kelts collected at LWG that did not meet their criteria. Of the kelts collected, 286 steelhead kelts were transported to Dworshak National Fish Hatchery for acclimation and feeding studies. Twenty-five steelhead died before handling including 16 clipped and 9 unclipped steelhead kelts and 3 steelhead died after handling including 1 clipped and 2 unclipped steelhead kelts. There was also 1 adult hatchery Chinook and 1 sucker inadvertently sent to the kelt tanks.

USGS-Emerging Issues to Recover the Snake River Fall Chinook Salmon Evolutionary Significant Unit

The goal of this research study was to determine the abundance of unmarked, untagged natural and hatchery origin subyearling fall Chinook salmon in the sample tank at LWG and to determine growth, and origin during the SBC part of the study. Fin clips were taken from 30 unclipped, untagged subyearling fall Chinook salmon per day from June 1 to June 15 and from July 8 to July 22, for parentage-based tagging analysis. For the season, 901 unclipped, untagged subyearling fall Chinook salmon were sampled, and 1 unclipped yearling Chinook salmon and 12 unclipped subyearling fall Chinook salmon were handled but not sampled. All fish used for this part of the study were transported along with the sample fish.

From October 4 to November 1 USGS personnel used the SBC system and facility sample to collect previously PIT-tagged subyearling Chinook salmon from the Clearwater River basin. There were 81 subyearling Chinook salmon evaluated to measure growth as it relates to

hatchery/wild origin and fish release group origin. There were 57 unclipped subyearling Chinook sampled from the SBC tanks and bypassed to the river during this portion of the study, 13 collected but not sampled, 10 fish were sampled from the SMP sample, and 1 fish was collected from the SMP sample but not sampled by USGS.

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 contains unit outages during 2019.

Table 17. Lower Granite turbine unit outages, 2019.

Unit	Date OOS	Reason out of service
Units 1 – 6	**Monthly**	**ESBS/VBS inspection**
Units 1 – 6	**Feb 25-27**	**Trash rack raking**
Units 1 – 6	**Mar 18-21**	**ESBS installation**
Units 1, 3 – 6		**RAS Testing**
Units 1 - 6	**Aug 12-16**	**Doble Testing**
Units 2 - 6	**Dec 06-17**	**ESBS Removal**
Units 1 - 6	**Aug 26**	**500 kV line outage to repair transformer nitrogen leak**
Unit 1	**Dec 27 - Feb15**	**Annual Maintenance/Digital Governor Upgrade/OPTO 22**
	Mar 14	**Correct wiring due to incorrect wiring diagram**
	Apr 17 - Apr 25	**Head cover issues**
	Nov 23 - Dec 19	**Field ground service (rotor)**
Unit 2	**Jan 29**	**Main unit breaker failed to open on trip**
	Feb 11 - Apr 04	**Annual Maintenance / Digital Governor Upgrade/OPTO 22**
	Aug 26 - Aug 29	**Forced OOS due to torn VBS screen.**
	Nov 04-Dec 31	**Overhaul – remains out of service**
Unit 3	**January 22 - 30**	**OPTO 22 installation**
	Sep 30 - Oct 17	**Annual Maintenance**
Unit 4	**Jan 7 – 17**	**GDACS PLC Replacement**
	Jan 29	**Main unit breaker failed to open on trip**
	Aug 5 - 22	**Annual Maint.**
	30 Sep - Oct 2	**Forced outage – Failed motor operated cooling water valve.**
Unit 5	**Jan 29 - Feb 06**	**86 GT & 86 GX lock out, main unit breaker also failed to trip causing Units 2 and 4 to trip.**
	April 09	**XJ2 breaker inspection and maintenance**
	Jul 08 - Aug 01	**Annual Maintenance/OPTO 22**
	Aug 15 - 16	**500 kV line outage**
	Aug 20 - 22	**XJO2 breaker upgrade**
Unit 6	**Jan22 - 31**	**VBS Replacement/Repair**
	Apr 15 - 16	**Governor relay valve repair**
	Aug 12, 13, 15, 16	**Doble**
	Sep 09 - 26 Sep	**Annual Maintenance**

	Oct 9 - 10	**Forced outage – Fish screen motor gearbox seal failed.**
	Dec 04	**Tighten wicket gate packing**
	Dec 05	**Suspected source of oil in tailrace**

Debris/Trash Racks

Trashracks were raked the February 25-27. Trashrack raking was not required during the fish passage season.

Extended-length Submersible Bar Screens (ESBSs)

ESBSs were inspected and tested prior to installation. ESBSs (Extended Length Submersible Bar Screens) were installed March 18-21. 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 2019 fish passage season. Detailed inspections were performed during the June ESBS inspection. VBS screen panel mesh has the potential to deteriorate and become brittle over time. VBS panels for screens that pass underwater camera inspection but showed potential for deterioration continue to be replaced/repaired during unit annual outages or 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

Orifices operation was determined by collection channel flow and forebay elevation during the 2019 season. When the forebay is raised above MOP 10” orifices in gatewells of non-priority units (typically units 4 & 5) are used to maintain acceptable flow to the PDW. Orifices were inspected every three hours and back-flushed with air as needed to remove debris March 18-May 25. Orifices were inspected and back flushed twice a shift May 25-November 1 when river debris loads were minimal. Orifice operation programming issues continue to be a problem resulting in solenoid failures. The facility was operated by two biological technician to monitor the orifice gallery and the operation of the relatively new system. Orifice lights were checked daily.

Primary Dewaterer

Lower Granite primary dewaterer (PDW) was in operation March 11-December 18. The collection channel orifice gallery was watered up in emergency bypass mode March 11 as part of

JBS upgrade commissioning to evaluation juvenile passage through the emergency bypass. Operations were changed to primary bypass mode at 1524 hours March 12. Water and fish were routed to the separator and out the adult release flume to test porosity plate control modifications from 0920 to 1005 hours on March 14. Primary dewaterer floor screen brushes, side screen brushes, and the pneumatic screen cleaners were operated in auto and manual mode powerhouse operators and JFF staff due to mechanical and programing issues with the system. Operational changes in response to programming, mechanical, and structural issues with the PDW continue as needed.

Wet Separator/Distribution and Sampling Systems

Water levels in the separator varied with the forebay elevation and PDW operations requiring adjustment in porosity control valves and separator exit gates. Adjustments in flume flow were made to reduce fish holding in the transport flume and under the separator. Porosity control valves modifications made during the winter outage distributed flow evenly across the porosity. These modifications to the porosity control unit balanced water across the plate and enabled adequate dewatering prior to entering the separator. Biological technicians adjusted porosity dewatering valves and exit gate positions in response to separator water elevation changes related to PDW weir operation. Separator exit gates were adjusted to improve PIT tag detection efficiencies as coordinated with PSMFC technicians.

Barge Loading Operations

Barge loading operations occurred from April 24 through July 30. Loading from the raceways went smoothly this season. Direct loading did not occur.

Truck Loading Operations

Truck transport occurred from August 1 through November 1. LWG transported fish from LGS August 5-15 and November 1.

Recommendations

1. Complete Phase 1a modifications and resolve programming issues.
2. Operate the PDW flume outflow between 35-40 cfs to reduce delays in system.
3. Eliminate void and install an additional flow fins at the downstream end of the porosity control unit to improve entrance into the separator.
4. Replace mesh tailscreens with porosity plates to allow lamprey and fry passage.
5. Improve sample recovery truck loading pipe slope to eliminate fish stranding in pipe.
6. Continue rebuilding motors on the 2000 series barges.
7. Replace barge bumper cable and tire system with bumpers.
8. Paint hulls on 8000 series barges.
9. Install ballast material in barges 4394 and 4382 voids to eliminate use of river water.
10. Receive and prepare trucks and transport tanks and service truck for the 2021 season.
11. Install electronic operators for raceway supply knife gate valves.
12. Improve juvenile collection facility pneumatic system air compressors and air lines.

13. Replace sample holding tank fish exit release manual valves with pneumatic valves.
14. Improve/modify anesthetic chamber door operation.
15. Permanently close the collection channel 5A research weir that is becoming a safety concern.
16. Modify the JFF sample anesthetic system and procedure to minimize volume of MS-222 waste and develop filter and disposal systems for LWG JFF MS-222.
17. Ensure all researcher working at LGW are accountable for anesthetic waste disposal in compliance with the EPA Clean Water Act.
18. Floor screen cleaner modification to allow backward movement that would eliminate continuous operational issues.
19. Modify side screen cleaners for reliability and ability to operate system in auto mode.
20. Replace temporary chain hoist on emergency bypass hatch with a permanent system that will enable the hatch to be operated as designed and reduce personnel safety concerns during fish rescues/dewatering.

APPENDIX TABLES

Appendix Table 1. Daily collection and bypass numbers and river conditions at Lower Granite Dam, 2019.

Appendix Table 2. Percent descaling and daily facility mortality numbers at Lower Granite Dam, 2019.

Appendix Table 3. Daily number of fish trucked and barged from Lower Granite Dam, 2019.

Appendix Table 4. Daily number of adult fallbacks and fallback mortality at Lower Granite Dam, 2019.