Evaluation of Reservoir Drawdown Effects on Outmigration Behavior and Survival at the Lookout Point Project During Fall 2024

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A court-imposed interim injunction required the U.S. Army Corps of Engineers to undertake a suite of actions aimed at improving fish passage and water quality at several Willamette Valley Project dams since 2021. One injunction measure required initiation of novel operations at Lookout Point Dam during summer/fall to drawdown Lookout Point Reservoir to an elevation of 750 feet by mid-November and to hold the reservoir at this elevation for 30 days. The goal of the drawdown was to improve survival through Lookout Point Reservoir and volitional passage past Lookout Point Dam in the fall for juvenile Upper Willamette Chinook Salmon. The target life histories for the drawdown were salmon fry and subyearlings that entered the reservoir in the previous winter–spring and reared through summer in the reservoir, and subyearlings that enter the reservoir in summer and fall. The intent of drawing the reservoir to a minimum elevation approximately 100 feet lower than the pre-injunction rule curve was to allow fish to access and volitionally pass through the regulating outlets (RO) of Lookout Point Dam with high passage efficiency and survival. U.S. Geological Survey (USGS) was contracted to evaluate downstream migration behavior and to estimate reservoir and dam passage survival for the target populations using acoustic telemetry during the drawdowns of 2023 and 2024.

During 2023, we released acoustic-tagged juvenile Chinook Salmon weekly from late August to late October to determine how fish responded to the drawdown. We fit a time-integrated migration survival (TIMS) model to the detection history data for each individual fish in the study which allowed us to examine the effects of individual and environmental covariates on fish movement and survival. We found that fish size was a significant predictor of survival, as fork length was positively related to survival probability in reservoir and free-flowing river reaches of our study area but negatively related to survival probability for fish passing Lookout Point Dam. We also found that Lookout Point Reservoir became isothermic during the drawdown, and water temperatures exceeded 18 °C during most of September 2023; these increased water temperatures were shown to have a negative effective on survival. Additionally, we found that increased regulating outlet flow at Lookout Point Dam resulted in increased survival probability for juvenile Chinook salmon. Overall, the data suggest that the 2023 drawdown failed to create conditions that facilitated downstream passage and survival of juvenile Chinook Salmon through the Lookout Point Project, primarily because of very low survival associated with high water temperatures. However, there was also a short period in late fall 2023 after temperatures had moderated and when the drawdown reached the deepest levels where outmigrant movement and survival was relatively high.

We conducted an acoustic telemetry study during August 2024–January 2025 to evaluate outmigration behavior and survival of juvenile Chinook Salmon in the Middle Fork Willamette

and mainstem Willamette rivers during the 2024 drawdown. The study design was modified from the 2023 drawdown in certain aspects. A small number of fish (233) were released in early August 2024 with the intent to identify evidence of effects of the drawdown on in-reservoir survival for reservoir rearing subyearling Chinook Salmon. A larger number of fish (1963) were released over 9 weeks from mid-September through mid-November 2024 with the final releases occurring after the drawdown had reached the target elevation. In this presentation, we will provide preliminary findings on reservoir survival, passage timing, and passage and downstream survival in 2024 and make qualitative comparisons to the results from the 2023 drawdown.

Evaluation of Spill Operations at Foster and Green Peter Dams for Juvenile Fish Passage: Year 3

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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 2024. 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 maintain populations of Upper Willamette River Spring Chinook salmon (*Oncorhynchus tshawytscha*) and winter steelhead (*O. mykiss*), listed as threatened under the Endangered Species Act, in the South Santiam Basin.

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 and fall to provide continued evaluations of the spring spillway and fall drawdown operations for juvenile Chinook salmon passage. In spring, two spill treatments were evaluated: nighttime only spill (March 13–April 11) and continuous spill for 24 hours a day, 7 days a week (24/7 spill; April 11–May 13). The turbines were not operated during these two spill tests. In fall, after the reservoir was drafted to the drawdown elevation of 780 feet, the regulating outlet (RO) operations occurred from October 16–November 22. The ROs were operated 24/7 and the turbines were not operated during the RO operations. Results will inform Green Peter operations for the fish passage in 2025.

This presentation will focus on the spring 2024 study results at Foster and Green Peter, as the fall 2024 study period was ongoing at the time of abstract submission. Geographically, Green Peter is located upstream of Foster on the Santiam River and will be presented first throughout the presentation.

The 2024 Green Peter spring effort was to inform spillway operations as a benefit for fish passage. The objectives for the study 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 implanted with an RT tag and released in the Green Peter Reservoir or Foster Reservoir (Tables 1 and 2, respectively).

Table 1. Spring 2024 sample sizes (*n*) at Green Peter Dam by release dates, species, treatment, and release location in the reservoir. Yearling Chinook salmon is denoted by CH1.

Pool Elevation	Release Dates	Species	Treatment and Operational Dates	Head-of-Reservoir (*n*)[1]	Mid-of-Reservoir (*n*)[1]	Green Peter Dam (*n*)[2]	Total
Full Pool	Mar 13–14	CH1	Nighttime spill Mar 13–Apr 11	135	130	50	315
	April 19–20	CH1	24/7 spill Apr 11–May 13	133	134	50	317
Total				**268**	**264**	**100**	**632**

[1] Live fish release.
[2] Dead fish release.

Table 2. Spring 2024 sample sizes (*n*) at Foster Dam by pool elevation, release dates, species, and release location in the reservoir. Yearling Chinook salmon is denoted by CH1, and age-2 winter steelhead is denoted by STH2.

Pool Elevation and Operational Dates	Release Dates	Species	Head-of-Reservoir (*n*)[1]	Mid-of-Reservoir (*n*)[1]	Foster Dam (*n*)[2]	Total
613 ft Low Pool Feb 1–May 15	Feb 2–6	CH1	55	58	25	138
		STH2	299	305	25	629
	Mar 23–27	CH1	59	59	25	143
		STH2	318	313	24	655
	Apr 26–29	CH1	82	77	26	185
		STH2	186	183	15	384
	Total		**481**	**999**	**995**	**140**
635 ft High Pool May 21–June 15	May 21–23	CH1	126	129	37	292
		STH2	33	32	13	78
	May 30–June 1	CH1	129	127	39	295
		STH2	52	52	16	120
	Total		**340**	**340**	**105**	**785**

Total	**1,339**	**1,335**	**245**	**2,919**

[1] Live fish release.
[2] Dead fish release.

Reach survival will be 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 will be 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 estimates survival from passage through Green Peter Dam to an RT detection array located ~6.0 rkm downstream of the dam. At Foster, ViRDCt estimates 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 Science Review.

Distribution and behavior results will be 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 for those fish that successfully passed the dam. Movement summaries and passage proportions of Green Peter-released fish will be 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. Passage proportions only describe movement through Green Peter. For Foster-released fish, movement summaries and passage proportions only describe movement through Foster Dam. Preliminary distribution and behavior results for dams are being analyzed and, if time permits during the presentation, will be presented during the Willamette Science Review.

The Influence of Reservoir Elevation on In-Reservoir and Downstream Water Temperatures: Implications for Fish

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The U.S. Army Corps of Engineers (USACE) operates and maintains a system of 13 dams and reservoirs within the Willamette River Basin, Oregon. This system operates for multiple authorized purposes including: Flood Damage Reduction, Hydropower, Navigation, Water Quality, Irrigation, M&I, Recreation, and Fish and Wildlife. Re-establishing Spring Chinook above dams with historic populations is an important tool to improve the status of fish listed under the Endangered Species Act. Management of stored water can influence water quantity and quality within and downstream of the dams. Implementation of injunction operations including spill, delayed refill, and drawdowns significantly changed water management at Willamette Project Dams. This presentation summarizes changes in water management at the Willamette Project and the influence on water temperatures in-reservoir and downstream with implications for fish.

Effects of dam operational changes on the incidence of eight types of injury in juvenile Chinook salmon at Willamette Valley System dam tailraces

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High head dams have contributed to Spring Chinook salmon (*Onchorhynchus tsawytscha*) populations in the Upper Willamette River (UWR) being listed as threatened under the Endangered Species Act. In 2021, the District of Oregon Court issued an interim injunction that required the US Army Corps of Engineers (USACE) to undertake specific measures to improve downstream fish passage and water quality at several Willamette Valley System (WVS) dams to benefit UWR Chinook salmon populations. The measures included deeper drawdowns of reservoir pool elevations late in the year, delayed reservoir refill in the spring, spreading of surface spill across an increased number of gates, and daytime-only turbine operations, with the aim to reduce reservoir residence times and allow fish to migrate volitionally while reducing risks of injury during dam passage. We used data recorded on injuries in juvenile Chinook salmon captured in rotary screw traps (RST) sited in dam tailraces to evaluate whether injury rates were affected by the injunction measures. To prepare these data for statistical analysis, injury counts at each RST site were first adjusted by trap efficiency (TE) estimates obtained from the statistical analysis of other data associated with release and recapture experiments at each RST site.

RST records on injury rates were available in periods before (2003-2016) and during (2021-2023) implementation of the injunction measures at nine tailrace RST sites located below Big Cliff, Cougar, Fall Creek, Lookout Point, and Hills Creek dams. In both periods, RST operators recorded incidence of over two dozen injury types on both live and dead fish captured in each trap event (typically 1–2-days). We consolidated these into eight broader categories for statistical analysis: body/fin injury, body/head missing or nearly decapitated, evidence of internal bleeding and bloating, head injury, eye damage, major descaling, gill damage, and copepod infection. We did not consider gas bubble disease, fungal infection or predation-related injuries within this analysis.

For each RST site, we used binomial regression to assess if there was a statistically significant injunction effect on the proportion of captured fish with a given injury category. TE-adjusted observations of each injury category were fitted individually, with the proportion of fish reported to have a given injury type in a trapping event serving as the dependent variable with a single explanatory factor, injunction period (before or during). Each trap event was weighted by the TE-adjusted numbers of Chinook salmon caught. At most RST sites there was no overlap in operator between periods, i.e., different operators ran traps in each period. Some RST sites during the injunction measures implementation period were run by different operators; therefore within this period at these sites we also tested for operator as an explanatory factor. Fall Creek provided the only opportunity to compare operator and injunction effects together; this is because the same operator ran the trap for several months during implementation of injunction measures and was the only RST operator at Fall Creek before the injunction period. For this site we fitted four

candidate models to explain observed injury rates: 1) a constant-only model; 2) a model including only injunction period as an explanatory variable; 3) a model including only operator as an explanatory variable; and 4) a model including both operator and injunction period.

Body injury was the most prevalent injury type across all sites. At most RST sites, rates of body and head injuries and eye and gill damage were significantly higher during implementation of injunction measures and reporting rates of these injuries also differed between operators during this period. The proportion of fish captured in an RST with only a head, only a body, or nearly decapitated was not consistently higher or lower during implementation. Considering fish with major descaling, there was only a significant injunction period effect at the Cougar powerhouse site, with increased reporting of descaling during injunction measures implementation. At Big Cliff, despite no significant difference in injury reporting before and with injunction measure implementation, reporting of major descaling differed between operators. Compared to most other injury types, copepod infection rates were relatively high and commonly reported during both periods. At several RST sites, the reported proportion of fish having a copepod infection was significantly higher during injunction measure implementation period, with no site reporting a significant reduction in copepod infections. There were both positive and negative injunction effects on internal bleeding and bloating. At Cougar RO and Big Cliff RST sites there was a significant reduction in internal bleeding and bloating injury reporting during the injunction period, but significant increases at Cougar powerhouse, Fall Creek, Hills Creek and Lookout Point powerhouse RST sites. At the Cougar RO and Fall Creek tailrace RST sites, internal bleeding and bloating rates differed by operator. At Fall Creek, the optimal model included both operator and period with or without injunction, as explanatory variables where for most injury categories, reporting of that injury increased with injunction implementation and differed between operators.

Injunction measure effects on injury and body condition were mostly unexpected. At many dam tailrace RST sites and for many injury categories, especially those with consistent and high reporting across sites like body injury, injury rates were higher during implementation of injunction measures. Only a few injury categories at a few sites declined during the injunction period, such as reduced incidence of decapitation at the Cougar RO trap. We recognise that these results do not indicate conclusively that injury rates increased as a result of injunction measures. At all sites except for Fall Creek, the RST operator changed between injunction periods, such that differences between operators may be obscuring an effect of injunction measures on injury rates. Supporting this is our finding that at many sites with significant differences in injury reporting with the change to implementation of injunction measures, there was also a statistically significant effect of operator (but not in all cases). Our more in-depth analysis comparing operator and injunction effects at Fall Creek indicated that both operator and injunction period were informative to observed injury rates of all categories.

Quantifying Changes in Project Passage Efficiency (PPE) of juvenile salmonids in Upper Willamette Valley Reservoirs and Dams

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We present a new fish passage metric, i.e., project passage efficiency (PPE), which represents the fraction of the juvenile salmonid downstream migrants at head of reservoir that successfully pass and survive their downstream journey through the reservoir to the dam tailrace. This is a cumulative project passage metric that takes the product of all of the passage and survival components going from head of reservoir to dam tailrace, i.e., including the fraction of juvenile salmonids surviving residence within the reservoir, the proportion of juvenile migrants that approach the dam that successfully make it through to the dam tailrace (dam passage efficiency (DPE)), and the proportion of those migrants making it through the dam that survive through to the dam tailrace (dam passage survival rate (DPS)). PPE can be computed for a single juvenile migrant type, e.g., fry, subyearling or yearling, based on expected arrival at the dam tailrace, or for an entire cohort based on the sum of all of its migrant types at the dam tailrace to indicate PPE for the entire cohort originating from a given broodyear of spawners. While there exist other useful passage metrics such as DPE and DPS, these by themselves do not necessarily correlate well with the total cumulative passage and survival of migrants from the head of reservoir to tailrace and resulting from the cumulative experience of a juvenile migrant from the time it enters the reservoir to when it may reach the dam tailrace. For example, with an earlier initiation of a fall drawdown, reservoir survival rate could be increased due to shortened residence time in the reservoir; however, dam passage survival could remain relatively low due to high rates of injury during dam passage. Alternatively, the survival rate in reservoir, DPE and DPS could all be higher due to a deliberate modification to dam operations and the net increase in cumulative PPE could be considerably higher than the net increase in any one of the individual components to PPE. The PPE metric thus represents the total project passage survival rate and thereby allows the assessment of the net effect on total survival rate from head of reservoir to tailrace from modifications to dam operations.

Using currently available data, PPE can be quantified using either tagging study records (e.g. PIT tags) or using Rotary Screw Trapping (RST) records corrected for trap efficiency (TE) from head of reservoir (HOR) and dam tailrace. The ratio of average catch rates at the dam tailrace RST to average catch rates of the same cohort at the HOR RST provides a directly measurable index for PPE for a given juvenile migrant type. Potential advantages of the use of RST records to quantify PPEs are as follows: 1) RSTs sited at dam tailrace sample downstream migrating natural origin juvenile salmonids that have survived and successfully passed the reservoir and dam and provides a cumulative measure of a cohort's success rate in passing the entire set of mortality risks and impediments to downstream migration from head of reservoir to dam tailrace. 2) The data used to compute PPE are derived from records of natural origin migrants captured in the RSTs; i.e., this avoids the difficulties of interpretation associated with the use of hatchery origin or surrogate fish in active tag studies which may behave differently than downstream migrating

untagged natural origin fish. 3) Assessment of PPE is not limited by the threshold minimum length of about 65 mm of fish that can be tagged with e.g., PIT or radiotelemetry tags, and the PPE of migrant fish of any size including those less than 65 mm in fork length can be assessed providing that RST records are appropriately corrected for TE. Unlike other available fish passage metrics, PPE thus provides a direct and wholistic empirical measure of project passage efficiency for a given cohort of natural origin fish.

To illustrate the use of PPE to evaluate project-wide effects of recent changes to operations of dams in the Upper Willamette Valley (UWV) Dams, we carried out statistical tests of whether PPE for juvenile Chinook salmon migrants has increased with the 2021 implementation of injunction measures on the Cougar, Lookout Point, and Fall Creek Dams. For fry and subyearlings, two years of RST records were available at the time of writing which enabled statistical estimation of an effect of injunction measures implementation on each of these dams. The injunction measures at the Cougar Dam included increased spring spill over the spillway and an earlier start to fall drawdown to regulating outlet (RO). Injunction measures at the Lookout Point Dam included modifying operations to increase the length and amount spill over the spillway in the spring, temporary stoppage of turbine operation in the spring, and a deep fall drawdown for one month in the late fall. Injunction measures at the Fall Creek Dam included operations to increase the period of spill in the spring, and a fall drawdown to riverbed as previously but extending the drawdown by one month.

We computed PPE separately for fry and also subyearling natural origin spring Chinook salmon at each of these dams, using RST records compiled and corrected for TE for years prior to and following the implementation of the above-mentioned injunction measures. We were unable to carry out statistical tests on PPE for yearlings because data for the second year with injunction implementation were not yet available and we required at least two years of RST records both prior to, and with injunction measures implemented, to carry out a statistical test.

For all three dams, parameters estimates were relatively imprecise due to the large amount of variability in RST records at each dam. Despite this, for all three dams, statistical models that included an injunction measures effect on PPE were among the best performing models based on the Akaike Information Criterion, AIC, i.e., models that had an AIC that was within two AIC units of the model with the lowest AIC. The best performing models also often included outflow at the dam as a linear covariate to explain variability in RST catch rates at the tailrace. For each dam we report results here on the best performing model that included an injunction measures effect. For the Cougar Dam, mean PPE for fry at the dam tailrace in spring months increased by a factor of 3.8 (Coefficient of Variation (CV) = 0.51) with the implementation of injunction measures. Mean PPE for subyearlings at the dam tailrace in the autumn increased by a factor of 80 (CV=0.14) with injunction measures implementation. For the Fall Creek Dam, mean PPE for fry at the dam tailrace in spring months increased by a factor of 1.5 (CV=1.3) with injunction measures implementation. Mean PPE for subyearlings at the dam tailrace in the autumn increased by a factor of 18 (CV=1.4) with injunction measures implementation. For the Lookout Point Dam, mean PPE for fry at the dam tailrace in spring months increased by a factor of 11.6 (CV = 1.3) with injunction measures implementation. Mean PPE for subyearlings at the dam

tailrace in the autumn increased by a factor of 6.3 (CV=0.78) with injunction measures implementation.

The estimated relatively small to large, i.e., 1.5 to 12-fold increases and large, i.e., 6 to 80-fold increases in mean PPE for fry and subyearlings, respectively, with the implementation of injunction measures at all three dams, suggests that they are leading to measurable and potentially substantial increases in PPE for downstream migrating juvenile Chinook salmon. To some extent, the large increases in estimated PPE could result from improvements in reservoir survival rates, reservoir and dam passage efficiency and also dam passage survival, rather than an improvement in just a single one of these. It is also possible that the surprising large estimated increases in estimated PPE could be a result of improved conditions for capture of juvenile Chinook salmon at dam tailraces following the injunction. For example, at the Fall Creek Dam, the period of drawdown was extended from two to six weeks and this could have led to much improved conditions for catching juvenile Chinook salmon below the dams and might not fully reflect a large increase in PPE as it appears to. The larger estimated increases in mean PPE for subyearlings than for fry may be plausible because the most common juvenile migrant type in spring Chinook salmon in UWV reservoirs has previously been found to be subyearlings and the more pronounced flows through the dams in fall with the injunction measures could be moving much larger numbers of subyearlings in the fall than previously.

Estimates of the rate of increase in PPE with change in dam operations in 2021 for two of the three dams were imprecise, with coefficients of variation between 0.8 and 1.5. This occurred due to the highly variable catch rates in RSTs sited at their tailraces, i.e., most catch rates being either very low or zero but with there being a few extremely large PPE ratios in the RST records when the injunction measures were in force but none so large prior to injunction measures implementation. For these dams, it could take another two to four years of monitoring before mean PPE estimates under injunction measures could become reasonably precise. The mean PPEs for fry and subyearlings at the Cougar Dam, however, were quite precisely estimated. The numerous TE experiments at the Cougar Dam RO tailrace RST site suggest that TE is relatively high and not that variable at this site, and thus allow for relatively precise estimates of changes in mean PPE within a few years at this site.

In addition to continued RST operation at heads of reservoir and dam tailraces to provide updates to estimates of mean improvements in PPE at given dams, it appears to be advantageous to continue to quantify also each of the component passage performance metrics associated with reservoir passage and survival and also dam passage and survival to better understand how juvenile salmonids in each of these components are being impacted by the recent changes to dam operations.

Next steps for this new analysis will be to estimate PPE for yearling Chinook salmon, now that two full years of RST records have accumulated for them following the initiation of injunction measures to UVS dam operations. This will also allow the computation of PPE for each brood year cohort for years both prior to, and with the implementation of injunction measures.

Willamette Valley Downstream Fish Passage Monitoring Project – Bulk Marking Task

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Cramer Fish Sciences was contracted by the U.S. Army Corps of Engineers to tag juvenile Chinook salmon with Passive Integrated Transponder (PIT) tags in 2023 and 2024. The project's goal is to evaluate the downstream movement patterns of juvenile Chinook salmon in response to water management strategies outlined in the Interim Injunction Order issued by the U.S. District Court of Oregon. The tagging occurred in the South Fork McKenzie, Middle Fork Willamette, South Santiam, and North Santiam subbasins, with juvenile Chinook salmon marked and released starting in May 2023. This effort is scheduled to continue through April 2025.

We have PIT tagged and released a total of 417, 727 juvenile Chinook salmon within the project area to date. Of those, 49,281 were released within the South Fork McKenzie subbasin, 166,333 within the Middle Fork Willamette subbasin, 92, 929 within the South Santiam subbasin, and 83,906 within the North Santiam subbasin. As of December 31, 2024, a total of 5,762 PIT-tagged fish have been recaptured or detected passing PIT tag arrays, yielding an overall detection rate of approximately 1.5%. The highest detection rate was observed for fish released into the South Fork McKenzie (n = 2,637; detection rate = 5.3%). In contrast, downstream detection rates for fish released in the Middle Fork Willamette and South Santiam basins were lower, with 1.1% of released fish detected (n = 1,748 and n = 1,102, respectively). The lowest detection rate was recorded for fish released in the North Santiam (n = 334; detection rate = 0.4%).

Rotary screw traps have detected the largest number of PIT tagged fish released overall (n = 4,162) and were the dominant detection method in the Middle Fork Willamette, South Fork McKenzie, and North Santiam basins. Instream PIT tag antenna arrays have accounted for a total of 1,190 detections and have detected the greatest number of fish recaptured from releases in the South Santiam basin. Additionally, the Columbia River Estuary Towed Array has detected 202 PIT-tagged fish from this study and the Bird Predation Mark Recovery project recovered 145 PIT tags in the Columbia River. Lastly, trap nets and gill nets deployed in Lookout Point Reservoir and Green Peter Reservoir have recaptured 97 PIT-tagged fish.

We calculated detection rates and travel times for each group of PIT-tagged fish and compared these metrics to dam operations implemented under the Injunction Measures. Broadly, our results indicate that detection rates increased and travel times decreased for fish released either just before or during dam operations designed to facilitate fish passage, such as reservoir elevation drawdowns, spill events, and regulating outlet operations. Additionally, fish released closer to the dam (e.g., in the forebay versus the head of the reservoir) exhibited higher detection rates and

faster travel times. This presentation will provide an overview of our tagging efforts to date and present a comparative analysis of detection rates and travel times in relation to dam operations.

Willamette Valley Fish Passage Monitoring Via Rotary Screw Traps

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Environmental Assessment Services (EAS) has conducted fish passage monitoring, utilizing rotary screw traps (RSTs), for the U.S. Army Corps of Engineers – Portland District (USACE) starting in October 2021 and which is ongoing at present. The data presented herein is for monitoring efforts conducted in 2024. The purpose of this study is to evaluate the biological effects of certain measures being implemented to improve fish passage and water quality at several WVP dam sites to benefit UWR spring Chinook salmon (*Oncorhynchus tshawytscha*) and winter steelhead (*Oncorhynchus mykiss*) as required under the Interim Injunction Order issued by the U.S. District Court for the District of Oregon. RST sampling, as part of this project, has occurred at the Breitenbush River, North Santiam River above Detroit Reservoir, Big Cliff Dam tailrace, Green Peter Dam tailrace, Green Peter Head of Reservoir- Middle Santiam River, Foster Dam Head of Reservoir- South Santiam River, Cougar Dam tailrace, Cougar Dam Head of Reservoir, Fall Creek Dam RO tailrace, Fall Creek Dam Head of Reservoir, Dexter Dam tailrace, Lookout Dam tailrace, Lookout Point Head of Reservoir, Hills Creek Dam tailrace, and Hills Creek Head of Reservoir- Middle Fork Willamette River.

The goals of this study are to provide juvenile salmonid data (e.g. emigration timing, injuries, and survival) in relation to dam passage and Army Corps operations including passage by route (e.g. powerhouse vs spillway, where feasible), and characterize injuries including mortality after 24 hour holds following capture in RSTs. Target species include wild Chinook salmon at all sites, and steelhead on the Santiam River (Breitenbush River, North Santiam above Detroit Reservoir, Big Cliff Dam, Green Peter Dam, Green Peter Head of Reservoir- Middle Santiam River, and Foster Dam Head of Reservoir). Additionally, trap efficiency (TE) trials were conducted with hatchery Chinook, and natural origin run of river (RoR) Chinook and Steelhead where possible.

During monitoring in 2024, the primary objectives were to operate RSTs to determine species composition, passage timing, and collect biological information including condition data (e.g., injuries) of fish passing the respective sample sites. RSTs were checked once per day unless conditions necessitated additional checks for fish and/or trap safety. Upon arrival at a trap site, crews collected data on cone rotation speed, cone rotation count from last check to current check, water temperature at trap, and time of fish collection. Additional environmental data was collected from U.S. Geological Survey gauges and USACE dam operations data and included inflow, outflow by route, water temperature, and dissolved oxygen concentration, where available. Biological data was collected for each target fish EAS captured (juvenile Chinook salmon and *O. mykiss* in the Santiam River sub-basin). Data collected included species, fork length (FL), weight, fish condition, injuries, and assessment of presence of tags or other marks. Scales were collected from fish >50 mm FL, and fin clips for future DNA analysis were collected from fish >45 mm FL. All fish with a FL 65 mm or larger, not being placed into a 24-hour hold to investigate delayed mortality from passage and capture, were PIT tagged and released. At the Breitenbush River, North Santiam River above Detroit Reservoir, Green Peter Head of Reservoir- Middle Santiam River, Cougar Dam Head of Reservoir, Fall Creek Head of Reservoir, Lookout Dam, Lookout Point Head of Reservoir, Hills Creek Dam, and Hills Creek Head of Reservoir- Middle Fork Willamette River

sites, fish smaller than 65 mm and larger than 35 mm were marked with visible implant elastomer (VIE). At the Foster Head of Reservoir- South Santiam Site, target fish between 45 and 64 mm in fork length were tagged with 8mm PIT tags. A summary of data for 2024 sampling collected by site is provided in Table 1.

Table 1. Summary of data collected at each RST site in 2024.

Rotary Screw Trap Sampling Site	Trap Efficiency Trials	Target Species	Biological and Injury Data	Scale and DNA Samples	24-hour Holds (post collection)	PIT Tagging (>65 mm)	Elastomer Tagging (<65 mm)
Breitenbush River	Yes, Run of River Fish, Hatchery Fish	Spring Chinook and *O. mykiss*	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes	Yes
Detroit Head of Reservoir – North Santiam River	Yes, Run of River Fish, Hatchery Fish	Spring Chinook and *O. mykiss*	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes	Yes
Big Cliff Dam	Yes, Hatchery Fish	Spring Chinook and *O. mykiss*	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hour holds	No
Green Peter Head of Reservoir – Middle Santiam River	Yes, Run of River Fish, Hatchery Fish	Spring Chinook and *O. mykiss*	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes	Yes
Green Peter Dam Tailrace – Middle Santiam	Yes, Run of River Fish, Hatchery Fish	Spring Chinook and *O. mykiss*	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	No
Foster Head of Reservoir – South Santiam River	Yes, Hatchery Fish	Spring Chinook and *O. mykiss*	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes, on fish 45 mm in FL and larger	No
Cougar Dam Head of Reservoir	Yes, Run of River Fish, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes	Yes
Cougar Dam Tailrace	Yes, Run of River Fish, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	No
Fall Creek Head of Reservoir	Yes, Run of River Fish, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	No	No
Fall Creek Dam	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes	No
Hills Creek Head of Reservoir – Middle Fork Willamette River	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes	Yes
Hills Creek Dam	Yes, Run of River Fish, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	Yes, on fish not included in 24-hr holds

Rotary Screw Trap Sampling Site	Trap Efficiency Trials	Target Species	Biological and Injury Data	Scale and DNA Samples	24-hour Holds (post collection)	PIT Tagging (>65 mm)	Elastomer Tagging (<65 mm)
Lookout Point Head of Reservoir	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes	Yes
Lookout Dam Tailrace	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	Yes, on fish not included in 24-hr holds
Dexter Dam Tailrace	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	No

*Run of River trials are performed at all sites when sufficient numbers of natural origin fish of a markable size are captured. Sites denoted with Run of River trials are those that received enough fish meeting our criteria to perform trials in 2024.

Trap Efficiency Trials. A total of 146 trapping efficiency trials occurred using marked hatchery Chinook in 2024. In addition to the hatchery fish trials, efficiency trials utilizing RoR fish occurred at the Breitenbush River, Detroit Head of Reservoir- North Santiam, Green Peter Head of reservoir- Middle Santiam, Green Peter Dam tailrace, Foster Head of Reservoir- South Santiam, Cougar Head of Reservoir, Cougar Dam, Fall Creek Head of Reservoir, and Hills Creek Dam sites. Recapture data was evaluated by site across variables such as flow, cone revolutions, and brood year. Additional trials will be conducted in 2025 to further evaluate these and other variables impacting the capture efficiency of RSTs at each site.

Target catch and passage. Total target raw catch consisted of 35,423 juvenile Chinook and 1,713 O. mykiss captured at all sites during sampling in 2024. Where dam operations allowed, daily catch rates were standardized and weekly catch was calculated from the standardized daily catch rates. Building on the work of previous studies in the area, EAS calculated weekly passage estimates based on TE trials (see above) Passage estimates by site are presented in Table 2.

Table 2. Raw catch, Passage Estimates with 95% confidence intervals of target species by site and route captured in 2024, where possible.

Site	Route	Species	n	Passage est.	95% C.I.
Breitenbush River		Chinook	3,329	57,064	39,986 to 99,608
Breitenbush River		*O. mykiss*	512		
Detroit HOR- North Santiam		Chinook	27,536	416,042	318,780 to 598,710
598,710Detroit HOR- North Santiam		*O. mykiss*	305		
Big Cliff Dam	Tailrace	Chinook	1,472	21,762	18,008 to 27,496
Big Cliff Dam	Tailrace	*O. mykiss*	122		
Green Peter HOR- Middle Santiam		Chinook	811		
Green Peter HOR- Middle Santiam		*O. mykiss*	26		
Green Peter Dam	Tailrace	Chinook	247	18,668	14,924 to 24,921

Site	Route	Species	n	Passage est.	95% C.I.
Green Peter Dam	Tailrace	*O. mykiss*	10		
Foster Dam HOR		Chinook	42	735	497 to 1,410
Foster Dam HOR		*O. mykiss*	738		
Cougar Dam HOR		Chinook	278	7,165	6,060 to 8,764
Cougar Dam	Powerhouse	Chinook	323	2,629	2,118 to 3,465
Cougar Dam	RO	Chinook	885	14,777	11,744 to 19,923
Fall Creek Dam HOR		Chinook	7	41	29 to 68
Fall Creek Dam	RO	Chinook	14		
Hills Creek HOR- MF Willamette		Chinook	47	2,134	1,252 to 7,238
Hills Creek Dam	Powerhouse	Chinook	254	3,612	2,606 to 5,884
Hills Creek Dam	RO	Chinook	88	4,980	3,461 to 8,880
Lookout Point Head of Reservoir		Chinook	56	2,283	1,420 to 5,816
Lookout Dam	Powerhouse	Chinook	71		
Lookout Dam	Spill	Chinook	28		
Dexter Dam	Tailrace	Chinook	35	6,587	5,013 to 9,600

Injuries. A total of 5,438 (15.4%) Chinook salmon displayed at least one of the injury codes listed in Table 4. The most common injuries observed, excluding the presence of copepods, were descaling less than 20% and fin damage, some of which likely incurred upon capture in the RST. Table 4 provides a list of injuries assessed on captured fish by type.

Table 4. Injury codes for Willamette Valley Downstream Fish Passage Monitoring Injury Assessments.

Description of Injury/Condition	Injury Code	Injury Category
Live fish with no external injuries	NXI	N/A
Mortality with no external injuries	MUNK	N/A
Descaling <20%	DS<2	N/A
Bloated	BLO	Barotrauma
Bloody Eye (hemorrhage)	EYB	Barotrauma
Bleeding from Vent	BVT	Barotrauma
Fin Blood Vessels Broken	FVB	Barotrauma
Gas Bubble Disease (fin ray/eye inclusions)	GBD	Barotrauma
Pop Eye (eye popping out of head)	POP	Baro/Mech
Head Injury	HIN	Mechanical
Operculum Damage	OPD	Mechanical
Body Injury (tears, scrapes, mechanical damage)	TEA	Mechanical
Bruising (any part of the body)	BRU	Mechanical
Hole Behind Pectoral Fin	HBP	Mechanical
Descaling >20%	DS>2	Mechanical
Head Only	HO	Mechanical
Body Only	BO	Mechanical
Head Barely Connected	HBO	Mechanical
Fin Damage	FID	N/A

Description of Injury/Condition	Injury Code	Injury Category
Predation Marks (vert. claw or teeth marks)	PRD	N/A
Copepods (on gills or fins)	COP	N/A
BKD (distended abdomen)	BKD	N/A
Fungus	FUN	N/A

Willamette Valley Downstream Fish Passage Monitoring Project

Reservoir Distribution Studies Task

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Cramer Fish Sciences (CFS) has been conducting juvenile salmonid sampling in Lookout Point and Green Peter Reservoirs under contract with the U.S. Army Corps of Engineers since 2023, as part of an ongoing monitoring effort. This presentation summarizes findings from sampling conducted in 2024. The project aims to assess juvenile Chinook salmon (*Oncorhynchus tshawytscha*) and winter steelhead (*O. mykiss*) habitat use, longitudinal distribution, and growth in relation to water management strategies implemented under the Interim Injunction Order issued by the U.S. District Court of Oregon. Sampling in 2024 took place from February through November.

Nearshore sampling was conducted biweekly in both reservoirs beginning in February and continued through mid-June using small Oneida Lake traps and box minnow traps. A stratified random sampling design was used to select daily trap placement locations within each reservoir zone (Lower, Middle and Upper). Captured Chinook salmon and *O. mykiss* were enumerated, examined for marks (adipose fin clips, PIT or VIE tags), measured for fork length and weight, given a body condition examination (including for presence of parasitic copepods), and if untagged, were given a PIT tag. Offshore reservoir sampling was conducted using small mesh suspended gill nets set at six fixed sites spread along the longitudinal axis of each reservoir. Gill net sampling occurred from mid-June through early November in Green Peter Reservoir and through late November in Lookout Point Reservoir. Limnological sampling (vertical profiles of temperature, dissolved oxygen and turbidity) were taken coincident with fish sampling events.

Nearshore sampling during 2024 in Lookout Point Reservoir spanned from February 05 – June 12 and consisted of n=247 box minnow sets and n=85 Oneida lake trap sets. Target species catch consisted of 3 hatchery yearling Chinook salmon (all bulk marking project recaptures), 5 natural origin Chinook salmon subyearlings, 10 natural origin Chinook salmon yearlings, 37 natural origin *O. mykiss* (adipose intact) juveniles (<200mm), and 2 natural origin *O. mykiss* adults (>200mm). Hatchery Chinook salmon were captured in the middle and lower reservoir zones during February and April. Natural origin Chinook salmon were captured in the upper and middle zones (none in lower) with highest catches seen during February. Natural origin *O. mykiss* were caught in all reservoir zones with highest catch rates in February, April and May. Overall, Lookout Point Reservoir nearshore catch rates were very low. Weekly mean surface water temperatures of nearshore trap sets ranged from 7.2 – 20.4ºC.

Offshore sampling in Lookout Point Reservoir during 2024 was conducted using suspended small mesh gill nets. Sampling occurred from mid-June through late November and consisted of n=216 sets. A total of 123 hatchery subyearling Chinook salmon, 2 hatchery yearling Chinook salmon, 50 natural origin Chinook salmon subyearlings, 4 natural origin Chinook salmon yearlings, 86 natural origin adult (>200 mm) *O. mykiss* and 4 juvenile (<200 mm) natural origin *O. mykiss* were captured. No juvenile Chinook salmon tagged with PIT tags as part of the bulk marking project were recaptured during 2024 gill net sampling in Lookout Point Reservoir. In late June, all subyearling Chinook salmon were captured in the lower reservoir zone nearest the dam. During July and August, subyearlings were distributed across the longitudinal extent of the reservoir. Starting in September, reservoir drawdown and declining water levels prevented sampling in the upper zone, and by late fall, the middle zone was also too shallow to access. Consequently, all Chinook salmon during these months were captured at stations within the lower zone. Natural origin *O. mykiss* were captured in the upper zone during June, and were predominately captured in the upper and lower zones during July. Beginning in August, natural origin *O. mykiss* were exclusively captured in the lower reservoir zone.

In Green Peter Reservoir, nearshore sampling was conducted from February through mid-June and consisted of n=257 box minnow trap sets and n=104 Oneida lake trap sets. Target species catch was comprised of 6 subyearling hatchery Chinook salmon (5 bulk marking project recaptures), 2 hatchery Chinook salmon yearlings (2 bulk marking project recaptures), 47 natural origin Chinook subyearlings, 3 natural origin Chinook salmon yearlings, 1 natural origin *O. mykiss* adult, and 11 natural origin *O. mykiss* juveniles. Catch of hatchery Chinook salmon occurred in the lower, upper and Quartzville zones during February and March, but catches were only seen in the upper zone during May and June. Natural origin Chinook salmon were found in all zones of the reservoir, but the largest catches occurred during February and March in the upper and middle zones. Fork lengths of natural origin Chinook salmon caught in the upper zone tended to be smaller than those seen in other zones. Natural origin *O. mykiss* were caught in the greatest number during February, spread between the upper, lower and Quartzville zones. Weekly mean surface water temperatures of trap locations ranged from 8.0 – 18.2°C.

Offshore sampling in Green Peter Reservoir for 2024 began in mid-June and continued through the first week of November, consisting of n=336 gill net sets. Over the course of the sampling season, a total of 1 adult Chinook salmon (an ODFW floy-tagged specimen that was a fallback from the outplant on the Middle Santiam), 124 hatchery subyearling Chinook salmon (86 recaptures from the bulk marking project), 422 natural origin subyearling Chinook salmon, 3 natural origin yearling Chinook salmon, 60 adult (>200 mm FL) natural origin *O. mykiss* and 12 juvenile (<200 mm FL) natural origin *O. mykiss* were captured. The majority of the offshore Chinook salmon catch occurred during the month of November, however the same pattern was not observed for natural origin *O. mykiss*. During late June through September, Chinook salmon were distributed throughout the reservoir and captured in all zones. Starting in October, sampling in the upper zone was suspended due to declining reservoir elevations, but Chinook salmon remained

distributed among the sampled zones. In November, the Quartzville zone became inaccessible and was also not sampled, with Chinook salmon distributed in the lower and middle zones of the reservoir. Fork lengths for Chinook salmon increased over the sampling season from approximately 100-150 mm in June to 200-250 mm by November. Natural origin *O. mykiss* were distributed across all reservoir zones throughout the sampling season.

Chinook salmon catch rates were low in both reservoirs, particularly for nearshore sampling. In comparison, juvenile Chinook salmon catch rates (number per set) were approximately 100 times greater in Lookout Point Reservoir during 2014 sampling conducted by ODFW (Monzyk et al. 2015) than in our 2024 nearshore sampling. Offshore catch rates in 2014 were also higher, roughly five times greater than our 2024 offshore catch per set. Several factors could explain these differences. One possibility is an actual decline in juvenile Chinook salmon abundance. In 2013, 1,966 adults were outplanted upstream of Lookout Point Reservoir to spawn, whereas only 168 were outplanted in 2023—a 12-fold decrease. While this could indicate lower nearshore abundance, it is also possible that fish were present but not effectively captured. Our traps appeared to be fishing properly, as evidenced by some large non-target catches exceeding 1,000 individuals. However, Chinook salmon fry exhibit schooling behavior, and their patchy distribution, combined with our relatively small sample size given the reservoir's size, may have contributed to low catch rates.

In contrast, juvenile salmonid catch rates in Green Peter Reservoir were higher in 2024—approximately 3.4 times greater than Lookout Point in the nearshore and 3.0 times greater offshore. For context, 800 adults were outplanted upstream of Green Peter Reservoir in 2023, about 4.8 times more than in Lookout Point, which may have contributed to the higher juvenile catch rates observed there.

Growth rates for natural origin subyearling Chinook salmon seen in 2024 sampling (Green Peter: 0.89 mm/d fork length; Lookout Point: 0.91 mm/d fork length) were similar to rates seen in Lookout Point Reservoir during 2012-2014 (Monzyk et al. 2015). Infection prevalence of the copepod *S. californiensis* peaked during late summer and fall in both reservoirs with 45% of hatchery Chinook salmon and 65% of natural origin Chinook salmon infected within Green Peter Reservoir and 24% and 38% infection prevalence for hatchery and natural Chinook salmon respectively in Lookout Point Reservoir.

Lookout Point Reservoir surface temperatures peaked above 22°C in August, with temperatures exceeding 18°C down to approximately 20m in the forebay. Unlike in 2023, dissolved oxygen levels below 20m remained suitable for salmonid use, though this refuge was limited to the forebay due to shallower and warmer depths upstream. Green Peter Reservoir followed a similar thermal pattern, with surface temperatures peaking above 22°C in August and temperatures greater than 18°C extending to approximately 15-20m. Turbidity increased in both reservoirs during the fall drawdown but was substantially lower than in 2023 for Lookout Point, ranging from 30-77 NTU through late November. Green Peter Reservoir experienced comparatively higher turbidity,

exceeding 500 NTU in early November before sampling was suspended due to reservoir access difficulties and safety concerns.

Evaluating total dissolved gas (TDG) effects on Chinook salmon injury and mortality rates at dam tailraces: how important is TDG?

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High head dams, i.e., taller than 30 meters, have contributed to Spring Chinook salmon (*Onchorhynchus tsawytscha*) populations in the Upper Willamette River (UWR) being listed as threatened under the Endangered Species Act. Dam operations that spill water over dams can result in supersaturation of total dissolved gas (TDG) in the river downstream. Juvenile salmonids exposed to supersaturated TDG during dam passage or while in below-dam reaches can develop gas bubble disease (GBD) and other barotrauma injuries which can result in mortality. Oregon water quality standards dictate that TDG saturation of water may not exceed 110%, except under exceptional flood discharge events, so operations at Willamette Valley System (WVS) dams aim to keep TDG levels below this. However, levels up to 125% for 24 hours each day are permitted in the Columbia River during spring surface spill operations that aim to improve downstream passage of juvenile salmonids. It is therefore important to examine the effects that TDG has on injury and mortality rates of fish migrating through and residing below WVS dams and how dam operations can mitigate these effects.

We evaluated the effect of variation in TDG levels on injury and mortality rates below Big Cliff, Cougar, and Green Peter dams using data from rotary screw traps (RSTs) sited at their tailraces. RSTs are commonly used to monitor downstream migrating fish populations, but the data can be noisy and difficult to interpret due to variable trap efficiency that may depend upon flow and fish condition, among other factors. We used records of Chinook salmon injury and mortality from RSTs located in the tailraces of these dams and adjusted for trap efficiency at each trapping event (typically a 1–2-day period) using flow, trap revolution speed, and length. Using data from two periods (2011-2016 and 2021-2024) allowed us to determine the effect of TDG on fish injury and mortality rates at each dam, but also how modifications to dam operations influenced these effects. For each trap check interval, we compiled data on % TDG, spill discharge, temperature and reservoir elevation. We then modelled proportions of injured or dead captured Chinook salmon in relation to TDG and other covariates using binomial logistic regression.

The effects of TDG appear to be site-specific as high levels of TDG do not necessarily result in higher rates of injury or mortality. For example, although the maximum TDG fish experienced below Big Cliff (134.6%) was higher than below Cougar (117.4%), GBD incidence below Cougar was higher (0.325 vs. 0.136). The 2021 court-ordered dam operation measures, such as spreading of spill, reduced the maximum TDG experienced by juvenile salmon when captured below Big Cliff from 134.6% to 127.9%. However, there was little change at Cougar in maximum TDG levels before and during these measures (117.4% compared to 119.7). No data were available for Green Peter before the modified measures, but high levels (>135%) were recorded during deep drawdown events. In optimal models where site was also a significant effect, the modified dam operations at Big Cliff and Cougar that kept TDG <130% led to reduced relative risks of GBD, other barotrauma injury, or death by 45%, 32%, and 67%, respectively.

Our analyses using RST data obtained at dam tailraces show that TDG itself is not the sole factor determining Chinook salmon injury and mortality rates as the effects are site-specific. Site characteristics that influence how quickly TDG dissipates downstream and how rapidly fish move through areas of elevated TDG are clearly important. Trap event duration also had a significant effect on GBD, highlighting that time spent under higher TDG levels is also important. While mortality was not similarly related to trap event duration, this has implications for injury rates of juveniles that are rearing in areas where TDG is elevated, although fish held near the surface in RST trap boxes are unable to depth compensate as resident fish otherwise could to reduce their risk of developing GBD. Understanding the impact of TDG through modeling tools that account for dissipation at different sites and that can predict injury and mortality rates based upon fish behaviour could therefore be useful in predicting future effects of modifications to dam operations on injury and mortality rates of juvenile salmonids exposed to elevated TDG at dam tailraces.

Evaluating tradeoffs between impacts of modifications to dam operations on juvenile salmonid run timing and other fish passage metrics through rotary screw trap monitoring in the Upper Willamette Valley

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In 2021, operations at several dams in the Willamette Valley System (WVS) were deliberately modified as a result of a Court Injunction, brought with the intent of improving downstream passage of juvenile ESA-listed spring Chinook salmon and winter steelhead. In previous talks we showed how rotary screw trap (RST) monitoring could reveal how recent modifications to some dam operations in the Willamette Valley System (WVS) could lead to both anticipated and unanticipated effects on downstream migrating juvenile salmonids, for example, reductions in total dissolved gas (TDG)-related injury rates but also increases in non-barotraumatic injury rates. This talk first briefly summarizes from recent findings about impacts of changes in dam operations on several fish passage metrics obtained through analysis of RST data, and second shows how run-timings of downstream migrating juvenile Chinook salmon may shift in response to modifications to dam operations under the injunction measures. Preliminary results connecting hydrology to run timing are then presented as a first attempt to better understand interannual variability of run timing. It concludes by reviewing how RST monitoring results can prove useful in the evaluation of tradeoffs in impacts of modifications to dam operations on key fish passage metrics.

Rotary screw traps at the head of reservoirs and tailraces of most WVS dams have long been used to study fish passage through reservoirs and dams. A principal use of these traps is to assess when within the year, and how many, fish are moving downstream. Trapped fish are also evaluated for different types of injuries, for example using analysis methods outlined in previous talks. Injunction measures that modified UWS dam operations in 2021 were intended, among other things, to create hydrological conditions in the spring and autumn that would facilitate downstream migrating juvenile salmonids to pass successfully through dams. We review RST records at dam tailraces of several WVS dams, i.e., Cougar, Detroit, Fall Creek, Lookout Point, and Green Peter, to characterize run timing in the spring and autumn for downstream migrating natural-origin spring Chinook salmon. We tested whether systematic changes in run timings of fry and subyearling spring Chinook salmon could be detected with the implementation of injunction measures on WVS dams starting in the autumn of 2021. Tests could not be performed for yearlings, since there was only one year of data available with injunction measures for yearlings. After adjusting for trap efficiency at each RST site, there was still considerable variation in the weekly RST catch rates during times of year when fish migrated. This may reflect variability between weeks in fish passage but also uncontrolled variability in RST trapping efficiency. Despite the pronounced variability in weekly RST records we were still able

to fit run timing curves by year for fry, subyearlings and yearlings for several of the dams. We also fitted run timing curves at given dam tailraces that averaged over years i) prior to the implementation of injunction measures in 2021 and ii) with the implementation of injunction measures in 2021. Associations between modifications to dam operations and shifts in the fitted mean run timing curves for all WVS dams were looked for and interpreted in relation to discharge through the dam.

Although there may be advantages to deliberately modifying dam operations to facilitate downstream fish passage at certain times of the year, and also reduce barotrauma-related injuries, RST monitoring allowed quantification of potential tradeoffs in such dam operations between improving run timing, reducing barotraumatic injuries to fish, and increasing non-barotraumatic injury rates. This joint evaluation of different passage metrics for downstream migrating natural origin juvenile salmonids is useful because it helps to refine understanding about which components of fish passage are enhanced but also which ones may be degraded by deliberate modifications to dam operations. This allows further consideration of new measures, for example, that could reduce elevated injury rates at dam passage that followed the deliberate modifications to dam operation. Quantification of component dam passage metrics will also help to offer potential reasons for, and assess the credibility of, observed changes in project passage efficiency with the implementation of changes to dam operations.

Synthesis of Habitat Dynamics for Spring Chinook Salmon in the Upper Willamette River Basin, Oregon.

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The Willamette Basin, Oregon is home to at least 69 species of fish, including spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) which is listed as "threatened" under the U.S. Endangered Species Act. Chinook Salmon and other aquatic organisms rely on the availability of suitable physical habitat, such as water depth, velocity, sediment size, and temperature to fulfill various aspects of their life cycle. These habitat variables are related, to varying degrees, to streamflow and channel hydraulics. In the Willamette River Basin (WRB), streamflow is managed, in part, by 13 US Army Corps of Engineers (USACE) dams located in tributaries upstream of the mainstem Willamette River.

To support federally protected salmonids, the 2008 Biological Opinion for the USACE's Willamette Valley Project established streamflow objectives which specified seasonal streamflow targets at several locations along the Willamette River and select tributaries. Since then, there has been significant effort to understand the distribution of habitat for Chinook salmon at various life stages and how sensitive that habitat is to streamflow. This presentation will summarize studies conducted since 2017 which have investigated what habitats juvenile and spawning Chinook salmon use in the WRB and how those findings have been used to develop models to estimate the spatial distribution of habitat below USACE dams. Results will focus on what has been learned from this body of work, including how the quantity and location of habitat changes with streamflow and how this flow-habitat dynamics vary throughout the basin. Finally, results will highlight web-tools under development which integrate this work to inform short-, medium-, and long-term streamflow management in the WRB.

A conceptual synthesis of thermal exposure metrics with case study examples using UWR spring Chinook salmon

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Measuring and predicting biological responses of fishes and other aquatic ectotherms to changes in physical conditions in aquatic habitats is a long-standing challenge. In our current era of warming river systems, there is a need for an integrated lexicon that can be applied to thermal management and conservation actions for coldwater species like salmon and steelhead. In this presentation, we will provide a conceptual synthesis of the current suite of tools and terminology used by hydrologists and biologists to quantify thermal habitats and biological thresholds across multiple spatial and temporal scales, and make some recommendations towards a shared conceptual framework using upper Willamette River Chinook salmon (*Oncorhynchus tshawytscha*) as a case study population. A key theme is that biological systems respond to thermal regimes at cellular to organismal scales and through both ecological and evolutionary pathways, with greater inherent system complexity and uncertainty in outcomes. Consequently, successfully linking the most appropriate metric(s) of the thermal regime to biological outcomes requires careful consideration of the specific "on-the-ground" management or conservation goals, key temporal and spatial scales, and mechanistic links between thermal regime and the factors limiting biological systems.

Physical sciences

In the upper Willamette River (UWR) basin, and elsewhere, physical scientists have used increasingly sophisticated monitoring and modeling tools to describe and predict water temperatures across both space and time at a range of spatial and temporal scales (i.e., river thermalscapes). This approach is particularly useful for addressing questions about human activities like reservoir and dam management, as well as larger weather- and climate-related impacts. The quantitative thermal metrics routinely estimated by thermalscape modeling approaches include magnitude (e.g., daily or monthly mean, accumulated thermal units), frequency and duration (e.g., time <> threshold values), change rate, threshold onsets, and variability. The spatial scales range from fine-scale studies within river segments (<1 m resolution) to mesoscale reaches (~100m- 1km) to medium or large watershed scales (Figure 1).

Biological sciences

Cold-water fish researchers use a variety of thermal metrics to examine homeostasis (e.g., incipient lethal temperatures), swim physiology (e.g., aerobic scope), growth and development (e.g., optimal growth temperature), and ecological interactions (e.g., pathogenesis, predation rate). Additional metrics have been used to examine ecological processes over broader spatial and temporal scales, such as species' distributions and life history phenology (Figure 1).

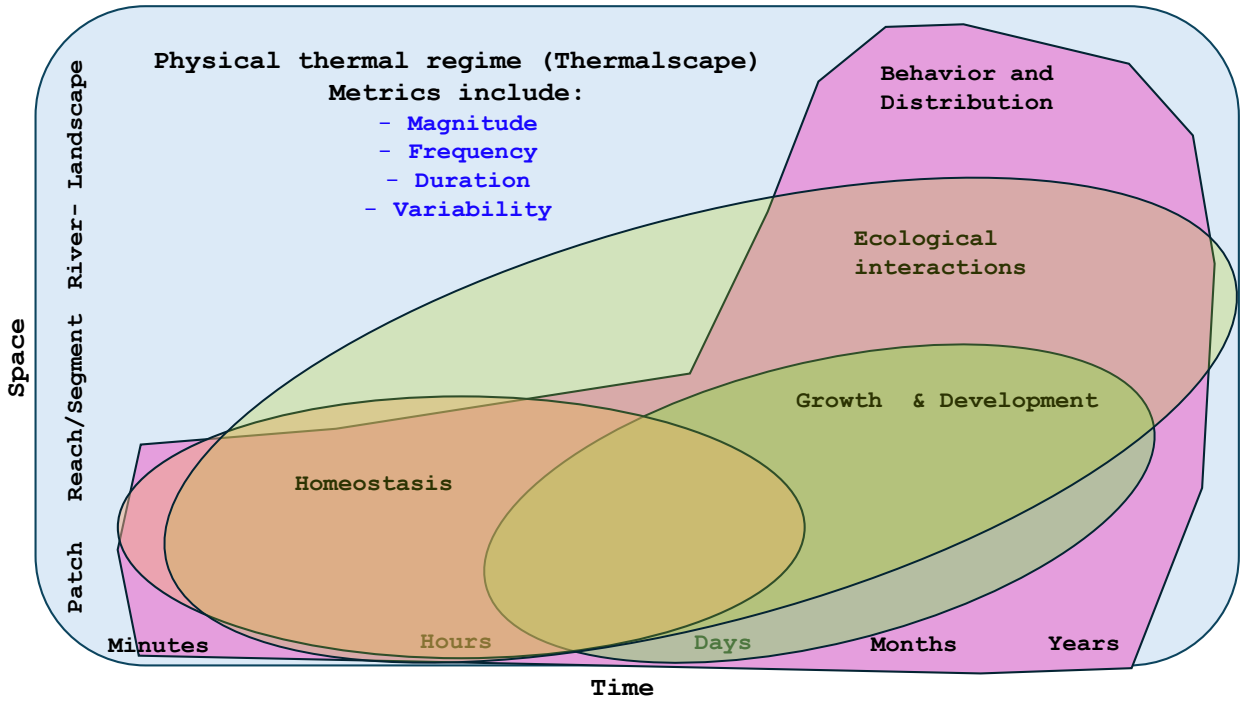


Figure 1. Conceptual diagram showing the spatiotemporal realms of common biologically-based thermal metrics (ellipses and polygons) superimposed on the physical thermal habitat realm (i.e., the 'Thermalscape').

While temperature is a fundamental organizing influence in the biology of fishes and other ectotherms, it has been relatively more challenging to develop standardized thermal metrics for biologists than in the physical sciences. In part, this is because the response of fishes to thermal regimes differs across life cycle stages and because they are mobile, moving among various habitats in response to environmental cues and their physiological status. Temperatures vary through time and thermal effects on animals can also be either short-term (i.e., acute) or accumulate over time (cumulative, chronic, or delayed effects), requiring different types of thermal exposure metrics. For instance, an individual's recent thermal history affect physiological acclimation which can in turn dramatically shift temperature thresholds and temperature tolerance. For these reasons, identifying limiting thermal effects within stage is recommended, particularly for species such as salmon with complex or migratory life cycles.

Example applications for upper Willamette Chinook salmon

The river thermalscapes of the UWR are relatively well characterized, with recent expansion in both spatial and temporal extent due to advances in process-based modeling applications such as the HEC-RAS and CE-QUAL-W2 models. Output from these models can provide insights into basic ecology and biogeography of Chinook salmon. For example, fine-scale thermalscape predictions can be used to map embryo mortality risk, because there are well-established acute exposure thresholds and embryos are not mobile. At the reach scale, juvenile salmon growth is

optimized under specific thermal conditions, with reduced growth above and below the optimum as individuals balance growth versus the metabolic costs of activity and recovery. Reach-scale thermalscape metrics may also be broadly associated with some adult salmon behaviors (e.g., thermal barriers to migration) and mortality risks, such as acute and cumulative exposure during prespawn holding. Cumulative effects require an understanding of temperature-mediated energetic depletion, the biology of pathogens, and underlying senescence processes. At sub-basin and UWR watershed scales, thermalscape metrics can be aligned with current salmon distribution and other information to refine maps of suitable habitat for Chinook salmon. Across life stages, the role of thermal acclimation has received considerable recent attention, with emerging evidence for higher biological thresholds in some cases and among-population differences in tolerance that may affect how we collectively address temperature-related challenges.

Aligning physical thermal metrics to biological outcomes will be a continuing challenge in coming years as habitat change and thermal effects on fish continue to evolve. Development and refinement of mechanistic frameworks such as presented here that identify key variables should improve integration of physical and biological models and lead to more refined thermal metrics. A critical component will be to evaluate thermal effects across the life cycle because the success of most management goals, e.g., ESA recovery planning, ultimately depend on cumulative biological responses that generate population-level growth rate above replacement.

Evaluating Spring Chinook Salmon Releases Above Fall Creek Dam Using Genetic Parentage Analysis

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Upper Willamette River spring Chinook salmon (*Oncorhynchus tshawytscha*) are listed as threatened under the U.S. Endangered Species Act. Fall Creek, a tributary of the Middle Fork Willamette River, provides critical spawning habitat for threatened spring Chinook salmon. However, recovery of spring Chinook salmon is limited by Fall Creek Dam, which blocks access to historical spawning habitat for this species. Beginning in 1998, primarily hatchery-origin (HOR; adipose fin removed) spring Chinook salmon were released above Fall Creek Dam with the aim of re-establishing natural production on historical spawning and rearing grounds. Since June 2009, only unmarked, natural-origin (NOR; adipose fin intact) spring Chinook salmon have been reintroduced above the dam.

Population productivity above Fall Creek Dam

Previous research has used genetic parentage analysis to evaluate the contribution of spring Chinook salmon released above Fall Creek Dam to subsequent adult salmon recruitment to the river (O'Malley et al. 2018). Here, we extend the genetic parentage analysis by assigning the 2016 – 2020 adult salmon returns to salmon reintroduced above Fall Creek Dam in 2011 – 2017. We found that the assignment rates of returning adult Chinook salmon to salmon previously reintroduced above Fall Creek Dam increased from 92% (391/423) in 2016 to 99% (803/809) in 2020. The inferred age structure based on the genetic parentage analysis results indicates that most salmon return to Fall Creek at age-3 and age-4 with few age-5 salmon.

Above Fall Creek Dam in 2011 – 2015, about 13% of Chinook salmon, on average, produced at least one adult offspring each year that was detected through genetic parentage analysis. The number of adult offspring produced by an individual salmon ranged from a low of 0 – 15 in 2014 to a high of 0 – 54 in 2012. Accordingly, the mean TLF was lowest in 2014 and highest in 2012. We found that length was a significant predictor of TLF, in that TLF increased with increasing length of fish. Total cohort replacement rate (CRR_{total}) was less than one in most years from 2011

– 2015, indicating that the reintroduced population above Fall Creek Dam is not replacing itself. However, in 2012, CRR_{total} was 1.49 indicating that replacement had been met. The minimum CRR_{total} (0.21) was observed in 2014.

Variation in the effective number of breeders (N_b) above Fall Creek Dam from 2011 – 2015 tracked with the number of candidate parents that produced one or more adult offspring ($n_{success}$). However, these two values did not correspond to the number of candidate parents (n_{cand}) released above Fall Creek Dam. For instance, as n_{cand} increased, $n_{success}$ and N_b decreased, except in 2015. This is reflected in N_b: N_{cand} ratio which was lowest in 2014 (0.07) when the second largest number of salmon (n = 453) were reintroduced above Fall Creek Dam. Overall, N_b ranged from 25.1 in 2015 to 50.0 in 2012.

Interestingly, population productivity of Chinook salmon above Fall Creek Dam from 2011 – 2015 resembled productivity in two of the other three Chinook salmon reintroduction programs in the UWR basin. For example, productivity of salmon reintroduced above dams in the North and South Santiam Rivers was also highest in 2012 and lowest in 2014 while productivity of Chinook salmon reintroduced above Cougar Dam on the South Fork McKenzie did not follow this trend. Furthermore, preliminary TLF estimates for the 2016 cohort in Fall Creek and the North and South Santiam Rivers are quite high. These findings suggest that basin-wide and/or ocean conditions may have been primary factor(s) influencing productivity in three of the four river systems from 2011 – 2016.

Release day above Fall Creek Dam

While the day of first release for salmon reintroduced above Fall Creek Dam shifted from May 5 in 2011 to April 13 in 2015, the day of first release for salmon reintroduced above the dam from 2016 – 2020 did not follow the same trend. Instead, we found that Chinook salmon release day was similar in 2016, 2018, and 2020, while all other cross-year comparisons to 2011 – 2020 were significantly different.

From 2011 – 2020, the median release day of males and females was significantly different in four of the years. For instance, in 2013 and 2019, release day for males was significantly later than female release day, whereas in 2016 and 2018, male release day was significantly earlier than female release day.

Comparing across years, we found that early released Chinook salmon in 2011 were significantly different from early released salmon in five years (2012, 2015, 2016, 2017, 2020) based on variation at *Ots515NWFSC.* In addition, early released salmon in 2017 were significantly different from early released salmon in most years based on variation at *OmyFbxw11*. The magnitude of differentiation at these two run timing markers (i.e., *Ots515NWFSC* and *OmyFbxw11*) was substantially greater than that of neutral microsatellite markers, suggesting these differences may reflect adaptive genetic changes over the time span evaluated.

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The dynamics of *Salmincola californiensis* infecting reservoir rearing juvenile Chinook Salmon

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Oregon State University' Cooperative Research Unit conducted a study to evaluate the infection dynamics of the ectoparasite *Salmincola Californiensis* on juvenile Chinook Salmon in Willamette Valley reservoirs. To evaluate infection dynamics of this parasitic copepod, three main objectives were addressed: 1) estimate the infection rates within a wild population of rearing juvenile salmon; 2) identify spatial and temporal patterns in parasite infection rates relative to reservoir conditions; and 3) determine the potential effects of infections on host survival in wild populations.

To estimate infection rates in wild fish, two separate sampling efforts took place from 2012 – 2015 in Detroit, Cougar, and Lookout Point reservoirs (historic sampling conducted by ODFW) and again in 2020 in Lookout Point Reservoir (contemporary sampling conducted by OSU). In the historic data set, mean weekly prevalence (proportion of infected fish in a population) ranged from 3% to 64% and the mean weekly intensity (number of parasites per infected individual) ranged from 1.2 to 4.4 adult copepods per infected fish. In the contemporary data set from Lookout Point Reservoir, mean prevalence was 37% and weekly mean intensity was 2.1 copepods per infected fish. Unlike previous years, juvenile stages (copepodids and chalimus) of the parasite were enumerated in 2020. These stages were detected in infected fish throughout the sample season. The peak juvenile parasite prevalence was found in the second week of sampling, at roughly 42%, with more copepodids being observed than chalimus. Although raw counts only led to the observation of 40 copepodids during the 2020 field season, adjusted values based on a host abandonment study estimated that each fish captured had at least one copepodid when captured, which has been shown to be the most damaging stage to fish of the parasite's life cycle.

To identify spatial and temporal patterns of parasite infection rates at the study sites, a mixed effects hurdle model that evaluated both infection prevalence and intensity was developed. The best fitting mixed effects hurdle model found that fish age and environmental (temperature 18.3m below the surface, water surface elevation) covariates, as well as week of year, were positively related to adult copepod prevalence. In contrast, infection prevalence and reservoir inflows were negatively related. Infection intensity was positively related to life stage, reservoir , and week of year. Intensity had no relationship with environmental conditions. Evaluation of these results suggests that there is an opportunity to manage reservoir water surface elevation throughout the year to reduce parasite infections that ultimately transport copepodids out of the reservoir and decrease hospitable conditions for their proliferation.

To determine the possible effects of infection on host survival, an evaluation of the infection rates above and below both Cougar and Detroit dams was conducted. Prevalence of infection was higher in fish collected in the reservoir compared to fish sampled below the dams for both subyearling and yearling life histories. Infection intensity was consistently higher in fish collected above the dams, and for yearlings collected in the reservoir. Given the long-lived nature

of the parasite, these results suggest that mortality is occurring in the reservoir as a result of infection. Additionally, survival rates based on the likelihood ratios fit using the full likelihood method found evidence of parasite associated mortality (PAM). This analysis revealed that the intensity at which 50% of the infected population experiences mortality ranged from three to eight adult parasites based on brood year and reservoir. While PAM was not detected in all years and reservoir combinations, juvenile Chinook Salmon remain vulnerable to decreased survival related to the physical effects of infection.

Overall, the combination of results of this study provides a suite of evidence indicating that wild juvenile Chinook Salmon are negatively effected by *S. californiensis* infection. These results could inform future management and research efforts to increase juvenile Chinook salmon survival through the reduction of *S. californiensis* infection rates.

2024 Chinook salmon spawning ground surveys above Green Peter Reservoir

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On September 1, 2021, the U.S. District Court for the District of Oregon issued an interim injunction that directs the Corps to implement interim injunction measures intended to improve conditions for fish passage and water quality in the Willamette Valley Project (WVP) to avoid irreparable harm to Endangered Species Act (ESA)-listed salmonids during the interim period until the completion of the reinitiated consultation.

The Court assigned an Expert Panel comprised of two of Plaintiffs' experts, two NMFS biologists, two Corps employees, and two "ad hoc" Federal experts to define the implementation plans of specific measures. As required by the injunction, the Expert Panel's proposed measures must "provide meaningful research, monitoring, and evaluation ("RM&E") of the interim measures." Further, the injunction mandates that the Corps "fund and/or carry out RM&E to evaluate the effects of the interim measures on Upper Willamette River (UWR) Chinook salmon and UWR steelhead."

The goal of interim injunction measure 11 (Green Peter Dam – Outplanting Plan) is to create an outplanting plan that will provide South Santiam UWR Chinook salmon and steelhead access to the Middle Santiam subbasin. Starting in 2022, the Corps began implementing injunction measure 11 by releasing hatchery adult South Santiam UWR Chinook salmon adults into the Middle Santiam River (600) and Quartzville Creek (200) on an annual basis. We conducted spawning ground surveys in autumn of 2024 to document the spatial and temporal distribution of redds, measure redd dimensions, and evaluate female spawning success in Quartzville Creek and the Middle Santiam River. Wildfires severely impacted access during the spawning period, especially in the Middle Santiam River. We were able to meet all objectives in Quartzville Creek and document redds in a portion of the Middle Santiam River.

STRUCTURE DECISION MAKING FOR AND FUTURE MONITORING OF NORTHWESTERN POND TURTLES IN THE WILLAMETTE VALLEY PROJECT, OREGON

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U.S. Army Corps of Engineers' (USACE) Willamette Valley Project (WVP) managers face a variety of competing interests when operating and managing the WVP reservoir systems. Flood risk management, hydropower, and impacts to Endangered Species Act (ESA) listed species are a few topics that create complex decision-making for managers. In the spring of 2025, northwestern pond turtles, *Actinemys marmorata*, may be added to the list of ESA-listed species affected by USACE WVP management actions. This presentation will provide an overview of the proposed Structured Decision Making (SDM) modeling that will help the USACE create a decision-making framework to evaluate competing interests and balance objectives. I will also outline our future monitoring plans for NWPT populations in the WVP.

NORTHWESTERN POND TURTLE MOVEMENT IN FLOOD CONTROL RESERVOIRS IN WILLAMETTE BASIN, OR

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Northwestern pond turtles (*Actinemys marmorata*; NWPT) are a semi-aquatic freshwater species native to the Pacific Coast. Due to population losses in parts of their range, the U.S. Fish and Wildlife Service proposed NWPT for federal listing under the Endangered Species Act in 2023. Several reservoirs within the U.S. Army Corps of Engineers' (USACE) Willamette Valley Project (WVP) support populations of NWPT. To complete their annual lifecycle, turtles move between aquatic and terrestrial environments for nesting and a period of winter dormancy. Because the timing of these seasonal movements may coincide with reservoir draw-down and refilling, altered water management stemming from a 2021 court injunction in the WVP may have implications for NWPT. To investigate how turtle movement and habitat use relate to changing water management, the U.S. Geological Survey Forest and Rangeland Ecosystem Science Center and USACE entered a partnership to capture and track NWPT in three WVP reservoirs between 2023 and 2026. The objectives of this study are to provide information regarding NWPT distribution, habitat use, and seasonal movement patterns in WVP reservoirs. Additionally, we are evaluating the feasibility of using GPS and satellite tracking technology to collect fine-scale geospatial information on terrestrial movement. We began trapping NWPT at Fall Creek, Hills Creek, and Lookout Point reservoirs in Spring 2023. Between 2023 and 2024, 58 turtles were tracked using a combination of VHF (n=48) and GPS (n=10) transmitters. NWPT were monitored closely throughout the year, including their migration from the reservoirs to the terrestrial environment or satellite ponds for overwintering. When the study concludes in 2026, results will provide biologists and managers with a better understanding of turtle movement and distribution patterns in WVP reservoirs, attempt to make inferences between NWPT movement and water level management, and determine the efficacy of GPS transmitters on turtles in the WVP.

Furthering Investigations in the Wild Fishes Surrogate Project's Methods and Discussing Future Experiments

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The Wild Fishes Surrogate Project rears juvenile Chinook salmon and steelhead trout for other USACE funded projects to investigate fish passage through infrastructure built in the Willamette River Basin and its tributaries. These surrogate fish are reared in such a way that their resulting phenotype is more akin to naturally reared salmonids as opposed to their hatchery reared counterparts. Over the past couple of years, the project has investigated the effects of intermittent fasting on juvenile Chinook salmon's energy allocation and growth. Two consecutive studies were conducted comparing body condition after cycles of intermittent fasting when fish were fed either BioOregon's BioVita diet or the project's Wild Chinook Grower (WCG) diet. We found that intermittent fasting appears to allow for a more wild-like growth curve as compared to daily feedings. Further comparisons of the WCG diet and BioOregon's BioClark's Fry diet showed that disease resistance is not affected by diet type.

Two key components to the Surrogate Project rearing method are in-tank structure and lowered rearing density. Our research has shown that these rearing methods benefit to hatchery-reared Chinook salmon by resulting in a reduced stress response when exposed to a transport-like stress test (Cogliati et al., 2019; Herron et al., 2023). We used a similar study design with steelhead trout to evaluate their stress response when reared using Surrogate methods. Results indicate that in-tank structure rearing leads to a mitigated stress response.

We are currently developing a new investigation for the Surrogate Project to quantify the extent of vateritic growth in the sagittal otoliths of Surrogate Chinook salmon. In teleost fishes, otoliths are primarily composed of aragonite, a stable form of calcium carbonate. However, research has shown hatchery-reared fish have a greater propensity for vateritic deposition, a less stable form of calcium carbonate. This structural alteration may compromise critical sensory functions, including balance, hearing, and spatial orientation, potentially affecting escape responses and survival. We will compare our findings with individuals from different natal origins, including wild and conventional hatchery-reared fish of the same stock.

Other further investigations being conceptualized include epigenetic differences between Surrogate, hatchery, and naturally-reared Chinook salmon. Epigenetics is the study of changes to the DNA molecule that do not include base changes but still influence genetic expression and can

be heritable. Epigenetic changes may be highly significant in explaining why salmon fitness may be impacted after just one or two generations of differing experiences.

Our research is refining rearing methods and providing further evidence that the resulting phenotype of our fish is more comparable to naturally occurring phenotypes. By improving these rearing techniques, we hope to enhance the overall performance of surrogate juvenile Chinook salmon and steelhead trout, which may ultimately contribute to the development of more successful fish passage in the Willamette River Basin. Our findings also provide valuable insights into fish behavior, survival, and adaptation, with implications for conservation and management efforts of wild salmonid populations.

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UPPER WILLAMETTE BULL TROUT PASSAGE AT COUGAR AND HILLS CREEK DAMS IN 2023–2024

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Bull Trout *Salvelinus confluentus* declined in the Willamette Basin over the last century and remained only in the McKenzie River drainage by the early 1990s. The Upper Willamette Bull Trout Working Group formed in 1989 to coordinate activities to improve the status of bull trout populations and the group continues to guide recovery and mitigation efforts in the upper McKenzie, South Fork McKenzie, and Middle Fork Willamette drainages. Measures taken to improve the species' status have aimed to reduce angling-related mortality, improve habitat conditions and connectivity, restore the historical prey base, and reintroduce Bull Trout into formerly occupied tributaries. Comprehensive population monitoring and research on potential limiting factors are essential components of this program.

We conducted monitoring efforts focused on Bull Trout passage at Cougar Dam and Hills Creek Dam through June 2024. We operated PIT tag interrogation stations below Cougar and Hills Creek dams to detect tagged Bull Trout, we conducted angling efforts at Hills Creek Dam, and we assisted with processing and transporting bull trout collected at the Cougar Dam upstream passage facility. The PIT tag detection systems in the Cougar Dam tailrace detected eight PIT-tagged Bull Trout during the period Oct 2023 – Jun 2024, including six previously detected upstream of the dam, one captured and tagged below the dam in April 2024, and one that was associated with an upper Mckenze River local population. The Cougar Dam upstream fish passage facility collected 12 Bull Trout during the 2024 operating season, including five of the eight PIT-tagged fish detected by our PIT tag antennas. One Bull Trout was collected on 2 May 2024, followed by 11 Bull Trout during the period 20 May – 10 Jun 2024. We documented four Bull Trout below Hills Creek Dam during the October 2023–June 2024 passage season. Initial detection below the dam occurred during 14–16 Dec 2023 for two fish and on 14 Feb 2024 for one fish. Conditions associated with initial detections beginning on 14 Dec 2023 included high discharge through the RO following a substantial storm event. Capture efforts in the tailrace began in March 2024 and continued through the project period, resulting in capture and upstream passage of two Bull Trout in May. One of these was detected by the PIT tag detection systems in the tailrace, while the other fish was untagged prior to capture. The other two Bull Trout detected in the tailrace included one that went uncaptured and one that we recovered in early June as a carcass having severe injuries.