Lower Coquille Tide Gate and Fish Passage Monitoring Project, Year 1

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1. Introduction

The Lower Coquille Tide Gate and Fish Passage Monitoring Program (LCM) leverages the close proximity both temporally (completed within a two year period) and spatially (seven river miles) of three tide gate upgrade and tidal floodplain habitat restoration projects within the lower Coquille River. The overarching goal is to work collaboratively to examine not only the functionality of individual tide gate projects but also how their proximal and potentially compounded uplift promotes recovery of the Oregon Coast ESU coho population. It is important to complete this effectiveness monitoring and document fish life-history linkages to these types of projects at the forefront of the tide gate replacement movement that is growing along the Oregon Coast to ensure we are maximizing ecological benefits and return on investment. These three tide gated projects are in the freshwater-marine ecotone, which makes it well situated to examine the cumulative benefit provided to overwintering juvenile coho and Chinook salmon.

Specifically, the LCM is a three-year monitoring project that is led by the Coquille Watershed Association (CoqWA) in collaboration with multiple branches of the Oregon Department of Fish and Wildlife (ODFW) facilitated by multiple individual grants. For greater detail on the collaboration and grant structure of the LCM program, please refer to the LCM Plan[1]. The LCM relies on Passive Integrated Transponder (PIT) technology and an expansive fish sampling effort to track juvenile coho throughout the freshwater estuary and passage through tide gates. A combination of passive and active capture techniques (e.g., hoop trap nets, beach seines) are used to sample juvenile coho in the restored project sites of Winter Lake, Seestrom and Lower Coquille River Wetland and Stream Enhancement (Cochran) (Figure 1), sampling also occurs at Beaver Slough (reference site) and in the lower Coquille River throughout the winter and spring.

2. Background

Since the mid-1800s, land-use practices have substantially decreased the amount and quality of tidal floodplain complexes in the Coquille basin and anadromous fish returns, including ESA listed Oregon Coast coho, have decreased to an estimated 8% of historical abundance. Tidal floodplains and associated wetlands provide critical rearing habitat and slow water refugia for salmonids. Functional fish passage to these habitats in the Coquille Valley has been reduced to ~600 acres, or <5% of historical acreage, by the use of levees, ditches and tide gates. Current tide gate styles are largely top-hinged wood or steel and restrict juvenile fish movements from the mainstem Coquille River into locations that would historically have provided high quality winter and spring rearing. The National Marine Fisheries Service (NMFS) ESA Recovery Plan for Oregon Coast Coho Salmon (2016), Oregon Department of Fish and Wildlife (ODFW) Oregon Coast Coho Conservation Plan (2014), and Coquille Indian Tribe (CIT) Coquille Subbasin Plan (2007) have all identified the depletion of slow-water refugia as one of the key limiting factors affecting the recovery of Oregon Coast coho salmon. Although these habitats are a priority, there is little published science on the migratory habits of juvenile coho into and within the tidally influenced estuaries of the Oregon

[1] The Lower Coquille Tide Gate and Fish Passage Monitoring Plan, 2021. https://www.coquillewatershed.org/wp-content/uploads/2021/11/LCTGFPM-Monitoring-Plan.pdf

Coast and specifically within tide gated habitats. Therefore, it is unknown how restoration projects that increase access to tidal floodplains affect the recovery of the Oregon Coast coho population.

3. Project Area and Overview

The Lower Coquille Tide Gate and Fish Passage Monitoring (LCM) study area focuses on the Lower Coquille River (Coquille Estuary) in the Coquille watershed. The Coquille watershed encompasses approximately 1,000 sq. mi. predominately located in Coos County, OR. The Coquille watershed is the largest watershed to originate from the Coast Range and has the second longest tidally influenced estuary on the Oregon Coast at 41 miles. The Coquille Estuary has the potential to provide high quality winter and spring rearing habitat for coho, Chinook, steelhead, and Pacific lamprey in addition to many other species of fish and wildlife. Predominate land uses in the Coquille Estuary include private and public forested lands, agriculture, and urban areas.

The beginning of a significant uplift to winter and spring rearing habitat in the Coquille Valley began in 2017 with three working lands tide gate upgrades and habitat restoration projects (Figure 1). Traditional lumber, steel, and plywood tide gates were nearly all top-hinged heavy designs. Gate door openness times were limited and angle of door opening most often reflected outflow head pressures, which rarely developed more than 20˚ gate door angle of openness. Generally, the gravitational pull resulted in high outflow velocities and poor fish passage. This was combined with no ability to allow for tidal inflow, thus fish passage into tidal habitats were restricted to inadequate conditions on drain out cycles at low tide. All three tide gate upgrades encompass technology advancements that enhance fish passage relative to traditional top-hinge gates. Specifically, two of the sites (Seestrom and Cochran) incorporate fully mechanical Muted Tidal Regulator (MTR), a device that allows for tidal inflow with the level set to a desired water elevation, whereupon the door closes. A third site (Winter Lake) incorporates electrically operated slide gates, which allows for fine-tuned gate door adjustments to provide for fish passage and water management. These technologies have also included side-hinged aluminum tide gate doors rather than vertically hung top hinged gates. Side-hinged gates open with very limited head differential and open to an angle of around 80˚. These combined advanced technologies allow for greater capacity of fish movement, since the duration and angle of door opening is substantially increased compared to the replaced structures. Furthermore, all three projects included habitat restoration actions that enhanced habitat connectivity to wetlands and productivity upstream of the new tide gates whether that be on the ODFW Coquille Valley Wildlife Management Area or on working ranch parcels. All Restoration consisted of newly constructed stream channels, riparian plantings and livestock exclusion fencing.

The first tide gate upgrade and habitat restoration project, completed in 2017, the Cochran project is at River Mile (RM) 13.5. Cochran is relatively small in size with respect to both tide gate upgrade and habitat restoration; a 6.0′ diameter culvert and side-hinged tide gate was installed with MTR technology and 3,500′ of tidal channel was created, Figure 2. The second project, Winter Lake Restoration, located at RM20.25 was completed in 2018 and is unprecedented in size and complexity on the Oregon Coast. A structure containing seven new 8′x10′ concrete box culverts and aluminum vertical slide style, electrically driven tide gates replaced the three failing old style vertical hinged wooden tide gates, Figure 3 - Figure 4. The seven tide gates drain 1,761 acres and a berm network separates the floodplain into 3 hydrologically independent units up to elevation 6.5ft (Figure 1). Agriculture is the management focus of two units (Units 1 and 3; Figure 1) while fish and wildlife habitat is the management focus of Unit 2 owned mostly by ODFW. Construction developed 6.3 miles of new channel that was connected to historically present networks resulting in a total of 8.1 miles of channel. In addition, five tidal depressions, creating additional fish rearing area, were constructed in Unit 2 and are connected with new channels. The third project, Seestrom Tidelands Restoration (Seestrom), is a moderate-sized project completed in the summer of 2019 located at RM 14.5. The upgraded side-hinged MTR aluminum side-hinged tide gate drains 135 acres of land, which includes 11,500' of newly constructed tidal channel and 1.4 acres of tidal depressions, Figure 5).

The above three restoration projects are the core LCM restoration sites in the study. There are two other linked fish sampling locations in the study. The fourth sampling site, Beaver Slough (also referred to as Beaver Creek), is the reference site for LCM. Although Beaver Slough contains a tide gate, it is an old top-hinged wooden, leaky structure. There is a relatively, high degree of fish passage at this tide gate that apparently is facilitated by either an eroded pathway through the earthen fill surrounding the three corrugated metal 6.0ft culverts or rust degradation of the pipes. Numbers of coho moving from downstream to upstream through the site are reflected by relatively high density of juvenile coho captured upstream. The fifth sampling site are the reaches of the mainstem of the Coquille River upstream of the LCM sites to the head of tide. The Coquille River reach tagging is important as it provides: 1) The opportunity to illuminate if coho juveniles migrating downstream are moving into only an individual wetland where the team captured them or multiple wetlands, and 2) Capture of riverine reared fish exhibiting differing body conditions prior to entering floodplain tidal wetlands.

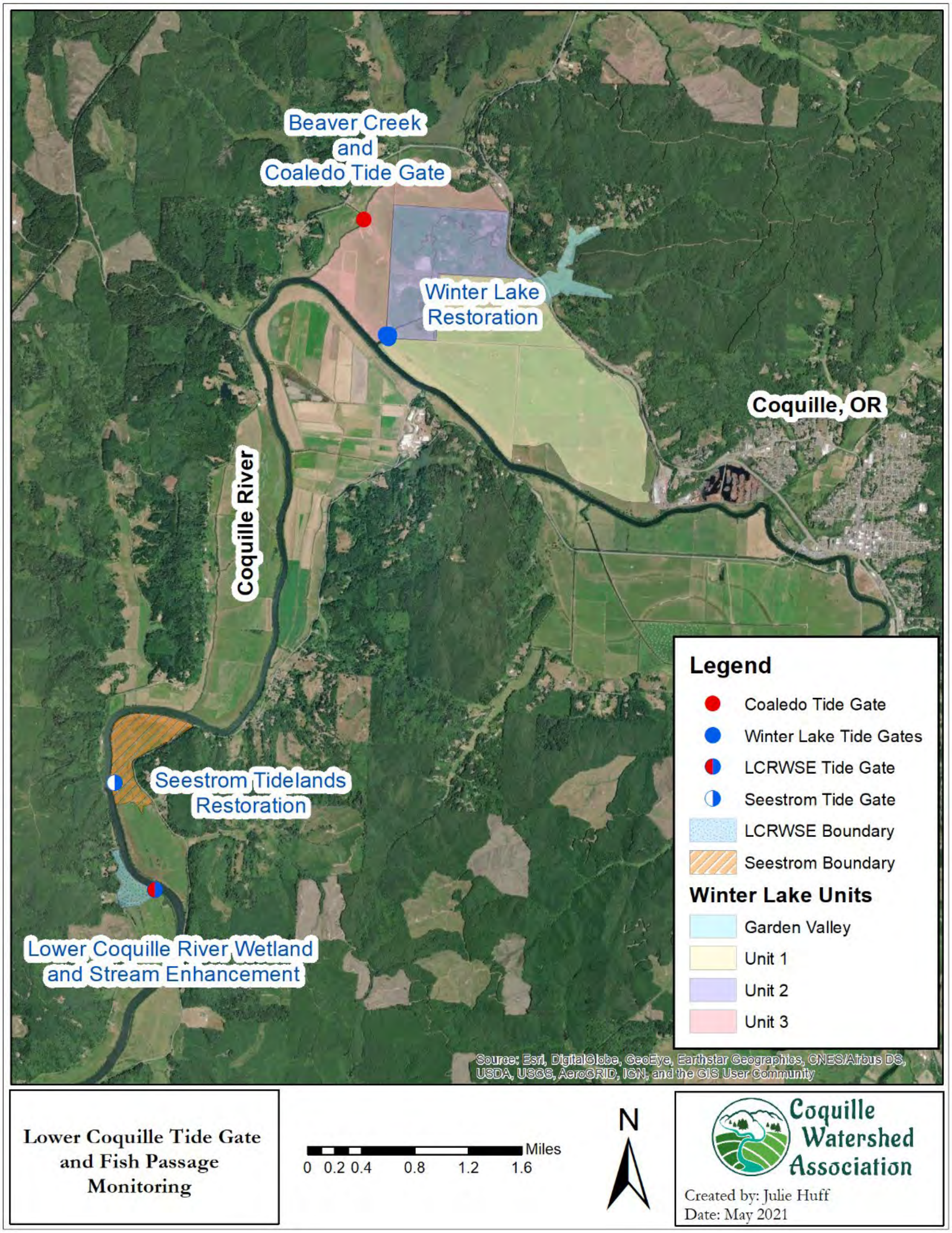

Figure 1. Lower Coquille Tide Gate and Fish Passage Monitoring location map.

Figure 2. A 6' diameter aluminum side-hinged MTR tide gate was installed at the Cochran project in 2017. The tide gate door is installed on the riverside of the culvert.

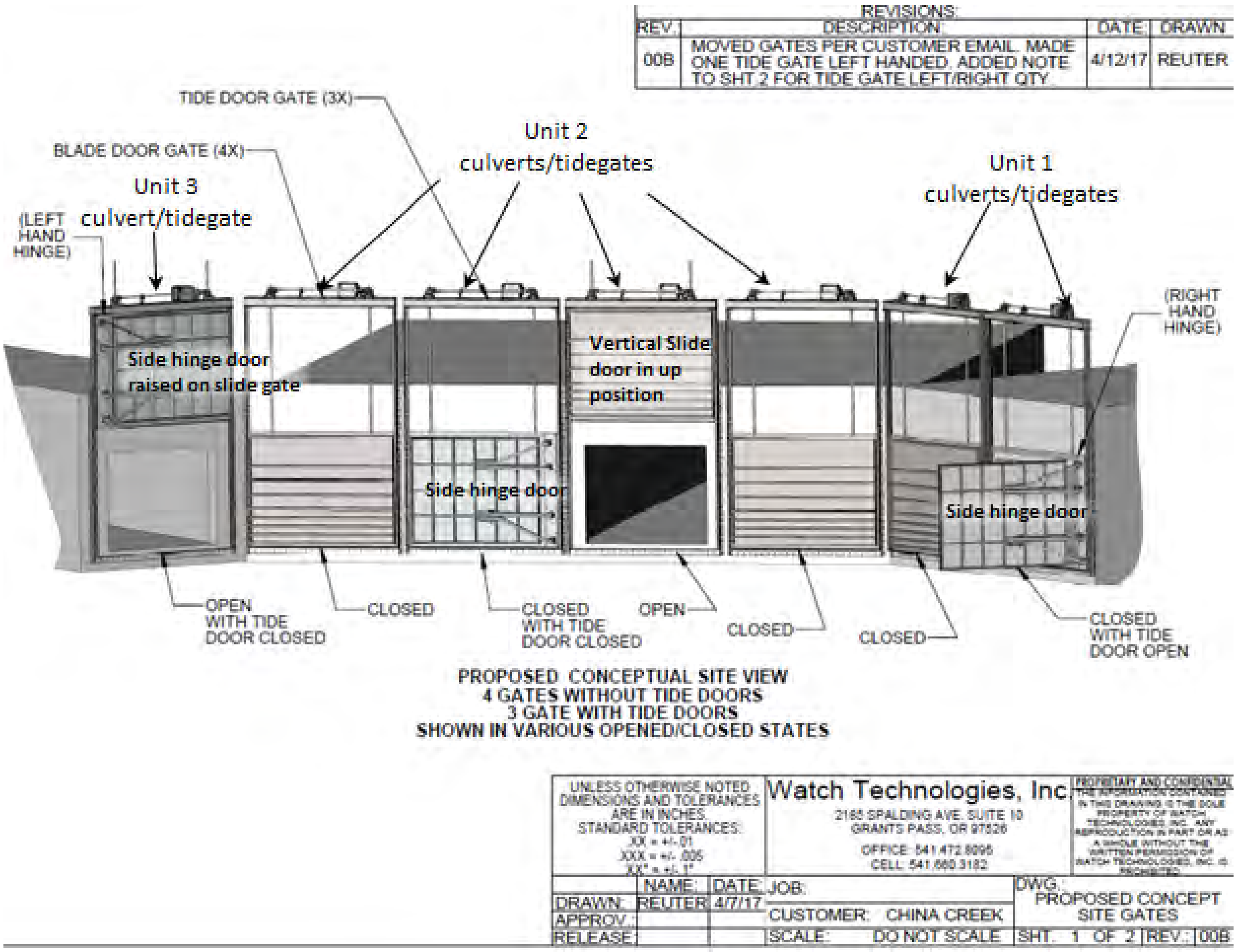

Figure 3. Winter Lake Project tide gate construction design drawing for box culverts and tide gates. Each Unit has one side-hinged tide gate door. Drawing depicts the river-side view of the tide gate structure.

Figure 4. Aerial view of the landward side of the Winter Lake tide gate structures during construction phase.

Figure 5. An 8'x8' aluminum side-hinged MTR tide gate was installed at the Seestrom project in 2019. The landward side of the MTR structure uses a counter weight to keep the tide gate door open during rising tides (left photo). The tide gate door is installed on the riverside of the concrete culvert (photo right).

4. Monitoring Questions

This monitoring project was designed to examine the effectiveness of several tide gate replacement projects and to assess how the collective uplift provided by these projects can promote recovery of coho salmon within the Oregon Coast Coho Salmon Evolutionarily Significant Unit. The primary goals for the project include improving understanding of juvenile coho general life-history in tidal floodplains, understanding coho salmon response to the sizes, design, and operation of new tide gates and overall use of the restored habitats. The monitoring is intended to inform adaptive management of the sites while providing information to help improve effectiveness of future tide gate replacements and tidal habitat enhancement projects. To these ends, fish monitoring is focused on several questions related to the condition, growth, survival, and movement of juvenile coho salmon in off-channel tidally influenced habitats following tide gate replacement.

Condition

- Is overall body condition of juvenile coho reared in the tide gate project areas greater than riverine-reared coho?

Growth

- Are growth rates of juvenile coho reared in tide gate project areas greater than riverine-reared coho? Does overall size of restored habitat affect growth rate?

Survival

- Does survival increase for juvenile coho residing in tide gate projects compared to riverine-reared coho? Does survival vary with overall size of restored habitat?

Abundance/Density

- Are rearing densities dependent on overall size of restored habitat behind an upgraded tide gate?
- What are the general densities of juvenile coho during winter/spring months upstream of the various tide gate structures within the project area with differing designs and operation plans (Water Management Plans)

Movement & Passage

- What is the residence time of juvenile coho in floodplain habitats upstream of redesigned, technologically advanced tide gates? Does residence time vary with overall size of restored habitat?
- What percentage of juvenile coho residing in the Coquille Estuary enter the restored project areas?
- Do juvenile coho enter more than one wetland restoration area during winter/spring downstream movements prior to entering the ocean?
- What are the fish passage effectiveness levels for the individual projects relating to water level and tide gate door operation?

5. Methods

The LCM program relies on Passive Integrated Transponder (PIT) technology and an expansive fish sampling effort to track juvenile coho throughout the freshwater estuary. The installation and operation of PIT antenna arrays are at the core of this study as they allow greater resolution of juvenile coho movement in both space and time due to the ability of PIT tagged fish to be individually identified. The arrays are attached directly to the landward side of the tide gate culvert so not only will PIT detections denote when a juvenile coho is moving throughout the estuary but it will also identify when passage of the tide gate has occurred. A total of 6 PIT antenna arrays have been installed; 4 on the Winter Lake tide gates, one on each of the Seestrom and Cochran tide gates and 2 on Beaver Slough 150 ft upstream of the tide gate (installed Oct 2021). The PIT antennas are operated continuously throughout the 3-year project[2].

A. Fish Sampling

A combination of passive and active capture techniques (e.g., hoop trap nets, beach seines) are used to sample juvenile coho in the restored project sites of Winter Lake, Seestrom and Cochran. Sampling also occurs at Beaver Slough (control area, mature freshwater wetland behind a leaking, old tide gate complex) and in the lower Coquille River upstream of RM 20.25 throughout the winter and spring (December – May). Capture efforts occur weekly in Winter Lake and Beaver Slough with a total 6 sampling events annually at both Seestrom and Cochran. Capture and tagging of juvenile coho upstream of the tide gate structures in the Coquille River will take place from December to April and will aim to tag a maximum of 2,000 coho. If necessary to achieve tagging targets, juvenile

[2] During the first year of monitoring there were multiple instances of PIT array outages. A table of operating dates during the 2020-2021 sampling season can be found in Appendix A.

coho may be captured a) in the Coquille River downstream from the tide gate structure and translocated upstream for release post-tagging or b) in the headwaters, higher up in the watershed.

The primary method of capture for fish at Winter Lake, Seestrom, Cochran and Beaver Slough are four foot diameter nylon hoop traps (Figure 6) with 25ft or 30ft leads. Traps were set using land or boat based methods in the thalweg of new and previously existing channels or canals with leads staked to both banks. Traps were mostly installed in sets of two with data recorded on data sheets. An 18.5ft North River boat and 126 ft beach seine are used to sample in the mainstem Coquille River. At Winter Lake, hoop traps were inefficient at capturing coho due to deeper channels allowing the coho to easily swim over the traps (Figure 7). Through trial and error, beach seining at dusk was deemed the most successful capture method, transition to seining occurred in late March and will be utilized in Year 2 (Figure 8). Winter Lake is prone to flooding due to it being the most upstream site and its low elevation, therefore during flood conditions at Winter Lake a purse seine was used for sampling.

Although juvenile coho are the target species for monitoring, all fish species, native and non-native, are counted and recorded. The captured juvenile coho and are weighed to the nearest 0.1g and measured fork length to the nearest 1.0mm. At the beginning of the season only a subset of juvenile coho captured (measuring over 65mm) within the lower LCM Project boundaries and at Beaver Slough were tagged with Passive Integrated Transponders (PIT tagged) due to uncertainty of estuary mobility and likelihood of exceeding ESA take prior to the end of the sampling season. In February, a fish tagged downstream at Cochran was recaptured by PIT tag antenna identification at the Winter Lake complex. It was determined this individual coho had traveled upstream the entire length of the tide gate portion of the LCM project area. From February through the end of the 2021 sampling season all juvenile coho captured at some sites were PIT tagged. Throughout the entire season, all coho captured at Winter Lake were measured and PIT tagged due to the low numbers captured. Trapping at Winter Lake was difficult due to the size of the project area, depth of water and access to sites therefore starting March 4, 2021 a portion of PIT tagged coho caught at Beaver Slough were transferred to Winter Lake Unit 2. Records of each individual PIT tagged coho were kept to ensure analysis accounted for the transfer of these fish. In addition, body condition including parasite loading and PIT data was recorded for individual tagged fish on the data sheets. Length, weight, and overall body condition was also noted for lamprey and salmonids other than coho. All coho were scanned with a Biomark HPR Plus or Lite hand held PIT tag reader in order to detect recaptured fish that had been tagged during a trapping event on a previous day. Recaptures were measured, weighed and recorded on data sheets for further analysis of body condition changes and mobility from where they were originally tagged.

Ideally, fish sampling locations within a project area would be randomly selected throughout the entire project area. The Coquille River floodplain habitats are nuanced and a lot of consideration on capture sites and effective tactics has been implemented with the project. Flow levels can increase up to 10ft overnight with heavy rain. Protection of fish from trap laydown mortality and the ineffectiveness of some tactics (seining) when the valley floor is fully flooded has dictated that capture sites be fishable at the greatest number of days possible. Each site has been chosen with specific criteria including: 1) the ability of the trap site to represent the habitat area in the immediate and general vicinity. The ability of known equipment to capture fish repeatedly throughout the sampling season. 3) The capacity to limit mortality of fish due to lay down or detachment of traps or high water levels preventing recovery of traps. 4) The capacity to conduct trapping and seining operations safely. For these reasons, sampling locations were mostly stationary. At Seestrom, Cochran, Winter Lake Unit 3 and Beaver Slough sampling sites were constant throughout the season (Figure 9 - Figure 10). Due to the difficulties of sampling deep water with hoop traps at Winter Lake, the fish sampling locations are spread throughout Unit 2 while trying to find ideal conditions, typically higher elevations (Figure 9). When seining methods are used at Winter Lake, the accessible locations, due to dry ground and riparian vegetation, are limited to just a few locations as seen in Figure 9. Likewise, seining locations in the mainstem Coquille River are limited to locations where water levels, tide cycles and sandy bank exposure are available on the date of effort; therefore, each seining event is unique.

Figure 6. A 4' hoop trap with 25ft leads installed at the Cochran site. Hoop traps were used at most sampling sites in the 2020-2021 field season (left). During flood periods a purse seine was used to sample in the flooded project site of Winter Lake (right).

Figure 7. High water levels at Winter Lake decreased trapping efficiencies when using the hoop traps due to juvenile coho swimming overtop the traps. The left photo shows Ivy Metzgus (CoqWA) and Morgan Davies (ODFW) in knee-deep water on the bank next to a sampling location. The right photo shows a marker buoy (circled in red) where the hoop trap leads are staked into the ground.

Figure 8. Dusk beach seining replaced hoop traps as the primary method of capturing juvenile coho at Winter Lake starting in March through the remainder of the season.

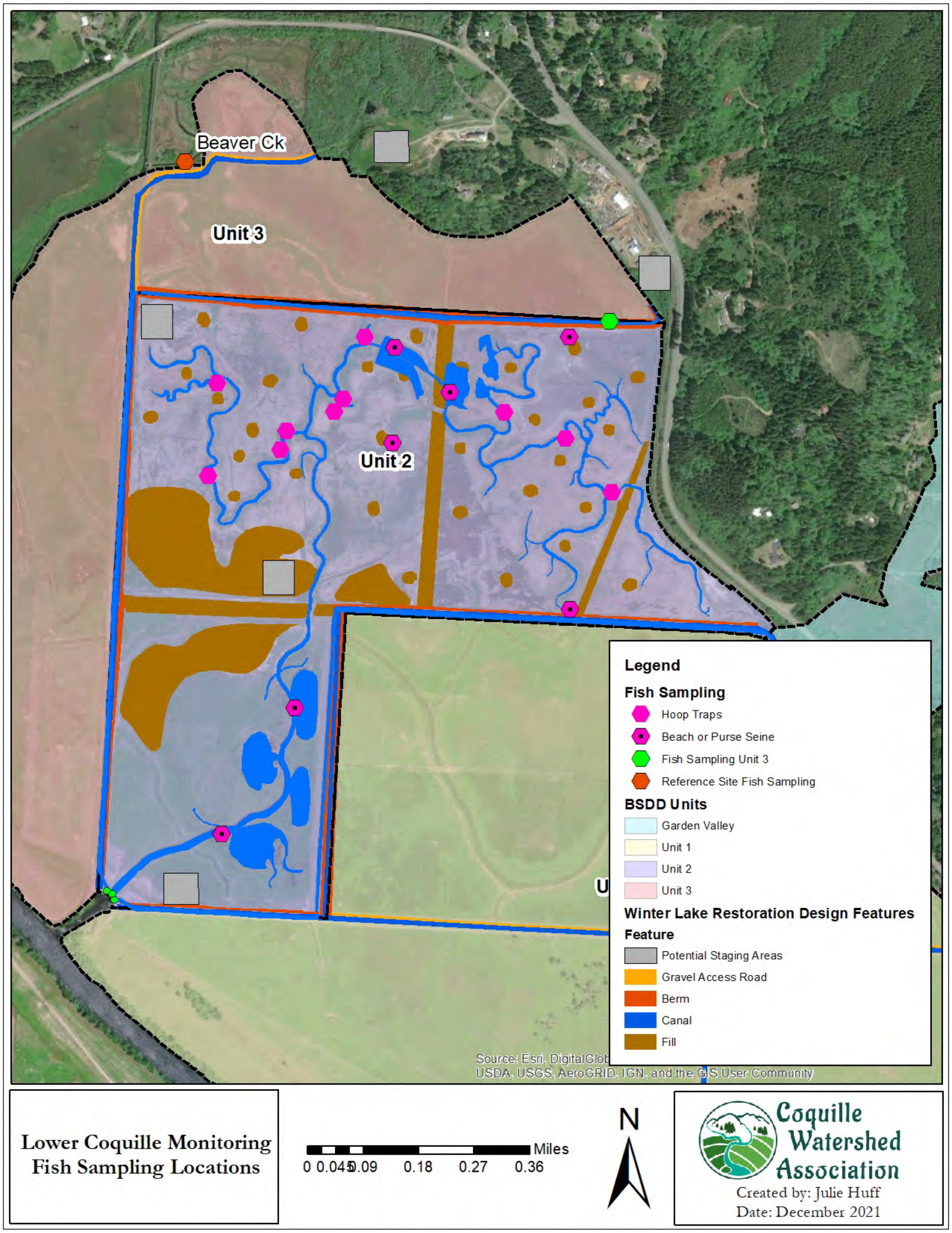

Figure 9. Sampling locations for the LCM site Winter Lake and Beaver Creek (Slough). Fish sampling in Unit 3 is a light pink hexagon, sampling in Beaver Slough is an orange hexagon and both stayed constant throughout the season. Fish sampling in Unit 2 are dark pink hexagons with the solid pink hexagon denoting hoop trap sites and the pink hexagon with a black dot denotes beach or purse seining sites. Due to the difficulties with sampling in the deep water of Unit 2, locations were chosen that had slightly higher ground.

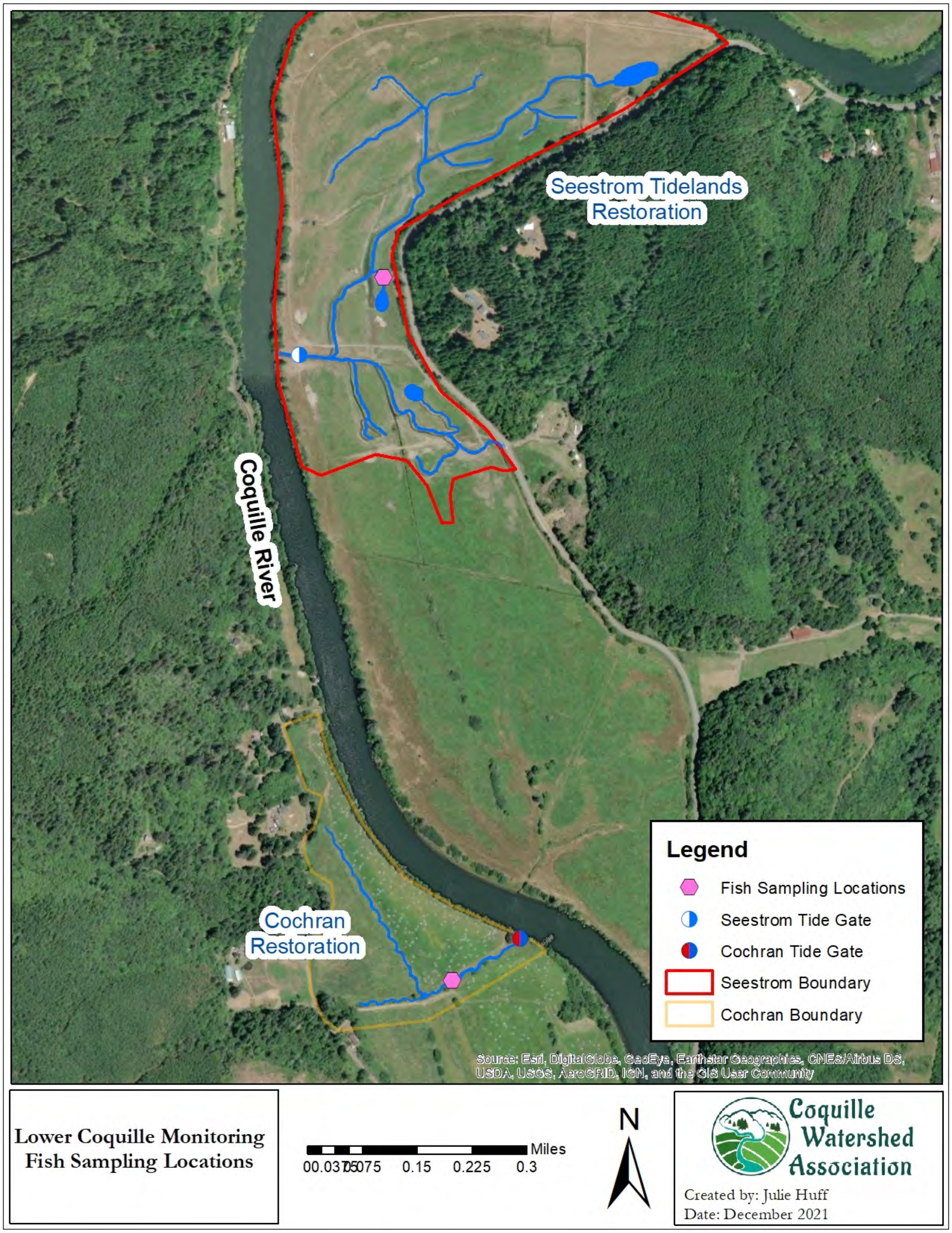

Figure 10. Sampling locations for LCM sites Seestrom and Cochran. At both locations, hoop traps were used throughout the season except the last sampling event when a beach seine was used.

6. Analytical Approach

A. Site Parameters

As part of the study, it is important to obtain information on water clarity, temperature, and water levels. Tide gate door management is just one of the factors that influence juvenile coho residence and movement throughout the estuary and affect these parameters due to the quantity of water exchanged. The site specific Water Management Plans correlate to not only the tide gate operations, but also weather conditions, which in turn affect water quantity and quality factors. We monitored these influential site parameters such as temperature, conductivity and water level at all of the sites. Velocity meters are installed at Winter Lake and Seestrom and accordingly, we obtained water velocity data for those two sites.

A suite of Onset aquatic data loggers were used for monitoring the site parameters, specifically, U24 conductivity loggers, U22 Pro v2 temperature loggers and U20 water level loggers. Each logger was set to 15-minute intervals and followed DEQ procedures for pre and post deployment calibration verifications. Furthermore, the data followed QA/QC standards as described in the Winter Lake Sampling and Analysis Plan approved by DEQ.

B. Species Abundance

Relative abundance of fish species in the four monitoring sites was determined by total individual counts of each species. Due to poor trapping efficiencies when water levels over topped the traps by multiple feet (frequently at Winter Lake, infrequently elsewhere) relative abundance was not fully representative of the monitoring sites compared across sites, thus we analyzed data accordingly with acknowledgement of this weakness.

C. Condition

Juvenile coho salmon were measured for length (fork length, mm) and weight (whole-body wet weight, g). A dimensionless body condition index was calculated from length and weight measurements as:

$$K = 10^5 \cdot (W/L^3) \qquad \text{(Eqn. 1),}$$

where K is Fulton's Condition Factor, W is whole-body wet weight (g), L is fork length (mm), and 10^5 is a scaling factor (Ricker 1975).

Weight-Length Relationships (WLR) at each location were assumed to follow:

$$W = aL^b \qquad \text{(Eqn. 2),}$$

where W is whole-body wet weight (g), L is fork length (cm), a is a constant intercept representing initial conditions, and b is the growth coefficient. The constants a and b were fit using least squares regression on the $\log_{10}$ transformed length and weight data as:

$$\log(W) = \log(a) + b \cdot \log(L) \qquad \text{(Eqn. 3).}$$

WLRs were calculated for each location (Beaver Slough, Winter Lake Unit 2, Cochran, Seestrom, and Mainstem Coquille) in each month (December – April, where capture data exist) and with length and weight data pooled across all sampling dates. Data from sampling sites within locations were aggregated together; and not analyzed separately. WLRs were not calculated for Winter Lake Unit 3 due to low captures (n = 1).

Length, weight, and condition factor data were evaluated for normality using the Shapiro-Wilk normality test (Shapiro & Wilk 1965) and for homogenous error variance using Bartlett's Test (Bartlett 1937a; 1937b). Logarithmic transformation failed to normalize distributions or to homogenize error variance for all locations in all months, so comparisons among locations were evaluated using the non-parametric one-way Kruskal-Wallis test (Kruskal & Wallis 1952). Significant results were followed by Dunn's method for post-hoc pairwise comparisons (Dunn 1964) with Bonferroni-adjusted p-values.[3] Regression coefficients for WLRs were compared using Analysis of Covariance (ANCOVA).

D. Growth

Instantaneous growth rates of recaptured PIT tagged fish were calculated assuming exponential growth as (Busacker *et al*. 1990):

$g_L = [\text{Log}_e(L_2)\text{-Log}_e(L_1)]/\Delta t$ (Eqn. 4), and

$g_W = [\text{Log}_e(w_2)\text{-Log}_e(w_1)]/\Delta t$ (Eqn. 5)

Where:

G_L = Growth Rate (Length), $mm \cdot d^{-1}$
G_W = Growth Rate (Weight), $g \cdot d^{-1}$
L_1 = Length at initial capture, mm
L_2 = Length at recapture, mm
w_1 = Weight at initial capture, g
w_2 = Weight at recapture, g
Δt = Time between capture and recapture, days

Specific growth rates, as a daily percent change in weight (G_w) or length (G_L), were calculated as:

$G = 100(e^g\text{-}1)$ (Eqn. 6),

Where e is the base of natural logarithms and g is g_L or g_w for length and weight, respectively (Crane *et al.* 2019).

Instantaneous growth rates were also calculated as the slope of the linear regression of mean $\log_e$-transformed lengths or weights of captured fish across sampling events. Specific growth rates then were calculated using equation 6. This approach assumes that captured fish were residents of their respective capture locations for the duration of the season (December – April). Approximately 2% of PIT tagged fish were detected at antenna arrays in locations different than where they were tagged,

[3] The Bonferroni method is a means of reducing the probability of a Type I error (false positive significant result) when performing multiple comparisons. In this approach, the α threshold for significance is reduced as α* = α divided by the number of comparisons. The implication is that, for the suite of all comparisons, the significance threshold remains α.

and locations were not closed to immigration/emigration through the study period. Regression coefficients for growth rates (Length, Weight, K) were compared using Analysis of Covariance (ANCOVA).

E. Survival

Detection of tagged fish at a PIT antenna array reflects the joint probability of survival from tagging to detection and the probability of detection by the antenna array. Fish that are not detected at the antennas may be mortalities or fish that the antennas failed to detect. To separate those two "losses" of tagged fish, we intended to calculate detection efficiency of each antenna in the array as:

$$P_1 = N_1/(N_1+M_1) \quad \text{(Eqn. 7),}$$

Where P_1 = Detection probability of antenna 1
N_1= Number of fish detected by antenna 1
M_1 = Number of fish missed by antenna 1 (number of fish that were detected at antenna 2 but not at antenna 1)

Equation 7 would also be used to calculate the detection efficiency of both antennas in the array, and the overall detection efficiency of the array, P, would be calculated as:

$$P = 1 - [(1-P_1) \cdot (1-P_2)] \quad \text{(Eqn. 8).}$$

However, juvenile coho frequently staged near the antenna arrays making it unclear which fish-detection events should be considered fish-passage events (i.e., directional movement rather than milling near the array) for calculation of detection efficiency. In the present analysis, actual losses to mortality are not separated from apparent losses that are due to failure of the antenna arrays to detect tagged fish.

F. Movement and Passage Conditions

Residence times were assessed as post-tagging residence times at locations with PIT antenna arrays at the tide gates (Winter Lake Unit 2[4], Cochran, Seestrom). The period of residence was calculated as the number of days between tagging and final detection at the tide gates within individual project areas. Residence within the overall project area was not known as once fish reentered the river leaving out through a tide gate PIT array, unless they entered another tide gated site with antennas, their disposition was not able to be determined. This assessment requires the assumption that fish are resident at their location of tagging prior to their final detection at the tide gate.

Two-sample Kolmogorov-Smirnov tests were used to assess whether the distribution of downstream passage conditions (out-migrating through tide gates from off-channel locations) used by juvenile coho differed from the distribution of conditions available when gates were open. This analysis requires the assumption that the time of the last detection of each tagged fish approximately

[4] Winter Lake Unit 3 was not included in the analysis due to the low number of juvenile coho tagged in Unit 3 (n = 1).

corresponds to the time of passage through the tide gate toward the river. Fish were excluded from the analysis if the gates were closed at the time of final detection.

The following passage conditions were assessed: hour of day, hydraulic head (upstream water level – downstream water level, meters), tidal bin[5] (categorical), velocity (centimeters·second^{-1}), upstream water level (i.e., water level on the landward side of the tide gate, meters), and rate of change of upstream water level (meters·minute^{-1}). Upstream passage was not evaluated due to low numbers of fish tagged in the mainstem Coquille River and relatively few detects of mobile coho entering locations different than their initial capture location: Seestrom, n =13; Cochran, n = 2; Winter Lake Unit 2, n = 1; Winter Lake Unit 3, n = 4, as depicted in Figure 11. Entrance conditions will be further evaluated as this year's data are aggregated with data collected in future years.

[5] Tidal bins were categorical classifications of tidal stage: 1 (Slack after Flood), 2 (Ebb), 3 (Slack before Ebb), 4 (Slack after Ebb), 5 (Flood), and 6 (Slack before Flood).

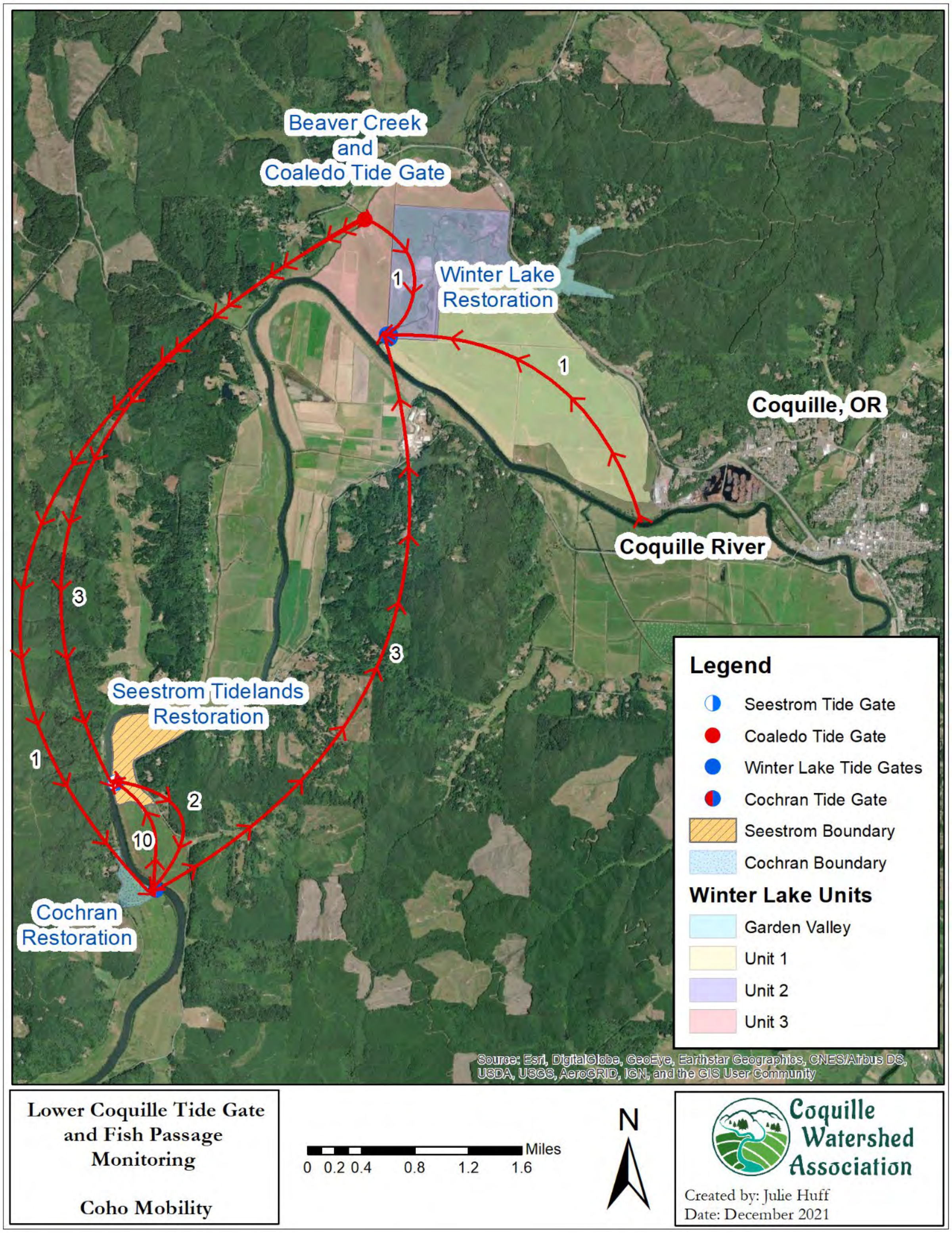

Figure 11. A schematic of the mobile juvenile coho over the winter and spring monitoring season. The red arrows depict the direction of movement between sites while the corresponding numbers are the total number of times traveled by coho. One select coho, 3DD.003D352386, traveled back and forth between Cochran and Seestrom twice.

7. Results

A. Site Parameters

Mean daily temperature for all sites are provided in Figure 12. Temperatures were similar until March when site temperatures diverged. Conductivity is a good measure for the salinity of water therefore conductivity is monitored throughout the winter and spring months. The mean daily conductivity for all sites are provided in Figure 13, as expected during low water periods in late May conductivity increases as salty tide waters are pushing higher up into the estuary.

Maximum daily velocity for Seestrom and the Winter Lake units are provided in Figure 14. Velocity is a function of the differential height of the headwater and tailwater, therefore as the tide is falling velocity will increase until low tide is reached and then velocity will decrease until the site drains and the door is closed or the rising tide eliminates the head differential. Maximum daily velocity not only represents the maximum velocity but also the range of velocities experienced in the culvert of the tide gate structure over the course of the day since nearly every day the tide gate door closes and velocities decrease to 0. Velocities of Seestrom and Winter Lake – Unit 3 are bidirectional therefore positive velocities are outflow while negative velocities are inflow. Negative velocities (inflow) are not present on the maximum daily velocity figure (Figure 14) for the Seestrom project because each day there was also outflow and since outflow is recorded as positive numbers outflow velocities are designated for daily maximums. The periods of negative velocities at Winter Lake Unit 3 in February are associated with the inflow of the rising limb of mild flood events when the project sites were being flooded with river water. These mild flood events can be seen in the water surface elevations of the Coquille River at each project site, Figure 15. Although all project sites are situated in the Coquille Estuary, the river behaves differently whether high in the estuary at Winter Lake or low in the estuary at Cochran. For this reason, the Winter Lake tide gates behave as flood gates during short to moderately long periods in the winter when storms cause the Coquille River to rise significantly and riverbank friction eliminates tidal signal.

A large factor in fish passage is the amount (% open) and duration that tide gate doors are open. The Cochran and Seestrom sites have side-hinge doors with an MTR that allows both inflow and outflow. The Winter Lake tide gates are electrical slide gates with one gate per unit (Gate 2C and 3A) that has a second, side-hinged tide gate mounted on the outside of the vertical slide gate. These gates with both vertical slide and side hinged secondary tide gates are able to provide manual outflow through the side hinged gate and inflow through the vertical slide gate. If the slide gate is not open on the dual function gates than the side-hinge gates provide outflow only[6]. Gate openness of the side hinge gates at all sites is provided in Figure 16. Slide gate heights of the Winter Lake tide gates during the monitoring period is provided in Figure 17.

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[6] For greater detail into how these gates function and are operated please refer to the Winter Lake Restoration Effectiveness Monitoring Report Year 3, 2021.
https://drive.google.com/file/d/1EWPnLf34eEuXnEi22tH1vRCuN4BQP3Y7/view?usp=sharing

Figure 12. Mean daily temperature at Cochran (blue), Seestrom (green), Winter Lake – Unit 2 (red), Winter Lake – Unit 3 (black).

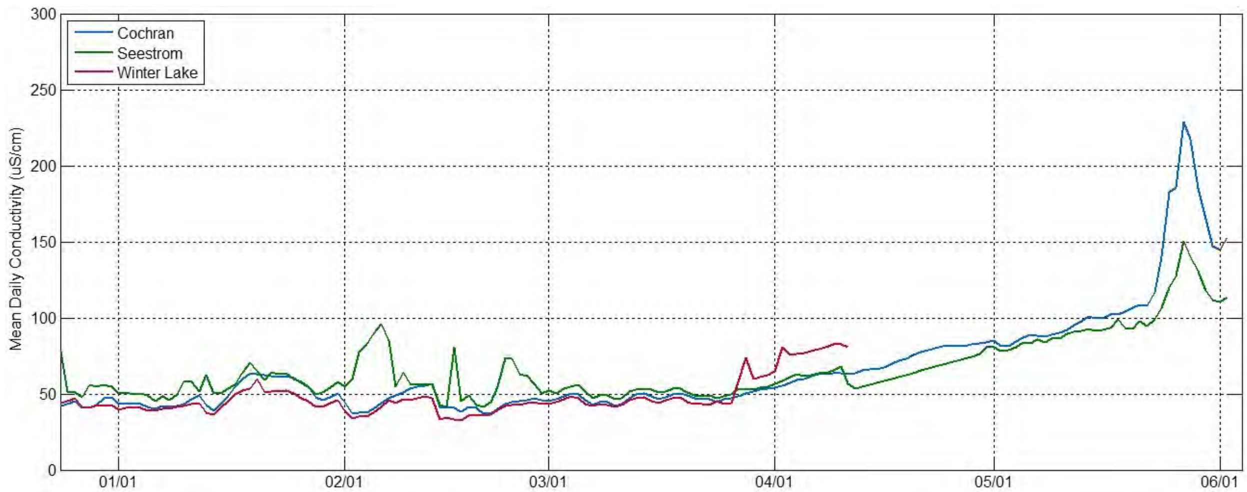

Figure 13. Mean daily conductivity (µS/cm) of the Coquille River at Cochran (blue), Seestrom (green), and Winter Lake (red). Winter Lake data stopped on April 11, 2021 due to full memory of the logger.

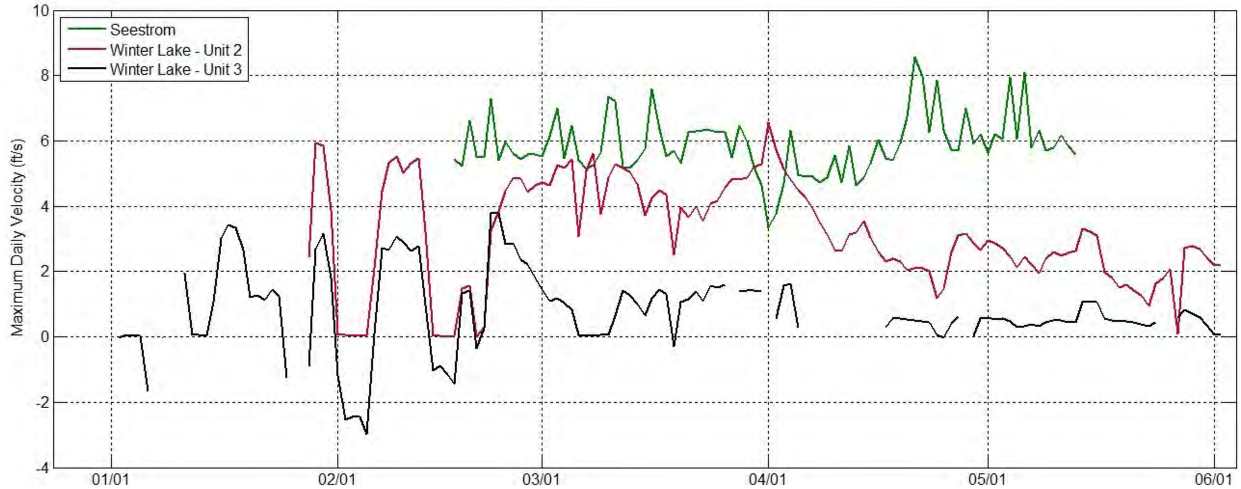

Figure 14. Maximum daily velocity (ft/s) at Seestrom (green), Winter Lake – Unit 2 (red), Winter Lake – Unit 3 (black). Both Seestrom and Winter Lake – Unit 3(Gate 3A) experience bi-directional flow, downstream flow is positive and upstream flow is negative. Winter Lake – Unit 2 velocity is from the culvert associated with Gate 2C and experiences only downstream flow. Note that velocity is in English units and was done so intentionally.

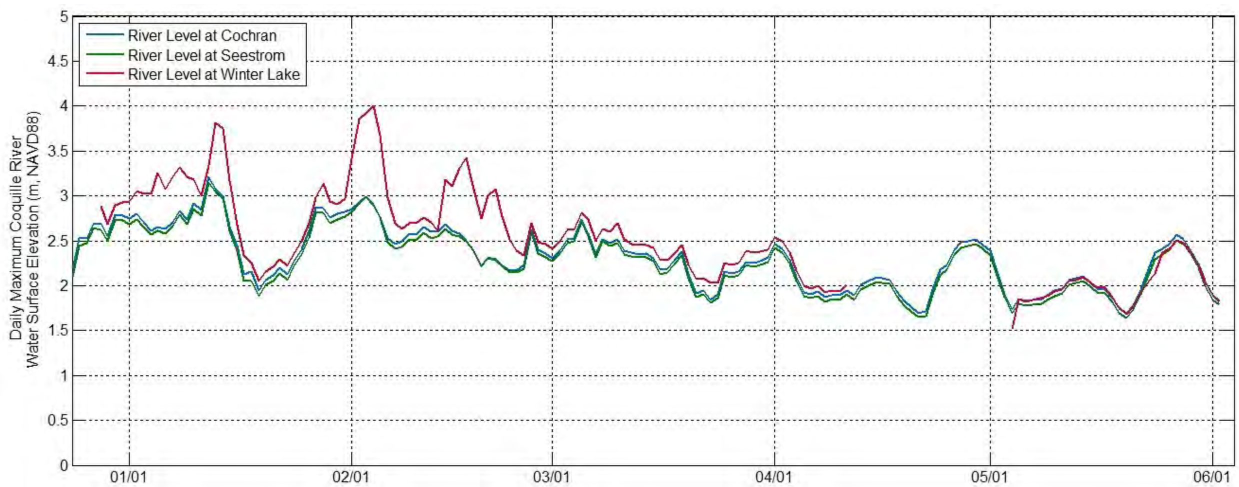

Figure 15. Coquille River water surface elevations (m NAVD88) at Cochran (blue), Seestrom (green), and Winter Lake (red). Winter Lake is positioned highest in the estuary and is influenced more by winter storm events than the other project sites.

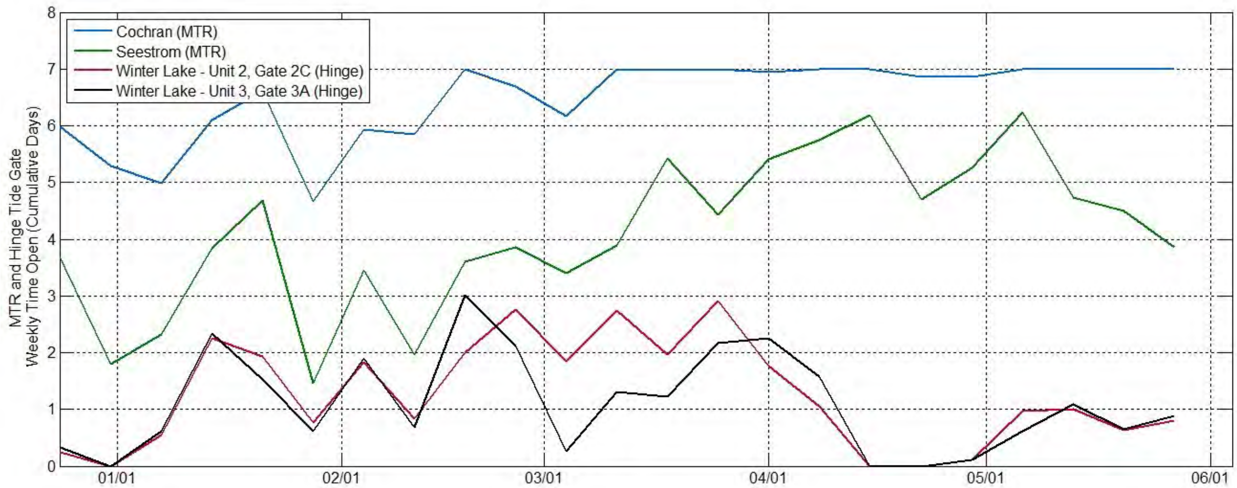

Figure 16. Tide gate weekly time open for Cochran (blue), Seestrom (green), Winter Lake – Unit 2 (red), Winter Lake – Unit 3 (black). Both Cochran and Seestrom are manual mechanical MTR style tide gates that allow inflow and outflow. Inflow at Winter Lake is managed using the vertical slide gates (Figure 17). The side-hinged gates at Winter Lake are duplicative and only allow outflow.

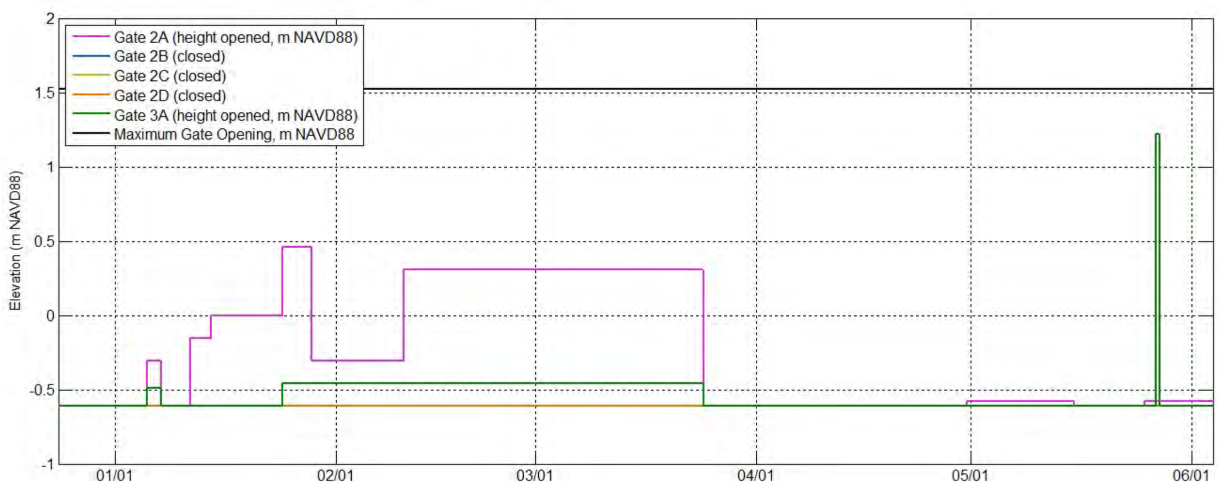

Figure 17. Slide gate openness at the Winter Lake site for Unit 2 and 3. Gate 2C and 3A are dual function slide and side-hinge gates. The slide gate function of Gate 2C was not used during the monitoring season.

B. Species Abundance

Fish sampling was initiated in early December of 2020 and concluded for the season in early May of 2021 due to rising water temperatures from an unseasonably warm and dry spring. A total of 2,185 pre-smolt coho juveniles were captured during the sampling season over a total of 43 sampling events with some days consisting of 2+ sampling events. The largest numbers of coho captured was at the reference site, Beaver Slough (Table 1), which is similar to previous years of sampling at the site. A total of 137 coho were caught at Beaver Slough, PIT tagged and then released into Winter Lake at a location

Table 1. Fish sampling summary from the Dec 2020-May 2021 sampling season.

	Mainstem Sampling	Cochran[1]	Seestrom	Beaver Creek	Beaver Creek Captured, Transferred to Unit 2	Winter Lake, Unit 1[2]	Winter Lake, Unit 2[3]	Winter Lake, Unit 3
# of Sampling Events[4]	9	6	7	11	4	0	19	6
Total coho caught	54	502	570	1045	137	0	67	1
Total coho tagged	54	139	271	428	137	0	62	1
Total Chinook caught	5	20	34	0	n/a	0	41	0

1 - The first sampling event (12/11) caught 0 coho, the 4th sampling event (2/25) caught few coho because a nutria had chewed a hole through the hoop trap

2 - No trapping was completed in Unit 1 and no detections were made by the PIT array on the tide gate for tagged fish entering the site

3 - Water levels were high during trapping events, causing low densities of coho and low trapping efficiency. See ODFW Winter Lake Volume Analysis for further information.

4 - Sampling events consisted of seining (beach or purse) and hoop traps. The number of hoop traps varied between 1 and 5, CPUE was not calculated for this chart.

A total of 21 other species of fish and aquatic organisms were captured in addition to coho, listed in Table 2. Winter Lake Unit 2 had the highest number of non-native fish species, a total of 1,051 bullhead catfish *(Ameiurus nebulosus)*, 3,287 bluegill *(Lepomis macrochirus)*, 283 yellow perch (*Perca flavescens*), and 269 largemouth bass *(Micropterus salmoides)*. All are competing for food with coho juveniles while the large non-native fish are considered a potential predator on coho juveniles. Pacific lamprey *(Entosphenus tridentata)* were captured in all Units of Winter Lake, including flooded pastures of southern Unit 1 (Cedar Pt 2). All Pacific lamprey caught, a total of 6, were ammocoetes.

A surprisingly high number of juvenile fall Chinook salmon were caught at all three tide gated project sites starting in April. During the planning phase of these restoration projects it was hypothesized juvenile fall Chinook would not use these restoration sites heavily, because they typically reside in larger channels. During the last sampling event at each project site only Chinook were captured using a beach seine and they were also the last PIT tagged salmonids to leave Winter Lake.

Table 2. Total species abundance for the Dec 2020-May 2021 fish sampling season not including mainstem Coquille River sampling.

		Winter Lake, Unit 3	Winter Lake, Unit 2	Cochran	Seestrom	Beaver Creek, Reference
Total Sampling Events		6	34	6	7	11
Species (native)						
Coho	2185	1	67	502	570	1045
Chinook	95	-	41	20	34	-
Cutthroat Trout	11	-	1	2	3	5
Gambusia	8		1	4	1	2
Lamprey (Western Brook)	3	-	1	2	-	-
Newts	175	4	1	103	28	39
Northwest Salamander	111	-	0	75	35	1
Pacific Lamprey	6	-	6	-	-	-
Red legged Frog	14	-	1	6	6	1
Sculpin sp.	91	-	19	53	17	2
Steelhead	1	-	1	-	-	-
Sucker	1	-	0	-	-	1
Three Spine Stickleback	1036	7	40	330	55	604
Unknown tadpole	487	135	296	-	-	56
Species (non-native)						
Black Crappie	1081	9	1006	1	60	5
Bluegill	3521	59	3287	-	172	3
Brown Bullhead	1626	114	1051	-	205	256
Bullfrog Tadpole	781	50	648	3	6	74
Crayfish sp.	358	18	271	11	17	41
Goldfish	37	-	22	2	11	2
Largemouth Bass	309	9	269	-	29	2
Yellow Perch	294	8	283	-	3	-

C. Condition

Mean lengths, weights, and condition factor for juvenile coho salmon by location and month of capture are provided in Table 3 Table 4 Table 5, respectively. Kruskal-Wallis tests indicated significant differences in length and weight among locations in each month and when data were pooled across all months (Table 6). Condition factor differed among locations in February, March, and April or when data were pooled across all months (Table 6).

Assessment of how differences among sites in length, weight, and body condition develop over time are complicated by disparities in the success of capturing juvenile coho. For example, not all locations were available for comparison in every month due to lack of data in some months at some locations (See Table 5). Sample sizes for Winter Lake Unit 2 were also quite small in December through February (See Table 5), and comparisons between fish rearing in off-channel areas and those captured in the mainstem Coquille River were not possible until April due to a lack of data from the mainstem in prior months.

Despite the constraints identified above, pairwise comparisons suggest that, after starting the monitoring period at similar lengths, by April juvenile coho salmon in Beaver Slough and Winter Lake Unit 2 grew significantly longer than their counterparts at Cochran, Seestrom, or in the mainstem Coquille River (Figure 18). The pattern is similar for weight, though pairwise comparisons could not clearly identify homogeneous groupings in April (Figure 19). In April, pairwise comparisons indicated that juvenile coho at Winter Lake Unit 2 were significantly heavier than those at Cochran, Seestrom, and in the mainstem Coquille River. Patterns were less pronounced for condition factor, where by April pairwise comparisons indicate three homogenous but overlapping groupings (Group A = Winter Lake Unit 2, Cochran, and Seestrom; Group B = Cochran, Seestrom and Mainstem; Group C = Beaver Slough and Mainstem) (Figure 20).

There were no significant differences in slopes of the WLRs among months within Beaver Slough, Cochran, and Seestrom (Table 7). The ANCOVA indicated significant differences in the WLR slopes among months in Winter Lake Unit 2, but sample sizes for paired length and weight measurements were low in December, January, and February (n = 6, 6, and 2, respectively). Given these results, WLRs were compared across locations using data aggregated across all sampling events (Table 8: Figure 21). There was no analysis for the mainstem location because juvenile coho were only caught in April at this location.

When data were pooled across all sampling events, there were significant differences in the slopes of the WLRs among locations (ANCOVA, F = 5.96, df = 4, 1216, p = 0.0001). Differences will be further assessed with post-hoc pairwise comparisons between locations.

Table 3. Mean fork lengths (millimeters, ±95% CI) of juvenile coho salmon sampled in Beaver Slough, Winter Lake Unit 2, Cochran, Seestrom, and the mainstem Coquille River from December 2020 – April 2021. 'NA' indicates Not Applicable, where no juvenile coho salmon were sampled in the applicable month.

	Beaver Slough		Winter Lake Unit 2		Cochran		Seestrom		Mainstem Coquille R.	
Month	n	Fork Length (mm)	n	Fork Length (mm)	n	Fork Length (mm)	n	Fork Length (mm)	n	Fork Length (mm)
December	22	72.6 (±2.7)	6	82.7 (±7.1)	0	NA	58	82.2 (±3.5)	0	NA
January	20	108.8 (±4.6)	6	106.5 (±10.1)	70	87.6 (±2.4)	16	94.4 (±5.0)	0	NA
February	23	112.2 (±4.4)	2	118.0 (±15. 7)	88	99.1 (±2.2)	101	102.0 (±2.0)	0	NA
March	411	130.5 (±0.9)	25	135.1 (±8.4)	0	NA	109	111.4 (±1.7)	0	NA
April	137	131.8 (±1.7)	28	136.5 (±5.6)	15	117.7 (±4.1)	59	117.1 (±3.5)	39	117.6 (±3.1)
All Months	613	127.4 (±1.2)	67	127.9 (±5.7)	173	96.1 (±2.0)	343	103.9 (±1.7)	39	117.6 (±3.1)

Table 4. Mean whole-body wet weight (grams, ±95% CI) of juvenile coho salmon sampled in Beaver Slough, Winter Lake Unit 2, Cochran, Seestrom, and the mainstem Coquille River from December 2020 – April 2021. 'NA' indicates Not Applicable, where no juvenile coho salmon were sampled in the applicable month.

	Beaver Slough		Winter Lake Unit 2		Cochran		Seestrom		Mainstem Coquille R.	
Month	n	Weight (g)	n	Weight (g)	n	Weight (g)	n	Weight (g)	n	Weight (g)
December	22	4.3 (±0.4)	4	6.0 (±1.0)	0	NA	58	7.4 (±1.2)	0	NA
January	20	14.1 (±1.8)	6	15.0 (±4.5)	69	7.6 (±0.6)	16	9.7 (±1.8)	0	NA
February	23	16.6 (±2.0)	2	18.9 (±9.0)	86	11.2 (±0.8)	99	12.0 (±0.7)	0	NA
March	412	24.1 (±0.5)	23	32.2 (±5.4)	0	NA	109	15.6 (±0.7)	0	NA
April	137	23.7 (±0.9)	28	30.2 (±3.2)	15	19.3 (±2.2)	59	19.4 (±1.7)	39	17.7 (±1.4)
All Months	614	22.7 (±0.5)	63	27.6 (±3.1)	170	10.5 (±0.7)	341	13.5 (±0.6)	39	17.7 (±1.4)

Table 5. Mean condition factor, K (±95% CI), of juvenile coho salmon sampled in Beaver Slough, Winter Lake Unit 2, Cochran, Seestrom, and the mainstem Coquille River from December 2020 – April 2021. 'NA' indicates Not Applicable, where no juvenile coho salmon were sampled in the applicable month.

	Beaver Slough		Winter Lake Unit 2		Cochran		Seestrom		Mainstem Coquille R.	
Month	n	K	n	K	n	K	n	K	n	K
December	22	1.12 (±0.07)	4	0.96 (±0.28)	0	NA	58	1.25 (±0.09)	0	NA
January	20	1.08 (±0.03)	6	1.20 (±0.07)	69	1.10 (±0.03)	16	1.11 (±0.06)	0	NA
February	23	1.15 (±0.03)	2	1.12 (±0.10)	86	1.11 (±0.02)	99	1.10 (±0.02)	0	NA
March	411	1.07 (±0.01)	23	1.20 (±0.03)	0	NA	109	1.12 (±0.02)	0	NA
April	137	1.02 (±0.01)	28	1.15 (±0.02)	15	1.17 (±0.05)	59	1.15 (±0.02)	39	1.07 (±0.02)
All Months	613	1.06 (±0.01)	63	1.16 (±0.03)	170	1.11 (±0.02)	341	1.14 (±0.02)	39	1.07 (±0.02)

Table 6. Results of Kruskal-Wallis tests (Kruskal-Wallis H Statistic, degrees of freedom, p-value) comparing fork lengths, weights, and condition factor among locations (Beaver Slough, Winter Lake Unit 2, Cochran, Seestrom, and Mainstem) by month and with data pooled across months. Critical values are Chi-squared approximated at α=0.05 with k-1 degrees of freedom. Significant results are shown in bold.

Parameter	Month	H	df	p-value
Length	December[i]	12.74	2	**0.0017**
	January[ii]	45.07	3	**<0.0001**
	February[iii]	20.91	2	**<0.0001**
	March[iv]	184.43	2	**<0.0001**
	April[v]	94.30	4	**<0.0001**
	All Months	558.13	4	**<0.0001**
Weight	December[i]	18.81	2	**0.0001**
	January[ii]	45.57	3	**<0.0001**
	February[iii]	23.61	2	**<0.0001**
	March[iv]	175.76	2	**<0.0001**
	April[v]	69.48	4	**<0.0001**
	All Months	517.31	4	**<0.0001**
Condition Factor	December[i]	3.42	2	0.1811
	January[ii]	6.30	3	0.0979
	February[iii]	6.82	2	**0.0330**
	March[iv]	62.96	2	**<0.0001**
	April[v]	120.10	4	**<0.0001**
	All Months	142.36	4	**<0.0001**

[i]December includes only Beaver Slough, Seestrom, and Winter Lake Unit 2; Winter Lake Unit 2 had low sample size (n = 6 & 4 for length and weight & condition, respectively)
[ii]January includes Beaver Slough, Seestrom, Cochran, and Winter Lake Unit 2; Winter Lake Unit 2 had low sample size (n = 6).
[iii]February includes Beaver Slough, Seestrom, and Cochran; Winter Lake Unit 2 was not included due to low sample size (n = 2).
[iv]December includes only Beaver Slough, Seestrom, and Winter Lake Unit 2
[v]April includes all locations

Table 7. ANCOVA results (F statistic, degrees of freedom, p-value) comparing slopes of Weight-Length Relationships among months within each sampling location. The mainstem Coquille River is not included because fish were captured only in April. Significant results are shown in bold.

Location	F	df	p-value
Beaver Slough	2.12	4, 603	0.0770
Winter Lake Unit 2[i]	23.61	3, 53	**<0.0001**
Cochran[ii]	1.32	2, 64	0.2708
Seestrom	1.00	4, 331	0.4079

[i]The Winter Lake Unit 2 assessment did not include February due to low sample size, n = 2.
[ii]Fish were captured within the Cochran location only in January, February, and April.

Table 8. Weight-length relationship parameters for juvenile coho salmon sampled in Beaver Slough, Winter Lake Unit 2, Cochran, Seestrom, and the mainstem Coquille River from December 2020 – April 2021. Parameters were estimated from the linear relationship between log10 transformed values for weight (g) and length (cm).

Location	n	r^2	p-value	a	b
Beaver Slough	613	0.96	<0.0001	0.0150	2.86
Winter Lake Unit 2	63	0.96	<0.0001	0.0095	3.08
Cochran	170	0.93	<0.0001	0.0088	3.10
Seestrom	341	0.93	<0.0001	0.0162	2.84
Mainstem Coquille R.	39	0.93	<0.0001	0.0099	3.03

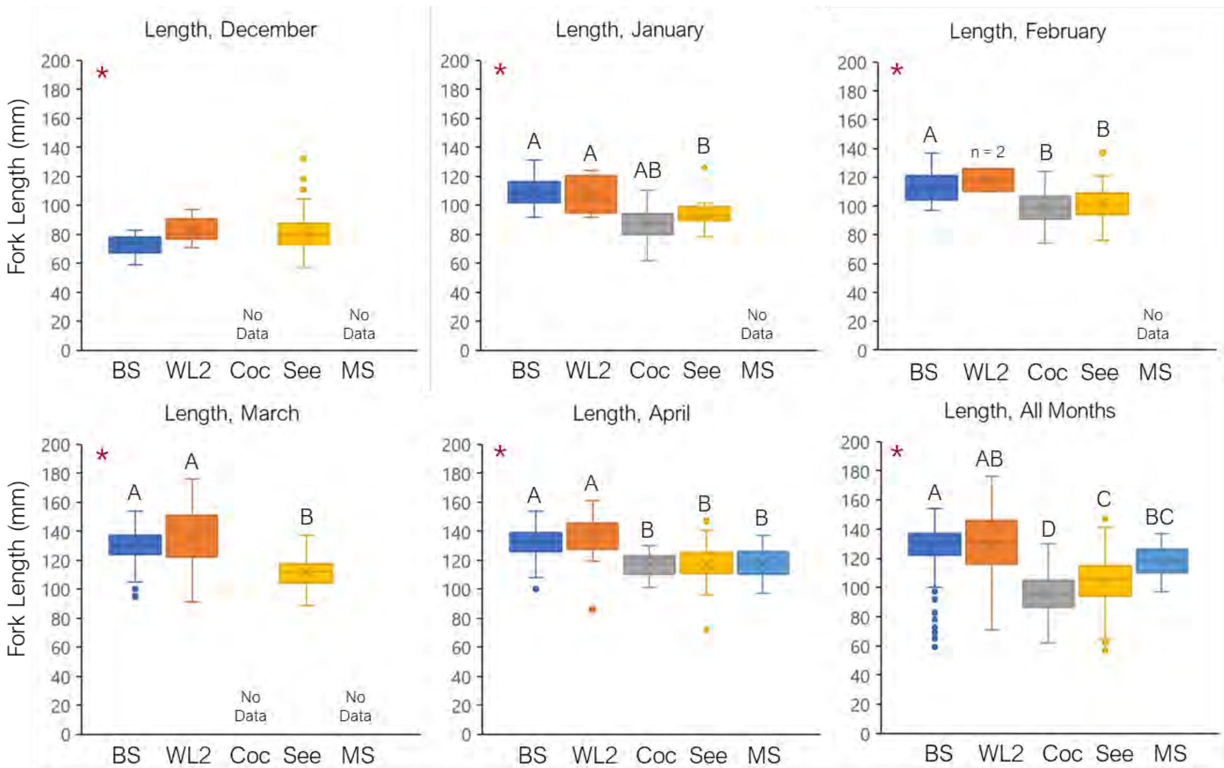

Figure 18. Box plots of fork length (mm) by month and pooled across months for Beaver Slough (BS), Winter Lake Unit 2 (WL2), Cochran (Coc), Seestrom (See) and the Mainstem Coquille River (MS). An asterisk (*) indicates significant Kruskall-Wallis tests. Letters (A, B, C) above boxes indicate homogenous groups identified through post-hoc pairwise comparisons with Bonferroni-adjusted p-values, p (p* = 0.017 in Dec, Feb, Mar; 0.008 in Jan; 0.005 in Apr & All Months). Winter Lake Unit 2 was not included in statistical analyses in February due to low sample size (n = 2). Post-hoc comparisons could not identify homogeneous groupings in December.*

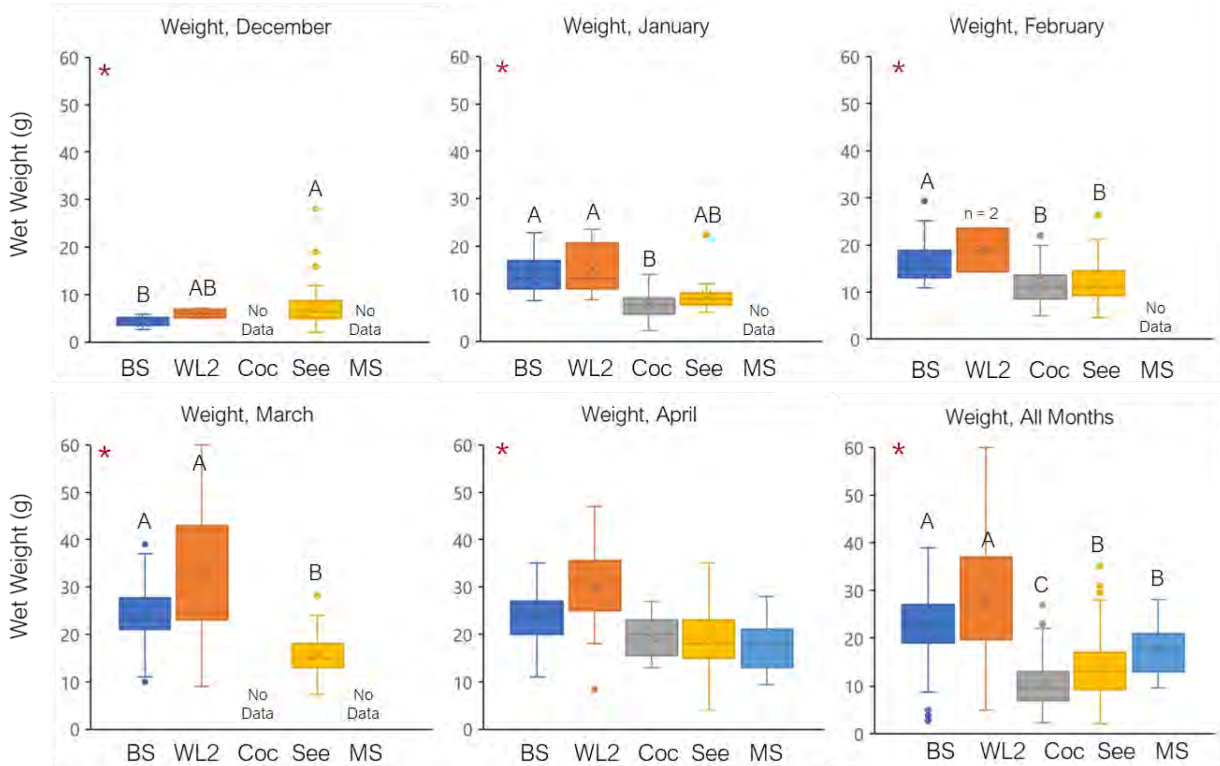

Figure 19. Box plots of whole-body wet weight (grams) by month and pooled across months for Beaver Slough (BS), Winter Lake Unit 2 (WL2), Cochran (Coc), Seestrom (See) and the Mainstem Coquille River (MS). An asterisk (*) indicates significant Kruskall-Wallis tests. Letters (A, B, C) above boxes indicate homogenous groups identified through post-hoc pairwise comparisons with Bonferroni-adjusted p-values, p (p* = 0.017 in Dec, Feb, Mar; 0.008 in Jan, & 0.005 in Apr & All Months). Winter Lake Unit 2 was not included in statistical analyses in February due to low sample size (n = 2). April post-hoc comparisons could not identify homogeneous groupings at p* = 0.005).*

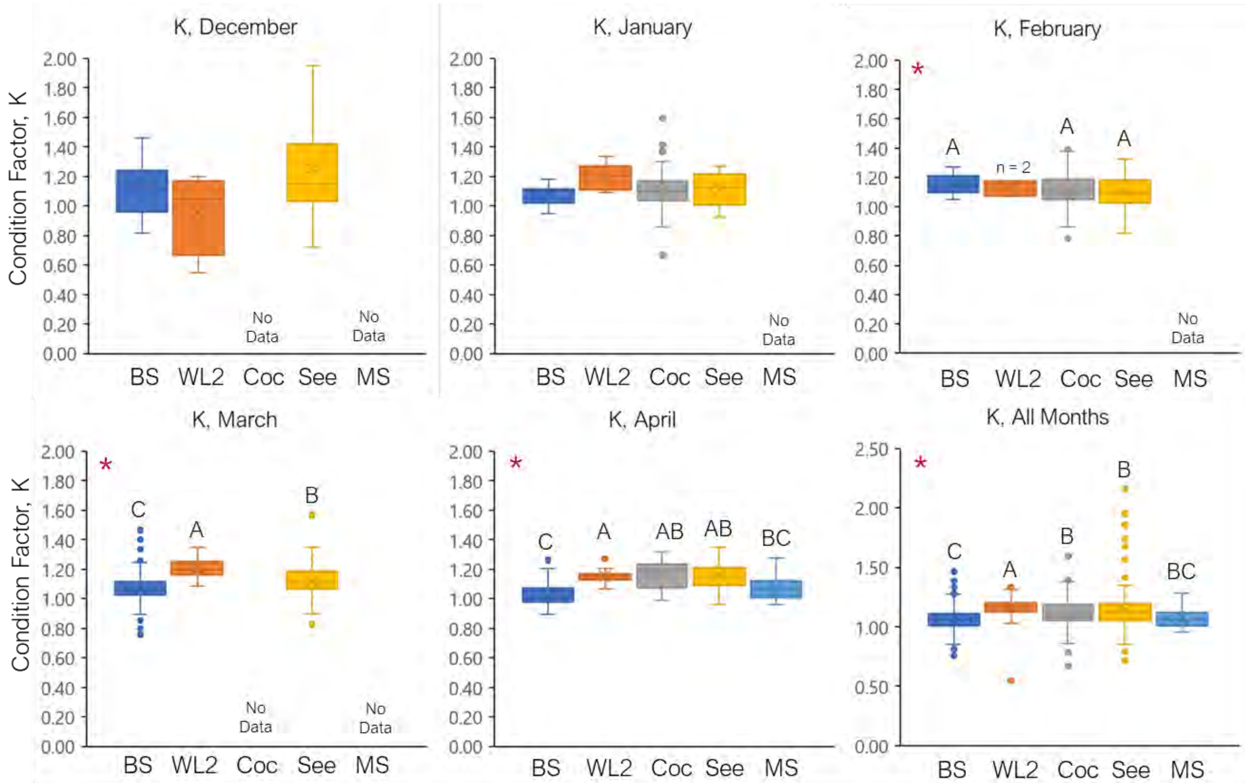

Figure 20. Box plots of Fulton's Condition Factor (K, nondimensional) by month and pooled across months for Beaver Slough (BS), Winter Lake Unit 2 (WL2), Cochran (Coc), Seestrom (See) and the Mainstem Coquille River (MS). An asterisk (*) indicates significant Kruskal-Wallis tests. Letters (A, B, C) above boxes indicate homogenous groups identified through post-hoc pairwise comparisons with Bonferroni-adjusted p-values, p (p* = 0.017 in Dec, Feb, Mar; 0.008 in Jan, & 0.005 in Apr & All Months). Winter Lake Unit 2 was not included in statistical analyses in February due to low sample size (n = 2); despite a significant Kruskal-Wallis Test in February, differences could not be discriminated with post-hoc comparisons at p* = 0.017.*

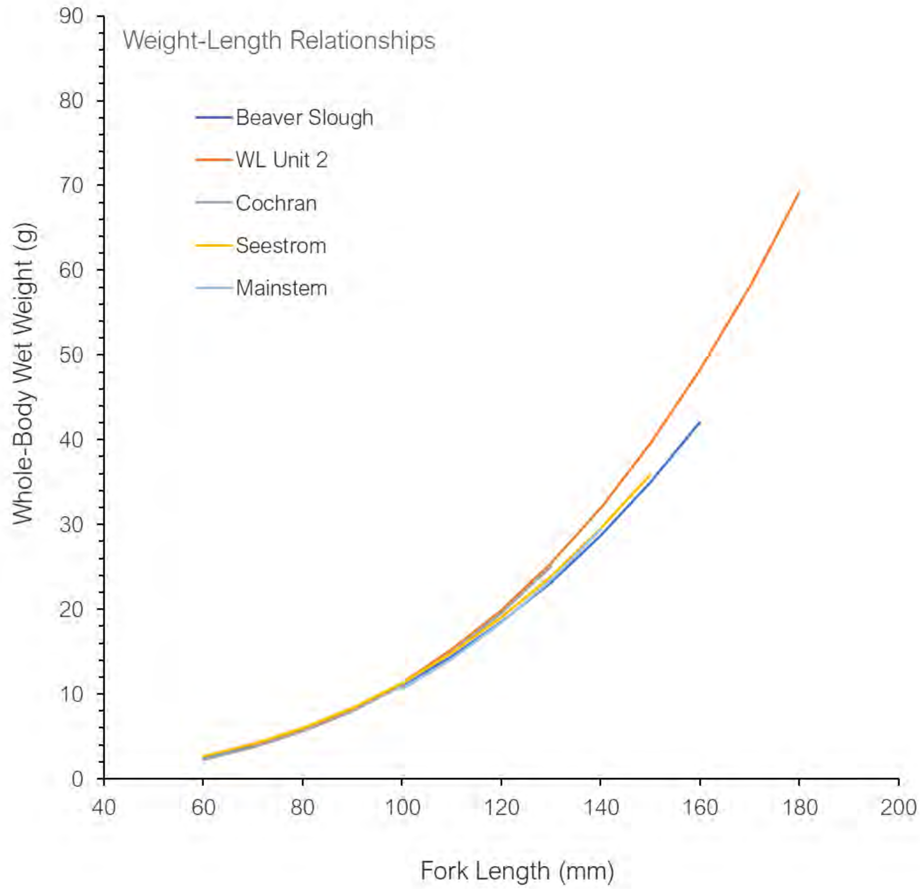

Figure 21. Weight-Length Relationships for juvenile coho salmon in Beaver Slough, Winter Lake Unit 2, Cochran, Seestrom, and the Mainstem Coquille River. Data points are omitted for figure clarity. Curves span the length ranges observed at each site.

D. Growth

Twenty-three tagged fish were recaptured after their initial capture (Table 9). No fish were recaptured more than once. Two fish that were recaptured after only one day at large were not included in analyses. With one exception, fish were recaptured in the same location at which they were tagged. These fish were assumed to have been residents of the initial capture location for the duration of their time at large. One mobile fish was recaptured at Beaver Slough 50 days after its initial capture at the Cochran location. Recaptures at Winter Lake (n=4) include three fish that were initially captured in Beaver Slough but translocated into Winter Lake following tagging.[7]

[7]After initially experiencing low capture numbers in Winter Lake Unit 2, some juvenile coho captured in Beaver Slough were tagged and translocated to Winter Lake for release.

Rates of growth calculated from recaptured individuals were similar to those inferred by regression of mean lengths and weights across sampling events (Table 10). However, small sample sizes for recaptured individuals and, in some cases, relatively few successful capture events or low captures in some events limits the precision of estimates (Table 10). There were no significant differences in the slopes of regressions for length (F = 0.96, df 3, 25, p = 0.4257) or weight (F = 1.00, df 3, 24, p = 0.1658) among locations.

Table 9. Dates of tagging and recapture, time at large (days), and size (length in mm and weight in g) of juvenile coho salmon at capture and recapture by residence location (Beaver Slough, Winter Lake Unit 2, Cochran, and Seestrom). One mobile individual was initially tagged at Cochran before being recaptured at Beaver Slough.

Location	PIT Tag ID	Tagging Date	Recapture Date	Days at Large	Fork Length, Tagging (mm)	Fork Length, Recapture (mm)	Weight, Capture (g)	Weight, Recapture (g)
Beaver Slough[i]	3DD.003D351D21	3/11/2021	3/26/2021	15	125	130	22.0	25.0
	3DD.003D351ED3	1/29/2021	3/26/2021	56	108	144	13.4	31.0
	3DD.003D351BAA	3/18/2021	3/26/2021	8	120	124	17.0	19.0
Winter Lake Unit 2	3DD.003D351D41	4/06/2021	4/13/2021	7	124	127	22.0	23.0
	3DD.003D351D52	3/26/2021	4/13/2021	18	124	140	20.0	32.0
	3DD.003D351D53	3/26/2021	4/06/2021	11	138	152	27.0	41.0
	3DD.003D351FFC	3/05/2021	3/30/2021	25	121	157	18.1	45.0
Cochran	3DD.003D352386	1/08/2021	2/04/2021	27	103	118	11.7	20.0
	3DD.003D352389	1/08/2021	2/04/2021	27	91	104	8.2	14.0
	3DD.003D35238C	1/08/2021	2/04/2021	27	81	91	6.0	10.5
	3DD.003D3523AB	1/08/2021	2/04/2021	27	86	99	6.9	12.5
	3DD.003D3523B7	1/08/2021	2/04/2021	27	77	90	5.7	9.0
Seestrom	3DD.003D351B65	3/19/2021	4/16/2021	28	104	115	14.0	17.0
	3DD.003D351B81	3/19/2021	4/16/2021	28	103	124	11.0	23.1
	3DD.003D351B8C	3/19/2021	4/16/2021	28	101	114	13.0	15.0
	3DD.003D351B99	3/19/2021	4/16/2021	28	104	121	11.0	20.4
	3DD.003D351FCA	2/17/2021	3/19/2021	30	95	115	10.0	16.0
	3DD.003D351FD0	2/17/2021	3/19/2021	30	97	116	10.8	17.0
	3DD.003D351FD1	2/17/2021	4/16/2021	58	92	127	8.0	24.0
	3DD.003D351FED	2/17/2021	3/19/2021	30	89	110	8.0	15.0
Mobile[ii]	3DD.003D351F2A	2/04/2021	3/26/2021	50	114	138	15.0	28.0

[i] *2 fish (3DD.003D351FA3 & 3DD.003D354004), recaptured after only one day at large in Beaver Slough are not included here.*

[ii] *3DD.033D351F2A was initially captured and tagged at Cochran but was subsequently recaptured at Beaver Slough.*

Table 10. Growth in length (Δ length, %·d^{-1}) and weight (Δ length, %·d^{-1}) determined from the growth of tagged and recaptured individuals and inferred from the mean length or weight of fish captured at fish sampling events at each location. Confidence Intervals are shown in parentheses.

Location	Source	Δ length (%·d^{-1})	Δ weight (%·d^{-1})
Beaver Slough	Inferred Growth (11 events)	0.41 (±0.16)	1.16 (±0.53)
	Recapture Growth (n = 3)	0.40 (±0.14)	1.25 (±0.39)
Winter Lake Unit 2	Inferred Growth (13 events)	0.38 (±0.11)	1.20 (±0.33)
	Recaptures (n = 4)[i]	0.73 (±0.30)	2.67 (±1.43)
Cochran	Inferred Growth (4 events)	0.25 (±0.60)	0.78 (±0.14)
	Recaptures (n = 5)	0.51 (±0.04)	1.99 (±0.15)
Seestrom	Inferred Growth (5 events)	0.29 (±0.14)	0.80 (±0.22)
	Recaptures (n = 8)	0.24 (±0.04)	1.64 (±0.51)

[i] *3 of 4 recaptures in WL Unit 2 were fish relocated from Beaver Slough.*

E. Survival

Actual losses to mortality could not be separated from apparent losses due to the failure of the antenna arrays to detect some individuals. The percentage of tagged fish detected at antenna arrays can be considered minimum rates of survival until the detection efficiency of the antenna arrays can be determined. Regardless, a large proportion of tagged individuals were subsequently detected at the tide gates at both the Seestrom (82%) and Cochran locations (91%). These results were generally consistent across months with some indication of an increasing trend through time at Seestrom (Table 11; Figure 22). The overall proportion of tagged fish subsequently detected at tide gate PIT antenna arrays was much lower at Winter Lake Unit 2 (19%) than at the Seestrom or Cochran locations (Table 11; Figure 22). This lower detection proportion is likely contributed to PIT antenna outages throughout the season (Appendix A) and flow being directed through Gate 2A (no PIT antenna) rather than Gate 2B (PIT antenna) due to the slide gate being disabled. Future estimates of detection probability at the Winter Lake Unit 2 location will be necessary to further assess the discrepancy in detection proportions at Winter Lake relative to the other locations.

Table 11. Time (days) elapsed from tagging to final detection and the percentage of tagged fish detected at the tide gate PIT tag antenna arrays by month and pooled across months by location.

	Month	Number Tagged	Time to Final Detection, Days		Percent of Tagged Fish Detected at Gate
			Avg ± 95% CI	Range	
Winter Lake Unit 2	December	5	N/A	N/A	0
	January	5	61 ± N/A	N/A	20
	February	2	N/A	N/A	0
	March	131[i]	22 ± 6	8 to 35	12
	April	77[i,ii]	10 ± 4	1 to 29	32
	May	0	N/A	N/A	N/A
Cochran	December	0	N/A	N/A	N/A
	January	48	11 ± 4	0 to 82	98
	February	76	4 ± 2	0 to 31	87
	March	0	N/A	N/A	N/A
	April	15	4 ± 1	1 to 10	93
	May	0	N/A	N/A	N/A
Seestrom	December	30	28 ± 10	0 to 74	67
	January	14	31 ± 11	12 to 57	79
	February	69	25 ± 5	1 to 70	90
	March	97	13 ± 3	1 to 47	76
	April	56	9 ± 2	1 to 31	89
	May	4[ii]	6 ± 7	1 to 15	100

[i]*Fish tagged at Winter Lake in March and April include fish captured at Beaver Slough and relocated on the tagging date to Winter Lake Unit 2).*
[ii]*Fish tagged in May at Seestrom were juvenile Chinook salmon (n =4); fish tagged in April at Winter Lake Unit 2 include 21 Chinook salmon.*

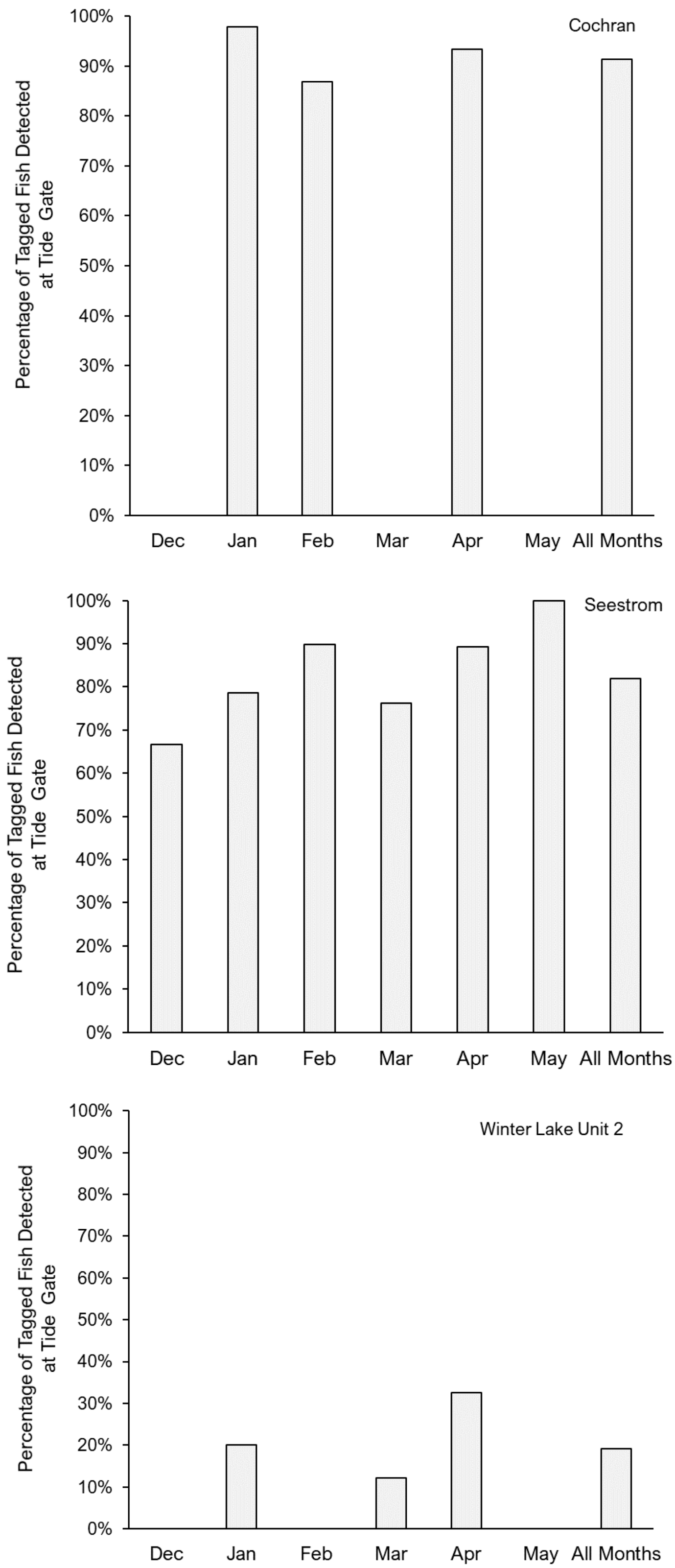

Figure 22. Percent of tagged fish detected at tide-gate antenna arrays by tagging month for each location (Cochran, Seestrom, Winter Lake Unit 2).

F. *Movement and Passage*

Post-tagging residence time generally decreased through time at all locations, and residence times tended to be longer in larger habitats Table 11; Figure 23). Lack of data or low sample sizes for some months at Cochran and Winter Lake limit the assessment of residence time in this initial year of monitoring.

The distribution of the hour of day used by juvenile salmonids to leave off-channel habitats was significantly different than the available conditions at all three sites (Winter Lake Unit 2, Seestrom, Cochran) (Table 12). At Cochran, fish tended to oversample the evening hours while under-sampling available morning hours. This pattern was nearly reversed at Seestrom, where fish tended to oversample a relatively narrow window of morning hours followed by a second mode of increased usage in the evening that aligns more closely to the available hours. A bimodal preference for passage was also apparent at Winter Lake Unit 2, where juvenile fish tended to favor morning and evening periods bracketing the distribution of hours available for passage (Figure 24).

Juvenile coho salmon used a distribution of velocities significantly different from the available velocities only in some months at the Seestrom location (Table 13). While fish at Seestrom tended to favor the most prevalent velocity bin (0 to 0.5 ft·sec^{-1}), they under-sampled the second most prevalent velocity bin (5 to 5.5 ft·sec^{-1}; Figure 25).

The distribution of upstream water levels used by juvenile coho was significantly different from the available conditions at the Cochran and Seestrom locations but not in all months (Table 14). At Cochran, fish tended to under-sample the lowest water-level bin, while oversampling some of the highest levels. Differences in Seestrom may be more attributable to an under-sampling of the lowest available levels (Figure 26).

Juvenile coho salmon used a distribution of water level change rate that differed significantly from the available conditions only at Cochran, though in some months significant differences were observed at Seestrom (Table 15). At Cochran, juvenile salmonids oversampled rates of water level rate change near zero while under-sampling higher rates of change (both positive and negative) (Figure 27).

The distribution of tidal classification bins used by juvenile coho for out-migration was significantly different than the available conditions at Cochran, and significant differences were observed in some months at Seestrom (Table 16). At Cochran, fish oversampled tidal bin 2 (ebb) and under-sampled tidal bin 5 (flood). At Seestrom, fish may have been oversampling the flood bin to a small degree (Figure 28).

The distribution of hydraulic head used by juvenile coho was significantly different than the available conditions at Seestrom and Cochran in most months and when data were aggregated across months (Table 17). At Cochran, fish may be oversampling slightly positive head (positive would favor outflow) with few observations during high-head conditions. At Seestrom, differences also seem to be driven by an under-sampling or lack of use at higher heads (Figure 29).

Table 12. Kolmogorov-Smirnov results (K-S D Statistic, p value, and number of individuals with a final detection at the tide gate array by month and pooled across months) for hour of final detection at the Seestrom, Cochran, and Winter Lake Unit 2 locations. Fish were included in analyses only if final detections occurred when gates were open. January includes the last week of December. May detections at Seestrom and Winter Lake include some juvenile Chinook salmon.

Location	Month	KS D Statistic	p	Detections (n)
Seestrom	Jan	0.1404	0.9135	16
	Feb	0.1838	0.2443	32
	Mar	0.3477	**<0.0001**	85
	Apr	0.4827	**<0.0001**	69
	May	0.4652	**0.0114**	12
	All Months	0.3322	**<0.0001**	214
Cochran	Jan	0.2293	**0.0427**	37
	Feb	0.3790	**<0.0001**	71
	Mar-May[i]	0.3816	0.0610	12
	All Months	0.2647	**<0.0001**	120
Winter Lake	April-May[ii]	0.3505	**0.0345**	17

[i]Due to low detections at Cochran in March (n=3), April (n=2) and May (n=7), data were pooled from March – May.

[ii]Final detections concurrent with open gates occurred only in April and May in Winter Lake Unit 2. Due to the low sample size (n = 17), data were pooled from April-May, and conditions available for passage (conditions when gates were open) were included only for those months.

Table 13. Kolmogorov-Smirnov results (K-S D Statistic, p value, and number of individuals with a final detection at the tide gate array by month and pooled across months) for velocity (ft·sec^{-1}) at final detection at the Seestrom and Winter Lake Unit 2 locations. Fish were included in analyses only if final detections occurred when gates were open. May detections at Seestrom and Winter Lake include some juvenile Chinook salmon.

Location	Month	KS D Statistic	p	Detections (n)
Seestrom	Jan	N/A	N/A	16
	Feb	0.1658	0.4340	32
	Mar	0.2429	**0.0001**	85
	Apr	0.1720	**0.0381**	69
	May	0.2766	0.5783	12
	All Months	0.0894	0.1045	214
Winter Lake	April-May[i]	0.2900	0.1242	17

[i]Final detections concurrent with open gates occurred only in April and May in Winter Lake Unit 2. Due to the low sample size (n = 17), data were pooled from April-May, and conditions available for passage (conditions when gates were open) were included only for those months.

Table 14. Kolmogorov-Smirnov results (K-S D Statistic, p value, and number of individuals with a final detection at the tide gate array by month and pooled across months) for upstream water level at final detection at the Seestrom, Cochran, and Winter Lake Unit 2 locations. Fish were included in analyses only if final detections occurred when gates were open. January includes the last week of December. May detections at Seestrom and Winter Lake include some juvenile Chinook salmon.

Location	Month	KS D Statistic	p	Detections (n)
Seestrom	Jan	0.2681	0.2046	16
	Feb	0.2077	0.1367	32
	Mar	0.1709	**0.0175**	85
	Apr	0.1645	0.0535	69
	May	0.2258	0.5772	12
	All Months	0.1034	**0.0230**	214
Cochran	Jan	0.1134	0.7353	37
	Feb	0.3875	**<0.0001**	71
	Mar-May[i]	0.2664	0.3629	12
	All Months	0.3177	**<0.0001**	120
Winter Lake	April-May[ii]	0.1823	0.6420	17

[i]Due to low detections at Cochran in March (n=3), April (n=2) and May (n=7), data were pooled from March – May.
[ii]Final detections concurrent with open gates occurred only in April and May in Winter Lake Unit 2. Due to the low sample size (n = 17), data were pooled from April-May, and conditions available for passage (conditions when gates were open) were included only for those months.

Table 15. Kolmogorov-Smirnov results (K-S D Statistic, p value, and number of individuals with a final detection at the tide gate array by month and pooled across months) for the rate of upstream water level change, m·min^{-1}) at final detection at the Seestrom, Cochran, and Winter Lake Unit 2 locations. Fish were included in analyses only if final detections occurred when gates were open. January includes the last week of December. May detections at Seestrom and Winter Lake include some juvenile Chinook salmon.

Location	Month	KS D Statistic	p	Detections (n)
Seestrom	Jan	0.1140	0.9862	16
	Feb	0.2620	**0.0281**	32
	Mar	0.1543	**0.0420**	85
	Apr	0.2068	**0.0065**	69
	May	0.1322	0.9852	12
	All Months	0.0635	0.3683	214
Cochran	Jan	0.2298	**0.0421**	37
	Feb	0.1685	**0.0399**	71
	Mar-May[i]	0.5612	**0.0011**	12
	All Months	0.2422	**<0.0001**	120
Winter Lake	April-May[ii]	0.2083	0.4701	17

[i]Due to low detections at Cochran in March (n=3), April (n=2) and May (n=7), data were pooled from March – May.
[ii]Final detections concurrent with open gates occurred only in April and May in Winter Lake Unit 2. Due to the low sample size (n = 17), data were pooled from April-May, and conditions available for passage (conditions when gates were open) were included only for those months.

Table 16. Kolmogorov-Smirnov results (K-S D Statistic, p value, and number of individuals with a final detection at the tide gate array by month and pooled across months) for tidal bin at final detection at the Seestrom, Cochran, and Winter Lake Unit 2 locations. Fish were included in analyses only if final detections occurred when gates were open. January includes the last week of December. May detections at Seestrom and Winter Lake include some juvenile Chinook salmon.

Location	Month	KS D Statistic	p	Detections (n)
Seestrom	Jan	0.1125	0.9881	16
	Feb	0.2013	0.1610	32
	Mar	0.1946	**0.0043**	85
	Apr	0.1905	**0.0156**	69
	May	0.1508	0.9490	12
	All Months	0.0927	0.0549	214
Cochran	Jan	0.1974	0.1158	37
	Feb	0.1919	**0.0125**	71
	Mar-May[i]	0.3919	0.0504	12
	All Months	0.2128	**<0.0001**	120
Winter Lake	April-May[ii]	0.1475	0.8648	17

[i]Due to low detections at Cochran in March (n=3), April (n=2) and May (n=7), data were pooled from March – May.
[ii]Final detections concurrent with open gates occurred only in April and May in Winter Lake Unit 2. Due to the low sample size (n = 17), data were pooled from April-May, and conditions available for passage (conditions when gates were open) were included only for those months.

Table 17. Kolmogorov-Smirnov results (K-S D Statistic, p value, and number of individuals with a final detection at the tide gate array by month and pooled across months) for hydraulic head (upstream – downstream water level) at final detection at the Seestrom, Cochran, and Winter Lake Unit 2 locations. Fish were included in analyses only if final detections occurred when gates were open. January includes the last week of December. May detections at Seestrom and Winter Lake include some juvenile Chinook salmon.

Location	Month	KS D Statistic	p	Detections (n)
Seestrom	Jan	0.2494	0.2778	16
	Feb	0.3814	**0.0002**	32
	Mar	0.1881	**0.0064**	85
	Apr	0.2716	**0.0001**	69
	May	0.1820	0.8240	12
	All Months	0.2300	**<0.0001**	214
Cochran	Jan	0.3364	**0.0005**	37
	Feb	0.4171	**<0.0001**	71
	Mar-May[i]	0.2325	0.5365	12
	All Months	0.2472	**<0.0001**	120
Winter Lake	April-May[ii]	0.2672	0.1886	17

[i]Due to low detections at Cochran in March (n=3), April (n=2) and May (n=7), data were pooled from March – May.
[ii]Final detections concurrent with open gates occurred only in April and May in Winter Lake Unit 2. Due to the low sample size (n = 17), data were pooled from April-May, and conditions available for passage (conditions when gates were open) were included only for those months.

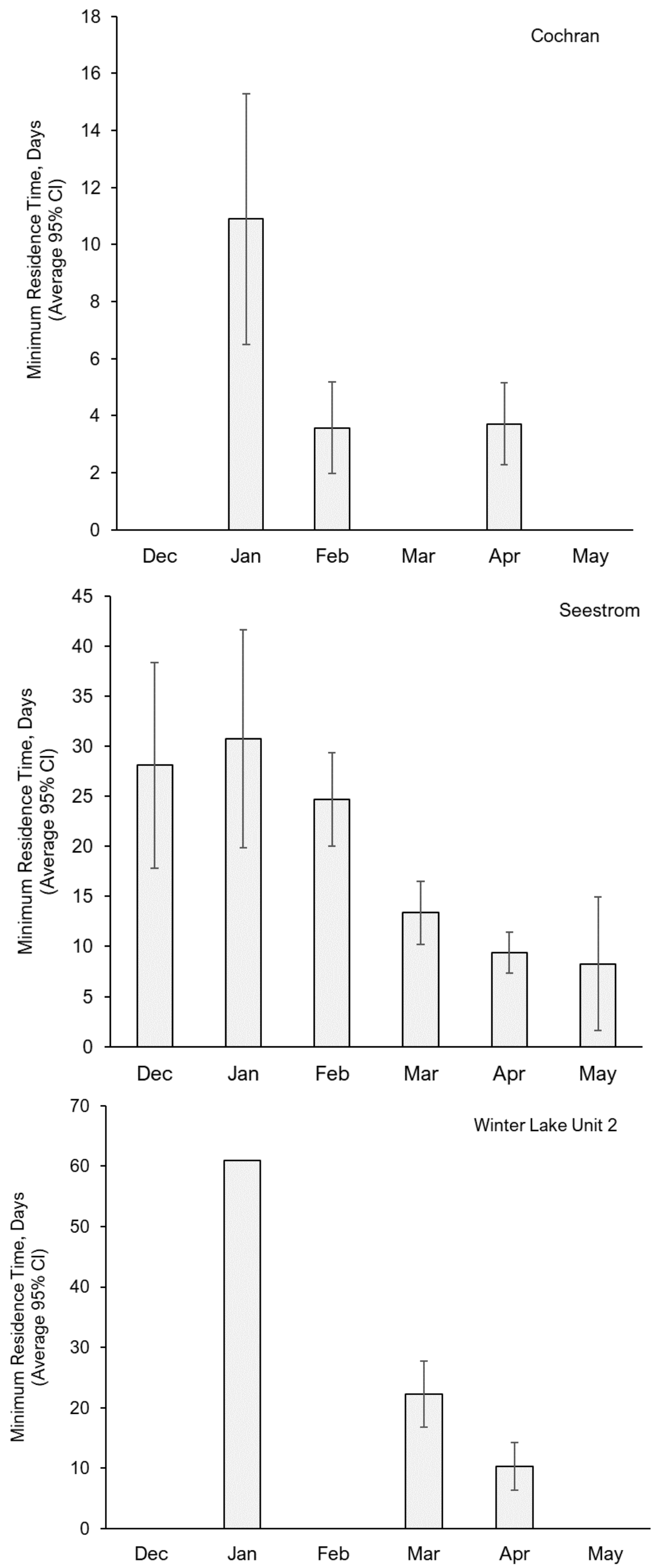

Figure 23. Minimum residence time (days from tagging until final detection at tide gate arrays), Average ±95% Confidence Intervals. Months indicate month of initial capture and tagging. No confidence interval is available for Winter Lake Unit 2 in January (n=1).

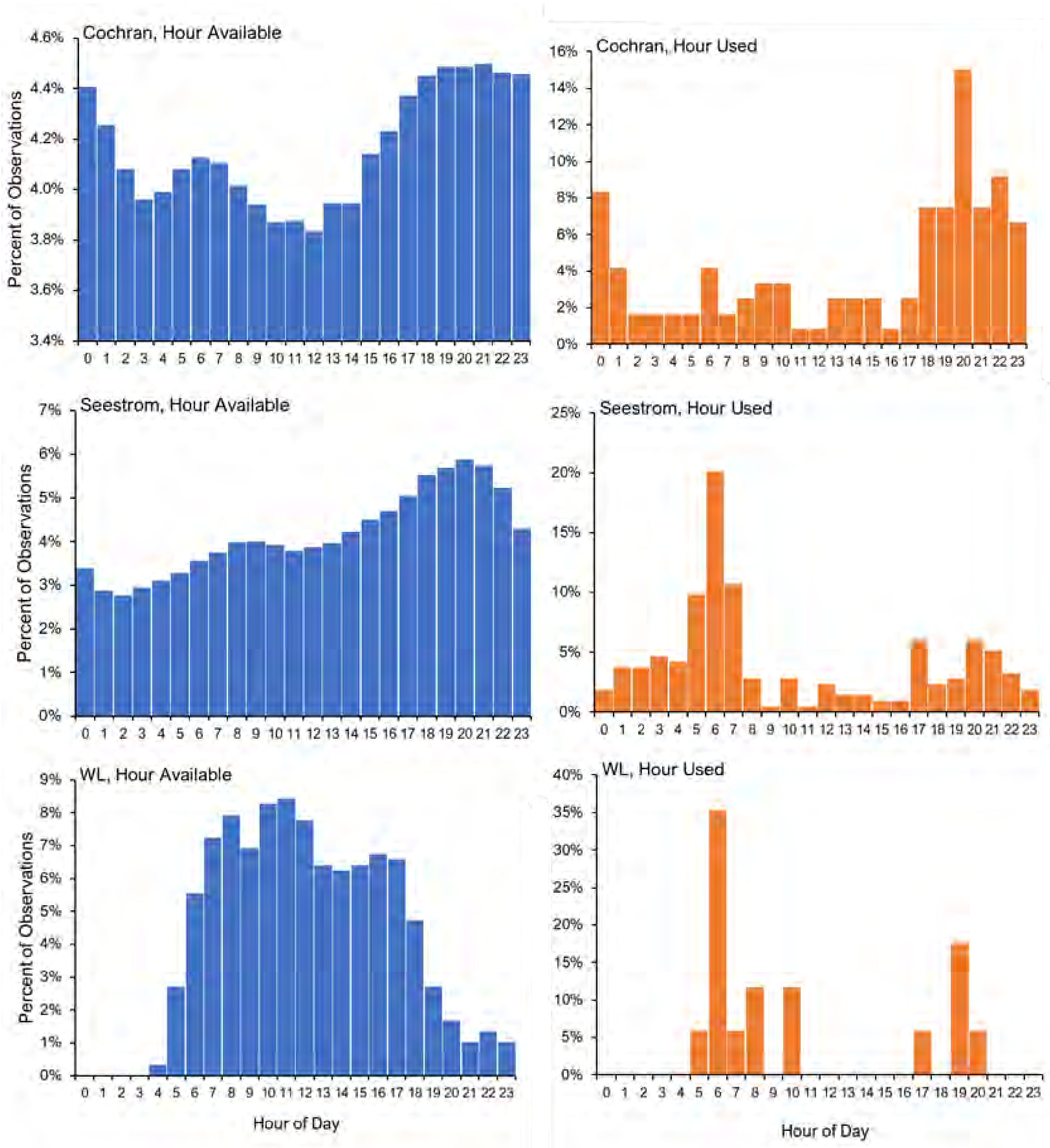

Figure 24. Frequency distributions of hours available for passage (gates open, blue) and hours used by juvenile salmonids (final PIT detection, orange) at Cochran, Seestrom, and Winter Lake Unit 2 (WL). Distributions for the Cochran and Seestrom locations reflect data from late December through May; data from Winter Lake Unit 2 are from April and May, the only months with final detections of PIT tagged fish at the tide gate antenna array.

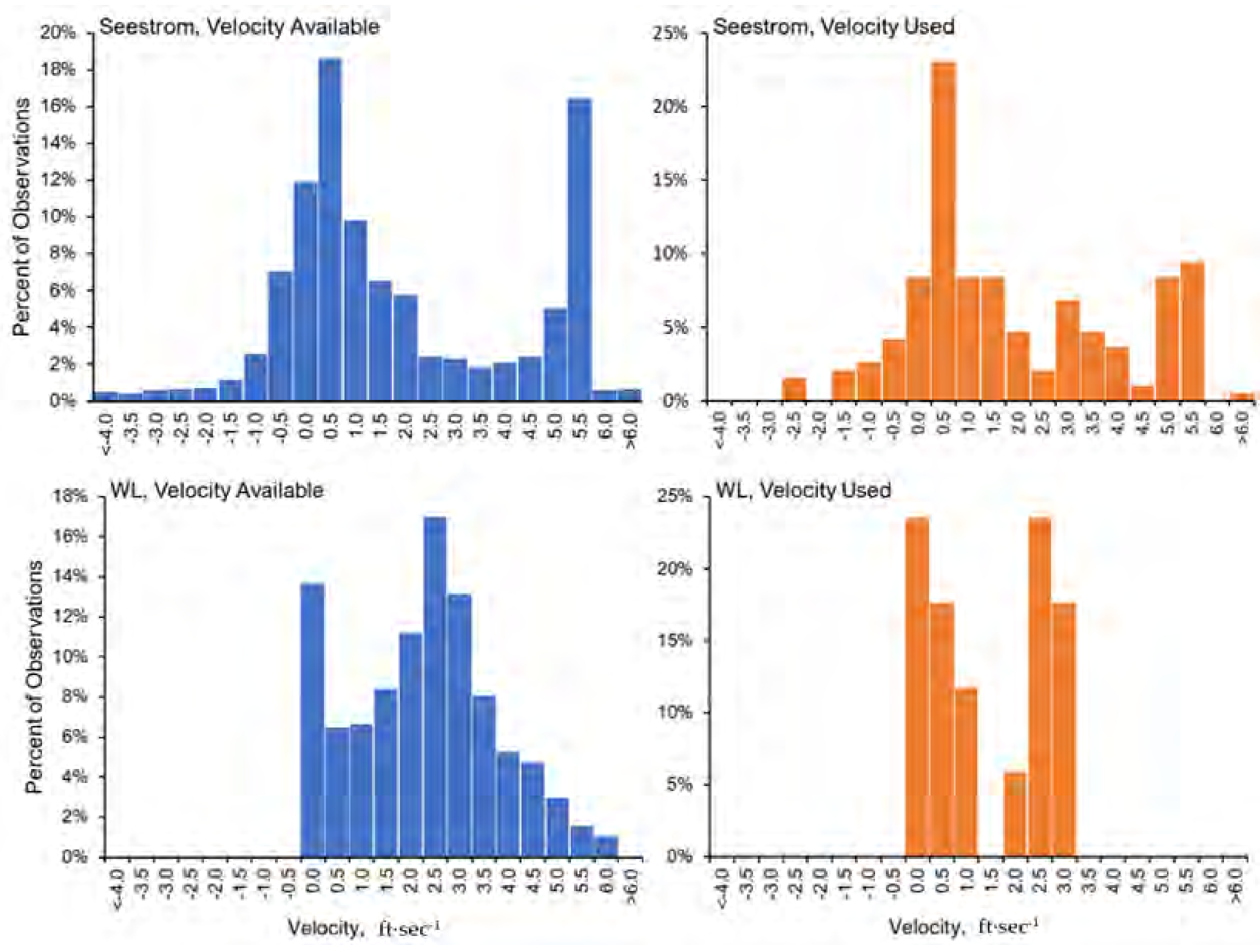

Figure 25. Frequency distributions of velocities (ft·sec^{-1}) available for passage (gates open, blue) and hours used by juvenile salmonids (final PIT detection, orange) at Seestrom and Winter Lake Unit 2 (WL). Negative velocities indicate inflow to off-channel areas upstream of tide gates; positive velocities indicate outflows to the river. Distributions for the Seestrom location reflect data from late December through May; data from Winter Lake Unit 2 are from April and May, the only months with final detections of PIT tagged fish at the tide gate antenna array.

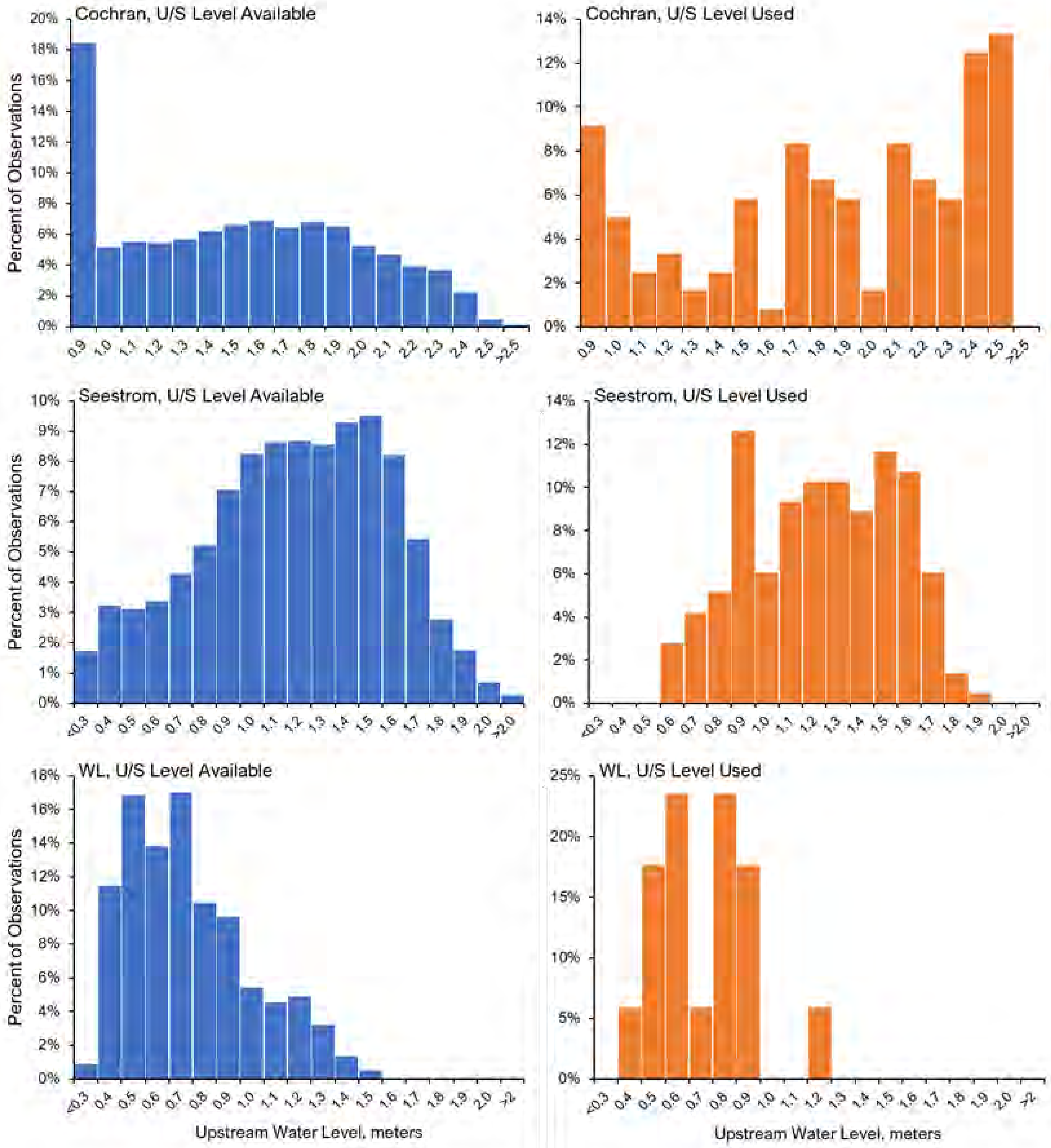

Figure 26. Frequency distributions of water levels above tide gates (meters) at times available for passage (gates open, blue) and when used by juvenile salmonids (final PIT detection, orange) at Cochran, Seestrom and Winter Lake Unit 2 (WL). Distributions for the Cochran and Seestrom locations reflect data from late December through May; data from Winter Lake Unit 2 are from April and May, the only months with final detections of PIT tagged fish at the tide gate antenna array.

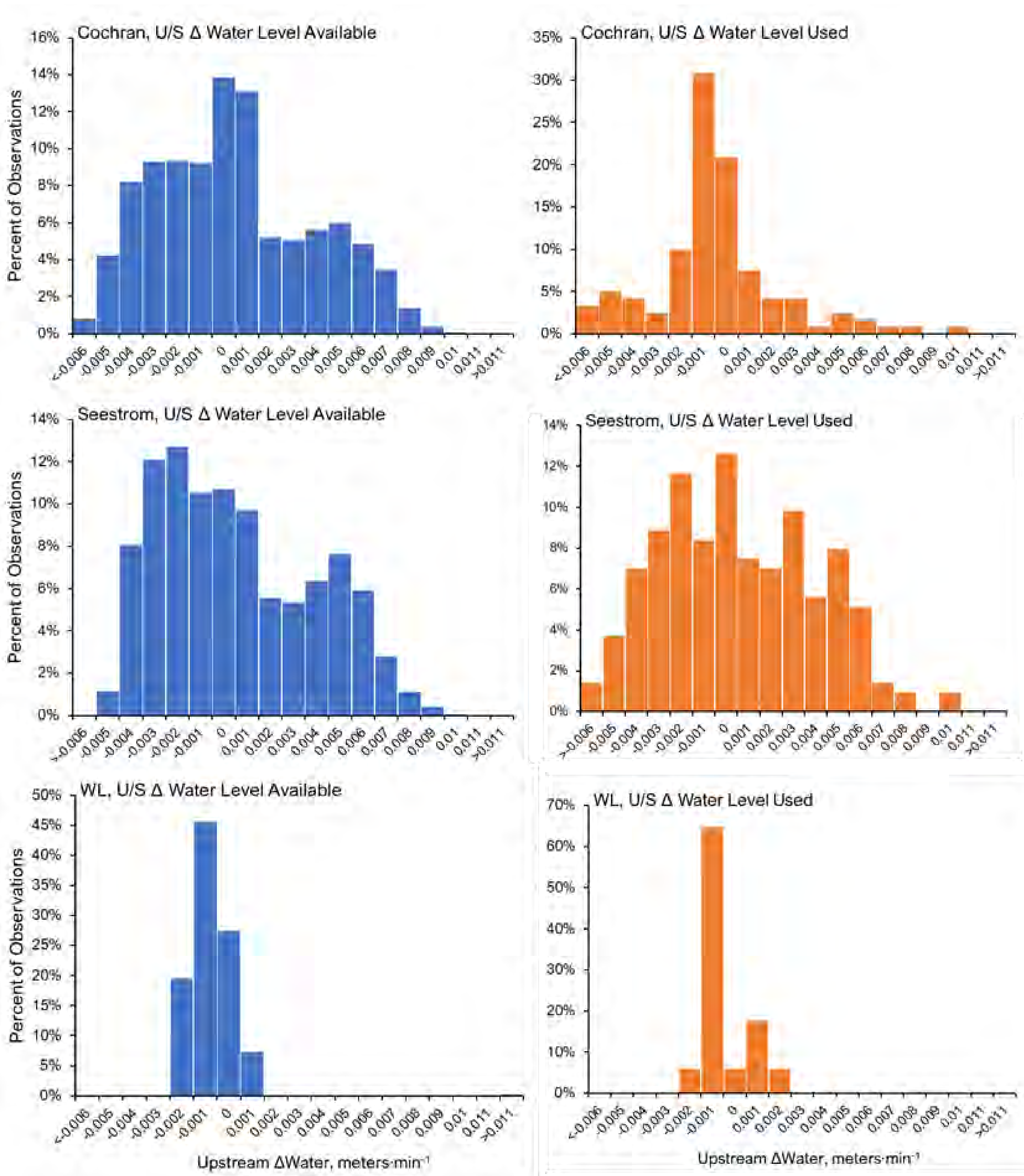

Figure 27. Frequency distributions of the rate of water level change (Δ Water Level) above tide gates (meters·min^{-1}) at times available for passage (gates open, blue) and when used by juvenile salmonids (final PIT detection, orange) at Cochran, Seestrom and Winter Lake Unit 2 (WL). Distributions for the Cochran and Seestrom locations reflect data from late December through May; data from Winter Lake Unit 2 are from April and May, the only months with final detections of PIT tagged fish at the tide gate antenna array.

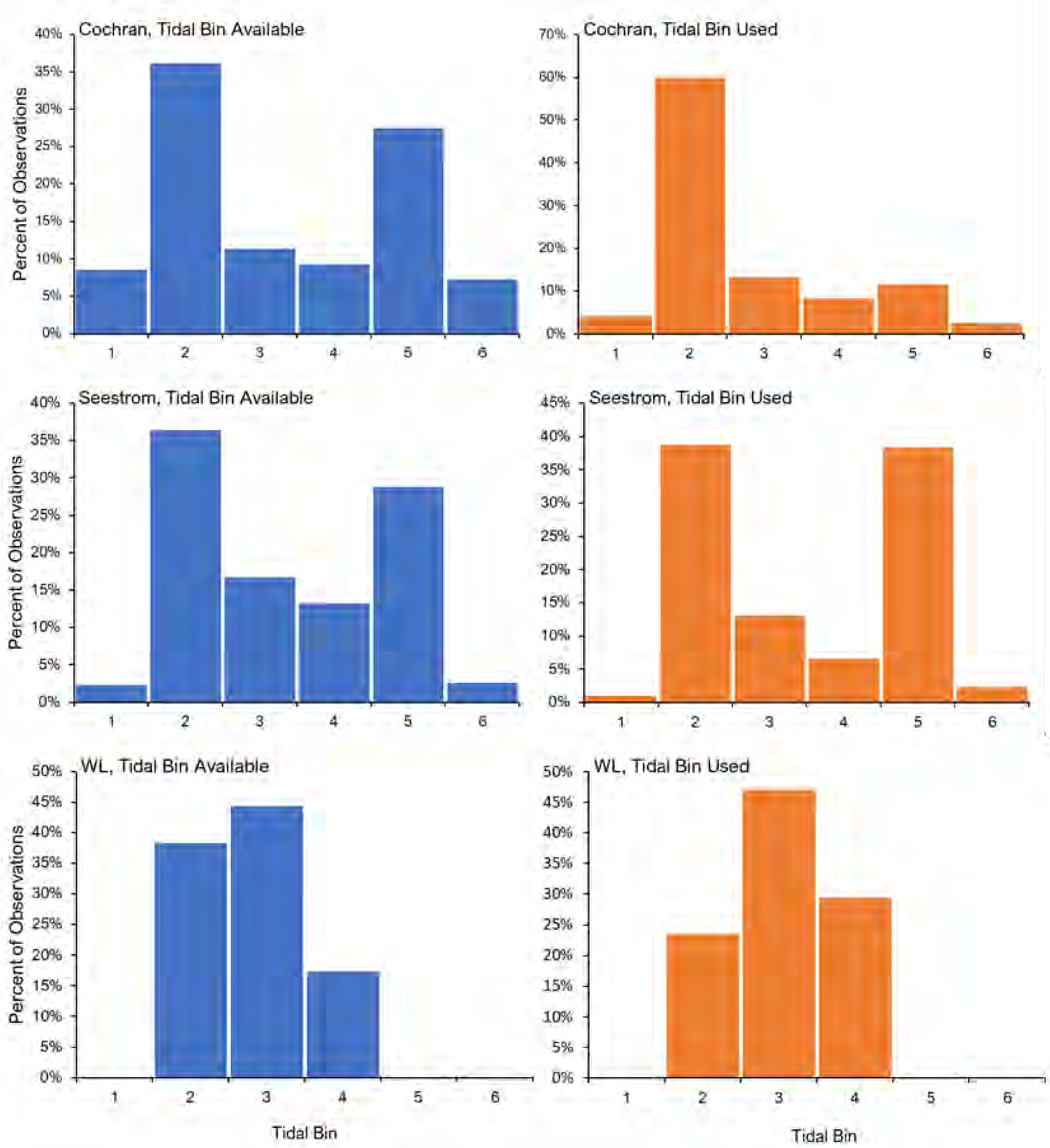

Figure 28. Frequency distributions of tidal bins available for passage (gates open, blue) and when used by juvenile salmonids (final PIT detection, orange) at Cochran, Seestrom and Winter Lake Unit 2 (WL). Tidal bins are 1 (Slack after Flood), 2 (Ebb), 3 (Slack before Ebb), 4 (Slack after Ebb), 5 (Flood), and 6 (Slack before Flood). Distributions for the Cochran and Seestrom locations reflect data from late December through May; data from Winter Lake Unit 2 are from April and May, the only months with final detections of PIT tagged fish at the tide gate antenna array.

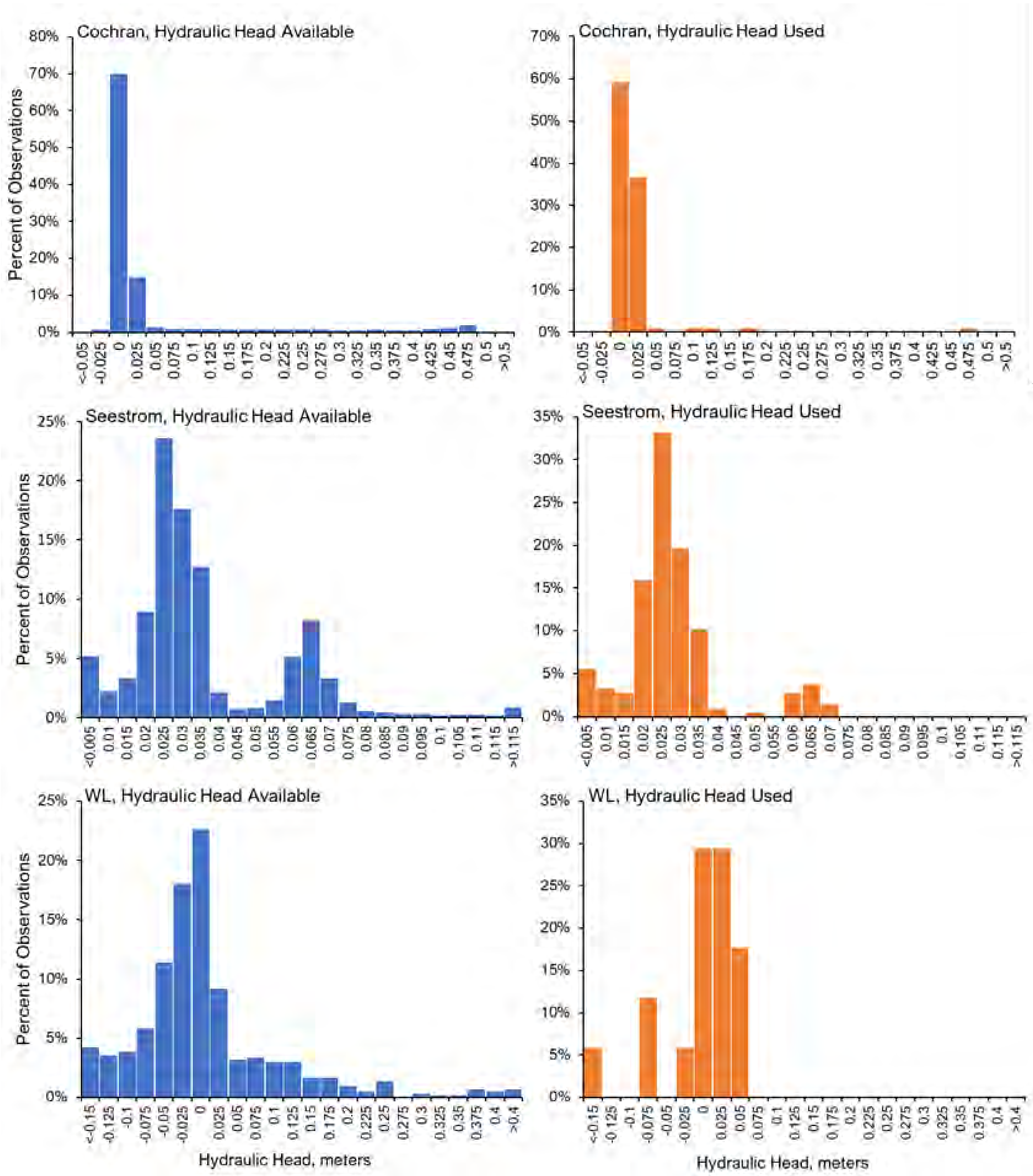

Figure 29. Frequency distributions of hydraulic head (upstream water level – downstream water level, meters) at times available for passage (gates open, blue) and when used by juvenile salmonids (final PIT detection, orange) at Cochran, Seestrom and Winter Lake Unit 2 (WL). Distributions for the Cochran and Seestrom locations reflect data from late December through May; data from Winter Lake Unit 2 are from April and May, the only months with final detections of PIT tagged fish at the tide gate antenna array.

8. Discussion

A. Condition

Is overall body condition of juvenile coho reared in the tide gate project areas greater than riverine-reared coho?

Near the end of the winter rearing period, when length, weight, and condition factor could be compared among all off-channel locations and the mainstem river, juvenile coho salmon captured at Winter Lake Unit 2 were significantly longer, heavier, and more robust in body condition than juvenile coho captured in the mainstem Coquille River. Juvenile coho salmon captured at Beaver Slough also approached the end of winter rearing longer and heavier than those captured in the mainstem, but condition factors were similar. Juvenile coho captured late in the season at the Cochran and Seestrom locations were similar in length, weight, and condition to fish captured in April in the mainstem (Table 3 - Table 5; Figure 18 - Figure 20). High weights relative to length at Winter Lake Unit 2 can also be seen in weight-length relationships (Figure 21).

The similarities in length, weight, and condition among the two smaller off-channel locations (Cochran and Seestrom) and the mainstem Coquille River may reflect greater exchange of fish in these locations with the mainstem (i.e., shorter residence times and higher mobility for juvenile coho using the smaller off-channel locations). Higher weights and condition in Winter Lake Unit 2 may be attributable to differences in resource availability and/or fish densities between these locations. Overall residence time at Winter Lake was greater, which may have contributed to a longer period of access to high quality wetland food items and improved body condition. Densities of fish in each sample area were not able to be ascertained for the 2020-2021 monitoring period. Reduced Competition in Winter Lake may have also been lower allowing for increased rate of growth. The Winter Lake invert channel elevation upstream of the tide gates and overall depth from that point upstream is lower than Seestrom or Cochran (WL -0.91m; Seestrom -0.5m; Cochran +0.5m). This may be contributing to longer residence times due to residual available habitat (water depth) on outgoing low tides. In addition, the tidal amplitude at Winter Lake is dampened, therefore, low tides do not reach the same lows of the other two sites downstream. The mean lengths of juvenile coho captured in April at Beaver Slough (131.8 ± 1.7 mm) and Winter Lake Unit 2 (136.5 ± 5.6 mm) are similar to those observed for out-migrating coho salmon at the Mill Creek life cycle monitoring site in the Yaquina basin (Avg. = 130.7 mm from 1997 through 2014). This site tends to have larger out-migrants and often higher marine survival rates relative to other life cycle monitoring sites within the Oregon Coast Coho ESU (Suring *et al*. 2015).

Comparisons of condition-related metrics was challenging in this first year of analysis due in part to differential capture success among locations and through time. Planned adjustments to sampling approaches and the aggregation of data with that collected in future sampling years is expected to improve our ability to discriminate the size and condition of juvenile coho salmon in the various off-channel and mainstem locations. However, the analytical approach currently applied also may be overly conservative. The Bonferroni adjustment we applied to post-hoc pairwise comparisons can substantially inflate Type II error rates, and the decision to apply the adjustment is neither straightforward nor routinely applied in a consistent manner (Cabin & Mitchell 2000). As additional data are collected, the decision to apply this adjustment warrants continued deliberation.

B. Growth

Are growth rates of juvenile coho reared in tide gate project areas greater than riverine-reared coho? Does overall size of restored habitat affect growth rate?

Because we did not recapture any of the juvenile coho salmon tagged in the mainstem and because we did not have multiple successful capture events in the mainstem, we could not determine growth rates from recaptures or infer growth rates for juvenile coho salmon in the mainstem Coquille River. However, larger sizes near the end of the winter rearing period in Beaver Slough and Winter Lake Unit 2 suggest that juvenile coho rearing in these areas likely grow at faster rates assuming the fish enter the monitoring period (late December) at similar sizes.

We were not able to discern statistically significant differences in growth rates (length or weight) among off-channel locations. However, in this first year of monitoring there were relatively few recaptures at each location and significant uncertainty around inferred growth rates at some locations (Table 10). Planned adaptation of capture effort/methods and continued data collection will help to identify the differences in growth rates among sites that seem apparent in the differential progression of lengths and weights through the winter period (Figure 18 - Figure 20).

C. Survival

Does survival increase for juvenile coho residing in tide gate projects compared to riverine-reared coho? Does survival vary with overall size of restored habitat?

As with growth (above), we intended to approach these questions using mark-recapture approaches that were precluded by low recaptures. Survival from tagging to final detection at the Seestrom and Cochran tide gates appears to be relatively high given that overall >80% of tagged individuals were subsequently detected at the tide gates after some time at large (Table 11; Figure 22). Lower proportions of tagged fish detected at the tide gates in Winter Lake Unit 2 (Table 11; Figure 22) are likely attributed to PIT antenna outages and flow being directed through a gate with no PIT antenna (Gate 1A) due to a malfunction of the PIT antenna gate (Gate 2B). Gate repairs have been completed in the summer of 2021 therefore, detections in the second monitoring season should align more closely with the other sites. Survival to final detection will be further resolved as we determined detection efficiencies for each tide gate antenna array. Estimates of detection efficiency will allow us to account for apparent losses (losses attributable to a failure to detect, unrealized losses due to mortality) in estimates of survival. Prior to next year's analysis, we will develop a rule set to formalize the discrimination of fish-passage events from fish-detection events (e.g., Connolly et al. 2008) or consider alternative approaches to estimate detection efficiencies (e.g., release of PIT tagged "dummy" fish; e.g., Street et al. 2015).

D. Abundance/Density

Are rearing densities dependent on overall size of restored habitat behind an upgraded tide gate?

We intended to address questions of abundance and rearing densities using abundances estimated through mark-recapture approaches. Limited recaptures precluded this approach in this initial year of monitoring. We will continue to pursue these methods as planned adaptation of capture effort and methods increases the number of fish tagged and recaptured.

What are the general densities of juvenile coho during winter/spring months upstream of the various tide gate structures within the project area with differing designs and operation plans (Water Management Plans)?

We had intended to also analyze the data to reflect densities in regards to the individual sites as the three tide gate projects have differing WMP's and infrastructure. A higher level of recaptured fish within individual sites may lend to determining densities in future years.

E. Movement & Passage

What is the residence time of juvenile coho in floodplain habitats upstream of a fully redesigned and technologically advanced tide gate? Does residence time vary with overall size of restored habitat?

Residence times determined through this work are residence time from tagging to final detection at tide gate PIT antenna arrays; they are not comprehensive residence times because we do not know how long the fish resided at the tagging location prior to tagging. These estimates may be considered as minimum residence times that are specific to the time of tagging. As more fish tagged in the mainstem are detected entering and subsequently leaving the off-channel areas, we will be able to estimate residence times that capture the full period of off-channel occupancy. Detections of mobile coho (fish that are detected at arrays other than their tagging location) will also help to address these questions.

Despite the limitations of our current estimates of residence time, they can provide for comparisons among locations if they are compared at similar points during the winter rearing period. Although data are limited in some months at both Winter Lake Unit 2 and Cochran, there appears to be a logical trend of longer post-detection rearing earlier in the monitoring period progressing to shorter residence times later in the period. Regardless of month, post-tagging residence tends to be longer in the largest habitat (Winter Lake Unit 2) and shorter in the smallest habitat (Cochran) (Table 11; Figure 23). As more data become available, we expect to further describe whether these apparent differences are statistically significant.

What percentage of juvenile coho residing in the Coquille Estuary enter the restored project areas?

This question will be addressed as we learn more about the proportion of juvenile coho in the mainstem that use restored project areas for winter rearing habitat.

Do juvenile coho enter more than one wetland restoration area during winter/spring downstream movements prior to entering the ocean?

A number of fish were detected entering another wetland area (Figure 7) following initial tagging. This information may contribute to increased understanding of the importance of having multiple available desired off-channel habitats available as fish move and feed in the floodplain. Additional data in upcoming years are expected to increase the knowledge on this aspect of juvenile coho life-history.

What are the fish passage effectiveness levels for the individual projects relating to water level and tide gate door operation?

Our current statistical approach to this question asks whether conditions used by tagged juvenile coho salmon to leave off-channel habitats are drawn from the same distribution as the conditions potentially available for use (i.e., when the tide gate doors were open). The null hypothesis is that fish are using conditions that are a random sampling of available conditions; significant results indicate that the fish are using conditions that are a non-random subset of available conditions. This test only identifies where the distribution of used conditions differs from the available conditions; it does not specifically indicate how the distributions differ.

Significant differences in used and available distributions were frequently observed only in months with the highest numbers of final detections at the tide gates (Table 12 - Table 17). At Winter Lake Unit 2, low sample sizes of final detections occurring when gates were open (n = 17) likely constrained the power to detect differences in most conditions. Analysis at Winter Lake Unit 2 was also limited by the lack of detections at the tide gate during open conditions prior to March.

Data collected to-date suggest that time of day is an important parameter related to out-migration timing through the tide gates. However, patterns of use are not fully consistent across sites (Figure 24). Increased sample sizes at Cochran and Winter Lake in underrepresented months will help to further discern patterns in other parameters.

9. Conclusion

The Lower Coquille Monitoring program has shown the three tide gate upgrade and habitat restoration projects are highly used by juvenile coho salmon during the winter and spring rearing period. Furthermore, the Winter Lake project sees the longest residence time of juvenile coho while simultaneously producing coho that are in similarly robust condition to the highly active and successful off-channel habitat of the reference site, Beaver Slough. This more robust condition could improve marine survival, as coho in similar condition at the Mill Creek life cycle monitoring site tend to have greater marine survival than other sites within the Oregon Coast coho ESU (Suring *et al.* 2015). Although the monitoring is unable to show a statistically significant difference in growth rate across the monitoring sites, due to low recaptures, it still appears that Winter Lake and Beaver Slough have higher growth rates due to the larger coho at the end of the season. Residence times at the smaller project sites, Cochran and Seestrom, tend to be shorter and could be a factor in why juvenile coho captured at these sites had weights and lengths similar to coho captured in the mainstem. Additional knowledge will be gathered from the accumulation of data over the next two years such as improving patterns of important passage parameters during in and out-migration and comparisons of body condition metrics and growth rates.

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11. Appendices

A. PIT Antenna Operation

Table 18. Table of PIT antenna operation dates for the 2020-2021 field season.

Winter Lake								Seestrom		Cochran	
Unit 1		Unit 2				Unit 3					
Gate 1A pass thru	Gate 1AB Sail	Gate AB Sail[1]	Gate 2B pass thru[2]	Gate 2C pass Thru[3]	Gate 2BC Sail[4]	Gate 3A sail	Gate 3A pass thru	Antenna 1	Antenna 2	Antenna 1	Antenna 2
12/1-12/24	12/1-12/24	12/1-12/24	12/1-12/24	12/1-12/24	12/1-12/24	12/1-12/24	12/1-12/24	12/1-6/9	12/1-6/9	12/1-6/9	12/1-6/9
1/6-2/20	3/10-6/9	1/6-1/26	12/29-2/20	12/29-3/24	12/29-2/4	12/29-6/9	12/29-6/9				
2/26-6/9		4/7-4/11	4/7-5/6	3/31-4/3	4/13-5/6						
			5/19-6/9	05-Apr							
				4/7-6/9							

1 - On 3/22/21 the sail antenna was unplugged and a second pass thru antenna was initiated on Gate 2B BUT capacitors were causing interference so detection was limited until 4/21/21

2 - Gate 2B was never open for the year, so although detections can tell us presence we can't use them for passage information

3 - Gate 2C pass thru had limited functionality from 4/9-4/21 due to incorrectly sized capacitors

4 - Sail antenna was disconnected on 4/9/21 and second pass thru antenna was connected on 2C beginning 4/13 but capacitors were adjusted on 4/21 to improve detection