Riparian Validation Monitoring Program (RVMP)

2021 Annual Report

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

Washington State
Department of Natural Resources
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Executive Summary

The Riparian Validation Monitoring Program (RVMP) was designed to meet the Washington State Department of Natural Resources' (DNR) commitment to the State Trust Lands Habitat Conservation Plan (HCP). This effort, beginning in 2016, combined with the Status and Trends Monitoring of Riparian and Aquatic Habitat (STRAH) 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 add more complex experimental studies as determined necessary. This flexible approach allows DNR to continually adapt sampling strategies based upon an increasing understanding of management impacts and the conditions of DNR-managed lands. In 2020, RVMP researchers joined the T3 Watershed Experiment to add experimentation. Adding experimentation increases DNR's ability to assess cause-and-effect relationships between DNR land management and salmonid populations under both current riparian management practices and alternative forest management prescriptions. We are currently monitoring juvenile salmonids (juvenile electrofishing and Clearwater River snorkeling), monitoring adult coho salmon spawning (redd surveys in Type-3 streams), assessing both current and alternative riparian stream management around variable-retention harvests (T3 Watershed Experiment), and assessing the removal of a partial fish-barrier culvert (Bear Creek culvert).

In 2021, DNR crews conducted population surveys to estimate juvenile salmonid densities (fish/100 meters) and biomass (grams/100 meters^2) in 34 watersheds from the annual panel (n=17) and the even-year rotating panel (n=17) of 50 watersheds. Thirty additional fish and habitat surveys were conducted in the 16 watersheds of the T3 Watershed Experiment — 20 at the reach and 10 at the pour point (the lowest point in a watershed). Monitoring also continued on the Bear Creek culvert removal (E-1400 Road in the Hoko River Watershed) with a reach sampled both above and below the site of a removed culvert. Finally, adult coho salmon redd surveys were conducted in 21 RVMP watersheds (12 of these sites are sampled annually), and snorkel and habitat surveys were completed in the three monitored reaches over 12 km of the Clearwater River.

Our long-term monitoring is beginning to reveal patterns of juvenile salmonid densities within some RVMP watersheds. We have identified two variations of Type-3 streams within our watersheds (high density and high variability; low density and low variability) which may prove to be informative. The high-density and high-variability watersheds likely have good salmonid habitat and are limited by either fish recruitment or yearly fluctuations in weather. The low-density and low-variability watersheds are likely limited by salmonid habitat deficits. Understanding the differences between these two Type-3 stream variations might lead to a greater understanding of what limits salmonid populations in waterways on DNR-managed lands.

In June 2021, the Pacific Northwest experienced a unique heat wave that resulted in earlier-than-normal high temperatures in many streams. After this event, we found both the highest average density of coho salmon within our annual panel of RVMP watersheds and the lowest density of juvenile coho salmon in the mainstream Clearwater River. It is possible these extreme densities were related. The high temperatures within the Clearwater River were likely to have affected juvenile coho salmon densities through some combination of increased movement into tributaries or other habitats with cooler temperatures and decreased survival.

Since its implementation in 2016, we have published four peer-review journal articles. In addition, a new article assessing the relationships between instream wood and pool formation has recently been accepted for publication. The findings described in these publications and in the 2019 status report helped inform the development of riparian treatments for the T3 Watershed Experiment and continue to improve our knowledge on potential connections between salmonids and DNR management.

Acknowledgements

We would like to thank Jacob Portnoy, Emily Gardner, Molly Hamilton, Michelle Joseph, Lincoln Baxter, Antonia Parrish, Henry Gould, and several University of Washington interns for conducting fieldwork in 2021, Dr. Teodora Minkova of DNR for providing supervising and managerial support, Dr. Warren Devine of DNR for providing data management and field support of the project, Allen Estep of DNR for providing managerial support, Luke Kelly of Trout Unlimited, John Hagan of the Northwest Indian Fisheries Commission, Alex Foster of the USDA Forest Service, and Noelle Nordstrom of DNR for conducting snorkel surveys. All photos in this report were provided by DNR staff.

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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

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Introduction

The Riparian Validation Monitoring Program (RVMP) was designed to meet the Department of Natural Resources' (DNR) commitment for Riparian Validation Monitoring as described 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 capable of supporting viable populations of salmonids and other species dependent on in-stream and riparian environments. Validation monitoring, as described in the HCP, was directed "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). It is the most complex and difficult of the three types of monitoring (implementation, effectiveness, and validation) within the HCP and aims 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, we use an observational approach to monitor 50 Type-3 watersheds, with 20 annually sampled watersheds and 30 watersheds sampled on a two-year rotation, and a 12 km stretch of the Clearwater River contained 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, they will then be developed to evaluate the cause-and-effect relationships between DNR management activities, riparian habitat, and salmonids. Once the underlying mechanisms are understood, DNR could use this information to affirm or adapt management practices.

The Olympic Experimental State Forest (OESF) is a working forest designated by DNR for research and monitoring to better integrate revenue production (primarily through timber harvesting) and ecological values (primarily habitat conservation; WADNR 2016). The HCP designated the OESF as the place for Riparian Validation Monitoring. DNR's Status and Trends Monitoring of Riparian and Aquatic Habitat program (STRAH)[1], which also takes place in the OESF, is a complementary study to the RVMP, studying the same reaches and sharing data to improve efficiency and avoid redundancy. Although the RVMP was primarily designed to meet the department's commitment to the HCP, this program and the STRAH have many other benefits, including its role as the only continuous field-based monitoring and assessment of riparian forests, fish, and stream habitat conditions on DNR-managed lands. This monitoring provides evidence of whether DNR riparian management is working as intended.

[1] 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.

Benefits to DNR from Riparian Validation Monitoring Program:

- Increases knowledge, confidence, and flexibility in DNR land management practices.
- Increases the ecological knowledge on the relationships between salmonid populations, habitat, and land management.
- Provides current information on salmonid population conditions in the OESF that may alleviate the perception that practices on DNR-managed lands are negatively affecting salmonid populations on the Olympic Peninsula (Smith 2000; WRIA 21 Lead entity 2011).
- Supplies information for predictive models of future habitat conditions and impacts on fish under different management alternatives. DNR staff use these models in planning documents such as the OESF Forest Land Plan and Sustainable Harvest Calculation.
- Monitors the potential effects of climate change on salmonid populations or habitat in the Pacific Northwest.
- Fulfills monitoring commitments and furthers the research priorities outlined in the DNR State Trust Lands HCP.
- Establishes stronger relationships with other natural resource agencies, research organizations, academia, and tribal nations.
- Informs DNR stakeholders about the state of natural resources and builds trust.

As recommended in the study plan (Martens 2016), an experimental study was added to the RVMP in 2020 as part of DNR's collaboration with the University of Washington and other research partners on the T3 Watershed Experiment[2]. The riparian component of the study was designed to assess both 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: 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 should ultimately provide the most comprehensive evaluation of DNR's current riparian management as well as information on potential management alternatives.

This report covers activities performed under the RVMP for the 2021 calendar year. More in-depth analyses from this program will come from peer-reviewed journal articles and the six-

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

year (three sampling rotations) status report currently scheduled for 2025[3]. During 2021, DNR crews conducted:

- Population surveys to determine juvenile salmonid densities (fish/meter) and biomass (grams/meter^2) estimates in 34 watersheds from the annual panel (n=17) and the even-year rotating panel (n=17) of the 50 RVMP watersheds;
- 30 fish and habitat surveys at the reach (n=20) and pour point (n=10) 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 21 RVMP watersheds (12 streams 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 silver fir zone (*Abies amabilis*). DNR-managed lands within the OESF mostly consist of second- and third-growth forests resulting from prior timber harvests, with fewer than 10 percent of the forests being older than 140 years (WADNR 2016).

DNR-managed lands in the OESF contain over 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 these smaller streams (Martens 2016).

[3] 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.

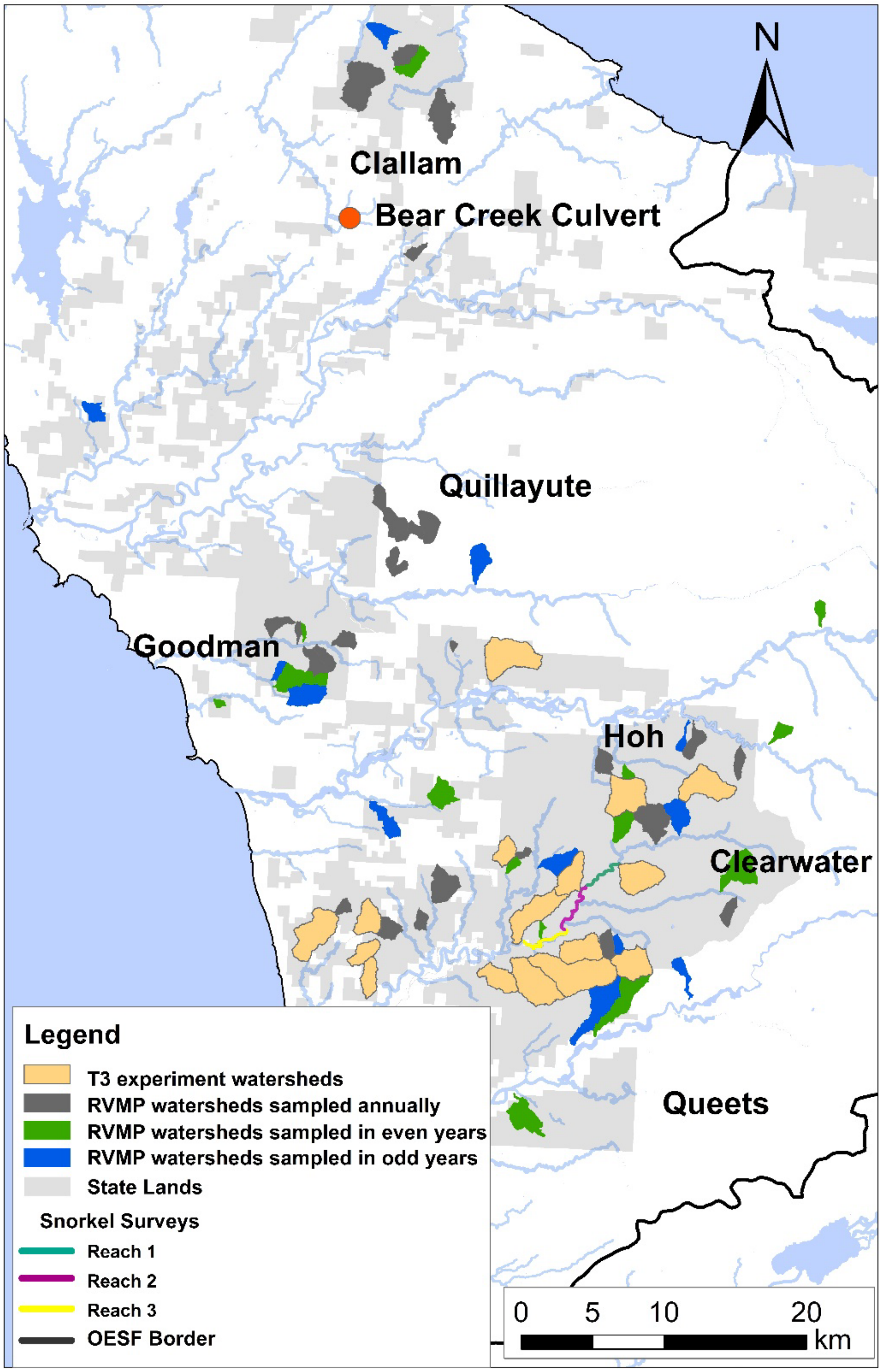

Figure 1. Map of OESF DNR-managed lands and sample watersheds.

Methods

Study Design

We use observational monitoring in 44, Type-3 watersheds[4] on DNR-managed lands (RVMP management watersheds) and six reference watersheds located on DNR-managed lands (n=2) and Olympic National Park (n=4; Figure 1; Martens 2016). Six reference watersheds within the Olympic National Forest that were previously sampled are no longer being sampled due to a lack of resources. Six watersheds were removed from the original 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 crews 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 based on their environmental condition (similar to the 44 managed watersheds), management history (> 95 percent of the watershed area never harvested), and location (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 harvested for VRH. This results in a total of 17 rotating watersheds sampled per year instead of the previously scheduled 15.

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

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[4] 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."

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. In addition, 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 of the sampled reaches 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 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 State Department of Fish and Wildlife (permit # 21-179) 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, additional sampling in the T3 Watershed Experiment watersheds includes stream shade (using hemispherical photos), bankfull width, pebble counts, and stream gradient.

Bear Creek Culvert Removal

During reviews of the 2016 RVMP annual report, a manager from DNR's Olympic Region office requested that we monitor the effectiveness of the region's culvert replacement program. The evaluation of the Bear Creek culvert (E-1400 road in the Hoko River Watershed) removal began in 2017 with the culvert removed after the 2018 sampling period (Figure 3).

Figure 3. Bear Creek culvert prior to removal.

Sampling consists of two years of pre-removal monitoring followed by at least three years of post-removal monitoring following a BACI design. Sampling includes juvenile population estimates (as described above) directly above the culvert (treatment) and directly below the culvert (control). A BACI design improves the ability to detect effects because the correlation between treatment and control sites accounts for a portion of the inter-annual variation (Zimmerman et al. 2012). For a BACI design to be effective, treatments must have sufficient contrast in order to detect changes in fish abundance (Crawford and Rumsey 2011). A more in-depth look into this addition to the program is in Chapter 2 of the 2019 annual report (Howell and Martens 2020).

Redd Surveys in Type-3 Streams

DNR 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). Surveys identify the presence of redds, any adult fish present, and mark locations with GPS (Figure 4). 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 4. 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 (Figure 5). 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 conditions 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 5. Snorkelers counting fish in the Clearwater River.

Results

Sixty-six stream reaches were sampled for juvenile salmon (including the RVMP [n=34] watersheds, T3 Watershed Experiment reaches [n=30] and Bear Creek [n=2]) in 2021. Additionally, 21 RVMP watersheds, including the 12 annual sites, were surveyed for coho salmon redds, and three reaches within the 12 km of the mainstem Clearwater River were snorkeled.

DNR-led crews handled 1,563 coastal cutthroat trout, 1,884 coho salmon, 2,799 juvenile trout (a combination of age-0 coastal cutthroat trout and steelhead/rainbow trout), and 135 steelhead/rainbow trout during juvenile surveys. Sculpin were often found but were not collected. Sculpin lack a swim bladder and are not as easily collected as juvenile salmon, and the HCP only calls for salmonid monitoring. Juvenile lamprey were found in 17 of the 66 watersheds. In addition to the species found in our 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*) 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 like tailed frogs (*Ascaphus sp.*) and Cope's giant salamanders (*Dicamptodon copei*) were often found. However, amphibians were not counted because project emphasis was focused on salmonid fishes.

Figures 6 and 7 show the salmonid density and biomass of fish collected in 2021. Salmonid variability remains high between the watersheds as was found in previous years (Martens 2021). Watershed 796 had the highest density of fish, which was primarily driven by coho salmon. Age-1 or older cutthroat trout, when present in larger numbers (328 and Cp Pour), made up the majority of the biomass within streams.

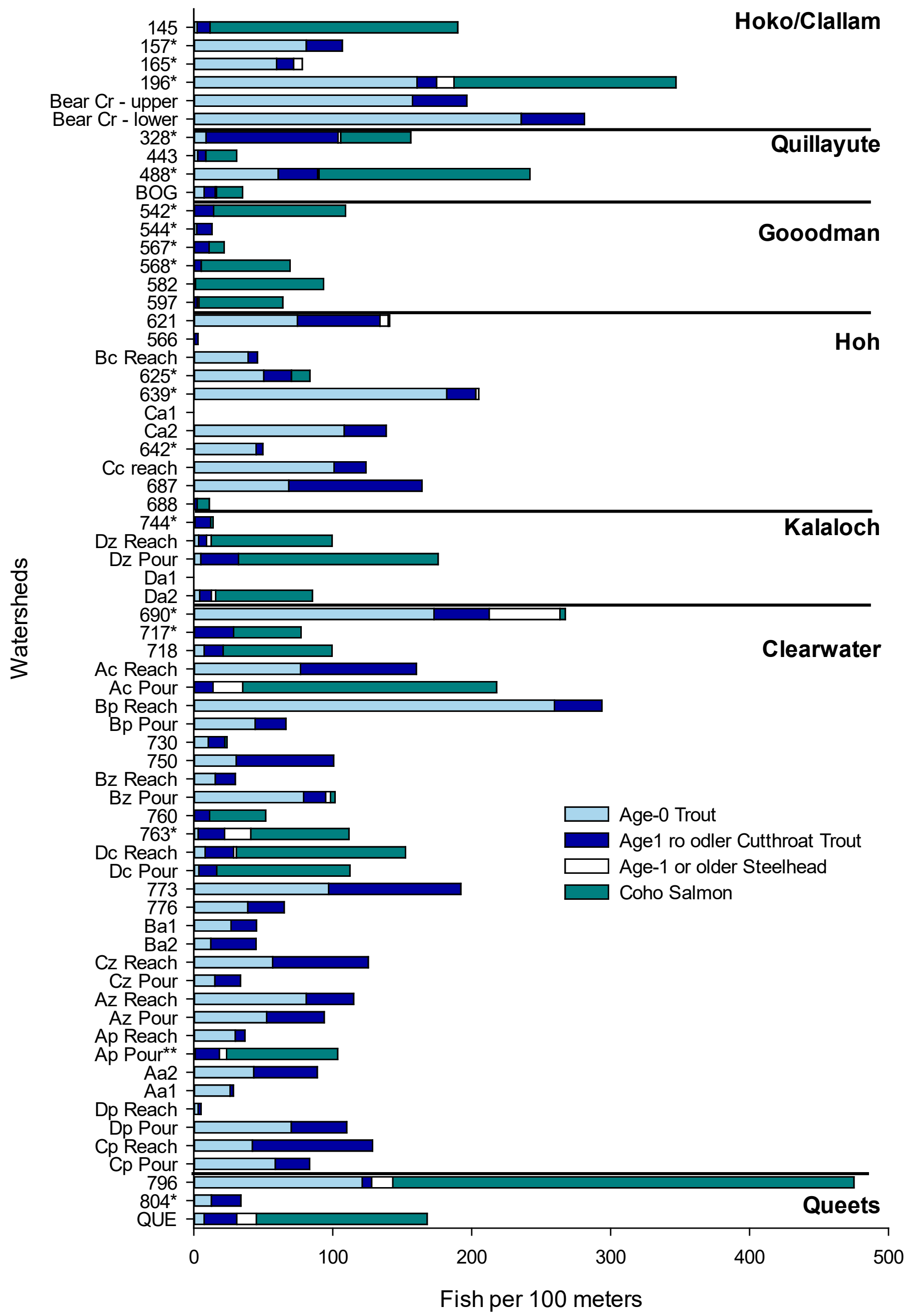

Figure 6. Density of juvenile salmonids (number per 100 meters), separated into larger watershed areas, collected during the summer 2021 field season (mid-July to mid-October) in the Olympic Experimental State Forest (OESF). The RVMP watersheds on DNR-managed lands are labeled with 3-digit number; the RVMP watersheds in Olympic National Park are labeled with three capital letters; the T3 Watershed Experiment reaches are labeled with upper and lower case letters.

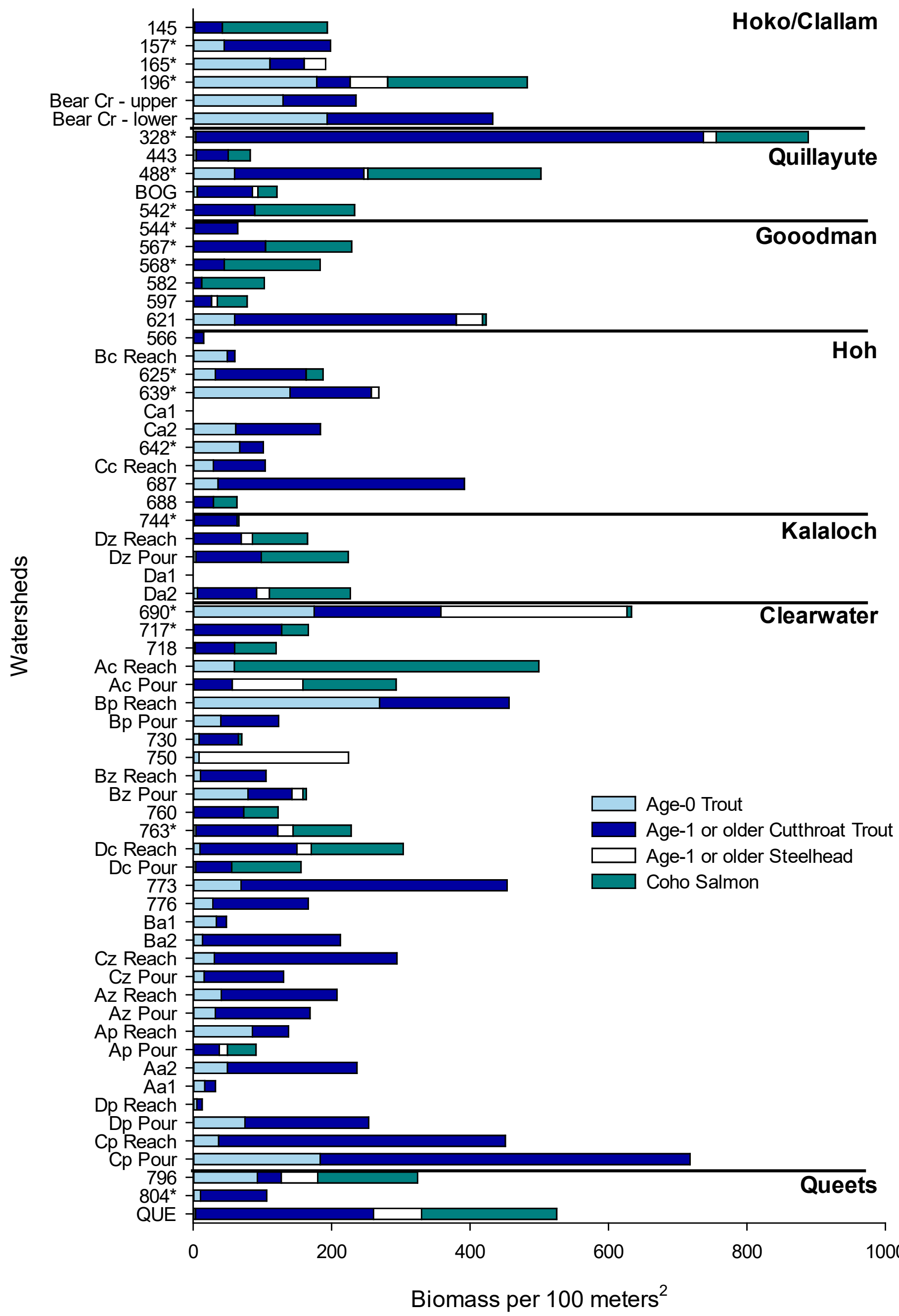

Figure 7. Biomass of juvenile salmonids (grams per 100 meters^2), separated into larger watershed areas, collected during the Riparian Validation Monitoring Program's summer 2021 field season (mid-July to mid-October) in the Olympic Experimental State Forest (OESF). The RVMP watersheds on DNR-managed lands are labeled with 3-digit number; the RVMP watersheds in Olympic National Park are labeled with three capital letters; the T3 Watershed Experiment reaches are labeled with upper and lower case letters.

The average density and biomass of salmonids within annually sampled RVMP management watersheds are shown in Figures 8 and 9. 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 2021, age-0 trout remained relatively high despite a decline from 2020 estimates. Juvenile coho salmon rebounded from the low densities observed in 2020 and had their highest densities recorded since sampling began in 2016. Age-1 or older cutthroat trout and rainbow trout/steelhead densities have shown the least amount of variability between years, however age-1 or older cutthroat trout densities have doubled since sampling began. Fish biomass was at the highest level we have recorded in 2021, which was primarily driven by an increase in age-1 or older cutthroat trout.

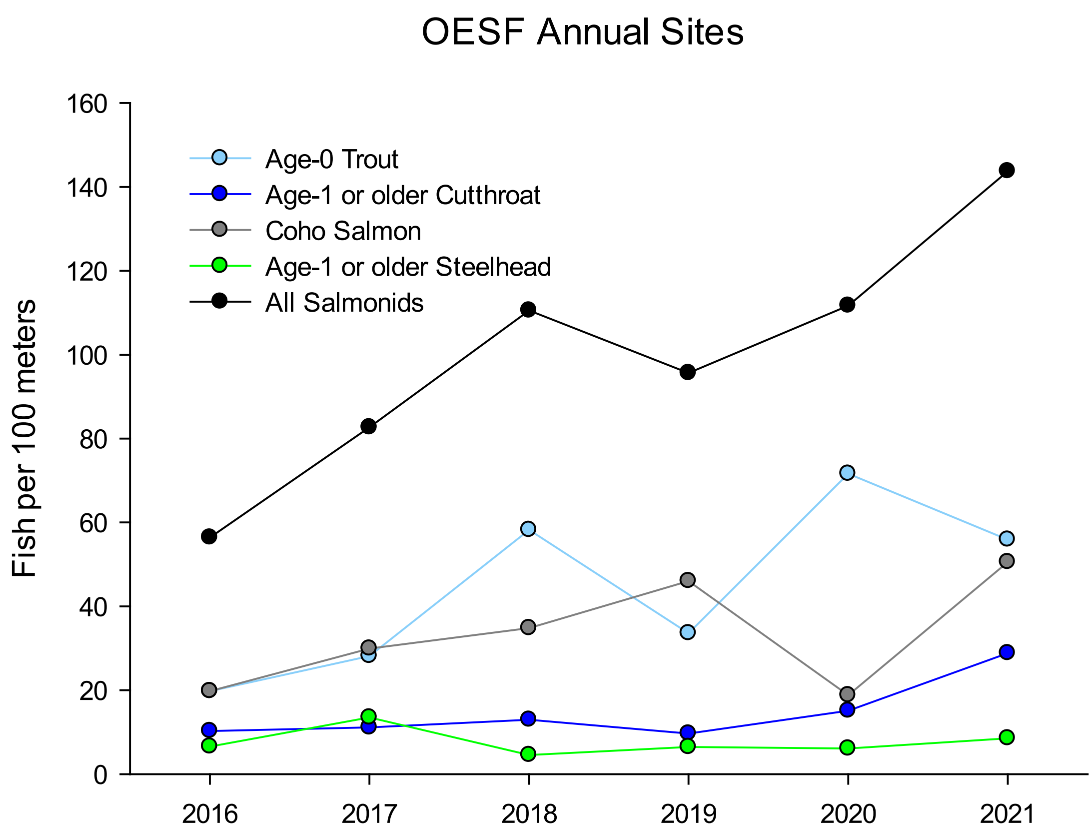

Figure 8. The average fish density (number per 100 meters) of juvenile salmonids collected from the 20 annual sampled sites during the Riparian Validation Monitoring Program's summer 2021 field season (mid-July to mid-October) in the Olympic Experimental State Forest (OESF).

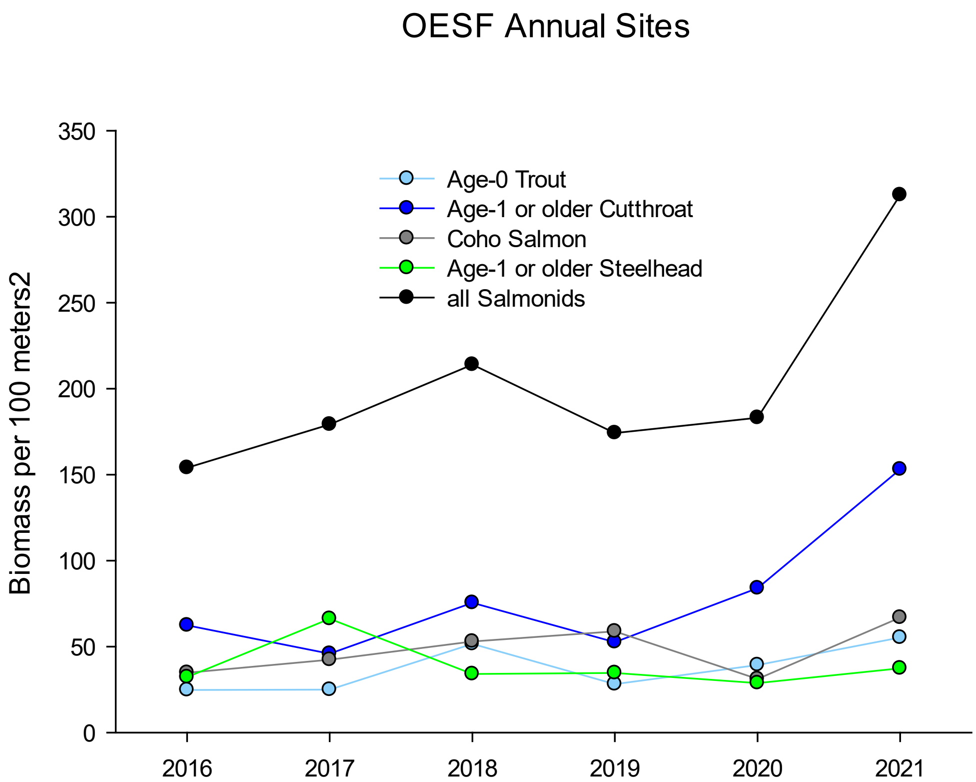

Figure 9. The average fish biomass (grams per 100 meters^2) of juvenile salmonids collected from 20 annual sampled sites during the Riparian Validation Monitoring Program's summer 2021 field season (mid-July to mid-October) in the Olympic Experimental State Forest (OESF).

Repeated samples of all of the RVMP watersheds are starting to reveal patterns among the watersheds (Figure 10). Some streams such as 196, 690, and 796 have consistently contained high densities of salmonids with high inter-annual variability. Another set of streams (544, 545, 550, 566, 567, 584, 605, 658, 724, 730, 744, 797, 804, 844, BOG, HOH,) have maintained low densities of salmonids with low inter-annual variability.

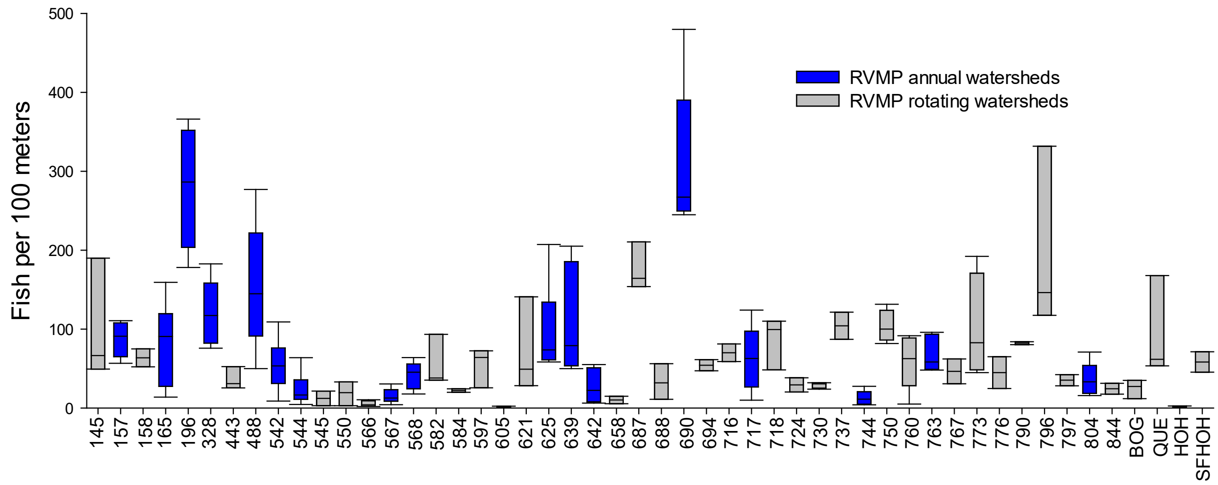

Figure 10. The fish density (number per 100 meters) of all juvenile salmonids sampled at sites from 2016 through 2021 (annually sampled watersheds were typically sampled for 6 years while rotating watersheds were sampled between 2-3 years) in the Olympic Experimental State Forest (OESF). The line in the bars represent the median, the boxes outline the 25th and 75th percentile and the bars represent the 10th and 90th percentile.

Bear Creek Culvert Removal Monitoring

Fish densities from 2017-21 above and below the former culvert site in Bear Creek are shown in Figure 11. There has been no obvious change in age-1 or older cutthroat trout since removal of the culvert, but the number of age-0 cutthroat trout both above and below the culvert has increased since removal. However, this increase in age-0 trout has followed a similar trend that is found in our annual panel of watersheds.

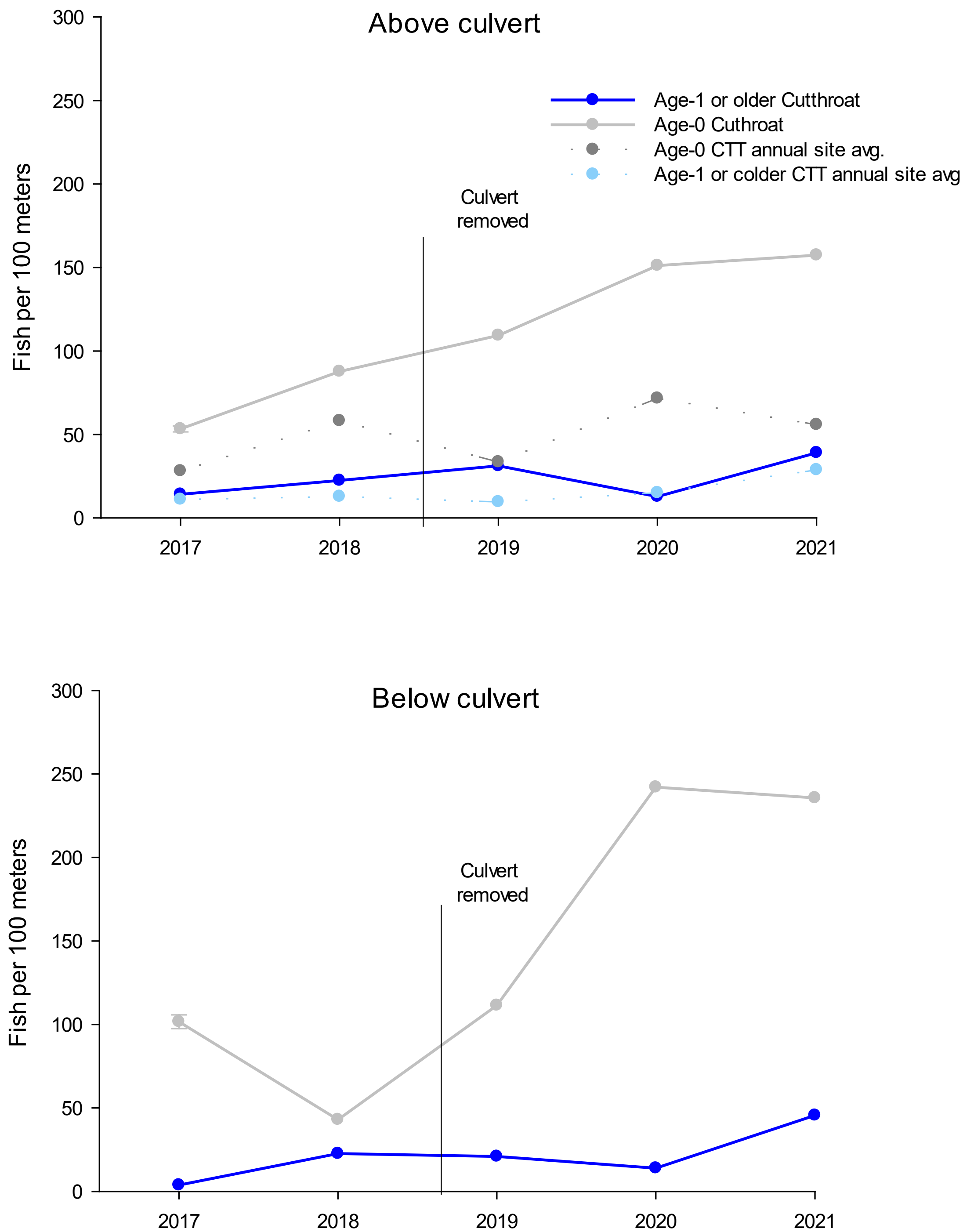

Figure 11. Fish density (number of fish per 100 meters of stream reach) above and below Bear Creek before (2017-18) and after (2019-21) a culvert removal. The dashed lines in the upper graph show the fish densities from the annual panel of watersheds from the Riparian Validation Monitoring Program.

Redd Surveys in Type-3 Streams

Annual numbers of coho salmon redds are in Figure 12. Redd surveys were conducted in 12 annually sampled streams from 2016 through 2021. Watershed 328 continues to have the highest number of redds and had a record number of 56 redds in 2021. Overall, many of these streams have consistently had a limited number (<5) or no redds.

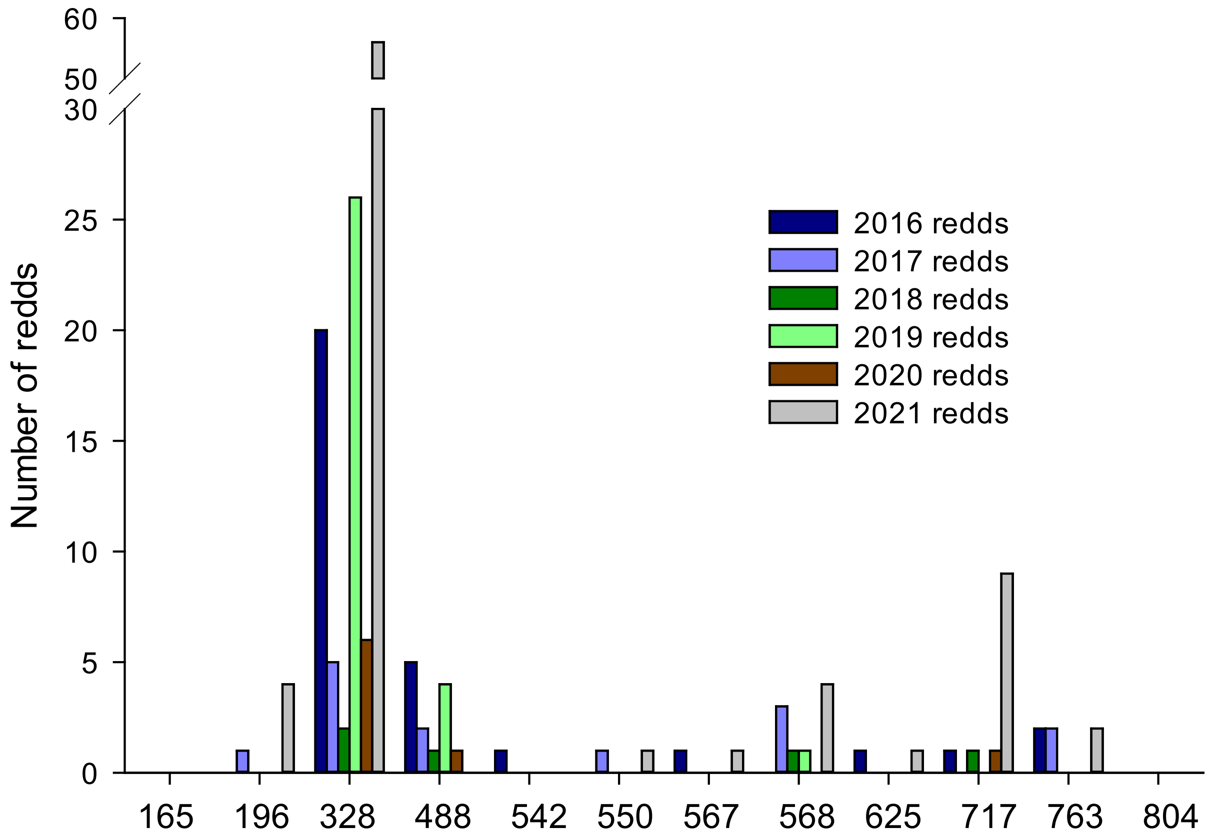

Figure 12. Coho salmon redd surveys conducted in the annual panel of watersheds from 2016 through 2021.

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 13). In 2021, we found low levels of juvenile trout and coho salmon, while mountain whitefish numbers were either at similar or slightly elevated levels. Juvenile coho salmon numbers were at the lowest levels since sampling began in 2016 (Figure 14). The low density of coho salmon was especially troubling when considering the timing of the surveys – before the rains when the water visibility is high and the fish are easier to count. In the other two years with lower densities (2018 and 2020), the surveys were conducted after rain events when higher water and turbidity (decreased clarity) most likely led to a lower detection probability and underestimated coho salmon densities. Additionally, most of the coho salmon observed in Reach 3 appeared trapped as they were found in backwater habitat units that were either fully or partially disconnected from mainstem flows.

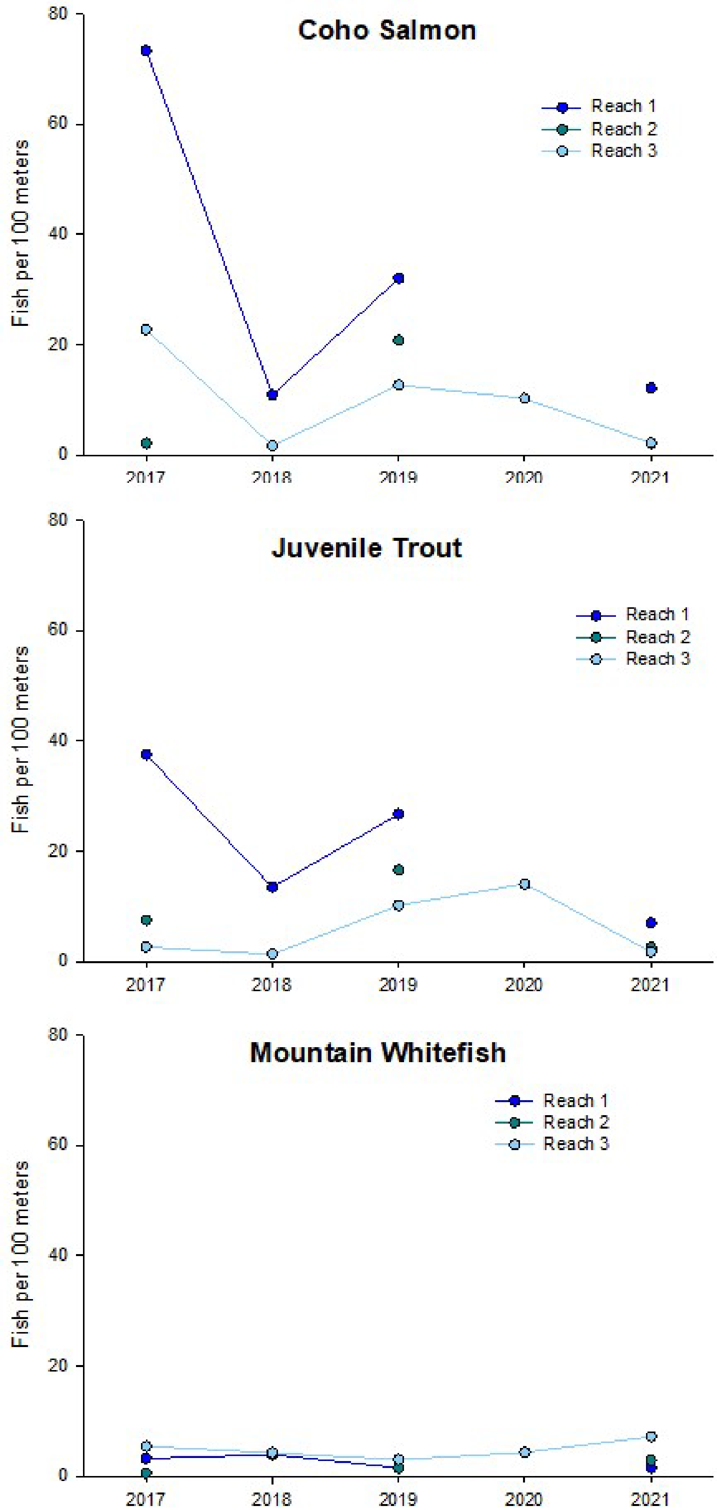

Figure 13. Annual densities of coho salmon, juvenile trout (rainbow trout/steelhead or coastal cutthroat trout), and mountain whitefish density in the Clearwater River snorkel surveys.

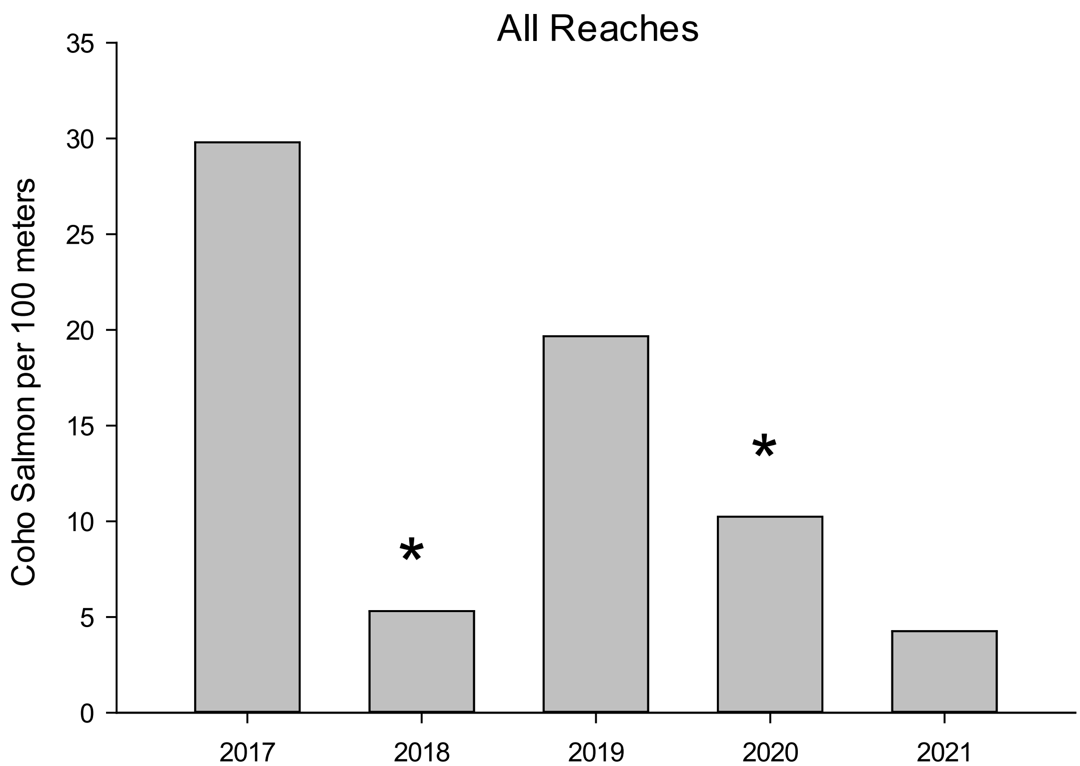

*Figure 14. Annual densities (fish per 100 meters) of juvenile coho salmon across all three monitored reaches of the Clearwater River. * These snorkel surveys did not include all reaches and were conducted after rains when the water had higher turbidity (reduced water clarity). Surveys with reduced water clarity tend to have lower detection probability, which would likely result in an underestimation of fish densities.*

Discussion

Riparian Validation Monitoring

RVMP crews began sampling in 2016 and we are still in the early stages of monitoring. As monitoring continues, we are better able to distinguish changes in salmonid populations across time and space. Detecting trends and patterns is made more difficult by the expected slow rate of long-term habitat restoration after the intensive and extensive harvests that preceded the 1997 HCP.

Modern forest management practices, most notably the use of riparian buffers left to protect against the negative impacts from forest harvests, were developed to minimize the effects of forest harvest on streams and salmonids, and recovery from some of the impacts of historic logging practices are likely to take place over hundreds of years (Martens et al. 2020). This means that any habitat and corresponding changes to salmonids are likely to be small. This anticipated small change can be even tougher to detect given the high amounts of variability between watersheds and years. The exact amount of time required to detect a change (if present) will be dependent on the combination of the amount of change in salmonid populations or habitat resulting from DNR management activities, the amount of year-to-year variation, and the amount of differences between the sites (Martens 2016). As a result, it was anticipated and supported by literature that many years of monitoring a relatively high number of sites would be required to separate both the spatial and temporal variation from any potential impacts of DNR management on salmonid populations (Kershner et al. 2004; Liermann and Roni 2008).

As we begin to look at the inter-annual variability in fish densities, patterns within the RVMP watersheds are beginning to emerge. Two types of streams within the OESF can now be identified. The first type maintains high salmonid densities with a high amount of variability, and the second type can be characterized by low densities with low variability.

The high-density/high variability streams appear to have the stream capacity to maintain higher densities of salmonid populations in most years and in years when densities are not at their peaks salmonid densities are likely limited by factors such yearly weather fluctuations or lack of fish recruitment. These streams are likely to have some of the highest quality habitat. The low-density/low-variability watersheds are likely habitat-limited.

Both these types of streams present opportunities to understand fish populations on the OESF. The high-density/high-variability streams can be evaluated to better understand what habitat features (which could simply be stream size) are important for salmonids. The low-density/low-variability streams can provide insights on which streams are either naturally limiting fish populations or may have been limited by anthropogenic influences.

Bear Creek Culvert Removal

To date, the Bear Creek culvert (E-1400 road in the Hoko River watershed) removal has produced mixed results. We detected no obvious changes in age-1 or older cutthroat trout densities after culvert removal. However, there have been increases in age-0 cutthroat trout densities in the reaches below and above the removed culvert. Because we are seeing this increase in both above and below the former culvert, we cannot say that this change is a result of the culvert removal. In fact, we see that the annually sampled RVMP management watersheds have shown similar increases in fish density. A more in-depth analysis of this data is needed before we make any final conclusions. The culvert was sampled again in 2022, which will likely be the final year of sampling under this project.

Environmental Factors and Fish Movement

The spring of 2021 experienced a unique heat wave from June 26 through July 2 that resulted in heat records of 43°C air temperature at the Quillayute Airport and 48°C at the Sol Duc weather station. This heat wave had potential to affect stream temperatures and fish populations. During this time, we saw an increase in stream temperatures within the RVMP watersheds (an average of 4.5° C maximum temperature increase at the peak of the heat wave; DNR unpublished data). It would be anticipated that a similar if not larger increase would occur in the mainstem Clearwater River, where stream temperatures can be several degree higher than tributary temperatures (up to 7° C; Isaak et al. 2017). Analyses from stream temperature monitoring within the STRAH found that most of our monitored Type-3 tributary streams recorded their highest temperatures of the summer during the heat wave, with the warmest streams having instantaneous point readings over 19° C and the average daily maximum of all streams below 17° C (DNR unpublished data).

If a similar increase in stream temperatures occurred in the mainstream Clearwater River, this may have increased stream temperatures to levels that were difficult for juvenile coho salmon. The lethality levels for juvenile coho salmon have been estimated at around 25° C (Carter 2005). However, juvenile coho salmon distributions have been found to change at temperatures lower than the lethal levels (Welsh et al. 2001; Madej et al 2006). One study in California found juvenile coho salmon were absent in streams where the maximum weekly maximum temperature was over 18° C (Welsh et al. 2001).

After the 2021 heat wave event, we saw both our highest average density of coho salmon in our annual tributary sites and our lowest density of coho salmon in the mainstream Clearwater River. This raises questions on whether these conditions are coincidental or if there is some link. Given the likelihood of high stream temperatures in the Clearwater River, the heat wave may have created some combination of fish movement into smaller tributaries or other suitable habitats and increased mortality. We had previously hypothesized that there is movement of juvenile coho salmon into our Type-3 streams based on our low counts of coho salmon redds and consistent levels of juvenile coho salmon (including streams without redds; Martens 2022).

Overall, the low density of juvenile coho salmon in the mainstem Clearwater River in 2021 is concerning; however, the higher density of juvenile coho salmon in the smaller Type-3 streams provides some hope that juvenile coho salmon may have moved rather than perished. Unfortunately, without tracking data of individuals, we do not know the fate of the juvenile coho salmon that typically have been found in the mainstem Clearwater River. It is also unknown whether it is better for overall juvenile coho salmon survival to rear in the mainstem or in tributaries waters.

Products and Publications

As data from the RVMP continues to accumulate, we are constantly learning more about the status of salmonids and habitat across the OESF. This work has led to an ever-increasing number of publications. This includes a new paper looking at the relationship between instream wood and pools within the RVMP management watersheds and T3 Watershed Experiment watersheds that has recently been accepted for publication.

Publications in peer-reviewed journals from data collected under the RVMP 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

Popular science publications, presentations, field tours, and other outreach activities have been ongoing.

RVMP Future Directions

With the addition of four T3 Watershed Experiment watersheds using current DNR practices and several RVMP management watersheds with either completed VRH (watersheds 488, 544, 568, 625, 642, 730, and 760) or scheduled for VRH over the next few years (watersheds 157, 545, and 642), the OESF is set up for a large, future BACI study that can directly assess the impacts of DNR's riparian conservation strategy (WADNR 1997) on stream habitat and salmonids. These 12 monitored VRH watersheds (watershed 545 is not sampled annually) can 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.

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

References

Carter, K. 2005. The effects of temperature on steelhead trout, coho salmon, and Chinook salmon biology and function by life stage. California regional water quality control board.

Connolly, P. J. 1996. Resident cutthroat trout in the central coast range of Oregon: logging effects, habitat associations, and sampling protocols. Doctoral Dissertation. Oregon State University. Corvallis, Oregon.

Cooch, E. and G. White. 2012. A gentle introduction to Program Mark. Colorado State University, Fort Collins.

Crawford, B. A., and S. M. Rumsey. 2011. Guidance for monitoring recovery of Pacific Northwest salmon and steelhead listed under the Federal Endangered Species Act. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Region, Portland, Oregon.

Franklin, J. F. and C. T. Dyrness. 1988. Natural vegetation of Oregon and Washington. Corvallis, OR: Oregon State University Press.

Gallagher, S. P., P. K. Hahn, and D. H. Johnson. 2007. Redd counts. *In* Johnson, D. H., B. M. Shrier, J. S. O'Neil, J. A. Knutzen, X. Augerot, T. A. O'Neil, and T. N. Pearsons. Salmonid field protocols handbook: Techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland.

Howell, A., and Martens, K. D. 2020. Chapter 2: Bear creek culvert removal. Washington State Department of Natural Resources, Forest Resources Division, Olympia, WA.

Isaak, D., S. Wenger, E. Peterson, J. Ver Hoef, D. Nagel, C. Luce, S. Hostetler, J. Dunham, B. Roper, S. Wollrab, G. Chandler, D. Horan, and S. Parkes-Payne. 2017. The NorWeST summer stream temperature model and scenarios for the western U.S.: A crowd-sourced database and new geospatial tools foster a user community and predict broad climate warming of rivers and streams. Water Resources Research 53: 9181-9205.

Kershner, J. L., M. Coles-Ritchie, E. Cowley, R. C. Henderson, K. Kratz, C. Quimby,, D. M. Turner, L. C. Ulmer, and M. R. Vinson. 2004. A Plan to monitor the aquatic and riparian resources in the area of PACFISH/INFISH and the Biological Opinions for bull trout, salmon, and steelhead. Gen. Tech. Rep. RMRS-GTR-121. US Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT.

Liermann, M. and P. Roni., 2008. More sites or more years? Optimal study design for monitoring fish response to watershed restoration. North American Journal of Fisheries Management 28(3):935-943.

Madej, M. A., C. Currens, V. Ozaki, J. Yee, and D. G. Anderson. 2006. Assessing possible thermal rearing restrictions for juvenile coho salmon (Oncorhynchus kisutch) through thermal infrared imaging and in-stream monitoring, Redwood Creek, California. Canadian Journal of Fisheries and Aquatic Sciences 63(6):1384-1396.

Martens, K. D., and P. J. Connolly. 2014. Juvenile anadromous salmonid production in upper Columbia River side channels with different levels of hydrological connection. Transactions of the American Fisheries Society 143(3):757-767.

Martens, K. D. 2016. Washington State Department of Natural Resources' Riparian Validation Monitoring Program for salmonids on the Olympic Experimental State Forest - Study Plan. Washington State Department of Natural Resources, Forest Resources Division, Olympia, WA.

Martens, K. D. 2018. Washington State Department of Natural Resources' Riparian Validation Monitoring Program (RVMP) for salmonids on the Olympic Experimental State Forest – 2017 Annual Report. Washington State Department of Natural Resources, Forest Resources Division, Olympia, WA.

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 doi.org/10.1007/s00267-019-01146-x

Martens, K. D. 2019. Assessment of the causal linkages between forests and fish: implications for management and monitoring on the Olympic Experimental State Forest – The 2016-2018 Riparian Validation Monitoring Program Status Report. Washington State Department of Natural Resources, Forest Resources Division, Olympia, WA.

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. doi.org/10.1139/er-2020-0035

Martens, K. D. 2021. Riparian Validation Monitoring Program (RVMP) 2020 Annual Report. Washington State Department of Natural Resources, Forest Resources Division, Olympia, WA.

Martens, K. D. 2022. Riparian Validation Monitoring Program (RVMP) 2020 Annual Report. Washington State Department of Natural Resources, Forest Resources Division, Olympia, WA.

Minkova T., J. Ricklefs, S. Horton, and R. Bigley. 2012. Riparian Status and Trends Monitoring for the Olympic Experimental State Forest. Draft Study Plan. DNR Forest Resources Division, Olympia, WA.

Minkova, T. and M. Vorwerk. 2015. Field Guide for identifying stream channel types and habitat units in Western Washington. Washington Department of Natural Resources, Olympia WA.

Pacific Fishery Management Council (PFMC). 2018. Salmon rebuilding plan for Queets River natural coho. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384.

Smith, C. J. 2000. Salmon and steelhead habitat limiting factors in the north Washington coastal streams of WRIA 20. Washington State Conservation Commission, Lacy, Washington.

Strahler, A. N. 1957. Quantitative analysis of watershed geomorphology. Eos, Transactions of the American Geophysical Union 38(6):913-920.

Thurow, R. F. 1994. Underwater methods for study of salmonids in the intermountain west. General Technical Report (INT-GTR-307). U. S. Department of Agriculture, Forest Service, Intermountain Research Station.

Washington State Department of Natural Resources (WADNR), 1997. Final habitat conservation plan: Washington State Department of Natural Resources, Olympia, Washington.

Washington State Department of Natural Resources (WADNR), 2013. Olympic Experimental State Forest HCP planning unit forest land plan revised draft Environmental Impact Statement. Olympia, Washington.

Washington State Department of Natural Resources (WADNR), 2016. Olympic Experimental State Forest HCP Planning Unit Forest Land Plan: Washington State Department of Natural Resources, Olympia, Washington.

Washington State Department of Natural Resources (WADNR), 2019. FINAL Environmental Impact Statement on alternatives for the establishment of a sustainable harvest level for forested state trust lands in western Washington. Washington State Department of Natural Resources, Olympia, Washington.

Welsh Jr, H. H., G. R. Hodgson, B. C. Harvey, and M. F. Roche. 2001. Distribution of juvenile coho salmon in relation to water temperatures in tributaries of the Mattole River, California. North American Journal of Fisheries Management 21(3):464-470.

WRIA 21 Lead Entity. 2011. WRIA 21 Queets/Quinault Salmon Habitat Recovery Strategy. http://www.onrc.washington.edu/MarinePrograms/NaturalResourceCommittees/QuinaultIndianNationLeadEntity/QINLE/OrganizingDocs/WRIA21SalmonHabRestorStrategyJune2011EditionFINAL.pdf

Zimmerman, M., K. Krueger, B. Ehinger, P. Roni, B. Bilby, J. Walters, and T. Quinn. 2012. Intensively Monitored Watersheds Program: an updated plan to monitor fish and habitat responses to restoration actions in the lower Columbia watersheds. Washington Department of Fish and Wildlife, Fish Program, Science Division. Available online at http://wdfw.wa.gov/publications/01398/wdfw01398.

Appendix 1. USFWS 2021 Annual Bull Trout Permit Report

Washington Department of Natural Resources' Salmonid Validation Monitoring Program for the Olympic Experimental State Forest - 2021 Annual Report.

Washington Department of Natural Resources
Kyle D. Martens, Fish Biologist
Olympia, WA.

Introduction

Washington Department of Natural Resources (DNR) conducted fish sampling across the Olympic Experimental State Forest (OESF) in 2021 under Section 10, Endangered Species Act Permit No. TE-64608B-1. The OESF contains areas that are protected in Unit 1 of U.S. Fish and Wildlife Services' Critical Habitat for bull trout (*Salvelinus confluentus*), though the exact extent of bull trout across the OESF is largely unknown. Fish sampling was conducted under DNR's salmonid validation monitoring program. The salmonid validation monitoring program is described in the 2016 study plan (http://file.dnr.wa.gov/publications/lm_oesf_riparian_monitor_salmonids_2016_plan.pdf) and follows the guidance from the state's Habitat Conservation Plan (HCP). The validation monitoring program will be used to assess the HCP's riparian conservation strategy in the OESF by assessing cause and effect relationships between DNR management activities, habitat, and salmonid populations. In 2020 a new study was in initiated to assess the use of current and alternative buffer configurations on streams. This study added 16 new streams to the existing sampling design (http://depts.washington.edu/sefsonrc/index.php/oesf-t3-experiment/).

Methods

In 2021, sampling was completed 51 in smaller headwater watersheds of the OESF (Figure 1), which included 2 reference sites on the Olympic National Park. The watersheds 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://file.dnr.wa.gov/publications/lm_oesf_long_term_monitoring_stations.pdf).

Backpack electrofishing was conducted to estimate fish densities at the reach level using multiple-pass removal electrofishing**.** Multiple-pass removal closely followed the methods of Martens and Connolly (2014) with all sampling occurring from mid-July through October. In addition, a snorkel survey was conducted over a 12 km section of the upper Clearwater River in September (Figure 1).

Results

During the 2021 field season, no bull trout were encountered.

Discussion

No bull trout have not been encountered from 2015-2021, 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 2016-2021. This may be due to low abundance, detection efficiency, or timing of our surveys. In 2022, we plan to resample the 20 annual watersheds, 20 watersheds in the even-year rotation of watersheds, 16 watersheds with 20 reach and 12 pour point locations in the T3 watershed experiment, and the 12 km section of the upper Clearwater River.

References

Martens, K.D. and Connolly, P.J., 2014. Juvenile anadromous salmonid production in Upper Columbia River side channels with different levels of hydrological connection. *Transactions of the American Fisheries Society*, 143(3), pp.757-767.

Martens, K. D. 2016. Washington State Department of Natural Resources' Riparian Validation Monitoring Program for salmonids on the Olympic Experimental State Forest - Study Plan. Washington State Department of Natural Resources, Forest Resources Division, Olympia, WA. https://www.dnr.wa.gov/publications/lm_oesf_riparian_monitor_salmonids_2016_plan.pdf

Martens, K. D. 2017. Washington State Department of Natural Resources' Riparian Validation Monitoring Program for salmonids on the Olympic Experimental State Forest – 2016 Annual Report. Washington State Department of Natural Resources, Forest Resources Division, Olympia, WA. https://www.dnr.wa.gov/publications/lm_oesf_rvmp_2016_annual_report.pdf

Martens, K. D. 2018. Washington State Department of Natural Resources' Riparian Validation Monitoring Program (RVMP) for salmonids on the Olympic Experimental State Forest – 2017 Annual Report. Washington State Department of Natural Resources, Forest Resources Division, Olympia, WA. https://www.dnr.wa.gov/publications/lm_oesf_rvmp_2017_annual_report.pdf

Martens, K. D. 2019. Assessment of the causal linkages between forests and fish: implications for management and monitoring on the Olympic Experimental State Forest – The 2016-2018 Riparian Validation Monitoring Program Status Report. Washington State Department of Natural Resources, Forest Resources Division, Olympia, WA. https://www.dnr.wa.gov/publications/lm_oesf_rvmp_2018_annual_report.pdf

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

Martens, K.D., Donato, D.C., Halofsky, J.S., Devine, W.D. and Minkova, T.V., 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), pp.517-527.

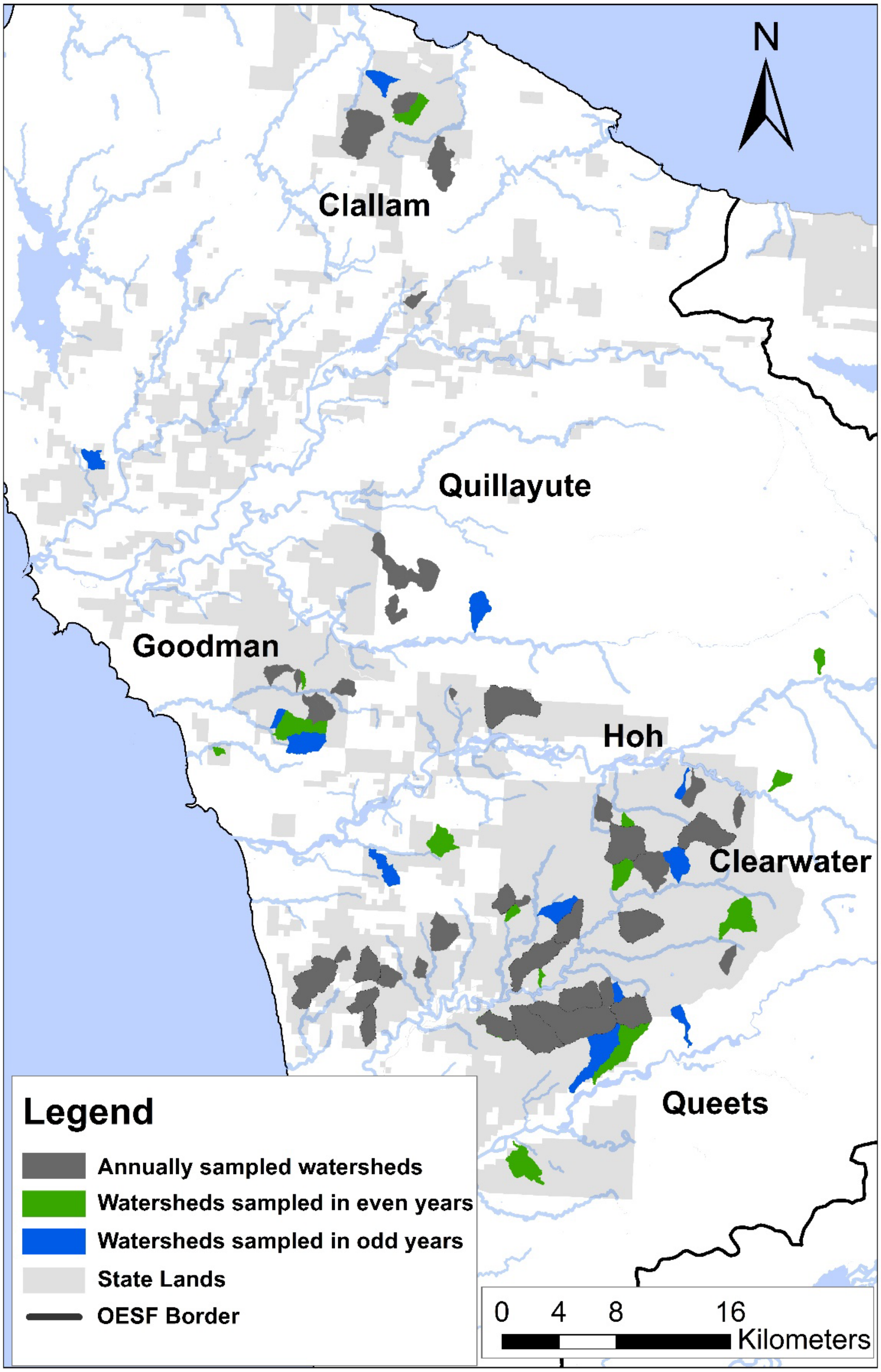

Figure 1. Map of snorkeling sites sampled in the 2021 field season across the Olympic Experimental State Forest.

Appendix Table 1. Watershed locations and fish species encountered during Washington Department of Natural Resources' fish sampling on the OESF in 2021. 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; UNK = DNR did not sample; and None = no fish were collected at site.

Basin	Latitude	Longitude	Fish Species
145	48.230597	-124.330753	COH, CTT, RBT, TRT, SCP
157	48.22385192	-124.2948482	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, RBT, TRT, SCP
443	47.982793	-124.583603	COH, CTT, TRT, LMP, SCP
488	47.94543555	-124.311738	COH, CTT, RBT, TRT, LMP, SCP
542	47.84627504	-124.4061643	COH, CTT, SCP
544	47.8429896	-124.3812407	COH, CTT, SCP
566	47.846652	-124.233881	CTT, TRT, SCP, LMP
567	47.84378017	-124.3631071	COH, CTT, TRT, LMP, SCP
568	47.84201489	-124.3753559	COH, CTT, TRT, LMP, SCP
582	47.825944	-124.397975	COH, CTT, LMP, SCP
597	47.811372	-124.370912	COH, CTT, RBT, TRT, LMP, SCP
621	47.79513	-124.017193	COH, CTT, RBT, TRT
625	47.80673077	-124.0082626	COH, CTT, RBT, TRT, SCP
639	47.79260891	-123.9626384	CTT, RBT, TRT
642	47.78772853	-124.0953962	CTT, TRT, LMP, SCP
687	47.747204	-124.01884	CTT, RBT, TRT
688	47.735903	-124.290812	CTT, COH, SCP
690	47.742588	-124.04108	COH, CTT, RBT, TRT
717	47.71952839	-124.1531565	COH, CTT, TRT, SCP
718	47.713129	-124.125936	COH, CTT, TRT, LMP, SCP
730	47.695933	-124.234346	COH, CTT, RBT, TRT, LMP, SCP
744	47.676491	-124.319234	COH, CTT, TRT, LMP, SCP
750	47.6970612	-123.9609047	CTT, TRT
760	47.672657	-124.252894	COH, CTT, TRT, LMP, SCP
763	47.66614737	-124.2697792	COH, CTT, RBT, TRT, SCP
773	47.673263	-124.076269	CTT, TRT
776	47.6638	-124.068889	CTT, TRT
796	47.62141	-124.086913	COH, CTT, RBT, TRT, LMP, SCP
804	47.63644366	-124.1426444	COH, CTT, TRT, SCP
Bear Creek	48.142	-124.326	CTT, TRT, SCP
Bogachiel	47.901242	-124.214975	COH, CTT, RBT, TRT, SCP

Queets	47.643235	-124.004597	COH, CTT, RBT, TRT, SCP
Aa	47.643166	-124.183549	CTT, TRT, SCP
Ac	47.6616	-124.1152667	CTT, RBT, TRT, SCP
Ap	47.63793333	-124.1359333	COH, CTT, RBT, TRT, LMP, SCP
Az	47.64249	-124.122	CTT, TRT, SCP
Ba	47.67301667	-124.1655333	COH, CTT, TRT, SCP
Bc	47.830166	-124.1941	COH, CTT, RBT, TRT, SCP
Bp	47.714	-124.179	CTT, TRT, SCP
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, RBT, TRT, SCP
Cz	47.709	-124.059	COH, CTT, RBT, TRT, SCP
Da	47.64683	-124.31185	COH, CTT, RBT, TRT, LMP, SCP
Dc	47.66763	-124.3106333	COH, CTT, RBT, TRT, LMP, SCP
Dp	47.64298333	-124.2977833	CTT, RBT, TRT, SCP
Dz	47.648249	-124.3575	COH, CTT, RBT, TRT, LMP, SCP