KALISPEL NON-NATIVE FISH SUPPRESSION PROJECT
2020 Annual Report

Project Number 2007-149-00

Report covers work performed under BPA contract # 74488 REL30
Report was completed under BPA contract # 74488 REL30

May 2020 - April 2021

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April 2021

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

This report should be cited as follows:

Shane Harvey, Nick Bean, Kalispel Non-Native Fish Suppression Project, May 2020-April 2021 Annual Report, Bonneville Power Administration Project Number 2007-149-00, BPA Contract No. 74488 Rel 30. 72 Electronic Pages.

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Executive Summary

Non-native fish species are impacting ecologically and culturally significant native fish populations throughout the Pend Oreille Subbasin. Competition, hybridization, and predation by non-native fish have been identified as primary factors in the decline of native Bull Trout *Salvelinus confluentus* and Cutthroat Trout *Oncorhynchus clarkii* populations. Therefore, the goal of this project is to implement actions to suppress or eradicate non-native fish in areas where native populations are declining or have been extirpated and then reintroduce native fish species. These actions have been identified as critical to recovering native Bull Trout and Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* in the Pend Oreille Basin.

The Kalispel Natural Resources Department (KNRD) resumed mechanical removal of Brook Trout *Salvelinus fontinalis* in Saucon Creek in 2014. Saucon Creek is a tributary to West Branch LeClerc Creek in the LeClerc Creek Subbasin, located in central Pend Oreille County, WA. In 2020, a total of 52 adult Brook Trout were removed from 2,100 m of stream, while 605 Westslope Cutthroat Trout were returned to Saucon Creek. Biological data was collected on 37% (n=224) Westslope Cutthroat Trout, with a mean total length of 106 mm and weight of 12.0 g. Biological data was collected on 58% (n=30) of the Brook Trout removed with a mean length of 111 mm and weight of 17.5 g. Through 2020, a total of 3,439 age-1 and older and 1,424 young-of-year Brook Trout have been removed from Saucon Creek. The Brook Trout population is annually decreasing with the Westslope Cutthroat Trout population increasing. This project is nearing completion and it is expected that assuming annual suppression treatments continue, complete eradication of Brook Trout will be accomplished within the next few years.

Mill Creek is a westerly flowing tributary to the Pend Oreille River in central Pend Oreille County, WA. Mill Creek offers a good location for Westslope Cutthroat Trout preservation as set of falls on Mill Creek near RKM 2.4, creates a natural fish passage barrier preventing re-invasion by downstream populations of non-native fish. The Mill Creek Subbasin project began in 2018 with Brook Trout suppression in the upper watershed. In 2020 the project was extended downstream to the fish passage barrier to include a total of 30.6 km of fish bearing habitat. In 2020 a total of 14,611 Brook Trout were removed from Mill Creek Drainage, with a mean total length of 108 mm and weight of 12.1 g (n=708 measured). There were 4,841 adult Westslope Cutthroat Trout captured and returned to the stream, with a mean total length of 112 mm with a mean weight of 14.3 g (n=380 measured). Through 2020, a total of 24,915 age-1 and older and 8,439 young-of-year Brook Trout have been removed from Mill Creek.

In addition to the suppression activities, KNRD and the Washington Department of Fish and Wildlife (WDFW) have begun monitoring of a novel effort in Mill Creek that involves the introduction of genetically YY male (M_{YY} or Trojan YY) Brook Trout. As these individuals can only produce male offspring, the intent is to drive the sex ratio toward predominantly males, which combined with suppression efforts, will contribute to the extirpation of the population. Early genetic results indicate the stocked M_{YY} Brook Trout are mating successfully, and, in some cases, there are localized streams and project areas already exhibiting a higher percentage of males present. This project is in its early years of implementation, and given the success of other projects, early M_{YY} genetics results, and the high number of Brook Trout removed over the last three years, this project should be successful with maintained intensive annual treatments and a continuation of the M_{YY} Brook Trout program.

As the intent of this project is to address non-native and invasive fish species likely to impact the conservation of native fish species, few have more potential impact than non-native Northern Pike *Esox lucius.* Illegally introduced in the Clark Fork River, Montana, Northern Pike have since established in Box Canyon Reservoir (BCR) of the Pend Oreille River, where they are causing declines in both native and game fish species being managed by the WDFW, KNRD and Idaho Fish Department of Fish and Game (IDFG). The Northern Pike population threatens to undermine current and future recovery efforts for Bull Trout and Westslope Cutthroat Trout, as well as other native salmonids, minnows, suckers, and managed game fish in the watershed. Northern Pike pose a significant risk to the anadromous fisheries of the Columbia River and Endangered Species Act recovery efforts if left to emigrate further downstream. The KNRD and WDFW developed a 3-pronged approach to suppressing the BCR Northern Pike population which includes: Northern Pike regulation and classification changes, promotion of harvest using angling contests (PikePalooza) and mechanical suppression using gillnets beginning in 2012.

The 2020 Northern Pike mechanical suppression effort in BCR was completed March 2 through March 18. On March 19, 2020, under guidance by the Washington State Governor, the Kalispel Tribe of Indians required all project staff to self-isolate due the COVID-19 pandemic, abruptly ending the 2020 netting effort. Upon returning and completion of the SPIN survey, netting would have resumed but due to warm water conditions, high reservoir elevations and NP dispersal from spawning locations, it was decided to not resume the 2020 season. A total of 115 Northern Pike (NP) were removed in 155 overnight gillnet sets during the suppression effort. The effort was assessed May 11 to May 14 during the annual Spring Pike Index Netting survey (SPIN). The 2020 SPIN survey mean CPUE was 0.54 NP/net-night in the core area of the reservoir and 0.00 NP/net-night in the northern ½ of the reservoir, which met the target abundances. Through 2020, a total of 18,006 Northern Pike have been removed from BCR through active suppression. This suppression project will continue in 2021, to maintain or further reduce the depressed population of Northern Pike population in BCR.

In 2016 a SPIN survey was conducted in the downstream Boundary Reservoir, which indicated the population of Northern Pike was more abundant than expected in this reservoir. Based on these results, KNRD and WDFW determined that mechanical suppression of Northern Pike was also necessary in Boundary Reservoir, and following a pilot effort in 2016, full annual implementation of the project was initiated in 2017. There were 26 Northern Pike removed during the 2020 suppression effort from March 9 to 12; this project was also influenced by the COVID-19 pandemic. The SPIN survey took place May 18 to 20 and the resulting CPUE for sloughs was 0.93 NP/net-night, with no pike (0.0 NP/net-night) caught in river sets. Through 2020, a total of 616 Northern Pike have been removed from Boundary Reservoir. As with BCR, continued suppression in 2021 is essential to maintain a reduced abundance of Northern Pike in Boundary Reservoir.

Over the last 25 years, the population of non-native Lake Trout *Salvelinus namaycush* in Upper Priest Lake expanded rapidly, causing concern for native salmonids. Lake Trout were not known to be present in Upper Priest Lake until mid-1980s at which time they were thought to have migrated from Priest Lake through the Thorofare that connects the two lakes. In 1998, the Lake Trout population in Upper Priest Lake was estimated at 859 fish. Since 1998, IDFG has been using gill nets to reduce Lake Trout abundance in Upper Priest Lake to lessen threats to declining Bull Trout and Westslope Cutthroat Trout populations. Since 2007, Lake Trout removal efforts in Upper Priest Lake have greatly increased and annual population estimates indicate that over 72% of the population is removed annually, yet Lake Trout have been able to maintain stability through immigration from Priest Lake and recruitment in Upper Priest Lake. The 2020 Lake Trout mechanical removal effort on Upper Priest Lake was completed between May 13 through May 21, through a contract with Hickey Brothers Research LLC. A total of 2,726 Lake Trout were removed from Upper Priest Lake in 2020. The redd count monitoring effort in the Upper Priest River basin, conducted annually since 1992, indicates the Bull Trout population trajectory has increased over this period. The Lake Trout suppression effort is scheduled to continue in 2021.

As invasive fish species continue to expand in terms of localized population size and distribution, management becomes more complex and requires coordination between local, state, regional, federal, and international management agencies. With the three primary non-native fish species that the KNRD currently operates projects to manage against (Brook Trout, Lake Trout and Northern Pike), having complex histories regarding stocking (illegal and legal), distribution, management of, and threats to conservation of native fish species, it is critical that the Kalispel Tribe engages in coordination and participation at all levels on management issues. During this contract period, KNRD staff including biologists, program managers and directors attended and participated in a variety of local and regional events on invasive species issues. Our intent is to continue participation and coordination as we work toward addressing primary invasive species issues from an active management and policy perspective.

Acknowledgements

The Kalispel Tribe is grateful to Bonneville Power Administration, US Bureau of Indian Affairs, US Fish and Wildlife Service, Washington Department of Fish and Wildlife, Idaho Department of Fish and Game, and the Avista Corporation for providing funding and/or project assistance and coordination necessary for the implementation of this project. Thanks to Glen Nenema (Chairman, Kalispel Tribal Council), the Kalispel Tribal Council and members of the Tribe for providing the support and opportunity to conduct this project. Special thanks go to Joe Maroney (KNRD Director of Fishery and Water Resources), Jason Connor and Jason Olson (KNRD Program Managers), and KNRD field staff for technical, administrative and project level support and review. Thanks also to Carlos Matthew (BPA Contracting Officer Technical Representative).

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Project Background

Introductions of non-native and invasive aquatic species are increasing (reviewed in Gozlan et al. 2010) and as a result, so are the prevalence of subject research, management, and publications relating to the invasions (Thomaz et al. 2015). Non-native species introductions present significant risk (Gozlan and Newton 2009), often altering the environmental ecology through reduction or elimination of other aquatic organisms in the recipient system (Mack et al. 2000; Gallardo et al. 2015). Non-native fish species are impacting native salmonid populations throughout the Pend Oreille Subbasin, which includes the Upper Pend Oreille, Priest River, and Lower Pend Oreille subbasin. Non-native fish species currently constitute an estimated 64% of the fish assemblage in the Pend Oreille Subbasin (KNRD 2017). Competition, hybridization, and predation by non-native fish have been identified as primary factors in the decline of are primary factors in the decline of native Bull Trout *Salvelinus confluentus*, Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*, and sucker and minnow populations native Westslope Cutthroat Trout populations. Therefore, the overarching intent of this project is to implement specific strategies and actions that suppress or eradicate non-native fish in areas where native species are in decline or have been extirpated and recover those populations. Actions conducted through this project have direct impacts on non-native fish species (e.g., reduced abundance, localized extirpation), lead to actions in which non-native fish species are directly impacted (e.g., collect population and distribution data to warrant action; develop management strategies; coordination) or evaluate the post-action response of native fish populations.

Bull Trout and Westslope Cutthroat Trout are two of the most ecological and culturally important native species in the Pend Oreille Subbasin, and both have been greatly impacted by non-native fish. Bull Trout have declined across their native range and have been listed a threatened species under the US Endangered Species Act (ESA) since 1999. While many factors have led to the declines (USFWS 2015a), the introduction of (Leary et al. 1993) and impacts by (Donald and Alger 1993; Reiman et al. 2006; Guy et al. 2011; Kovach et al. 2019) non-native species continue to impact Bull Trout. Within the Pend Oreille Subbasin, Bull Trout were historically abundant, with multiple life histories present (e.g., resident, fluvial, and adfluvial). Bull Trout populations are now primarily restricted to the Pend Oreille Basin upstream of Albeni Falls Dam, Idaho, which was installed without fish passage, consequently eliminating connectivity to the Lower Pend Oreille Subbasin. Due to a half century of disconnection with the upper Basin, Bull Trout observed in the Pend Oreille River and its tributaries below Albeni Falls Dam are now rare. Bull Trout in the Upper Pend Oreille Subbasin—those utilizing Lake Pend Oreille and its tributaries, are presently stable, yet continue to face threats of hybridization, predation, and competition by non-native fishes.

Populations of Westslope Cutthroat Trout are in decline across their historic distribution (Shepard et al. 1997, 2005). Westslope Cutthroat Trout historically occupied over 99% of the streams in the Pend Oreille River Basin located in the northeast corner of Washington State (Shepard et al. 2005). Based on a Kalispel Natural Resources Department (KNRD) analysis of stream mile data, these streams represented 47% of the entire Westslope Cutthroat Trout distribution for the state of Washington (KNRD unpublished data). The KNRD has completed fish surveys in nearly 500 km of streams within the Pend Oreille River Basin. Westslope Cutthroat Trout occupied only approximately 35% of the stream reaches surveyed. Of these currently occupied reaches, 38% were allopatric populations, primarily existing upstream of natural or anthropogenic passage barriers. Fish passage barriers (both natural and man-made) have played a major role in preserving existing Westslope Cutthroat Trout populations by limiting natural upstream expansion of non-native species.

Although protected from invasion, many of the isolated Westslope Cutthroat Trout populations persist in small segments and due to population size and limited length of habitat, those populations are at a high risk of extinction from stochastic environmental events and loss of genetic variation (Harig and Fausch 2002; Hilderbrand, 2002, 2003). An estimated 3.4 Km of stream length is required to support a Westslope Cutthroat Trout population of 500 age-1 and older fish (Young et al. 2005). Of the 19 isolated allopatric populations evaluated in the Lower Pend Oreille Subbasin, 14 are limited to stream segments less than 3.4 Km (KNRD data). Currently there are few areas where allopatric populations of native salmonids exist in the lower Pend Oreille Subbasin and it is therefore critical to expand their range to bolster their persistence.

The Pend Oreille Subbasin has many non-native and invasive fish species directly impacting native fish populations, yet Brook Trout *Salvelinus fontinalis* are considered one of the most ubiquitous and problematic. Brook Trout were widely stocked over the last century and are currently the most broadly distributed non-native species in Pend Oreille River tributaries. Brook Trout directly compete with native salmonids, also posing predatory risks to juvenile fish, which over time diminish and potentially eliminate the impacted populations. Significant efforts have taken place to understand their distribution and present management actions to address Brook Trout populations, where recovery of native species is feasible. While these actions often include addressing connectivity and habitat issues that directly benefit all species, collaborative management activities such as physical suppression and/or eradication of Brook Trout have and will continue to be implemented to further the protection of native species. Cumulatively, these actions have both long-term and immediate benefits toward native species protection and recovery in the Pend Oreille Subbasin.

In contrast to the significant long-term impacts of Brook Trout, Northern Pike *Esox lucius*, a recently established species, has created sudden, immediate, and substantial impacts to the ecosystem. Northern Pike are a large apex predator with a Holarctic distribution (Scott and Crossman 1973), naturally occurring in North America from portions of Alaska south to Missouri and Nebraska east of the Rocky Mountains and west of the Appalachian Mountains, but historically absent in Pacific drainages south of Alaska. Northern Pike have been introduced outside of their native range in the northwestern contiguous United States (Fuller and Neilson 2019), southern British Columbia, Canada (Baxter and Doutaz 2017) and Alaska (ADFG 2007). Illegal introductions (1950's-1990's) established populations in the Blackfoot, Clark Fork, and Flathead rivers in Montana (Huston 1985; Berg 2003; summarized in Bernall and Moran 2005), which form the headwaters of the Pend Oreille Basin. Northern Pike has recently and rapidly become a primary management concern within the region.

Following decades of surveys with no detection, a Northern Pike were first documented Box Canyon Reservoir (BCR) of the Pend Oreille River in 2004. Founding through immigration from the Clark Fork system or illegal transport nearby lakes or rivers, Northern Pike became firmly established in BCR between 2006-2010, growing exponentially from hundreds of fish to more than 5,500. Their rapid establishment and growth caused dramatic declines in native species and game fish managed by Washington Department of Fish and Wildlife (WDFW), KNRD, and the Idaho Department of Fish and Game (IDFG). Northern Pike are a direct threat to recovery efforts for Westslope Cutthroat Trout and ESA listed Bull Trout. Northern Pike also undermine the conservation and management of other native salmonids, minnows, suckers, and introduced game fish within the watershed. Moreover, Northern Pike pose a significant risk to the anadromous fisheries of the Columbia River and ESA recovery efforts as they emigrate and establish downstream populations. Following extensive studies and evaluation efforts, the KNRD and WDFW proposed (2011) and began to implement (2012) a suite of measures, including mechanical suppression, Washington State fishing regulation changes, declassification as a game fish, fishing contests and encouraging harvest of Northern Pike. Mechanical suppression of the population, using gill nets, has occurred annually since 2012 in BCR and was initiated in 2016 in Boundary Reservoir.

An additional large-bodied piscivore, Lake Trout *Salvelinus namaycush*, were introduced to Priest Lake (Priest River Subbasin) in 1925, leading to significant impacts to the native fishery. Bull Trout were once abundant in this system, providing a harvest-oriented trophy fishery in Priest and Upper Priest lakes (Bjornn 1957; Mauser et al. 1988). Following substantial population declines, harvest opportunities were discontinued in 1984. A positive population response did not occur (Mauser et al. 1988) as a result of this action, as non-native species continued to impair the remaining population. The introduction of Kokanee *Oncorhynchus nerka* in the 1940’s provided an additional food source for Lake Trout which lead to higher growth rates and a trophy Lake Trout fishery (Rieman and Lukens 1979). The increase in Lake Trout abundance has been speculatively linked to increased juvenile survival rates attributed to the introduction of *Mysis relicta* in 1965 (Mauser et al. 1988). Although abundant in Priest Lake, Lake Trout were not known to be present in Upper Priest Lake until mid-1980s at which time they were thought to have migrated from Priest Lake through the Thorofare (Mauser 1986). The Lake Trout population in Upper Priest Lake in1998, was estimated at 859 fish and appears to have grown rapidly over the past 25 years (Fredericks 1999). Since 1998, IDFG has used gill nets to reduce Lake Trout abundance in Upper Priest Lake in a conservation effort to protect the declining Bull Trout and Westslope Cutthroat Trout populations.

SECTION 1: MECHANICAL SUPPRESSION OF NON-NATIVE FISH IN TRIBUTARIES

1.1. Pend Oreille Tributary Brook Trout Mechanical Suppression and Eradication

Introduction

To conserve and improve native salmonid population, KNRD has conducted several mechanical removal projects over the past two decades, intent on suppressing and potentially eliminating Brook Trout using electrofishing techniques. These projects typically occur in tributaries that have standing sympatric populations of Westslope Cutthroat Trout and Brook Trout, although other species may be present. While some of the projects have been successfully completed, they often take considerable effort and time. Mechanical removal efforts in Saucon Creek began in 2014, largely based on the success and completion of similar projects (e.g., Graham Creek, West Branch LeClerc Creek Tributary 1). Saucon Creek, like previous successful projects, is relatively small and one of the few viable projects remaining of this scale.

Populations of non-native fishes can be challenging to manage with traditional suppression (e.g., electrofishing, gill netting) or eradication (e.g., piscicide) techniques (Britton et al. 2011). This is especially difficult in cases where a genetically important population of native salmonids exist, as those populations would be impacted by eradication activities, such as piscicide applications. Therefore, it is critical that novel suppression and eradication techniques are considered, tested, and applied to ensure timely conservation of the target native fish population. One such consideration is eradication, via shift in the gender ratio of a population so that one sex becomes functionally extirpated. This concept has recently been hypothesized and modeled, but not been extensively tested in a field application setting (Gutierrez and Teem 2006; Teem and Gutierrez 2010). Shifting the sex ratio of a population could be accomplished through the production and stocking of male fish that are genetically YY (Trojan YY), into areas inhabited by the non-native species targeted for removal (Gutierrez and Teem 2006; Teem and Gutierrez 2010). Theoretically, if stocked YY males (M_{YY}) successfully spawned with females from the target population and contributed sufficient offspring, the sex ratio of the target population should shift toward male fish. Over time, given continued stocking of M_{YY}, and reduction of the target population abundance through physical removal efforts, the target population should eventually become 100% male, ultimately resulting in extirpation.

In 2018, the KNRD, in partnership with WDFW, implemented measures to suppress and/or eradicate non-native Brook Trout within the Mill Creek Subbasin via largescale mechanical suppression via backpack electrofishing and the implementation of a WDFW-led M_{YY} Brook Trout introduction program. The Brook Trout suppression project will include >90% of the Mill Creek drainage and be one of two largescale M_{YY} Brook trout trials in Washington.

Description of Study Area

Saucon Creek is in the headwaters of the West Branch LeClerc Creek (LeClerc Creek Subbasin) and lies within property boundaries of the Colville National Forest and Stimson Lumber Company (Figure 1). The removal effort begins at the confluence of Saucon Creek and West Branch LeClerc Creek, where 300 m upstream of the confluence lies a section of stream consisting of a series of cascades, with no pools or holding water, and a ~1 m steep cascade at the top that prevents or significantly reduces upstream fish passage (Figure 2). The removal project terminates 2.1 km upstream of this point at a natural fish passage barrier (Figure 2). The fish abundance in 2014 above the lower barrier suggests that the habitat will support a healthy Westslope Cutthroat Trout population.

Mill Creek (Mill Creek Subbasin) is a westerly flowing tributary to the Pend Oreille River in central Pend Oreille County, WA. (Figure 3). With more than 30 Km of fish bearing habitat above a natural fish passage barrier (near RKM 2.4; Figure 4) and a standing population of Westslope Cutthroat Trout, this system presents a good conservation opportunity. The fish abundance above the barrier suggests that the habitat will support a robust Westslope Cutthroat Trout population. The 2020 project area included all fish bearing waters upstream of the barrier.

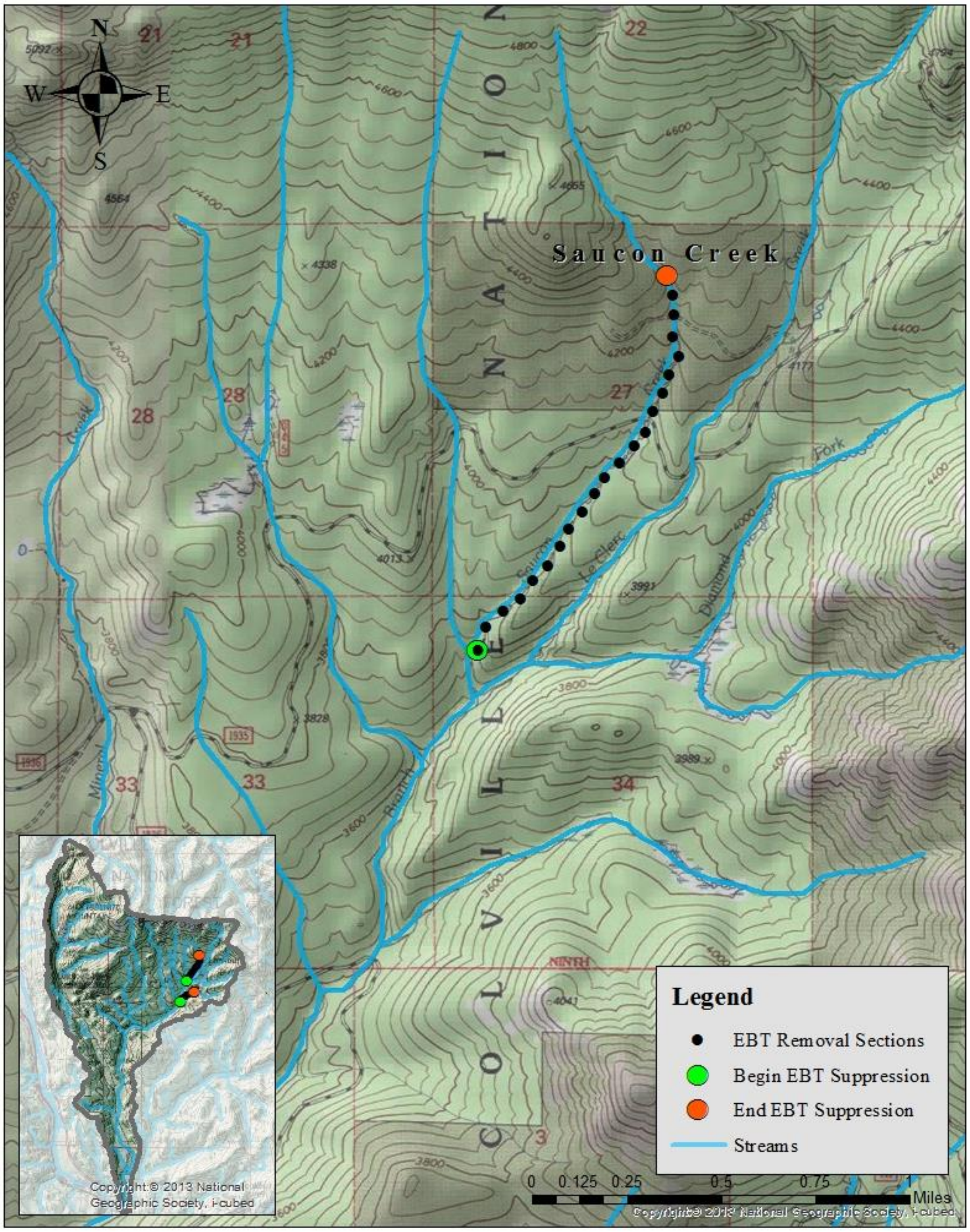

Figure 1. West Branch LeClerc Creek Subbasin. Location of Brook Trout removal in Saucon Creek.

Figure 2. Lower natural barrier; fall 2019 (left) and upper natural barrier (right) on Saucon Creek.

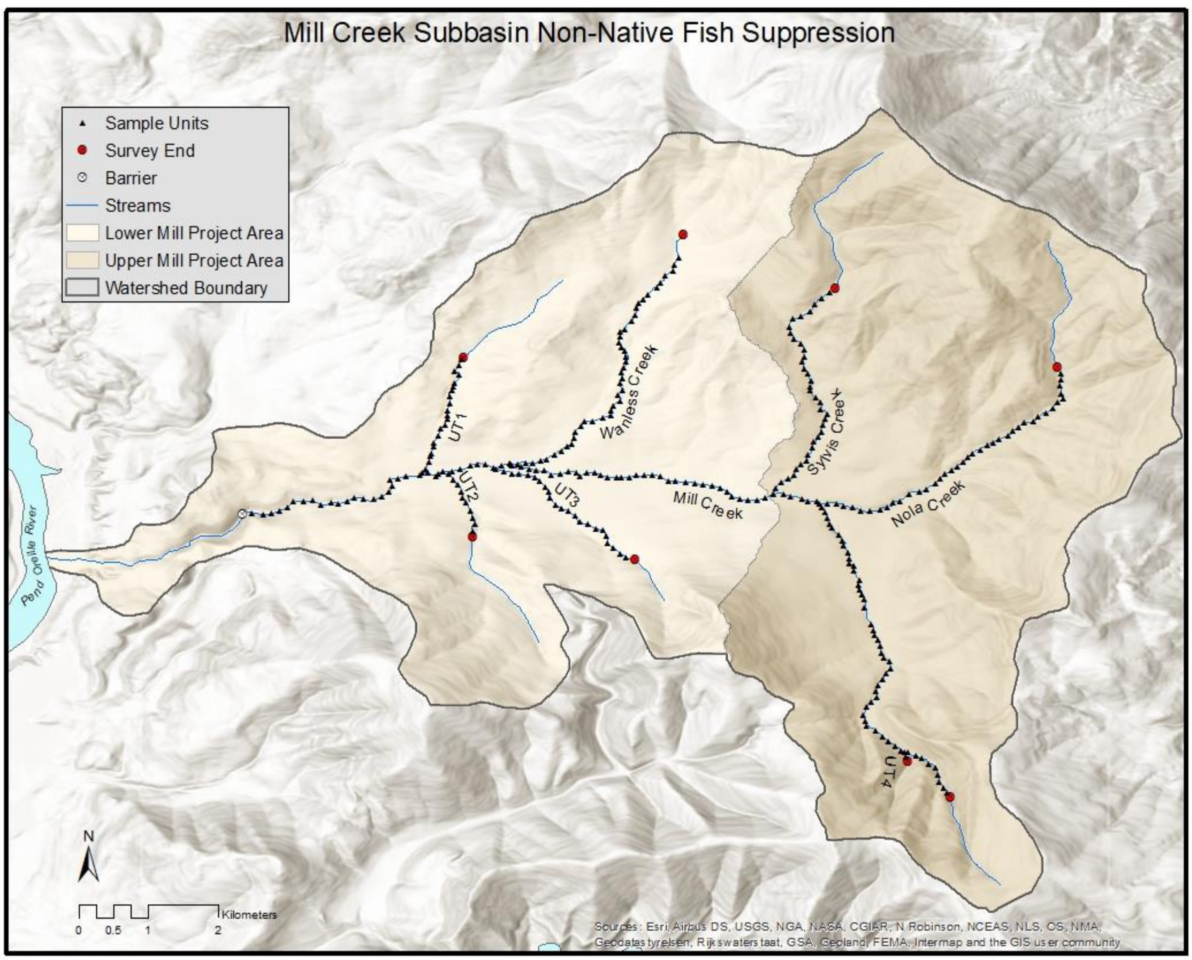

Figure 3. Mill Creek Subbasin. Location of Brook Trout removals.

Figure 4. Lower falls fish passage barrier on Mill Creek, located at RKM 2.4.

Methods

All streams were electrofished in an upstream direction using Smith-Root LR-series battery-powered backpack electrofishing units operated in the range of 500-990 V DC, frequencies of 20-35 Hz with a duty cycle of 12–25%. To avoid re-invasion by non-native fish, removal efforts commenced at a point in the stream channel where fish passage is difficult, if not impossible. When multiple passes were made, the stream was sectioned off in 100 m sample units (SU) using 3 mm mesh block nets securely placed at the upstream and downstream ends to prevent immigration or emigration of fish (Kulp and Moore 2000). Up to three consecutive electrofishing passes were made in each SU then the downstream net was leapfrogged 100 m above the upstream net (Buktenica et al. 2013; Thompson and Rahel 1996; Shepard et al. 2014). In the event all passes were not completed for an SU, block nets were left in place over night to prevent movement into or out of the SU; multiple block nets were placed at the upstream end to prevent downstream movement of fish for periods of two or more days of inactivity at the project site. All passes were electrofished with consistent effort and care was taken to capture all stunned fish. All fish captured during individual passes were removed from the SU and held in a perforated 5-gallon bucket, either held in the stream or refreshed with water frequently.

In the Mill Creek Drainage, SU's were classified into three categories: standard, monitoring, or single-type treatment. In standard SU's all salmonid species encountered (≥ 65 mm total length; TL) were tallied. For monitoring SU's, all captured fish (≥ 65 mm) were weighed (g) and measured (mm). For single pass-type SU's, fish were tallied, and no block nets were used. Young-of-year (YOY) salmonids (≤ 65 mm) were tallied (by species) and up to 10 caudal fin clips were taken for genetic analysis from each SU regardless of treatment classification. In all other project areas (e.g., Saucon) SU's, TL and weight was recorded from a minimum of 25 of each salmonid species encountered (≥ 65 mm); all other species and YOY salmonids were tallied by species. Captured Westslope Cutthroat Trout were held until all electrofishing passes are completed and then dispersed back into the same SU. All Brook Trout captured were removed from the stream and euthanized.

Population estimates were conducted using an electrofishing multi-pass depletion estimator (Zippin 1956). The assumptions for multi-pass depletion estimator are that (1) the population is closed, (2) fishing effort is constant, and (3) capture efficiency remains equal among passes. To meet the first assumption block nets were placed at the upper and lower ends of each section, although violation of this assumption in small streams is often minor (Young and Schmetterling 2004). The second assumption can be met by maintaining a relatively constant time electrofishing or by ensuring all habitats are thoroughly electrofished on each pass because substantially more electrofishing time may be needed in the first pass when there are more fish to capture (Riley and Fausch 1992). Meeting the assumption of constant capture efficiency is difficult, as the relative low abundance of fish in small streams does not allow for an accurate calculation of capture proficiency for subsequent passes (Riley and Fausch 1992). This can be attributed to fish not captured in first pass being more likely to seek refuge in complex habitat such as root wads, large substrate, undercut banks, woody debris, or overhanging vegetation (Peterson et al. 2004; Rosenberger and Dunham 2005); for this project we assumed equal capture probability for all passes.

Genetic Monitoring

Modeling conducted by Schill et al. (2017) indicates that stocking of M_{YY} Brook Trout in streams has the potential to eradicate a naturalized Brook Trout population. Results suggest that stocking M_{YY} fish into a stream at 50% of the annual expected production of age-0 Brook Trout could result in eradication of the naturalized population. Time required for eradication of naturalized Brook Trout populations could be reduced through concurrent suppression of the target population. Successful eradication of naturalized Brook Trout populations can be reduced with a combination of suppression of the target population and a M_{YY} Brook Trout stocking.

In 2018, the Washington Department of Fish and Wildlife, in cooperation with KNRD, proposed and implemented stocking of M_{YY} Brook Trout into the upper Mill Creek project area in support of ongoing non-native Brook Trout suppression and eradication activities. Additional M_{YY} Brook Trout stocking took place in 2019 in the upper Mill Creek project area, with stocking in 2020 expanded throughout the Mill Creek project area (i.e., upper and lower project areas). Monitoring will occur annually to determine impact of stocking M_{YY} fish on the Mill Creek Brook Trout population, primarily through spawning contribution and changes to the sex ratio of YOY Brook Trout collected.

Brood year 2017 M_{YY} Brook Trout stocked into the upper Mill Creek project area in 2018 are anticipated to contribute to the 2019 spawn. Monitoring of reproductive success will begin in 2020 as this is the first year YOY progeny may be present. Caudal tissue samples were collected from a sub-sample of YOY Brook Trout captured. Fin clips were stored on sheets of blotter paper and submitted to the WDFW Molecular Genetics Laboratory (MGL) for analysis. Samples collected throughout the project area were prioritized for analysis, concentrating largely on the upper Mill project area as it received the earliest outplants and suppression efforts.

Sex ratio of YOY in the Brook Trout population in the Mill Creek project area will be the primary long-term monitoring metric and is anticipated to skew toward males over time. Sex ratio will be examined for each SU, upper and lower Mill Creek project area and the cumulative project area. Additional genetic metrics will be monitored to determine the effect of M_{YY} Brook

Trout stocking which include effective population size (N_e), effective number of breeders (N_b), heterozygosity and Hardy-Weinberg Equilibrium.

Results

Saucon Creek

Brook Trout suppression occurred from September 3 to 8, and a secondary single pass removal effort occurred on October 6 and 7. A third treatment conducted in reaches 14-19, occurred on October 15 to remove Brook Trout from the highest density area, which was determined from the previous treatments. There was a total of 55 Brook Trout removed during the 2020 treatments combined, of which only 3 were YOY (n = 39, n = 10, n = 6 respectively; Figure 5). A total of 605 Westslope Cutthroat Trout were captured (Figure 5) and returned during the primary treatment. The 2020 cumulative Brook Trout population estimate, based on the primary treatment, was calculated at 40 (95% C.I. ± 4) individuals ≥ 65 mm, while the Westslope Cutthroat Trout estimate was 632 (95% C.I. ± 16) individuals ≥ 65 mm.

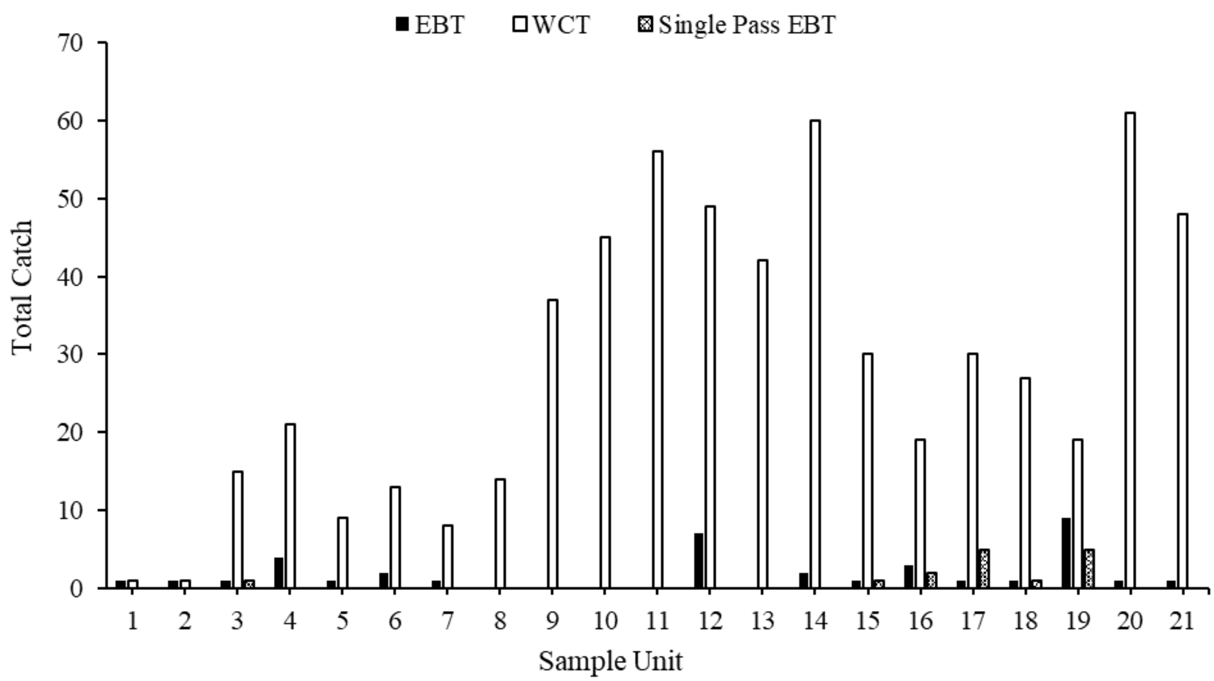

Figure 5. Age-1 and older fish (≥ 65 mm) captured by reach during the 2020 Saucon Creek suppression efforts.

Mean total length for Westslope Cutthroat Trout (n = 243; 61% of total; Figure 6) was 108 mm (65 mm to 190 mm). The mean weight of Westslope Cutthroat Trout was 12.7 g (2.1 g to 48.2 g). Total length and weight were collected on 64% (n = 50; Figure 6) of the Brook Trout removed, with a mean total length of 101 mm (65 mm to 200 mm) and a mean weight of 14.0 g (2.1 g to 70.7 g).

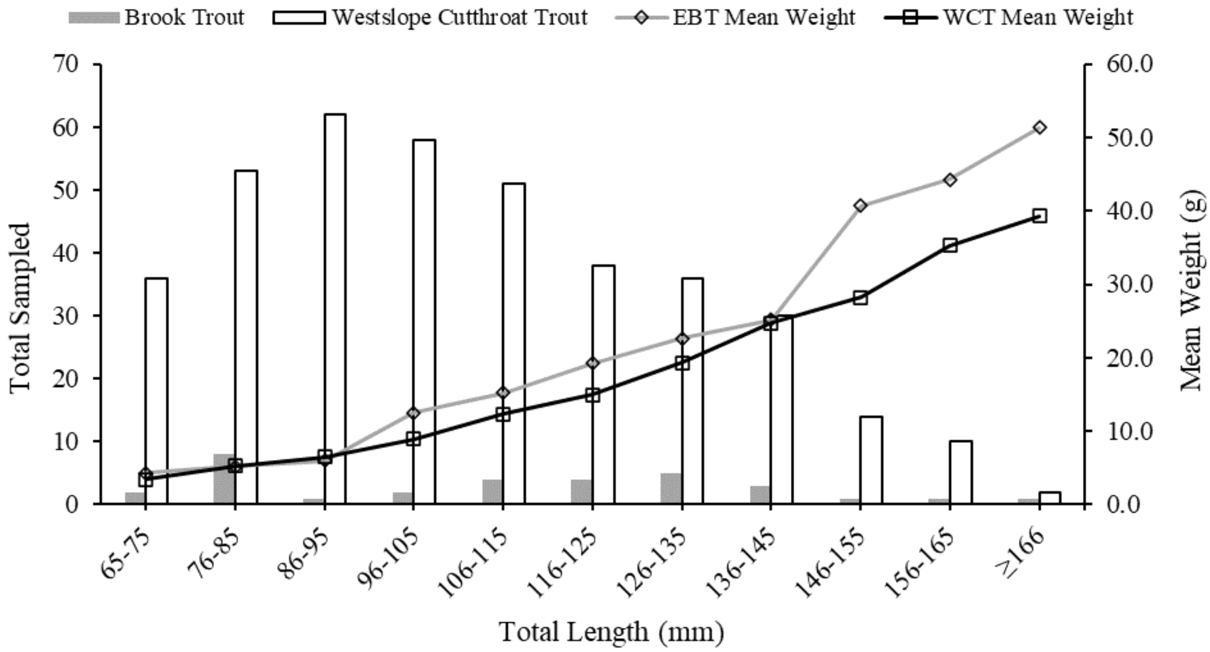

Figure 6. Total catch and mean weight for Brook Trout (n=32, 86%) and Westslope Cutthroat Trout (n=390, 64%) per 10 mm length frequency in Saucon Creek project area.

The fish passage barrier on Saucon Creek consists of a series of natural features, when combined likely prevent upstream fish passage. To confirm that this was a definitive barrier, approximately 150 (50 per year in 2014, 2016 and 2017) Brook Trout had their adipose fin removed and released below the barrier to determine if any were able to ascend the feature. In 2016, two marked Brook Trout were captured in the treatment area and four more were removed in 2018, the smallest being 140 mm. Beginning in 2017, a single pass electrofishing removal effort has been conducted annually below the barrier to reduce the number of Brook Trout that could potentially ascend the barrier. A total of 52 Brook Trout were removed from below lower barrier in 2020; those were excluded from the suppression data analyses.

Mill Creek

Brook Trout suppression started on May 15 and was completed on October 22, 2020. During that period electrofishing crews spent 55 days conducting suppression activities in the Mill Creek Subbasin. The habitat of Mill Creek and its tributaries is complex and includes many split channels, relict beaver ponds, significant undercut banks, and fire-driven conditions (extensive tree blow down and early-stage overhanging riparian vegetation). Given these conditions, and the requirement of multiple passes, even tandem electrofishing, crews were able to electrofish an average of 550 meters of stream each day throughout the season.

In 2020 a total of 302 sample units received some level of suppression treatment (multiple pass, n=291 or 96%; single pass, n=11 or 4%), totaling 30.6 km of stream. The total number of age-1 and older Brook Trout (≥ 65 mm) removed from the project area was 11,603 (n = 7,820; 1,428; 793; 1,003 and 559 in Mill, Nola, Sylvis, Wanless creeks and four unnamed tributaries, respectively: Figure 7). A total of 4,841 age-1 and older Westslope Cutthroat Trout (≥ 65 mm) were captured (n = 2,611; 1,487; 609; 29 and 105 in Mill, Nola, Sylvis, Wanless Creeks and four unnamed tributaries, respectively; Figure 7) and returned to the stream. In total there were 3,008 Brook Trout YOY removed from the entire project area in 2020 with an additional 201 Westslope Cutthroat Trout YOY returned to the stream. The cumulative population size of salmonids (≥ 65 mm) within the suppressed section of Mill Creek Drainage was estimated to be 16,574 salmonids (n=16,444 captured).

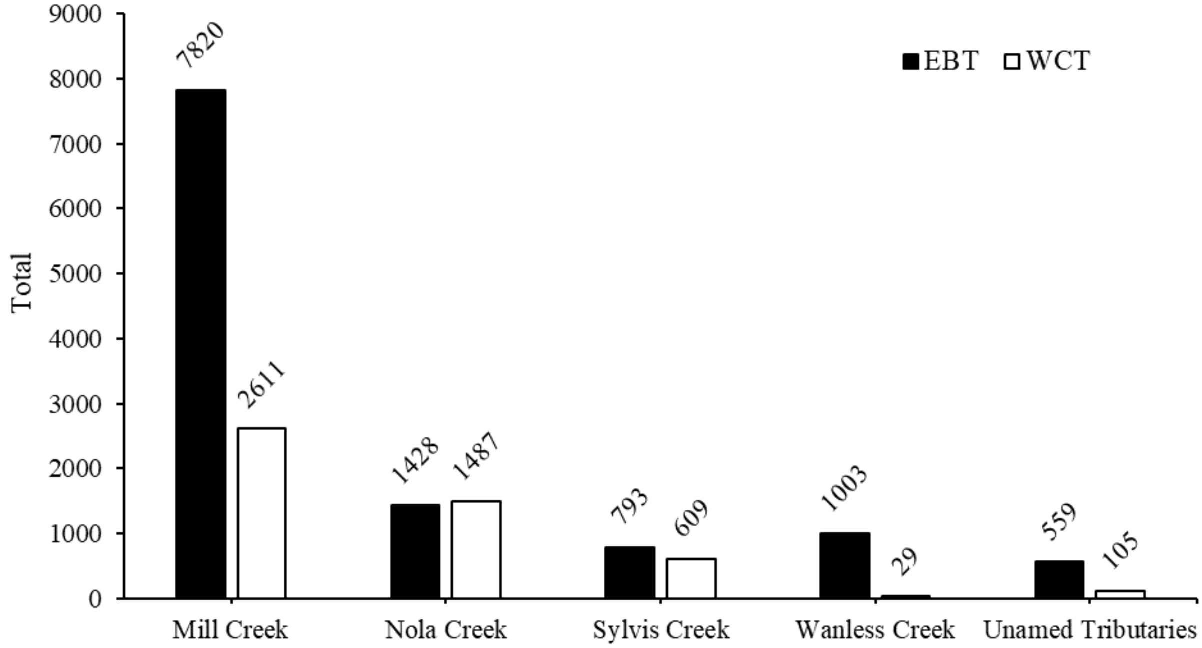

Figure 7. Total fish >65 mm in length captured during 2020 Brook Trout suppression efforts in the Mill Creek project area.

Total length and weight were collected on 9.7% (n = 987; Figure 8) of the Brook Trout removed, with a mean total length of 107 mm (65 mm to 195 mm) and a mean weight of 12.1 g (1.4 g to 72.8 g). Mean total length and weight were collected on 475 (9.8%; Figure 8) Westslope Cutthroat Trout. They ranged in length from 65 to 232 mm with a mean total length of 112 mm. The mean weight of Westslope Cutthroat Trout was 14.3 g (1.2 g to 107.2 g).

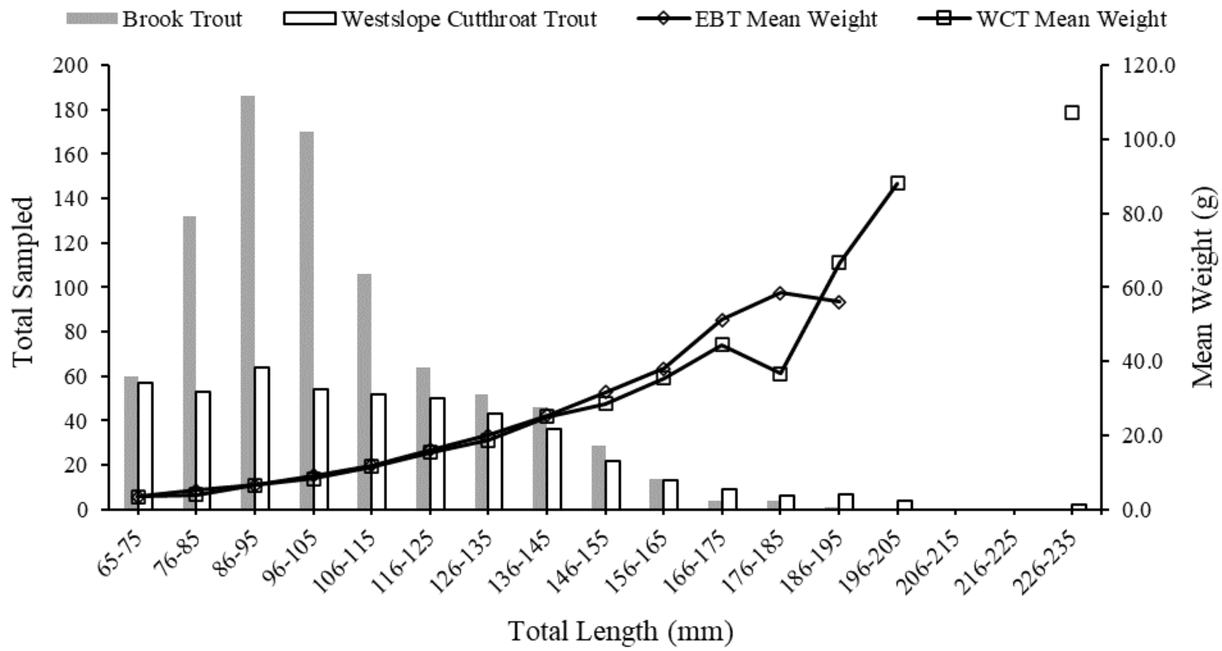

Figure 8. Length Frequency and mean weight for Brook Trout (n=868, 8.5%) and Westslope Cutthroat Trout (n=475, 9.8%) in the Mill Creek project area.

Genetic Monitoring

A total of 674 tissue samples were collected from YOY Brook Trout during the 2020 suppression efforts in Mill Creek. Of those samples, 469 were collected from SU's that received M_{YY} Brook Trout in 2018-2019. Those samples were submitted to the WDFW MGL for genotyping and analysis in winter 2020/21. Of the YOY samples genotyped (n=295, 31, 143 in upper Mill, Nola, and Sylvis creeks, respectively), 253 were male. Ninety of those were offspring of a naturalized (wild) parent and an M_{YY} male Brook Trout. Those 90 individuals were distributed across 45 of 63 Sample Units (71.4%) where YOY were collected in upper Mill and Sylvis creeks. No M_{YY} progeny were detected in Nola Creek; this was likely due to the limited sample size (n=46). Although the percentage of males was low in upper Mill Creek, it was high in Sylvis Creek (71%; Appendix A, Table 2) and specific SU's within upper Mill Creek (Appendix A, Table 3); Nola Creek YOY samples were 50% males. For more specific and complete M_{YY} Brook Trout genetic results, refer to the M_{YY} report found in Appendix A.

Discussion

Saucon Creek

Saucon Creek was identified as a candidate for the mechanical removal of Brook Trout, largely based on the success of similar projects in West Branch LeClerc Creek Tributary 1 (LeClerc Subbasin) and Graham Creek (Winchester Subbasin). Although previous suppression efforts had taken place in Saucon Creek, the project had been suspended to address higher priority actions; during this timeframe, the Brook Trout population fully rebounded to pre-suppression levels. Since 2014, the number of Brook Trout removed has been reduced by 96% (Table 1) and Westslope Cutthroat Trout have expanded further downstream and increased in abundance in SU's that were previously occupied by Brook Trout (Figure 10 and Figure 11, respectively). Through 2020, a total of 3,250 age-1 and older and 1,424 YOY Brook Trout have been removed from Saucon Creek. At the current rate of reduction, the Brook Trout population will likely be extirpated within a few years, at which point we will shift to periodic (5-10 year) monitoring of the Westslope Cutthroat Trout population.

Table 1. Total number of Brook Trout (EBT) removed from and Westslope Cutthroat Trout (WCT) collected and returned to Saucon Creek from 2014 to 2020.

Year	WCT	WCT YOY	EBT	EBT YOY
2014	271	17	1490	457
2015	4	0	168	0
2016	355	4	831	628
2017	365	43	494	231
2018	380	65	137	48
2019	399	145	78	57
2020	605	90	52	3
NOTE:	*2015 Partial removal effort due to wildfire and weather*			

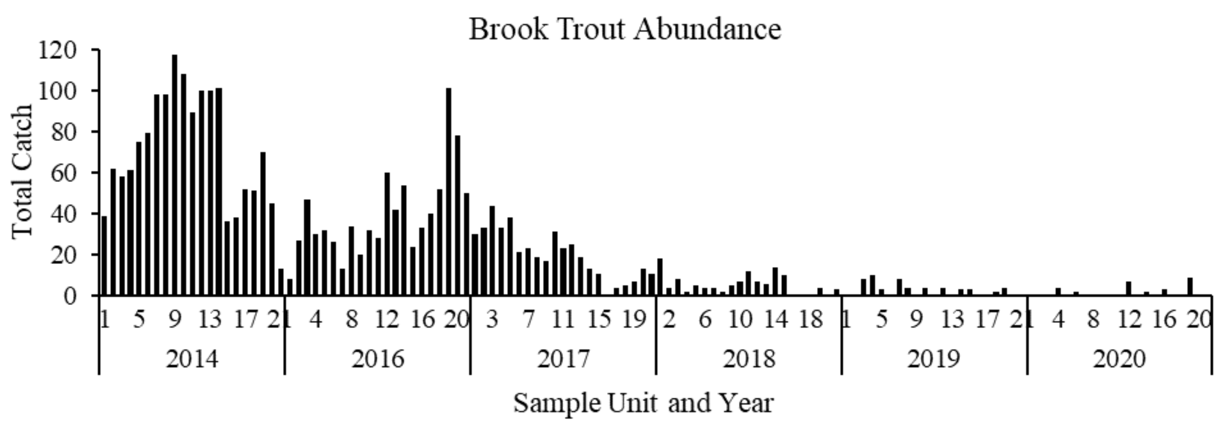

Figure 9. Annual total catch per Sample Unit for Brook Trout in Saucon Creek, demonstrating population decline.

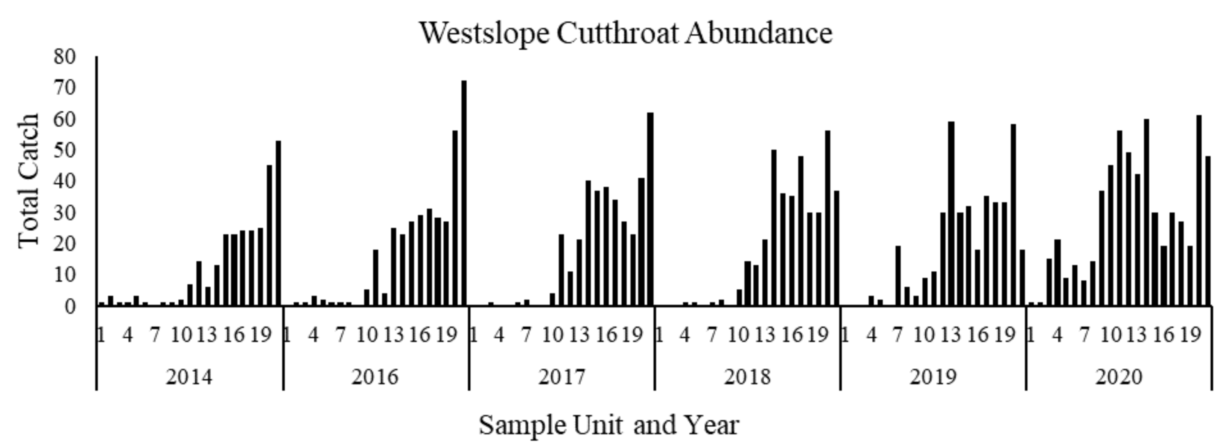

Figure 10. Annual total catch per Sample Unit for Westslope Cutthroat Trout in Saucon Creek, showing downstream population expansion since 2019.

In 2018 the barrier began accumulating materials which may have further reduced upstream passage and therefore the number of fish that can successfully ascend the barrier. No marked Brook Trout have been captured above the barrier since 2018; these results may further indicate the completeness of the barrier in preventing upstream passage. While these are promising results, the lack of marked Brook Trout passing the barrier may be due to the multiple years of suppression below the barrier and the subsequent removal of marked Brook Trout (Table 2). We will continue to remove Brook Trout below the barrier annually to reduce those available to potentially ascend into the project area

Table 2. Total number of Brook Trout (EBT) removed from and Westslope Cutthroat Trout (WCT) collected and returned to Saucon Creek below the barrier from 2017 to 2020.

Year	WCT	WCT YOY	EBT	EBT YOY
2017	7	1	125	37
2018	5	2	56	10
2019	35	2	39	5
2020	40	0	52	5

The objective for this project is to reduce the overall abundance of Brook Trout present in the project area and ultimately reduce their spawning success. Following the removal effort this year, we anticipate the continued expansion of Westslope Cutthroat Trout downstream, with increased YOY abundance, and the reduction in abundance or elimination of both YOY and adult Brook Trout throughout the project area. Based on results to date, we expect that complete eradication of Brook Trout is feasible within the next several years. We will continue to suppress Brook Trout in 2021 and report changes to the community structure in subsequent annual reports.

Mill Creek

Due to the size of the project area, the initial effort (2018) focused on the upper portion of the Mill Creek watershed, with the intention of expanding in 2019 to a substantially more comprehensive effort to suppress the entire Mill Creek watershed above the lower barrier falls (≈ 90%). This plan was followed, and all the 30+ km of Brook Trout occupied habitat has now received suppression treatment. Through 2020, a total of 24,915 age-1 and older and 8,439 YOY Brook Trout have been removed from Mill Creek. Environmental DNA samples may also be collected in future efforts to assist in determining the distribution of both species present in the project area. Any modifications of the treatment strategy or extent will be largely based on those results.

The habitat in the upper project area is complex, when compared to the lower project area, due to split channels, relict beaver ponds, undercut banks and fire-driven conditions such as extensive wood-loading, blow down, and early-stage overhanging riparian vegetation. The suppression crews were more effective at collecting fish in these areas in 2020 due to increased training, experience gained through suppression of the lower project area earlier in the season and improved project communication and guidance.

Comparing the Upper Mill Creek Project Area SU's consistently treated since 2018, (n=94 of 138 possible SU's or 68.1%;), each of the three creeks within show an increase in age

1+ Westslope Cutthroat Trout (Table 3), which is one of the project objectives. In the Upper Project Area, all possible SU's (n=171 or 100%) can be compared, yet the data available is limited to two years (2019-2020). Similar to the Upper Project Area, Westslope Cutthroat Trout numbers are also stable (i.e., Wanless Creek, Unnamed Tributaries) or showing a notable increase (i.e., Lower Mill; Table 3). Throughout the comprehensive project area, Brook Trout numbers have been more variable, which could be due to their prolific nature in this system as well as the project being in its relative infancy. Based on previous efforts in specific Lower Pend Oreille Basin tributaries (i.e., Graham Creek, West Branch LeClerc Tributary 1, Saucon Creek), it will take several years to observe marked declines in total Brook Trout captured on an annual basis. It is encouraging however, that the Westslope Cutthroat Trout population has remained resilient throughout the Mill Creek project area (Table 3).

Table 3. Comparing treated SU's in the Upper Project and Lower Project areas of the Mill Creek Basin. In total, there are 94 of 138 possible SU's (68.1%) from the Upper Project Area that can be compared since 2018. All 171 possible SU's (100%) from the Lower Project Area can be compared since 2019.

		Brook Trout		Westslope Cutthroat Trout	
Stream	Year	Age-1+	Age-0	Age-1+	Age-0
Upper Project Area					
Upper Mill Creek (n=37)	2018	2538	898	521	64
	2019	2609	1059	792	21
	2020	1922	657	760	24
Nola Creek (n=24)	2018	958	641	571	144
	2019	761	608	855	11
	2020	1193	98	998	38
Sylvis Creek (n=33)	2018	826	187	130	51
	2019	897	355	379	14
	2020	737	138	547	4
Lower Project Area					
Lower Mill Creek (n=68)	2019	3151	773	1041	21
	2020	3774	628	1432	48
Wanless Creek (n=47)	2019	1254	713	31	6
	2020	1003	374	29	3
Unnamed Tribs 1,2,3 (n=57)	2019	724	317	74	21
	2020	553	177	90	36

As with all tributary suppression projects, the principal objective is to reduce the total number of Brook Trout present, to benefit the native species population. Acknowledging the project is still in its early stages, following the removal effort this upcoming year (i.e., 2021), we would like to observe an increase in Westslope Cutthroat Trout abundance throughout suppressed reaches, coupled with a notable decrease in the YOY and adult Brook Trout abundance. We will continue the full Brook Trout removal effort in 2021 and report changes to the community structure and progress in the watershed in subsequent reports.

Project success will be dependent on the marked reduction of Brook Trout in the project area and the sex ratio of the population becoming increasingly skewed toward males over time.

M_{YY} Brook Trout must produce an increasing proportion of the YOY Brook Trout in the Mill Creek project area for this to occur. As the results (Appendix A) indicate, M_{YY} Brook Trout have successfully spawned and produced male offspring in the upper Mill Creek project area. Not only is the first critical step in documenting the feasibility in this method, but the contribution rate (i.e., number of M_{YY} progeny) was also higher than anticipated given the relative newness and uncertainty of this technique, as well as limited survival of released M_{YY} Brook Trout. Of the areas examined, Sylvis Creek shows the most promise. With 71% of the YOY being males and 38% being M_{YY} progeny (Appendix A, Table 2), this technique, coupled with ongoing Brook Trout suppression, could lead to a more rapid achievement of project goals and objectives there.

There was a substantial amount of variability amongst the YOY present and corresponding genetic results at the SU level (Appendix A, Table 3). The variability in sex ratio is likely due, in part, to bias created in SU's with an extensive number of YOY collected and limited genetic samples processed (i.e., lower sample proportion). Ultimately this strategy may artificially skew the stream- or project-level sex-ratio results, as well as the detection probability of M_{YY} progeny in specific SU's. Compensating for this will involve an adjustment to sample protocols which may include establishing a minimum percentage of the YOY collected per SU that are submitted for genotyping (e.g., 30%), collecting a proportionally higher number of samples from high-density YOY areas or SU's, and oversampling YOY where possible and working with the WDFW MGL to subsample from the cumulative collection at the appropriate rate. Regardless of adjustments to the sampling strategy, the 2020 results clearly indicate the application of this technique has promise and will require subsequent efforts to ensure it is assisting in achieving desired project outcomes.

Moving forward, stocking WDFW-determined stocking numbers will be directed in part by criteria detailed in Figure 12. If the proportion of YOY males increases by ≥10% every 2 years, stocking numbers and strategies as described in this framework will be maintained. Otherwise, rearing and stocking strategies will be adjusted to promote better M_{YY} survival and/or reproduction. Adjustments to rearing and stocking strategies include, but not limited to, changes in the number of M_{YY} Brook Trout planted, fish size, timing/location of stocking and employment of naturalized rearing strategies. As the M_{YY} Brook Trout stocking aspect of this project is the responsibility of WDFW, we can only provide guidance and technical assistance toward those decisions. That said, the collaboration between the Tribe and WDFW has been significant and consistent, as we respectfully contribute project aspects that will ultimately promote achievement of common projects goals and objectives.

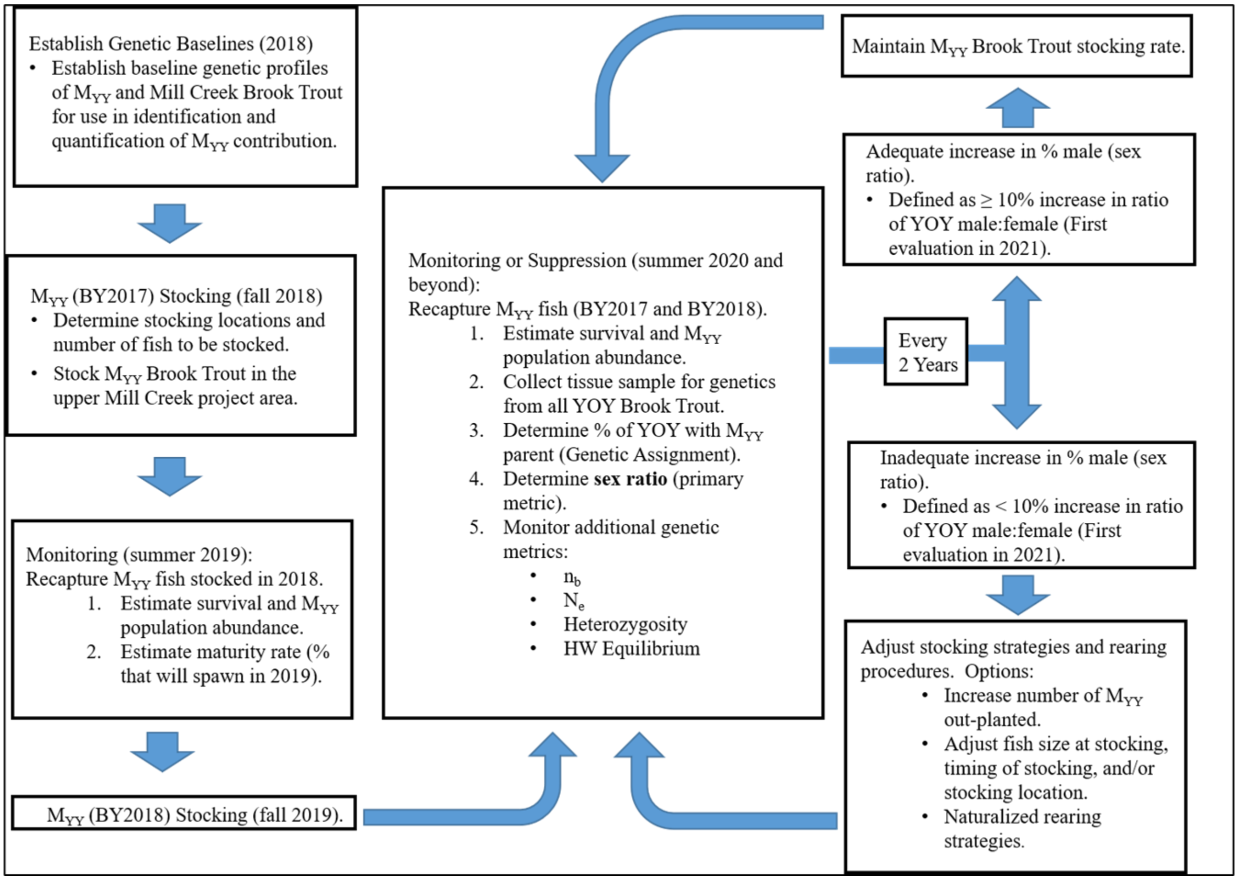

Figure 11. Adaptive management decision tree to guide M_{YY} Brook Trout stocking in Mill Creek project area.

Recommendations

The two Brook Trout mechanical suppression projects conducted under this contract are in varying stages of completion, but each have been successful by the standards set for the projects. The Saucon Creek project has been successful in depressing and with subsequent efforts and time, potentially eradicating the Brook Trout population. Considering the low numbers of Brook Trout removed in the Saucon Creek suppression effort we would encourage the redistribution of Westslope Cutthroat Trout throughout the vacated habit in the lower reaches, assuming it does not occur naturally in the near term. In both the Saucon and Mill creek project areas we will continue suppression as described here in 2021. Based on the positive results of the M_{YY} Brook Trout contribution in Mill Creek, we plan on continuing the genetic monitoring component in the upper Project Area and potentially expanding to monitor portions of the lower Project Area. Our broader intentions are to model other successful projects, adapt as new techniques present themselves and continue suppression annually until the Brook Trout populations are extirpated within each respective project area.

SECTION 2: NON-NATIVE FISH SUPPRESSION IN RIVERS AND LAKES

2.1. 2020 Mechanical Suppression of Northern Pike in the Pend Oreille River

Introduction

This region has experienced a complex history with predatory non-native fish and following a relatively recent detection in Box Canyon Reservoir, Northern Pike *Esox lucius*) were an unwelcomed and potentially disastrous addition. Northern Pike were illegally introduced in the Clark Fork River, Montana and from there potentially immigrated to Box Canyon Reservoir (BCR), of the Pend Oreille River, where they are causing declines in native species and game fish being managed by the KNRD, WDFW and IDFG. The Northern Pike population grew exponentially in BCR from <400 in 2006 to >5,500 in 2010 in the section between river kilometer 98 (Riverbend community) and river kilometer 135 (Pioneer Park campground, Kanisku National Forest). Since their establishment in BCR, Northern Pike have entrained and established a self-sustaining population downstream in Boundary Reservoir.

Northern Pike threaten to undermine current and future recovery efforts for Bull Trout and Westslope Cutthroat Trout, as well as other native salmonids, minnows, suckers, and managed gamefish within the watershed. Reducing the predatory impact of Northern Pike on ESA listed Bull Trout will increase the probability that entrained fish are collected and transported upstream of Albeni Falls Dam to complete their life history and contribute genetic diversity to already depressed upstream populations. Reducing the abundance of Northern Pike demonstrates risk management and abatement for future efforts to increase the relative abundance of native salmonids in the lower Pend Oreille River through mainstem fish passage projects, tributary restoration, and conservation aquaculture.

Northern Pike pose significant risks to the anadromous fisheries of the Columbia River and ESA recovery efforts if allowed to continue emigrating downstream. As of 2016, spawning populations of Northern Pike have been detected in the Columbia River in British Columbia and Lake Roosevelt in Washington; projects are currently underway in both areas to ensure a rapid reduction takes place. Significant coordination at the local, regional, state, federal and international level continues to take place and develop, which is critical to addressing this invasive predator as expansion continues. This project provides direct benefits to recovery and conservation of native fish species and gamefish both locally and in the broader Columbia River basin, by reducing the potential for continuous downstream migration.

Objective: Maintain a reduced abundance of Northern Pike, measured by catch-per-unit-effort in the spring pike index netting survey to:

- < 1.7 Northern Pike/net-night in southern ½ of BCR
- < 0.5 Northern Pike/net-night in northern ½ of BCR
- < 0.5 Northern Pike/net-night in Boundary Reservoir

Description of Study Area

The Northern Pike suppression program is divided into two discrete sampling areas that include Box Canyon Reservoir and Boundary Reservoir. Box Canyon Reservoir is a 55-mile long (89 km) portion of the Pend Oreille River, extending from Albeni Falls Dam in Idaho to

Box Canyon Dam in northeast Washington State (Figure 13). The reservoir varies between 7,000-9,000 acres with an average discharge 26,320 ft^3/s (745.3 m^3/s) at Box Canyon Dam. The southern portion of the reservoir consists of sloughs and shallow areas containing optimal habitat and environmental conditions for Northern Pike. The northern portion of the reservoir is generally more confined and fewer favorable locations for Northern Pike. In total there are more than 50 independent locations that have been targeted during suppression efforts in BCR.

Boundary Reservoir is in the northeast corner of Washington State and is created by the impoundment of the Pend Oreille River by Boundary Dam, located approximately one mile south of the U.S.-Canada border. Boundary Dam is located at RKM 27.3 and the reservoir extends 28.3 Km upstream to Box Canyon Dam. The reservoir has a surface area of approximately 1,794 acres with an average discharge of 30,706 ft^3/s (869.6 m^3/s) at Boundary Dam. The southern portion of the reservoir consists of several sloughs and shallow areas containing minimal habitat for Northern Pike (Figure 14). The northern two-thirds of the reservoir is deeper, consisting of sheer walls and limited habitat for Northern Pike. There are up to 12 independent sites targeted during suppression efforts in Boundary Reservoir and are dependent on operations of Boundary Dam.

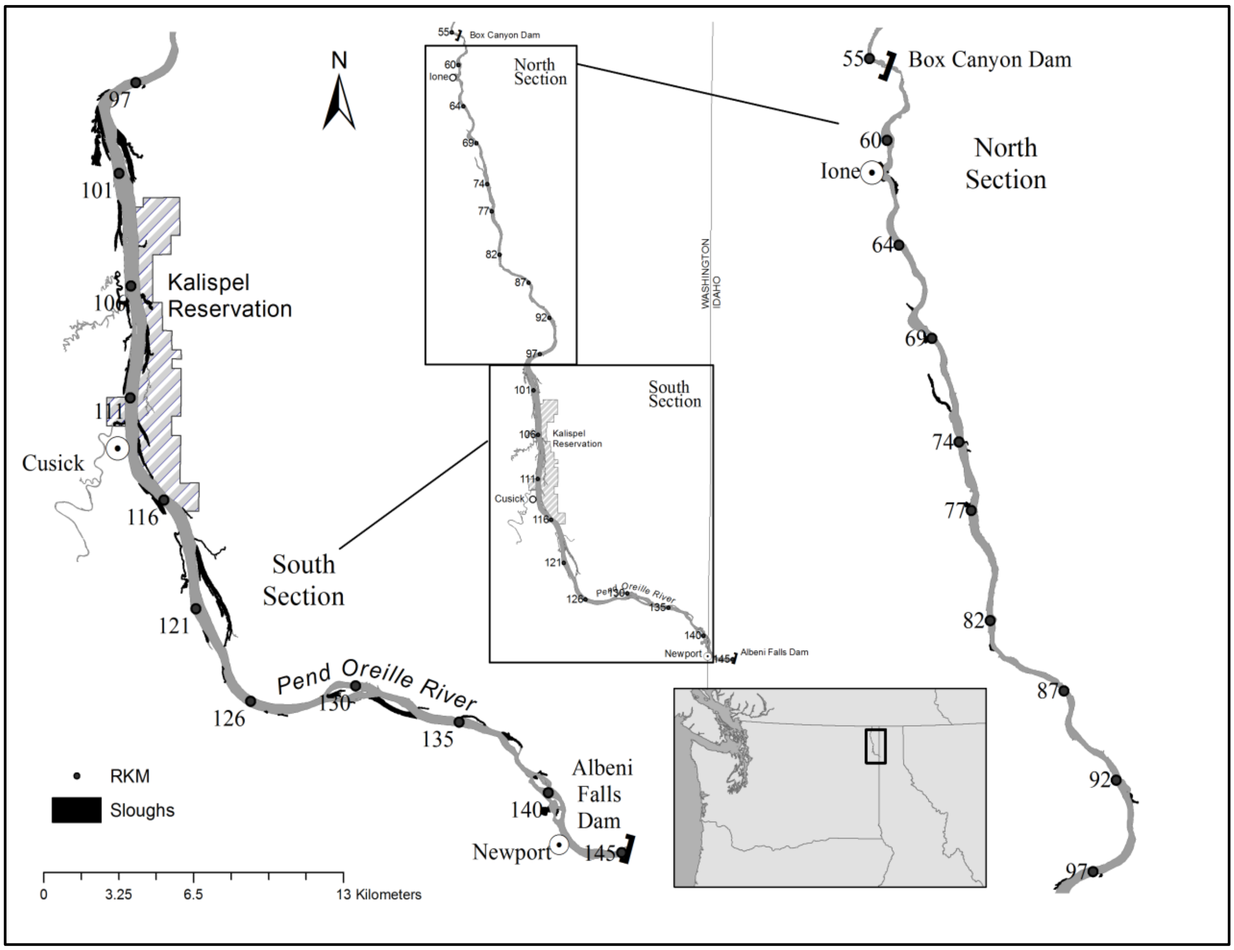

Figure 12. Map of Box Canyon Reservoir, with Northern Pike suppression target areas.

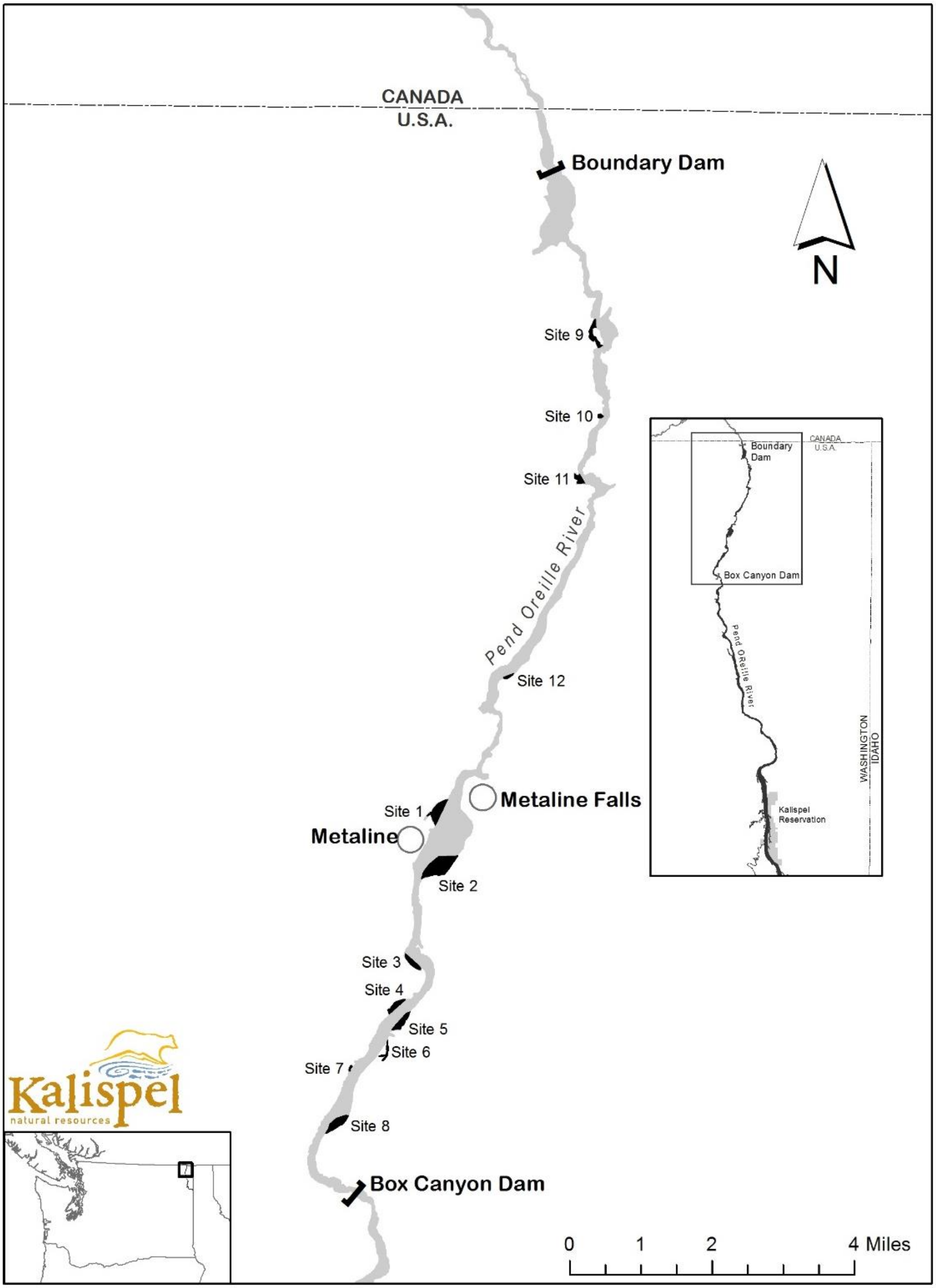

Figure 13. Map of Boundary Reservoir, with Northern Pike suppression target areas.

Methods

Box Canyon and Boundary Reservoir suppression efforts are independent projects within a broader program and therefore have individual management objectives, monitoring surveys and resulting datasets. However, the overall project methodology, timing and data collection are generally consistent in each respective project area. The KNRD implemented the mechanical suppression effort between March 02 and March 18, 2020 with funding and assistance provided by Bonneville Power Administration, US Bureau of Indian Affairs, WDFW, Kalispel Tribe of Indians, and Avista Corporation. Crews worked 4 days per week deploying and retrieving up to 31 gill nets per day using a 21' (6.5 m) Bloodsworth skiff and a 24' (7.3 m) North River landing craft outfitted with a hydraulic drum roller. Nets used in this project measured 150' X 6' (45.7 X 1.8 m) with 5 equal panels of 1", 1.25", 1.5", 1.75" and 2" (2.5, 3.2, 3.8, 4.4, 5.1 cm) bar meshes; these nets effectively recruit Northern Pike > 350 mm TL.

Box Canyon Reservoir suppression netting was initially established to consist of two phases, pre-spawn (March-April) and post-spawn (May-June), which was planned and occurred in 2012-2014. Effectiveness of the suppression effort is monitored between the two phases, during a reservoir-wide Spring Pike Index Netting survey (SPIN). Since 2015, target objectives have been met and all netting activities have occurred during the pre-spawn phase. Boundary Reservoir suppression was established to consist of a pre-spawn phase due to a less abundant population and smaller project sampling area and monitored with a SPIN survey post suppression effort. Currently, a post-spawn phase would only be initiated in the event of a significant and unexpected increase in Northern Pike abundance in either reservoir.

All Northern Pike caught during the 2020 suppression efforts were selected for biological data collection in collaboration with WDFW. Data collected included total length (mm), weight (g), sex and maturity. Growth/aging structures were collected during the 2020 SPIN survey and sent to the WDFW Aging Lab where they will be processed and archived.

Results

In 2020 the intent of the suppression netting was to target pre-spawn aggregations of NP during March and April but was suspended abruptly due to the COVID-19 pandemic. On March 19, 2020, under guidance by the Washington State Governor, the Kalispel Tribe of Indians required all project staff to self-isolate due the COVID 19 pandemic, abruptly ending the 2020 netting effort. Upon return from isolation and completion of the SPIN survey, netting would have resumed but due to warm water conditions, high reservoir elevations and NP dispersal from spawning locations, it was determined the 2020 season would not resume.

Box Canyon Reservoir

A total of 115 Northern Pike were removed in 155 overnight net sets during the 2020 suppression effort in BCR (Table 4). The May 11-14, 2020 BCR SPIN survey mean catch-per-unit-effort (CPUE) of 0.54 NP/net-night (95% CI: ± 0.42) in core area of the reservoir (target < 1.7) and 0.00 NP/net-night north of Riverbend (target < 0.5; Table 4) met the project objectives.

Females made up 37% of the total Northern Pike catch in the suppression effort and juveniles (Northern Pike < 450 mm in total length) represented 44% of the catch. The mean total length of Northern Pike captured during the suppression effort was 486 mm for males and 610 mm for females; the range for all Northern Pike combined was 285 mm to 1,168 mm.

Table 4. Summary of 2020 Northern Pike catch statistics for suppression efforts and SPIN survey in Box Canyon Reservoir.

	Suppression	SPIN Survey
Sampling Dates:	March 02 to March 18	May 11 to May 14
Days per Week:	4	4
Nets/Day:	10-31	6-7
Total Nets:	155	62
NP Catch-Per-Unit-Effort (CPUE):		
CPUE:	0.75	North: 0.0 Slough and South: 0.54
Percent Positive Catch:	40%	18%
Most Northern Pike in one net:	7	9
NP Catch Statistics:		
Total Number:	115	28
Total Weight:	0.165 mT	0.03 mT
Total Length Range:	285 mm to 1,168 mm	365 mm to 725 mm
Weight Range:	136 g to 12,739 g	311 g to 2,763 g
Mean TL Males:	486 mm	514 mm
Mean TL Females:	610 mm	601 mm
Sex Ratio (% female):	37%	25%
Juvenile Catch (<450 mm):	44%	43%

Bycatch was comprised of 15 fish species with 1,770 individuals caught (Table 5). Non-native Yellow Perch *Perca flavescens*, Black Crappie *Pomoxis nigromaculatus*, Pumpkinseed *Lepomis gibbosus* and Tench *Tinca* which accounted for 89.1 % of the total bycatch (949; 273; 246 and 109 individuals, respectively). Westslope Cutthroat Trout (n=1) were the only native salmonids captured in 2020 (0.06% of total bycatch). Catch and mortality of non-target species generally increased with increasing water temperatures, with observed immediate survival of incidental catch was estimated at >90%. (Table 5).

Table 5. Summary of fish bycatch captured during the 2020 Northern Pike suppression effort in Box Canyon Reservoir. Observed bycatch survival rates were > 90% for the project.

Common Name	Species Name	Number	% of Total
Salmonidae			
Brown Trout	*Salmo trutta*	22	1.24
Eastern Brook Trout	*Salvelinus fontinalis*	35	1.98
Lake Trout	*Salvelinus namaycush*	2	0.11
Rainbow Trout	*Oncorhynchus mykiss*	11	0.62
Westslope Cutthroat Trout	*Oncorhynchus clarkii lewisi*	1	0.06
Esocidae			
Grass Pickerel	*Esox americanus vermiculatus*	21	1.19
Cyprinidae			
Northern Pikeminnow	*Ptychocheilus oregonensis*	21	1.19
Tench	*Tinca*	109	6.16
Catostomidae			
Largescale Sucker	*Catostomus macrocheilus*	3	0.17
Ictaluridae			
Brown Bullhead	*Ameiurus nebulosus*	29	1.64
Centrarchidae			
Black Crappie	*Pomoxis nigromaculatus*	273	15.42
Largemouth Bass	*Micropterus salmoides*	43	2.43
Pumpkinseed	*Lepomis gibbosus*	246	13.90
Percidae			
Walleye	*Sander vitreus*	5	0.28
Yellow Perch	*Perca flavescens*	949	53.62
Grand Total (all species)		1,770	100

Boundary Reservoir

In total, 616 NP have been removed since mechanical suppression effort began in Boundary Reservoir in 2016. In 2020, a total of 30 nets were deployed and 26 Northern Pike removed between March 9 and March 12, with a final catch-per-unit-effort (CPUE) of 0.87 NP/net-night. The KNRD collected 28 Northern Pike during the 2020 Spring Pike Index Netting (SPIN) survey conducted May 18 through May 20. The resulting CPUE of 0.93 NP/ net-night in sloughs and mainstem river between Box Canyon Dam and Metaline Falls (Table 6). Although this was higher than ≤ 0.50 NP/net-night it fell within the 95% CI (0.43 to 1.43) meeting the abundance target for the reservoir.

Females made up 23% of the total Northern Pike catch in the 2020 suppression effort in Boundary Reservoir and juveniles (Northern Pike < 450 mm in total length) comprised 81% of the catch. The mean total length of Northern Pike captured during the suppression effort was 449 mm for males and 500 mm for females; the range for all fish combined was 400 mm to 880 mm (Table 6).

Table 6. Summary of 2020 Northern Pike catch statistics for suppression efforts and SPIN survey in Boundary Reservoir.

	Suppression	SPIN Survey
Sampling Dates:	March 9 to March 12	May 18 to May 20
Days per Week:	4	4
Nets/Day:	10	7-8
Total Nets:	30	30
NP Catch-Per-Unit-Effort (CPUE):		
Overall CPUE:	0.87	0.93
Percent Positive Catch:	47%	40%
Most Northern Pike in one net:	4	5
NP Catch Statistics:		
Total Number:	26	28
Total Weight:	0.02 mT (21.5 pounds)	0.019 mT (41 pounds)
Total Length Range:	400 mm to 880 mm	368 mm to 597 mm
Weight Range:	376 g to 5,540 g	331 g to 1,425 g
Mean TL Males:	449 mm	461 mm
Mean TL Females:	500 mm	458 mm
Sex Ratio (% female):	23%	32%
Juvenile Catch (<450 mm):	81%	43%

Bycatch included 11 fish species and was comprised of 44 individuals (Table 7). The most encountered species were Yellow Perch and Brown Trout *Salmo trutta*, which accounted for 59.0% of the total catch (19 and 7 individuals, respectively). Westslope Cutthroat Trout was the only native salmonid captured during 2020, accounting for only 4.5% of the total catch (n = 2).

Table 7. Summary of fish bycatch captured during the 2020 Northern Pike mechanical suppression effort in Boundary Reservoir. Observed bycatch survival rates were > 90% for the project.

Common Name	Species Name	Number	% of Total
Salmonidae			
Brown Trout	*Salmo trutta*	7	15.91
Lake Trout	*Salvelinus namaycush*	1	2.27
Rainbow Trout	*Oncorhynchus mykiss*	2	4.55
Westslope Cutthroat Trout	*Oncorhynchus clarkii lewisi*	2	4.55
Cyprinidae			
Northern Pikeminnow	*Ptychocheilus oregonensis*	2	4.55
Tench	*Tinca*	1	2.27
Catostomidae			
Largescale Sucker	*Catostomus macrocheilus*	3	6.82
Ictaluridae			
Brown Bullhead	*Ameiurus nebulosus*	1	2.27
Percidae			
Walleye	*Stizostedion vitreum*	5	11.36
Yellow Perch	*Perca flavescens*	19	43.18
Gadiformes			
Burbot	*Lota*	1	2.27
Grand Total (all species)		44	100

Discussion

Box Canyon Reservoir

Thus far we have been effective at removing large numbers (n=18,006) of Northern Pike from BCR. During the first three years the mean weekly CPUE varied annually, consisting of a strong initial presence of Northern Pike followed by a steady decline for the remainder of the season. Beginning in 2014, after the initial peak in catch rates, we began to see a decline in weekly CPUE due to the population experiencing the effects of multiple years of suppression (Figure 15). With no significant increase in the catch rates in recent seasons, combined with the low SPIN survey CPUE, results indicate that the Northern Pike population has been largely suppressed in BCR.

A total of 5,329 overnight gill net sets have been set over the course of the suppression project in BCR. Most netting locations in BCR began to see declines in catch rates during 2014, and by 2015 all locations saw considerable declines (Figure 14). The four locations with the highest catch rate in 2020 were Everett Island (n=29, 0.91 CPUE), Tacoma Slough (n=28, 2.3 CPUE), Cusick/Gardner Slough (n=13, 1.2 CPUE) and Dalkena Rocks (n=11, 1.2 CPUE).

Information gained through the Northern Pike suppression effort has led to adaptations that guide future activities, especially those focused on maintaining a now reduced Northern Pike population in BCR. One adaptation was to reduce mortality of non-target species by starting the suppression efforts in early March to avoid the increasing water temperatures of late spring and early summer. With the reservoir fish assemblage in a depressed state from substantial predation by Northern Pike, reducing project mortality will aid in its recovery. Combined catch of non-native Tench and Yellow Perch accounted for 60.4% of total bycatch for the duration of the project, with salmonids (native and non-native) accounting for only 2.0% (n = 1,355) of the total. A total of 55 native salmonids (Bull Trout, Westslope Cutthroat Trout, and Mountain Whitefish) were captured and accounted for < 0.1% of the total catch. Therefore, it is unlikely that this effort has impacted native salmonids in the project area.

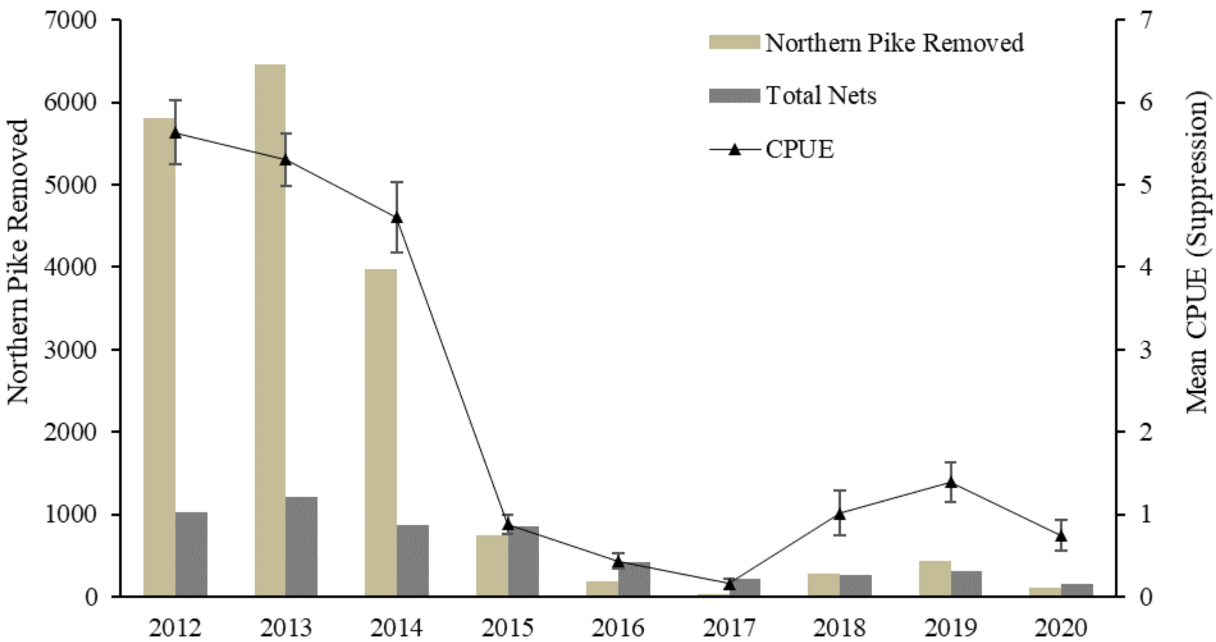

Figure 14. Effort, total catch, and mean annual suppression CPUE (95% CI) of Northern Pike from Box Canyon Reservoir from 2012 through 2020.

Biological data collected throughout the duration of the suppression effort shows that male Northern Pike begin to sexually mature at 250 mm with the majority being sexually mature by 550 mm. Mature females have been observed at 325 mm, with most maturing by the time they reach 650 mm. The nets designed for this project are efficient at targeting mature age classes and therefore limit their ability to successfully spawn. Individuals that remain in the system have the potential to successfully spawn and their offspring may have a greater recruitment rate due to reduced competition and predation, resulting in the need for continued suppression in BCR. Mann (1982) suggests that a significant amount of mortality of young pike, after the early fry stage, is a result of cannibalism from older cohorts. The removal of larger individuals may have resulted in reduced predation on the younger cohorts, potentially leading to an increased survival rate of juvenile Northern Pike in BCR. An increased abundance of smaller cohorts (350-500 mm) has not been observed on a reservoir-wide scale although this may have occurred on a localized scale (Everett Island) in 2018. In 2019 there was an anticipated increase in the larger size classes (600-750 mm) near Everett Island. It is important to consider that an estimated 87% of the female Northern Pike < 650 mm are removed from the reservoir, prior to having the opportunity to spawn.

As we are unable to fully detect strong sizes classes until they exceed 350 mm, there is a continued need to monitor upcoming cohort strength, to detect any trends that may indicate a need to rapidly respond or consider alternate management strategies. Recent netting results continue to confirm the depressed status of the adult Northern Pike population in BCR, which is also supported by 2020 SPIN results. Although the spawning segment of the Northern Pike population has been greatly reduced from pre- and early-suppression years, and recruitment continues to remain low, it is still imperative that suppression efforts continue, and the population is closely monitored.

Boundary Reservoir

While Boundary Reservoir does not have the quantity or quality of optimal Northern Pike habitat, when compared to BCR. Typical power generating operations at Boundary Dam can fluctuate the reservoir elevation by several feet daily, thereby creating unfavorable conditions for successful recruitment of Northern Pike. However, concerns on the potential establishment of a self-sustaining population prompted KNRD to monitor the population in 2016 with a SPIN survey. Even with the limited habitat available, Northern Pike have successfully established here, at a population abundance higher than anticipated.

The successful establishment of Northern Pike in Boundary Reservoir might be due to the spring freshet producing periods of high flow, which creates adequate high and stable reservoir elevation, inundating littoral spawning and rearing habitat during critical spring months. The frequency of these periods is not consistent, and as such population persistence likely results from infrequent spawning and recruitment events that maintain the population at a relatively low level. With the rapid suppression response following the 2016 SPIN survey, the project appears to have reduced Northern Pike presence in the reservoir and held the population at a moderated level (Figure 16).

As this system is far less complex and difficult to address than BCR, we often use results and trends from BCR to look at possible conditions that may occur in Boundary Reservoir. Based on the limited annual catch (Mature and immature), low relative abundance consistently observed during SPIN surveys, and very limited recruitment or recruitment potential (i.e., reservoir fluctuations and limited habitat), monitoring compensatory response is less of an issue in Boundary Reservoir. One of the primary concerns is further downstream entrainment, which will continue to hinder efforts to address population segments in the British Columbia sections of the Pend Oreille and upper Columbia rivers. To reduce escapement of Northern Pike, we sample and suppress locations downstream of Metaline Falls as conditions allow. We anticipate the need to continue suppression efforts in the broader Boundary reservoir to maintain the population at a reduced abundance.

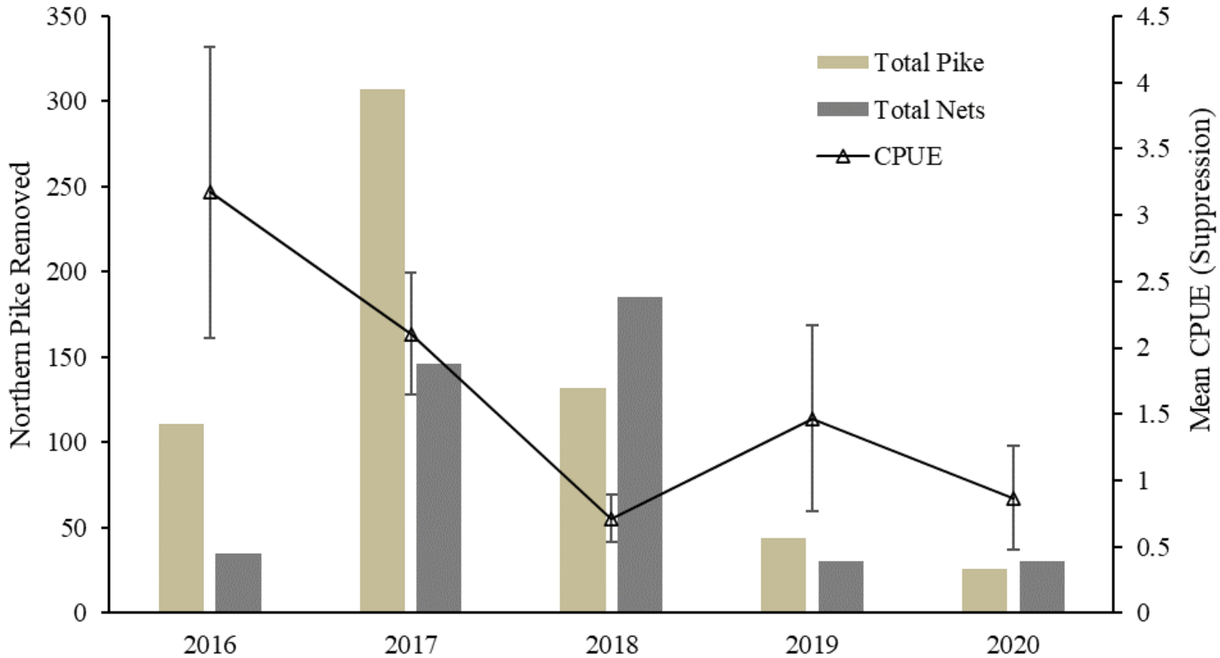

Figure 15. Effort, total catch and mean annual suppression CPUE (95% CI) of Northern Pike from Boundary Reservoir from 2016 thru 2020.

Recommendations

Considering the amount of data and knowledge gained since the project began and the continued need to maintain a depressed Northern Pike population, KNRD and WDFW continue to cooperatively adapt a long-term Northern Pike management process for Washington's Pend Oreille River. Currently, WDFW and KNRD meet annually to discuss the results of suppression and monitoring efforts and use that information to plan for future efforts. As a result of these meetings, monitoring protocols, action triggers and actions can be adapted to varying population levels. The intention of this process is to be useful in varying situations and locations and be adjusted as new data or information is presented. With continued downstream expansion in the Columbia River Watershed, there is a broader awareness of the invasive nature of Northern Pike. The effectiveness of this project has shown that tools and strategies now available can reduce the abundance of Northern Pike and eventually limit their spread. Using this project as a template, similar strategies are now being applied elsewhere by Columbia River Basin fisheries managers including the Pend Oreille and upper Columbia rivers in British Columbia, Coeur d' Alene Lake in Idaho, and Long Lake of the Spokane River and Lake Roosevelt of the Columbia River in Washington State.

Since the Northern Pike suppression project began, annual and within season adjustments have been made to netting strategies that have afforded the success observed to date. As indicated by relative abundance declines observed during the SPIN surveys, reductions in both overall catch rates and CPUE, this project has been successful at meeting its objectives. Moving forward, the project objective is to maintain a reduced relative abundance through similar but less intensive netting efforts in both reservoirs. Future efforts will be based on management decisions as determined at annual meetings between agencies. These decisions will be based on the previous year's data, funding availability and the expected level of effort required to maintain the population. Based on our reduced 2020 suppression efforts and subsequent SPIN results, it is our recommendation to implement the 2021 Northern Pike suppression at an increased level of effort from 2020 in BCR and Boundary Reservoir, beginning in March 2021. We will continue the annual SPIN survey in each reservoir and use that information, along with cumulative suppression data, to make outyear management decisions.

2.2. 2021 Mechanical Suppression of Northern Pike in the Pend Oreille River

The 2021 project to mechanically suppress Northern Pike in Box Canyon Reservoir and Boundary Reservoir of the Pend Oreille River is scheduled to begin March 1, 2021 and end April 23, 2020. In addition to the 2021 suppression effort, the population will be monitored with a SPIN survey in both reservoirs (May 2021). Although the implementation portion will be completed during this contract period, data reporting will not occur until the April 30, 2022 submission requirement for next year's annual report for this project.

2.3. 2020 Lake Trout Suppression in Upper Priest Lake

Historically, Bull Trout were common throughout the Priest Lake watershed with major tributaries supporting adfluvial spawning Bull Trout populations which supported an annual angler harvest of over 600 Bull Trout in the 1950's (Bjorn 1957). From the 1950's to 1978, annual Bull Trout harvest in Priest and Upper Priest lakes was 1,000 to 2,300 fish (Bjorn 1957, Mauser et al 1988). Bull Trout were subjected to overharvesting and by 1983, Bull Trout harvest had declined to less than 100 fish. By 1989, adfluvial Bull Trout populations were deemed functionally extinct in Priest Lake (Mauser and Ellis 1985; Mauser et al. 1988; PBBTTAT 1998). The Westslope Cutthroat Trout fishery was historically important in Priest and Upper Priest Lakes, with 30 fish limits being common in the 1940's (Mauser et al. 1988). Due to interspecific competition, predation, and degradation of spawning habitat the Westslope Cutthroat Trout population declined, and harvest was subsequently closed in 1988 (Liter et al. 2012).

To reduce the threats to the declining Bull Trout and Westslope Cutthroat Trout populations, IDFG began using gillnets in 1998 to reduce Lake Trout *Salvelinus namaycush* abundance in Upper Priest Lake (Figure 17). Lake Trout were not known to be present in Upper Priest Lake until mid-1980s at which time they were thought to have migrated from Priest Lake through the Thorofare (Mauser 1986). From 150-5,000 Lake Trout have been removed annually from Upper Priest Lake since efforts began (Liter et al. 2012). Lake Trout removal efforts have greatly increased since 2007 and annual Lake Trout population estimates have been calculated using a Leslie Depletion Model (Ricker 1975). These estimates indicate that over 72% of the population is removed annually, yet Lake Trout have been able to maintain stability through immigration from Priest Lake and recruitment in Upper Priest Lake.

The 2020 Lake Trout mechanical removal effort on Upper Priest Lake was completed between May 13 through May 21. Hickey Brothers Research LLC was contracted to provide equipment and labor for completion of the netting project. An 11 m commercial gill net boat was used to complete sampling efforts. Funding for completion of the Lake Trout removal effort was provided by IDFG, United States Fish and Wildlife Service (USFWS) and Kalispel Tribe (BPA). A total of 2,726 Lake Trout were removed from Upper Priest Lake in 2020. For detailed information on the 2020 efforts, see Appendix B of this report which contains the section of IDFG's 2020 Annual Report describing the netting activities in Upper Priest Lake. For information on Bull Trout spawning trends in the Upper Priest Lake system, see Appendix C of this report containing a figure with recent Bull Trout redd count surveys, which will be included in IDFG's Annual Report upon completion. The Lake Trout netting efforts on Upper Priest Lake will be implemented in 2021 and will continue to be required if Lake Trout are not controlled (suppressed or eradicated), access to Upper Priest Lake is not eliminated, management strategies change, or alternative control methods are implemented.

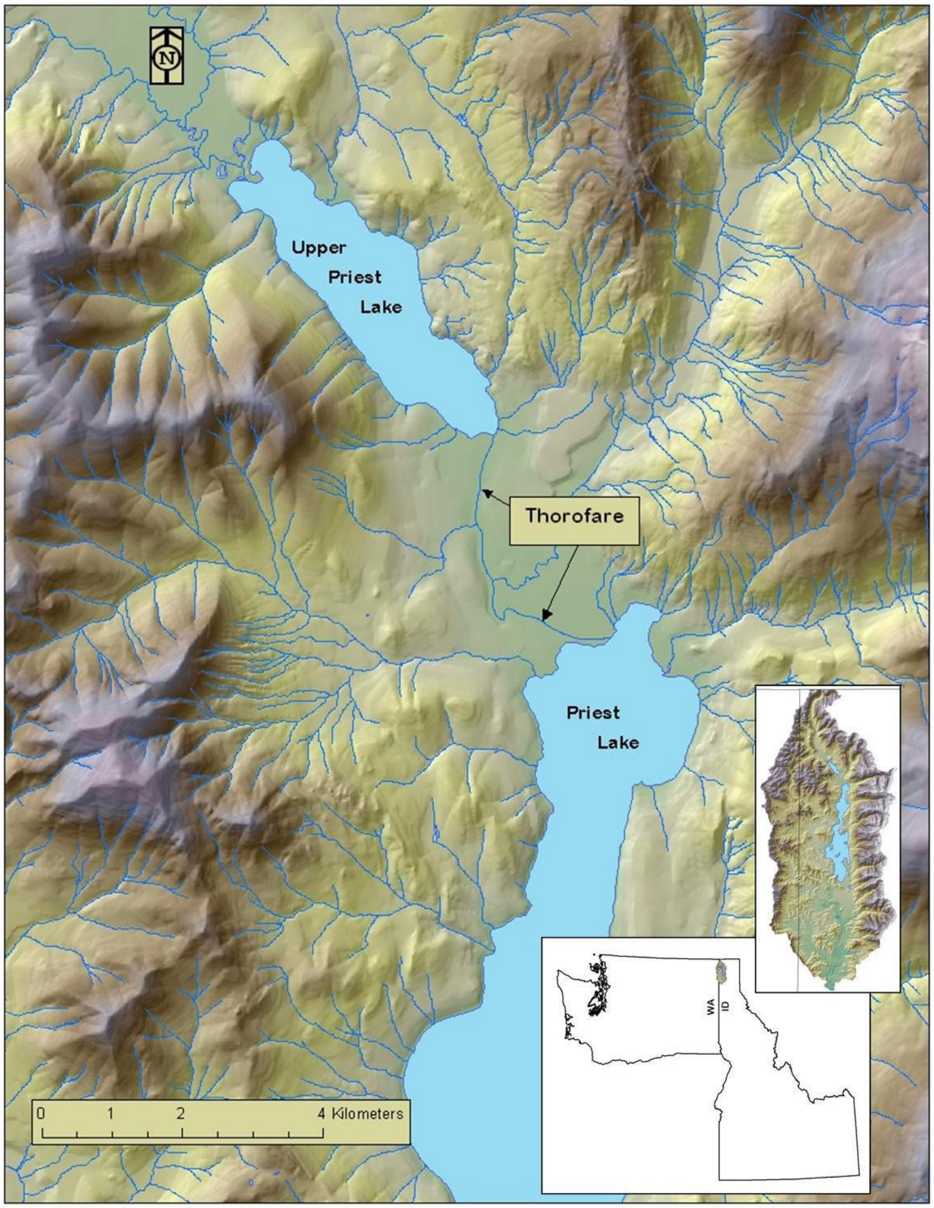

Figure 16. Map showing Idaho's Upper Priest Lake, Priest Lake and the Thorofare that connect the two lakes.

SECTION 3: NON-NATIVE AND INVASIVE FISH MANAGEMENT COORDINATION

3.1. Participation in Coordination Meetings and Forums on Invasive Species Issues

Introduction

As invasive fish species continue to expand in terms of localized population size and distribution, management becomes more complex and requires coordination amongst local, state, and regional management agencies. There are three primary non-native fish species that the Kalispel Tribe (Tribe) currently operates projects to manage against: Lake Trout, Brook Trout, and Northern Pike. All three have complex histories regarding stocking (illegal and legal), distribution, management, and threats to conservation of native fish species. Due to the varied nature surrounding the management of these species, it is critical that the Tribe engages in coordination and participation at a local and regional level on management issues.

Participation

During this contract cycle, biologists, managers, and directors of the Tribe's Natural Resources Department participated in a variety of coordination meetings, forums and events focused on invasive species management at both the local and regional level. Below is a table with many of the events and meetings in which Tribal staff participated from May 2020-April 2021 (Table 7). It should be noted that not all events are included in this table and that funding to attend and prepare for the events was not solely provided by this contract; many of the events were funded by various entities or contracts.

Table 8. Participation in events held on invasive species issues from May 2020-April 2021.

Event	Date
UCUT Fish Committee/Northern Pike Policy Planning	May 6, 2020
UCUT Fish Committee/Northern Pike Policy Planning	June 3, 2020
Washington Invasive Species Council	June 6, 2020
UCUT Fish Committee/Northern Pike Policy Planning	July 1, 2020
UCUT Fish Committee/Northern Pike Policy Planning	September 2, 2020
Washington Invasive Species Council	September 24, 2020
Western Invasive Species Council Partners Meeting	November 18, 2020
Salmon Recovery Funding Board Presentation	November 19, 2020
Washington Invasive Species Council	December 10, 2020
UCUT Regional Pike Forum Planning Meeting	December 17, 2020
UCUT Regional Pike Forum Planning Meeting	January 26, 2021
Annual WDFW/Kalispel Tribe Coordination-Northern Pike	February 11, 2021
UCUT Regional Northern Pike Forum	February 17, 2021
Pacific Salmon Commission's Okanagan Workgroup – Northern Pike	February 23, 2021
Washington Invasive Species Council	March 18, 2021
Regional Pike Forum Subgroup Planning Session	April 13, 2021
Regional Pike Forum Technical Workgroup	April 21, 2021
Pacific Salmon Commission's Okanagan Workgroup – Northern Pike	April 21, 2021

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Appendix A

Upper Mill Creek Project Area M_{YY} Brook Trout Genetics Report

Mill Creek M_{YY} Brook Trout Genetic report 2021

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Final Report, April 29, 2021

Introduction

Beginning in 2018, the Washington Department of Fish and Wildlife (WDFW), in cooperation with Kalispel Tribe Natural Resource Department (KNRD), initiated the stocking of M_{YY} Brook Trout into the Mill Creek Watershed (Figure 1) in support of on-going non-native Brook Trout suppression and eradication activities. The Mill Creek project is divided into two discrete segments: the Upper Project Area, which includes all waters upstream of and including Sylvis Creek (i.e., upper Mill Creek, Sylvis Creek, Nola Creek, UT 4), and the Lower Project Area which includes all waters downstream of Sylvis Creek to the partial natural barrier falls in mainstem Mill Creek at RKM 2.4 (i.e., lower Mill Creek, Wanless Creek, UT 1, UT 2, UT 3). Brook Trout suppression was initiated in the Upper Project Area in 2018, with annual M_{YY} Brook Trout releases beginning the same year (2018). The Lower Project Area suppression treatments began in 2019, with annual releases of M_{YY} Brook Trout initiated the following year (2020). Annual suppression treatments and M_{YY} Brook Trout releases are expected to continue in both project areas for a minimum of five years.

Annual genetic monitoring, beginning in 2020, will evaluate the impact of released M_{YY} Brook Trout on the existing Mill Creek Brook Trout population. The Mill Creek stocking and monitoring framework (Bean et al. 2019) will provide the general strategy for monitoring the Mill Creek Brook Trout population and outline the expectations for genetic evaluations. In this report, we characterize young-of-year (YOY) collected in 2020 from the Upper Mill Creek Project Area. We determined whether YOY were offspring of two naturalized Brook Trout or had a hatchery-origin M_{YY} Brook Trout parent by comparing their genotypes to those of the two potential parental populations. We determined the sex of the YOY to document and monitor potential changes to the sex ratio for future YOY collections.

Methods

Genomic DNA was extracted from tissue samples using silica membrane kits (Macherey-Nagel). SNP genotypes at the Sfo_GTseq242 Brook Trout panel were generated with a GTseq protocol (Campbell et al. 2015): briefly, samples are subjected to an initial tailed, multiplex PCR reaction that adds sequencing primer sites to target DNA, in a second PCR reaction unique barcode DNA sequences are added to the target DNA (amplicon), barcoded amplicons are pooled and sequenced on a next-generation sequencer. Using the barcodes, perl scripts split pooled sample sequences into individual files and assemble the SNP genotypes for each individual. The SNP loci described by Whiteley (2018) were developed in a collaboration between Whiteley and IDFG (Matt Campbell and Ninh Vu). The SNP panel includes five sex ID loci (Sfo_356897_48 and Sfo_74221_58), SalveSDYU4sep15_GTseq, BrunelliSex_GTseq, SexyBrook_GTseq, as well as the locus Sfo_ImBringingSexyBrook.

The Brook Trout YOY genotypes were compared to the M_{YY} Brook Trout genotypes in a factorial correspondence analysis plot using the program GENETIX (Belkhir et al. 2004) as a first examination to estimate parentage. We estimated ancestry for the YOY in a STRUCTURE analysis (Pritchard et al. 2000) where we compared the naturalized Brook Trout and M_{YY} Brook Trout genepools. STRUCTURE conducts a Bayesian analysis to partition genotypes into genetic clusters that minimize Hardy-Weinberg Equilibrium and linkage-disequilibrium. With two genetic clusters, we hypothesized that the naturalized Brook Trout would occupy one cluster and the M_{YY} Brook Trout would occupy the other cluster and offspring of a naturalized Brook Trout and an M_{YY} Brook Trout would occupy both clusters. STRUCTURE outputs cluster membership values that can be plotted as a bar of color to view cluster membership: individuals that are pure naturalized Brook Trout would be one color, individuals that are M_{YY} Brook Trout would be another color and offspring between the two types would be roughly half of each color. We conducted 5 STRUCTURE runs with 50,000 burn-in runs (to move the analysis away from starting conditions) and 200,000 iteration runs and averaged the results. We estimated effective population sizes (Ne) for the naturalized Brook Trout collections using the linkage method implemented in LDNe (Waples and Do 2010) and calculated genetic statistics using GENEPOP (Rousset 2008) and GenAlEx (Peakall and Smouse 2012).

Results and Discussion

Samples and Genotyping

There were a few discrepancies between the collection data sheet and the number of samples in the envelopes submitted with the Upper Mill Creek samples. However, with discrepancies accounted for, we genotyped 469 samples (Table 1, see Supplementary Information for details). Genotyping was successful for nearly all samples; only one sample from Sylvis Creek (20ID0090) failed to amplify. On average, samples had about 94% genotypic data which provides sufficient information to genetically characterize the samples. However, 38 samples were missing the same 145 loci, were mostly homozygous at the loci where there was data, and they failed at all but one or two of the sex loci (summarized in Table 2). We suspected that these were likely Westslope Cutthroat Trout (WCT) YOY that were misidentified in the field (see Supplementary Data sheet for status of individual samples and Table 3). We plan to genotype a known WCT at the Brook trout loci and compare the genotypes of these suspected WCT to the known WCT to confirm species identity. The following loci amplified poorly in Brook Trout: sf002353_02AT, sf003018_09CT, sf004521_CG, Sfo_10042_6742, Sfo_11109_72991, Sfo_2112_21892, Sfo_3500_32686, Sfo_4439_37744, and Sfo_9909_66805. These loci also do not perform well for Brook Trout genotyped by Idaho Department of Fish and Game (IDFG) (personal comm. Thomas Delamos). In 67 of the 469 samples, there were differences among the five sex ID loci, usually where one locus out of three to five loci assigned as the opposite sex. The sex was assigned where there was a clear majority and was left unassigned for four individuals with equal numbers of male and female sex ID loci – those individuals appeared to be WCT YOY because they failed at the same loci as the other suspected WCT YOY.

We compared genotypes of the Mill Creek naturalized Brook Trout to genotypes of the M_{YY} Brook Trout (provided by Matt Campbell (IDFG)) in a factorial correspondence analysis (FCA) using GENETIX (Belkhir et al. 2004). The FCA creates axes that explain the maximum amount of genetic variation in the data set and then plots individuals within the space. The FCA showed that the YOY of naturalized Brook Trout occupy a different genetic space distinct from the M_{YY} Brook Trout (Figure 2). The probable offspring of mating between naturalized Brook Trout and M_{YY} Brook Trout were identified as YOY that were genetically midway between these two groups (Figure 2). Figure 2 also illustrates the distinction between the fish suspected to be WCT YOY and Brook Trout. Because the presence of the WCT YOY compressed the Brook Trout to the left side of the plot and obscured their differences, we conducted a second FCA without the suspected WCT YOY. The relationships between the naturalized Brook Trout, the M_{YY} Brook Trout, and the probable M_{YY} Brook Trout offspring are better viewed in Figure 3, which shows that the first axis captured nearly 10% of the genetic variation in the data set. The naturalized Brook Trout plotted to the right of axis 1, M_{YY} Brook Trout plotted to the left of axis 1, and probable M_{YY} Brook Trout offspring (N=90) plotted between the two clusters. All the probable M_{YY} Brook Trout offspring were males (see individual fish status on the Supplementary Information worksheet), which is expected for offspring of M_{YY} and F_{XX} fish (XX chromosome females) because the M_{YY} can only produce male offspring.

The STRUCTURE analysis showed a clear distinction between the gene pools of the naturalized Brook Trout and the M_{YY} Brook Trout and highlighted the YOY that appeared to have ancestry in both gene pools (Figure 4). There was a distribution of the YOY ancestry in the M_{YY} Brook Trout genetic cluster that ranged from near zero (0.005) to 0.619 (Figure 4 and see Supplementary Information for actual values). We compared these results to the FCA plot where some of the YOY plotted between the naturalized Brook Trout YOY and the M_{YY} Brook Trout clusters. For the YOY that plotted between the two clusters (naturalized Brook Trout and M_{YY}) in the FCA which were suspected to be M_{YY} offspring, average M_{YY} ancestry was 0.436 (2SD 0.177, range 0.259 to 0.612). While we initially hypothesized a $50_{naturalized}$:50_{Myy} ancestry for M_{YY} offspring, we suspect that because there is shared common ancestry between the Brook Trout gene pools, the estimated ancestry for the M_{yy} offspring is slightly skewed towards the naturalized gene pool. Because 2019 was the first year in which M_{YY} Brook Trout planted into Mill Creek were expected to spawn, there would be no possibility that the YOY collected in 2020 were the grand-offspring of a M_{YY} Brook Trout (expected ancestry $75_{naturalized}$:25_{Myy}). Thus, we concluded that YOY with at least 30% ancestry in the M_{YY} Brook Trout cluster were offspring of a mating between a naturalized Brook Trout and a M_{YY} Brook Trout (see STRUCTURE values in the Supplementary Information).

Although all calculated effective population sizes (Ne) were small, the Ne for the Upper Mill Creek collection was larger than for the other two tributaries (Table 4). The Ne was calculated without removing the M_{YY} Brook Trout offspring because they are part of the population; including them would increase linkage and reduce estimated Ne. The Upper Mill and Sylvis collections departed from Hardy-Weinberg equilibrium (HWE) expectations with deficits of heterozygotes (Table 4). There were a higher percentage of locus pairs in linkage disequilibrium (loci inherited together rather than independently) than expected by chance at the 5% level in all collections and when corrected to 0.5%, Upper Mill and Sylvis creek collections had higher linkage than expected by chance. This higher than expected linkage reflects the recent mixing of the naturalized Brook Trout and M_{YY} Brook Trout gene pools detected in the probable M_{YY} Brook Trout offspring collected in those tributaries (Table 2). Loci on the same chromosome are inherited together from each parent group. In the next generation the linkage starts to break up with recombination and random distribution of alleles to offspring. The Nola Creek collection departed from HWE expectations with excess heterozygotes, and no probable M_{YY} Brook Trout offspring were detected in Nola Creek. The allelic richness (average number of alleles per locus, corrected for different collection sizes) and heterozygosity were similar in the three collections (Table 4).

As this was the first year M_{YY} Brook Trout spawning contribution was expected, these samples will be the baseline for monitoring future changes in sex ratio and M_{YY} Brook Trout contribution. The proportion of YOY samples processed versus number collected was highly variable depending on the Sample Unit (SU; Table 3) and stream (Table 2). Due to this variability, estimating the cumulative percentage of male offspring for the individual streams or project based solely on the genotyped samples, would likely artificially skew the values. Considering this, we used the calculated percent male values for individual SU's (Table 3) to estimate the number of male YOY Brook Trout we could expect from the total collected. Summing this value for the collective SU's in each stream, we were able to estimate the percentage of YOY which were males (38, 50, and 71% in upper Mill, Nola and Sylvis creeks, respectively; Table 2). This is likely a conservative value that is most accurate in streams where we genotyped a high proportion of YOY collected (i.e., Sylvis and Nola creeks; 76 and 79%, respectively; Table 2, Figures 5 and 6). In some SU's in upper Mill Creek, abundant YOY were collected, but only a small proportion were genotyped (e.g., MC3-01 through MC3-06 and MC3-20; Table 2, Figure 5). Results indicate that the estimated percentage of males in those SU’s may be skewed downward. Conversely, these SU’s may actually have been composed of predominantly female fish. To account for this uncertainty, the future sampling protocol will target an increased proportion of YOY tissue samples for genetic analysis from these SU’s (30% of YOY collected will be genotyped), providing increased confidence in the estimated sex ratio.

Conclusion

Results demonstrate that M_{YY} Brook Trout released within the Upper Mill Creek Project Area have been mating successfully with the naturalized Brook Trout in Upper Mill and Sylvis creeks. Successful spawning in these two streams also appears to be broadly distributed, with M_{YY} offspring detected in 45 of 63 SU’s (71.4%) sampled. The sex ratio already appears to be skewing towards males in Sylvis Creek and specific SU’s within upper Mill Creek. We suspect that the sample size from Nola Creek was too small to detect probable M_{YY} Brook Trout offspring due to low overall abundance of Brook Trout in that stream compared to Upper Mill and Sylvis creeks.

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Figures and Tables

Figure 1. Map of project area. YOY genetic samples processed in 2020 were limited to the Upper Mill Creek Project Area.

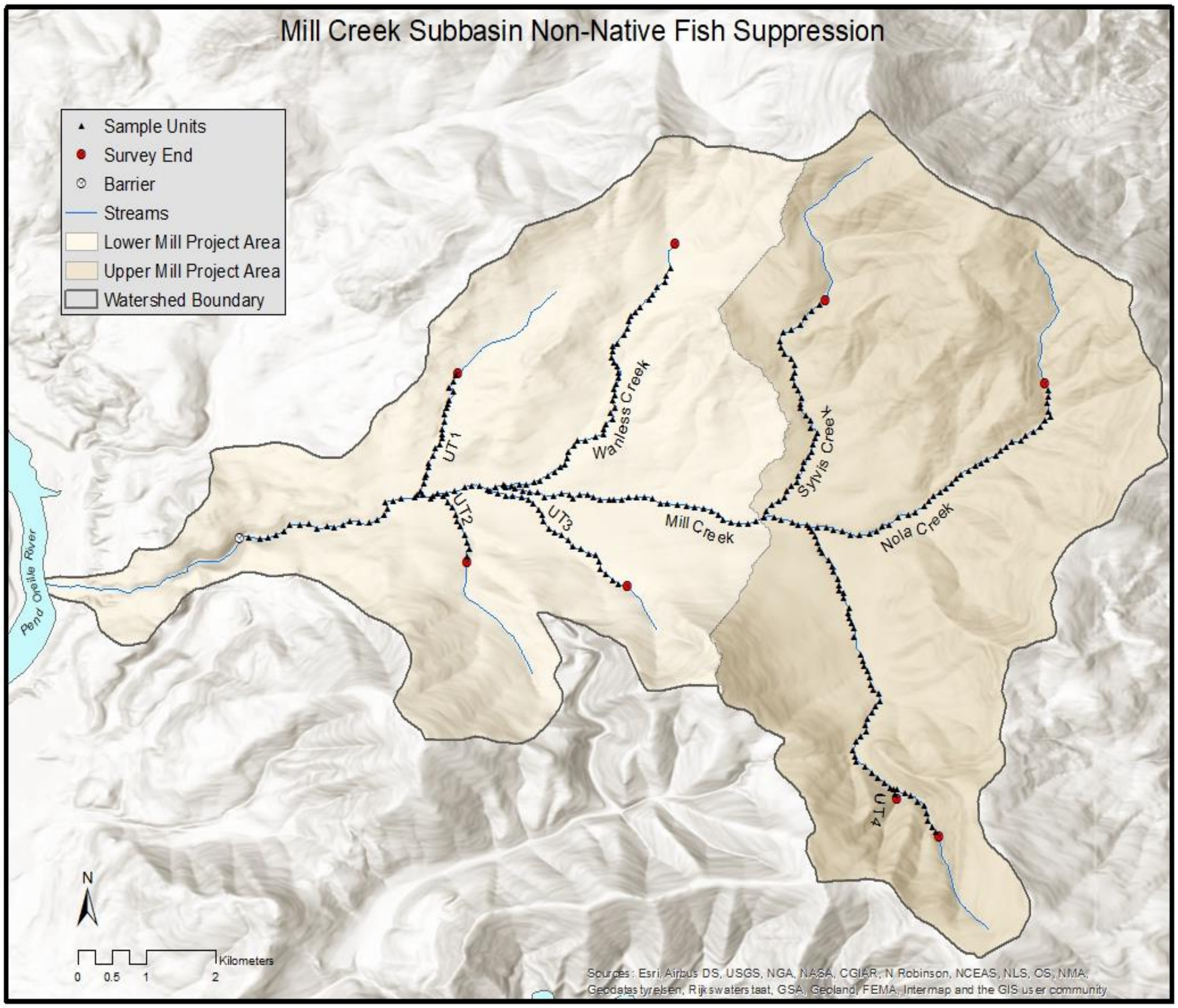

Figure 2. A factorial correspondence analysis (FCA) plot in three dimensions MYY Brook Trout, Mill Creek naturalized Brook Trout, and YOY: samples that appeared to be YOY Westslope Cutthroat Trout are circled and identified in the upper right corner.

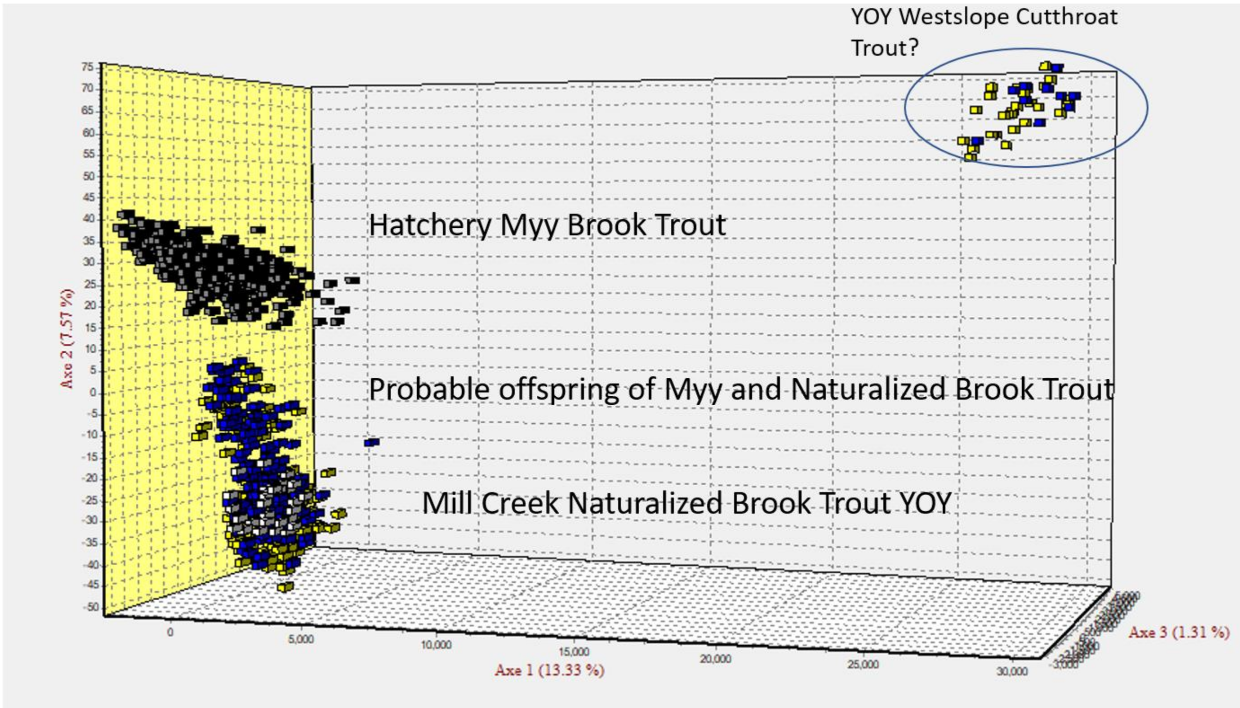

Figure 3. A two-dimensional FCA plot excluding the "Westslope Cutthroat Trout YOY" in Figure 2. The circled individuals in the center of the plot, labeled "All males" were the YOY from Upper Mill and Sylvis that were probable MYY offspring. The circle is to highlight this group of samples.

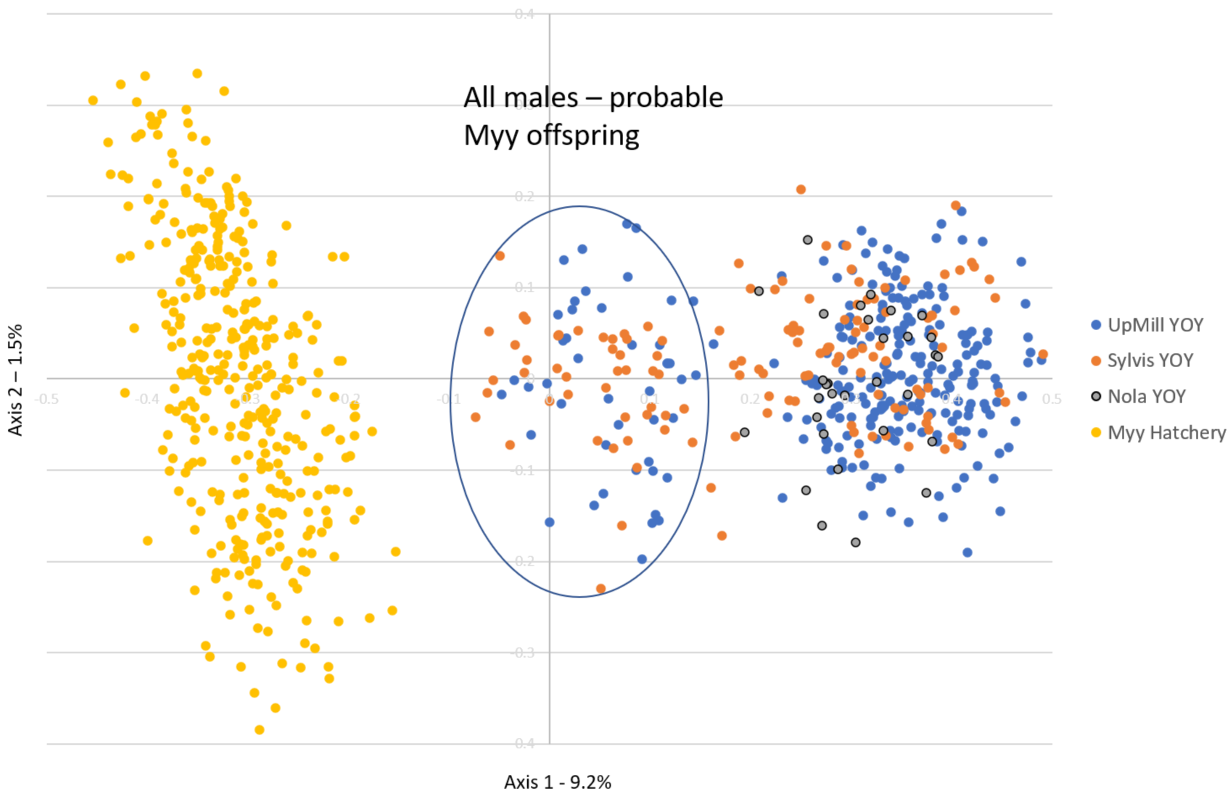

Figure 4. STRUCTURE plot of ancestry values for YOY Brook Trout collected in the Upper Mill Creek Project tributaries compared to MYY Brook Trout ("hatchery_Myy"). The orange color represents the gene pool of the naturalized Brook Trout population in Mill Creek and tributaries and the blue color represents the gene pool of the MYY Brook Trout.

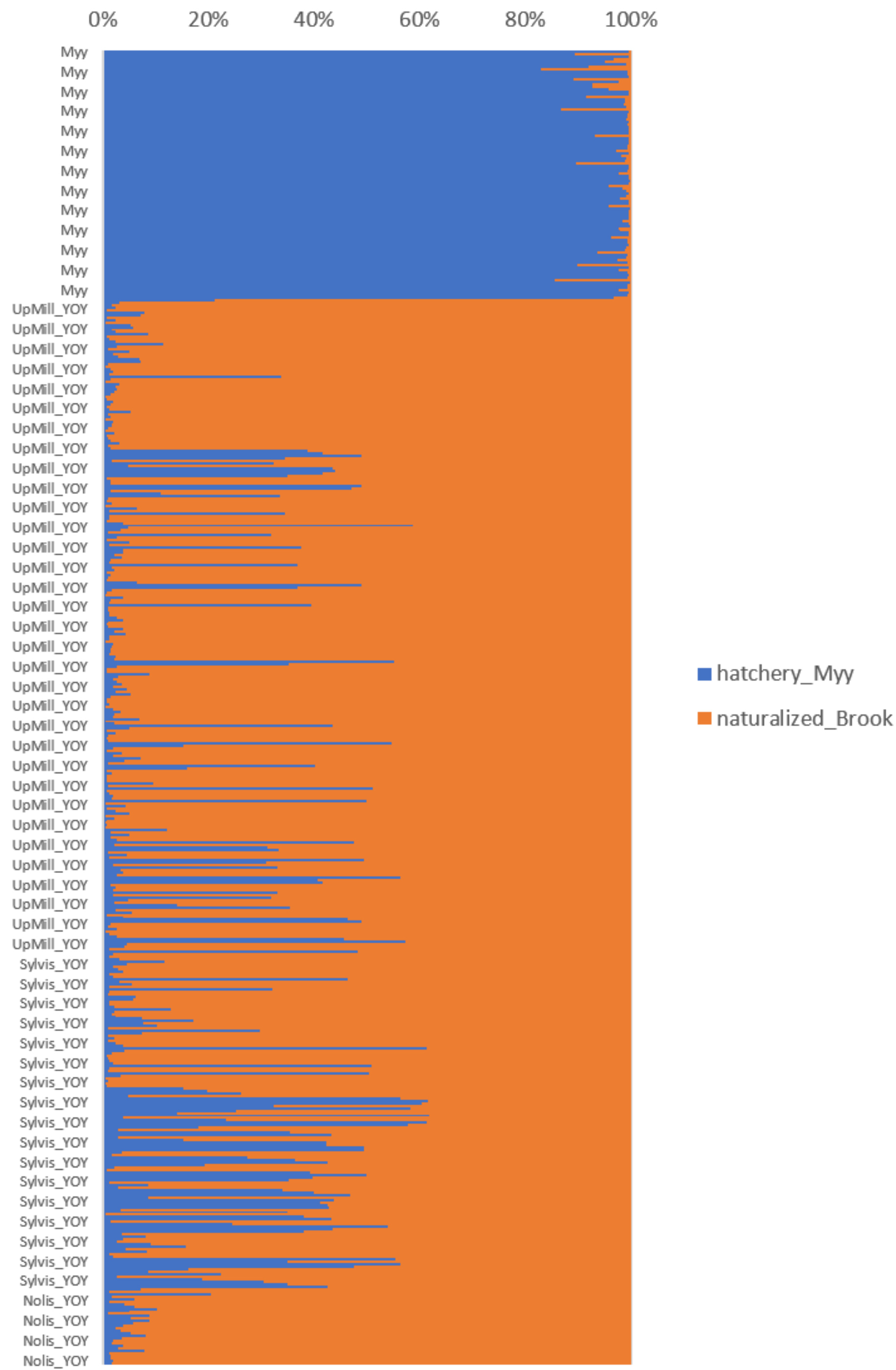

Figure 5. Distribution by Sample Unit of percent male YOY (grey bars) and percent of total YOY samples collected that were genotyped (light grey area) for Sylvis Creek. Dashed black line indicates the weighted percentage of males in the sample collection.

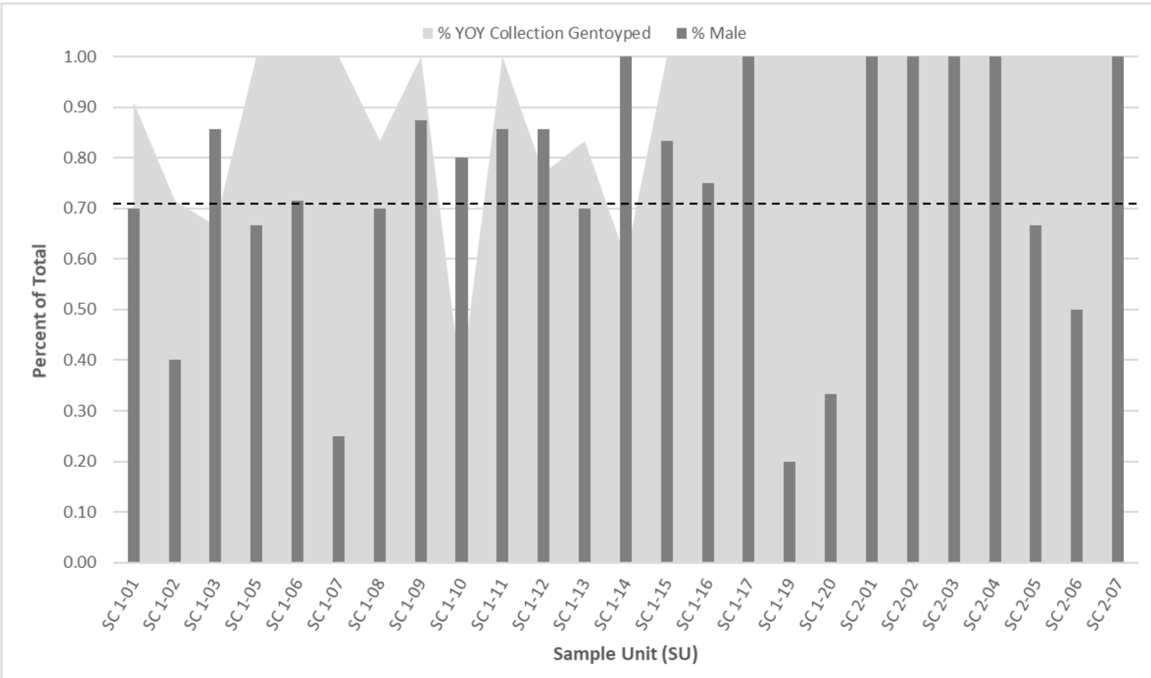

Figure 6. Distribution by Sample Unit of percent male YOY (grey bars) and percent of total YOY samples collected that were genotyped (light grey area) for Nola Creek. Dashed black line indicates the weighted percentage of males in the sample collection.

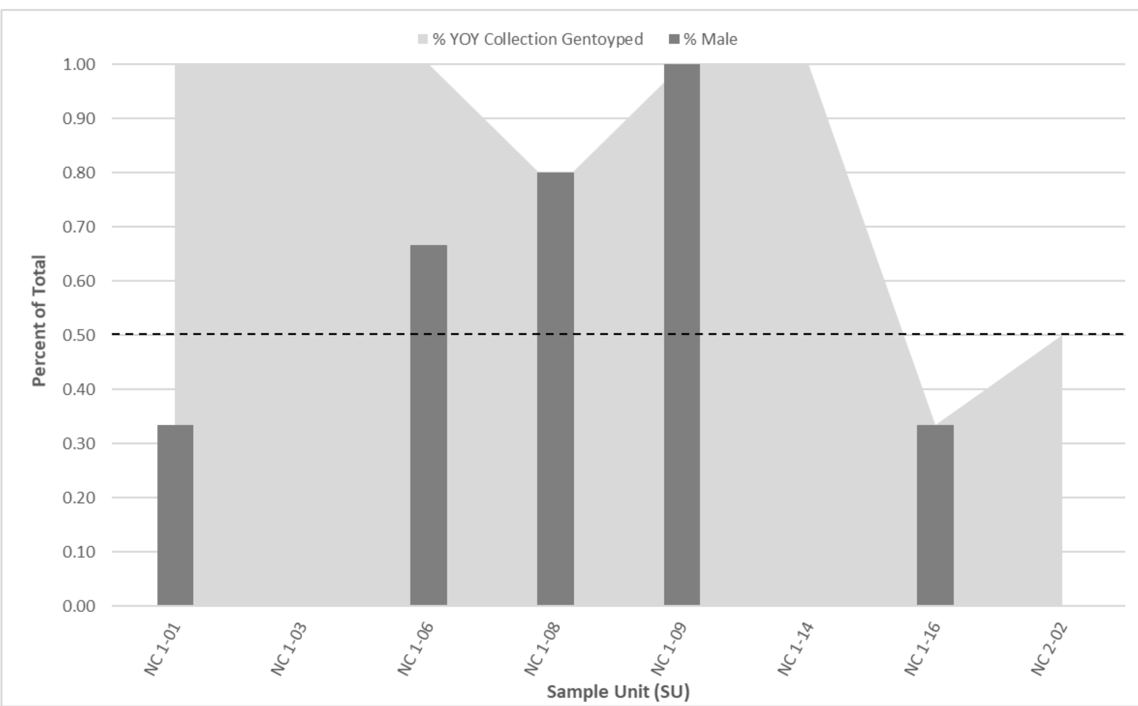

Figure 7. Distribution by Sample Unit of percent male YOY (grey bars) and percent of total YOY samples collected that were genotyped (light grey area) for upper Mill Creek. Dashed black line indicates the weighted percentage of males in the sample collection.

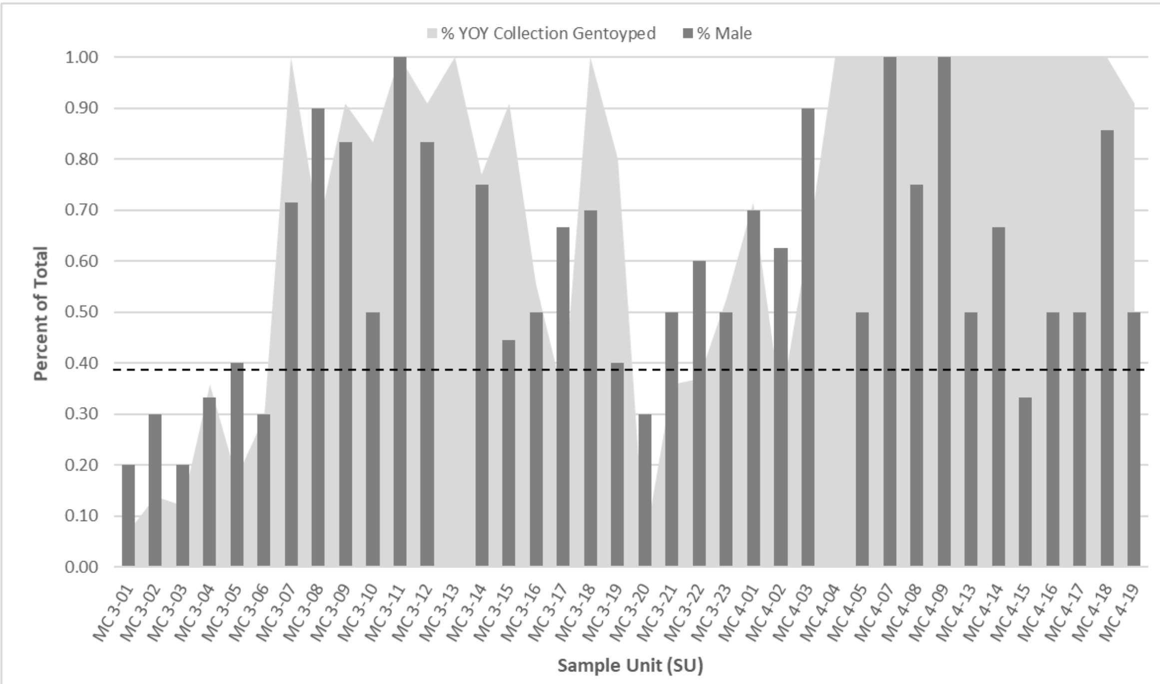

Table 1. The number of YOY Brook Trout samples collected in 2020 from the Upper Mill Creek Project Area and genotyped in 2021 for the MYY Brook Trout project.

Collection (Stream)	Code	N
Upper Mill Creek	20IB	295
Nola Creek	20IE	31
Sylvis Creek	20ID	142

Table 2. Summary of YOY samples collected by stream in the Upper Mill Creek Project Area in 2020. “MYY Offspring” are males from the “Male” column that were probable offspring of MYY males based on the FCA and STRUCTURE analyses. “WCT” were samples that failed at the same 145 loci, as well as all but one or two of the sex loci, and appeared to be Westslope Cutthroat Trout YOY based on their genotypes, the FCA, and knowledge of species composition in the tributaries. “Weighted % Male” and “Weighted % MYY Offspring” are expanded estimates based on genetic analysis for a subsample of YOY collected in each SU and accounting for removal of WCT. See Supplementary Information for details of individual fish status.

Stream (SU)	YOY Collected	YOY Genotyped	% YOY Genotyped	Female	Male	WCT	Weighted % Male	M_{YY} Offspring	Weighted % M_{YY} Offspring
Upper Mill (MC 3-01 to 4-19)	996	295	0.30	123	144	28	0.38	45	0.06
Nola (NC 1-01 to 2-02)	41	31	0.76	15	16	0	0.50	0	0.00
Sylvis (SC 1-01 to 2-07)	180	143	0.79	40	93	10	0.71	45	0.38
Grand (Project) Total	1217	469	0.39	178	253	38	0.43	90	0.10

Table 3. Summary of YOY samples collected by Sample Unit (SU) for the Upper Mill Creek Project Area in 2020. See Supplementary Information for data.

SU	YOY Collected	% YOY Processed	Total	Female	Male	WCT YOY	Myy_ offsp	% Male	SU	YOY Collected	% YOY Processed	Total	Female	Male	WCT YOY	Myy_ offsp	% Male
MC 3-01	145	0.07	10	8	2			0.20	**MC 4-18**	7	1.00	7	1	6		2	0.86
MC 3-02	72	0.14	10	7	3			0.30	**MC 4-19**	11	0.91	10	5	5		3	0.50
MC 3-03	83	0.12	10	8	2			0.20	**NC 1-01**	9	1.00	9	6	3			0.33
MC 3-04	28	0.36	10	6	3	1	1	0.33	**NC 1-03**	2	1.00	2	2				0.00
MC 3-05	57	0.18	10	6	4			0.40	**NC 1-06**	3	1.00	3	1	2			0.67
MC 3-06	34	0.29	10	7	3			0.30	**NC 1-08**	13	0.77	10	2	8			0.80
MC 3-07	8	1.00	8	2	5	1	4	0.71	**NC 1-09**	2	1.00	2		2			1.00
MC 3-08	15	0.67	10	1	9		6	0.90	**NC 1-14**	1	1.00	1	1				0.00
MC 3-09	11	0.91	10	1	5	4	2	0.83	**NC 1-16**	9	0.33	3	2	1			0.33
MC 3-10	12	0.83	10	2	2	6		0.50	**NC 2-02**	2	0.50	1	1				0.00
MC 3-11	6	1.00	6		1	5	1	1.00	**SC 1-01**	11	0.91	10	3	7		1	0.70
MC 3-12	11	0.91	10	1	5	4	1	0.83	**SC 1-02**	14	0.71	10	6	4		1	0.40
MC 3-13	2	1.00	2	2				0.00	**SC 1-03**	15	0.67	10	1	6	3		0.86
MC 3-14	13	0.77	10	2	6	2	2	0.75	**SC 1-05**	3	1.00	3	1	2		1	0.67
MC 3-15	11	0.91	10	5	4	1	1	0.44	**SC 1-06**	7	1.00	7	2	5		1	0.71
MC 3-16	18	0.56	10	5	5		2	0.50	**SC 1-07**	4	1.00	4	3	1			0.25
MC 3-17	12	0.33	4	1	2	1	1	0.67	**SC 1-08**	12	0.83	10	3	7		2	0.70
MC 3-18	10	1.00	10	3	7			0.70	**SC 1-09**	8	1.00	8	1	7		4	0.88
MC 3-19	25	0.80	20	12	8		2	0.40	**SC 1-10**	28	0.36	10	2	8		4	0.80
MC 3-20	242	0.04	10	7	3			0.30	**SC 1-11**	7	1.00	7	1	6		5	0.86
MC 3-21	28	0.36	10	5	5		1	0.50	**SC 1-12**	13	0.77	10	1	6	3	3	0.86
MC 3-22	27	0.37	10	4	6		1	0.60	**SC 1-13**	12	0.83	10	3	7		4	0.70
MC 3-23	19	0.53	10	5	5		1	0.50	**SC 1-14**	5	0.60	3		3		3	1.00
MC 4-01	14	0.71	10	3	7		2	0.70	**SC 1-15**	6	1.00	6	1	5		4	0.83
MC 4-02	31	0.32	10	3	5	2		0.63	**SC 1-16**	8	1.00	8	1	3	4	3	0.75
MC 4-03	16	0.63	10	1	9		3	0.90	**SC 1-17**	4	1.00	4		4		2	1.00
MC 4-04	1	1.00	1	1				0.00	**SC 1-19**	5	1.00	5	4	1		1	0.20
MC 4-05	2	1.00	2	1	1			0.50	**SC 1-20**	6	1.00	6	4	2			0.33
MC 4-07	3	1.00	3		2	1	2	1.00	**SC 2-01**	1	1.00	1		1		1	1.00
MC 4-08	4	1.00	4	1	3		1	0.75	**SC 2-02**	1	1.00	1		1		1	1.00
MC 4-09	4	1.00	4		4		3	1.00	**SC 2-03**	1	1.00	1		1		1	1.00
MC 4-13	2	1.00	2	1	1			0.50	**SC 2-04**	1	1.00	1		1		1	1.00
MC 4-14	3	1.00	3	1	2		1	0.67	**SC 2-05**	3	1.00	3	1	2			0.67
MC 4-15	3	1.00	3	2	1		1	0.33	**SC 2-06**	4	1.00	4	2	2		1	0.50
MC 4-16	2	1.00	2	1	1		1	0.50	**SC 2-07**	1	1.00	1		1		1	1.00
MC 4-17	4	1.00	4	2	2			0.50	*Grand Total*	*1217*		*469*	*178*	*253*	*38*	*90*	

Table 4. Genetic statistics for Upper Mill Creek tributaries YOY collections including allelic richness (Arich), average heterozygosity over all loci, Hardy-Weinberg Equilibrium (HWE) value as expressed by FIS and p values for tests for departures from HWE with heterozygote (het) deficit and excess, the percentage of locus pairs in linkage with uncorrected p value (0.05) and with p value corrected to 0.005, and effective population size calculated with linkage disequilibrium method (LDNe) and 95% confidence interval.

	A_{rich}	Heterozygosity	F_{IS}	p het deficit	p het excess	% link $p < 0.05$	% link $p < 0.005$	LDNe	low	high
20UpMill	1.65	0.3737	0.0255	0	1	15.1	3.9	31.7	30.9	32.5
20Sylvis	1.64	0.3692	0.0209	0	0.9999	19.0	5.3	22.9	22.2	23.6
20Nola	1.62	0.3635	-0.0393	0.9852	0.0149	8.9	1.4	23.9	21.9	26.1

Appendix B

Upper Priest Lake Lake Trout Management Report

Completion Report for USFWS Grant Award #F19AP00390

ABSTRACT

Upper Priest Lake is currently managed for the conservation of native species. In support of this objective, removal of non-native Lake Trout *Salvelinus namaycush* has occurred since 1998. In 2020, gill nets were used to remove 2,726 Lake Trout during a nine-day period from May 13 to May 21. Average daily catch rate from standard gill net mesh sizes was 10.2 fish/box (± 3.0, 80% C.I.), which was similar to recent years. Lake Trout length varied from 117 mm to 1026 mm. The incidental Bull trout *Salvelinus confluentus* catch rate (0.08/box) was below average when compared to the previous ten year period. Trend data suggest that Lake Trout abundance remained stable and low, supporting continuation of removal efforts to benefit native fishes in Upper Priest Lake.

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INTRODUCTION

Native fishes, including Bull Trout *Salvelinus confluentus* and Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi,* played an important role in the history of Priest and Upper Priest lake fishing. Historically, Bull Trout provided a harvest-oriented trophy fishery in Priest and Upper Priest lakes (Bjornn 1957). However, harvest opportunities were discontinued in 1984 following declines in Bull Trout abundance. Although the influence of fishing mortality on the population was removed, a positive population response did not occur (Mauser et al. 1988). Today, the Bull Trout population in Upper Priest Lake is considered depressed while the population in Priest Lake is considered functionally lost (DuPont et al. 2007). Native Westslope Cutthroat Trout were also historically abundant in Priest Lake and Upper Priest lakes and provided the primary fishery in both lakes prior to the 1950's (Mauser et al. 1988). Westslope Cutthroat Trout harvest opportunities were closed in 1988, following a perceived decline in overall abundance. Overharvest, interspecific competition, predation, and degradation of spawning habitat were all believed to contribute to the decline of native fish in this system.

Although multiple factors have likely influenced the abundance of native fishes in Priest and Upper Priest lakes, increasing Lake Trout *Salvelinus namaycush* abundance was the primary cause of population-scale changes in native fish communities. Lake Trout, where introduced as a non-native sport fish, are often linked to negative responses in other native and non-native species through predation and/or competition (Martinez et al. 2009). In Upper Priest Lake, Lake Trout were not known to be abundant until the late 1990's (Fredericks 1999). By 1998, Lake Trout abundance in Upper Priest Lake was estimated to be 859 fish (Fredericks 1999). At that time, fishery managers were concerned that native fish communities in Upper Priest Lake were at risk.

Native fish conservation has been an ongoing management focus on Upper Priest Lake. In an effort to reduce the potential impacts of Lake Trout on native fish populations in Upper Priest Lake, the Idaho Department of Fish and Game (IDFG) began a Lake Trout removal program in 1998. Gill nets have been used annually to remove Lake Trout and reduce their abundance in the lake. Commercial-scale gillnetting equipment, operated by a contractor, has been used since 2006. This transition in technique dramatically increased annual fishing effort. These management efforts have removed between 150 and 5,000 Lake Trout annually from Upper Priest Lake (Fredericks et al. 2013). In 2020, we continued Lake Trout reduction efforts in Upper Priest Lake with the intent of benefiting native fish species.

OBJECTIVE

Conserve native fish populations in Upper Priest Lake by maintaining low Lake Trout abundance.

STUDY SITE

Upper Priest Lake is located approximately 21 kilometers (km) south of the Idaho British Columbia border in the northwest corner of the Idaho Panhandle. It is a glacial lake that has roughly 13 km of shoreline, a surface area of 566 hectares (ha), a maximum depth of approximately 31 meters (m) and a maximum surface temperature of approximately 21°C. The lake is bathtub-shaped with steep shoreline slopes and a flat bottom. Upper Priest and Priest lakes are held at 743 m elevation from the end of spring runoff until mid-October, which is controlled by a low-head dam located at the outlet of Priest Lake. Upper Priest Lake is connected to Priest Lake by a channel known as the Thorofare. The Thorofare is roughly 3.2 km long, 70 m wide and 1.5-3 m deep at summer pool. At low pool, water depth in the Thorofare outlet is < 0.15 m and prohibits most boat passage.

METHODS

In 2020, we completed Lake Trout removal in Upper Priest Lake between May 13 and May 21. Hickey Brothers Research, LLC was contracted to provide equipment and labor for completion of the project. An 11 m commercial gill net boat was used to complete removal efforts. Funding for completion of the Lake Trout removal effort was provided by the United States Fish and Wildlife Service (USFWS), Kalispel Tribe, and Idaho Department of Fish and Game.

We used monofilament sinking gill nets to capture and remove Lake Trout from Upper Priest Lake. Individual gill net dimensions were 91 m long by 2.7 m high. Multiple nets were tied together end-to-end to create a single net gang. Collectively, the net gang was comprised of a range of mesh sizes. Standardized mesh sizes (stretch-measure) were 45, 51, 64, 76, 89, 102, 114, and 127 mm (Table 1). Fishing effort was measured in units defined as net boxes. Boxes were used to transport nets onboard the boat and each box of net was equivalent to approximately 273 m or three 91 m nets. Daily effort was split between morning and afternoon sets. The combined effort per day was 30 boxes of gill net. A total of 240 boxes of gill net was placed over nine days. Both morning and afternoon sets were made on each day, except the first and last days during which only one set was made on each date. The combined total effort for the first and last day was 30 boxes of net. Typically, 18 boxes of net were set in the morning and 12 boxes of net were set in the afternoon. The combined effort by mesh size was consistent within morning and afternoon sets, respectively. The time between net placement and initiating net lifting varied from two to five hours for all sets. Gill nets were set throughout Upper Priest Lake over the course of the project at depths varying from 10 m to 31 m. Placement of nets in and around the primary inlets and outlet of Upper Priest Lake was avoided to reduce bycatch of Bull Trout and Westslope Cutthroat Trout.

Relative abundance of Lake Trout in Upper Priest Lake was measured as average daily catch per unit of effort (CPUE) or fish per net box per day for catch associated with 51, 64, and 76 mm gill net mesh sizes. These mesh sizes were selected as standards because they represented the longest time series of mesh sizes fished during Upper Priest Lake removal efforts. We compared these standardized catch rates to prior years to evaluate trends in abundance. We only used data from 2010 to 2020 because catch by mesh was not recorded prior to 2010. We calculated 80% confidence bounds around estimates of average daily catch rate and used those bounds to infer differences in catch rate between years. We also evaluated change in size structure of the Lake Trout catch using catch rate from individual gill net mesh sizes. Lake Trout length was found to generally increase with gill net mesh size (Ryan et al. 2014) suggesting mesh-specific catch rates provide a relative measure of size-specific abundance. We compared meshspecific catch rates from 2014 and 2020. Prior to 2014, a standard set of mesh sizes was not used and limited complete comparisons with prior years.

All Lake Trout caught during netting efforts were measured for total length (mm) and examined for marks. A portion of the Lake Trout catch greater than 400 mm were cleaned, packed on ice, and distributed to local food banks. Remaining Lake Trout were dispatched and returned to the lake because of logistical challenges with food bank distribution.

Bycatch of non-target species associated with the removal effort was recorded and fish were released if alive. Total length and condition were collected from all Bull Trout. Bull Trout condition was ranked from zero to three, with zero representing mortality and three representing excellent condition. We reported Bull Trout catch rate as the average of daily catch per unit of effort or fish per net box per day among all mesh sizes and compared catch rates from 2007 to 2020. Variance around catch rate estimates was described using 80% confidence bounds. Confidence bounds were only estimated for years during which standardized gill net effort and mesh were used (i.e., 2014-2020). A passive integrated transponder (PIT) tag was inserted into the dorsal sinus of each live released Bull Trout. Future recaptures will be used to generally describe recapture rates and survival of Bull Trout encountered in netting efforts over time.

RESULTS

We caught 2,726 Lake Trout during the nine-day gillnetting effort. Average daily catch rate from 51, 64, and 76 mm mesh sizes was 10.2 fish/box (± 3.0, 80% C.I.; Figure 1) and continued to demonstrate a long term negative trend. Mesh-specific catch rates differed from those observed in 2019. Increased catch rates in 89 mm and 102 mm mesh sizes represented the most dramatic changes observed in 2020 (Figure 2).

Total length of Lake Trout varied from 117 mm to 1026 mm and averaged 461 mm (Figure 3). In general, fish length increased with increasing gill net mesh size (Table 1). Catch rates were greatest in 45 and 89 mm mesh sizes and accounted for 57% of the total catch. However, these mesh sizes only represented 27% of total effort expended.

Incidentally caught species included Bull Trout, kokanee *Oncorhynchus nerka*, Longnose Sucker *Catostomus catostomus*, Largescale Sucker *C. macrocheilus*, Northern Pikeminnow *Ptychocheilus oregonensis*, Peamouth *Mylocheilus caurinus* and Westslope Cutthroat Trout. We caught 21 Bull Trout, representing an average daily catch rate of 0.08 fish per box of net. This catch rate was below the average rate observed over the previous ten years (0.16 Bull Trout per box, Figure 4). Bull Trout total length varied from 238 mm to 795 mm and averaged 488 mm. The majority of Bull Trout caught in gill nets were in good or fair condition upon capture. These fish were PIT tagged and released. Direct mortality of bycaught Bull Trout in gill nets was 29%.

DISCUSSION

Gill net catch rates of Lake Trout from Upper Priest Lake removal efforts suggest Lake Trout relative abundance remained low in 2020. The long-term trend in standard meshes continued to be negative. In addition, short-term (i.e., 2014 to present) catch rates in the broader collection of mesh sizes were generally stable.

Although Lake Trout catch rate reflected stability in relative abundance overall, we detected higher catch in 89 and 102 mm mesh sizes. Mesh-specific catch rates provide insight into fine-scale changes in the Lake Trout population. However, identifying a specific cause for minor shifts in mesh-specific catch rates is difficult. We hypothesize potential causes may include immigration, influences on catchability due to growth within a cohort, seasonal influences on catchability (e.g., water temperature), or random catch rate fluctuation. Immigration of Lake Trout from Priest Lake to Upper Priest Lake is known to occur (Fredericks and Venard 2001) and has been assumed to be a factor influencing Lake Trout abundance in Upper Priest Lake at some level.

Our data indicate that native fishes have benefited from maintenance of reduced Lake Trout abundance in Upper Priest Lake. For example, Bull Trout redd counts in Upper Priest Lake tributaries demonstrate an increasing population trend (Ryan et al., *In preparation*). This example not only suggests that Lake Trout removal efforts are beneficial to Bull Trout, but that bycatch related mortality associated with the use of gill nets in this project is also inconsequential relative to the benefits. Although evidence exists to suggest native fish populations have benefited, Bull Trout catch rate in our netting effort was low relative to catch rate in some previous years. This inconsistency highlights a need to cautiously interpret Bull Trout catch rates resulting from a single spring gillnetting effort. A number of environmental variables may influence Bull Trout catch rates during this period. In addition, gill nets set during the Lake Trout removal efforts are specifically avoided in some areas of Upper Priest Lake with the intent of minimizing Bull Trout bycatch.

Lake Trout presence in Upper Priest Lake is the primary limiting factor relative to the conservation of native species. Currently, catch rates suggest the Lake Trout population in Upper Priest Lake remains low and suppression efforts are successfully preventing population growth. Concurrent to Lake Trout suppression, Bull Trout have exhibited an increasing population trend. Therefore, the negative impacts that Lake Trout pose to native species are being minimized. As such, we recommend continuation of Lake Trout removal efforts in Upper Priest Lake as a tool for conserving native fishes.

RECOMMENDATIONS

1. Continue annual gillnetting at existing effort levels on Upper Priest Lake to conserve native fishes.

TABLES

Table 1. Gill net effort and Lake Trout (LKT) catch by gill net mesh size in Upper Priest Lake, Idaho during 2020. Size of Lake Trout by mesh size is depicted as average total length (Avg TL) and standard deviation (SD TL) of total length.

Mesh (mm)	Effort (m)	% of Total Effort	LKT Caught	LKT/Box	Avg TL	SD TL
45	13167	20%	658	13.7	377	133
51	13167	20%	604	12.6	421	125
64	13167	20%	483	10.1	474	81
76	4389	7%	134	8.4	506	88
89	4389	7%	331	20.7	517	54
102	8778	13%	379	11.8	541	66
114	4389	7%	99	6.2	585	73
127	4389	7%	38	2.4	628	133

FIGURES

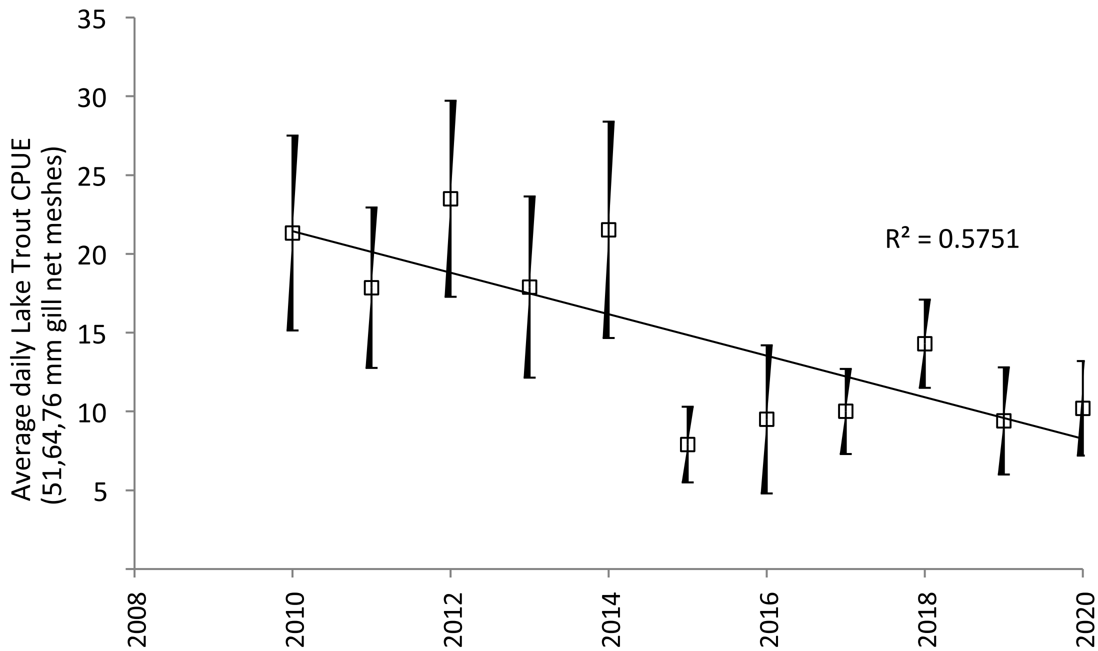

Figure 1. Average daily Lake Trout catch rates and 80% confidence intervals by year from combined standard gill net mesh sizes (51, 64, and 76 mm) fished in Upper Priest Lake, Idaho from 2010 through 2020.

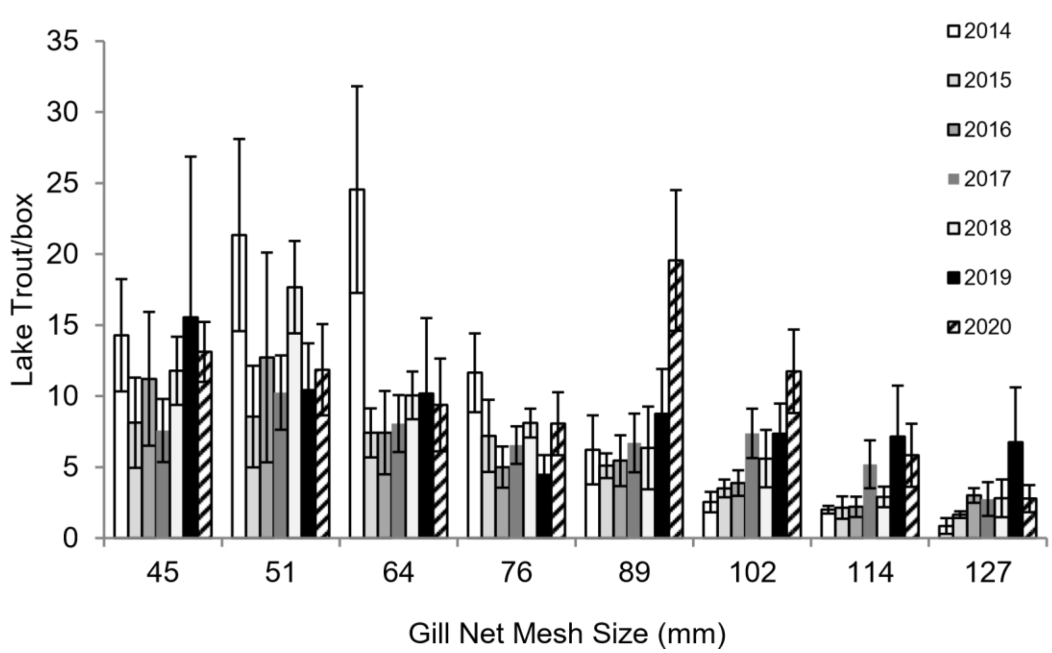

Figure 2. Average daily Lake Trout catch rate (Lake Trout/box) and 80% confidence intervals by mesh size from all standardized gill nets fished in Upper Priest Lake, Idaho from 2014 through 2020.

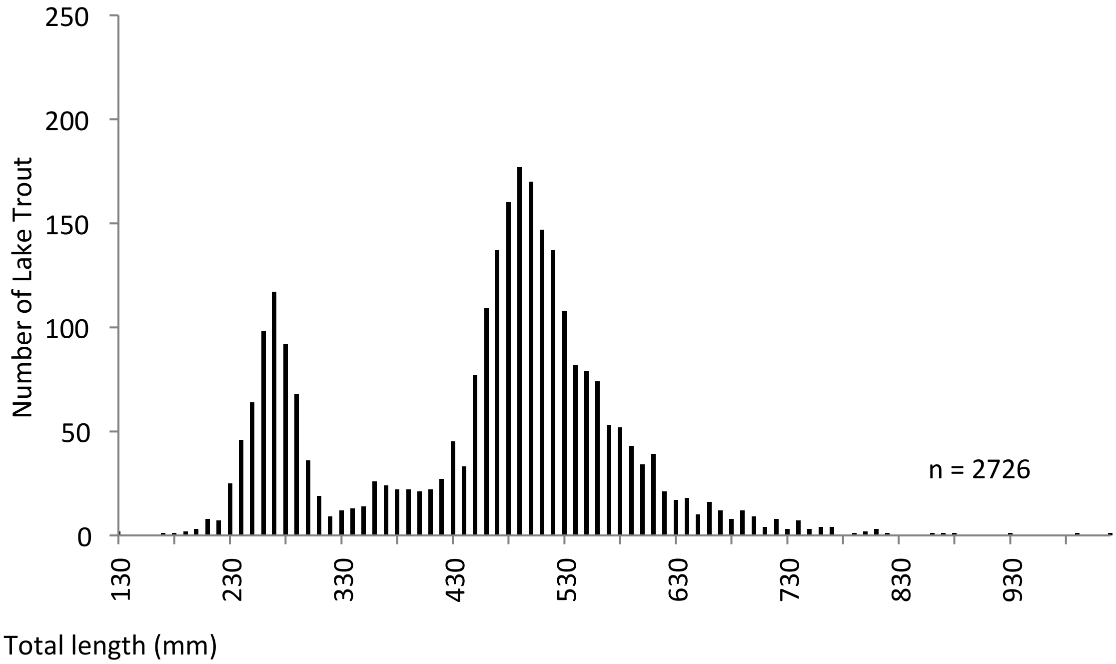

Figure 3. Size structure of Lake Trout sampled in Upper Priest Lake, Idaho during 2020.

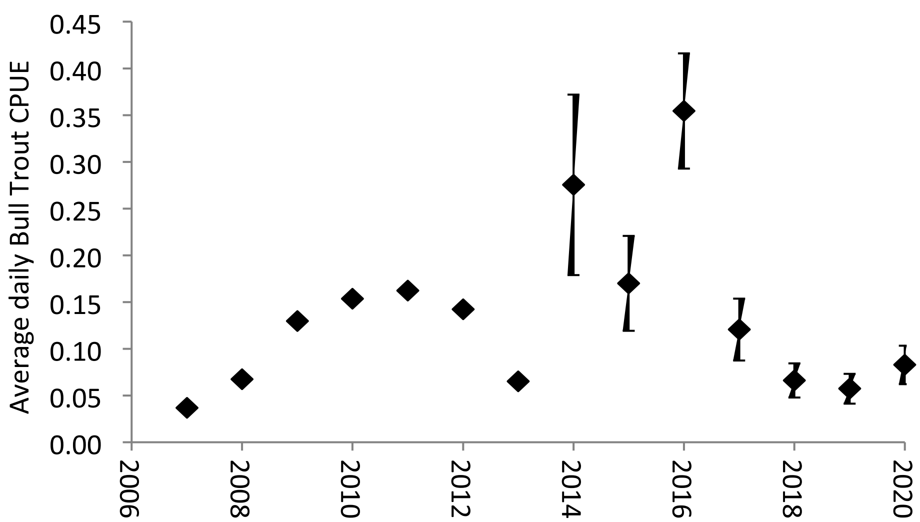

Figure 4. Average daily Bull Trout catch rate (Bull Trout/box) and 80% confidence intervals from all gill net mesh sizes fished in Upper Priest Lake, Idaho from 2007 through 2020. Confidence intervals were only estimated for years in which gill nets mesh and effort were standardized.

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Appendix C

Upper Priest River and Tributaries Bull Trout Redd Counts

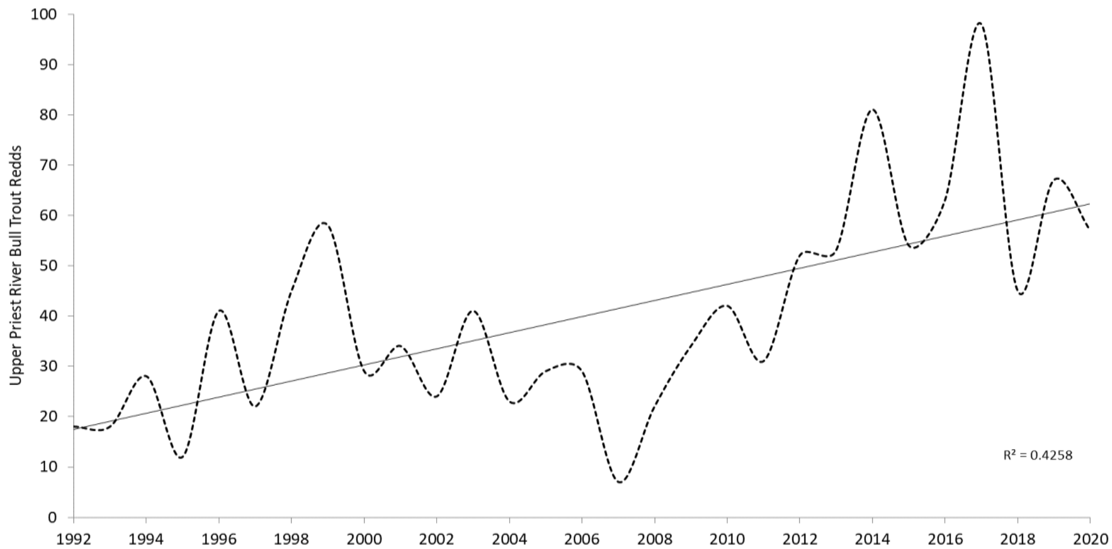

Figure1. Bull Trout redd counts 1992-2019 in the Upper Priest River and tributaries.

Table 1. Bull Trout redd survey results by location including distance surveyed and number of redds observed in the Upper Priest River drainage, Idaho, 1993-2020.

Stream	Transect Description	Length (km)	Avg 1993-2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Upper Priest River	Falls to Rock Cr.	12.5	13	17	10	36	34	58	25	17	21	16	49	23
	Rock Cr. to Lime Cr.	1.6	1	4	1	0	7	8	12	34	36	12	1	21
	Lime Cr. to Snow Cr.	4.2	6	3	1	3	6	9	13	11	24	10	12	8
	Snow Cr. to Hughes Cr.	11.0	4	0	7	2	2	0	1	0	4	1	5	1
	Hughes Cr. to Priest Lk	2.3	0	0	0	0	--	--	--	--	--	--	--	--
Rock Cr.	Mouth to F.S. trail 308	0.8	0.3	1	0	0	--	--	--	--	--	--	--	--
Lime Cr.	Mouth upstream 1.2 km	1.2	0.2	0	0	0	--	--	--	--	--	--	--	--
Cedar Cr.	Mouth upstream 3.4 km	3.4	0.3	0	0	0	--	--	--	--	--	--	--	--
Ruby Cr.	Mouth to waterfall	3.4	0	0	--	--	--	--	--	--	--	--	--	--
Hughes Cr.	Trail 311 to trail 312	2.5	1	0	0	0	--	--	--	--	--	--	--	--
	F.S. road 622 to Trail 311	4.0	1	0	7	5	0	3	0	0	0	0	0	2
	F.S. road 622 to mouth	7.1	1	11	3	2	1	2	3	1	11	1	0	2
Bench Cr.	Mouth upstream 1.1 km	1.1	0.3	0	0	0	--	--	--	--	--	--	--	--
Jackson Cr.	Mouth to F.S. trail 311	1.8	0	0	0	0	--	--	--	--	--	--	--	--
Gold Cr.	Mouth to Culvert	3.7	2	6	2	4	3	1	0	0	2	5	0	0
Boulder Cr.	Mouth to waterfall	2.3	0	0	--	0	--	--	--	--	--	--	--	--
Trapper Cr.	Mouth upstream 5.0 km	5.0	2	0	--	0	--	--	--	--	--	--	--	--
Caribou Cr.	Mouth to old road crossing	2.6	0.2	0	--	--	--	--	--	--	--	--	--	--
All stream reaches combined		70.5	29	42	31	52	53	81	54	63	98	45	67	57