EVALUATION OF FOSTER DAM SPILLWAY AND GREEN PETER DAM SPILLWAY OPERATIONS FOR JUVENILE FISH PASSAGE

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Pacific Northwest National Laboratory (PNNL) conducted a fish passage and survival radio telemetry (RT) study for the U.S. Army Corps of Engineers – Portland District (USACE) during 2022. There were two efforts for this study, with results to help inform USACE biologists, engineers, resource managers, and regional decision makers. Both efforts are intended to help rebuild populations of Upper Willamette River Spring Chinook salmon (*Oncorhynchus tshawytscha*) and winter steelhead (*O. mykiss*) listed as threatened under the Endangered Species Act.

The first effort occurred at Foster Dam (Foster) and evaluated fish passage and survival and the efficiency and effectiveness of the interim nighttime spillway operations during spring (February 1–June 15) and fall (October 1–December 15) months as a benefit for passing juvenile Chinook salmon and winter steelhead. Results will inform the timing of operational adjustments for improved downstream fish passage at Foster.

The second effort occurred at Green Peter Dam (Green Peter) during spring only and provided a baseline evaluation of spring spillway operations for juvenile Chinook salmon passage. Two spill treatments were evaluated: nighttime only spill for two weeks (April 1–15) and continuous spill for 24 hours a day, 7 days a week (24/7 spill) for two weeks (April 16–30). Results will inform operations of the spillway for fish passage in 2023.

This presentation will focus on the spring 2022 study results at Foster and Green Peter, as the Foster fall 2022 study results are currently being analyzed. Although the primary effort was to evaluate the interim nighttime spillway operations at Foster, geographically Green Peter is located upstream of Foster on the Santiam River and will be presented first throughout the presentation.

The 2022 Green Peter effort was a baseline study to inform spillway operations and prepare for a larger-scale study in 2023. The objectives for the Green Peter effort were to release fish during nighttime only spill (no turbines) and 24/7 spill (no turbines) to assess the following metrics:

I. Diel distribution, behavior, and movements of juvenile Chinook salmon into and within the forebay of the dam.
II. Diel downstream passage, including reservoir survival, forebay residency time, dam passage efficiency, and reach survival.
    i. Reach survival will be measured to the confluence of the Santiam River with the mainstem Willamette River.

The objectives of the Foster effort were to determine if the nighttime spillway operations were a safer and more efficient passage route compared to the turbines for sub-yearling and yearling Chinook salmon and age-2 winter steelhead using the following metrics:

I. Seasonal and diel distribution, behavior, and movements of juvenile fish into and within the forebay of the dam.
II. Seasonal and diel downstream passage, including reservoir survival, forebay residency time, route distribution, dam passage efficiency, route specific survival, and reach survival.
    i. Reach survival will be measured to the confluence of the Santiam River with the mainstem Willamette River.
III. Efficiency and effectiveness of the nighttime spillway operation compared to the turbines.

Chinook salmon and winter steelhead surrogates (for wild fish in the South Santiam River) were provided by the Oregon State University Wild Fish Surrogate Program. Fish were double tagged with an RT tag and a Passive Integrated Transponder (PIT) tag (Tables 1 and 2).

Table 1. Spring 2022 sample sizes at Green Peter Dam by release dates, species, treatment, and release location in the reservoir. CH1 = yearling Chinook salmon.

Pool Elevation	Release Dates	Species	Treatment	Head-of-Reservoir (*n*)	Mid-of-Reservoir (*n*)	Green Peter Dam (dead fish) (*n*)	Total
974 ft	Apr 2 & 4	CH1	Nighttime spill	105	107	35	247
	Apr 16 & 17	CH1	24/7 spill	103	105	38	246
Total				**208**	**212**	**73**	**493**

Table 2. Spring 2022 sample sizes at Foster Dam by pool elevation, release dates, species, and release location in the reservoir. CH1 = yearling Chinook salmon and STH2 = age-2 winter steelhead.

Pool Elevation	Release Dates	Species	Head-of-Reservoir (*n*)	Mid-of-Reservoir (*n*)	Foster Dam (dead fish) (*n*)	Total
613 ft (Low Pool)	Mar 2–5	CH1	79	79	25	183
		STH2	160	160	25	345
	Mar 29–Apr 1	CH1	79	81	25	185
		STH2	163	164	24	351
	Total		**481**	**484**	**99**	**1,064**
635 ft (High Pool)	May 27–31	CH1	147	149	25	321
		STH2	211	210	25	446
	Jun 6–10	CH1	126	125	25	276
		STH2	235	238	26	499
	Total		**719**	**722**	**101**	**1,542**
Total			**1,200**	**1,206**	**200**	**2,606**

Reach survival was estimated through Green Peter and Foster dams to the confluence of the Santiam and Willamette rivers (88.5 river kilometers [rkm] downstream of Green Peter and 77 rkm downstream of Foster) using the Cormack-Jolly-Seber model adjusted for tag life within the

program ATLAS (Acoustic Tag Life-Adjusted Survival; Columbia Basin Research). Dam passage survival was estimated using the Virtual Release with Dead Fish Correction (ViRDCt) model to isolate dam and route-specific survival to a shorter river reach, because the reach survival estimates include mortality that occurs well downstream of the dams. ViRDCt estimated survival from passage through Green Peter Dam to an RT detection array located ~6.0 rkm downstream of the dam. At Foster, ViRDCt estimated survival from passage through Foster Dam to an RT detection array located ~2.5 rkm downstream of the dam. Preliminary survival results for both models are being analyzed and will be presented during the Willamette Fisheries Science Review.

Distribution and behavior results are presented by movement summaries and passage proportions. Movement summaries describe fish that were released but never detected on an RT array; fish detected at the dam but never passed; and fish that successfully passed the dam. Passage proportions describe the route of dam passage. Movement summaries and passage proportions of Green Peter-released fish are described at both Green Peter and Foster dams because Foster is downstream of Green Peter and juveniles are required to pass both dams during their migrations (Table 3). Passage proportions only describe movement through Green Peter (Table 4). For Foster-released fish, movement summaries and passage proportions only describe movement through Foster Dam (Tables 5 and 6, respectively).

Table 3. General statistics (sample sizes [*n*], lengths, weights) and movement summaries (proportions and *n*) of Chinook salmon released alive at the Green Peter head-of-reservoir or mid-of-reservoir. Lengths and weights depict the means with the ranges in parentheses. Movement summaries are described for Green Peter Dam (GPR) and Foster Dam (FOS).

						Never Detected at GPR[1]	Detected at GPR Dam Never Passed		GPR Downstream Passage		Detected at FOS Dam		Detected at FOS Dam Never Passed		FOS Downstream Passage	
Operational Treatment	Released Alive (*n*)	Fork Length (mm)	Weight (g)	Head-of-Reservoir (*n*)	Mid-of-Reservoir (*n*)	*n*	Proportion	*n*	Proportion	*n*	Proportion	*n*	Proportion	*n*	Proportion	*n*
Nighttime spill	212	163 (113–229)	45.1 (13.6–109.9)	105	107	56	0.19	30	0.81	126	0.48	61	0.11	7	0.89	54
24/7 spill	208	164 (102–219)	46.3 (13.5–109.2)	103	105	84	0.21	26	0.79	98[2]	0.46	44	0.11	5	0.89	39

[1]These fish were removed from the analyses because their final disposition was unknown.
[2]Two fish were caught in the screw trap in the GPR tailwaters and were removed from analysis after GPR downstream passage.

Table 4. Passage proportions of Chinook salmon that passed Green Peter Dam (GPR) during each operational treatment and by route. Two fish were caught in the screw trap in the GPR tailwaters and were included in the GPR passage proportions as the capture occurred after dam passage.

	GPR Downstream Passage *(n)*	Spill Passed		Turbine Passed		Total	
Operational Treatment		Proportion	*n*	Proportion	*n*	Proportion	*n*
April 1-16 at 0659 (Nighttime Spill)	126	0.992	117	0.008	1	0.527	118
April 16 at 0700-May 1 at 0659 (24/7 Spill)	98	1.000	106[1]	0.000	0	0.473	106[1]

[1]Fish released during the Nighttime Spill operation could pass during the 24/7 Spill operation, resulting in a greater number of fish that passed during the 24/7 Spill operation than the number of fish released.

Table 5. General statistics (sample size [*n*], lengths, weights) and movement summaries (proportions and *n*) of Chinook salmon (CH1) and winter steelhead (STH2) released alive at the Foster head-of-reservoir or mid-of-reservoir. Lengths and weights depict the means with the ranges in parentheses. Movement summaries of CH1 and STH2 are described for Foster Dam (FOS).

Pool Elevation	Species	Released Alive (*n*)	Fork Length (mm)	Weight (g)	Head-of-Reservoir (*n*)	Mid-of-Reservoir (*n*)	Never Detected at FOS[1]	Detected at FOS Forebay Never Passed		FOS Downstream Passage	
							n	Proportion	*n*	Proportion	*n*
Low Pool	CH1	318	158 (114–215)	38.7 (12.9–98.9)	158	160	39	0.38	106	0.62	173
	STH2	647	168 (114–221)	44.2 (13.8–109.7)	323	324	119	0.81	426	0.19	102
High Pool	CH1	547	182 (123–244)	59.0 (16.2–138.7)	273	274	75	0.26	121	0.74	351
	STH2	894	186 (115–239)	60.6 (14.1–124.6)	446	448	231	0.73	483	0.27	180

[1]These fish were removed from the analyses because their final disposition was unknown.

Table 6. Passage proportions of Chinook salmon (CH1) and winter steelhead (STH2) that passed Foster Dam (FOS) during the spring season. SP1–3 = Spill Bays 1, 2, and 3; SP4 = Spill Bay 4 (weir); PS1–2 = Penstock Units 1 and 2. The spill and turbine general indicate a specific route of passage (SP1–4 or PS1–2) was unable to be determined. No route identified indicates the fish passed the dam, but the route of passage was unable to be determined. Note: the weir was not in operation during the spring study.

Species	FOS Downstream Passage (*n*)	Spill Passed								Turbine Passed				Dam Passed					
		SP1		SP2		SP3		SP4		PS1		PS2		Spill – general		Turbine – general		No route identified	
		Proportion	*n*	Proportion	*n*	Proportion	*n*	Proportion	*n*	Proportion	*n*	Proportion	*n*	Proportion	*n*	Proportion	*n*	Proportion	*n*
CH1	524	0.05	27	0.27	139	0.35	183	0.32	166	0.01	4	0.00	0	0.004	2	0.00	0	0.01	3
STH2	282	0.08	23	0.21	60	0.19	53	0.46	130	0.02	6	0.02	5	0.004	1	0.00	1	0.01	3