Riparian Validation Monitoring Program (RVMP)

2022 Annual Report

WASHINGTON STATE DEPARTMENT OF
NATURAL RESOURCES
HILARY S. FRANZ | COMMISSIONER OF PUBLIC LANDS

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Acronyms and Abbreviations

COH – Coho Salmon

CTT – Cutthroat Trout

DNR – Washington State Department of Natural Resources

HCP – Habitat Conservation Plan

MS222 – Tricaine mesylate

OESF – Olympic Experimental State Forest

ONP – Olympic National Park

RKM – River kilometer

RVMP – Riparian Validation Monitoring Program

STH – Steelhead/rainbow trout

STRAH – Status and Trends Monitoring of Riparian and Aquatic Habitat in the Olympic Experimental State Forest Program

T3 – Type 3 stream; the smallest fish-bearing stream, according to the Washington Forest Practices classification

VRH – Variable retention harvest

Executive Summary

The Washington State Department of Natural Resources designed its Riparian Validation Monitoring Program to fulfill the agency's commitment to the State Trust Lands Habitat Conservation Plan. Commencing in 2016, this program, in conjunction with the Status and Trends Monitoring of Riparian and Aquatic Habitat program, represents DNR's largest systematic habitat and salmonid monitoring program and provides the best indication of riparian forest, stream, and salmonid conditions on DNR-managed lands.

The 2016 RVMP study plan was designed to first use an observational monitoring approach and then add more complex experimental studies as necessary. This flexible approach allows DNR to continually adapt sampling strategies based upon an increasing understanding of management impacts on fish and stream habitat and the conditions of DNR-managed lands. In 2020, RVMP researchers joined the T3 Watershed Experiment to introduce experimentation, enhancing DNR's ability to assess cause-and-effect relationships between DNR land management and salmonid populations. This assessment encompasses both current riparian management practices and alternative forest management prescriptions.

In 2022, DNR crews conducted population surveys to estimate juvenile salmonid densities (fish/100 meters) and biomass (grams/100 meters^2) in 35 RVMP watersheds. These surveys covered the annual panel (n=20) and the even-year rotating panel (n=15) of 50 watersheds. Additionally, 24 fish and habitat surveys were carried out in the 16 watersheds of the T3 Watershed Experiment, with 20 at the reach (prescription site) and 4 at the pour point (the lowest point in a watershed). Monitoring activities also persisted for the Bear Creek culvert removal (E-1400 Road in the Hoko River watershed, with sampling conducted both above and below the site where the culvert was removed in 2018. Adult coho salmon redd surveys were conducted in 19 RVMP watersheds, with 12 of these sites sampled annually. Snorkel and habitat surveys were also completed in three monitored reaches, spanning more than 12 km of the Clearwater River.

In 2022, we concluded the Bear Creek study. The culvert would have been classified as a 33 percent passable culvert using the Washington Department of Fish and Wildlife's fish passage criteria. No differences were observed in fish composition, density, or biomass before or after the culvert removal or between the upstream and downstream sites. This study underscores the uncertainty surrounding fish responses to partial-barrier culvert removals when there is some level of fish passage and similar fish species present above and below the culvert.

Since the implementation of the RVMP in 2016, DNR has published five peer-reviewed journal articles. The findings presented in these publications, along with the 2019 status report, informed the development of riparian treatments for the T3 Watershed Experiment and continue to enhance our understanding of potential connections between salmonids and DNR management. Moreover, collaborations with natural resource agencies have expanded our knowledge of fish distributions, species interactions, and steelhead and habitat conditions, providing valuable information to federal regulating agencies.

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Chapter 1: RVMP Annual Report

Introduction

The Washington State Department of Natural Resources established the Riparian Validation Monitoring Program (RVMP) to fulfill DNR's commitment for riparian validation monitoring outlined in the State Trust Lands Habitat Conservation Plan (HCP; WADNR 1997). The HCP allows for long-term certainty of forest management (primarily timber harvest) by allowing incidental take of federally listed species in exchange for mitigation and minimization of environmental impacts on DNR-managed state trust lands (DNR-managed lands). The HCP Riparian Conservation Strategy aims to protect, maintain, and restore habitat that can sustain viable populations of salmonids and other species dependent on in-stream and riparian environments.

Validation monitoring, as described in the HCP, is the most complex and challenging of the three types of monitoring (the others being implementation and effectiveness) within the plan. Its purpose is "to evaluate cause-and-effect relationships between habitat conditions resulting from implementation of the conservation strategies and the animal populations these strategies are intended to benefit" (WADNR 1997). The RVMP is designed to test the hypothesis that forest management practices implemented under the HCP will restore and maintain habitat capable of supporting viable salmonid populations.

Following the RVMP study plan (Martens 2016), we employ an observational approach to monitor 50 Type-3[1] watersheds. This monitoring includes annual sampling of 20 watersheds and a two-year rotation of 30 additional watersheds. We also monitor a 12-km stretch of the Clearwater River within DNR-managed lands, into which a number of these watersheds drain.

If negative trends are detected or suspected in salmonids (density, biomass, species composition, age structure, and number of redds) or in their habitat, experimental studies, similar to the T3 Watershed Experiment, will be developed. These studies will evaluate the cause-and-effect relationships between DNR management activities, riparian habitat, and salmonids. Understanding the underlying mechanisms will allow DNR to affirm or adapt its management practices accordingly.

[1] Type 3 water – "segments of natural waters that are not classified as Type 1 or 2 Water and have a moderate to slight fish, wildlife, and human use. (A) Stream segments having a defined channel of 2 feet or greater in width between the ordinary high-water marks in western Washington and having a gradient 16 percent or less; (B) Stream segments having a defined channel of 2 feet or greater in width between the ordinary high-water marks in Western Washington and having a gradient greater than 16 percent and less than or equal to 20 percent; and having greater than 50 acres in contributing basin size in western Washington."

The Olympic Experimental State Forest (OESF), designated by DNR for research and monitoring, integrates revenue production — primarily through timber harvesting — with ecological values, primarily habitat conservation (WADNR 2016). The HCP designates the OESF as the location for riparian validation monitoring. DNR's Status and Trends Monitoring of Riparian and Aquatic Habitat program (STRAH)[2], which also takes place in the OESF, is a complementary study to the RVMP. Both programs study the same reaches and share data to improve efficiency and avoid redundancy. Although the primary purpose of the RVMP is to meet the DNR's commitment to the HCP, it provides additional benefits: It serves as the only continuous field-based monitoring and assessment of riparian forests, fish, and stream habitat conditions on DNR-managed lands, providing evidence of whether DNR riparian management is working as intended.

The Riparian Validation Monitoring Program offers numerous benefits to the DNR, including:

- Increasing knowledge, confidence, and flexibility in DNR land management practices.
- Enhancing ecological understanding of the relationships between salmonid populations, habitat, and land management.
- Providing current information on salmonid population conditions in the OESF, which helps address concerns that DNR-managed lands negatively affect salmonid populations on the Olympic Peninsula (Smith 2000; WRIA 21 Lead entity 2011).
- Supplying information for predictive models of future habitat conditions and their effects on fish under different management alternatives. These models are used in planning documents such as the OESF Forest Land Plan.
- Monitoring the potential effects of climate change on salmonid populations or habitat in the Pacific Northwest.
- Fulfilling monitoring commitments and advancing research priorities outlined in the DNR State Trust Lands HCP.
- Establishing stronger relationships with other natural resource agencies, research organizations, academia, and tribal nations.
- Informing DNR stakeholders about the state of natural resources and fostering trust.

As recommended in the study plan (Martens 2016), an experimental study was added in 2020 through DNR's collaboration with the University of Washington and other research partners on the T3 Watershed Experiment[3]. The riparian component of this study aims to assess current DNR riparian management and three alternative forest management strategies adjacent to variable retention harvests (VRH; Martens 2016).

One alternative riparian management prescription (active habitat restoration) was designed to reduce hypothesized limiting habitat factors identified through STRAH and RVMP monitoring:

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[2] Refer to the DNR website at https://www.dnr.wa.gov/programs-and-services/forest-resources/olympic-experimental-state-forest/research-projects for study plan, sampling protocols and annual reports of the STRAH program.

[3] Refer to the UW website at https://www.onrc.washington.edu/t3-watershed-experiment for study plans and other information on T3 Watershed Experiment.

insufficient instream wood and excessive stream shading. Another alternative prescription will use variable-width, site-specific buffers designed to increase revenue while maintaining ecological protections. The final alternative will use heavy thinning and alder under-planting to allow for short-rotation alder crops designed to provide both economic and environmental benefits. Monitored watersheds will follow a Before-After, Control-Impact (BACI) design, with two to three years of pre-treatment monitoring followed by at least four years of post-treatment monitoring. This study will provide a comprehensive evaluation of DNR's current riparian management and information on potential management alternatives.

This report covers the RVMP activities performed in the 2022 calendar year. More in-depth analyses from this program will come from peer-reviewed journal articles and the six-year (three sampling rotations) status report currently scheduled for 2025[4]. During 2022, DNR crews conducted:

- Population surveys to determine juvenile salmonid densities (fish/meter) and biomass (grams/meter^2) estimates in 35 watersheds from the annual panel (n=20) and the even-year rotating panel (n=15) of the 50 RVMP watersheds;
- 24 fish and habitat surveys at the reach (prescription site; n=20) and pour point (the lowest point in a watershed; n=4) of the 16 watersheds where the T3 Watershed Experiment is implemented;
- Surveys above and below a removed culvert in Bear Creek (E-1400 road in the Hoko River watershed);
- Coho salmon (*Oncorhynchus kisutch*) redd surveys in 20 RVMP watersheds, 12 of which are sampled annually; and
- Snorkel and habitat surveys in 12 km (divided into three reaches) of the Clearwater River.

Study Area

The OESF includes approximately 110,000 ha of DNR-managed lands on the western Olympic Peninsula (Figure 1) within the boundaries of three Water Resource Inventory Areas (19, 20, and 21). The boundaries follow the Olympic Mountain crest, the West Twin Creek and Lake Crescent watersheds to the east, the Strait of Juan de Fuca to the north, the Pacific Ocean to the west, and the Quinault River watershed to the south. Elevations within the OESF range from sea level to 1,155 m.

The OESF is a coastal rain forest that receives heavy precipitation (203 to 355 cm per year) with the majority falling in the winter. It contains a diversity of forests within three vegetation zones (Franklin and Dyrness 1988). The majority of the OESF is within the western hemlock zone (*Tsuga heterophylla*; 150 to 550 m elevation), while the lower elevations (0 to 150 m) are in the Sitka spruce zone (*Picea sitchensis*) and the upper elevations (550 to 1,155 m) are in the Pacific

[4] Previous RVMP annual reports are available on the DNR website at https://www.dnr.wa.gov/programs-and-services/forest-resources/olympic-experimental-state-forest/research-projects.

silver fir zone (*Abies amabilis*). DNR-managed lands within the OESF mostly consist of second- and third-growth forest resulting from prior timber harvests, with less than 10 percent of the forest being older than 140 years (WADNR 2016).

DNR-managed lands in the OESF contain more than 4,300 km of streams, including portions of several major rivers, such as the Queets, Clearwater, Hoh, Bogachiel, Calawah, Sol Duc, Dickey, Hoko, and Clallam (WADNR 2013). The smallest fish-bearing streams (stream order 1-3; Strahler 1957) typically have some combination of juvenile coho salmon, rainbow trout/steelhead (*O. mykiss*), coastal cutthroat trout (*O. clarkii clarkia*), lampreys (*Lampetra spp.*) and/or sculpins (*Cottus spp.*). Coastal cutthroat trout are the most commonly found salmonid species within this size of stream (Martens 2016).

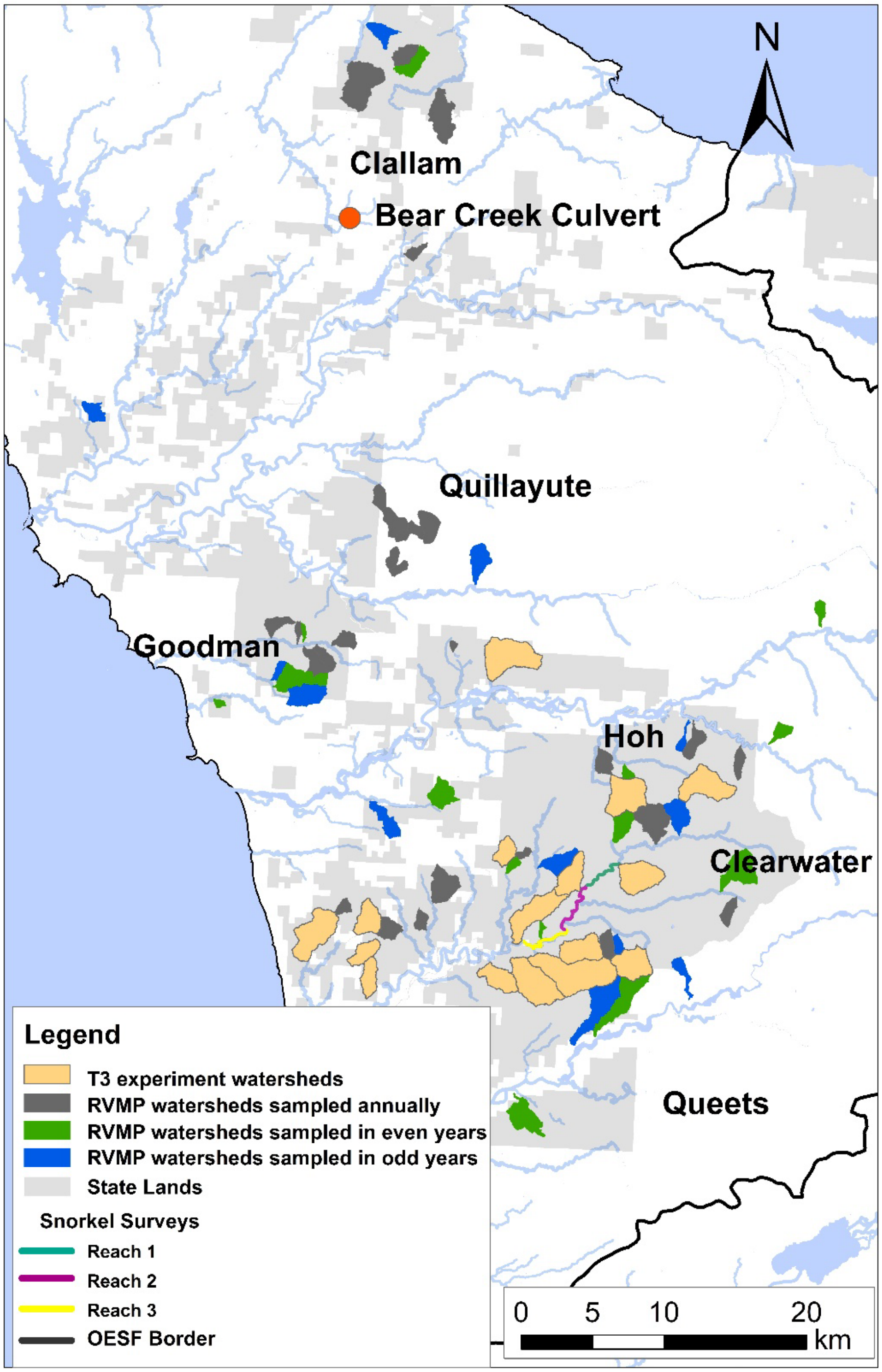

Figure 1. Map of OESF DNR-managed lands and sample watersheds.

Methods

Study Design

We use observational monitoring in 44 managed, Type-3 watersheds[5] on DNR-managed lands and six reference watersheds, two of which are located on DNR-managed lands and four in the Olympic National Park (Figure 1; Martens 2016). Six reference watersheds within the Olympic National Forest that were sampled in 2018-2021 are no longer being sampled due to a lack of resources. Six managed watersheds were removed from an original set of 50 watersheds on DNR-managed lands due to either a lack of fish or an inability to properly sample (mostly due to excessive vegetation limiting the crew's ability to continuously move within the reach).

The 44 managed watersheds were selected through a stratified random design under the STRAH program (Minkova et al. 2012). Reference watersheds (n=6) were selected to have environmental conditions similar to the 44 managed watersheds, to have no or minimal historic management history (> 95 percent of the watershed area never harvested), and to have reasonably easy access. As not all of the 50 watersheds could be sampled within a field season (summer), the RVMP calls for 20 watersheds to be sampled annually (annual panel), and an additional 30 watersheds to be sampled on a two-year rotation (even and odd years; Martens 2016). In addition to the 20 annual watersheds, we are now sampling two additional rotating panel watersheds (730 and 760) annually because portions of the watersheds were recently harvested. This results in a total of 17 rotating watersheds sampled per year instead of the previously scheduled 15.

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[5] Type 1 water – "all waters, within their ordinary high-water mark, inventoried as "shorelines of the state" under Chapter 90.58 RCW and the rules promulgated pursuant to Chapter 90.58 RCW, but not including those waters' associated wetlands as defined in Chapter 90.58 RCW."

Type 2 water – "segments of natural waters that are not classified as Type 1 Water and have a high fish, wildlife, or human use. (i) Stream segments having a defined channel 20 feet or greater in width between the ordinary high-water marks and having a gradient of less than 4 percent."

Type 3 water – "segments of natural waters that are not classified as Type 1 or 2 Water and have a moderate to slight fish, wildlife, and human use. (A) Stream segments having a defined channel of 2 feet or greater in width between the ordinary high-water marks in western Washington and having a gradient 16 percent or less; (B) Stream segments having a defined channel of 2 feet or greater in width between the ordinary high-water marks in Western Washington and having a gradient greater than 16 percent and less than or equal to 20 percent; and having greater than 50 acres in contributing basin size in western Washington."

Type 4 water – "segments of natural waters which are not classified as Type 1, 2 or 3, and for the purpose of protecting water quality downstream are classified as Type 4 Water upstream until the channel width becomes less than 2 feet in width between the ordinary high-water marks."

Type 5 water – "natural waters not classified as Type 1, 2, 3, or 4; including streams with or without well-defined channels, areas of perennial or intermittent seepage, ponds, natural sinks and drainage ways having short periods of spring or storm runoff."

Sampling reaches for juvenile fish and stream habitat surveys are located near the watershed outlet, just above the floodplain of its confluencing stream. Reaches are 20 times the bankfull width or are a minimum of 100 meters in length. A section of the Clearwater River, a Type-1 stream[4], is also snorkel-surveyed to assess the effects of DNR management on larger streams of the OESF. Redd surveys are conducted over the lower 1,000 meters of streams in the 50 monitored watersheds with a known coho salmon presence. Two reaches are also monitored above and below the Bear Creek culvert (E-1400 road in the Hoko River watershed) both before and after its removal to look at the fish response to removing a partial fish-passage barrier.

Starting in 2020, the T3 Watershed Experiment monitors two stream reaches in each of the study's 16 experimental watersheds (Figure 1). Within each watershed, one sampled reach is next to a planned experimental timber harvest and the other is at the pour point of the watershed (except for in Alterative 2 watersheds, which have two prescriptions and where monitoring only takes place at the reaches).

Juvenile Fish Sampling in Type-3 Streams

Juvenile fish surveys for the RVMP watersheds, T3 Watershed Experiment, and Bear Creek watersheds are conducted using multiple-pass removal electrofishing. Sample reaches in the T3 Watershed Experiment watersheds and Bear Creek are 100 meters long, while sample reaches in the RVMP watersheds range from 100 to 120 m long. Before sampling, seine nets are placed at the top and bottom of a reach to block fish movement. After a reach is blocked, a Smith-Root model 24b backpack electrofisher is used to collect fish with a forward and backward pass through the reach (Figure 2). Electrofishing is typically conducted using a frequency of 60 hertz with 25 percent duty cycle and voltage ranging from 300 to 600 volts.

Figure 2. DNR field crew conducting juvenile population surveys using a backpack electrofisher.

Fish sampling uses a variable pass (three to six passes) form of multiple pass-removal electrofishing. The number of passes is determined through the charts of Connolly (1996) and used as described in Martens and Connolly (2014).

After electrofishing, all salmonids are anesthetized with MS-222, visually inspected, measured and weighed, and released. Fish collection activities were permitted through Washington Department of Fish and Wildlife (permit #22-166) and the U.S. Fish and Wildlife Service (permit

#TE64608B-1). Fish population estimates are calculated using the program CAPTURE (Cooch and White 2012) and extrapolated over the length and area of the reaches.

After all passes are completed, stream habitat surveys are conducted. The habitat survey identifies habitat units based on the field guide of Minkova and Vorwerk (2015), counts the number of instream wood pieces, identifies pool-forming mechanisms, measures the lengths and widths of habitat units, and measures the depths of habitat units and pool-tail crests. In addition to the habitat unit surveys, sampling in the T3 Watershed Experiment watersheds includes stream shade (using hemispherical photos), bankfull width, pebble counts, stream gradient, leaf litter sampling, and riparian vegetation.

Bear Creek Culvert Removal

Please refer to Chapter 2 for further details.

Redd Surveys in Type-3 Streams

Redd (spawning nests) surveys are conducted over the first 1,000 meters or to the end of anadromous fish for each RVMP watershed with known coho salmon occurrences. Coho salmon were found in 62 percent of the basins during initial sampling in 2015 (Martens 2016). Twelve of the 20 annual watersheds have previously contained coho salmon and are sampled every year. Surveys identify the presence of redds, any adult fish present, and mark locations with GPS (Figure 3). All scheduled watersheds are sampled three times over the sampling season. Surveys begin in November and end in mid-January, following the methods of Gallagher et al. (2007).

Figure 3. Adult coho salmon creating a redd, or spawning nest.

Snorkel Surveys on the Clearwater River

Snorkeling surveys help to understand the distribution of larger resident, anadromous adults, and juvenile salmonids in larger streams of the OESF (Figure 4). They also provide insights on possible movements between Type-3 and larger streams.

The 12-km sampled section (starting near river kilometer 46 [downstream of Kunamakst Creek] and ending near river kilometer 33 [upstream of Bull Creek]) of the Clearwater River was chosen because it is fully contained within DNR-managed lands and any impacts related to land management could be attributed to DNR management practices. This section was subsequently separated into three reaches based on the distribution of mountain whitefish (which were absent in the middle section in 2017; Martens 2018). This middle reach is dominated by bedrock with steep banks, creating a canyon stretch of river.

Methods closely follow the protocols of Thurow (1994), with a two- to three-person crew snorkeling in a downstream direction counting fish of each species per habitat unit (e.g. pools, riffles, and glides). Habitat surveys are conducted simultaneously with the snorkel surveys. This survey collects information on habitat units, instream wood, and substrate. Habitat units are separated into pools, glides, and riffles, and unit length and width are measured with a laser rangefinder. Instream wood pieces were segregated into two groups: pieces 10-45 cm diameter and >2 m length, and “key pieces” >45 cm diameter and >2 m length. The percentage of channel substrate by categories (sand, gravel, cobble, boulder, and bedrock) are also visually estimated within each habitat unit.

Figure 4. Snorkelers counting fish in the Clearwater River.

Results

Sixty-one stream reaches were sampled for juvenile salmon (including the RVMP watersheds [n=35], T3 Watershed Experiment reaches [n=24] and Bear Creek n=2) in 2022. Additionally, 21 RVMP watersheds were surveyed for coho salmon redds, and three reaches within the 12 km of the mainstem Clearwater River were snorkeled.

DNR crews identified and measured 1,041 age-1 or older coastal cutthroat trout, 2,022 coho salmon, 3,409 juvenile trout (a combination of age-0 coastal cutthroat trout and steelhead/rainbow trout), and 52 age-1 or older steelhead/rainbow trout during juvenile surveys. Sculpin were often found but were not collected because 1) sculpin lack a swim bladder and are not as easily collected as juvenile salmon, and 2) the HCP only calls for salmonid monitoring. Juvenile lampreys were found in 9 of the 66 watersheds.

In addition to the species found in Type-3 watersheds, mountain whitefish (*Prosopium williamsoni*) and longnose dace (*Rhinichthys cataractae*) were found during snorkel surveys in the mainstem Clearwater River. Bull trout (*Salvelinus confluentus*), the only ESA-listed salmonid species that has potential to be found within our sampling area, have never been found during our sampling efforts (a bull trout-specific report is prepared annually for the U.S. Fish and Wildlife Service; Appendix 1). In addition, aquatic amphibians including tailed frogs (*Ascaphus sp.*) and Cope's giant salamanders (*Dicamptodon copei*) were often encountered. However, amphibians were not counted because the project emphasis is salmonid fishes.

Figures 5 and 6 show the salmonid density and biomass of fish collected in 2022. Salmonid variability remains high among the watersheds as was found in previous years (Martens 2021). Watershed 196 had the highest density of fish, which was primarily driven by age-0 trout and coho salmon. Although age-0 trout and juvenile coho make up the majority of fish, the streams with the most biomass typically have larger numbers of age-1 or older cutthroat trout or steelhead.

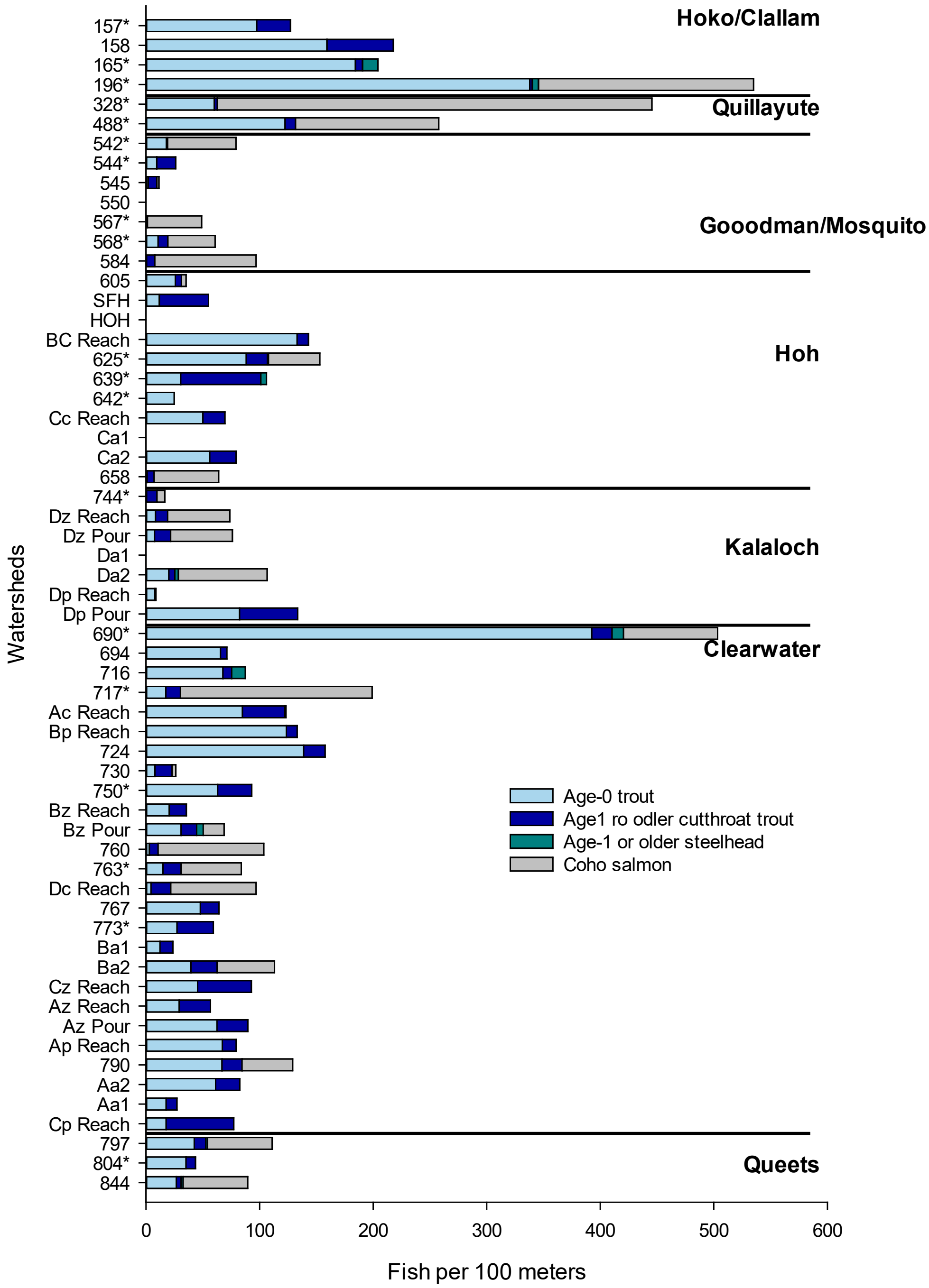

Figure 5. Density of juvenile salmonids (number per 100 meters), separated into larger watershed areas, collected during the summer 2022 field season (mid-July to mid-October) in the Olympic Experimental State Forest. The RVMP watersheds on DNR-managed lands are labeled with a 3-digit number; the RVMP watersheds in Olympic National Park are labeled with three capital letters; the T3 Watershed Experiment reaches are labeled with uppercase and lowercase letters. The asterisks identify the annually sampled watersheds.

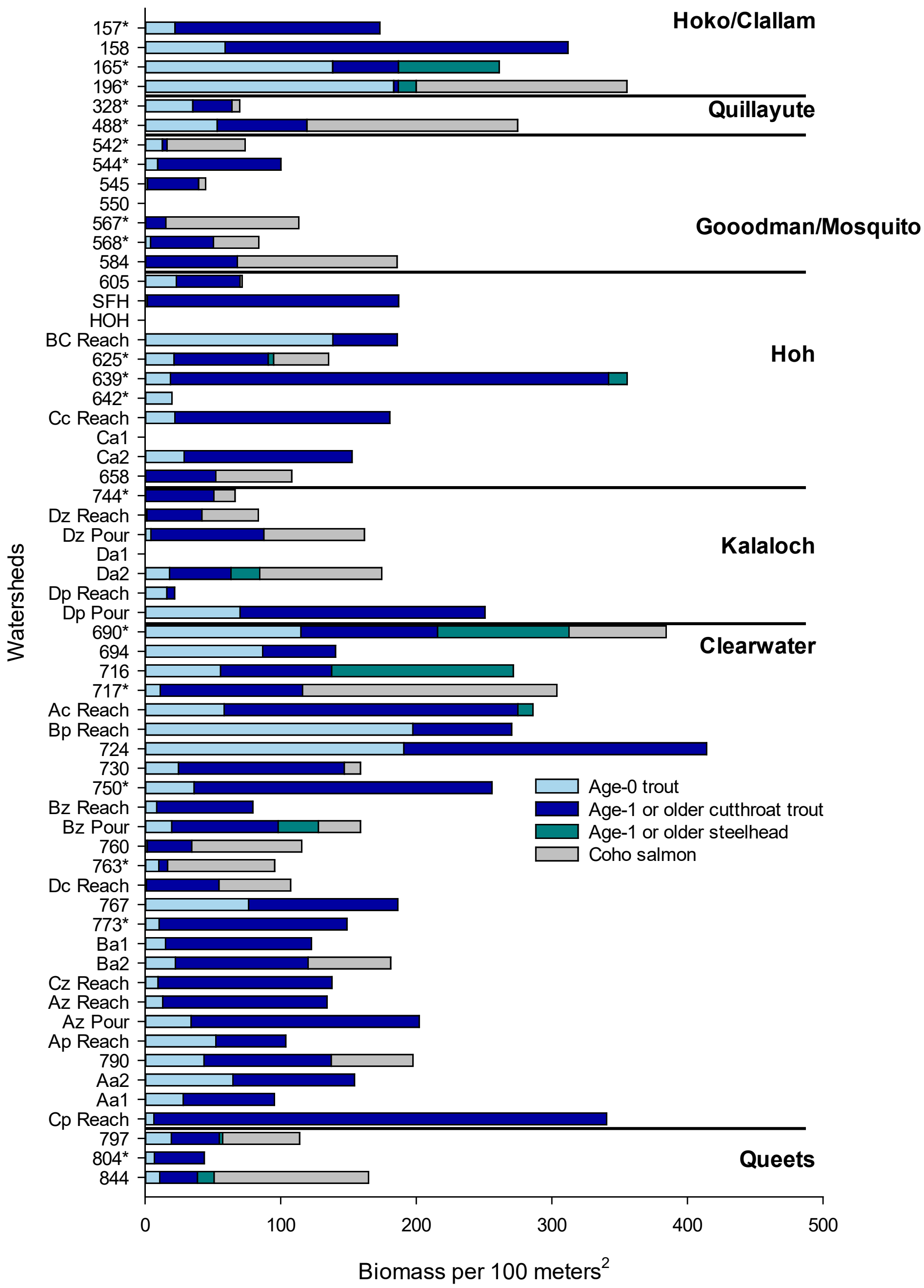

Figure 6. Biomass of juvenile salmonids (grams per 100 meters^2), separated into larger watershed areas, collected during the Riparian Validation Monitoring Program's summer 2022 field season (mid-July to mid-October) in the Olympic Experimental State Forest. The RVMP watersheds on DNR-managed lands are labeled with a 3-digit number; the RVMP watersheds in Olympic National Park are labeled with three capital letters; the T3 Watershed Experiment reaches are labeled with uppercase and lowercase letters. The asterisks identify the annually sampled watersheds.

The average density and biomass of salmonids within annually sampled RVMP managed watersheds are shown in Figures 7 and 8. Salmonid densities in the annually sampled watersheds continue to remain high when compared to the first two years of sampling in 2016 and 2017. In 2022, age-0 trout and juvenile coho abundance remained relatively high, leading to the highest recorded densities of juvenile salmonids. Age-1 or older cutthroat trout and rainbow trout/steelhead densities declined from 2021 levels despite the high overall densities of fish in 2022. Due to these declines, we saw a decrease in biomass despite the record number of salmonids.

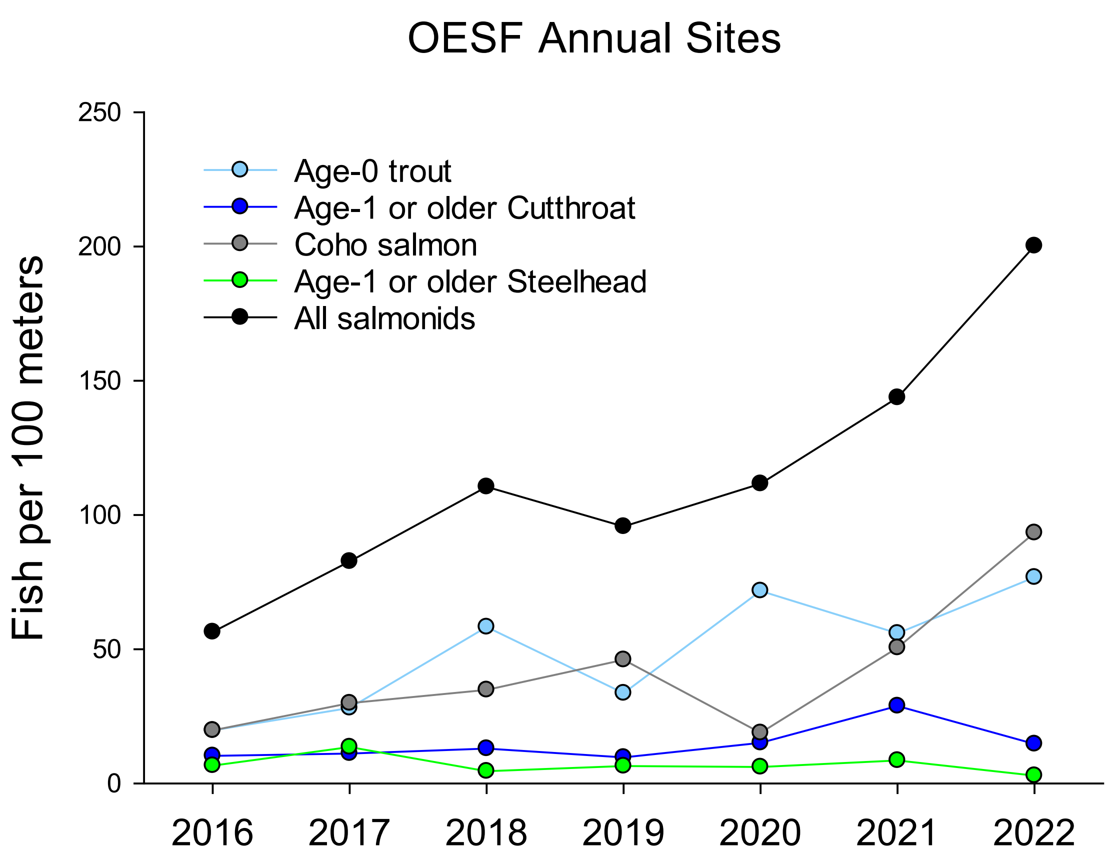

Figure 7. The average fish density (number per 100 meters) of juvenile salmonids collected from the 20 annual sampled sites during the Riparian Validation Monitoring Program's summer 2022 field season (mid-July to mid-October) in the Olympic Experimental State Forest (OESF).

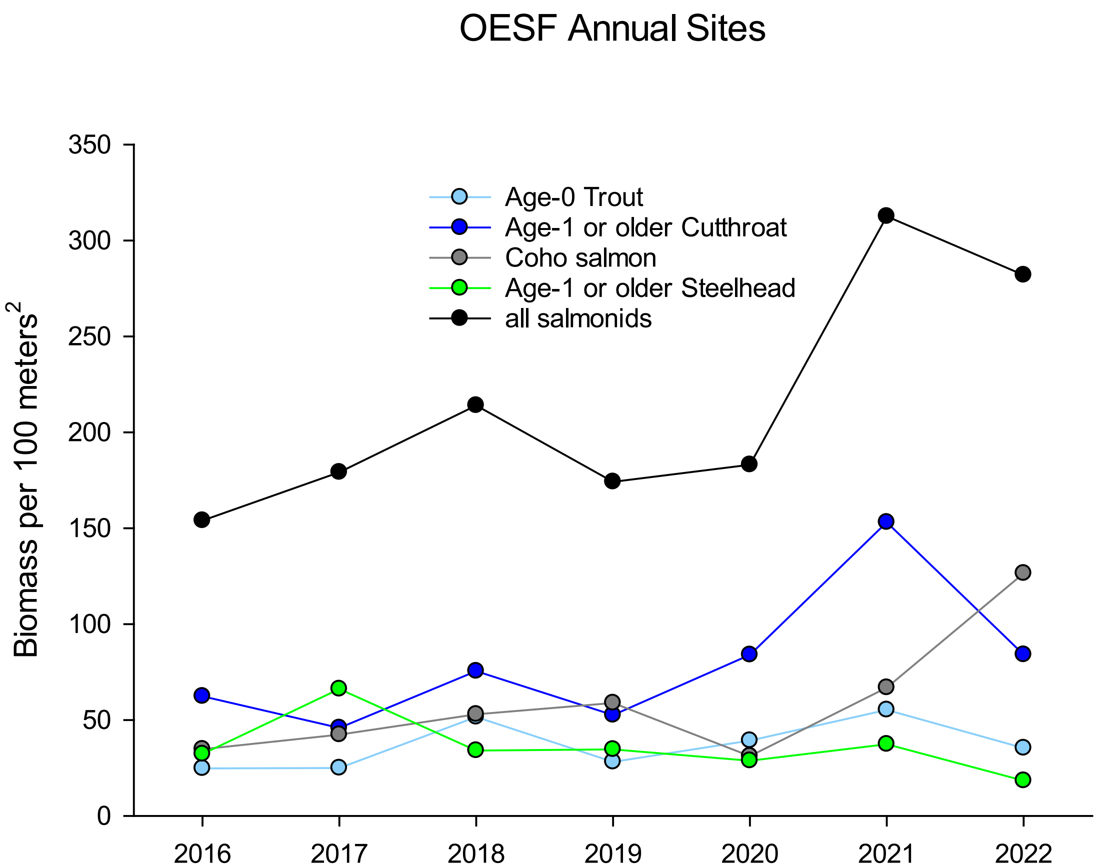

Figure 8. The average fish biomass (grams per 100 meters^2) of juvenile salmonids collected from 20 annual sampled sites during the Riparian Validation Monitoring Program's summer 2022 field season (mid-July to mid-October) in the Olympic Experimental State Forest (OESF).

Samples repeated for 7 years in all the RVMP watersheds are starting to reveal patterns among the watersheds (Figure 9). Some streams, such as 196, 690, and 796, consistently contain high densities of salmonids with high inter-annual variability. Another group of streams (544, 545, 550, 566, 567, 605, 730, 744, 804, BOG, HOH) have maintained low densities of salmonids with low inter-annual variability.

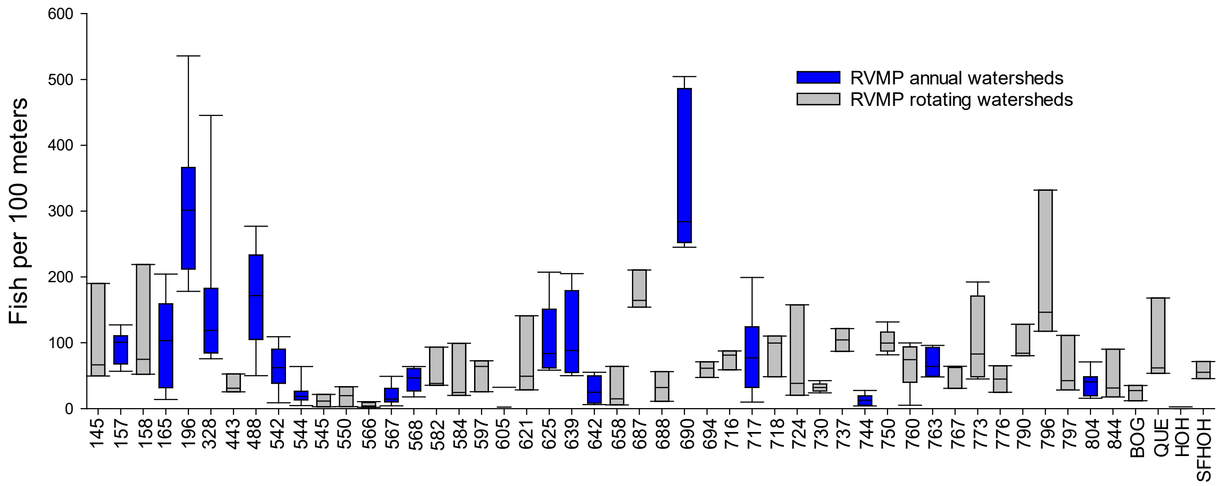

Figure 9. The fish density (number per 100 meters) of all juvenile salmonids sampled at sites from 2016 through 2022 (annually sampled watersheds were typically sampled for 6 years while rotating watersheds were sampled 3 years) in the Olympic Experimental State Forest. The line in the bars represent the median, the boxes outline the 25th and 75th percentile and the bars represent the 10th and 90th percentile.

Redd Surveys in Type-3 Streams

Redd surveys were conducted in 12 annually sampled streams from 2016 through 2022. Annual numbers of coho salmon redds are presented in Figure 10. Watershed 328 continues to have the highest number of redds; however, only two redds were found in 2022. No redds were found outside of watershed 328 in 2022. Most streams have contained a limited number (<5) or no redds despite a consistent juvenile coho presence.

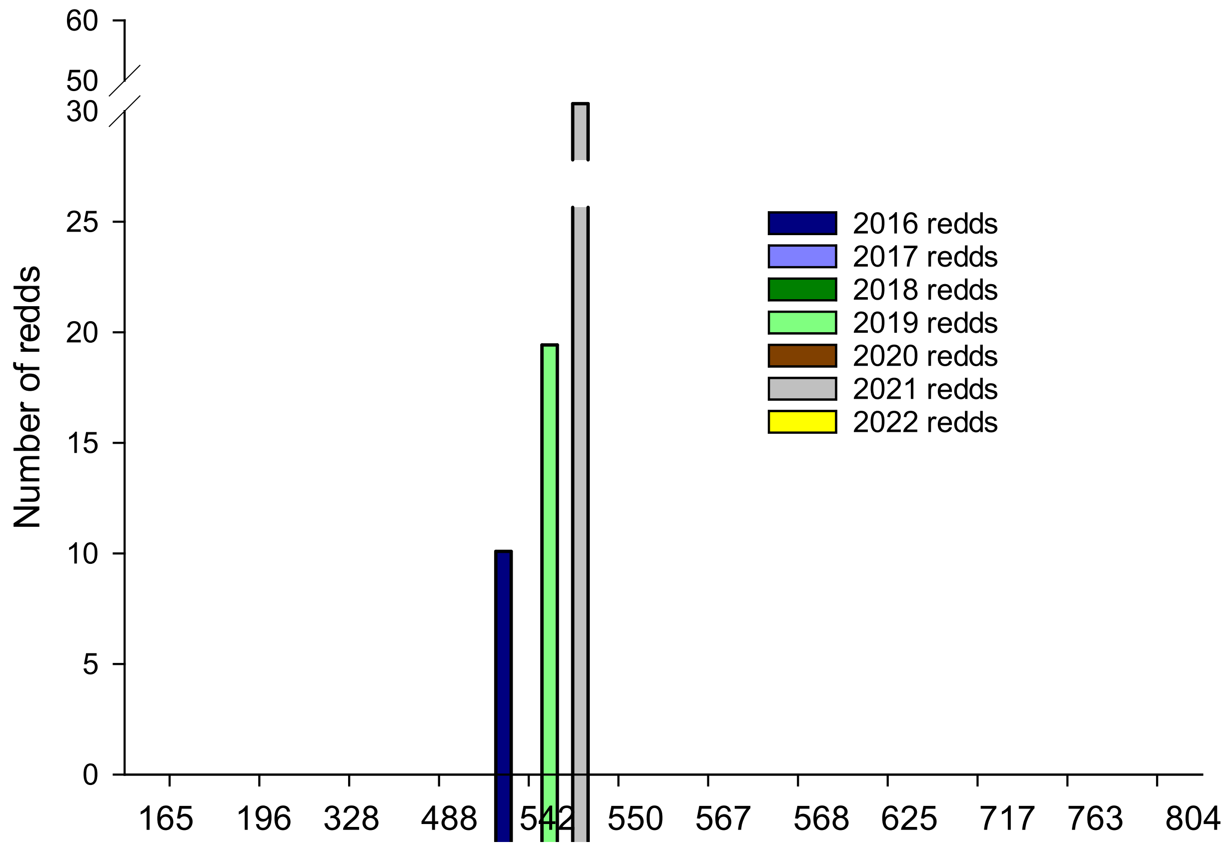

Figure 10. Coho salmon redd surveys conducted in the annual panel of watersheds from 2016 through 2022.

Snorkel Surveys on the Clearwater River

Annual fish densities, calculated from snorkel data collected in the three sampled reaches of Clearwater River, are presented separately for each of the three main species – coho salmon, juvenile trout (rainbow trout/steelhead or coastal cutthroat trout) and mountain whitefish (Figure 11). In 2022, we found some of the highest densities of juvenile trout and coho salmon since our sampling began in 2016 (Figure 11).

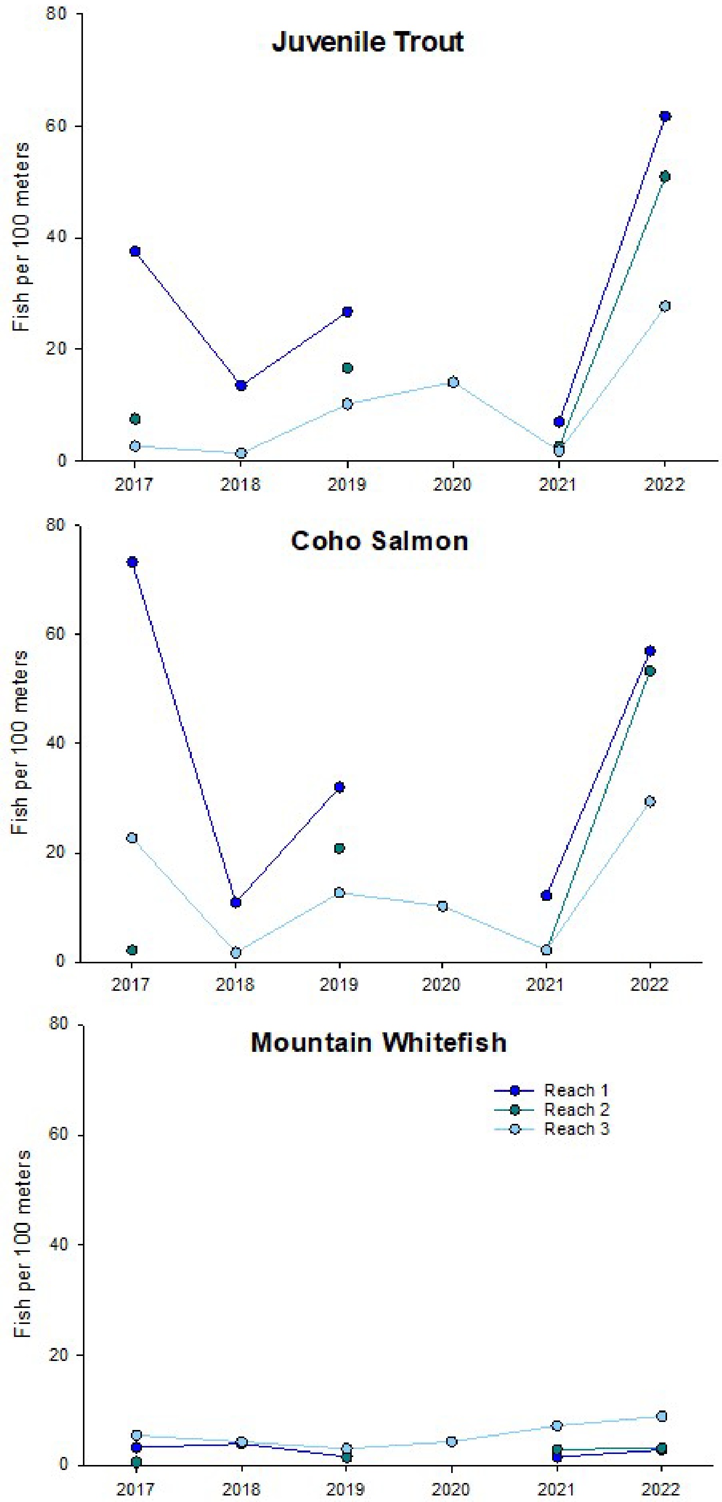

Figure 11. Annual densities of coho salmon, juvenile trout (rainbow trout/steelhead or coastal cutthroat trout), and mountain whitefish density in the Clearwater River.

Discussion

Riparian Validation Monitoring

Although the RVMP is still in the early stages of monitoring, we are gradually improving our ability to identify changes in salmonids populations over time and across different areas. Detecting trends and patterns is challenging due to the slow rate of long-term habitat restoration following extensive harvests preceding the 1997 HCP.

Recovery from the impacts of historic logging practices is expected to take hundreds of years (Martens et al. 2020), resulting in gradual habitat changes and corresponding effects on salmonids. The high variability between watersheds and years further complicates the detection of these changes. The time required to detect any changes will depend on factors such as the magnitude of change resulting from DNR management activities, year-to-year variation, and site differences (Martens 2016). Consequently, many years of monitoring and a relatively high number of sites are necessary to differentiate spatial and temporal variation from potential impacts of DNR management on salmonid populations (Kershner et al. 2004; Liermann and Roni 2008).

In 2022, we observed the highest densities of salmonids across the OESF, primarily driven by an increase in juvenile coho and age-0 trout. However, there was an overall decrease in biomass compared to 2021, mainly due to a decrease in age-1 or older cutthroat trout and steelhead. This trend may indicate increased recruitment into OESF streams, but the decrease in older fish warrants continued monitoring. An increase in age-0 fish (trout and coho) without a corresponding increase in older fish could be an indicative of limited rearing habitat. Further data collection and exploration is required to determine if this is a habitat effect or a response to the previous year's recruitment of age-0 fish.

Reduced habitat capacity could result in juvenile fish mortality or movement. Although movement possess risks such as increased predation opportunities, it could also lead to enhanced fitness by using under-seeded or higher-quality habitat. It remains unclear whether increasing capacity in natal streams (habitat improvement) or downstream locations with potentially superior habitat (such as off-channel habitat) but risks (predation) would have the greatest overall benefit on these populations.

Analysis of fish variation between sites reveals a range of conditions within the OESF. Some streams exhibit minimal variation and low fish densities and are likely limited by physical habitat. The question arises as to whether these limitations result from natural variation or reduced habitat due to anthropogenic influences. It is likely a combination of both factors. Many small type-3 streams naturally have conditions that restrict the potential capacity of fish, such as water availability, especially during the summer when flows are typically at their lowest. However, past anthropogenic influences may have also reduced fish capacity in streams, and restoration could increase capacity in these cases.

Furthermore, if climate change leads to reduced summer flows (as expected; Halofsky et al. 2011), the already marginally suitable habitat in these streams may become unsuitable for fish. Additionally, streams currently supporting higher fish populations may experience a decline in capacity and shift toward a low density/low variation pattern. Such a shift would likely impact juvenile cutthroat trout, coho salmon, and sculpin, which are the most commonly found fish species in these smaller streams, more than salmonid species that use larger streams.

Products and Publications

The RVMP has continuously expanded our knowledge of salmonids and their habitat across the OESF, resulting in a growing number of publications. Our most recent paper examines the relationship between instream wood and pools (Martens and Devine 2022).

Peer-reviewed journal publications based on RVMP data collected to date include:

Martens, K. D., W. D. Devine, T. V. Minkova, and A. D. Foster. 2019. Stream conditions after 18 years of passive riparian restoration in small fish-bearing watersheds. Environmental Management 63(5):673-690.

Martens, K. D., D. C. Donato, J. S. Halofsky, W. D. Devine, and T. V. Minkova. 2020. Linking instream wood recruitment to adjacent forest development in landscapes driven by stand-replacing disturbances: a conceptual model to inform riparian and stream management. Environmental Reviews 28(4):517-527.

Devine, W. D., E. A. Steel, A. D. Foster, T. V. Minkova, and K. D. Martens. 2021. Watershed characteristics influence winter stream temperature in a forested landscape. Aquatic Sciences 83(3):1-17.

Martens, K. D. and J. Dunham. 2021. Evaluating coexistence of fish species with coastal cutthroat trout in low order streams of western Oregon and Washington, USA. Fishes 6(4) doi.org/10.3390/fishes6010004

Martens, K.D. and Devine, W.D., 2022. Pool Formation and The Role of Instream Wood in Small Streams In Predominantly Second-growth Forests. Environmental Management, pp.1-13.

In addition to these publications, the RVMP produces popular science publications, and conducts presentations, field tours, and other outreach activities.

RVMP Future Directions

With the addition of four T3 Watershed Experiment watersheds managed under current DNR practices and several RVMP management watersheds with either recently completed VRH units (watersheds 488, 544, 568, 730, and 760) or units scheduled for VRH over the next few years (watersheds 157, 545, 625 and 642), the OESF is set up for a large muti-site BACI study that can assess potential impacts of VRH and the associated riparian conservation measures. These 12 monitored VRH watersheds (watershed 545 is not sampled annually) will be compared with the four control watersheds in the T3 Watershed Experiment and eight RVMP management watersheds with no planned harvest over the next four to 10 years to evaluate both treatment and controls across the OESF.

This extensive monitoring effort should provide managers and stakeholders information on the effects of current DNR practices and whether the HCP riparian conservation strategy, as implemented in the OESF, is meeting expectations.

Additional Value of the RVMP

The implementation of the RVMP has generated crucial information about fish populations within the OESF. Our sampling activities have allowed us to cooperate with other agencies and provided insights beyond the program's scope at minimal additional cost. For example, our crews have collected genetic information and taken pictures of juvenile lamprey, which have proven valuable to the wider fish community. These efforts have expanded the known distribution of Pacific lamprey and documented the absence of hybridization between cutthroat trout and O. mykiss in the monitored Type-3 streams.

The knowledge gained from our fish and habitat monitoring has also supported a large effort to prioritize restoration and monitoring efforts in the Queets/Clearwater watershed led by the Quinault Indian Nation. Furthermore, we presented data on juvenile steelhead, forest conditions, and stream habitat to NOAA Fisheries as part of their review to determine if Washington coastal steelhead warrant listing under the Endangered Species Act.

These examples demonstrate that monitoring through a Habitat Conservation Plan not only contributes to achieving desired outcomes but also fosters collaboration with other agencies, facilitates additional information gathering, and provides insights into unforeseen issues.

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Chapter 2: Salmonid response to the removal of partial-salmonid-barrier culverts

Abstract

Fish passage barriers have been identified as a significant contributor to the decline of salmonids in the Pacific Northwest. One of the most common forms of anthropogenic fish passage barriers are road-crossing culverts; many older ones were installed without considering fish passage.

Restoring fish passage at barriers is considered one of the more effective ways to restore salmonids because they not only impact the immediate culvert site but also allow access to upstream habitat. As a result, there has been a significant effort to identify the status of culverts and replace those that impede fish passage. In Washington state, The Department of Fish and Wildlife uses a protocol that classifies culverts into four categories (0 percent, 33 percent, 67 percent or 100 percent passable) based on adult salmonids (≥ 152 millimeters [6 inches] fork length).

Despite the well-documented benefits of restoring fully impassable culverts, there is less understanding of the benefits of restoring partial-salmonid-barrier culverts. To evaluate the response of salmonids to the removal of a 33 percent passable culvert, a Before-After-Control-Impact (BACI) study was conducted. Monitoring was performed using multi-pass removal electrofishing in two 100-m reaches above (i.e., Impact) and below (i.e., Control) the culvert. Sampling was conducted for two years before the culvert removal and for four years after removal.

During the study, only coastal cutthroat trout were found either above or below the culvert site. No significant differences were detected in salmonid densities or biomass before or after the culvert was removed or between the control and impact sites. These findings, along with the results of other studies, raise doubts about the benefits of restoring partial-barrier culverts for salmonids and should be taken into account when prioritizing salmonid restoration actions.

Introduction

Human activities have altered the course of many rivers and streams in the Pacific Northwest have been altered from their historic conditions, resulting in widespread declines in salmonid populations. Anthropogenic fish-passage barriers, such as dams or culverts, pose one of the many threats to salmonids in the Pacific Northwest (Nehlsen et al. 1991; Sheer and Steel 2006).

In Washington state, Conroy (1997) found that more than 7,500 km of otherwise-suitable spawning habitat was inaccessible due to impassable culverts, while Sheer and Steel (2006) found that the majority of watersheds in the Willamette and Lower Columbia River Basins had lost more than 40 percent of their potential fish habitat because of anthropogenic fish barriers. Additionally, impassible culverts have been estimated to decrease coho salmon (*Oncorhynchus kisutch*) smolt production by 30 to 58 percent in two Washington state rivers (Roni 2002). Therefore, removing fish-passage barriers is one of the most effective and popular types of salmonid restoration, because it can provide access to large lengths of streams with a single action.

Although several studies have found successful fish recolonization following the removal of complete barriers, including culvert barriers (Pess et al. 2005; Roni et al. 2008; Shrimpton et al. 2008; Clark et al. 2020), limited peer-reviewed information exists regarding the effectiveness of culvert restoration (Roni et al. 2008).

Even less is known about the impact of partial-salmonid-barrier culverts (culverts that allow some fish passage; PSB culverts) on salmonids. It is relatively unknown whether these culverts primarily delay fish movement or have more negative consequences, such as altering presence/absence, genetic composition, or abundance. If the primary response to barrier removals is a delay in migration, then barrier removal may have limited impact on salmonid recovery.

The uncertainty of salmonid responses to PSB culvert removal or modification becomes important when prioritizing restoration efforts. With the limited information available, it is unclear whether PSB culverts should be treated as equal to complete salmonid passage barriers (which are often one of the highest priority forms of restoration) or should be ranked with or even below site-specific forms of instream restoration, such as floodplain reconnection, instream wood additions, or reed canary grass removal.

In Washington state, the removal of all fish-barrier culverts under state control was mandated through a 2013 court injunction, which required state agencies to modify or remove all culverts "in order to pass all species of salmon at all life stages at all flows where the fish would naturally seek passage" (United States v. Washington, No. CV 70-9213, [W.D. Wash. March 29, 2013]). As a result, all state-controlled PSB culverts in Washington will eventually be removed or replaced, regardless of their restoration value. However, many salmonid restoration funding mechanisms and local watersheds groups receive limited funding and need to prioritize multiple forms of restoration projects.

In this chapter, I evaluate the response of a PSB culvert that was removed in 2018, using a Before-After-Control-Impact design to assess its impact on salmonid presence/absence, density, and biomass. I hypothesize that the removal of the culvert will lead to an increase in the number of species, biomass, and abundance.

Methods

Culvert Information

The Washington Department of Fish and Wildlife (WDFW) categorizes fish passage barriers based on adult salmonid, which is defined as fish greater or equal to 152 millimeters (6 inches) fork length (WDFW 2019). The barriers are classified into four categories:

- 0 percent passability - total barrier to adult salmonids within the range of fish passage flows.
- 33 percent passability - severe partial barrier to adult salmonids within the range of fish passage flows.
- 67 percent passability - moderate partial barrier to adult salmonids during a period within the range of fish passage flows.
- 100 percent passability - no impeded to adult salmonids passing through the feature within the range of fish passage flows.

Classification is determined through a Type-A or Type-B assessment. The Type-A assessment considers the water surface drop from the culvert and the slope and length of the culvert to determine if it is a barrier. Any water drops from the culvert outlet to the stream of more than 0.24 m or a slope greater than 1 percent qualifies as a barrier. If a culvert is a barrier through both water drop and slope, the lower passability level is assigned (i.e., if a culvert is 67 percent passable due to the water drop but 33 percent passable due to the slope, the culvert is determined to be 33 percent passable). The Type-B assessment, conducted when a barrier cannot be determined through the Type-A survey, assesses velocity and water depth in the culvert through a hydraulic analysis.

The culvert used in this assessment was located in Bear Creek, 7.4 km upstream of its confluence with the Hoko River on the abandoned E-1400 road (Figure 1). Bear Creek is a second order (DNR Type-3) stream on the western Olympic Peninsula of Washington state. The Hoko River watershed contains populations of Chinook salmon (*O. tshawytscha*), chum salmon (*O. keta*), coho salmon, steelhead (*O. mykiss*), and coastal cutthroat trout (*O. clarkii clarkii*).

The Bear Creek culvert was selected for monitoring as it was scheduled for removal in summer 2018 and had potential for juvenile coho salmon below the culvert while no coho salmon were found above the culvert. The presence of coho salmon would allow for the ability to identify a change in species composition (the most obvious sign of fish passage improvement). Other culverts were rejected for inclusion in this study due to the size of the stream, location within the watershed, or the presence or absence of salmonid species. The Bear Creek Culvert was a 40-foot-long corrugated metal pipe with a gradient of 4.5 percent, which would be classified as a 33 percent passable, or severe barrier, based on WDFW criteria (WDFW 2019). The culvert was removed after fish sampling in the summer of 2018 (Figure 1).

Figure 3. Pictures of the Bear Creek culvert site before and after removal.

Sampling Design

This study employed a Before-After-Control-Impact (BACI) design. A BACI design is one of the more robust designs and has been recommended to evaluate environmental changes (Stewart-Oaten et al. 1986; Mahlum et al. 2018). This type of study evaluates the response of restoration to both a control site and to the restoration site prior to restoration. Monitoring began in 2017 and included two years of pre-removal monitoring and four years (2019-22) of post-removal monitoring. Two 100-meter reaches were established above and below the culvert, with the reach above the culvert considered the treatment or impact reach and the downstream reach considered the control reach.

Sampling

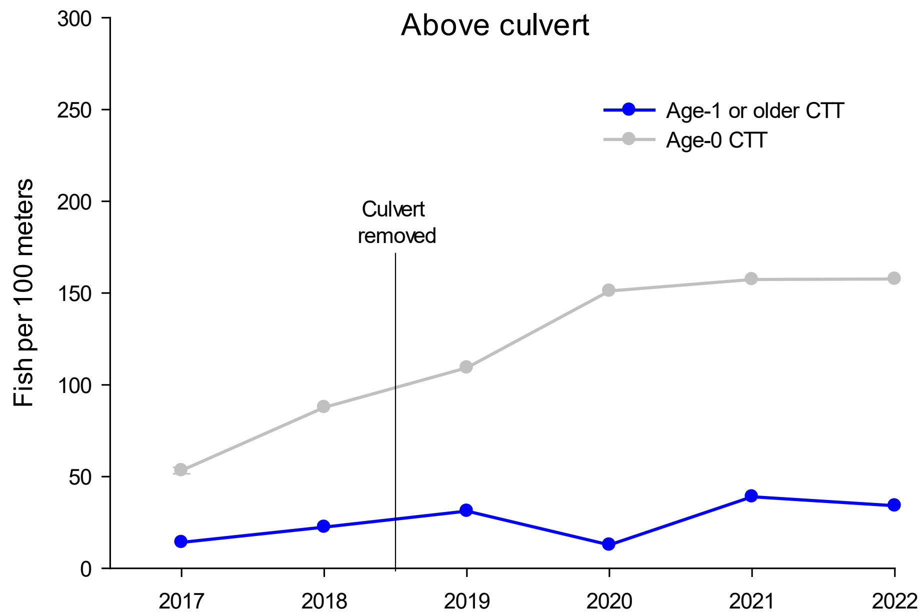
Salmonid density and biomass surveys were conducted using multi-pass removal electrofishing with three to six passes per survey. Seine nets (block nets) were placed at the top and bottom of reaches to prevent fish movement. Electrofishing was performed using a Smith-Root model 24b backpack electrofisher, with a frequency of 20 hertz with 10 percent duty cycle and voltage ranging from 300 to 600 volts. A minimum of three passes were conducted per survey, with additional passes determined based on the charts by Connolly (1996) and used as described in Martens and Connolly (2014). The fish were anesthetized with MS-222, visually inspected, measured for fork length and weight, and released back into the stream after all passes were complete. Following electrofishing, a habitat survey was conducted over the sampled reach to determine the amount of instream wood, characterize habitat units (riffle, pool, etc.), and measure each unit's length, width, and depth.

Analysis

Fish population estimates were calculated using the program CAPTURE, standardized over the length and area of the reaches, and analyzed by species and age class. The BACI comparisons were conducted with a one-way ANOVA test (F-test) using a Tukey comparison. Tests were conducted for equal variance and normality to meet the ANOVA assumptions. If the tests failed, one of the assumptions a Kruskal-Wallis One Way Analysis of Variance on Ranks (H-test) with a Dun comparison was performed in place of the ANOVA. Results were considered significant at an alpha of 0.05. Altogether, comparisons of age-0 density, age-1 or older density, age-0 biomass and age-1 or older biomass of cutthroat trout were conducted. For each comparison the data were separated into four groups: Before Impact (BI), Before Control (BC), After Impact (AI), and After Control (AC). A significant increase after culvert removal between both the BI and AI and the AC and AI groups would need to be detected in order to determine whether the PSB culvert removal was successful.

Results

During the study period (2017-22), only age-0 and age-1 or older cutthroat trout were collected above or below the culvert. There was no change in species composition. Densities of age-1 or older cutthroat trout were consistent throughout the study period. However, densities of age-0 cutthroat trout increased over time, with higher and more variable densities found below the culvert (Figure 2). The biomass of both age-0 and age-1 or older cutthroat trout above the culvert showed a slight increase over the study period (Figure 3).



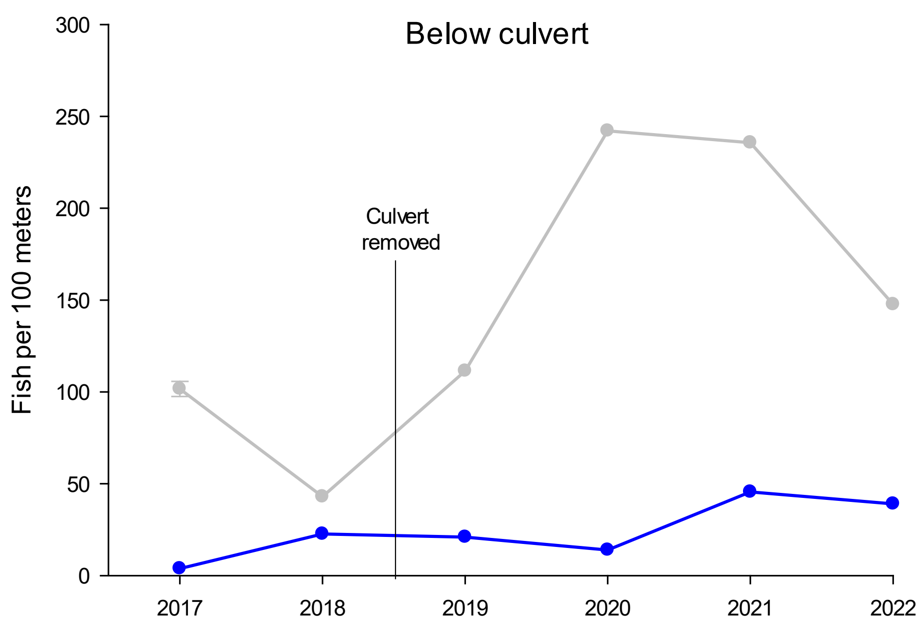


Figure 4. Cutthroat trout densities above and below the Bear Creek culvert site. The culvert was removed after sampling during summer 2018.

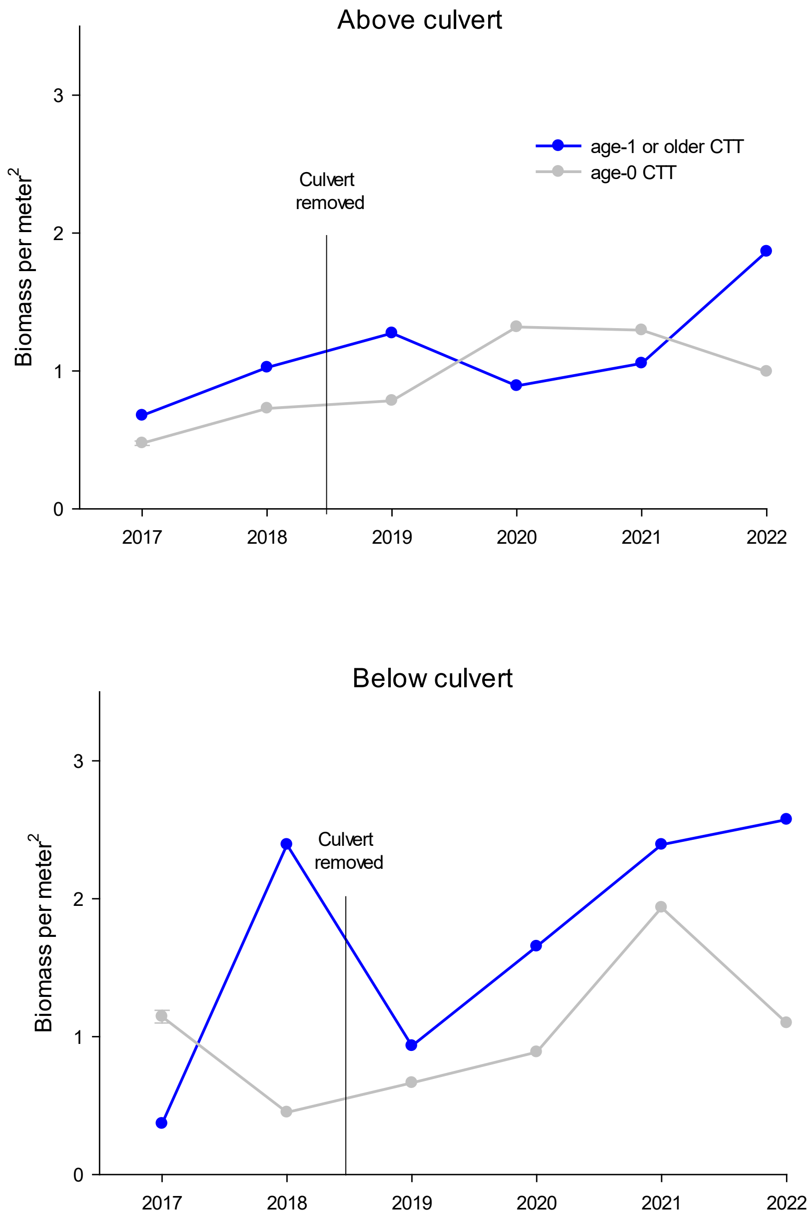


Figure 5. Cutthroat trout biomass above and below the Bear Creek culvert site. The culvert was removed after sampling during summer 2018.

None of the statistical tests found a significant difference (P > 0.05) between the groups (Figure 4). The age-0 cutthroat trout density was the closest test to finding a significant difference (H = 7.538, P = 0.057) between the BACI groups. However, the BI and AI (Q = 1.761) and the AC and AI (Q = 0.392) comparisons were more similar than some of the other comparisons (i.e., AC vs BI, Q = 2.082 and AC vs BC, Q = 2.082). All other tests (P > 0.39) were not close to finding a significant difference between groups.

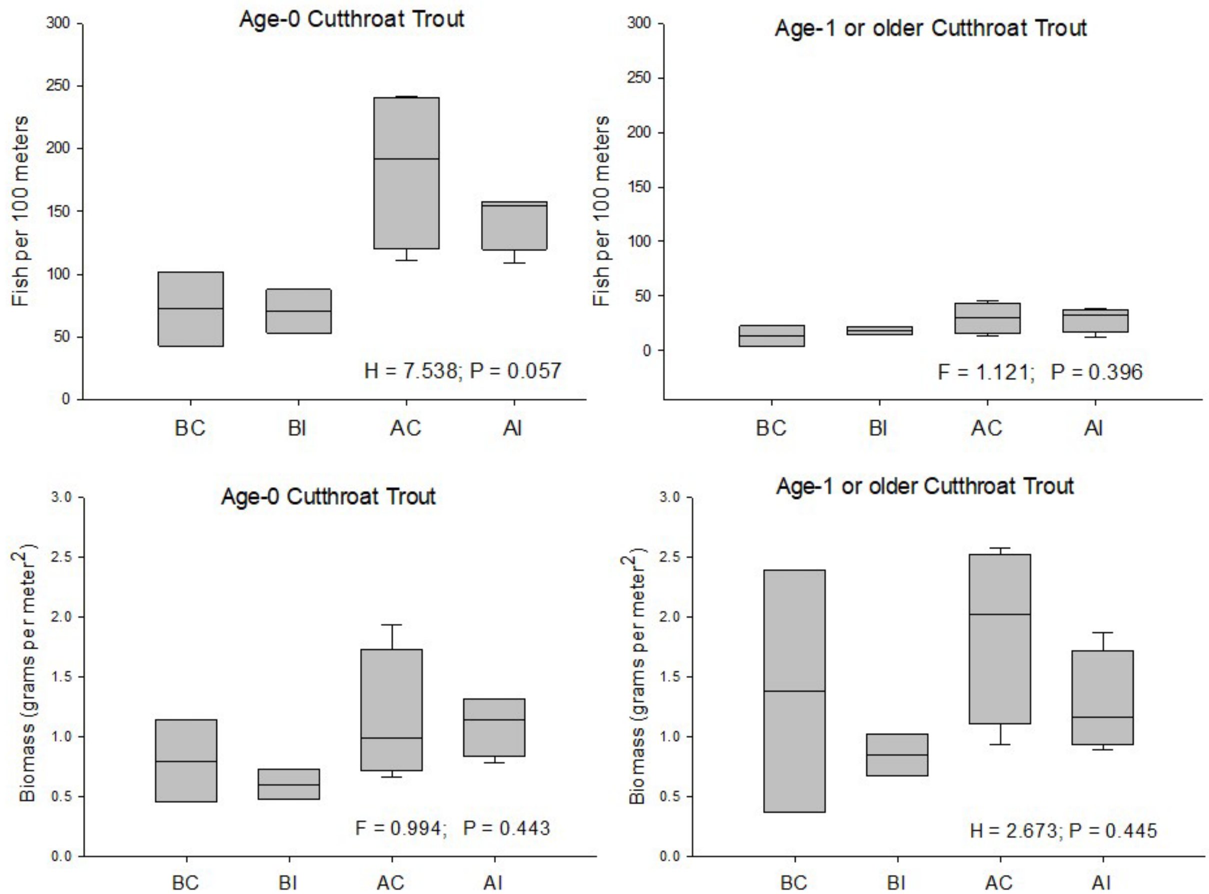


Figure 6. Comparison of fish density and biomass between the four BACI groups. BC = Before control site, BI = Before impact site, AC = After control site, and AI = After impact site.

Discussion

No significant differences in cutthroat trout density or biomass were detected after removal of the Bear Creek Culvert. Additionally, determining whether the culvert removal increased passage was not possible due to the absence of coho salmon.

Although there have been a limited number of studies on PSB culvert restoration, a few studies have documented similar responses from salmonid populations. For instance, Mahlum et al. (2018) found that restoring PSB culverts in Canada did not result in the restoration of brook trout (*Savelinus fontinalis*) populations. Neville et al. (2016) found no effect on cutthroat trout densities after removing PSB culverts in two creeks, but they did detect a threefold increase after removing two complete barriers. DeVault (2011) did not detect an increase in pre- and post-restoration abundance of juvenile salmonids (including coho salmon), or in adult returns after modifying a PSB culvert, but did detect a significant increase in out-migrating age 2+ trout. These studies, along with my results, highlight the uncertainty of a salmonid response after restoration of PSB culverts. It is possible that some of these PSB culverts allow enough fish passage to maintain healthy fish populations (Mahlum et al. 2018).

This study was limited by the fact that the movement of individual fish was not monitored, which restricted my ability to understand the amount of fish passage at the culvert site.

Studies have shown that PSB culverts can delay fish passage. Burford et al. (2009) found that upstream movement of cutthroat and brook trout was 2.45 times lower through culverts than in over natural areas of streams. They also found that upstream cutthroat trout densities declined when culvert slopes exceeded 4.5 percent and brook trout densities declined when outlet drop sites exceeded 20 cm. Using WDFW's passage standards, a 4.5 percent slope would be considered a 100 percent barrier, but the barrier status for an outlet drop in Washington state does not begin until 24 cm. The Burford et al. (2009) study also found that 2 of 11 fish (>100 mm) but no fish less than 100 mm were able to move through a culvert with an outlet drop of 61 cm. Macpherson et al. (2012) found no evidence of rainbow trout densities or travel being restricted over larger gradients (>5.7 percent) and outlet drops (>0.42 m), but found significant differences for other less-mobile fish species.

Some variability in salmonid passage is likely based on differences among species' swimming and jumping abilities, the size of fish, and the physical conditions of the culvert. These variables make developing an easy-to-follow standard for determining fish passage barriers very difficult. It should also be noted that developing a standard that underestimates passage ability has fewer risks to salmonid recovery than overestimating passage ability. However, when prioritizing restoration actions, culverts classified as full barriers or partial barriers with differences in fish species composition above and below the culvert are likely to provide the greatest benefits towards salmonid recovery.

There is evidence that smaller and less-mobile fish species and invertebrates can benefit from the culvert restoration (Resh 2005; Blakely et al. 2006; Macpherson et al. 2012). The removal of culverts can also bring non-ecological benefits, such as road maintenance or property protection, and has been speculated to improve local or downstream conditions for accumulation of sediment, wood loads, organic material, and nutrients (Clark et al. 2020; Roni et al. 2002).

There are few studies on the local impacts of culvert restoration. In one of these studies, Lachance et al. (2008) found that fine sediment was significantly higher in areas directly below culverts compared to above culverts, which lasted up to 1,442 meters downstream of the culverts. However, they attributed these accumulations to road construction or erosion, which may not be alleviated if a culvert is replaced. Additional studies on the local impacts of culvert removal would help restoration practitioners and funders to better understand potential benefits and help guide salmonid and stream recovery.

This study would have been improved by monitoring the individual movement of salmonids before and after the culvert was removed. This would have provided more definitive information on fish passage and the extent to which the Bear Creek culvert was restricting fish movement. However, this type of study would have been more costly and would have required a large number of tagged fish because the motivations of individual fish are unknown, and some fish may not be motivated to move upstream. It would also have been improved if another species, such as coho salmon, was present below the culvert and not above the culvert prior to removal. The high variability of salmonid densities and biomass between years could have concealed a small positive response. Adding more years of sampling before culvert modification and increasing the number of monitoring sites would have improved the influence of the study beyond a case study. Increasing pre-restoration monitoring would have required more advanced knowledge of restoration sites and timing, which proved to be difficult.

During the study, we continued to look for additional barriers to add monitoring sites, but no other good candidates were identified. This is likely due to higher-priority barriers being removed earlier than lower-priority barriers.

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Appendix 1: Washington Department of Natural Resources' Salmonid Validation Monitoring Program for the Olympic Experimental State Forest - 2022 Annual Bull Trout Report.

Washington Department of Natural Resources
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Introduction

The Washington State Department of Natural Resources (DNR) conducted fish sampling throughout the Olympic Experimental State Forest (OESF) in 2022 under Section 10, Endangered Species Act Permit No. TE-64608B-1. Areas within the OESF are protected under Unit 1 of The U.S. Fish and Wildlife Services' Critical Habitat for bull trout (*Salvelinus confluentus*), although the extent of bull trout within the OESF is not well understood. Sampling was conducted under the DNR's salmonid validation monitoring program, described in the 2016 study plan, available at http://dnr.wa.gov/publications/lm_oesf_riparian_monitor_salmonids_2016_plan.pdf. The monitoring program follows the direction of the state's habitat conservation plan (HCP) and is being utilized to determine the conservation strategy of the HCP within the OESF through assessing cause-and-effect relationships between DNR management activities, habitat, and salmonid populations. In addition, a new study assessing the use of current and alternative buffer configurations on DNR Type-3 streams within the OESF was initiated in 2020, adding 16 streams to our sampling schedule (http://depts.washington.edu/sefsonrc/index.php/oesf-t3-experiment/).

Methods

In 2022, sampling was completed in 51 watersheds within the OESF (Fig. 1), including 1 reference site (SF Hoh, see appendix) in Olympic National Park. These sites were located in small, fish-bearing tributaries of the Hoko River, Clallam River, Quillayute River (including the Sol Duc River, Dickey River, and Calawah River), Goodman Creek, Mosquito Creek, Hoh River, and the Queets River (including the Clearwater River; http://dnr.wa.gov/publications/lm_oesf_long_term_monitoring_stations.pdf).

To estimate fish density, we conducted backpack electrofishing over 100 m reaches using multiple-pass removal electrofishing following methods outlined in Martens and Connolly (2014). Sampling took place from mid-July through October. In September, a snorkel survey was conducted in a 12 km section of the upper Clearwater River (Fig. 1)

Results

No bull trout were encountered during the 2022 field season.

Discussion

No bull trout have been encountered from 2015-22 and may not be present in the smaller headwater streams of the OESF. Bull trout are thought to use the larger portions of the Clearwater River but have not been identified in the areas snorkeled from 2016-22. This may be due to low abundances, detection efficiency, or survey timing. In 2023, we plan to resample the 20 annual watersheds, 20 watersheds in the odd-year rotation of watersheds, 32 reaches within the 16 watersheds reaches per watershed of the T3 watershed experiment, and the 12 km section of the upper Clearwater River. A list of the publications from this work can be found in the following section.

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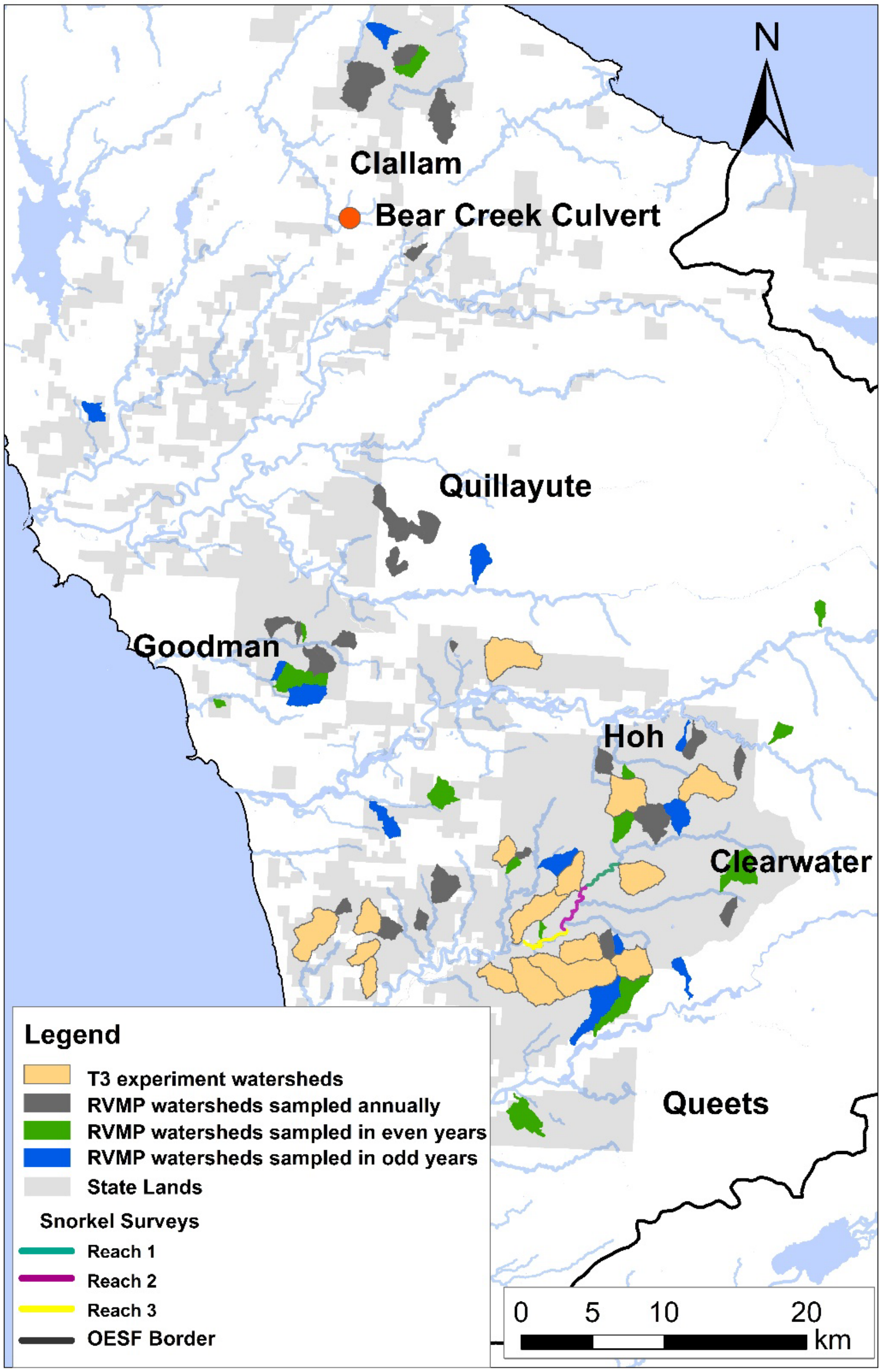

Figure 1. Map of watersheds and sites sampled in the 2022 field season across the Olympic Experimental State Forest.

Appendix Table 1. Watershed locations and fish species encountered during Washington State Department of Natural Resources' fish sampling on the OESF in 2022. COH = coho; CTT = coastal cutthroat; RBT = steelhead or rainbow trout; TRT = unknown juvenile trout species (CTT or RBT); SCP = Sculpin (Cottus species); LMP = juvenile lamprey; and None = no fish were collected at site.

Basin	Latitude	Longitude	Fish Species
157	48.22385192	-124.2948482	CTT, TRT
158	48.223841	-124.29488	CTT, TRT
165	48.21168359	-124.3569823	CTT, RBT, TRT, SCP
196	48.19762618	-124.2741879	COH, CTT, RBT, TRT, SCP
328	48.091938	-124.2994254	COH, CTT, TRT, SCP
488	47.94543555	-124.311738	COH, CTT, TRT, SCP
542	47.84627504	-124.4061643	COH, CTT, TRT, SCP
544	47.8429896	-124.3812407	CTT, TRT, SCP
545	47.844564	-124.376208	COH, CTT, TRT, SCP
567	47.84378017	-124.3631071	COH, CTT
568	47.84201489	-124.3753559	COH, CTT, TRT, SCP, LMP
584	47.815533	-124.402262	COH, CTT, SCP, LMP
605	47.79513	-124.017193	COH, CTT, TRT, SCP
625	47.80673077	-124.0082626	COH, CTT, RBT, TRT, SCP
639	47.79260891	-123.9626384	CTT, RBT, TRT
642	47.78772853	-124.0953962	TRT, SCP
658	47.746714	-124.248597	COH, CTT, TRT, SCP, LMP
690	47.742588	-124.04108	COH, CTT, RBT, TRT
694	47.728741	-124.078429	CTT, TRT
716	47.727889	-123.953892	CTT, RBT, TRT, SCP
717	47.71952839	-124.1531565	COH, CTT, TRT, SCP, LMP
724	47.705386	-124.176911	CTT, TRT
730	47.695933	-124.234346	COH, CTT, TRT, SCP, LMP
744	47.676491	-124.319234	COH, CTT, SCP
750	47.6970612	-123.9609047	CTT, TRT
760	47.672657	-124.252894	COH, CTT, TRT, SCP, LMP
763	47.66614737	-124.2697792	COH, CTT, TRT, SCP
767	47.66427	-124.140339	CTT, TRT
773	47.673263	-124.076269	CTT, TRT
790	47.648024	-124.1871	COH, CTT, SCP, TRT
797	47.604905	-124.087034	COH, CTT, RBT, TRT, SCP
804	47.63644366	-124.1426444	CTT, TRT, SCP
Bear Creek	48.142	-124.326	CTT, TRT, SCP
SF Hoh	47.794138	-123.937157	CTT, TRT
Aa	47.643166	-124.183549	CTT, TRT, CTT
Ac	47.6616	-124.1152667	CTT, RBT, TRT

Ap	47.63793333	-124.1359333	CTT, TRT, SCP
Az	47.64249	-124.122	CTT, TRT, SCP
Ba	47.67301667	-124.1655333	COH, CTT, TRT, SCP
Bc	47.830166	-124.1941	CTT, TRT
Bp	47.714	-124.179	CTT, TRT
Bz	47 41.936	124 06.838	COH, CTT, RBT, TRT, SCP
Ca	47.76421667	-124.0783167	CTT, TRT, SCP
Cc	47.769	-123.312	CTT, TRT
Cp	47.652	-124.0527833	CTT, TRT, SCP
Cz	47.709	-124.059	CTT, TRT
Da	47.64683	-124.31185	COH, CTT, RBT, TRT, SCP
Dc	47.66763	-124.3106333	COH, CTT, TRT, SCP, LMP
Dp	47.64298333	-124.2977833	CTT, TRT, SCP
Dz	47.648249	-124.3575	COH, CTT, TRT, SCP, LMP