Pacific Northwest
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Summary Memo on Juvenile Sockeye Rearing

WBS 4.2.1.601, Deliverable 2.1.1

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Jill Janak
Brian Bellgraph
Glen Manley

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1.0 Introduction

This memo includes information on the holding of sockeye broodstock and rearing of juvenile sockeye salmon for a technical support project to the Upper Columbia United Tribes under Milestone 2.1 (Deliverable 2.1.1) of the DOE-WPTO funded project WBS 4.2.1.601.

2.0 Background

The Upper Columbia United Tribes (UCUT) consortium as well as partner tribes including the Confederated Tribes of the Colville Reservation (CTCR), Spokane Tribe of Indians, and Coeur d'Alene Tribe of Indians (herein Tribes) are working on a multi-decadal reintroduction of Sockeye salmon and Chinook salmon to the blocked area of the Columbia River upstream of Grand Coulee Dam, Chief Joseph Dam, and three Spokane River dams. In 2022, the UCUT and Tribes requested assistance by Pacific Northwest National Laboratory (PNNL) researchers with expertise in acoustic telemetry studies to help them conduct several tasks in preparation for fish survival studies through Grand Coulee and Chief Joseph dams. The original tasks as part of this technical support project included: 1) Assisting with the spawning and rearing of sockeye salmon for use in reintroduction efforts because no other hatchery facilities within the watershed had capacity for rearing sockeye salmon, and to act as an interim rearing location until the Tribes can build their own rearing facility; 2) Performing an analysis of historical acoustic telemetry data that PNNL staff have collected for migrating juvenile salmon at other hydropower projects to determine optimization of acoustic telemetry gear installed at Grand Coulee and Chief Joseph dams; 3) Developing and testing a delayed-start acoustic transmitter compatible with the Juvenile Salmon Acoustic Telemetry System (JSATS) that could be implanted in small subyearling sockeye salmon, delay 6 months, and then ping for 6 months to learn about their migration behavior in future studies, and 2) Building a hydrodynamic model of the forebay or tailrace of Grand Coulee or Chief Joseph Dams. In 2025, the hydrodynamic modeling task and funds were repurposed to task #1 due to other entities performing hydrodynamic modeling and because UCUT desired further spawning and rearing of sockeye salmon.

3.0 Sockeye Broodstock and Juvenile Rearing

This memo covers activities from July 2024 to November 2025. In July 2024, the first cohort of adult sockeye salmon was brought to the Aquatic Research Lab at PNNL by staff from the CTCR. These fish were held, then spawned in the fall of 2024. Juvenile subyearling sockeye were released into Lake Roosevelt in July and September of 2025. Another group of adult sockeye were brought to PNNL in July 2025 and spawned in the fall of 2025; however, high mortality rates decreased the number of fish produced and the remaining fertilized eggs (about 5,000) were transferred to the Coeur d'Alene Tribe (CDAT) in November 2025 to finish rearing.

3.1 Brood Year 2024

In July of 2024, 26 adult sockeye salmon were captured in the Okanogan River by the CTCR and transported to the Pacific Northwest National Laboratory's Aquatic Research Laboratory (ARL). Ultrasound performed at the time of capture identified 13 males and 13 females. Males

and females were split evenly into two 8-foot-diameter circular fiberglass tanks outside the ARL, supplied with a mix of groundwater and chilled Columbia River water. Tanks were covered with a PVC-framed mesh enclosure that allowed fish to jump out of the water while minimizing the risk of injury. The enclosures were covered on the top with shade cloth that was fastened to the PVC frame with clamps. Early in the season, 4 mortalities occurred when fish jumped out of the tanks through small openings between the clamps. The shade cloths were reinforced with additional clamps, and no more fish escaped. Water quality was monitored daily, and Formalin treatments were carried out 2-3 times per week as needed to control fungus throughout the holding period. The average water temperature over the entire holding period was 14.2°C (SD = 0.98), and the average dissolved oxygen (DO) was 101.8% (SD = 2.4). Fish were held from July 18th until the last fish was ready to spawn on October 31st.

Between October 14th and October 31st, a total of 8 females were successfully spawned. Tissue samples were taken from each female at the time of spawning and sent to a diagnostic laboratory for pathology testing; all samples had negative results for all viruses tested, including Infectious hematopoietic necrosis virus (IHN), which was the primary virus of concern. After disinfection with iodophor, fertilized eggs were incubated in Heath trays inside the ARL supplied with Columbia River water at an average temperature of 8.2°C throughout incubation. Egg survival was generally high during incubation; however, eggs from the last egg take (2 females) had higher mortality. After the second round of picking eggs (removing mortalities after the eyed stage), we had an estimated 22,283 eggs, and the number of eggs per female ranged from 2,016 to 4,594. Approximately 5,000 eyed eggs were transferred to the CDAT to be raised at their facility, and PNNL retained the remaining ~17,000 eggs to raise in the ARL.

Once the hatched alevin had nearly depleted their yolk sacs, they were transferred from the incubation trays to rearing troughs and began feeding after a short acclimation period. Rearing temperature began at 10°C in March and was gradually increased to a maximum of ~17°C in July. Fish were measured bi-weekly to monitor growth rates and to update temperature regimes and feeding rations to achieve growth goals for target tagging sizes. The minimum fork length target for acoustic tagging was 95mm, and the minimum for Passive Integrated Transponder (PIT) tagging was 65mm. Although we ultimately met the target size for acoustic tagging in mid-July, the wide size distribution limited the number of fish large enough to PIT tag in June (conducted by BioMark under contract with CTCR at the ARL) and release with the acoustic fish in July. This resulted in an additional trip for Biomark staff in September to complete the PIT tagging once the fish were large enough. A total of 736 juvenile sockeye was tagged with acoustic transmitters and 7,717 with PIT tags and released above Grand Coulee Dam in July and September of 2025. Approximately 500 fish were retained at the ARL for potential use in future studies in the Spring of 2026, and the remaining ~8,000 fish were lost to a combination of natural mortality, an adverse mortality event due to insufficient flow, low DO levels, and insufficient trough screens in early rearing.

3.2 Brood Year 2025

For the second year of the project, 38 adult sockeye were transported to the ARL on July 16th, 2025, and split evenly between the two outdoor tanks. The adult holding tanks were set up very

similarly to the previous year, with only minor modifications to the inlet spray bars to reduce the potential for injury and to the center screens to improve drain flow. Although the fish transported to Richland were an equal mix of males and females, as determined by ultrasound at capture, some were rejected due to condition/injury on arrival, and we did not know the final sex composition of our broodstock. A mix of groundwater and chilled Columbia River water was delivered to the tanks at an average temperature of 14.3°C (SD = 0.4) throughout the holding period and an average DO of 97.6% (SD = 2.7). Water quality was monitored daily, and Formalin treatments were administered twice per week. The first pre-spawn mortality occurred on August 21st, and we lost a total of 4 males and 6 females over the entire holding period. The first fish was spawned on October 20th, and the last spawned on November 3rd. Low-quality males (i.e., reduced quantity or quality of gametes) were evident after the first spawning event, where fertilization and egg survival was very poor. After that, we adopted a 2:1 male: female spawning strategy to double the chances of successful fertilization and we observed higher fertilization and egg survival in the next 2 egg takes. We also encountered 2 females that had either non-viable or low-quality eggs. We successfully spawned 8 females. Tissue samples were taken from the females at the time of spawning and sent for pathology testing. Fertilized eggs were disinfected with iodophor and incubated in the ARL on chilled Columbia River water at ~10°C. Our final egg count from the 8 females that successfully spawned was approximately 20,000 eggs. Over the course of incubation, we continued to observe low egg viability and high mortality in eggs/embryos produced by multiple females, resulting in the loss of many of them. Approximately 5,000 eyed eggs were transferred to the CDAT for rearing at their facility, and approximately 300 fry are currently being raised at the ARL.

3.3 Brood Year Comparisons

Brood year 2025 had a significant number of pre-spawn mortalities compared to brood year 2024. Although we started with 12 additional adult fish in 2025, we ultimately ended up with ~7,000 fewer fertilized eggs due to a combination of higher pre-spawn mortality, lower quality gametes, and lower fertilization rates. There were no significant differences in the holding conditions of adults between years, except for higher tank densities in 2025. We started with a density of ~0.6 lbs/ft^3 in 2025 compared to ~0.4 lbs/ft^3 in 2024, which is still within the recommended range for long-term holding of adult salmon. Temperatures and DO were very similar between years, indicating adequate flow rates and overall good water quality. The spawning and fertilization protocols were essentially the same across years, except for the change in male:female ratio for fertilization after the first egg take in 2025. Pre-spawn mortality is an unfortunate yet common phenomenon in salmon populations, and rates can vary widely from year to year. Evidence suggests that environmental stressors during migration can contribute to pre-spawn mortality, including high temperatures, pathogens, and high flow conditions that increase metabolic demands and deplete energy stores before fish reach their spawning grounds. The average temperature recorded in the lower Okanogan River in June 2024 was 17.3°C compared to 20.7°C in June 2025. Communication with staff from the Okanogan Nation Alliance (ONA) sockeye hatchery indicated they had observed a similar pattern for their 2024 and 2025 brood years with higher pre-spawn mortality, lower quality of gametes, and lower fecundity in 2025 compared to 2024. It seems probable that warmer water temperatures in 2025 had a significant impact on the health and spawning success of Okanogan sockeye.

3.4 Lessons Learned and Next Steps

Broodstock and spawning success varied between 2024 and 2025, but followed the general trends observed for Okanogan sockeye during these years. Our communications with the ONA hatchery staff revealed very similar annual patterns in pre-spawn mortality, gamete viability, and fecundity between years. Since pre-spawn mortality is primarily attributable to higher temperatures and environmental stress before our sockeye arrived at the ARL, we plan to focus our efforts next year (2026 with funding from the UCUT) on improving the spawning process. To maximize fertilization rates, we plan to modify our spawning protocol by 1) collecting milt and eggs in separate containers so that we can observe milt under the microscope to confirm viability before fertilization, 2) starting with a 2:1 ratio of males:females, and 3) adding milt activator to gametes to increase the odds of fertilization.

Growing fish to a taggable size on schedule was a challenge we faced for brood year 2024. Space constraints in the ARL resulted in higher than ideal densities in rearing troughs that translated to slower growth rates and a wide distribution in size despite our best efforts to target optimal temperature regimes and feeding rations. To improve on this for brood year 2026, we plan to lower the densities in rearing troughs and invest more labor into hand-feeding fish. Hand-feeding at several intervals throughout the entire day will help decrease the spread in fish size that often accompanies the use of automatic feeders and should promote faster growth rates. Incubation temperatures may also be increased in 2026 to give sockeye an earlier start on feeding and put them ahead of schedule.

Pacific Northwest National Laboratory

902 Battelle Boulevard
P.O. Box 999
Richland, WA 99354
1-888-375-PNNL (7665)

www.pnnl.gov