FISHERY MANAGEMENT INVESTIGATIONS

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HENRYS LAKE

ABSTRACT

Henrys Lake is one of the most popular recreational fisheries in Idaho and is known to support a robust trout fishery. Due to the reduction in available staff, and work priorities throughout the region in response to the COVID-19 pandemic, our annual gillnet survey was conducted by a graduate student with the University of Idaho. We reduced our annual gill net effort from 50 net-nights to 30 net-nights of effort in the spring of 2020 to evaluate the Henrys Lake fish population. Total trout catch per unit effort (CPUE) was 14.9 trout/net-night (± 2.6; 95% CI), which was above the 25-year long-term average of 11.6 and the management target of 11 trout/net-night. Catch rates also increased for each trout species and were coupled with decreased mean relative weight (W_r) for all species and size classes. Utah Chub *Gila atraria* (UTC) CPUE remained stable from 2019 at 13.8 UTC/net-night (± 18.6; 95% CI). Mean lengths for age-2 and age-3 fish were slightly higher for phenotypically identified hybrid trout (*Oncorhynchus mykiss* x *Oncorhynchus clarkii bouvieri*; HYB) compared to Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri* (YCT). We estimated wild YCT made up 4.2% of the population captured in gill nets using parentage based tagging (PBT). We monitored dissolved oxygen levels under the ice to assess the possibility of a winterkill event from December 11, 2019 through February 18, 2020. Based on depletion estimates, we predicted dissolved oxygen would not reach critical levels (10 g/m^2) by the end of the Henrys Lake spawn and did not deploy aeration pumps. Total angler effort during the 2020 ice fishery was the highest recorded (69,144 h) since an ice fishery has been available. Angler catch rate was 0.4 trout/h, which is below our management goal of 0.7 trout/h and anglers harvested an estimated 6,175 total trout. Favorable water conditions, high reservoir volumes, and increased stocking rates have all lead to increased survival and increased numbers of trout in Henrys Lake.

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INTRODUCTION

Henrys Lake, located in eastern Idaho in the Greater Yellowstone Ecosystem, has provided a recreational trout fishery since the late 1800s (Van Kirk and Gamblin 2000). A dam was constructed on the outflow of the natural lake in 1924 to increase storage capacity for downstream irrigation. This dam increased total surface area to 2,630 ha with a mean depth of 4 m and inundated lower portions of tributary streams. The mouths of tributary streams historically provided spawning habitat for adfluvial Yellowstone Cutthroat Trout, prompting concerns for recruitment limitations. To mitigate for this potential loss of recruitment, the Idaho Department of Fish and Game (IDFG) acquired a private hatchery on the shores of Henrys Lake and began a fingerling trout stocking program that continues today (Garren et al. 2008). The lake supports a robust fishery for native Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri* (YCT), hybrid trout (Rainbow Trout *O. mykiss* x Yellowstone Cutthroat Trout; HYB) and Brook Trout *Salvelinus fontinalis* (BKT), with an average of approximately 130,000 hours of annual angling effort. Surveys of Idaho's anglers indicate Henrys Lake has been the most popular lentic fishery in the state (IDFG 2001). Since 1923, IDFG has stocked a total of over 92 million YCT, 11.5 million HYB, and 4.3 million BKT. Stocking ratios averaged 84% YCT, 12% HYB, and 4% BKT from 1966 to 2010. Beginning in 1998, all HYB were sterilized prior to release to reduce the potential for hybridization with native YCT. Although hybridization was not a concern with BKT, only sterile fingerlings have been stocked since 1998 (with the exception of 50,000 fertile fish in 2003) to reduce the potential for naturally-reproducing BKT to compete with native salmonids.

Anglers view Henrys Lake as a quality fishery capable of producing trophy trout. As early as the mid-1970s, 70% of interviewed anglers preferred the option of catching large fish even if it meant keeping fewer fish (Coon 1978). Since that time, management of Henrys Lake has emphasized restrictive harvest regulations consistent with providing a quality fishery as opposed to liberal harvest regulations that are more consistent with a yield fishery. In 1984, fisheries managers created specific, quantifiable objectives to measure angling success on Henrys Lake. Based on angler catch rate information and harvest data collected during creel surveys conducted between 1950 and 1984, managers thought it was possible to maintain angler catch rates of 0.7 trout/h, with a size objective of 10% of harvested YCT exceeding 500 mm. These objectives remain in place today, although the size objective is now measured from gill-net sampling as opposed to fish caught by anglers and measured during creel surveys (IDFG 2019). To evaluate these objectives, annual gill-net monitoring occurs in May, immediately after ice off and prior to the fishing season, while full season creel surveys are conducted at three- to five-year intervals.

Catch rates of trout observed in during annual gill-net surveys from 2013 through 2018 were lower than expected, despite annual increases of fall-stocked hatchery trout. This suggests trout may have experienced a higher-than-normal mortality rate between 2012 and 2017. Some potential factors limiting trout survival may include abiotic factors (e.g. temperature, dissolved oxygen, nutrient concentrations) or biotic factors (e.g. food availability, intra and interspecific competition). Understanding these potential limiting factors is key to maintaining a stable trout population to meet angling objectives in the lake. Limited information is available on the role of water quality, phytoplankton and zooplankton affecting trout abundances in Henrys Lake. The most recent water quality assessment performed in Henrys Lake occurred more than two decades ago (Hill and Mebane 1998). As such, there is a need to conduct an in-depth water quality assessment to determine the abiotic factors, nutrient availability and food availability constraints on trout in Henrys Lake.

STUDY SITE

Henrys Lake is located 1,973 m above sea level, between the Henrys Lake Mountains and the Centennial mountain range, approximately 29 km west of Yellowstone National Park. The lake is approximately 6.4 km long and 3.2 km wide, with a surface area of 2,630 ha (Figure 1). The outlet of Henrys Lake joins Big Springs Creek to form the headwaters of the Henrys Fork Snake River.

OBJECTIVES

To obtain current information on the fish population, and to develop appropriate management recommendations to achieve management objectives stated in the State Fisheries Management Plan.

METHODS

Population monitoring

This year, due to restrictions and shifting regional project prioritizes in response to the COVID-19 pandemic, all gill nets were set, pulled, and processed by a University of Idaho graduate student conducting research on the lake. Gill nets were set at six traditional locations in Henrys Lake in paired floating and sinking nets. Nets were set from May 11 – 20, 2020 for a total of 30 net-nights (Figure 1) versus the regular 50 net-nights standard. Gill nets consisted of alternating between floating and sinking types measuring 46-m long by 2-m deep, with equal length panels ordered from smallest to largest of 2-, 2.5-, 3-, 4-, 5- and 6-cm bar mesh. As part of the research being conducted by the University of Idaho, an additional 34 net-nights of customized American Fisheries Society gill nets (customized AFS gill nets) were set at the six traditional locations and five additional near-shore locations around the lake (Figure 1). The customized AFS gill nets consisted of alternating between floating and sinking types measuring 27-m long by 1.8-m deep, with equal length panels ordered randomly of 1.3-, 2-, 2.5-, 3-, 4-, 4.5-, 5-, 6-, and 6.5-cm. All nets were set at dusk and retrieved the following morning. Results of fish captured using the customized AFS nets were only included in the trout and Utah Chub ageing analysis. All other analyses use information from fish captured using the 30 traditional gill net-nights only.

We identified captured fish to species and recorded total lengths (TL; mm) and weights (g). Gill-net catch per unit effort (CPUE) was calculated as mean fish per net-night with 95% confidence intervals. Due to the high variability and schooling behavior of Utah Chub *Gila atraria* (UTC), we cannot assume normal distribution and calculated CPUE as the median UTC per net-night.

We calculated proportional size distribution (PSD) and relative stock density (RSD-400 and RSD-500) to describe the size structure of trout populations in Henrys Lake. We calculated PSD for YCT, HYB and BKT using the following equation:

$$\text{PSD} = \frac{\text{number} \geq 300 \text{ mm}}{\text{number} \geq 200 \text{ mm}} \times 100$$

We calculated RSD-400 for YCT, HYB, and BKT using the following equation:

$$\text{RSD-400} = \frac{\text{number} \geq 400 \text{ mm}}{\text{number} \geq 200 \text{ mm}} \times 100$$

Criteria used for PSD and RSD-400 values for YCT, HYB, and BKT populations were based on past calculations and kept consistent for comparison purposes. We also calculated RSD-500, using the same equation as above, but used the number of fish greater than 500 mm as the numerator. This methodology (and size designation) is used on other regional waters to provide comparison between lakes and reservoirs throughout the Upper Snake Region.

We calculated relative weights (W_r) by dividing the actual weight of each fish (in grams) by a standard weight (W_s) for the same length for that species and multiplied by 100 (Anderson and Neumann 1996). Relative weights were averaged for each length class (< 200 mm, 200-299 mm, 300-399 mm and fish > 399 mm). We used the formula, log W_s = -5.194 + 3.098 log TL (Anderson 1980) to calculate W_r of HYB, log W_s = -5.189 + 3.099 log TL for Cutthroat Trout (Kruse and Hubert 1997) and log W_s = -5.186 + 3.103 log TL for BKT (Hyatt and Hubert 2001). For Utah Chub, we used the formula log W_s = -4.984 + 3.049 log TL (IDFG, unpublished data).

We removed the sagittal otoliths of trout captured in all gill nets for age and growth analysis. After removal, all otoliths were cleaned and stored in individually labeled vials and were analyzed as whole otoliths. Whole otoliths were immersed in water on a slide and the annuli were counted. Images of otoliths were captured using a microscope interfaced with a desktop computer and digital images were taken of whole otoliths. Two trained readers independently assigned ages for each structure without reference or knowledge of fish length. A total of 10 otoliths per 20-mm size class for each species (BKT, HYB and YCT) were randomly subsampled and their ages were assessed. When less than 10 otoliths were present per size class, all otoliths were used to assign ages to fish.

We estimated ages of UTC using fin rays (Griffin et al. 2017) by removing the left leading pectoral fin ray from each individual fish by cutting as close to the girdle as possible (Koch et al. 2008). After drying, fin rays were embedded in epoxy in centrifuge tubes and a thin section (~0.3-mm thick) was cut from the base of the pectoral fin ray with an isomet saw (Koch and Quist 2007). Fin rays were read by a graduate student at the University of Idaho, Moscow using a microscope (Lieca DM 1000 LED, Lieca Microsystems, Wetzlar, Germany) with transmitted light supplied from dual-strand fiber optics. Otoliths and fin rays were imaged using a microscope interfaced with a desktop computer and digital images were taken of sectioned fin rays. We subsampled a total of 10 fin rays per 10-mm size class to assign age. When less than 10 fin rays were available in a size class, we used samples from all the individuals.

We examined all YCT handled through the year for adipose fin clips as part of our evaluation of natural reproduction. Beginning in the 1980s and continuing through 2016, 10% of all stocked YCT were marked with an adipose fin clip prior to stocking (Appendix A). To estimate contributions to the YCT population from natural reproduction, we calculated the ratio of marked to unmarked fish collected in annual gill-net surveys and trout captured ascending the fish ladder on Hatchery Creek. Since 10% of all stocked fish were marked with an adipose clip, ratios near 10% in the at-large population would be expected in the absence of additional, un-marked fish (natural reproduction). When the ratio of marked fish is less than 10%, we assumed that natural reproduction was contributing to the population. In 2017, the program shifted to using Parentage Based Tagging (PBT) to gather information on the percent of hatchery-origin and wild-origin fish, which is described in detail below.

Parentage based tagging

Since 2017, we have implemented PBT in conjunction with the annual YCT spawning operations. During each spawning season, we collected genetic samples from all YCT spawned at the Henrys Lake Hatchery. Genetic samples taken via fin clips were stored on Whatman paper appropriately labeled by spawn date and lot number. Whatman paper was pre-labeled with seven horizontal sample locations on each plane. The first seven-slot plane was identified as male with the next plane identified as female. These two horizontal planes were identified as Family 1. This was then repeated vertically down the Whatman paper with the next two male/female planes identified as Family 2 and so forth. Each individual genetic sample was genotyped to generate a database of Henrys Lake YCT broodstock by spawn year. This in turn "tags" all offspring and assigns individual offspring back to its parents through parentage analysis, thus identifying hatchery origin YCT and the age of the sampled fish. To identify hatchery offspring genetic samples were also obtained from all phenotypically identified YCT and HYB encountered during our annual gill-net survey via an upper caudal fin clip and stored on pre-labeled Whatman paper.

Winter dissolved oxygen

Winter dissolved oxygen concentrations (mg/L), snow depth (m), ice thickness (m), and water temperatures (°C) were measured at five established sampling sites (Pittsburg Creek, Outlet, County Boat Dock, Wild Rose, and Hatchery; Figure 1) on Henrys Lake between December 11, 2019 and February 18, 2020. Holes were drilled in the ice with an electric ice auger prior to sampling. A YSI model Pro-20 oxygen probe was used to collect dissolved oxygen and temperature readings at the bottom of the ice and at subsequent one-meter intervals until the bottom of the lake was encountered. Dissolved oxygen mass was calculated from the dissolved oxygen probe's mg/L readings and converted to total mass in g/m^2. This was a direct conversion from mg/L to g/m^2 (i.e., 1000 L = 1 m^2). The individual dissolved oxygen readings at each site were then summed to determine the total available oxygen within that sample site. To calculate this value, we used the following formula;

[Average (bottom of ice + 1m)] + [Sum (readings from 2 m to lake bottom)] = Total O_2 mass

The total mass of dissolved oxygen at each sample site was then expressed in g/m^2 (Barica and Mathias 1979). Data were then transformed using the natural logarithm (ln) for regression analysis. We used linear regression to develop a dissolved oxygen depletion model used to predict the likelihood of the Henrys Lake environment reaching the critical threshold for fish survival. Historically, the critical threshold at Henrys Lake has been 10 g/m^2. The likelihood of reaching the critical dissolved oxygen threshold prior to April 1, the projected recharge date, is one factor which was used to decide whether to deploy aeration at the mouth of Hatchery Creek.

Creel

We conducted a creel survey from October 29 through January 1, 2020 to assess harvest and angler catch rates during the ice fishery. Creel clerks counted the number of anglers, huts and vehicles at each access point at two separate, randomly selected times during each creel shift. The ice fishing season was stratified into two-week intervals with two weekend and two weekdays per interval randomly selected as creel dates. We assumed equal effort across the entire day and randomly selected each creel shift as either morning (0800 – 1230) or afternoon (1230 – 1700). Creel clerks collected information on angler fishing location, number of anglers in

the party, number of vehicles per party, residency and zip codes of anglers, duration of time anglers spent fishing, gear type used, and number and species of fish both caught and harvested. When harvested fish were encountered, clerks identified species, measured fish for total length (mm) and identified any fin markings present. Angler count data was expanded by total daylight hours and total available fishing days to estimate total angler effort during the fishery.

RESULTS

Population monitoring

We collected 862 fish in 30 net-nights in May 2020, with our traditional gill net survey. Gill-net catch rates (catch per unit effort; CPUE) for all trout species combined was 14.9 ± 2.6 (95% CI; Figure 2). Catch composition was 48% UTC, 22.3% YCT, 21.9% HYB, and 7.8% BKT. Mean trout CPUE (± 95% CI) was highest for YCT at 6.4 (± 1.3) fish per net-night, followed by HYB and BKT at 6.3 (± 1.3) and 2.2 (± 0.98) fish per net-night, respectively (Figure 2). The average total length (± 95% CI) and range of HYB was 415 mm (± 8.1; range 245 - 635 mm; Figure 3). The average total length of YCT was less than HYB, with an average total length of 377 mm (± 9.2; range 175 - 565 mm). BKT total length ranged from 170 to 464 mm, with a mean of 382 mm (± 19.1; Figure 3, Table 1). We did not observe an adipose-clipped YCT during this gill net survey (Appendix A). The median CPUE of UTC was 13.8 fish/net-night (± 95% CI 18.6; Figure 4). Utah Chub gill-net catch rate has remained stable from 2019 which had a median of 13.9 (± 10.4) fish per net-night. Utah Chub total lengths ranged from 140 to 390 mm with an average of 237 mm (± 6.0; Figure 5).

Proportional size distribution (PSD) was highest for HYB (96) followed by BKT (94), and YCT (84). Relative stock density (RSD-400) was highest for HYB (65) followed by BKT (63), and YCT (43; Table 2). Mean W_r for all size classes combined was 92 ± 1.0 for HYB, 90 ± 2.8 for BKT, while slightly lower at 86 ± 1.0 for YCT (Table 2, Figure 6). Mean W_r for UTC (all sizes combined) was 91 ± 0.8 and ranged between 88 and 93 for size classes (100 – 199 mm, 200 – 299 mm, 300 – 399 mm; Table 2). Overall mean W_r of UTC slightly increased from 2019 (Figure 7), whereas, YCT mean W_r decreased from 2019 (Figure 6).

We estimated the ages of 189 YCT, 131 HYB, 70 BKT, and 240 UTC. Ages ranged from age-1 to age-6 for YCT, age-2 to age-8 for HYB, age-1 to age-4 for BKT, and age-2 to age-17 for UTC (Table 3 & 4). Mean lengths for age-2 phenotypically identified HYB at 306 mm TL (range 235 to 346 mm) were slightly longer than YCT at 275 mm TL (range 216 to 346 mm; Table 3). The same trend was evident for age-3, and age-4 HYB and YCT.

Parentage based tagging

A total of 2,688 YCT were genotyped for the 2020 Henrys Lake YCT spawn. A combined total of 800 YCT and HYB genetic samples from our gill-net survey were analyzed for parentage. Of the samples collected, 250 samples were genetically identified as HYB, 511 as YCT, and 39 (4.9%) failed to genotype. For the YCT genotyped samples, 5 YCT exhibited total lengths >470 mm indicating these fish to be older than 3 years (> BY2017) and would not be able to assign to a PBT-marked brood year. This left a total of 506 YCT which should assign to either BY2017, BY2018, or BY2019. A total of 435 and 50 YCT were assigned to both hatchery parents from BY2017 and BY2018, respectively. This left a total of 21 fish which failed to assign to hatchery

parents and indicated 4.2% of the captured YCT in our gill-net survey were of wild descent. Based on the length distributions of assigned YCT, we estimated a wild contribution of 2.0% for age-3 YCT (BY2017), and 16.7% wild contribution for age-2 YCT (BY2018). Field staff were 83.8% accurate in phenotypically identifying YCT and 58% accurate for HYB.

Winter dissolved oxygen

Total dissolved oxygen diminished from 39.4 to 12.5 g/m^2 at the Pittsburgh Creek site, from 21.7 to 9.2 g/m^2 at the Outlet site, from 32.5 to 5.1 g/m^2 at the County dock site, from 52.7 to 16.9 g/m^2 at the Wild Rose site, and from 36.3 to 5.0 g/m^2 at the Hatchery site (Table 5). Depletion estimates indicated dissolved oxygen would remain above the level of concern (10 g/m^2) throughout the annual Henrys Lake spawn which was completed on February 27, 2020. Trout did not congregate in large numbers at the mouth of Hatchery creek following the spawn and no aeration was initiated (Figure 8).

Creel

We conducted 154 interviews during the ice fishery season where Idaho residents composed 80% of the anglers. Total estimated effort for the ice fishing season was 69,144 hours and season angler catch rate was 0.4 trout/h. Anglers caught an estimated 27,756 trout and harvested an estimated 6,172 trout. Species composition of angler catch was 46% YCT, 42% HYB, and 12% BKT. The mean total length of trout harvested by anglers and measured by creel clerks was 480 mm for HYB, 450 mm for YCT, and 463 mm for BKT (Table 6).

DISCUSSION

The annual gill-net monitoring survey has indicated total trout CPUE in the 2020 traditional gill nets was above the long term 25-year average of 11.6 trout/net-night and our management goal of 11 trout/net-night (IDFG 2019). This followed a 5-year decline in CPUE from 2013 to 2018. To counteract the declining CPUE, we have consistently increased annual trout stocking to the lake from a minimum of 979,000 in 2013 to 1,505,000 total trout in 2019. In addition, since 2018, the Henrys Lake watershed has had lower than average summer air and water temperatures, high reservoir volumes, and reduced cyanobacteria blooms (NRCS SnoTel; Heckel et al. 2020; IDFG unpublished data; USGS). These factors have likely led to reduced summer stress and increased over winter survival of trout in the lake.

In conjunction with increased CPUE this year, the W_r of all trout species continues to decline, suggesting a decrease in trout condition. Various factors may be limiting trout growth in the lake such as changing abiotic factors (ex. temperature and dissolved oxygen, water-level fluctuation; Johnson et al. 1992), decreased or community shift in the forage base (Flickinger and Bulow 1993), or intraspecific and interspecific competition (Blackwell et al. 2000). Density-dependent growth has been a well-documented concern in Henrys Lake. In years where trout densities are high, food resources may become limited with increased fish competition and lead to lower growth rates (High et al. 2015). The high overall CPUE and large age-3 YCT and age-2 YCT cohorts present in the gill-net catch suggests high overwinter survival rates as age-2 YCT dominated the gill-net catch in 2019 (Heckel et al. 2020). Furthermore, proportional size distribution (PSD), and both relative stock density (RSD-400, RSD-500) indices were higher than

observed in past surveys across trout species (Heckel et al. 2020; IDFG unpublished data). This indicates that increased numbers of quality-sized trout are present in the population. As such, managers have decreased the stocking rate for 2020 and may look to decreasing stocking rates in the coming years when water quality parameters are favorable and allow increased survival throughout the year. It is not likely that abiotic factors have led to the decrease in W_r, as water quality monitoring on the lake has shown high water quality and quantity over the last three years (IDFG unpublished data). This monitoring program also estimated high densities of phytoplankton and zooplankton in the lake in both 2018 and 2019. Furthermore in 2018, we found amphipods, instead of zooplankton, dominated the diet of recently stocked fingerling YCT in Henrys lake (IDFG 2018 unpublished data).

We estimated the highest contribution of wild YCT to the gillnet catch for 2020 at 4.2% ever recorded since the implementation of PBT. When we looked closer into the wild contribution by brood year, we estimated a higher wild contribution of age-2 YCT at 16.7% (BY2018) over the 2.0% for age-3 YCT (BY2017). This is not surprising, as there is commonly an increase in natural and harvest mortality as trout age in the system. Due to the short lifespan of YCT in Henrys Lake, following the PBT tagging of BY2021, we will be able to accurately identify the origin of >95% of the YCT captured. This will allow us to more accurately understand and estimate the total wild YCT production in the lake. Prior to 2017, 10% of the stocked YCT in Henrys Lake were marked by an adipose fin clip. In the last three years prior to PBT (2014-2016), the ratio of adipose clipped to unclipped YCT was above or equal to 10%, although a precise percentage of the contribution was not possible with this method. There is error associated with mass marking techniques including missed clips (partial or no clip), improper identification of missed clips and the low rate at which fish are clipped. Only 10% of approximately one million stocked YCT each year were identified as hatchery origin trout. These sources of error have likely led to an over-estimation of the wild YCT contribution to the lake. From 2009 to 2013, the average ratio was 5%, suggesting an increase in the wild YCT contribution to the lake's population. A variety of projects may have helped increase natural recruitment of YCT, including fish passage improvements, irrigation canal screening, and riparian fencing.

Field staff were consistently accurate in phenotypically identifying YCT and HYB between 2020 (83.8%) and 2019 (86%; IDFG unpublished data). However, phenotypic identification of HYB has been consistently below 60% each year (2020 58%; 2019 53%). In general, we have been phenotypically misidentifying YCT as HYB in the field across all sizes. Due to the wide degree of overlap in phenotypes from YCT and Rainbow Trout, it can be difficult to quickly and accurately identify HYBs in the field by external characteristics. The Henrys Lake hybrid grows fast, commonly displays a "football" body shape, and does not display the common white fin tips characteristic of many HYBs and Rainbow Trout. This increases the chance of misidentification between these two species. Staff will need to incorporate a greater number of phenotypic identifying characteristics to increase the accuracy of species identification in the field. These characteristics may include the number of head spots, prominence of a throat slash, body spots, and belly hue as outlined by Meyer et al (2017a).

Utah Chub densities are a concern at Henrys Lake due to the potential negative interactions between Utah Chub and trout. Utah Chub was illegally introduced into Henrys Lake and were first documented in 1993. Utah Chub abundance first began to increase in the late 1990s and continued to increase through the early 2000s. Even though UTC densities have remained stable for two years, we continue to be concerned of the potential UTC population in Henrys Lake. Utah Chub are currently the most abundant species caught in our gill-net surveys. There is evidence of competition between UTC and trout for both food resources and space in many other lakes and reservoirs. For example, in Schofield Reservoir, Utah, small (< 360 mm)

Cutthroat and Rainbow Trout exhibited a high degree of dietary overlap with small (< 250 mm) UTC (Winters and Budy 2015). Furthermore, in Flaming Gorge Reservoir which borders Utah and Wyoming, introduced Utah Chub had a 99.7% diet overlap with Rainbow Trout (Schneidervin and Hubert 1987). As densities of Utah Chub continued to increase in Flaming Gorge Reservoir, kokanee growth declined dramatically (Teuscher and Luecke 1996). In addition, literature suggests that the thermal tolerance for UTC is between 15 – 31°C (Sigler and Sigler 1987), while temperatures over 20°C can be lethal for Cutthroat Trout (Bear et al. 2007). This higher thermal threshold for UTC may allow this species to feed and grow when summer temperatures limit the activity of trout. To further understand the interactions between UTC and YCT in Henrys Lake, a graduate student with the University of Idaho, Idaho Cooperative Fish and Wildlife Unit is currently conducting research on the lake. This study will evaluate the population dynamics of YCT and UTC using historical data and describe the movement and habitat characteristics of these species in the lake. The results of this project will provide managers with a better understanding to track UTC abundance in the lake and provide specific growth metrics of YCT to better monitor the impacts of UTC in this waterbody through time.

Total angler effort for the 2020 ice fishery increased two-fold over the previous year and was the highest recorded since an ice fishing season has been available on the lake. This increase in fishing effort during 2020 is likely in part due to the excellent fishing observed during the previous two years at Henrys Lake, including a stellar 2019 ice fishing season which boasted the highest catch rate (1.28 trout/h) observed to date (Heckel et al. 2020). Additionally, the COVID-19 pandemic has increased angler use across the region in 2020 and Henrys Lake was no exception. As people transitioned to working from home or became unemployed and indoor activities were heavily restricted, there was increased time and opportunity for angling and other outdoor activities. In Idaho, we observed an increase in the public use of access sites across the state. In 2020, there was a 52% overall average increase in IDFG sales of all resident and nonresident licenses and tags sold compared to 2019 (IDFG unpublished data). Reports of increased catch rates over the last few years coupled with increased use by anglers in general due to the COVID-19 pandemic, likely led to increased angler effort on Henrys Lake.

While angler effort was high during the 2020 ice fishery, total harvest was only about 25% of the harvest estimated for the 2019 open water season, which was 91 days longer than the ice fishery (Heckel et al. 2020). When compared to the 2019 ice fishery, anglers harvested an estimated 2,161 additional trout in the 2020 ice fishery. In perspective, our annual stocking rate averaged 1.38 million trout over the past 5 years (2015 – 2019; Appendix B). Harvest during the ice fishery continues to contribute only a low amount of mortality to the population. Coupled with high trout gillnet catch the following spring in 2020, we expect this trend to continue in 2021.

Angler catch rates were significantly lower this ice fishery than 2019. Furthermore, angler catch rate declined from the 2019 open water season and was slightly below our management goal (0.7 trout/h) r at 0.4 trout/h. As oxygen levels decline, trout seek out oxygen rich environments which include tributary mouths and springs which are most abundant in near shore habitats. This is also the most common location for ice anglers to fish. Oxygen levels during the 2019-2020 winter revealed high dissolved oxygen throughout the lake (IDFG unpublished data), indicating trout may not be congregating at those high oxygen rich locations as in other years. Further anecdotal evidence supported that anglers who ventured further away from the shoreline were more successful. Despite the increase in angling effort during the 2020 ice fishery, angler harvest is still low, and likely has a negligible effect on the fish population.

Winter dissolved oxygen profiles have been monitored for almost 30 years, with aeration deployed using our Helixor aeration system when oxygen profiles forecast potential lethal

overwinter conditions. Although our oxygen depletion model indicated the lake would reach critical oxygen levels throughout the winter, we did not implement the aeration system. This decision was made because three of the five monitoring sites and the average oxygen depletion were estimated to not reach critical levels until after the annual Henrys Lake spawn was completed. During the winterkill event of 1991 (~9,000 trout), and the low oxygen levels coupled with trout kills (~2000 trout) during the winter of 2003-2004, trout were observed crowding tributary mouths as oxygen levels diminished (Gamblin 1995; Garren et al. 2006a; Herron 1991). Crowding was not observed in 2020, nor did we observe increased trout mortalities at the mouth of Hatchery Creek following the spawn through to ice-off. As such, we did not deploy aeration. The current aeration system was installed in 1993, and has been maintained periodically since installation. This system was last utilized implemented in 2015, and is due for a thorough evaluation of the effectiveness of the current system.

MANAGEMENT RECOMMENDATIONS

1. Continue our annual spring suspended gill-net monitoring to evaluate relative abundance, age, and growth of all trout species in order to quantify the current state of the fishery.

2. Continue to monitor UTC densities and evaluate potential impacts of increased densities of UTC on trout.

3. Utilize PBT to evaluate the percentage of wild YCT production in Henrys Lake, determine the accuracy of phenotypically identifying YCT vs HYB, and validate otolith ages.

4. Continue to monitor winter dissolved oxygen levels to determine when using the aeration system is required

Table 1. Summary statistics of total length (mm), weight (g), and relative weights (W_r) for Brook Trout (BKT), Hybrid Trout (HYB), Yellowstone Cutthroat Trout (YCT), and Utah Chub (UTC) collected using gill nets set at traditional netting locations in Henrys Lake, 2020.

	BKT			HYB			YCT			UTC		
	TL (mm)	WT (g)	W_r	TL (mm)	WT (g)	W_r	TL (mm)	WT (g)	W_r	TL (mm)	WT (g)	W_r
Mean	382	686	90	415	802	92	377	587	86	237	202	91
Confidence level (95%)	19.0	77.2	2.8	8.1	50.2	1.0	9.2	40.0	1.0	6.0	14.7	0.8
Median	415	759	90	411	770	91	392	609	86	229	146	91
Minimum	170	43	33	245	135	72	175	51	67	140	32	34
Maximum	464	1256	120	635	2961	120	565	2019	113	390	795	112
Count	67	67	67	189	189	189	192	192	192	414	413	413

Table 2. Proportional size distribution (PSD), relative stock density indices (RSD-400, and RSD-500), and relative weights (W_r) for Brook Trout (BKT), Hybrid Trout (HYB), Yellowstone Cutthroat Trout (YCT), and Utah chub (UTC) collected in the traditional gill nets locations in Henrys Lake, 2020.

	BKT	HYB	YCT	UTC
PSD	94	96	84	--
RSD-400	63	65	43	--
RSD-500	--	4	2	--
W_r				
<200 mm	80	--	88	88
200-299 mm	86	85	85	93
300-399 mm	91	91	88	92
>399 mm	92	92	86	--
Mean	90	92	86	91

Table 3. Mean length-at-age data based on otoliths from Yellowstone Cutthroat Trout (YCT), Hybrid Trout (HYB), and Brook Trout (BKT) captured with combined samples from traditional gill nets and American Fisheries Society gill nets set in Henrys Lake, 2020.

		Age							
Species	Summary statistic	1	2	3	4	5	6	7	8
YCT	Mean TL (mm)	175	275	392	467	535	531	--	--
	Min TL	--	216	305	373	505	506	--	--
	Max TL	--	346	486	565	565	552	--	--
	No. Analyzed	1	47	96	38	3	4	--	--
HYB	Mean TL (mm)	--	306	408	484	583	654	--	719
	Min TL	--	235	353	390	557	623	--	--
	Max TL	--	346	516	578	635	680	--	--
	No. Analyzed	--	39	47	38	3	3	--	1
BKT	Mean TL (mm)	198	339	423	482	--	--	--	--
	Min TL	170	285	372	--	--	--	--	--
	Max TL	254	402	489	--	--	--	--	--
	No. Analyzed	9	17	43	1	--	--	--	--

Table 4. Mean length-at-age based on pectoral fin rays for Utah Chub (UTC) captured with combined samples from traditional gill nets and American Fisheries Society gill nets set in Henrys Lake, 2020.

		Age																
Species	Summary statistic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
UTC	Mean TL (mm)	--	117	159	191	225	247	270	298	313	337	329	331	337	363	342	--	355
	Min TL	--	107	114	140	167	186	207	216	280	311	280	287	312	340	330	--	--
	Max TL	--	140	190	250	285	294	329	350	375	369	365	361	378	390	366	--	--
	No. Analyzed	--	4	26	54	23	24	21	22	18	15	9	10	7	3	3	--	1

Table 5. Dissolved oxygen (DO) (mg/l) levels recorded in Henrys Lake winter monitoring 2019 – 2020.

Location	Date	DO Ice bottom	DO 1 meters	DO 2 meters	DO 3 meters	DO 4 meters	DO 5 meters	DO 6 meters	Total g/m^2
Pittsburgh Creek	Dec. 11, 2019	12.3	10.6	10.0	9.5	5.6	2.8		39.4
	Dec. 17, 2019	12.4	10.5	10.0	8.5	4.5	2.5		37.0
	Jan. 6, 2020	10.8	10.0	8.6	3.8	0.7	--		23.5
	Jan. 16, 2020	11.6	9.8	7.9	2.6	0.7	--		21.9
	Jan. 21, 2020	11.6	9.5	6.9	4.1	1.0	--		22.6
	Feb. 18, 2020	9.3	5.4	3.7	0.9	0.5	--		12.5
Outlet	Dec. 11, 2019	10.4	9	7.3	2.2	2.5	--		21.7
	Dec. 17, 2019	12.8	11.2	6.4	4.9	3.6	3.4		30.3
	Jan. 6, 2020	--	--	--	--	--	--		--
	Jan. 16, 2020	10.9	7.5	5.3	2.2	1.5	--		18.2
	Jan. 21, 2020	8.7	3.7	2.9	2.1	--	--		11.2
	Feb. 18, 2020	6.3	5.6	2.0	0.7	0.5	--		9.15
County Ramp	Dec. 11, 2019	13.2	11.4	8.8	4.6	3.4	3.4		32.5
	Dec. 17, 2019	11.8	10.7	8.0	4.5	2.8	--		26.6
	Jan. 6, 2020	--	--	--	--	--	--		--
	Jan. 16, 2020	10.5	4.4	3.7	0.6	--	--		11.8
	Jan. 21, 2020	--	--	--	--	--	--		--
	Feb. 18, 2020	4.1	2.9	1.1	0.5	--	--		5.1
Wild Rose	Dec. 11, 2019	13.2	12.0	11.2	10.3	8.7	5.6	4.3	53.7
	Dec. 17, 2019	12.7	11.6	10.9	10.6	7.4	4.1	--	45.2
	Jan. 6, 2020	--	--	--	--	--	--	--	--
	Jan. 16, 2020	11.3	9.8	8.0	3.3	0.7	--	--	22.6
	Jan. 21, 2020	11.6	9.5	7.7	3.8	0.6	--	--	22.7
	Feb. 18, 2020	9.7	6.9	4.7	2.7	0.7	0.5	--	16.9
Hatchery	Dec. 11, 2019	13.1	11.5	10.7	7.7	5.6	--		36.3
	Dec. 17, 2019	11.5	10.5	10.1	5.3	3.8	3.5		33.7
	Jan. 6, 2020	10.7	7.9	6.5	3.0	2.0	--		20.8
	Jan. 16, 2020	9.0	5.3	4.6	2.2	1.5	--		15.5
	Jan. 21, 2020	7.5	4.9	4.5	2.2	1.0	--		13.9
	Feb. 18, 2020	3.0	3.0	1.2	0.8	---	--		5.0

Table 6. Estimates of total angler effort, catch and harvest collected from creel surveys during the 2013, 2016, 2018, 2019, and 2020 ice fishing seasons on Henrys Lake, Idaho.

							Catch composition (%)			Mean size (mm)			Angler Residency (%)	
Year	Effort (hour)	No. caught	No. harvested	Catch rate (trout/hour)	% Harvested	% Released	YCT	HYB	BKT	YCT	HYB	BKT	Res	Non Res
2013	21,833	25,657	6,046	1.18	24	76	48	36	15	428	473	414	95	5
2016	9,354	962	308	0.10	32	68	61	34	6	488	519	465	83	17
2018	34,556	23,099	2,993	0.67	13	87	51	33	17	455	365	574	78	22
2019	34,511	44,006	8,336	1.28	19	81	45	45	9	420	458	417	81	19
2020	64,144	27,756	6,175	0.40	22	78	46	42	12	450	480	463	80	20

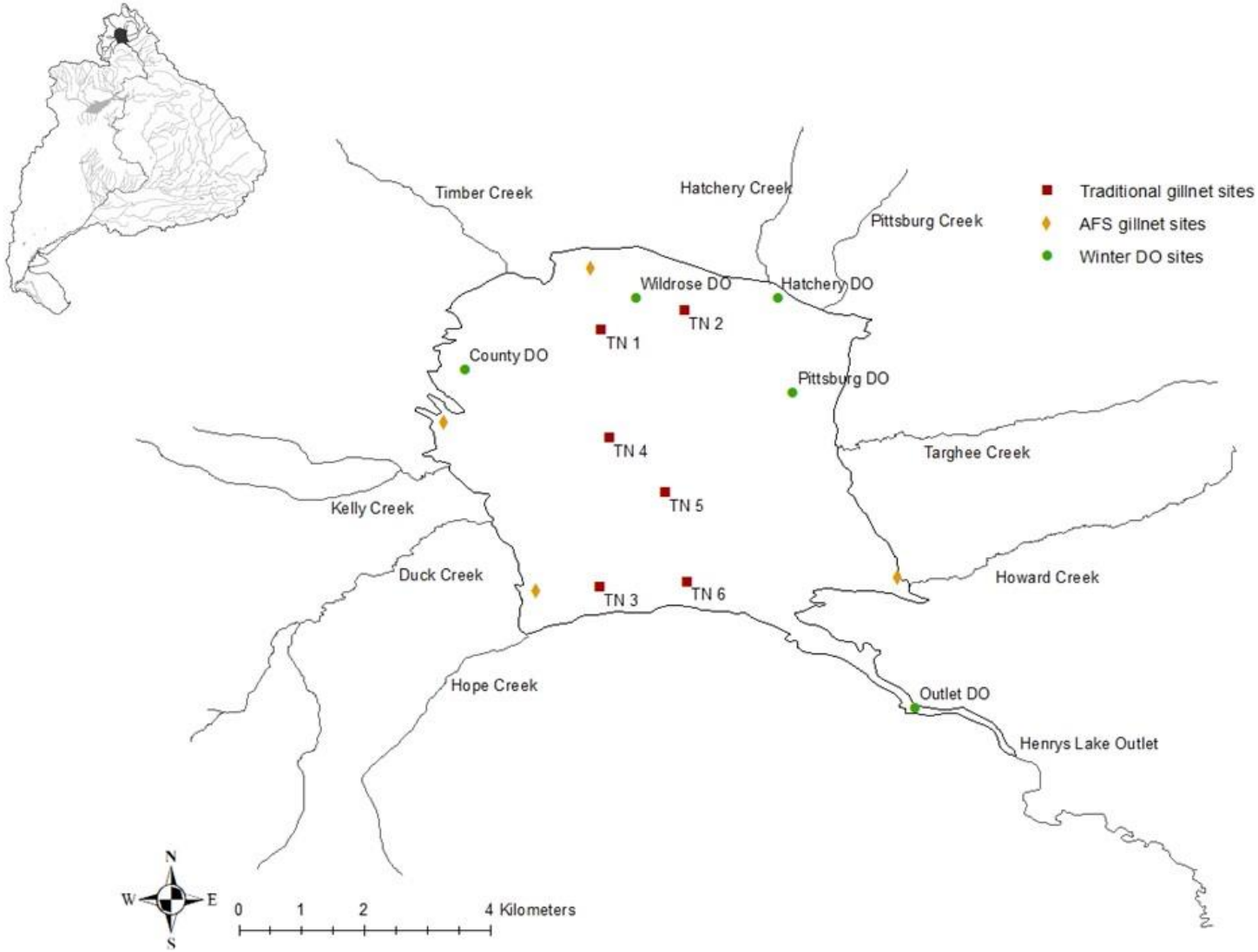

Figure 1. Location of traditional gill nets (TN1 through 6; red square), AFS gill nets (orange diamond), winter dissolved oxygen sites (green circle), and major tributaries of Henrys Lake, 2020.

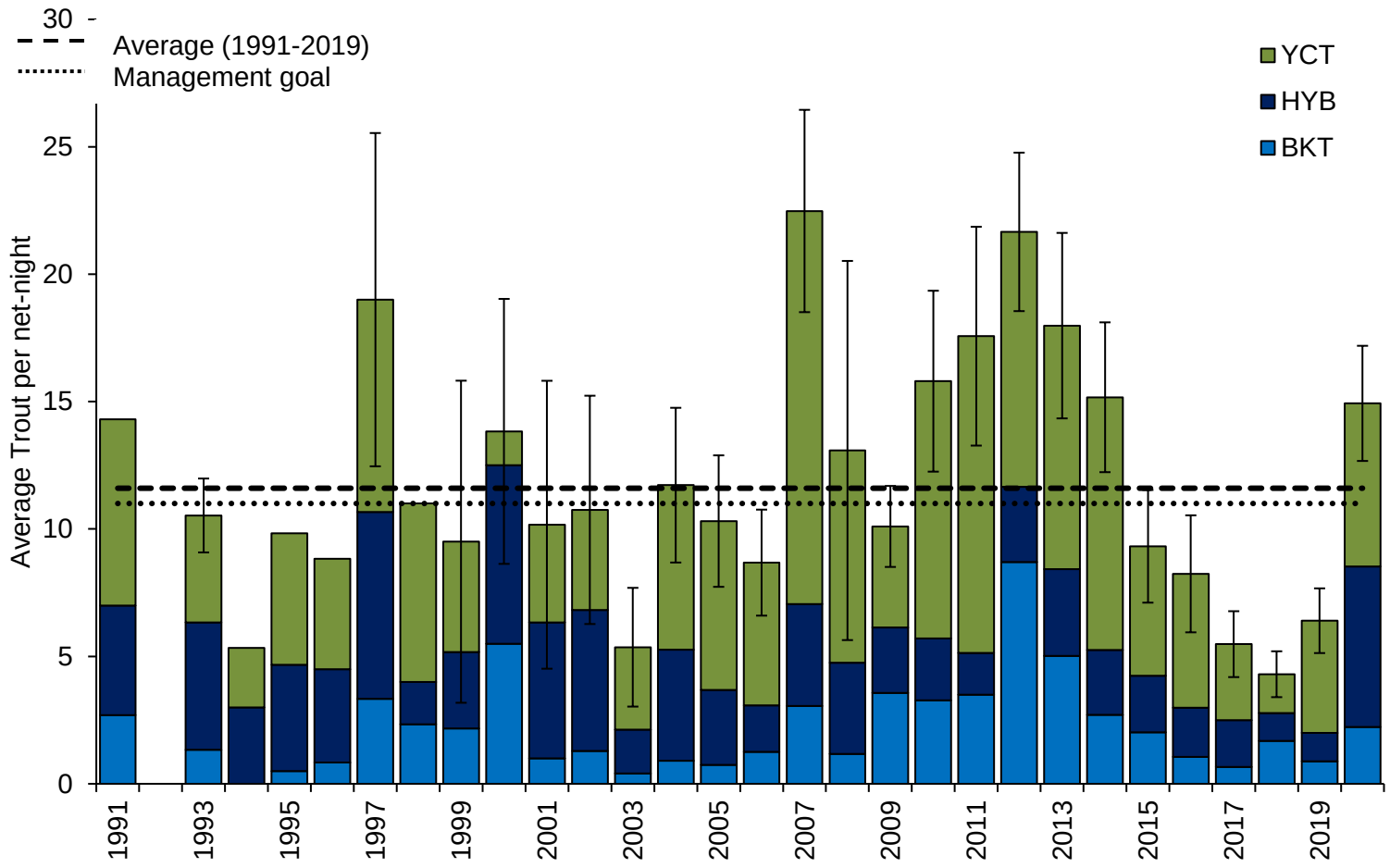

Figure 2. Catch per unit effort (CPUE) of trout per net-night of traditional gillnetting sites for Yellowstone Cutthroat Trout (YCT), Hybrid Trout (HYB), and Brook Trout (BKT) in Henrys Lake from 1991 – 2020. Error bars represent 95% confidence intervals. Lines represent the average gillnetting CPUE from years 1991 – 2019 (dashed line) and management target of 11 trout per net-night (dotted line).

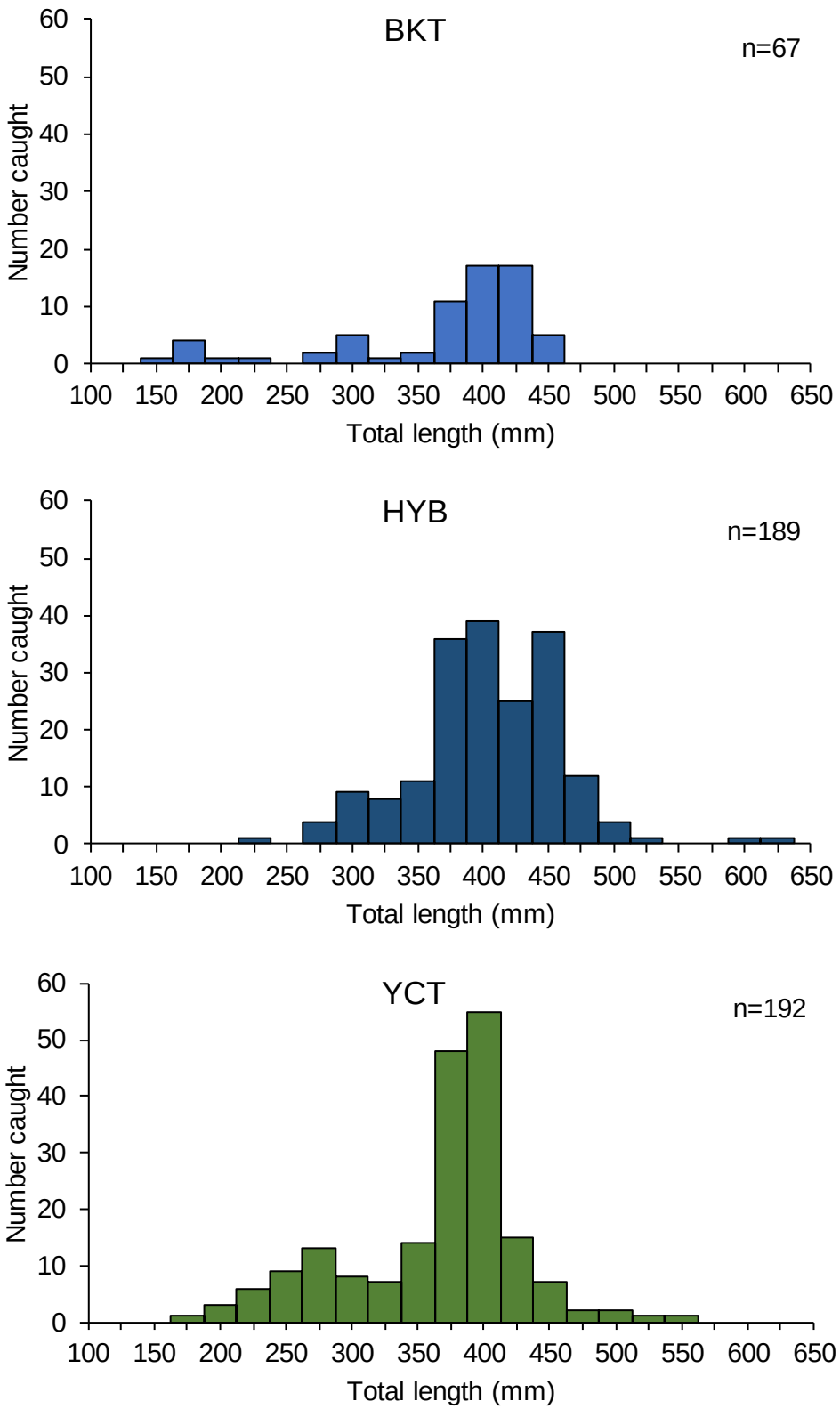

Figure 3. Brook Trout (BKT), Hybrid Trout (HYB) and Yellowstone Cutthroat Trout (YCT) length-frequency distributions from traditional gill nets set in Henrys Lake, 2020.

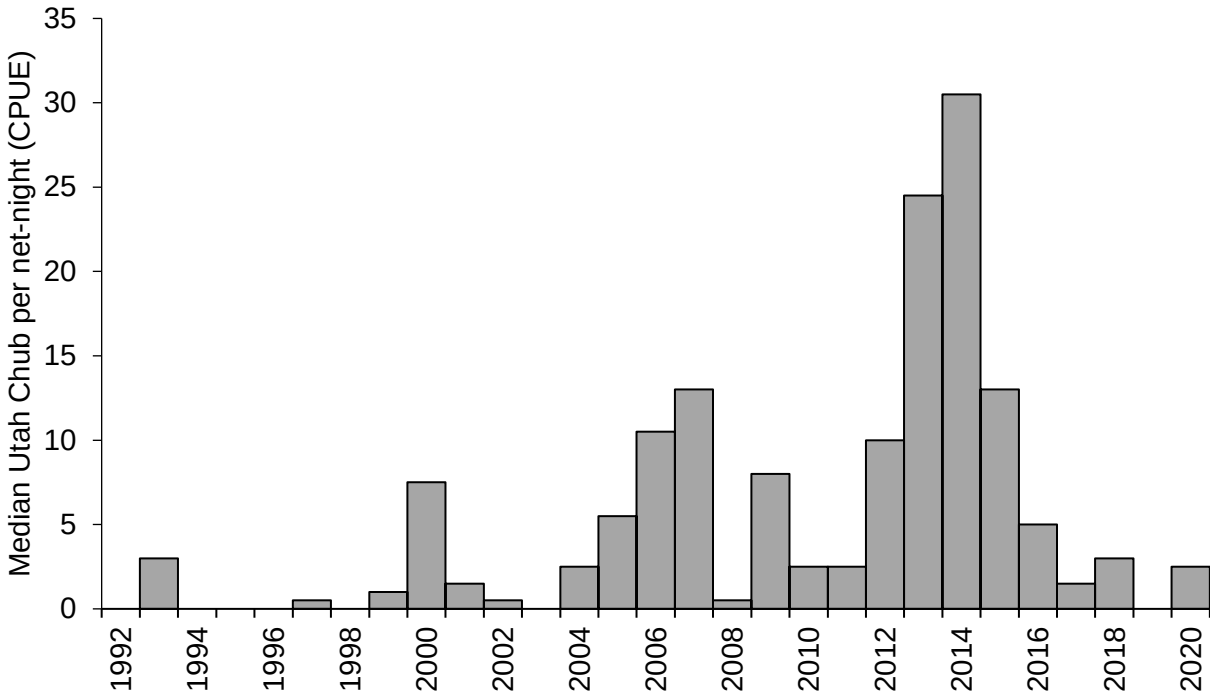

Figure 4. Median catch per unit effort (CPUE) for Utah Chub in Henrys Lake, Idaho between 1991 and 2020 using traditional gill nets set in Henrys Lake. Error bars represent 95% confidence intervals.

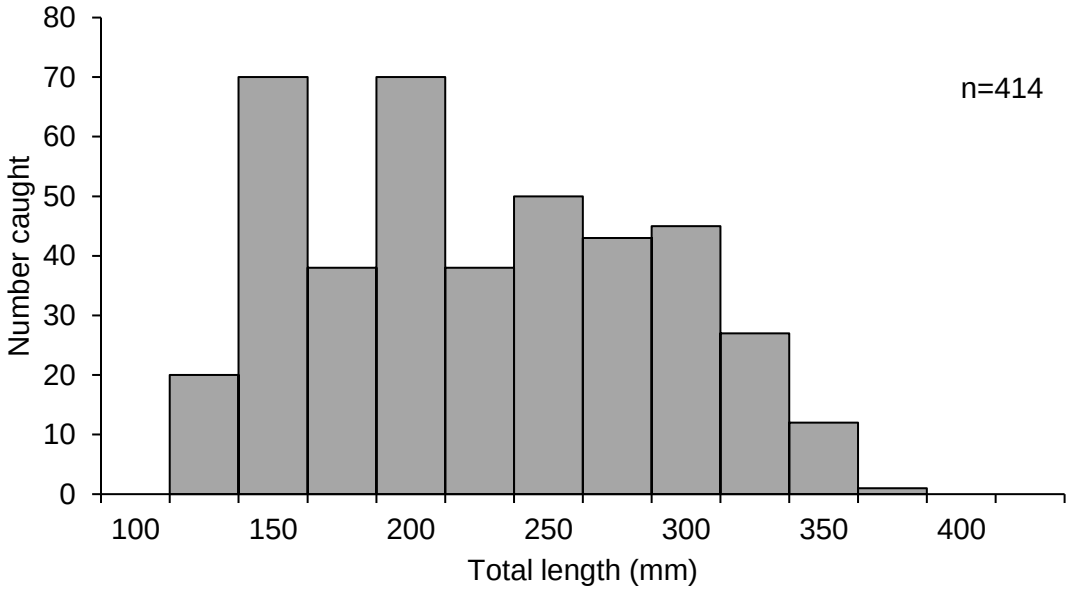

Figure 5. Utah Chub length frequency distribution from traditional gill nets set in Henrys Lake, 2020.

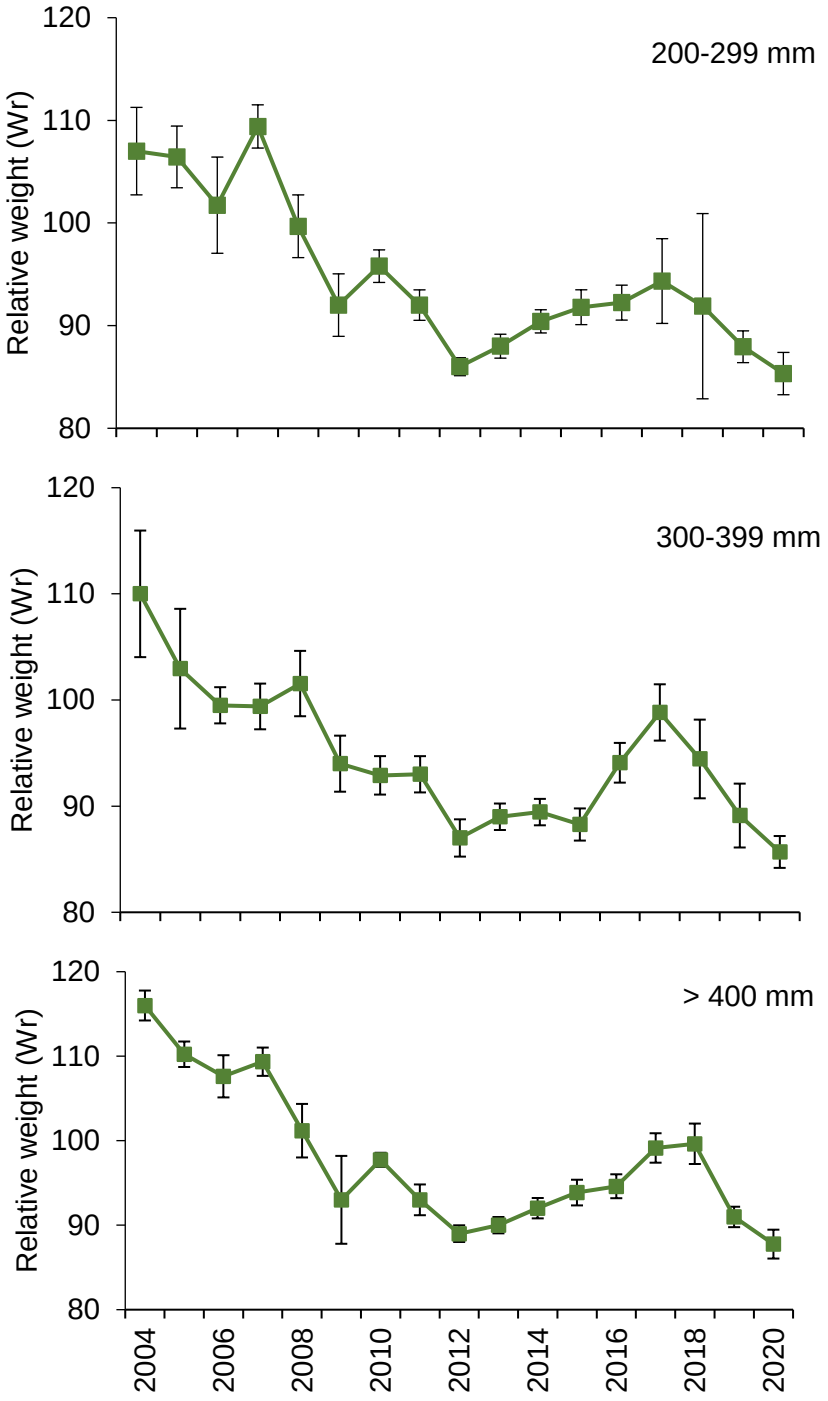

Figure 6. Relative weights (W_r) for three size classes (200 – 299 mm, 300 – 399 mm, and > 400 mm) of Yellowstone Cutthroat Trout from traditional gill nets set in Henrys Lake, 2004 – 2020. Error bars represent 95% confidence intervals.

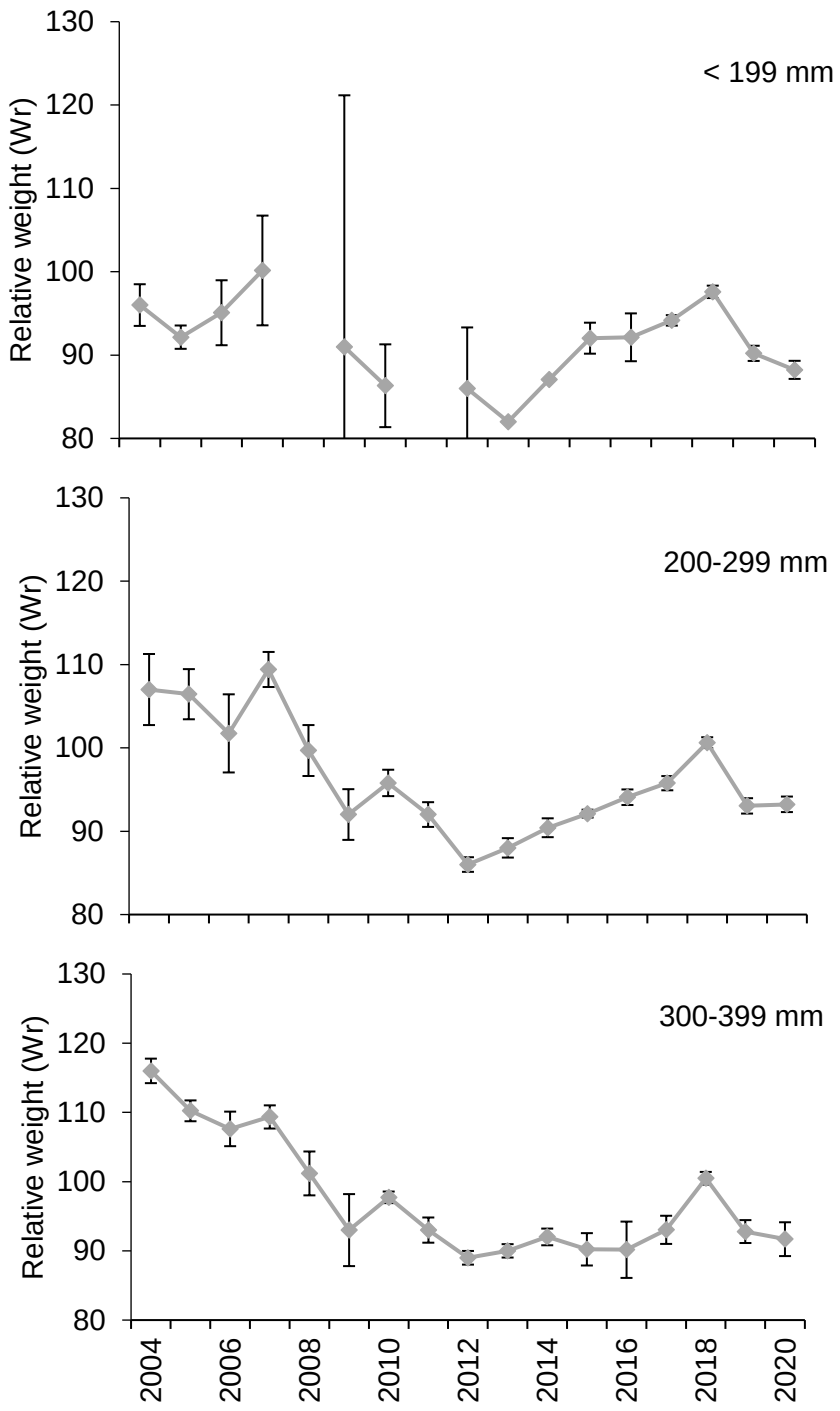

Figure 7. Relative weights (W_r) for three size classes (< 199 mm, 200 – 299 mm, 300 – 399 mm) of Utah Chub from traditional gill nets set in Henrys Lake, 2004 – 2020. Error bars represent 95% confidence intervals.

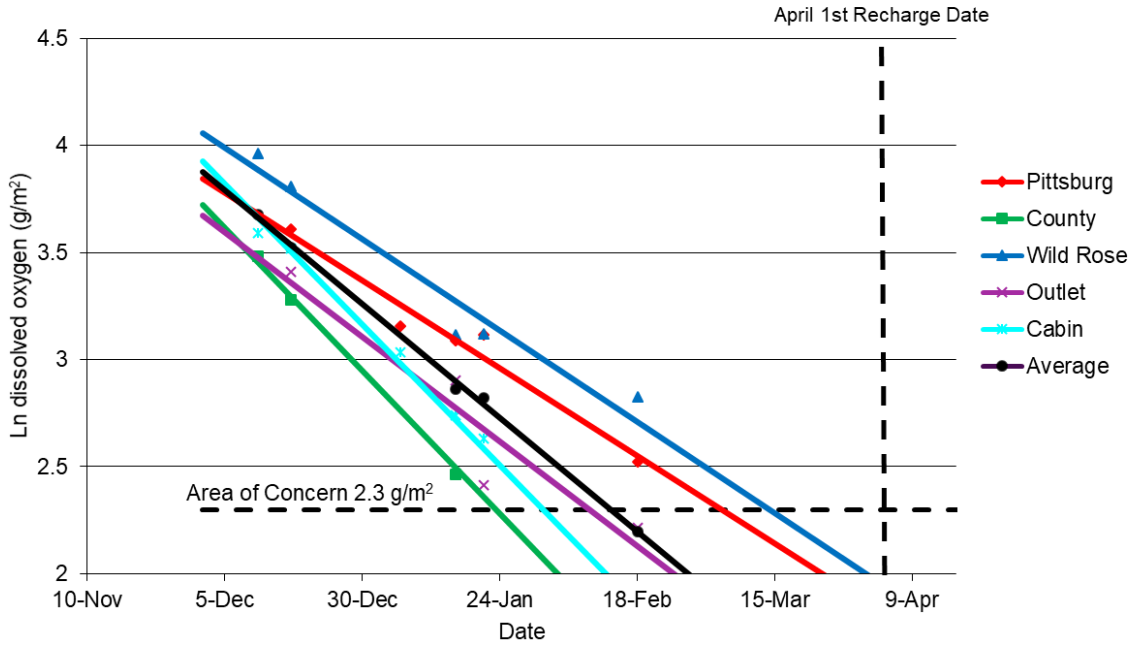

Figure 8. Dissolved oxygen depletion estimates from Henrys Lake, 2019 – 2020. Dotted lines indicate area of concern (2.3 g/m^2) and recharge date (April 1).

RIRIE RESERVOIR

ABSTRACT

We conducted our sixth year of monitoring the kokanee *Oncorhynchus nerka* population in Ririe Reservoir using gill nets suspended in the thermocline. Average catch-per-unit-effort (± 95% CI) of kokanee in gill nets was 24 fish/net-night (± 8), which was lower than catch rates in 2019 (i.e., 51 ± 18) and lower than the 5-year average (i.e., 2014-2019; 68 ± 27). Kokanee comprised the majority of the overall species composition (i.e., 74%), followed by Yellow Perch *Perca flavescens* (20%), and Utah Sucker *Catastomus ardens* (6%). Kokanee proportional size distribution (PSD) and relative stock density-preferred (RSD-P) were 26 and 6, respectively. We also conducted our eighth year of Fall Walleye Index Netting (FWIN). We caught three Walleye *Sander vitreus* in gill nets this year (0.17 fish/net-night ± 0.18), which was lower than in previous years and below the 7-year average (2011-2017; 0.60 ± 0.11), but they are still present in the reservoir. In the FWIN gill nets, Yellow Perch comprised the majority (i.e., 57%) out of the total gill-net catch, followed by Utah Sucker (24%), kokanee (13%), Yellowstone Cutthroat Trout *O. clarkii bouvieri* (3%), Utah Chub *Gila atraria* (2%). Rainbow Trout *O. mykiss*, Walleye *Sander vitreus*, and tiger trout *Salmo trutta* × *Salvelinus fontinalis* were less than 1% of the catch. We will continue monitoring kokanee on an annual basis to inform anglers about the population and to follow trends in abundance, as well as continue monitoring Walleye on a five-year cycle.

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INTRODUCTION

Ririe Reservoir is located on Willow Creek, approximately 32 km east of Idaho Falls (Figure 9). Ririe Dam was constructed in 1977, with the reservoir being filled to capacity for the first time in 1978. Ririe Reservoir is fed by approximately 153 km of streams in the Willow Creek drainage and has a total storage capacity of 124,015 megaliters. Ririe Reservoir is approximately 17 km long, is less than 1.5 km wide along the entire length, has a surface area of approximately 631 ha, and mean depth of 19.5 m. Ririe Reservoir is managed primarily for flood control and irrigation storage (BOR 2001).

Multiple sportfish species are targeted by anglers that fish Ririe Reservoir. It supports a popular fishery for Yellow Perch *Perca flavescens*, kokanee *Oncorhynchus nerka*, Smallmouth Bass *Micropterus dolomieu*, Rainbow Trout *O. mykiss*, Yellowstone Cutthroat Trout *O. clarkii bouvieri*, Brown Trout *Salmo trutta*, and tiger trout *Salmo trutta* × *Salvelinus fontinalis*. Utah Chub *Gila atraria*, Utah Sucker *Catostomus ardens*, and Bluehead Sucker *Catostomus discobolus* are also found in Ririe Reservoir. In 2019, creel surveys estimated angler use was approximately 90,024 angler hours and we estimated an average of 50,000 hours of angler use since 1993 (Heckel et al. 2020). Furthermore, we estimated that angler's harvested 53% (all species combined) of the fish they caught in 2019.

Fingerling kokanee have been stocked annually in Ririe Reservoir in the spring since 1990. In 2004, kokanee stocking rates were increased from approximately 70,000 to 210,000 in an effort to improve catch rates and meet increased angler demand. From 2014 to 2018, kokanee stocking numbers were increased an additional 50,000 to 110,000 to approximately 260,000 to 320,000 fingerlings per year. Very little natural production of kokanee occurs in Ririe Reservoir. Up until 2012, approximately 18,000 catchable Yellowstone Cutthroat Trout were stocked annually to provide additional angler opportunity. Following relatively poor performance of those fish (low fish growth, poor recruitment to creel, and dissatisfied anglers), they were replaced by similar numbers of stocked sterile Rainbow Trout. Based on creel results in 2019, anglers caught an estimated 12,144 of the 18,000 (67%) Rainbow Trout stocked and harvested an estimated 46% (Heckel et al. 2020). The high angler use and harvest of Rainbow Trout observed in 2019 suggests that hatchery Rainbow Trout are providing a diverse angling opportunity as well as meeting angler expectations. In an effort to diversify the fishery, approximately 1,700 catchable-sized tiger trout were stocked in 2019 and 2,800 in 2020.

Salmonids are not the only species that anglers can catch and harvest in Ririe Reservoir, but there are also opportunities to catch Yellow Perch, Smallmouth Bass, and even Walleye. A Yellow Perch fishery also exists in Ririe Reservoir and has become more popular over the past several years as spring reservoir levels have remained high with a resultant increase in condition and size of perch (Schoby et al. 2010). A self-sustaining population of Smallmouth Bass has developed from IDFG introductions into Ririe Reservoir from 1984-1986. Although limited by the short growing season at this latitude and altitude (Dillon 1996), Smallmouth Bass provide more non-salmonid opportunities for anglers in the Upper Snake Region. Walleye *Sander vitreus* were illegally introduced to Ririe Reservoir and were first discovered in 2008 (Schoby et al. 2010). In 2009, annual monitoring of the Walleye population began to determine the status of the Walleye population and evaluate changes to the existing fishery. Fall Walleye Index Netting (FWIN) began in 2010 and ran consecutively until 2017. Biologists found that the Walleye population abundance was low and stable, so they chose to change monitoring to a three-year rotation in 2017.

OBJECTIVES

1. Use annual summer gill netting to describe size structure, age, and growth of kokanee in Ririe Reservoir to assist in developing appropriate stocking rates.

2. Estimate the relative abundance and size structure of Yellow Perch in Ririe Reservoir to describe the Yellow Perch fishery.

3. Continue monitoring the Walleye population on a triennial basis using FWIN.

METHODS

Population monitoring

We sampled the kokanee population from June 7 to 10, 2020 using experimental gill nets with a neutrally buoyant design suspended in the thermocline. We used a water quality meter (YSI Inc., Yellow Springs, Ohio) to take water temperature at the surface and every subsequent meter down the water column until the thermocline was identified by a several degree water temperature difference from the previous depth. Experimental gill nets measured 49-m long by 6-m deep consisting of 16 panels that were 3 m long with two panels for each mesh size randomly positioned. The mesh sizes of the panels were 13-, 19-, 25-, 38-, 51-, 64-, 76-, and 102-mm bar mesh monofilament. We set nets at dusk and retrieved them the following morning. Sites were randomly selected by overlaying a grid system (100 × 100 m) in mapping software (IDFG 2012). For site selection, Ririe Reservoir was stratified into three strata: lower, middle, and upper. Nets were set in depths ranging from 10 to 16 m to ensure adequate coverage in the thermocline. All fish captured were identified to species, measured for total length to the nearest millimeter (mm), and weighed to the nearest gram (g). We calculated catch-per-unit-effort (CPUE) for each species as the number of fish/net-night and calculated 95% confidence intervals.

We removed sagittal otoliths, scales, and fin rays from ten kokanee per 10-mm length group collected from gillnetting for age and growth analysis. We followed the methods in Branigan et al. (2019) to compare structures to evaluate and validate which structure would provide an estimated age that was most accurate to the true age. From the subsample of kokanee, one whole otolith was sanded to evaluate thermal marking to determine the true age. The second otolith and fin rays were sectioned, polished, and age was estimated under a compound microscope in cross-section view with transmitted light. Additionally, an individual scale was mounted onto a microscope slide and viewed under a compound microscope. We captured digital images of each structure using the microscope interfaced with a desktop computer, then two readers independently estimated the age of each structure. A third reader was used to reconcile the age when the first two readers' estimates differed. We used age bias plots to evaluate the accuracy of our age estimates compared to the known age of our subsample of kokanee. Accuracy was calculated as the number of samples that were reconciled among all readers to match the known age of the sample divided by the total number of samples for that structure multiplied by 100. We created an age-length key from our subsample of kokanee, then applied the age-length key to unknown age kokanee. We calculated mean (and standard deviation) length-at-age using the Isermann and Knight (2005) method in the FSA package in program R (R Core Team 2020).

We calculated proportional size distribution (PSD), relative stock density-preferred (RSD-P), and relative weights to describe the size structure and condition of kokanee and Yellow Perch in Ririe Reservoir. We used the standard weight (W_s) equation

$$log_{10}(W_s) = -5.062 + 3.033 * log_{10}(L),$$

for kokanee (Hyatt and Hubert 2000) where L is the total length, then used the equation

$$W_r = \left(\frac{W}{W_s}\right) * 100,$$

where W_r is relative weight and W is measured weight. We used the same equations for Yellow Perch, but changed the intercept to -5.386 and the slope to 3.230 (Willis et al. 1991).

Kokanee PSD was calculated as the number of fish greater than or equal to 250 mm divided by the number of fish greater than or equal to 120 mm, multiplied by 100. Kokanee RSD-P was calculated as the number of fish greater than or equal to 300 mm divided by the number of fish greater than or equal to 120 mm, multiplied by 100. Yellow perch PSD was calculated as the number of fish greater than or equal to 200 mm divided by the number of fish greater than or equal to 100 mm, multiplied by 100. Yellow Perch RSD-P was calculated as the number of fish greater than or equal to 250 mm divided by the number of fish greater than or equal to 100 mm, multiplied by 100.

Fall Walleye Index Netting (FWIN)

The fall of 2020 marked the eighth year of FWIN and the first event since we switched to sampling on a triennial basis. We set six gill nets per night from October 26 to 28, for a total of 18 gill net-nights of effort. Netting effort was established based on FWIN protocol recommendations by water body size (Morgan 2002). Each night we set three sinking gill nets and three floating gill nets. Gill nets were 61-m long by 1.8-m deep, and consisted of eight panels (7.6-m long each) of stretched-bar mesh measuring 25-, 38-, 51-, 64-, 76-, 102-, 127-, and 152-mm bar mesh monofilament. We calculated PSD, RSD, and relative weights to describe the size structure and condition of kokanee, Yellow Perch, Walleye, and Yellowstone Cutthroat Trout in Ririe Reservoir. Walleye PSD was calculated as the number of fish greater than or equal to 380 mm divided by the number greater than or equal to 250 mm multiplied by 100, and for RSD-P the numerator was replaced with the number of fish greater than or equal to 510. Yellowstone Cutthroat Trout PSD was calculated as the number of fish greater than or equal to 350 mm divided by the number greater than or equal to 200 mm, and for RSD-P the numerator was replaced with the number of fish greater than or equal to 450 mm. We extracted whole otoliths from Walleye and estimated ages following the methods outlined in the population monitoring section above. Stomachs were removed from all Walleye and the contents were evaluated to estimate the diet of those Walleye.

RESULTS

Population monitoring

We collected 64 Yellow Perch, 237 kokanee, 1 Rainbow Trout, and 18 Utah Sucker from 10 gill nets set in the thermocline. Species composition was 20% Yellow Perch, 74% kokanee, 0.3% Rainbow Trout, and 6% Utah Sucker. The mean CPUE in fish/net-night (± 95% CI) of Yellow

Perch, kokanee, Rainbow Trout, and Utah Sucker were 6.4 (± 6), 23.7 (± 7.7), 0.1 (± 0.2), and 1.8 (± 1.7) fish/net-night, respectively (Figure 10). The 23.7 kokanee per net-night was the estimated CPUE (Figure 11), and we further evaluated catch rates from 2015-2020 excluding age-0 kokanee (Figure 12). Kokanee ranged in length from 86 to 428 mm with a mean length of 222 mm (SD ± 61; Figure 13). Kokanee mean relative weight was 87 (SD ± 7) and increased slightly with total length (r^2 = 0.12; Figure 14). Kokanee PSD and RSD-P were 27 and 6, respectively. We sampled more age-1 kokanee (81%) than age-0 (14%) and age-3 (5%) kokanee, and we did not sample any age-2 kokanee. The highest catch rates occurred for age-1 (i.e., 19 fish/net-night; 95% CI ± 5.4) and age-0 (3.2 fish/net-night ± 3.1) kokanee (Figure 15). Total length (mm) by respective age of kokanee is similar to other years (Figure 16), even though we were missing the age-2 year class in our sample. The average TL of age-1 kokanee was 236 mm (SD ± 21; *n* = 190) and 354 mm for age-3 kokanee (SD ± 32, *n* = 12).

We were most accurate in estimating kokanee age using sectioned otoliths, as 55% of the samples were reconciled to be the known age, followed by fin rays (50%), scales (37%), and whole otoliths (36%). Age bias plots indicated that we generally overestimated rather than underestimated ages for all structures (Figure 17).

Gill-net catch rates for Yellow Perch (6.4 fish/net-night ± 6.0; Figure 18) were lower than the average from 2015-2019 (77 fish/net-night ± 12.6). Yellow Perch ranged in length from 118 to 257 mm with an average total length of 223 mm (SD ± 30.2; Figure 19). The Yellow Perch PSD was 89, RSD-P was 7, and Yellow Perch comprised 20% of all fish caught. Yellow Perch mean relative weight was 80 (SD ± 6.5) and declined slightly with increasing total length (r^2 = 0.17; Figure 20).

FWIN

We collected 1,521 fish in 18 net-nights of effort including three Walleye. We caught 754 fish in our sinking nets and 767 fish in our floating nets. The catch composition was dominated by Yellow Perch (57.4%) followed by Utah Sucker (23.6%), kokanee (13.3%), Yellowstone Cutthroat Trout (3.3%), Utah Chub (1.8%), Rainbow Trout (0.2%), Walleye (0.2%), Rainbow × Cutthroat Trout hybrid (0.1%), and tiger trout (0.1%; Figure 21). The CPUE for Walleye was very low (0.2 fish/net-night ± 0.2), similar to all other years, and less than the average from 2012-2017 (0.62 ± 0.10). We observed the highest CPUE for Yellowstone Cutthroat Trout (2.8 fish/net-night ± 3.2) and kokanee (11.2 ± 10) compared to previous surveys. Yellow Perch CPUE (49 ± 37) was less than compared to previous surveys and less than the average from 2012-2020 (71 ± 24). We captured three Walleye that measured 267, 351, and 277 mm in TL, respectively (Table 7). We estimated the PSD and RSD-P values of Yellow Perch that we caught in FWIN nets as 86 and 10, respectively, and the average TL was 224 mm (SD ± 23; Figure 22). For kokanee, we estimated PSD and RSD-P as 66 and 18, respectively, with an average TL of 260 mm ± 67 (Figure 23). We estimated Yellowstone Cutthroat Trout PSD and RSD-P values as 66 and 4, respectively, with an average TL of 359 mm ± 48 (Figure 24). The mean relative weight (± SD) for Yellow Perch was 94 (± 5) (Figure 25), 91 (± 2) for kokanee (Figure 26), and for 88 (± 3) Yellowstone Cutthroat Trout (Figure 27). Although we caught a small sample size (*n* = 3) of Walleye, we estimated the mean relative weight to be 87 (± 26). We analyzed the diet of all Walleye captured; one stomach was empty, one contained an unknown fish, and one stomach contained a fish with orange muscle, suggesting it was a kokanee (Table 7).

DISCUSSION

The missing kokanee age class we observed in 2019 is still missing in the population as seen by a lack of age-2 kokanee being sampled. The effects of not receiving our fingerling request of early-run kokanee in 2018 can be seen in the fishery for several years, but gill net catch rates (excluding age-0 kokanee) show the fishery is rebounding. However, we did observe a strong age-1 year class, which will provide opportunities for anglers during the upcoming ice fishing season, and should also provide great fishing for kokanee during the open water period. Because we also sampled in the fall using FWIN, we observed an increase in body condition of kokanee, indicating that they were putting on weight prior to winter.

This was the first year that we analyzed kokanee otoliths for thermal marks in the Upper Snake regional fisheries lab using our regional sander and compound microscope. Based on our age validation study using thermal marks, we were only 55% accurate at correctly estimating the ages of kokanee. Therefore, we will no longer estimate age using kokanee hard structures, but we will continue taking a subsample of kokanee otoliths to evaluate thermal marks for the true age to better understand the age structure of the kokanee population in Ririe Reservoir.

The current catch rates of kokanee in suspended gill nets were lower than the 6-year average, but the catch rate of kokanee in FWIN was the highest on record, even though FWIN uses some sinking nets which are typically less effective for sampling kokanee. Therefore, we anticipate that the kokanee fishery is rebounding after the poor survival of fish stocked in 2018. Furthermore, we hypothesized that several days of unseasonably cold and windy weather prior to our suspended gill netting effort in June affected the water temperature and thermocline throughout the reservoir. Kokanee may have responded by migrating to other areas of the reservoir and shifting catch rates by location. For example, catch rates for kokanee were historically high near the dam and low near the Blacktail Boat Ramp because that portion of the reservoir is shallower, but they were opposite of that this year. We recommend continuing to use suspended gill nets in the thermocline in June to monitor population trends of kokanee in Ririe Reservoir.

The Yellow Perch fishery in Ririe is a popular fishery which requires continual monitoring to evaluate population trends and predict how the fishery will perform. Yellow Perch abundance was the lowest on record during our June netting, but showed an increase during our FWIN netting. The decline in Yellow Perch abundance could be an artifact of the weather phenomenon in June because we did have higher catch rates in our FWIN netting, and an artifact of sampling design because suspended gill nets are used to target kokanee specifically. However, fall netting with sinking and floating gill nets is likely a better time to sample and evaluate Yellow Perch abundance in Ririe Reservoir. This strategy is a similar design that the McCall sub-region uses to monitor the Yellow Perch population in Lake Cascade (Janssen et al. 2020), and using paired sinking and floating gill nets aligns with our Standard Fish Sampling Protocol for Lowland Lakes (IDFG 2012). We recommend that using the CPUE of Yellow Perch in FWIN netting is a better index of monitoring the relative abundance of Yellow Perch in Ririe Reservoir than using suspended gill netting. However, because we still capture Yellow Perch in suspended gill nets, we should continue reporting those numbers. We recommend taking a subsample of Yellow Perch in the next round of FWIN to estimate age and growth to help identify years when recruitment and growth rates are high so that we can better understand the environmental variables associated with the population parameters.

The Walleye population appears to be low and stable with catch rates estimated to be the second lowest on record, suggesting the population is stable and at low abundance. We have

anecdotal evidence that anglers target Walleye in the Willow Creek arm of the reservoir, which could be providing some harvest of the population, but no Walleye were caught by anglers interviewed during our creel census, indicating catch rates are very low. The Willow Creek arm and upstream 2 km of Willow Creek are where a telemetry study tracked Walleye during their spawning period in April-May 2009-2010 (Schoby et al. 2014). We hypothesize that Walleye are trying to spawn in poor habitat in the Willow Creek arm and their eggs are becoming buried by sediment as the reservoir fills, but this has not been evaluated. However, Walleye expansion throughout the reservoir could have a negative impact on the kokanee fishery, which is a very popular fishery. The 2019 creel survey indicated anglers harvested kokanee at over 80% (Heckel et al. 2020). We recommend continuing to monitor the Walleye population on a triennial basis. This monitoring protocol may allow detection of a rapid population expansion, should it occur, and development of appropriate suppression strategies. We recommend investigating interactions such as competition and interspecific predation of other species with and by Walleye, and describing effects of factors like time of spawning, larval growth, and duration of egg incubation on Walleye recruitment. The life history characteristics of Walleye may not be suited to the environmental dynamics (e.g., high spring runoff flows out of tributaries, variable reservoir water levels) of Ririe Reservoir (Quist et al. 2003). However, we need to continue monitoring the Walleye population and take steps to reduce their abundance should population density increase.

MANAGEMENT RECOMMENDATIONS

1. Continue annual monitoring of kokanee relative abundance, age, and growth to predict how the fishery will perform.

2. Increase the number of kokanee stocked if catch rates in suspended gill nets remain below the 5-year average for two consecutive years after all age classes are present.

3. Evaluate abundance of Yellowstone Cutthroat Trout in Willow Creek and whether there is an adfluvial component to the population to help direct future stream restoration efforts.

4. Describe the Yellow Perch population in terms of age, growth, and mortality so as to improve understanding of factors that influence variable year-class strength, allowing for better predictors of fishery quality.

5. Monitor Smallmouth Bass population abundances on a five-year cycle to maintain this fishery and identify when/if management intervention is required.

6. Continue monitoring the Walleye population on a triennial basis using FWIN, and combine FWIN with spring electrofishing sampling in Willow Creek to obtain a larger sample size of Walleye and better quantify growth and survival rates using back-calculated length-at-age analysis.

Table 7. Summary data for Walleye caught during 2020 FWIN in Ririe Reservoir. NA represents data that were not available.

Net type	Net #	Mesh size	FL (mm)	TL (mm)	Weight (g)	W_r	Sex	Maturity	Age	Visceral fat wt (g)	Gonad wt (g)	Stomach contents
Sink	6	51	250	267	158	86	M	Immature	1	15.5	NA	unidentified salmonid; orange muscle suggests kokanee
Float	5	72	330	351	426	97	M	Immature	2	9.26	NA	empty
Float	10	51	241	277	157	76	M	Immature	1	NA	NA	unknown fish

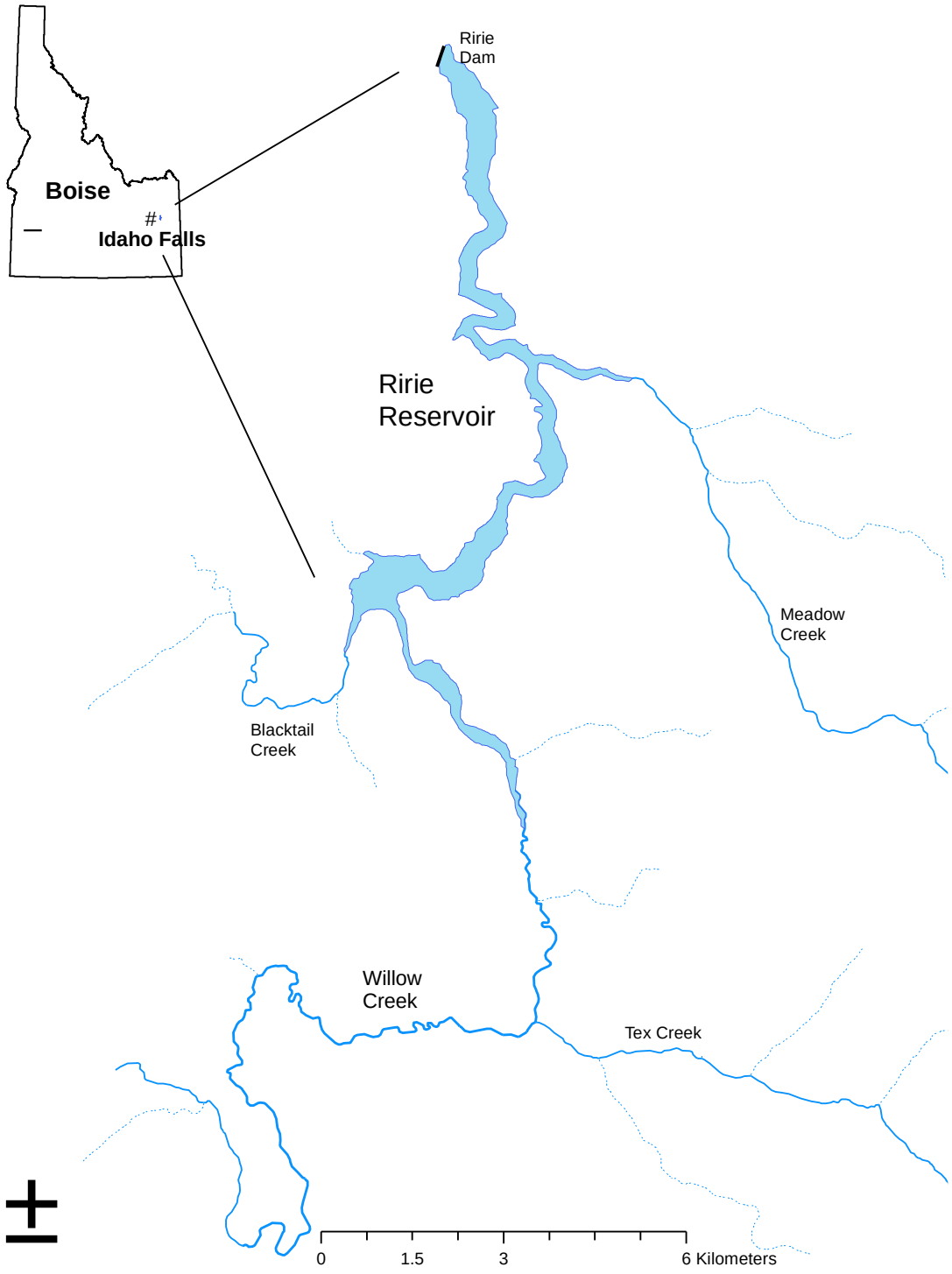

Figure 9. Location of Ririe Reservoir and major tributaries.

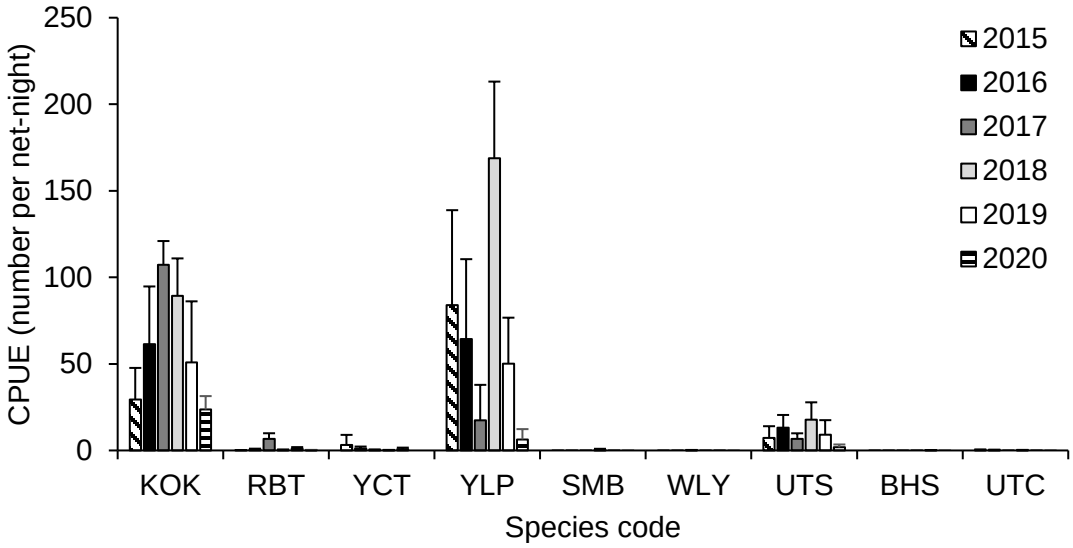

Figure 10. Catch per unit effort (CPUE; fish/net-night) from suspended gill nets for kokanee (KOK), Rainbow Trout (RBT), Yellowstone Cutthroat Trout (YCT), Yellow Perch (YLP), Smallmouth Bass (SMB), Walleye (WLY), Utah Sucker (UTS), Bluehead Sucker (BHS), and Utah Chub (UTC) in Ririe Reservoir during 2015–2020. Error bars represent 95% confidence intervals.

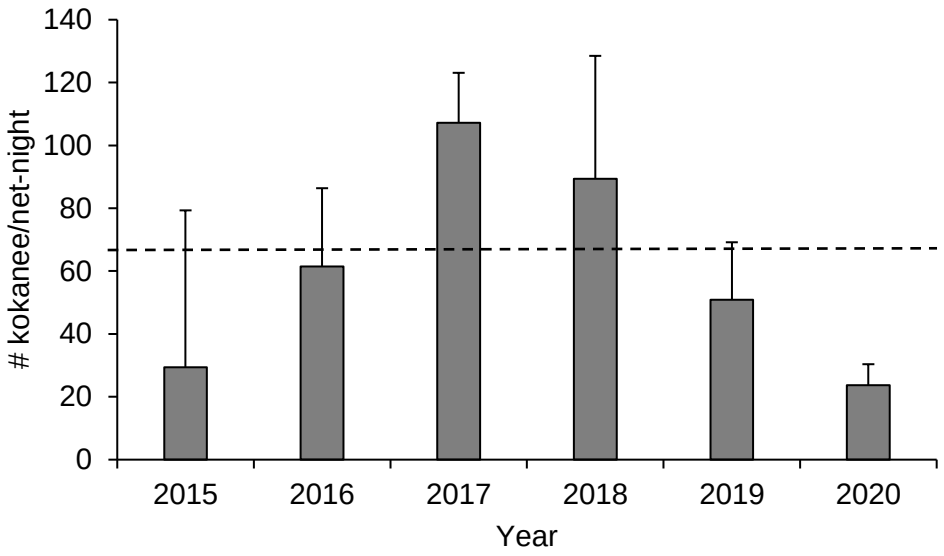

Figure 11. The mean number of kokanee caught per net-night from 2015 to 2020. Error bars represent 95% confidence intervals. The dashed line represents the 5-year mean catch per from 2015 to 2019 (i.e. 67.7 kokanee/net-night).

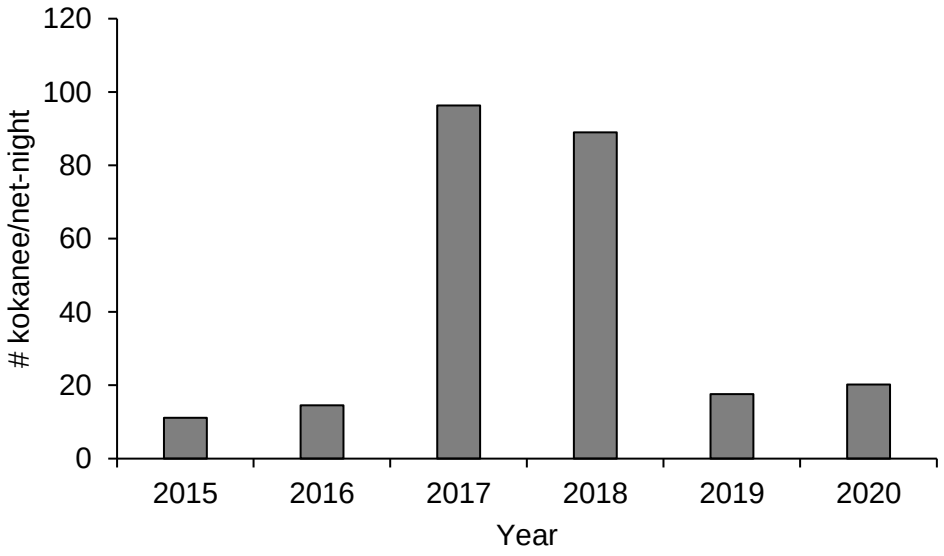

Figure 12. Catch rates of kokanee/net-night in suspended gill nets from 2015-2020 excluding age-0 kokanee.

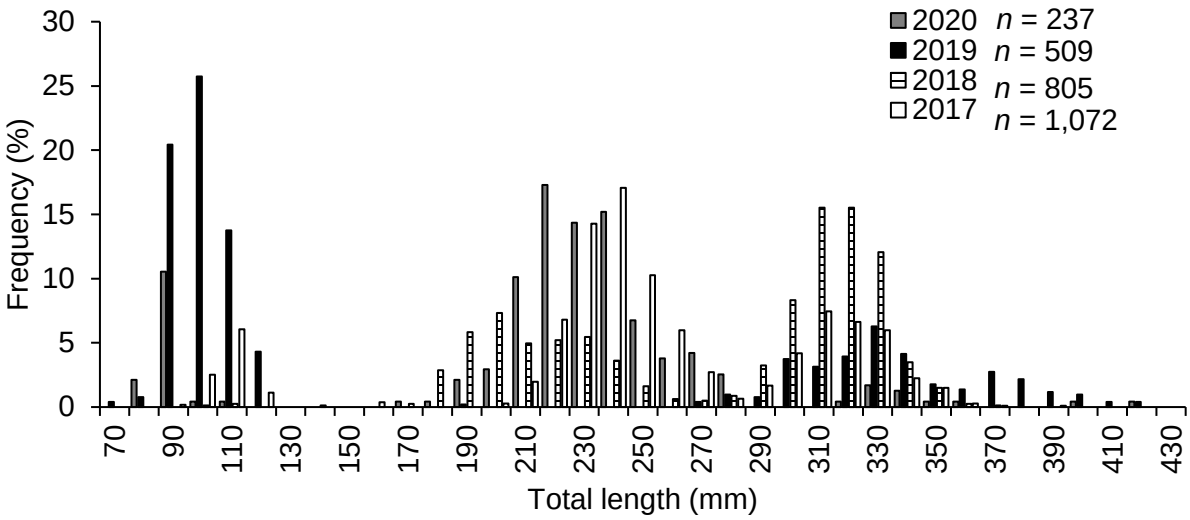

Figure 13. The length-frequency (%) distribution of kokanee caught in suspended gill nets in Ririe Reservoir in 2017-2020.

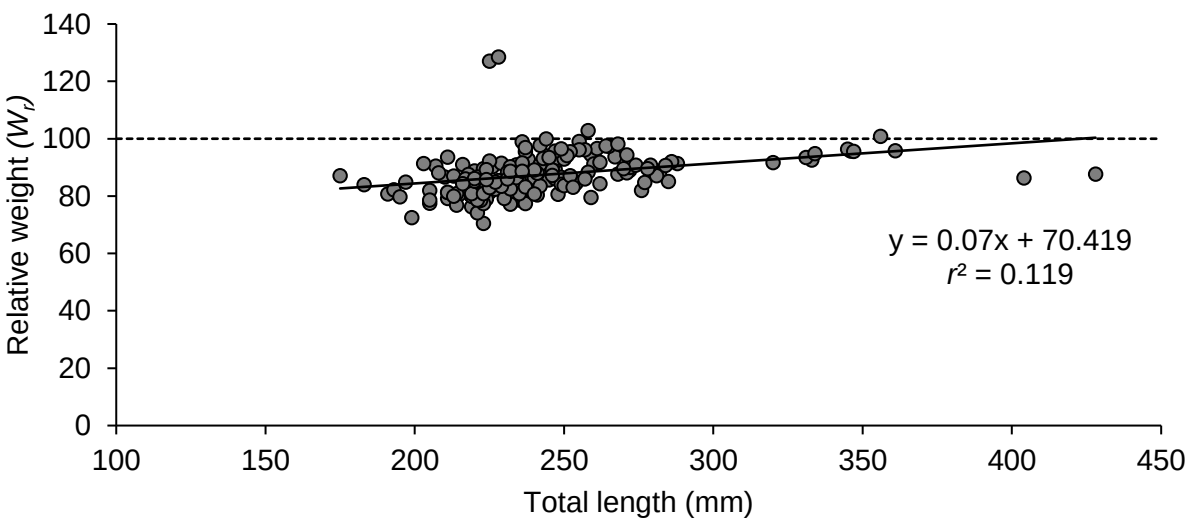

Figure 14. The relative weight (W_r) of kokanee across total length (mm) caught in suspended gill nets in Ririe Reservoir in 2020. The dashed line represents a relative weight of 100 and the solid line is the regression line for the points.

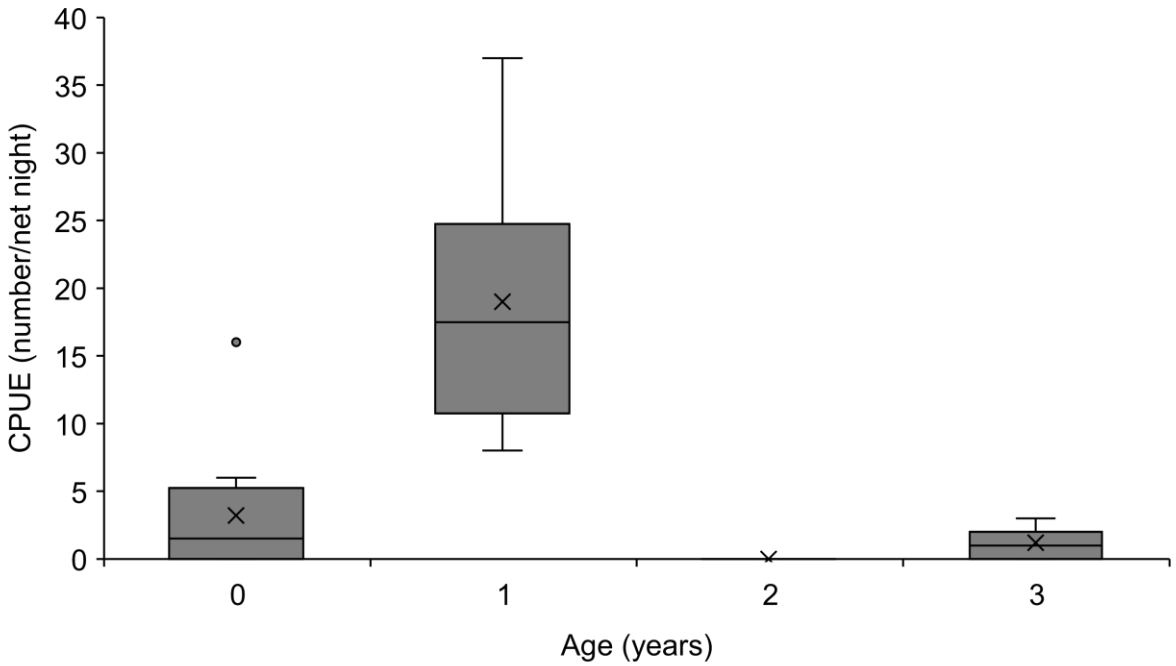

Figure 15. Catch rates (CPUE; number of kokanee/net-night) by age class for kokanee in Ririe Reservoir in 2020. The line in each box represents the median, the X represents the mean, the box represents the range between the first and third quartiles, the whiskers represent the maximum and minimum values, and dots represent outliers.

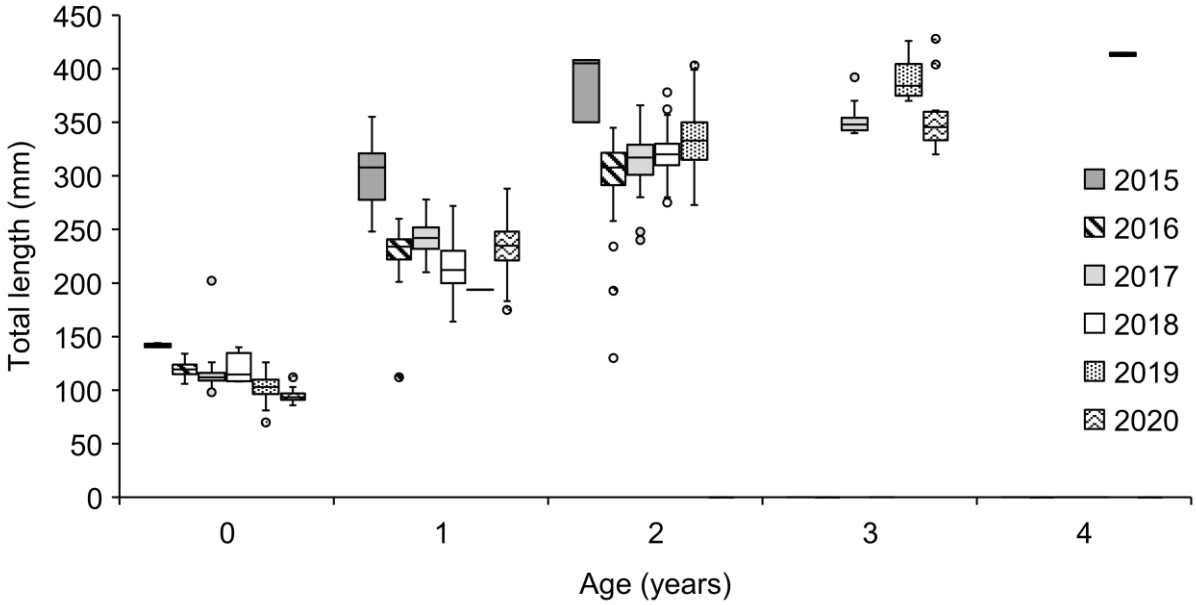

Figure 16. Total length (mm) by age (years) of kokanee caught in suspended gill nets in Ririe Reservoir from 2015 to 2020.

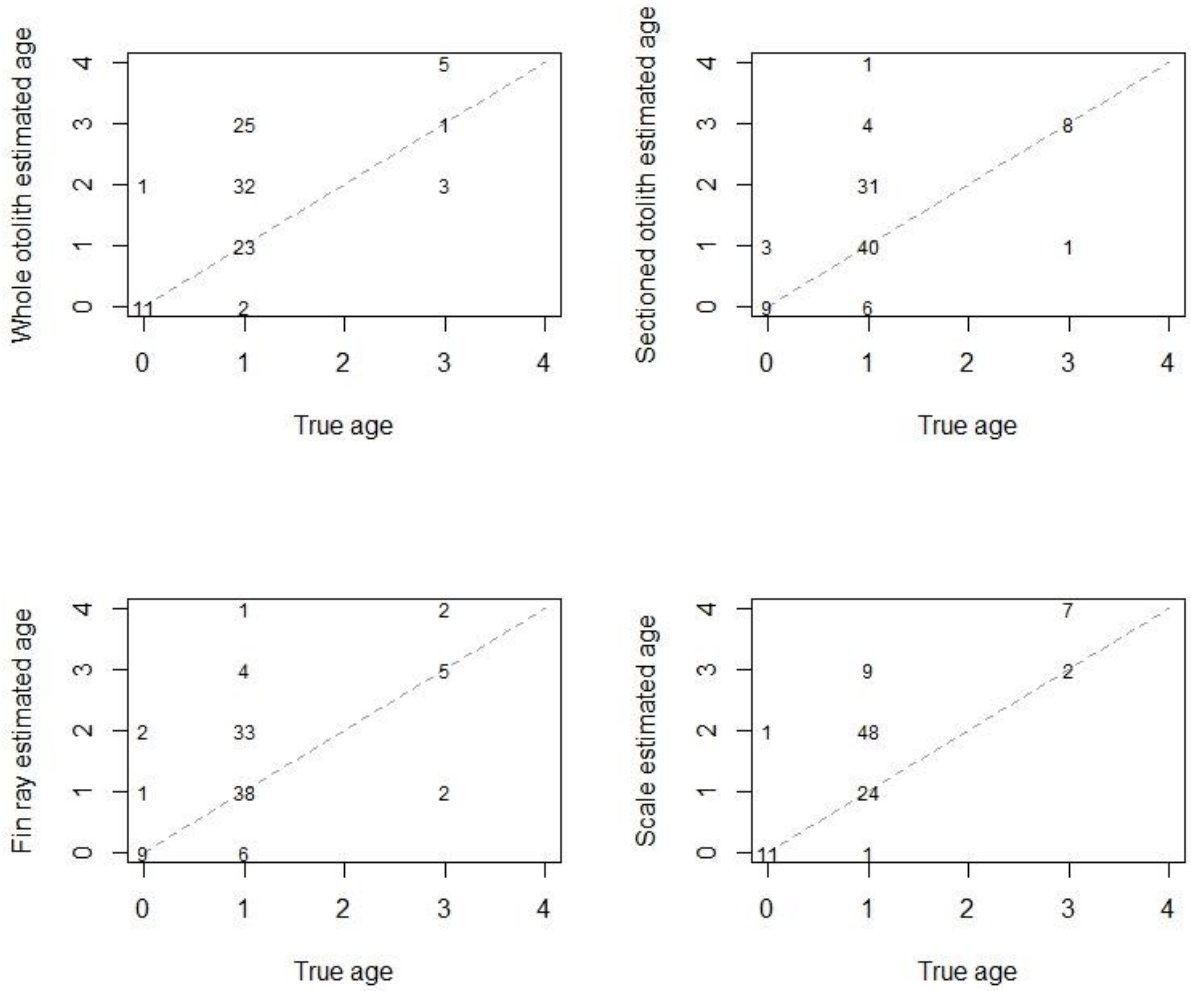

Figure 17. Age bias plots comparing the estimated age of whole otoliths, sectioned otoliths, fin rays, and scales compared to the true age of kokanee caught in suspended gill nets evaluated by thermal marks. The dashed line represents a 1:1 ratio of 100% accuracy between estimated age and true age. The numbers that fall on the dashed line are the count of accurately estimated ages, the numbers above the line are overestimates, and the numbers below the line are underestimates of age.

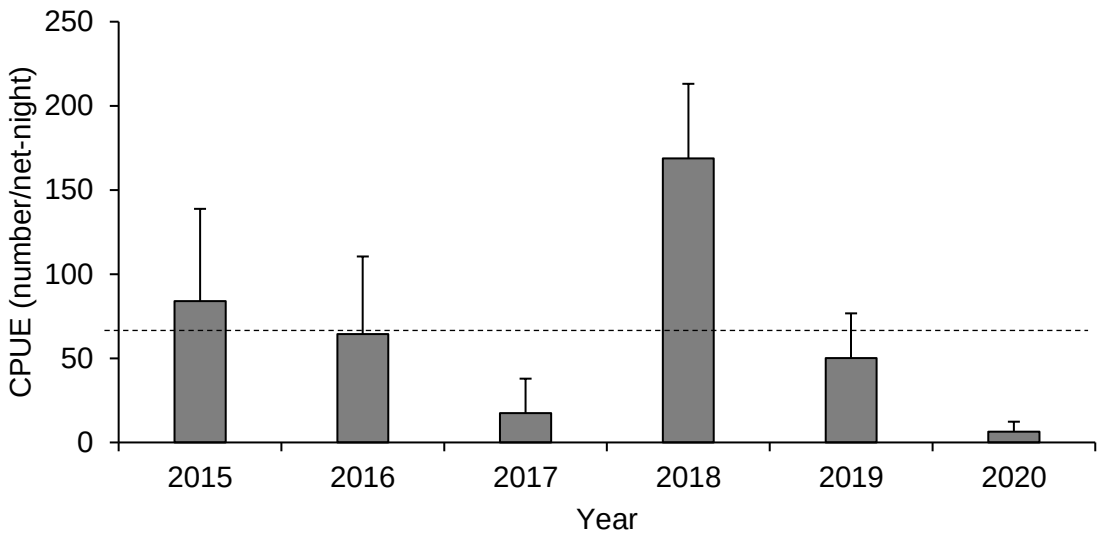

Figure 18. Catch rates (CPUE; number of fish/net-night) of Yellow Perch in suspended gill nets in Ririe Reservoir from 2015-2020. The dashed line represents the mean from 2015-2019 (77 fish/net-night) and error bars represent 95% CI.

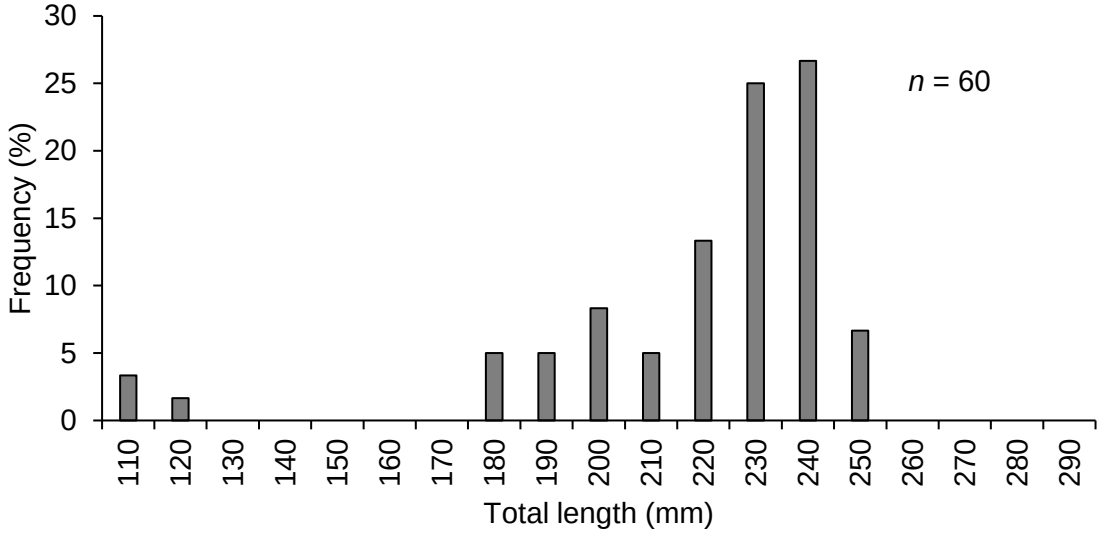

Figure 19. The length-frequency distribution of Yellow Perch caught in suspended gill nets in Ririe Reservoir in 2020.

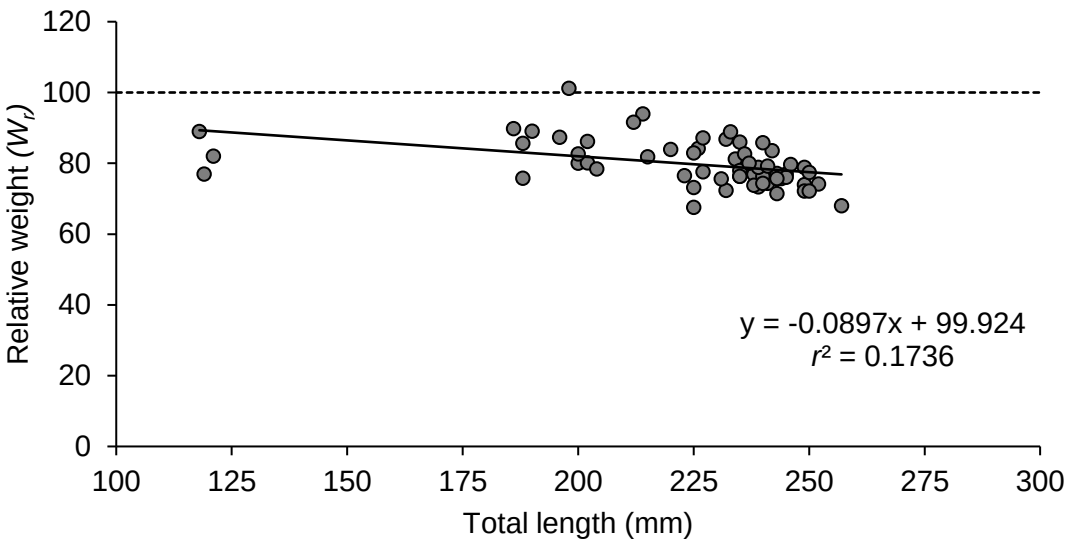

Figure 20. Relative weight (W_r) of Yellow Perch across total length (mm) caught in suspended gill nets in Ririe Reservoir in 2020. The dashed line represents a relative weight of 100 and the solid line is the regression line for the points.

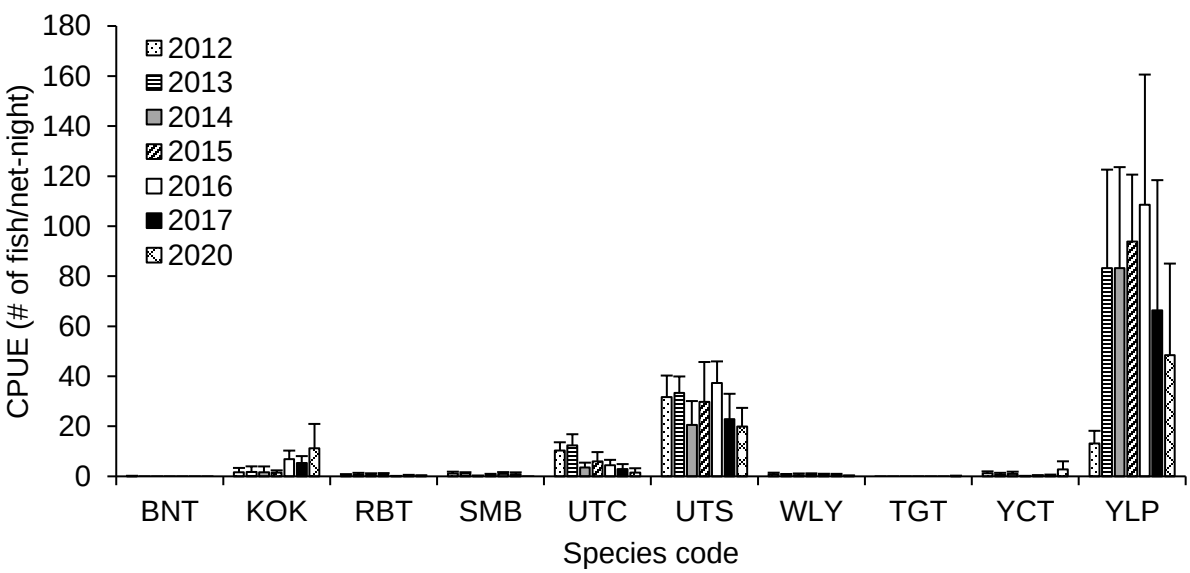

Figure 21. The number of fish caught per unit effort (CPUE; fish/net-night) from 18 FWIN nets for Brown Trout (BNT), kokanee (KOK), Rainbow Trout (RBT), Smallmouth Bass (SMB), Utah Chub (UTC), Utah Sucker (UTS), Walleye (WLY), tiger trout (TGT), Yellowstone Cutthroat Trout (YCT), and Yellow Perch (YLP) in Ririe Reservoir during 2012–2020. Error bars represent 95% confidence intervals.

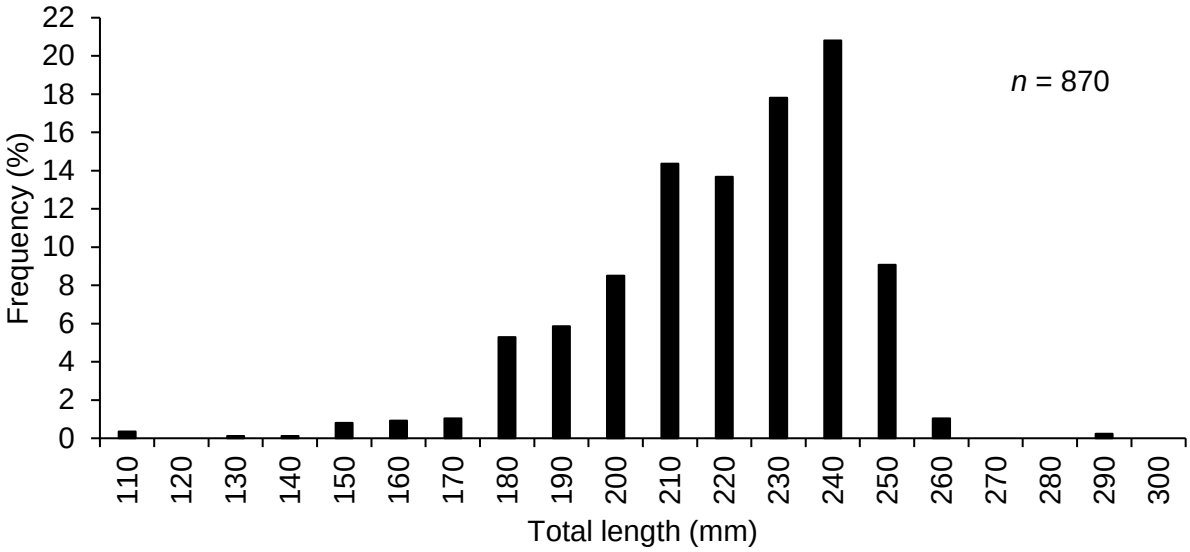

Figure 22. The length-frequency distribution of Yellow Perch caught in FWIN nets in Ririe Reservoir in October 2020.

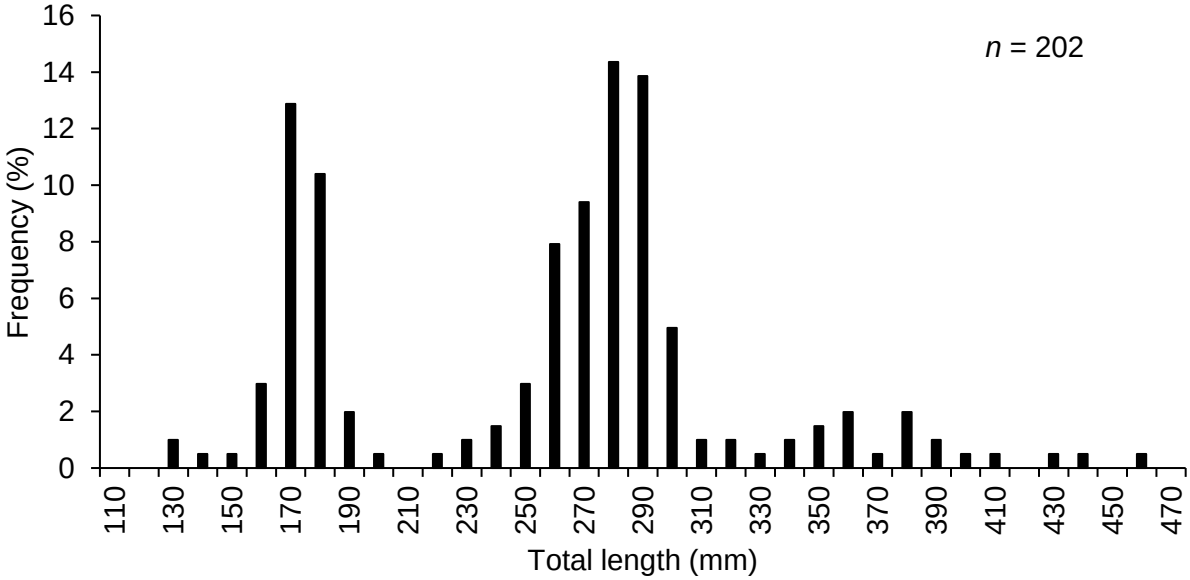

Figure 23. The length-frequency distribution of kokanee caught in FWIN nets in Ririe Reservoir in October 2020.

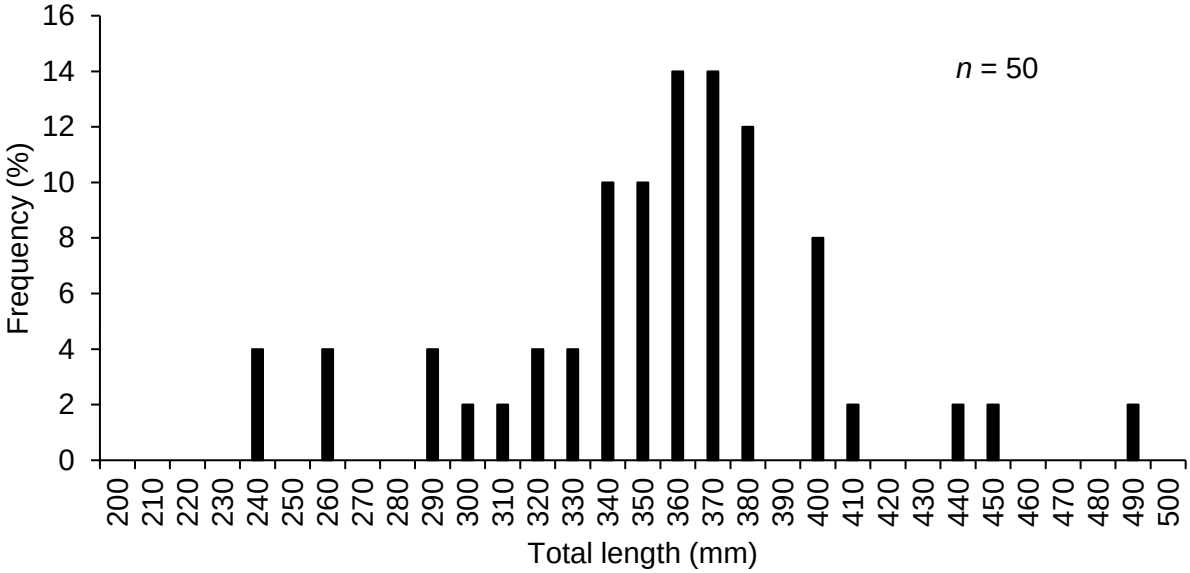

Figure 24. The length-frequency distribution of Yellowstone Cutthroat Trout caught in FWIN nets in Ririe Reservoir in October 2020.

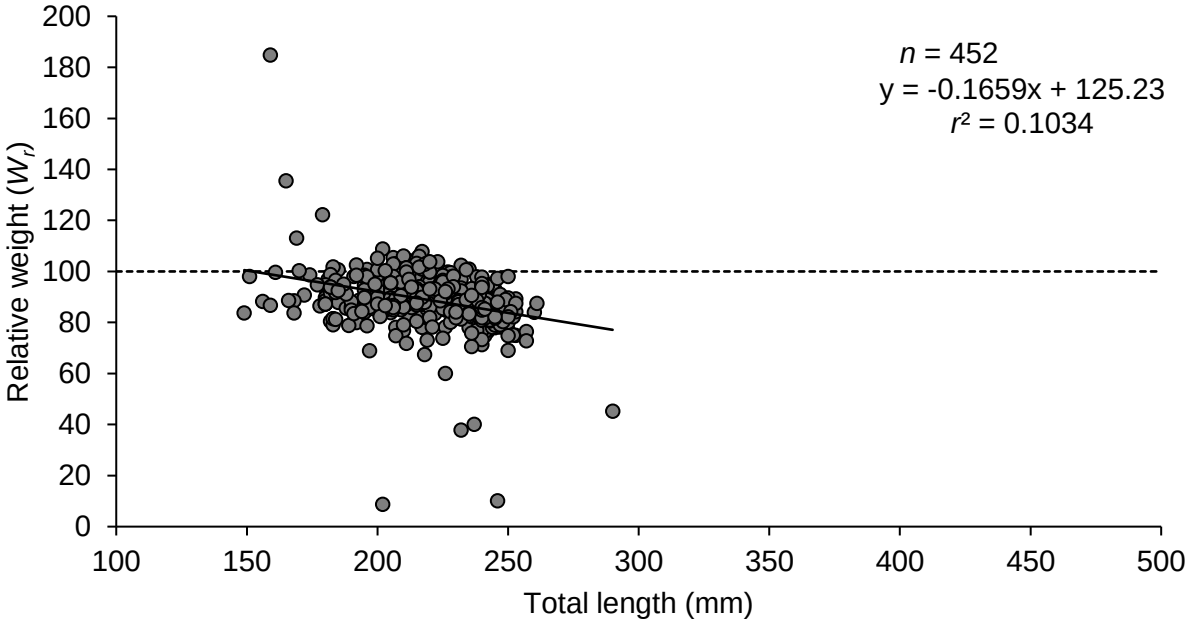

Figure 25. The relative weight (W_r) by total length (mm) for Yellow Perch caught in FWIN nets in Ririe Reservoir in October 2020.

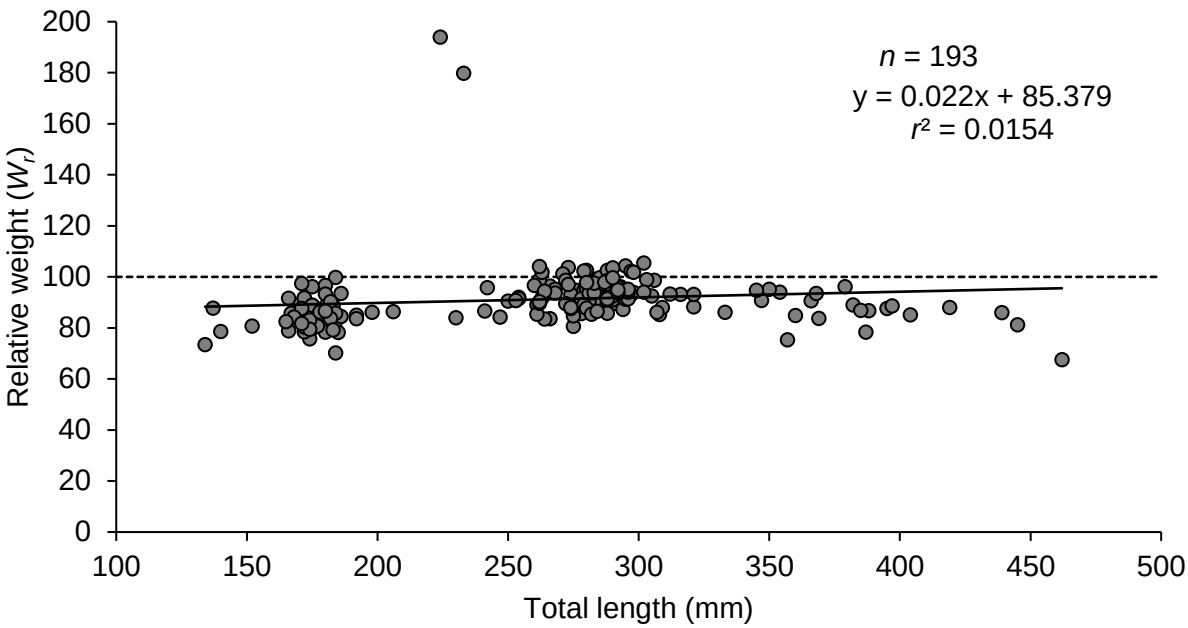

Figure 26. The relative weight (W_r) by total length (mm) for kokanee caught in FWIN nets in Ririe Reservoir in October 2020.

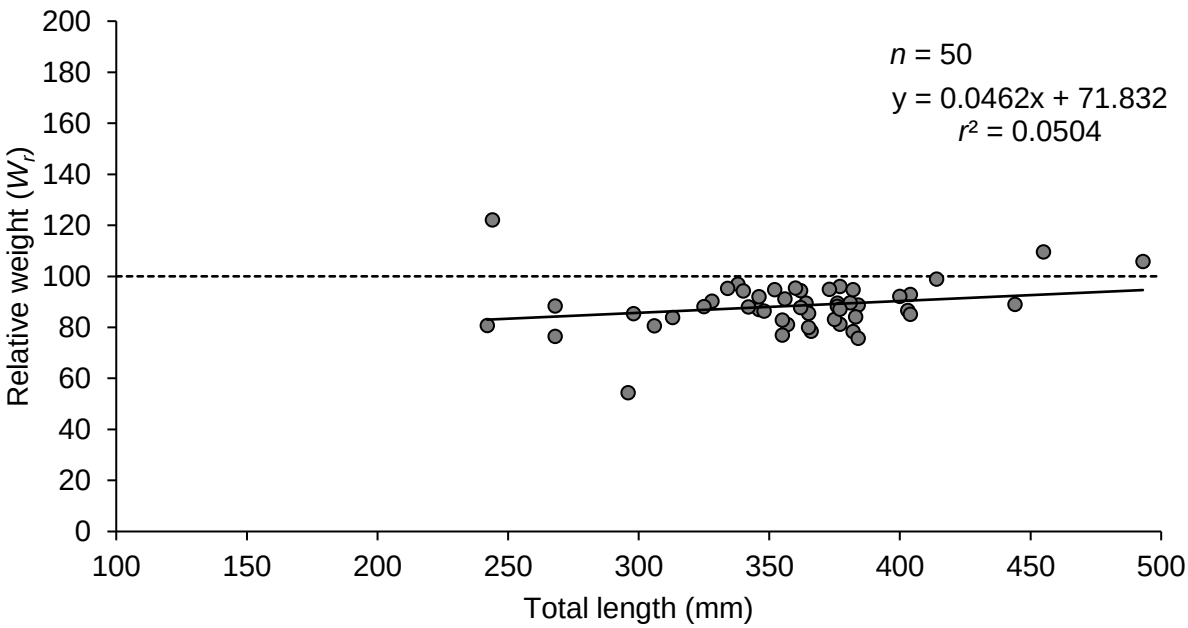

Figure 27. The relative weight (W_r) by total length (mm) for Yellowstone Cutthroat Trout caught in FWIN nets in Ririe Reservoir in October 2020

HIGH MOUNTAIN LAKES

ABSTRACT

We surveyed nine high mountain lakes throughout the Upper Snake Region during 2019-2020 to assess the current state of the fisheries and inform stocking rates. Habitat, fishery, and amphibian surveys were conducted on each lake. In addition, overall lake metrics and human use were assessed. Angel, Bellas, North Bellas, Bench, Goat and Swauger Lakes met the Fisheries Management angling catch rate goal of 1 fish/hour while Big, Divide Creek, and Packsaddle Lakes did not meet the catch rate goal. The Angel Lake fishery is supported by a wild-reproducing population of Rainbow Trout numbering 1,618 (1,108 to 3,004 fish). Relative weights of Rainbow Trout (RBT) in Angel Lake are low (average = 75) and average total length (194 mm) has declined since the previous survey conducted in 2004. The Angel Lake fishery could be improved by decreasing the Rainbow Trout population. The average total length (TL) of Yellowstone Cutthroat Trout (YCT) in Bellas Lake was 168 mm with an average relative weight of 91, with relative weight decreasing as length increased. Increasing the number of fish stocked could help improve this fishery and evaluating length-at-age will provide data on whether there is a density dependence issue preventing a higher abundance of fish greater than 254 mm. Catch rates for YCT in North Fork Bellas Lake were 3.56 fish/h, the average TL was 266 mm, and the average relative weight was 81. This wild-reproducing fishery does not need hatchery supplementation and should be continued to be surveyed with angling to monitor the population. We experienced very high catch rates (22 fish/h) at Bench Lake, but the size structure was poor with the average TL of RBT at 179 mm and an average relative weight of 74. Fish density in Bench Lake is likely too high, so introducing a predatory fish like tiger trout could help improve size structure and provide anglers with another unique opportunity of catching this unique species in an alpine setting. Although catch rates (0.87 fish/h) were below the management objective in Big Lake, it does provide a unique opportunity to catch tiger trout and YCT in an alpine setting. From our gill-net catch, the average TL of tiger trout was 308 mm and 210 mm for Cutthroat Trout. Relative weights decreased with increasing length, but on average fish with a TL less than 300 mm displayed a relative weight greater than 100 and fish greater than 300 mm displayed a relative weight less than 100. Catch rates in Goat Lake were 7 fish/h for the spinning rod and 5.5 fish/h for the fly rods, and there appears to be wild reproduction in addition to our triennial stocking. The average TL was 290 mm and the average relative weight was 88. The Goat Lake fishery is unique in that it is the highest elevation lake in the state with fish in it, these fish can reach the 17-18” mark and potentially larger, and it is in close proximity to several other lakes (e.g., Baptie and Betty lakes) with exceptional fishing. Packsaddle Lake is popular for anglers and recreationalists alike. Gillnet catch rate for YCT was 28.5 per net-night and captured YCT averaged a TL of 170 mm. Ages in the gillnet catch ranged from age-1 to -3 and overall relative weights increased with TL. Due to the popularity of this lake, we recommend conducting both a gill-net and angler survey on a triannual basis. No fish were captured in the Divide Creek Lake or Swauger Lake surveys.

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INTRODUCTION

Idaho has over 3,700 high mountain lakes that offer enhanced fishing experiences in scenic places that often offer solitude and remoteness. Anglers value these fisheries. During the recent angler opinion survey conducted by the department, anglers utilizing mountain lakes expressed the second highest level of satisfaction with their fishing experience just behind stream trout fisheries and consider the management of mountain lakes one of the important activities of IDFG, assigning this with a rank of 7th most important thing we do (IDFG 2019). In the Upper Snake Region, we have 43 high mountain lakes which currently support fish populations. Of these, we routinely stock 34 lakes with hatchery fish, and the remaining nine lakes have fish populations supported by natural reproduction. Most of the alpine lakes in the Upper Snake Region are in the Big Lost Drainage. Guidelines for regional high mountain lake management were jointly established with the Lost River Ranger District of the Salmon-Challis National Forest. Our goals are to maximize the effective use of hatchery introductions, manage for diversity of species within a given drainage, maintain angler catch rates of at least one fish per hour, and maintain some lakes in each drainage as "fishless" to benefit native nongame aquatic species. High mountain lakes in other drainages are managed for a goal of 1 fish per hour catch rates and sometimes focused on native fish (Upper and Lower Palisades lakes). Most of the high mountain lakes in the Upper Snake Region have previously been surveyed (Garren et al. 2006a; Garren et al. 2006b; Garren et al. 2006c), but changes in stocking practices, changes in environmental conditions, and the level of interest from our angling public necessitate regular monitoring of these important fisheries to ensure management actions are appropriate and efforts are directed at achieving our management goals. This report summarizes the high mountain lake monitoring and research efforts conducted by regional staff in 2019 and 2020.

OBJECTIVES

To obtain current information for fishery management decisions on mountain lakes, including angler use and success, fish population characteristics, spawning potential, stocking success, limnology, morphology, and notes on other aquatic life and develop appropriate management recommendations.

METHODS

Fishery survey

To gather information on the current state of the fishery, at least one overnight gillnet was set at each lake as outlined in Table 8. Floating, Swedish-style, experimental gill nets (36 m long by 1.8 m deep) consisting of nylon mesh panels of 10.5-, 12.5-, 18.5-, 25.0-, 33.0-, and 38.0-mm bar mesh were set and fished overnight. Nets were set in locations to maximize catch and were retrieved the following morning in the order in which they were set. A total of one gill net was set at Bellas, North Bellas, Divide Creek, and Swauger lakes; two gill nets were set at Big, Goat, and Packsaddle lakes; and eight were set in Angel Lake. We identified all captured fish to species and recorded total lengths (TL; mm), weights (g), and calculated standard deviation (SD) of the mean length for each species. Gill-net catch per unit effort (CPUE) was calculated as the number of fish caught per net-night for lakes with one net set, and the average number of fish caught per net-night with 95% confidence intervals for lakes where more than one net was set. When time

allowed, a hook and line survey was also conducted on each lake to estimate catch rates (Table 8). Each angler recorded the amount of time spent angling, method of angling (fly, bait, or lure), and the number of fish caught. Captured fish were identified to species and measured for TL and weight when possible.

We removed sagittal otoliths from a subsample of trout captured in gill nets for age and growth analysis at Bench, Goat and Packsaddle Lakes. After removal, all otoliths were cleaned and stored in individually labeled vials and were analyzed as whole otoliths for Bench and Packsaddle Lakes. Whole otoliths were immersed in water on a slide and the annuli were counted using a microscope interfaced with a desktop computer. Two trained readers independently assigned ages for each structure without reference to fish length. The second otolith from fish captured at Goat Lake were sectioned, polished, and age was estimated under a compound microscope in cross-section view with transmitted light.

At Angel Lake, we conducted a multiple mark/multiple recapture population estimate. Trout were collected for marking using hook and line efforts and fish were marked with a caudal hole punch. Hook and line efforts were conducted during four separate time frames and lasted two days each. In addition to the hook and line sampling efforts, we used gill nets for the final efforts to recapture fish, but only trout ≥130 mm were included in the population estimate to be comparable with the size range of trout captured with using hook-and-line methods. We employed the Schnabel method with the Chapman modification to estimate trout abundance (Chapman and Overton 1966). We set four gillnets for two consecutive nights in an effort to maximize recaptured fish numbers. Catch data, or CPUE for the first night only, are included in the gillnet summary portion of this report, as catch during the second night was less than half of that observed the night before.

Amphibian survey

We conducted a modified Visual Encounter Survey (VES; Crump and Scott 1994) to evaluate the diurnal amphibian community. Surveys were conducted by walking the entire edge of the lake during the warmer periods of the day. All encountered amphibians were counted and identified to species and life stage.

Lake survey

At each lake we measured max depth (m), secchi depth (m), pH, and conductivity (µS/cm), and collected bathymetry data. We visually estimated the trophic state (eutrophic, mesotrophic, or oligotrophic). We estimated human use and impacts by walking the shoreline and documenting the trail conditions and locations, amount of litter, number of campsites, and number of fire rings present.

RESULTS

Angel Lake

Angel Lake is located in the Fall Creek drainage (43.801108, -114.051979), a tributary of Wildhorse Creek in the upper Big Lost River drainage. The lake is 6.2 ha in size, sits at 3,133 m

above sea level in the Pioneer Mountain Range, and has an eastern aspect. The lake is located near tree line with surrounding habitat dominated by boulders, bedrock, and scree with a few trees on the northeastern portion of the lake. Access to Angel Lake starts at the Fall Creek trailhead (43.852236, -114.078448) and can be accomplished two ways. One way is to follow a maintained trail 7.4 km to Moose Lake climbing approximately 366 m (1,200 feet) and then continuing 2.2 km cross-country and climbing over steep ridge climbing another 427 m (1,400 feet) before dropping 152 m (500 feet) down to the lake. The second access route begins at the same trailhead and follows Fall Creek up the bottom of the canyon 8.3 km on a maintained trail climbing 427 m (1,400 feet) and then continuing up the west side of the canyon cross-country a difficult 1.6 km and climbing 488 m (1,600 feet) to the lake.

We captured 222 trout while hook-and-line sampling with flies and spinners. Catch rates averaged 3.5 fish/h for the 15 anglers who fished Angel Lake (Table 9). We captured 97 fish with gill nets. We obtained length data from 279 trout caught with hook-and-line and gill-net techniques. Trout in Angel Lake had an average length of 194 mm (SD = 39.9) and a range from 83 to 265 mm (Figure 28). Trout composition was 99% Rainbow Trout and 1% YCT.

We captured 97 trout during the first night of setting four gillnets for an average CPUE of 21 fish/net-night with a 95% confidence interval of ± 11.2. The average total length of fish caught in gill nets was 158 mm with a SD of 58.8.

We calculated relative weights for 276 fish which we had total length and weight information on. These trout included 70 fish captured in gillnets and an additional 206 fish caught during hook-and-line sampling. The lengths of fish included in this analysis ranged from 83 to 265 mm TL, which included the range of trout captured during both gill-net and hook-and-line sampling efforts. The average relative weight for trout in Angel Lake was 75 and relative weights decreased with increasing TL (Figure 29).

During six sampling/marking/recapture events for this multiple mark/multiple recapture population estimate, we captured 278 trout and recaptured an additional 16 trout (Table 10). We captured 222 trout during the hook-and-line sampling. Of these 222 trout, 13 were recaptures, four died during capture, and five were released without a mark. Thus, we had 200 marked trout in Angel Lake. We captured 97 trout during the gill-net efforts, with 57 of these fish ≥130 mm and large enough to be included in the population estimate (Table 10). We recaptured a total of 16 trout during the hook-and-line and gill-net efforts included in the estimate. We estimated the abundance and 95% confidence interval of trout >130 mm in Angel Lake at 1,618 (1,108 to 3,004).

Angler use is low with a trail only around a portion of the eastern side of the lake. There are no inlets and the outlet immediately goes over a waterfall such that no spawning habitat in these areas are available to fish. There are two campsites and three fire rings, and we did not observe litter at the lake. This oligotrophic, cirque lake had a conductivity of <20 µS and a pH of 9.1 on August 28, with a surface temperature of 11.5 C when air temperature was 18 C, and a secchi depth of 9.7 m. No amphibians were observed during the survey.

Bellas Lake

Bellas Lake is an east-facing lake located at approximately 2,872 m above sea level and is accessible via the Bellas Canyon Trail (4060) off of the Copper Basin Loop Road (USFS Rd. 138) in the Pioneer Mountains. The lake is part of the Star Hope drainage, which flows into the East Fork Big Lost River. There are two inlets and one outlet with fair spawning habitat, but no

redds were observed. The lake receives intermediate usage based on four fire rings and a trail established around the lake. We have stocked Bellas Lake with YCT on a triennial basis since 1973. Stocking quantities have varied in the past, but we have consistently stocked 1,500 fry each stocking year since 1994. We only conducted a fishery survey at Bellas Lake.

In 2019, one net was set on August 6 and pulled on August 7. We caught 23 fish with an average TL of 168 mm (SD ± 69; Figure 30). The average relative weight (W_r) of YCT was 91 (95% CI ± 5) and relative weight decreased as length increased (Figure 31). Three anglers fished for 1.5 hours (i.e., 4.5 angling hours) using a combination of fly and spinning tackle to catch 8 fish, resulting in a catch rate of 1.78 fish/h (Table 9).

North Fork Bellas Lake

North Fork Bellas Lake is more difficult to visit because travel to the lake from Bellas Lake is entirely off-trail. There is a game trail that is to the northwest of Bellas Lake where one inlet enters the lake. Anglers can travel in a northwesterly direction about 0.75 km over two benches to a third bench where North Fork Bellas is located in a cirque at 3,010 m above sea level. North Fork Bellas is a low-use lake with only two, old fire rings found and no established trail around the lake. There are spring upwellings in the lake and one inlet and one outlet. We observed no active spawning, but natural reproduction does occur because the lake has not been stocked with YCT since 1989. Rainbow Trout were stocked twice (1968 and 1971), and YCT were stocked in 1976, 1982, 1985, and 1989. We attempted to stock Arctic Grayling, but the species did not survive, and YCT remained the only salmonid that survived and grew to catchable length. Three anglers fished in August for 1.5 hours equating to 4.5 total hours of effort and they caught 18 fish, which was a catch rate of 3.56 fish/h (Table 9). The average TL of YCT in North Fork Bellas was 266 mm (SD ± 20; Figure 32) and the average relative weight was 81 ± 3, which exhibited decreasing relative weight with increasing length (Figure 33). For a detailed description of lake habitat refer to IDFG 2006. No amphibian surveys were conducted at either lake in 2019.

Bench Lake

Bench Lake is located at 3,054 m above sea level and is accessible from the Jarvis Trailhead (4247), which can be accessed from the Copper Basin Loop Rd. (138) in the Pioneer Mountains. Visitors to Bench Lake must travel off-trail about a half kilometer in a southerly direction through a meadow and up onto a bench. The lake receives moderate use because there was a partial trail around the lake, five fire rings, four campsites, and a low amount of litter. The stocking history of Bench Lake began in the 1960s with YCT, then we transitioned to stocking 500 Rainbow Trout on a triennial basis. We fished for 30 minutes using two fly rods and one spinning rod and caught 33 Rainbow Trout for a combined catch rate of 22 fish/h (Table 9). A severe thunderstorm moved into the basin on the evening of July 27 when we set our gill net and stayed in the basin until July 29. We set the gill net on July 27 and pulled it on July 28 and caught 48 fish. The average TL was 179 mm ± 12 (Figure 34) and the average relative weight was 74 ± 10 (Figure 35). Fish exhibited a decreasing relative weight with increasing TL. We estimated all fish to be age 2 in our ageing analysis. Spawning habitat is poor and we observed no inlets and one intermittent outlet that had no flow in late-July. We estimated the maximum depth at 3.81 m, a Secchi depth at 1.83 m, and a pH of 8.7. Water temperature was 15°C and the air temperature was 11.9°C at the time we set our gill net. We observed no amphibians around the lake.

Big Lake

Big Lake is located at 2,958 m above sea level and is on the Lake Creek trail, which is accessible via OHV, hiking, or on horseback. Most visitors to the lake use OHV access. The trailhead is accessible from the Copper Basin Loop Rd. (138) in the Pioneer Mountains. Because this lake is accessible by OHV it does receive high use. We observed eight fire rings around the lake and an established trail around the lake. We only conducted a fishery survey on Big Lake, but we observed three inlets, one outlet, and did not observe redds or active spawning. There is a long history of stocking Big Lake, which began with Rainbow Trout in the 1960s and 1970s then switched to YCT in the 1970s-2010s (mean 2,863 fish/year; SD ± 830). We also began stocking tiger trout fry in 2016 (500 fish) and 2018 (300 fish). Yellowstone Cutthroat Trout stocking occurs on a triennial basis and tiger trout stocking occurs on a biennial basis. Five anglers fished for a total of 15 hours and caught 13 fish, equating to a catch rate of 0.87 fish/h (Table 9). Two gill nets were set over night on August 5 and pulled on August 6, 2019. The average catch rate for YCT was 24.5 fish/h (± 8.82) and for tiger trout was 7.5 fish/h (± 8.82). The average TL for YCT was 210 mm (± 85) and for tiger trout was 308 (± 43, Figure 36). The average relative weight (W_r) of YCT in gill nets was 101, but displayed a decreasing relative weight with increasing TL (Figure 37). On average, fish with a TL less than 300 mm displayed a relative weight greater than 100 (109) and fish with a TL greater than 300 mm displayed a relative weight less than 100 (86).

Divide Creek Lake

Divide Creek Lake is located at the headwaters of Medicine Lodge Creek near the Montana state boundary and the continental divide. Divide Creek Lake is situated at 2,680 m above sea level, north facing, with a low (46 m) ridge providing shade from the southwest. The hike was approximately 9.7 km on a well-traveled path from the trailhead (44.461695°, -112.785319°). On August 17, 2020, IDFG staff used horses to pack 1,500 trout fry, and sampling equipment to the lake. After allowing 10-15 minutes for the fish to acclimate to the lake water temperature, Grayling (GR; n = 500) and YCT (n = 1,000) were planted into the lake. The maximum depth of the lake was 9.0 m, with surface temperature, pH and conductivity of 19.4 °C, 8.5, and 969 µS/cm, respectively. The lake was considered eutrophic based on the large amount of submerged aquatic vegetation, relatively warm surface temperatures, and a secchi depth of 4.7 m (Table 9). A hook and line survey was conducted for 1.5 hours by one angler. Zero fish were captured via angling, and no other fish were observed during angling or other surveys (Table 9). Amphibians were absent as well. One gill net was set and fished overnight with zero fish captured in the gill net. As such, CPUE was zero fish/h for both angling and the gill net.

Goat Lake

Goat Lake is the highest lake in Idaho that contains fish. It is an eastern-facing lake located in a cirque at 3,183 m above sea level in the Pioneer Mountain Range. There are two ways to reach Goat Lake from the Broad Canyon Trailhead off of Copper Basin Loop Rd. There is access via the Jarvis Trail (4247) that connects to the Broad Canyon trail (4061) at Betty Lake, or directly to the lake via the Broad Canyon Trail that passes by Baptie Lake. There is another much longer route that begins at the Fall Creek Trailhead off of Wildhorse Rd (136) that follows the Fall Creek Trail (4045) through the Surprise Valley, which connects to the Broad Canyon Trail at Betty Lake. We found 3 very old fire rings, but Goat Lake is entirely exposed with no tree cover, therefore we do not believe many anglers camp at the lake. However, the lake does receive moderate to high use since the trails to the lake are established and we observed four additional anglers fishing the

lake when we visited. There is an intermittent trail that is trampled around a portion of the lake, but the south and southwestern portions of the lake are steep-sided rock/talus fields. There are no inlets and one outlet that is a waterfall/cascade down to Baptie Lake. We observed no redds nor active spawning, but some fish we captured in gill nets were very ripe.

Yellowstone Cutthroat Trout have been stocked on a triennial frequency since 1969 and stocking has been 2,000 fish per stocking year since 1997. We fished the lake with two fly rods and one spinning rod for one hour. Catch rates were 7 fish/h for the spinning rod and 5.5 fish/h for the fly rods (i.e., 11 fish in one hour/2 anglers) combined (Table 9). We set two gill nets on July 29 and pulled them the following morning on July 30. One net was positioned off a point on the eastern shore and the other was set in the bowl of the cirque near the northwestern shore. We caught a total of 58 fish between two gill nets (29 fish/net-night ± 0). The average TL of YCT was 290 mm (± 60, Figure 38) and the average relative weight was 88 (± 15, Figure 39). Fish exhibited a decreasing relative weight with increasing TL, however there was some egg loss when fish were pulled from gill nets which skewed some weights to be lower than expected. We estimated the age of 58 fish using whole otoliths and sectioned otoliths. Two readers agreed on 74% of the estimated ages using sectioned otoliths, and agreed on 55% of age estimates using whole otoliths. Therefore, sectioned otoliths were selected to use for ageing analysis and readers were able to reconcile estimates to 97% agreement (n = 56 samples). The structures that could not be reconciled were excluded from analysis. We estimated ages of fish from 2-8 years old, but most fish were estimated to be age 2 (n = 18) and age 5 (n = 22; Table 11; Figure 40).

About 70% of the shoreline (30% of shoreline was a scree/boulder field and was not surveyed) and all adjacent grassy areas around the lake were surveyed for amphibians following VES protocol. No amphibians were observed during the hour-long VES.

Packsaddle Lake

Packsaddle Lake is located in the Teton River drainage at the headwaters of Packsaddle Creek (43.770413, -111.340540), a tributary to the Teton River near Tetonia, Idaho. The lake measures 675 m in circumference (1.9 ha) and sits at an elevation of 2,271 m. Two high use trails allow access to the lake. A hiking trailhead (~0.8 km) allows access to the northwest side of the lake from a parking lot on U.S Forest Service road 381. The second route, for both hiking and ATV use (3 miles long) allows access from U.S Forest Service road 207 to the east side of the lake. An intermittent well used hiking trail exists around the shoreline of the lake. This lake is utilized mostly for day trips and frequented by anglers, off-highway vehicle enthusiasts, recreationalists, hikers and swimmers alike, due to its easy access and proximity to Tetonia and Driggs, Idaho. There is one large campsite (5-6 tents) and 2 small campsites (1-2 tents) each with a fire ring. We observed low amounts of litter at the lake. There are two inlets and one outlet to the lake. The outlet, North Fork Packsaddle Creek was completely dry during both the July and September surveys. On July 14, 2020 staff stocked the lake with 2,000 YCT using backpacks and conducted an angling survey. Three anglers (fly rod) fished for 6 hours total and caught 5 YCT resulting in an angling catch rate of 0.8 fish/h ranging from 234 to 251 mm in length.

We conducted a full mountain lake survey on Packsaddle Lake on September 9-10, 2020. We set two gill nets and collected 57 YCT which resulted in a gill-net CPUE of 28.5 YCT/net-night (± 57.2, 95% CI; Figure 41). No other species were captured. The average TL (± 95 CI) and range of YCT was 170 mm (± 18.5) and 87 – 273 mm, respectively (Figure 41), with an average relative weight of 91.3 (± 2.48, Figure 42). We estimated the ages of 38 YCT which ranged from age-1 to 3 (Table 12). Relative weights decreased with increasing total length. We measured a maximum

depth of 7.69 m, conductivity at 85 µS/cm, a pH of 10, and surface and air temperatures of 15.5 and 14.4°C, respectively in the late morning of September 9, 2020. We observed no amphibians on our shoreline survey, but did observe many fingerlings around the edge and multiple adult fish rising in the lake.

Swauger Lake

Swauger Lake is located at the headwaters of Dry Creek in the Little Lost River drainage at approximately 2,771 m above sea level. Its aspect faces generally northeast. In 2020, surveys were conducted on September 9, beginning at approximately noon on a sunny day with 10.9 °C air temperature. Golden Tout fry (*N* = 1,000) were stocked in the lake upon arrival. One gill net was set for four hours beginning at 12:15 p.m. Hook and line surveys were conducted by three anglers for a total angling time of 6 hours. Seven YCT (average TL = 396 mm, > 500 g) and one Golden Trout (GN; TL = 280 mm, 270 g) were captured via angling and one YCT (448 mm, > 500 g) was captured in the gill net. Gill net and angling CPUE was 0.25 and 1.3 fish/h, respectively (Table 9). No fry or fingerlings were observed, but approximately 30 additional GN were observed between 200 – 300 mm in length.

The maximum depth was 5.8 m, with surface temperature, pH and conductivity of 12.5 °C, 9.0, and 263 µS/cm, respectively. The lake was considered eutrophic, based on the large amount of submerged aquatic vegetation, relatively warm surface temperatures, and a secchi depth of 1.9 m. Amphibians were absent.

DISCUSSION

Angel Lake

Angel Lake is currently meeting management objectives for catch rates with a self-sustaining wild population of Rainbow Trout. With no spawning habitat available to fish in the outlet and no overland inlet, Rainbow Trout must be successfully spawning in springs providing upwelling areas within Angel Lake. Reproduction is so successful that Rainbow Trout in Angel Lake appear to be stunted as evidenced by low relative weights and mean TL of 158 mm. Additionally, the average length of Rainbow Trout in Angel Lake has decreased since the previous survey conducted in 2004 (Garren et al. 2006a). During our extensive 2020 survey, the largest trout observed was 267 mm. During the 2004 survey with substantially less sampling effort, the largest trout observed was roughly 320 mm in length. The fishery at Angel Lake could be improved by reducing the Rainbow Trout population in the lake. One technique would be introducing a sterile piscivore, which could decrease Rainbow Trout abundance resulting in increased relative weights for the remaining Rainbow Trout and provide diversity in the catch for the angler. Both of these results would enhance the fishery and are consistent with the objectives for high mountain lakes in both the regional plan and the Statewide Fisheries Management Plan (IDFG 2019).

Bellas and North Fork Bellas lakes

We sampled a wide range of length groups in Bellas Lake using gill nets suggesting that multiple age classes exist. Bellas Lake does appear to receive a fair amount of angling effort because there was a very large, stone-built fire pit that looked to be constructed for group

camping. Furthermore, based on a lower abundance of fish greater than 254 mm and higher abundance of fish less than 150 mm, harvest might be a factor limiting the number of adult-sized trout. Age and growth analyses should be conducted to make inferences on why the population size structure appears stunted. At a minimum, stocking rates of 1,500 fish every three years should continue, but there is evidence to support stocking 2,000 fish on the next round, then evaluate size structure after those fish have been in the lake for several years. In addition, taking a subsample of fish to estimate age from otoliths would also inform length-at-age to evaluate if there is a density dependence issue in the lake.

Catch rates for YCT in North Fork Bellas Lake were good and exceeded the management objective of at least 1 fish/h (IDFG 2019). The North Fork Bellas Lake fish population persists by wild reproduction, thus no stocking is recommended. There was little to no human use and likely very little harvest occurring. We recommend visiting this lake for angling and visual surveys at a minimum when Bellas Lake is surveyed, but if possible when Bellas Lake is stocked.

Bench Lake

Similar to other alpine lakes in the Upper Snake Region, Bench Lake has a long history of stocking dating back to the 1960s. We originally stocked the lake with YCT until 1997, when we switched to Rainbow Trout and continued stocking 500 fish on a triennial rotation. Bench Lake is a smaller alpine lake at only 1.5 hectares, but evidence of a trampled trail and established fire rings indicates that the lake does receive use. The small size structure of Rainbow Trout in the lake suggests that fish density may be too high and reducing stocking to 250 fish, or 250 Rainbow Trout and 250 tiger trout could provide anglers with another unique tiger trout fishery and it could also help improve the size structure of Rainbow Trout in Bench Lake.

Big Lake

Big Lake offers a very unique fishery consisting of tiger trout in an alpine lake setting. Gill net catch was predominately YCT consisting of two size classes; fish less than 180 mm and fish greater than 310 mm, suggesting that the middle size class is missing due to the triennial stocking regime and a lack of wild reproduction. Because this lake receives a high amount of use and harvest, the stocking rotation of YCT every three years at 3,500 fish and tiger trout every other year at 500 fish should continue. Furthermore, the catch rate of 0.87 fish/h did not meet the management goal of 1.0 fish/h. A multi-hour angling survey with multiple gear types and bait should be conducted at the next time of stocking to evaluate how catch rates may differ among gear types and whether the lake is meeting the management objective. If Big Lake continues to not meet the management goal of 1.0 fish/h, then the stocking rotation should change to biennial stocking for both species and potentially reduce the quantity of Cutthroat Trout stocked to 2,000 every other year. However, because tiger trout are known to be piscivorous predators (Winters et al. 2017) fry stocked in the lake may have poor survival and that could be contributing to a missing age class.

Divide Creek Lake

Divide Creek Lake did not meet the criteria for catch rates at alpine lakes, and it appears that fish were not present prior to our arrival in 2020. However, if fish were absent prior to stocking in 2020, then it will be informative to survey this waterbody in 2021 to assess the possibility of high winter

mortality. This lake has a long history of stocking, dating back to 1970. Past reports suggest this lake has provided good angling opportunities resulting from past stocking efforts. Most recently, approximately 3,000 GR were stocked in 2018, and GR (2,800) and YCT (1,000) were stocked in 2017. Over the past few years, anglers have reported poor fishing here despite the significant stocking efforts. Further evaluation is necessary to determine if this lake should continue to be stocked, or if high winter mortality warrants the discontinuation of stocking here.

Goat Lake

Goat Lake is the highest alpine lake in the state that supports a fishery. We have been stocking YCT in Goat Lake since the 1960s, except in 1982 when we stocked Rainbow Trout, and we continue stocking 2,000 YCT on a triennial rotation. The size structure of YCT is diverse, with multiple age classes present and there is evidence of some wild reproduction based on the diversity of age classes that do not match stocking frequency. Additionally, catch rates are exceptional for all gear types with spin fisherman and fly fisherman both averaging greater than 1.0 fish/h. We spoke with several bait fisherman at the lake during this year's survey and they also were averaging more than 1.0 fish/h. Goat Lake is an excellent alpine fishing opportunity, as it is also near Baptie Lake, which supports Golden Trout, and Betty Lake which supports another robust Cutthroat Trout fishery. All of these lakes can be visited on a single backpacking trip without long hikes between the lakes, and if on horseback anglers could visit and fish all lakes in a single day. We recommend continuing the same stocking rotation as this cold, deep lake supports catchable YCT up to 17" and fish of greater size may be present.

Packsaddle Lake

Packsaddle Lake is a high-use alpine lake which has been stocked with YCT on a triannual basis since the early 1990s. Our angling survey resulted in a catch rate of 0.8 fish/h, which is significantly lower than the previous survey conducted in 2005 which exhibited a catch rate of 3.5 fish/h (Garren et al. 2006c) and is below our management goal of 1 fish/h (IDFG 2019). Although our angling survey indicated low catch rates, our gillnet CPUE of 28.5 fish/net-night was significantly higher than the 2005 survey of 10 fish/net-night (1 gill-net; Garren et al. 2006c). Furthermore, we sampled a wider range of length groups in Packsaddle Lake in our gill net catch this year. This increase in gillnet CPUE of YCT less than 100 mm is likely due to the stocking of 2,000 YCT fingerlings about two months earlier in July 2020. The presence of age-3 YCT in the population is positive and indicates survival of stocked hatchery fish, as this lake was last stocked in 2017. At a minimum, our stocking rate of 2,000 YCT should continue on a triannual basis, although the lake could support higher densities of fish. In addition, due to the high degree of human use at this lake, we recommend conducting both a gill-net and angler survey on a triannual basis to fully understand the continued use of this lake.

Swauger Lake

Swauger Lake has a long history of stocking dating back to 1969. This has been a popular fishery know to grow large trout, and this was one of the first mountain lakes in the state to be managed with a trophy regulation. The trophy regulation was used because angling pressure was so high that stocked fish were all captured with little carryover to the next season. The trophy regulation was adopted to ensure catch rates were more consistent among years. Over the years, access has changed where this lake used to be accessible to ATVs and motorcycles, though foot traffic

(hike or horse) is only permitted now. In 2020, Swauger Lake met the angling criteria for YCT, though not for GN. The lake is generally shallow and small, which are major factors to its trophic state considering that it is relatively high elevation and likely receives less direct sunlight than other lakes, due to its aspect and location to the east of the tallest mountain range in Idaho. We estimated moderate to high angler use due to the amount of traffic on the trail, and the litter around the lake. We have stocked Golden Trout for the past four years, with the hopes of establishing a population, and are the only species that we stocked since we last stocked YCT in 2011. However, routine sampling and anecdotal angler reports have not identified that GN are surviving to catchable-size at a high rate. This may be due to the persistence of YCT that are now generally larger and likely prey on freshly stocked fish. The remaining YCT in Swauger Lake were likely a minimum of nine years old in 2020.

MANAGEMENT RECOMMENDATIONS

1. Survey Divide Creek Lake in 2021 to assess the potential for high winter mortality at this waterbody.

2. Introduce a sterile piscivore in Angel Lake to reduce the stunted Rainbow Trout population, increase relative weights of surviving Rainbow Trout, and increase catch diversity for anglers.

ACKNOWLEDGEMENTS

We would like to thank Bart Gamett and his crew with the U.S. Forest Service for their assistance with the Angel Lake sampling. This work could not be accomplished without the continued assistance of our in house fisheries staff and all the additional regional staff outside of fisheries who took the time to hike into these lakes.

Table 8. Mountain Lake survey dates and locations.

Lake	Survey	Sampling date	Lat	Long
Angel	Gill net and angling	08.08-20.2020	43.801108	-114.051979
Bellas	Gill net and angling	08.06.2019	43.78098	-113.98057
Bench	Gill net and angling	07.27.2020	43.77877	-114.00160
Big	Gill net and angling	08.05.2019	43.72947	-113.85560
Divide Creek	Gill net and angling	08.17.2020	44.402790	-112.819841
Goat	Gill net and angling	07.29.2019	43.77864	-114.01690
North Fork Bellas	Angling	08.07.2019	43.78706	-113.98634
Packsaddle	Angling	07.14.2020	43.770413	-111.340540
Packsaddle	Gill net and angling	09.09.2020	43.770413	-111.340540
Swauger	Gill net and angling	09.09.2020	44.081623	-113.582301

Table 9. Results from lake surveys in the Upper Snake Region, Idaho 2020.

Lake Name	Drainage	Surface Area (ha)	Max Depth (m)	Secchi Depth (m)	Fish species Present[a]	Fry Present	Fingerlings Present	Amphibians Present[b]	Angling CPUE	Gill Net CPUE	Campfire Rings (No.)	Access Difficulty	Angler Use
Angel	Big Lost												
Bellas	Big Lost	2.1	--	--	YCT	N	N	N	1.8	23	4	Moderate	Moderate
Bench	Big Lost	1.5	3.8	1.83	YCT	N	N	N	22	48	5	Moderate	Moderate
Big	Big Lost	5.7	--	--	YCT, TGT	N	N	N	0.87	24.5, 7.5	8	Easy	High
Divide Creek	Medicine Lodge		9.0	--	None	N	N	N	0	0	6	Moderate	Low
Goat	Big Lost	7.2	10.5	5.9	YCT	N	N	N	Spin 7; fly 5.5	29	3	Moderate	Moderate
North Fork Bellas	Big Lost	1.4	--	--	YCT	N	N	N	3.56	--	2	Difficult	Low
Swauger	Little Lost		5.8	--	YCT, GN	N	Y	No	1.3	0	2	Moderate	Moderate
Packsaddle	Teton	1.9	7.69	--	YCT	Yes	Yes	No	0.8	28.5	3	Easy	High
Angel	Big Lost	6.2	36.6	9.7	RBT, YCT	N	Yes	No	3.5	21.0	3	Difficult	Low

[a] – Fish species abbreviations: RBT = Rainbow Trout; YCT = Yellowstone Cutthroat Trout; GN = Golden Trout; TGT = tiger trout
[b] – Amphibian abbreviations: LTS = long-toed salamander; CSF = Columbia spotted frog; TIG = tiger salamander

Table 10. Multiple-mark, multiple-recapture catch data for Rainbow Trout caught at Angel Lake, 2020.

Event	Number caught (C_t)	Recaptures R_t	Number marked	Marked fish at large
Aug 8-9	45	0	45	0
Aug 10-11	61	5	49	45
Aug 20-21	28	0	28	94
Aug 25-26	88	8	78	122
Aug 27 gillnet	44	1	0	200
Aug 28 gillnet	13	2	0	200

Table 11. Mean length-at-age data for Yellowstone Cutthroat Trout caught in gill nets in Goat Lake in 2020.

	Age				
	2	3	4	5	8
Mean TL (mm)	226	234	323	323	388
Min TL	170	210	302	281	370
Max TL	260	257	335	370	430
Count	18	6	5	22	5

Table 12. Mean length-at-age data based on otoliths from Yellowstone Cutthroat Trout captured from gill nets in Packsaddle Lake, 2020.

	Age		
Summary statistic	1	2	3
Mean TL (mm)	104	193	248
Min TL	89	165	221
Max TL	126	232	273
No. Analyzed	17	4	17

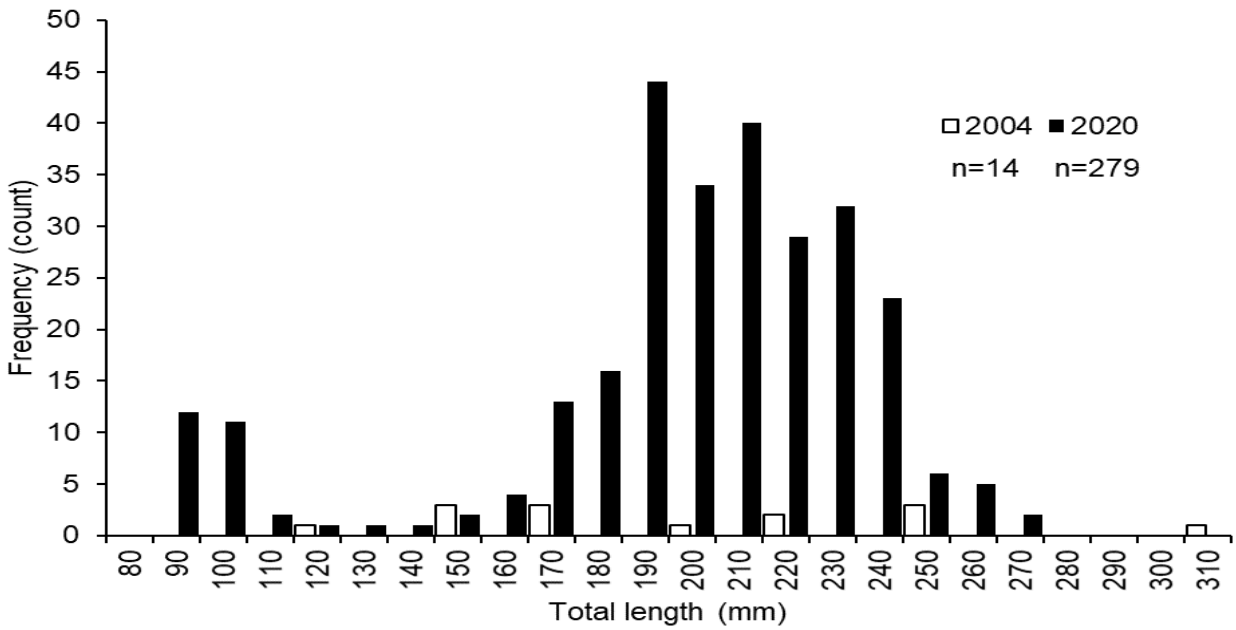

Figure 28. The length-frequency distribution of trout caught in gill nets in Angel Lake in 2020.

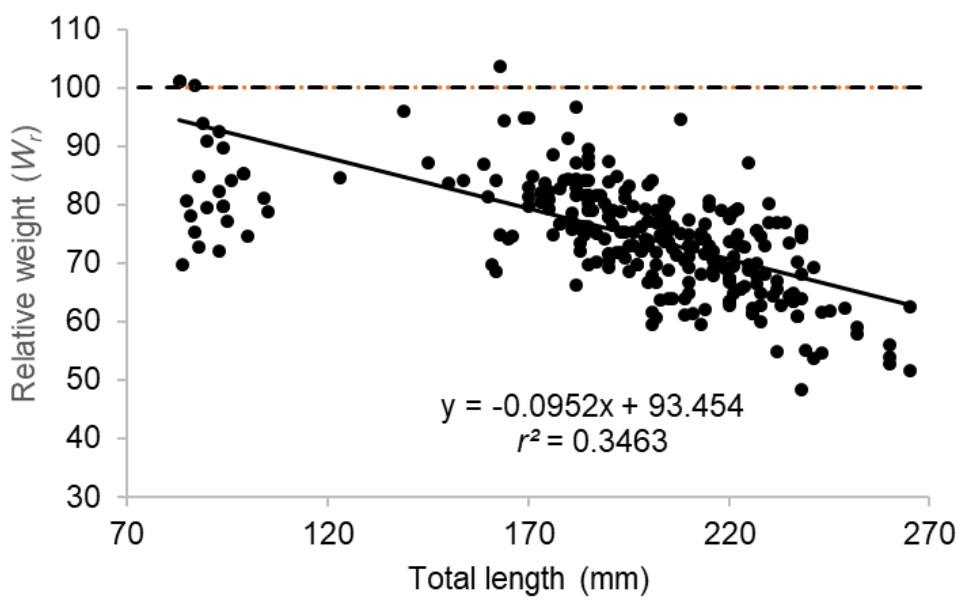

Figure 29. Relative weights for Rainbow Trout (*n* = 70) captured in gill nets in Angel Lake.

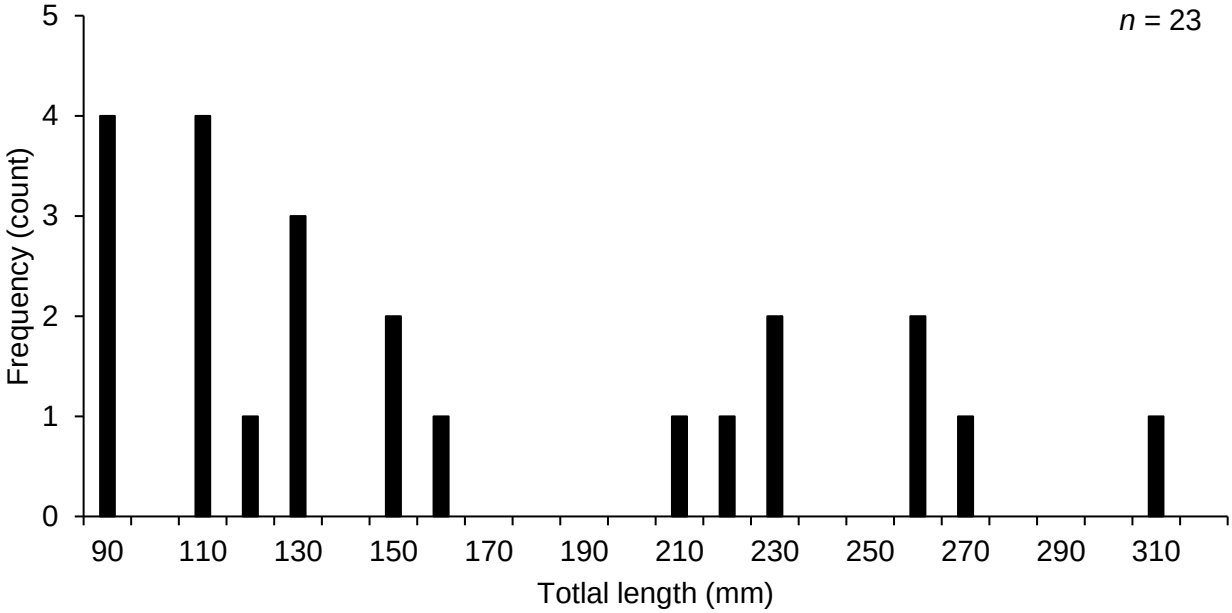

Figure 30. The length-frequency distribution for Yellowstone Cutthroat Trout caught in gill nets in Bellas Lake in 2019.

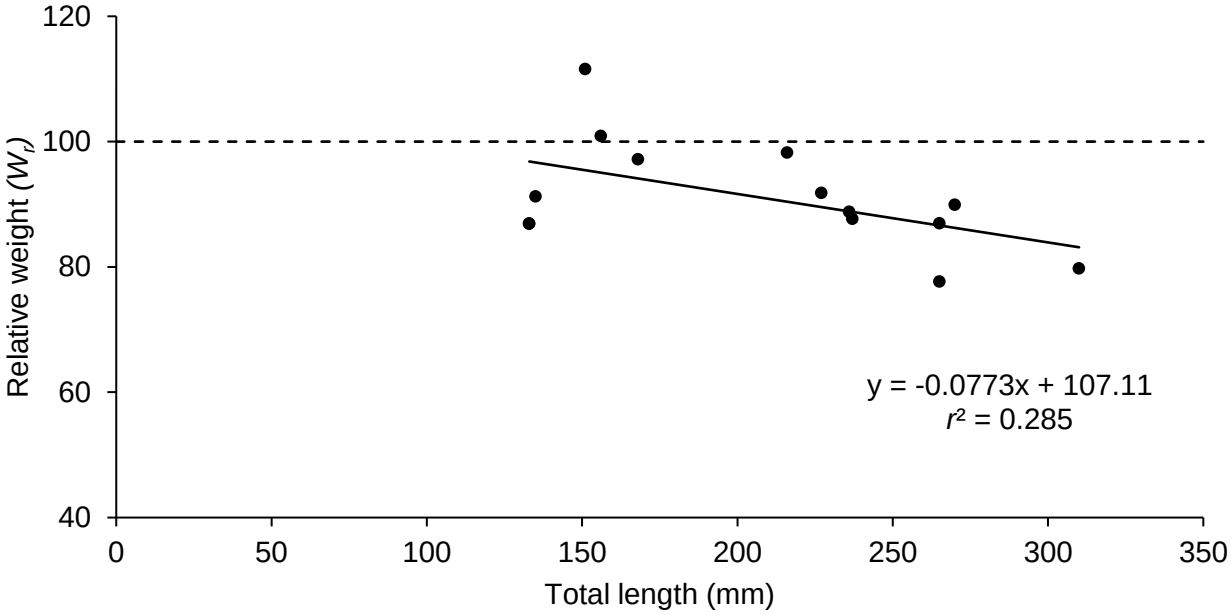

Figure 31. The relationship between relative weights by total length (mm) of Yellowstone Cutthroat Trout caught in gill nets from Bellas Lake in 2019.

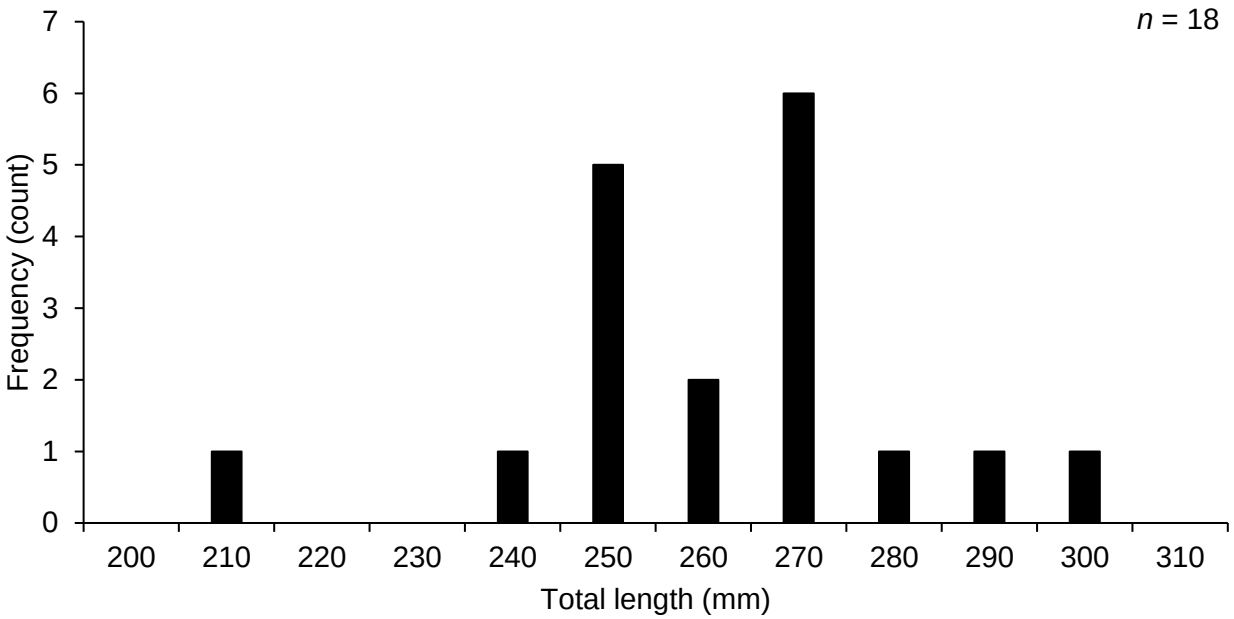

Figure 32. The length-frequency distribution of Yellowstone Cutthroat Trout caught by angling in North Fork Bellas Lake in 2019.

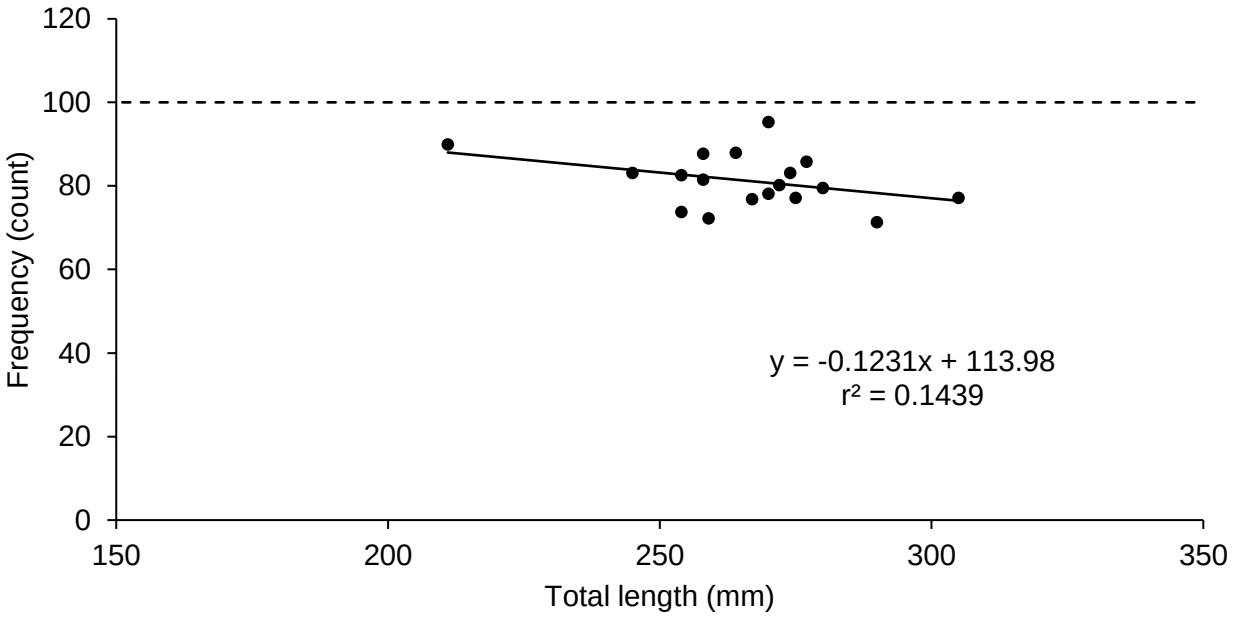

Figure 33. The relationship between relative weight by total length (mm) of Yellowstone Cutthroat Trout caught by angling in North Fork Bellas Lake in 2019.

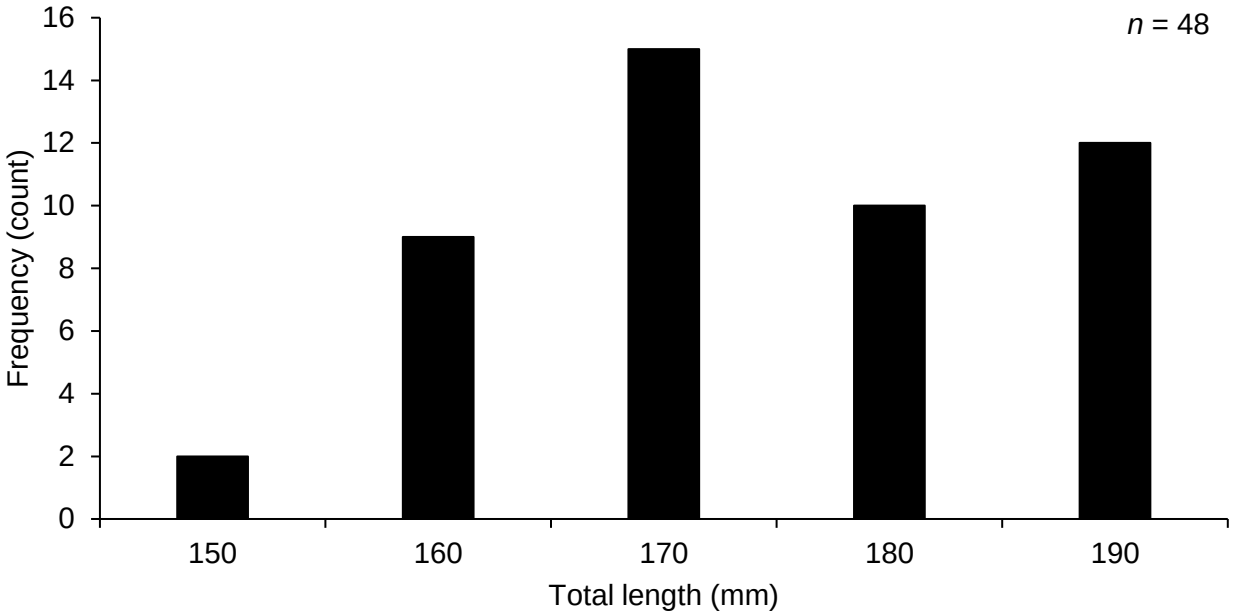

Figure 34. The length-frequency distribution of Rainbow Trout caught in gill nets in Bench Lake in 2020.

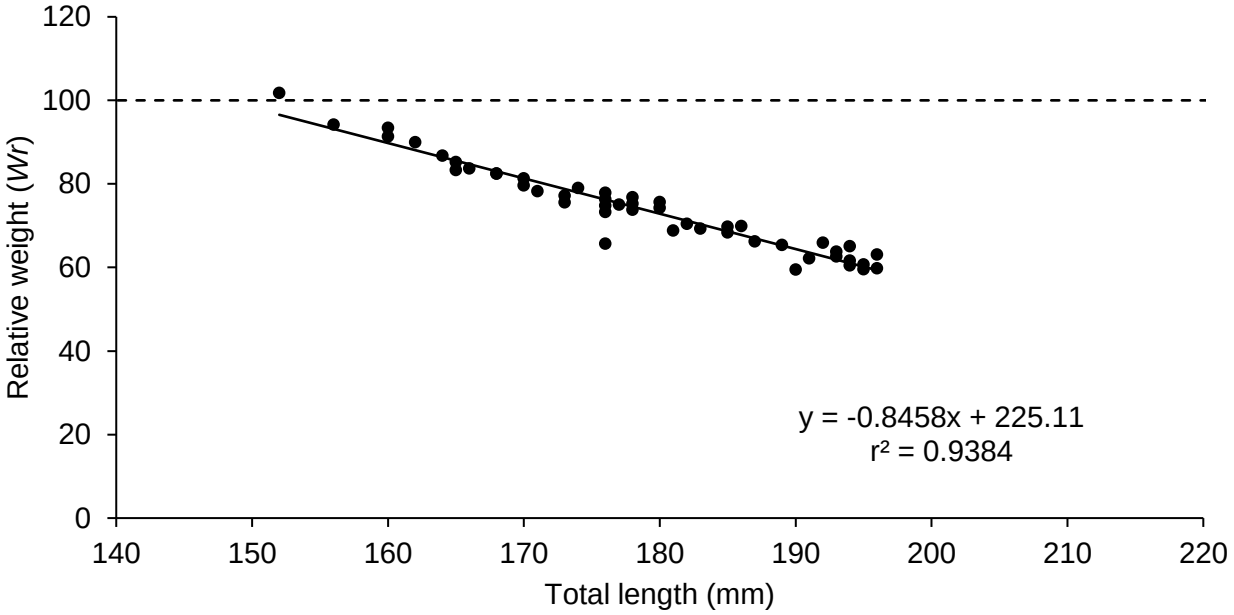

Figure 35. The relative weight by total length (mm) of Yellowstone Cutthroat Trout caught in gill nets in Bench Lake in 2020.

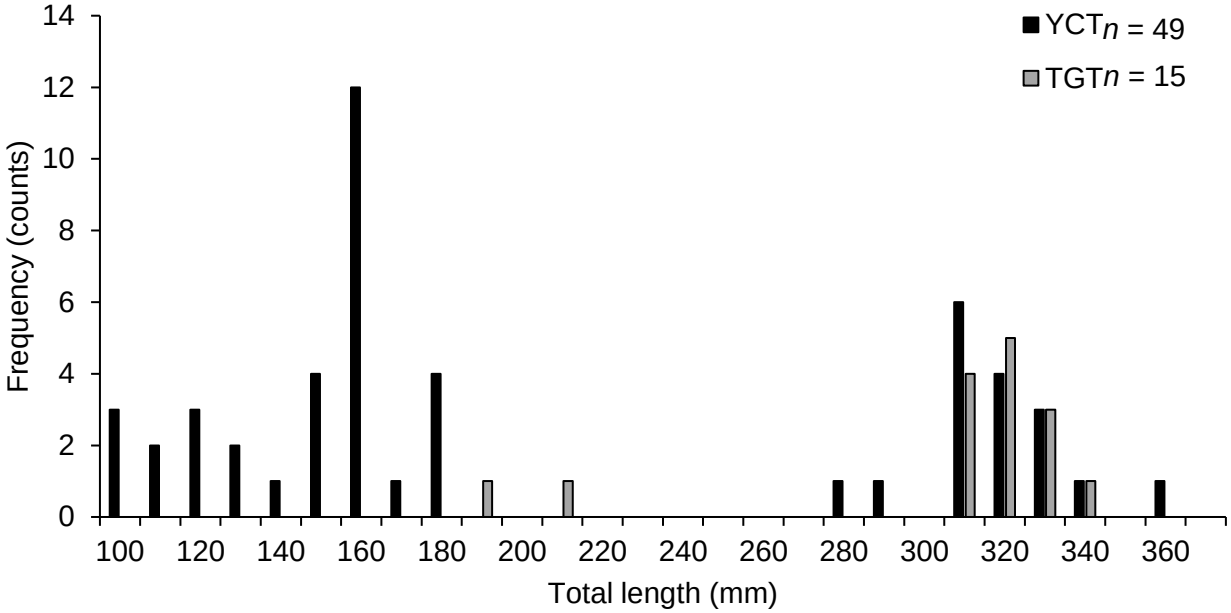

Figure 36. The length frequency distribution of Yellowstone Cutthroat Trout (black bars) and tiger trout (gray bars) caught in gill nets in Big Lake in 2019.

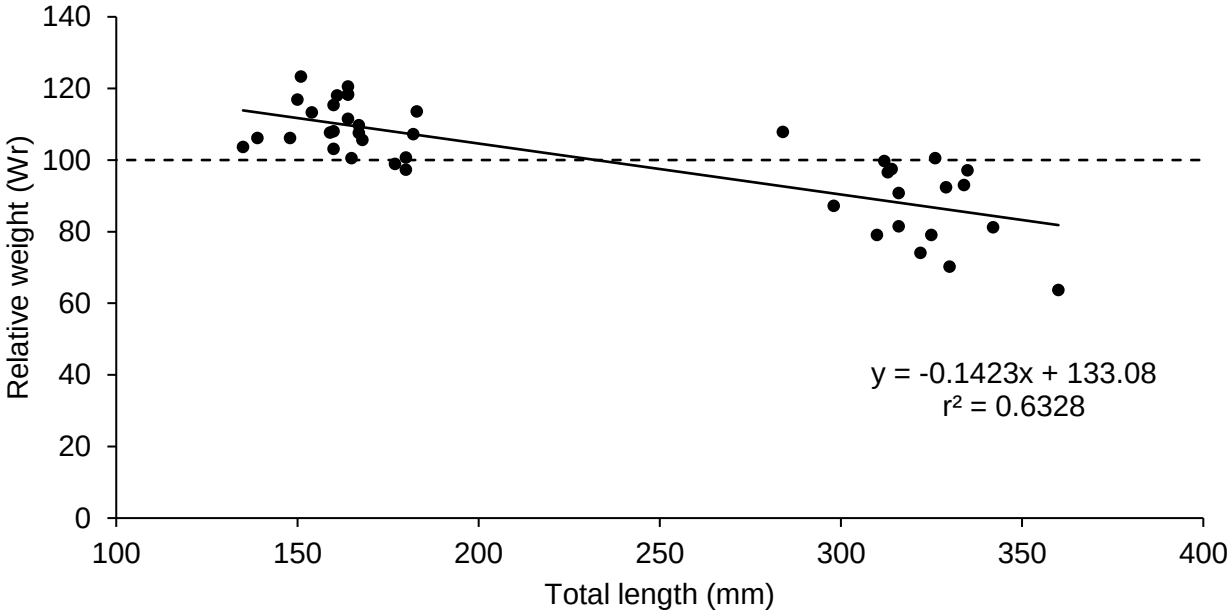

Figure 37. The relative weight by total length (mm) of Yellowstone Cutthroat Trout caught in gill nets in Big Lake in 2019.

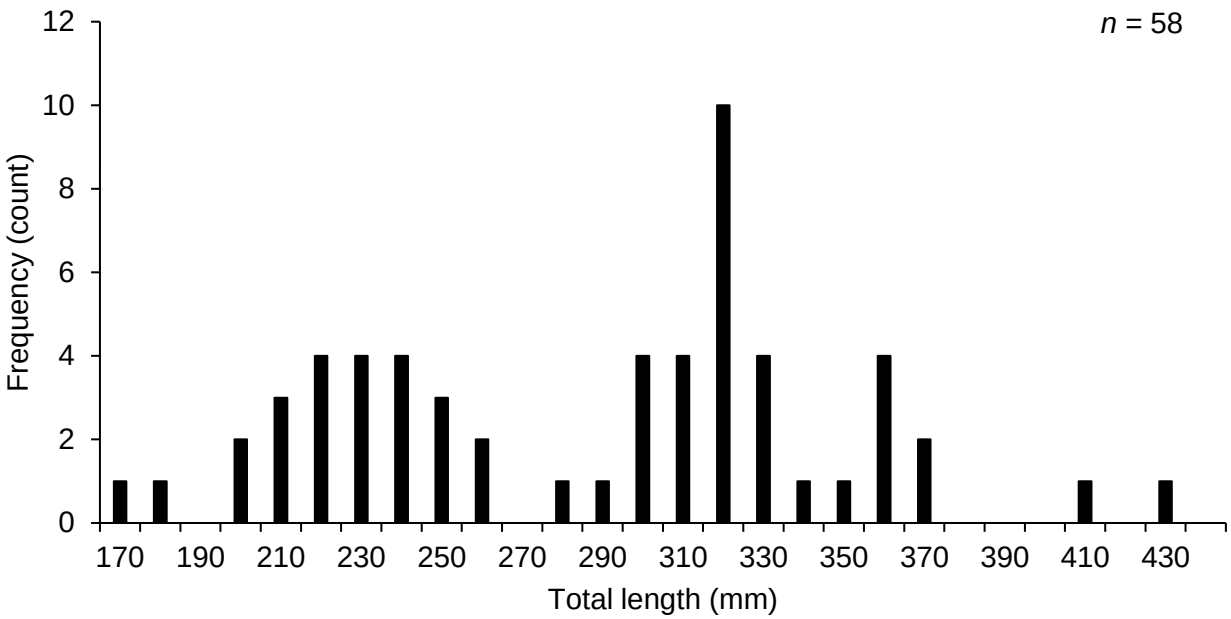

Figure 38. The length-frequency distribution of Yellowstone Cutthroat Trout caught in gill nets from Goat Lake in 2020.

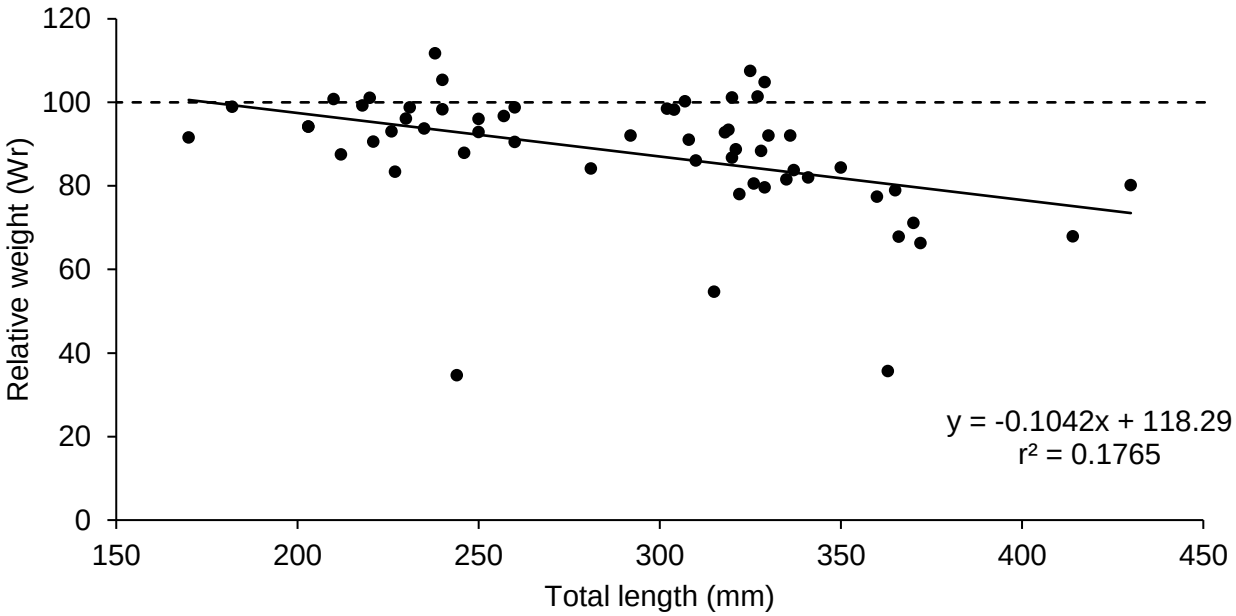

Figure 39. The relative weight by total length (mm) of Yellowstone Cutthroat Trout caught in gill nets in Goat Lake in 2020.

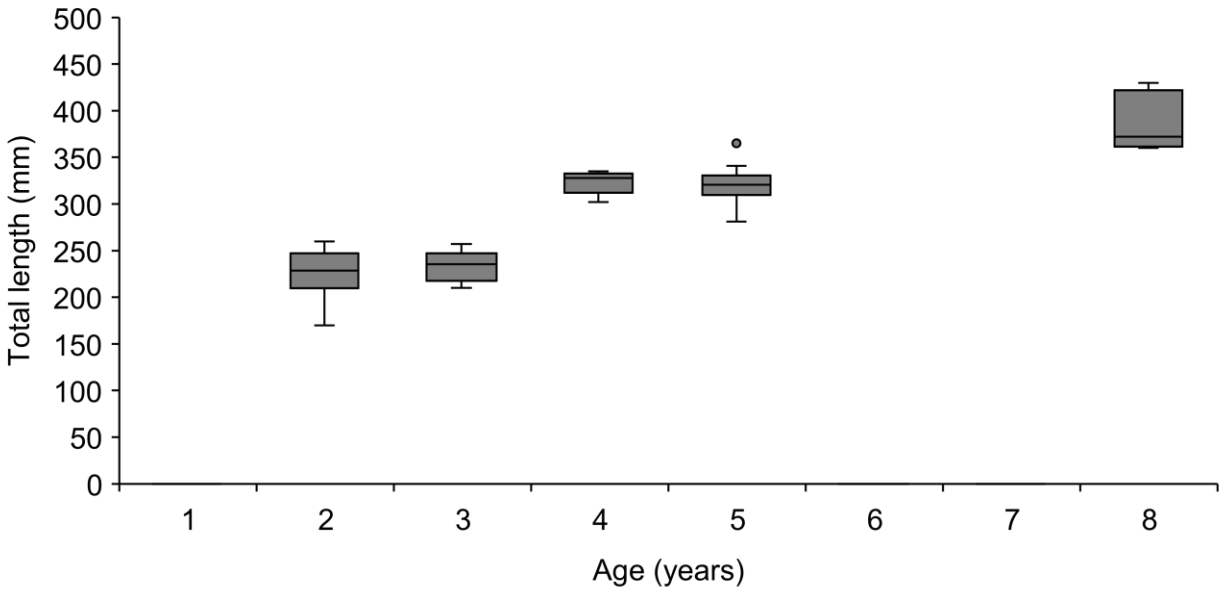

Figure 40. The distribution of length-at-age for Yellowstone Cutthroat Trout caught in gill nets at Goat Lake in 2020. The line in each box represents the median, the box represents the range between the first and third quartiles, and the whiskers represent the maximum and minimum values. Dots are outliers.

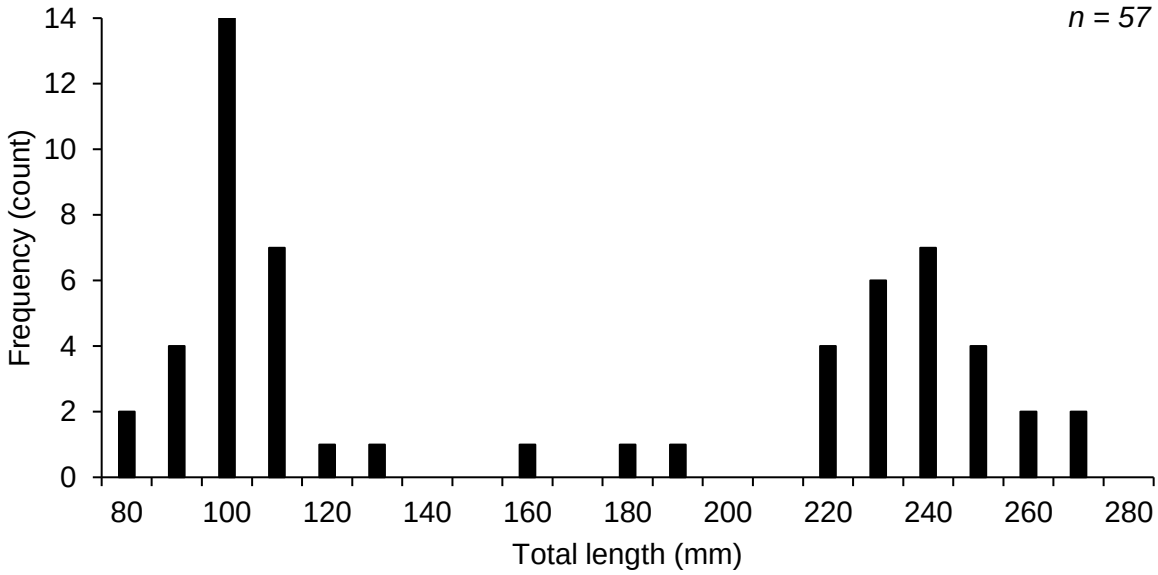

Figure 41. Length-frequency distribution for Yellowstone Cutthroat Trout captured in gillnets set in Packsaddle Lake in 2020.

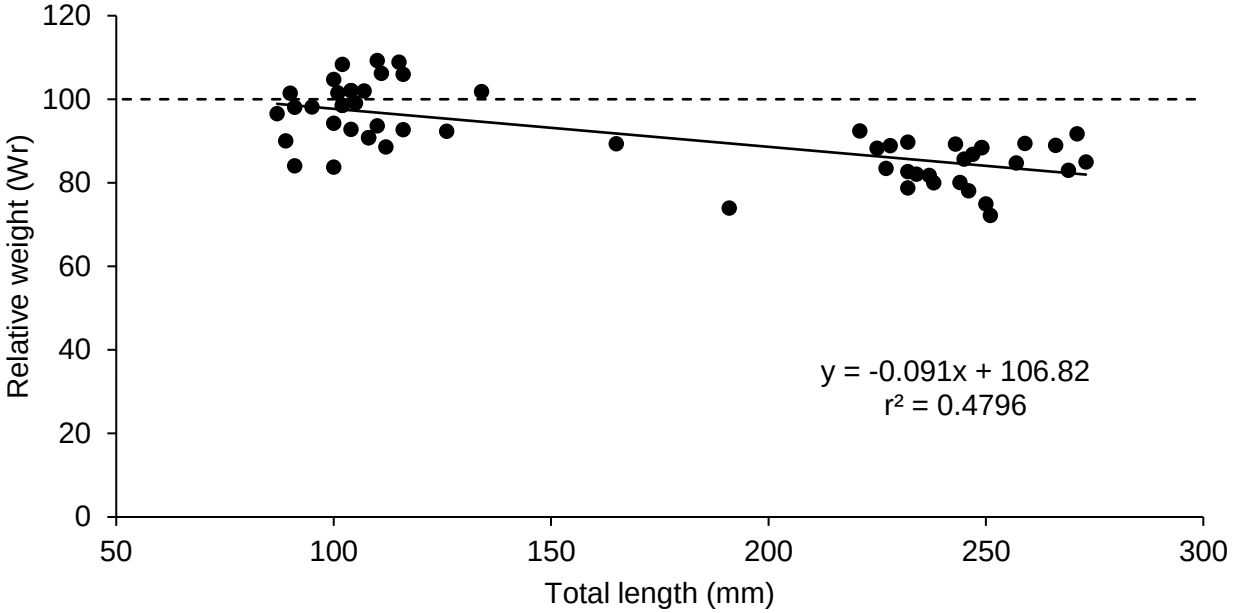

Figure 42. The relative weight by total length (mm) of Yellowstone Cutthroat Trout caught in gill nets in Packsaddle Lake in 2020.

SOUTH FORK SNAKE RIVER

ABSTRACT

The South Fork Snake River (SFSR) supports the largest population of native Yellowstone Cutthroat Trout *Ocorhynchus clarkii bouvieri* (YCT) in Idaho and is one of the few native populations with fluvial and resident life histories intact. Rainbow Trout (RBT) are their largest threat through hybridization and competition. Suppression of RBT at tributary weirs, with electrofishing, and with incentivized angler harvest combined may be effective tools for managing RBT abundance in the SFSR. For the RBT harvest incentive program, fisheries staff marked 201 RBT with coded wire tags. Anglers turned in 3,266 RBT heads including 92 with tags (2.8%) worth a payout of $6,750. During the course of the program, anglers have turned in 32,334 RBT heads including 717 with tags (2.2%) worth $58,550. Fisheries staff operated weirs at four tributaries and trapping efficiencies averaged 82.7%, below the ten-year average (88.5%). Spawning run sizes for YCT indexed at four large tributaries exceeded the ten-year average, but we only trapped 87 YCT at Rainey Creek, the largest of the four tributaries. Escapement of fluvial YCT past all four weirs combined was the highest on record (N = 5,854), since 2001. We estimated record high abundances of total trout in the upper SFSR at the Conant monitoring reach, and we estimated record high abundances of YCT in the lower SFSR at the Lorenzo monitoring reach. We confirmed these high estimates with high escapement of fluvial YCT into tributaries and positive long-term intrinsic rates of population growth, suggesting that YCT are doing well in the SFSR. The IDFG Fish Management Plan has an objective for the SFSR that RBT (and RBT x YCT hybrids) represent less than 10% of the trout species composition. Currently, RBT compose 43.1% of the trout species, so significant effort is still required to achieve management objectives.

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INTRODUCTION

The South Fork Snake River (SFSR) supports the strongest remaining fluvial population of native Yellowstone Cutthroat Trout *Ocorhynchus clarkii bouvieri* (YCT) within their historical range in Idaho. The SFSR is one of only a handful of large rivers in the species' range that supports a robust population of YCT (Thurow et al. 1988; Van Kirk and Benjamin 2001; Meyer et al. 2006). Across the majority of the species range, YCT have experienced dramatic reductions in abundance and distribution (Behnke 1992). In August 1998, conservation groups petitioned the United States Fish and Wildlife Service (USFWS) to list YCT under the Endangered Species Act (ESA). In February 2001, the USFWS denied the listing petition, and conservation groups filed a lawsuit in January 2004, which led to a 12-month review of the status of YCT. The USFWS determined that YCT did not warrant ESA listing in February 2006 (USFWS 2006). However, across their historical range YCT have continued to sustain declines in their abundance and distribution (Endicott et al. 2016).

The primary goal for the SFSR, as directed by our constituency (Koenig 2020) and the Idaho Department of Fish and Game (IDFG) Commission, is the preservation of the genetic integrity and population viability of YCT (IDFG 2019). In the late 1990s and early 2000s, Rainbow Trout *O. mykiss* (RBT) abundance increased in the main stem SFSR. During the same period, RBT increasingly pioneered tributary habitat for spawning. Rainbow Trout and RBT x Cutthroat Trout hybrids (collectively RBT hereafter) are the biggest threat to the continued persistence of YCT in the SFSR (Moller and Van Kirk 2003, IDFG 2007; Van Kirk et al. 2010) because of risks through competition (Seiler and Keely 2007a) and hybridization (Henderson et. al 2000). Interspecific competition can cause increased mortality as individual fish aggressively compete for food resources or niche space (Seiler and Keely 2007a; Seiler and Keely 2007b; Van Kirk et al. 2010). Additionally, hybridization may result in the loss of genetically distinct YCT as gene flow transfers from one species to another through backcrossing of interspecific hybrids (Young 1995; Huxel 1999; Kruse et al. 2000; Kozfkay et al. 2007; Gunnell et al. 2008). Abundance of RBT has increased significantly in recent years to the extent that RBT were twice as abundant as YCT in 2018, increasing the potential for hybridization and competition.

Since 2004, the IDFG and collaborators have implemented several YCT conservation management strategies in the SFSR drainage to support the viability and genetic integrity of these populations. In 2017, a statewide survey of anglers identified that management for native cutthroat was a top priority (Koenig 2020). Current management objectives in the State Fish Management Plan (IDFG 2019) include preserving the genetic integrity and population viability of native YCT. This included limiting RBT prevalence to less than 10% of the trout species composition of the catch at the Conant monitoring reach measured during annual fall electrofishing surveys. The 10% threshold would return species compositions similar to those documented during the early to mid-1980s.

The primary management strategy for YCT conservation utilizes fish weirs and traps on four, primary spawning tributaries. At weirs, we trapped and removed RBT from spawning runs annually. The IDFG began experimenting with fish weirs and traps on spawning tributaries in 1996 and have been manually removing RBT from spawning runs since 2001 to limit RBT invasion and hybridization with YCT. The IDFG struggled with low effectiveness of previous weirs and traps during high flows (Schrader and Fredericks 2006). Weir modifications (from picket or floating weirs to electrical weirs or vertical/velocity barrier) have increased trap efficiency, especially during high spring flows (High et al. 2011). The trap and weir program on these tributaries has greatly reduced the occurrence of RBT accessing spawning areas upstream of weirs, improving the long-term viability of fluvial Snake River YCT populations (Van Kirk et al. 2010). Modeling by Van Kirk et al.

(2010) highlighted the importance of reproductive segregation resulting from this weir program. Weir management strategies in the SFSR tributaries are unique because they maintain the YCT fluvial life history while reducing threats from RBT invasion and hybridization. Commonly, managers have installed in-stream passage barriers to reduce hybridization, which unfortunately reduce life history variation and gene flow (Neville et al. 2006). If RBT are to invade the major spawning tributaries, there may be little chance of securing long-term viability of YCT in the SFSR (Van Kirk et al. 2010). However, weirs alone only provide areas of refuge for YCT to spawn in the absence of RBT, and do not affect the status of RBT in other portions of the watershed.

In 2004, IDFG modified harvest regulations on the SFSR to year-round seasons and unlimited bag limits for RBT. Prior to 2004, the season was from Memorial Day to November 30, and the bag limit was six trout, except only two YCT or BNT, none under 16". In 2004, IDFG removed the bag limit on RBT and hybrids, and IDFG prohibited the harvest of YCT. IDFG did not change the regulations on Brown Trout at that time. This modification resulted in a brief increase in RBT harvest (Schrader and Fredericks 2006). However, now that the regulations have been in place for several years, RBT harvest has decreased. To increase harvest of RBT, we developed a program that provided a monetary incentive for RBT harvest. This second management strategy intended to further reduce the RBT population through angler harvest in the main stem SFSR. Anglers have the ability to play a key role in YCT management efforts on the SFSR should they choose through RBT harvest. However, annual harvest rates were low largely due to the prevalent catch-and-release ethic embraced by many trout anglers. Population modeling suggests that RBT harvest and manual suppression combined must exceed 20% annually to result in a decreasing RBT population (Van Kirk et al. 2010; Devita 2014; Oldemeyer and Van Kirk 2018). Despite attempts to incentivize harvest, RBT harvest rates have been less than 20% except for one year since 2004 (High et al. 2011).

Beginning in 2018, IDFG tested the effectiveness of boat electrofishing to suppress RBT in the main stem of the SFSR. We removed RBT from the SFSR and transported them to other RBT fisheries within the Upper Snake Region. In effect, this third management strategy could additionally suppress RBT abundances to exceed 20%. In 2018, IDFG sampled known RBT spawning areas to determine if localized suppression of RBT would result in reduced catch in these areas, or if other RBT would repopulate these areas. If RBT repopulated these locations, then suppression at a larger scale and yielding higher numbers of RBT would be feasible. This pilot study in 2018 identified that electrofishing catch did not decline after initial suppression, suggesting larger suppression efforts might be effective. In 2019, IDFG tested available equipment and staffing to estimate the number of RBT that a moderate level of suppression could achieve (Heckel et al. 2020). This effort resulted in the suppression of approximately 6,000 RBT. This result was encouraging and with additional efforts might provide a significant benefit to the YCT population. Several more years of successive suppression will help estimate the efficacy of these efforts in significantly reducing the RBT abundances.

Age composition for trout species in the SFSR was last estimated in 1995 (Schrader and Fredericks 2006). At that time, cross-sectioned sagittal otoliths were the most reliable method, though poor concordance between three ageing labs limited biologists' confidence in those results. Since then, researchers have developed several improvements to fish aging methods, including microscope and imaging technology, as well as increased use of fin-ray structures that may allow for non-lethal sampling (Koch and Quist 2007). We used age composition and specifically length-at-age for fisheries management on the SFSR to estimate adult abundance and age-1 recruitment to describe population stability and index year-class strength and assess progress toward management goals on the SFSR (IDFG 2019).

The IDFG designed the above management strategies to achieve two primary goals, which are the preservation of the genetic integrity of YCT in the SFSR and maintaining the YCT population's long-term viability (IDFG 2007; IDFG 2019). To assess the effectiveness of the aforementioned management strategies, IDFG evaluated trends in abundance and recruitment. This report summarizes IDFG management actions in the SFSR during 2020.

STUDY AREA

The Snake River originates in Yellowstone National Park and flows south through Grand Teton National Park and the Jackson Hole valley before turning west and flowing into Palisades Reservoir at the Idaho – Wyoming state line. The SFSR is the 106 km (65 mi) portion of the Snake River that flows from Palisades Dam to the confluence with the Henrys Fork. This section of the SFSR is a world-class trout fishery and is an important factor to local economies. Anglers and biologists divide the SFSR into three segments. The first section, known as "the upper river," flows from Palisades Dam to Pine Creek through a relatively unconfined valley. A simple channel characterizes the first 13 km of the upper river downstream of the dam. From this point, the river braids around numerous islands. All but one of the four main YCT spawning tributaries enter the SFSR in this upper river, including Palisades, Rainey, and Pine creeks. The second section of the SFSR, also known as "the canyon", flows from Pine Creek downstream to Heise. Burns Creek, the fourth major YCT spawning tributary enters the SFSR in the canyon. The last section of the SFSR, known as "the lower river", flows from Heise to the confluence with the Henrys Fork. There are not any major YCT spawning tributaries in the lower river. Stable water temperatures from Palisades Dam moderate winter conditions in the upper river and canyon sections, winter conditions in the lower river are usually more severe than upstream with colder temperatures (Moller and Van Kirk 2003). The Conant and Lorenzo monitoring reaches of the SFSR are in the upper and lower river sections, respectively.

In addition to native YCT and RBT, other salmonids in the SFSR include Brown Trout *Salmo Trutta* (BNT), Lake Trout *Salvelinus namaycush*, and native Mountain Whitefish *Propsopium williamsoni*. Utah Sucker *Catostomus ardens*, Bluehead Sucker *C. discobolus*, and Mountain Sucker *C. platyrhynchus* are the native catostomids. The native Cottids are the Paiute Sculpin *Cottus beldingii* and members of the Mottled Sculpin complex *C. sp.*

OBJECTIVES

1. Operate weirs on Burns, Pine, Rainey, and Palisades creeks to remove RBT and limit RBT access to YCT spawning and rearing areas.

2. Increase suppression of RBT in the main stem SFSR by maintaining the RBT harvest incentive program and by other creative solutions.

3. Suppress resident RBT in Palisades Creek to reduce hybridization and competition with YCT.

4. Continue monitoring trout abundance and species composition at Conant and Lorenzo monitoring reaches of the main stem SFSR.

5. Monitor genetic integrity of the spawning YCT run at tributary weirs, and YCT abundance and distribution at Burns and Pine creeks.

6. Estimate population demographics, including growth and survival, of BNT in the SFSR to assess length-at-age for future analyses of abundance and recruitment.

METHODS

Main Stem South Fork

Abundance Monitoring

Since 2009, fisheries staff have estimated trout abundances annually at the Lorenzo and Conant monitoring reaches of the SFSR, using mark-recapture boat electrofishing. Staff attempted surveys annually at Conant since 1982 and at Lorenzo since 1987; though the frequency of surveys at Lorenzo was more sporadic in the late 1990s and early 2000s. We completed surveys during the fall when river flows decreased after the majority of the irrigation season was completed. The Conant reach is representative of the upper SFSR, and begins at the Swan Valley Bridge (43.450674°, -111.397284°) continuing downstream 4.9 km (43.478871°, -111.428777°). The Lorenzo reach is representative of the lower SFSR and is 4.8 km long, approximately equally distributed upstream (43.721271°, -111.859816°) and downstream (43.746023°, -111.89158°) of U.S. Highway 20. We used pulsed direct current (DC) at 9 – 12 amps, 200 – 350 volts, 50% pulse width, and a frequency of 60 Hertz. Netters attempted to capture all trout encountered. Crew members identified captured fish to species and measured them to the nearest mm (total length; TL) and we weighed a subsample ($n > 272$) for each species to the nearest gram. Prior to release, trout were marked with a hole punch in the caudal fin during our marking pass so that previously captured fish were identified during our recapture pass 5 – 7 days later.

In 2020, we sampled the Lorenzo monitoring reach September 15 – 17 (marking pass) and September 22 – 24 (recapture pass). We sampled the Conant monitoring reach October 6 – 8 (marking pass) and October 13 – 15 (recapture pass). We estimated abundance (trout/km) separately for each species for age-1 and older trout at each monitoring reach. The minimum length of age-1 trout for each species (YCT ≥ 102 mm, BNT ≥ 178 mm, and RBT ≥ 152 mm) was previously estimated from an ageing study using sagittal otoliths (Schrader and Fredericks 2006).

We also estimated abundance for all trout species combined which included all trout ≥102 mm at each monitoring reach. We used the Fisheries Analysis+ program (developed by the Montana Department of Fish, Wildlife, and Parks) to calculate abundance estimates and standard deviations using the Log-likelihood method for 25.4-mm size groups. Confidence intervals (CIs; 95%) were calculated by multiplying the standard deviation by 1.96.

We calculated the trend of the estimated abundance for the past 17 years for each trout species at each monitoring reach. We selected this duration to monitor changes with trout abundances since the IDFG last modified harvest regulations on the SFSR in 2004. We used linear regression to estimate the intrinsic rate of change in abundance for each species, with sample year as the independent variable and the $\log_e$ transformed abundance estimate (trout/km) as the dependent variable. The slope of the regression line fit to the $\log_e$ transformed abundance data is the intrinsic rates of change (r) for the population (Maxell 1999; High et al. 2008; Kennedy and Meyer 2015). Positive intrinsic rates of change ($r > 0$) indicate that abundance is increasing, and negative estimates of r indicate decreasing abundance in the population. Confidence intervals were estimated (90%) around the slope of the regression line. If 90% CIs did not include zero, the trend was significant. We used 90% CIs for more power to detect significant trends in abundance (Peterman 1990; Maxell 1999).

In addition to evaluating abundance, we compared length-weight relationships for each trout species caught at the Lorenzo and Conant monitoring reaches of the SFSR. We compared observed weights with standard weights published for each species. We used the standards published by Kruse and Hubert (1997) for YCT, Simpkins and Hubert (1996) for RBT, and Milewski and Brown (1994) for BNT. We calculated relative weights (W_r) for each of the trout that were weighed and compared these with W_r from 2012 – 2018 for trout at the Lorenzo and Conant reaches. We made comparisons using 95% CIs and 100-mm length groups, where we determined that non-overlapping intervals were statistically significant.

Rainbow Trout Harvest Incentive Program

In March, RBT were individually marked with coded wire tags (CWT) in the snout. We used boat electrofishing to capture RBT. We tagged all RBT with total lengths between 150 – 400 mm to avoid tag loss associated with mortality of young and old RBT. We captured, tagged, and released RBT from Palisades Dam downstream to Heise. Coded-wire tags were marked with five different six-digit numbers corresponding to the following monetary values: $50, $100, $200, $500, and $1,000. Currently, we attempt to tag approximately 575 fish annually from Palisades Dam to Byington boat ramp including 300 $50 tags, 200 $100 tags, 50 $200 tags, 20 $500 tags, and 5 $1,000 tags. Anglers wishing to participate in the program were required to turn in the heads of RBT and provide their contact information to the IDFG regional office directly or via freezers placed at the Byington and Conant boat ramp areas. On the first Friday of every month, “Fishead Friday”, we collected RBT heads from the freezers and scanned them for CWTs (Northwest Marine Technology blue or T-wand). Anglers were welcome to observe the scanning process in the fish lab at the IDFG region office. When we identified CWTs, we notified the angler with a phone call to verify their address and inform them of the reward amount. We mailed rewards as checks to winners.

Brown Trout Age Composition and Population Demographics

During the fall surveys at Conant and Lorenzo in 2019 (Heckel et al. 2020), we lethally sampled 205 BNT to compare calcified structures for age determination, and demographic parameters (i.e., age composition, sex ratios, fecundity, growth, and survival) for the BNT

population in the SFSR. We sampled 205 BNT with a goal of 10 fish per 20-mm size class from 80 – 500 mm and 10 fish greater than 500 mm.

We euthanized fish and froze them whole for later processing in the lab. In the lab, we measured fish for total length (mm) and weighed them to the nearest gram. We determined sex by the presence of egg skeins or milt sacks, and we weighed eggs to estimate fecundity. We determined maturity by the presence of enlarged eggs or milt sacks, where immature fish were characterized by small eggs and little to no milt. The calcified structures we used in this analysis included paired sagittal otoliths, the left leading pectoral fin ray (Koch et al. 2008), and 10 – 20 scales from the left dorsal side above the lateral line. We preserved otoliths dry in 1.5-mL micro-centrifuge tubes, and we preserved fin rays and scales dry in coin envelopes. Samples were stored indoors away from direct sunlight.

We set fin rays in epoxy using centrifuge tubes as a form, and a thin section (0.3 – 0.5 mm) was cut from the base of the pectoral fin ray with an Isomet low speed saw (Koch and Quist 2007). We mounted otoliths in epoxy in silicone trays and sectioned them in a similar manner as fin rays. We viewed sections of structures in immersion oil using a Leica compound microscope (model DM 1000 LED) at 40X using transmitted light, and photographed using a Leica (Model DC 500) digital camera. Using the photographs of each otolith or fin ray section, three independent readers, unware of fish length, enumerated presumptive annuli to estimate the age of the fish. When the readers disagreed on the age of a fish, fish length was included for consideration to resolve the discrepancy and determine the consensus age. We viewed and imaged scales at 25X magnification in immersion oil, using the same Leica microscope. We estimated precision of fin rays and otoliths by the coefficient of variation (CV) from ages among readers, as well as concordance between hard structures.

To estimate growth, we fit the von Bertalanffy growth function (von Bertalanffy 1938) to the estimated length for each fish using the formula:

$$l_t = L_\infty\left(1 - e^{-K(t-t_0)}\right),$$

where L_t is the length of BNT at a given age (t), L_∞ is the theoretical average maximum length that a BNT in the population can achieve, *K* is the Brody growth coefficient describing the rate at which a fish approaches maximum length, t is the age, and t_0 the theoretical age when length equals 0 mm (Quist et al. 2012; Ogle et al. 2017). We calculated mean (and standard deviation) length-at-age using the Isermann and Knight (2005) method in the FSA package in program R (R Core Team 2020).

Annual survival (S) and instantaneous total mortality (Z) were also estimated using a catch curve with the Chapman and Robson (1960) method and Peak Plus criterion in the FSA package in program R (Pauly 1984; Smith et al. 2012; R Core Team 2020). We also calculated total (natural mortality plus fishing mortality) annual mortality (*A*; Ricker 1975) for BNT where,

$$A = 1 - e^{-Z}$$

Back-calculated length-at-age was estimated for age-1 and older fish by measuring the radial distance from the center of the otolith (kernel) to each respective annuli and the edge of the otolith using Image J software (Rueden et al. 2017). We used the Dahl-Lea model to estimate length-at-age (Lea 1910).

We estimated fecundity for each mature female by removing a sample of 12 – 21 eggs and weighing to the nearest thousandth of a gram to determine the average egg weight. We weighed the remaining eggs to the nearest gram, and then we divided by the average egg weight to estimate the total number of eggs per fish. We characterized immature fish by underdeveloped and small egg skeins and removed from the sample. We removed partially spawned fish, subjectively determined by loose skeins and low egg masses, from the final estimates.

Wild Fish Health Inspection Report

Suppression of RBT in the main stem of SFSR remains an important objective to understand the feasibility and effectiveness of this strategy to benefit YCT. In 2020, we were not able to complete RBT suppression due to COVID-19 and the inability to socially distance in an electrofishing boat. We anticipate suppressing RBT in the future to better understand if suppression can benefit YCT populations in the SFSR. In anticipation of future RBT transport into other waters, we sampled RBT in the SFSR via electrofishing and IDFG's Eagle Fish Health Laboratory tested each for pathogens including viruses and bacteria.

South Fork Tributaries

Weirs

To limit RBT access to YCT spawning and rearing areas, and to monitor the genetic integrity of the YCT population, one combination vertical and velocity barrier (Burns Creek) and three electric weirs (Pine, Rainey, Palisades creeks) were maintained and operated at the four main spawning tributaries of the SFSR. In the past, we started the electrical weirs and installed the trap boxes at least one day prior to the earliest dates we captured RBT in previous years. In 2020, trapping began the first week in April. We checked each trap every three days until daily catch exceeded 20 fish, then we checked traps daily. We operated weirs through mid-July, until the number of trapped fish was less than one YCT per day.

We modified weirs by adding check boards before peak discharge to increase the head of the pool upstream of the weir, and to provide an obstacle for trout. The obstacle requires the fish to stop or slow down, where the electricity is more effective as a barrier, and forces them into the trap. This resulted in increased efficiency in past years (Heckel et al. 2020). We operated the electric weir at Palisades Creek through August to prevent late-spawning RBT from accessing tributary habitat. The fish trap and ladder boards were removed from Burns Creek after the weekly YCT capture reached zero and the spawning run was complete, to prevent BNT and RBT from re-colonizing habitat upstream of the weir.

We identified all fish captured at weirs to species, sexed according to expression of gametes or based on head morphology, and measured to the nearest mm (TL). Cutthroat Trout were marked with a PIT tag (12 mm; FDX) and an adipose clip, or a caudal fin punch and released upstream of the weir. We removed the adipose fin from YCT that received PIT tags as a secondary mark to make future scanning for PIT tags more efficient. All YCT captured in the trap with adipose fin clips were scanned for PIT tags. We identified fish that moved below the weir after interrogation at the trap by caudal fin punches or fresh adipose clip scars. Similarly, we used these marks to evaluate weir and trapping efficiency. We identified Yellowstone Cutthroat Trout that fell back below the weir to calculate accurate escapement numbers and fallback rates. We estimated the peak of the spawning run for each tributary as the date when we passed 50% of the total YCT escapement. We removed Rainbow Trout collected at the weirs.

All fish that were phenotypically determined (Meyer et al. 2017a) to be pure YCT were tissue sampled and passed upstream of the weir. Tissue samples were provided to the IDFG Eagle Fish Genetics Lab in the fall, where a subsample (n = 200) from each tributary was randomly selected from all samples for evaluation of hybridization and introgression. At Rainey Creek, where YCT spawner escapement is lower than 200, all tissue samples were processed. To identify hybrids and evaluate introgression, samples were analyzed using Cocut GTseq v 3.0 201 single nucleotide polymorphism (SNP) panel. There were 38 SNP markers in this panel that were diagnostic between RBT and YCT. We estimated genotypes using Bayesian model-based program, NEWHYBRIDS (Anderson 2008) to calculate the posterior probability of individuals belonging to one of six categories: (1) YCT, (2) RBT, (3) first generation hybrids, (4) second generation hybrids, (5) YCT backcrosses, and (6) RBT backcrosses. We used results from this test to assess the accuracy of identifying YCT x RBT hybrids by staff at the weirs. We retained all tissue samples at the Lab for archival purposes.

We used backpack electrofishing units on Burns and Pine creeks during the spawning season to estimate weir efficiencies. We captured fluvial-sized (≥ 300 mm) YCT upstream of the fish weirs and assessed each for marks and evidence of prior interrogation at the weirs. There is a canal head gate associated with the Palisades Creek weir and a fish screen downstream from the head gate in the canal. A bypass pipe above the fish screen returns downstream migrants back to the creek safely. We used a downstream trap on the Palisades Canal screen bypass pipe to estimate weir efficiencies at Palisades Creek. We could not evaluate weir efficiencies at Rainey Creek due to the limited number of YCT passed upstream. We calculated efficiencies for the Burns Creek, Pine Creek, and Palisades Creek weirs as the number of YCT ≥ 300 mm with PIT tags or caudal fin punches divided by the total number of YCT ≥ 300 mm captured. The length cutoffs, used to discriminate between fluvial and resident fish, were previously calculated for each year from 2009 – 2012. The length cutoffs were similar from year to year through that period so we averaged the yearly length cutoffs to form a standard cutoff length (300 mm) at all the SFSR tributary weirs. We identified the yearly length cutoffs by subtracting 1.96 standard deviations from the mean length of YCT caught at the weirs during each respective year, and effectively eliminated skewing error resulting from erroneously including YCT with resident life history in the efficiency calculations. We re-evaluated this cutoff in 2020 using data from 2013 – 2020 replicating previous methods.

Cutthroat were PIT-tagged during several sampling objectives throughout the course of each year in tributaries and in the main stem SFSR. We evaluated tag retention at each weir by sex since YCT were sexually dimorphic during sampling at the weirs. We estimated PIT tag retention by subtracting from 100, the number of adipose clipped YCT without a PIT tag and divided by the total number of adipose clipped YCT. We estimated tag retention by sex at each weir and calculated the average tag retention for all weirs for 2013 – 2019, and separately for 2020.

Tributary YCT Abundance and Distribution

Since 2016, each year we used multiple-pass, depletion, backpack electrofishing techniques to estimate abundance and distribution of YCT in one of the four main tributaries to the South Fork. We utilized natural transitions between pools and riffles instead of block nets, and we adjusted site lengths accordingly. We originally selected sites using a stratified random design, where the length that the stream order composed of the entire tributary weighted the number of sites selected in each stream order. During random selection of sites, we first identified all of the potential 100-m reaches in the drainage at the 1:24,000 scale using Forest Service maps projected in the web-based program CalTopo. To maximize precision of the drainage-wide estimate, we limited the number of sites in first order streams known to be intermittent, and

proportionally increased the number in perennial first order, and third order streams (Meyer et al. 2006). We estimated the proportion of stream length (m) in first order intermittent, and perennial first order, second order, and third order streams from 1:24,000 Forest Service. We then multiplied the proportion of the drainage in these orders by the following weights: 0.1 for intermittent first order, 0.5 for perennial first order, 0.1 for second order, and 0.3 for third order. We used a random number generator to select sites from all available 100-m reaches in each stream order.

We completed the first drainage-wide survey in Burns Creek during the late summer and fall of 2012 and 2013; with 35 sites surveyed. Of these sites, 8 were first order, 21 were second order, and 6 were third order. In 2019, we re-surveyed 20 of the original sites in Burns Creek with 14 second order sites and 6 third order sites. Sites that were fishless or dry in the 2012 – 2013 survey identified the extent of YCT distribution in those years. When we replicated the drainage-wide survey in 2019, we sampled all sites that previously had fish, and we surveyed one additional site further upstream to identify the extent of trout distribution.

We completed the first drainage-wide surveys in Pine Creek in 2016. Originally, a total of 42 sites were planned in 2016 and 40 sites were surveyed with 11 first order sites, 13 second order sites, 4 third order sites, and 12 fourth order sites. In 2020, we surveyed 42 sites in Pine Creek, with the same stream order as in 2016. We sought to estimate the extent of trout distribution in the same manner as at Burns Creek in 2019.

Electrofishing teams consisted of one person with a backpack electrofisher and one person with a net and bucket. When stream widths exceeded 3 m, we used two backpack electrofishing units. We used a pulsed DC waveform operated at 60 Hz, 200 – 600 V, and a 2–5 ms pulse width. During sampling, persons with backpack electrofishers moved upstream covering all available habitats. We identified captured fish to species, measured each to the nearest mm (TL), and checked for marks and tags. We planned three passes at each site, unless we encountered zero fish on the first pass. If we captured fish on the first pass, we completed subsequent passes until we captured < 50% of the prior pass, regarding trout > 100 mm.

We calculated the drainage-wide estimate of abundance (trout > 100 mm) and associated variances, and abundance by stream order and associated variances using the stratified-random-sampling formulas in Schaeffer et al. (1996).

Palisades Creek Rainbow Trout Suppression

We used backpack electrofishing units to capture trout in Palisades Creek and manually removed phenotypically identified RBT (Meyer et al. 2017a). We released all YCT. We completed electrofishing surveys during midsummer during base flow conditions to maximize capture efficiencies. In 2019, stream flows were high because of a large snowpack the preceding winter. High stream flows in combination with complex habitat in the upper 6.4 km of the suppression reach made electrofishing inefficient and unsafe. Because of this, and because previous efforts had successfully reduced RBT in this section (Meyer et al. 2017b), we did not attempt suppression efforts in this upper reach. We performed one removal pass in the lower 3.2 km of Palisades Creek.

Electrofishing suppression started at the weir and proceeded upstream. Teams consisted of two people (depending on stream flow) with backpack electrofishers and 2 – 3 people with nets and buckets. We used a pulsed DC waveform operated at 60 Hz, 200 – 600 V, and a 2 – 5 ms pulse width. During sampling, persons with backpack electrofishers moved upstream covering all available habitats. We identified captured fish to species, measured to the nearest mm (TL), and checked for marks and tags.

RESULTS

Main Stem South Fork

Abundance Monitoring

During 2020, we captured 1,444 trout at the Lorenzo monitoring reach, including 528 YCT, 69 RBT, and 847 BNT. The estimated abundance (± 95% CI) for all trout combined was 1,999 trout/km (± 228). There were an estimated 782 age-1 and older YCT/km (± 310) and 863 age-1 and older BNT/km (± 109; Figure 43). We captured too few RBT to calculate an estimate using mark-recapture techniques, but RBT did compose 4.8% of the catch. Extrapolating 4.8% with the total trout estimate (1,645 trout/km) provides a RBT abundance of 96 RBT/km at Lorenzo. Trends in abundance from 2004 to 2020 at Lorenzo were stable with no significant changes for BNT (r = -0.011; ± 0.026 90% CI), but YCT abundance significantly increased (r = 0.061; ± 0.082 90% CI). Average relative weights, for all size classes, for YCT at Lorenzo in past years (2012 – 2018) ranged from 93 to 100. Relative weights for YCT were higher in 2020 than past years with an average of 105. Brown Trout relative weights were consistent with past estimates and averaged 95, whereas past estimates ranged from 92 to 97.

At the Conant monitoring reach, we captured 3,008 trout during the 2020 survey. This included 1,011 YCT, 1,297 RBT, and 700 BNT. We estimated total trout abundance at 3,831 trout/km (± 274). There were an estimated 1,694 age-1 and older YCT/km (± 294), 833 age-1 and older BNT/km (± 168), and 1,383 age-1 and older RBT/km (± 161; Figure 44). Currently, RBT compose 35.4% of the total trout composition, while YCT represent 43.3% of the trout composition. At Conant, the intrinsic rate of change for all three trout species increased significantly in abundance from 2004 to 2020 [YCT (r = 0.035; ± 0.022 90% CI), BNT (r = 0.056; ± 0.028 90% CI), and RBT (r = 0.055; ± 0.027 90% CI)].

Relative weights, averaged for all size classes, for YCT at Conant in past years (2012 – 2018) ranged from 89 to 102. Relative weights for the same period for BNT ranged from 92 to 99 and from 92 to 102 for RBT. In 2020, relative weights for YCT, BNT, and RBT at Conant were consistent with past estimates and averaged 101, 99, and 96, respectively.

Rainbow Trout Harvest Incentive Program

In 2020, we continued the RBT harvest incentive program for the eleventh year. We marked 201 RBT with coded wire tags (CWT) in February and March 2020. This was significantly fewer than the average tagged annually from 2010 – 2019 (average = 1,020). Tags released in 2020 included 84 RBT with $50 tags, 101 with $100 tags, 8 with $200 tags, 5 with $500 tags, and 3 fish with $1,000 tags. Anglers ($n$ = 142) turned in 3,266 RBT in 2020 (Table 13). There were 92 tagged fish for a reward rate of 2.8%. The tag values and number that were turned in were $50 ($n$ = 67), $100 ($n$ = 20), $200 ($n$ = 2), and $500 ($n$ = 2) for a total of $6,750, which was above the eleven-year average (average = $5,180). The vast majority of the tagged fish turned in by anglers in 2020 were from past tagging events. In 2020, 66% of recovered tags were originally released in 2018 – 2019, 21% were released in 2017, 10% were released in 2014 – 2016, and 3% were released in 2020.

Since 2010, we tagged 10,398 RBT (average = 945) and 717 (2.2%) were returned by anglers (Table 13). From 2010 through 2015, 650 tags were released annually on average, but from 2016 through 2019 the number of tags released annually increased by 142.6% (average = 1,575). The average reward rate (2.2%) ranged from a low (0.63%) in 2010 to a high (3.18%) in 2018, but has

remained relatively consistent since 2013. Anglers have turned in a total of 32,334 RBT for a total of $58,550 rewarded to anglers over the course of the program.

2019 Brown Trout Age Composition

We estimated ages for 205 BNT ranging from 85 – 555 mm in length (average = 311 mm) weighing from 7 – 1,680 g (average = 428 g). We successfully estimated age using otoliths from 179 BNT, from age-0 to age-14. We used fin rays to estimate age from 193 BNT from age-0 to age-10. We used a subset of scales (*n* = 10) to determine age, but discrepancy between annuli was poor and age was indeterminable on 50% of scale samples. We did not conduct any further analyses with scales.

We estimated ages for 171 fish using both fin rays and otoliths. Concordance between structures averaged 56% across all ages. Concordance was high in young fish, but decreased with age (Table 14). Variation among readers was higher for fin rays (average CV = 21.0) than otoliths (average CV = 12.8). Of the 205 fish sampled, 87% of otoliths and 94% of fin rays provided usable images for aging.

We estimated length-at-age of BNT ages 0 – 5, 7 – 11, and 14 (Table 15). Back-calculated lengths-at-age (Table 16) were generally larger than non-back-calculated length-at-age. Growth of BNT was modelled using otolith ages, and L_∞ was 543 mm ($K = 0.317$; $t_0 = -0.752$). Catch curve analyses estimated annual survival (S) of BNT across all age classes was 48.1% (± 7.9; $Z = 0.726$), so total annual mortality (A) was 51.6%.

Sex was determined in 168 of the 205 fish collected, though 37 fish exhibited underdeveloped gametes and sex was unknown. When sex was unknown, fish were determined to be immature. For mature fish where sex was determined, total length averaged 342 mm (range 127 – 555 mm). Females composed 50.6% (*n* = 85) of the sample and averaged 345 mm (range 145 – 555 mm) and 512 g (range 25 – 1,680 g). Males composed 49.4% (*n* = 83) of the sample and averaged 339 mm (range 127 – 505 mm) and 497 g (range 25 – 1,569 g). Of the 205 fish in the sample, 73 (35.6%) were mature and 132 (64.4%) were immature. The majority of fish were mature by age-3 with all fish mature at age-5 (Table 17).

Fecundity was estimated from 33 fish which ranged in length from 305 – 530 mm. Fish under 300 mm were dissected for eggs, but were all determined to be immature, and thus, removed from the final estimate. We determined that five fish had partially spawned and we removed these from the final estimate. Brown Trout of lengths represented by age-2 and older averaged 1,636 eggs (range 755 – 4,685), and individual eggs averaged 0.052 g (range 0.017 – 0.091 g).

Wild Fish Health Inspection Report

On March 17, 2020, RBT were sampled from two reaches of the SFSR, between Dry Canyon and Lufkin Bottom (*n* = 30) and between Palisades Dam and Pine Creek (*n* = 30). Samples were negative for most pathogens in the tests, but two fish tested positive for *Tetracapsuloides bryosalmonae* (Bacterial kidney disease) and one fish tested positive for whirling disease (Table 18).

South Fork Tributaries

Weirs

From April 3 through July 9, we captured 1,816 migrating trout at the Burns Creek weir, including 7 male RBT, 9 female RBT, and 1,800 YCT (893 males, 837 females, 70 unknown; Table 19). The YCT spawning run peaked in Burns Creek on June 11. We observed 17% of the male YCT and 11% of the female YCT captured at the Burns Creek trap fell back below the weir. To estimate efficiency, we captured 60 fluvial-sized YCT upstream of the Burns Creek weir, and found 57 of 60 were marked. Thus, the 2020 trapping efficiency estimate for the Burns Creek weir was 95%.

We operated the Pine Creek weir from April 6 through July 13, capturing 3,199 trout, of which 16 were RBT (11 males and 5 females; Table 19). The 3,183 YCT included 1,271 males, 1,907 females, and 5 of unknown sex. The YCT spawning run in Pine Creek peaked on June 5. The fallback rates were 11% for female and 13% for male YCT. Upstream of the weir, we caught 39 YCT, of which 33 had been marked. The efficiency estimate for the Pine Creek weir was 85% in 2020.

We operated the Rainey Creek weir from April 3 through July 3, capturing 87 trout, including two female RBT (Table 19). The 85 YCT included 38 male, 46 female, and 1 of unknown sex. The YCT spawning run peaked in Rainey Creek on May 30. We observed one of each the male and female YCT captured had fallen back through the Rainey Cr weir, so fallback rates were 5% for male and female YCT.

At the Palisades Creek weir, we caught 799 trout between April 3 and July 8. We caught 13 RBT including 9 males and 4 females (Table 19). The remaining 786 fish were YCT and included 313 male, 466 female, and 7 of unknown sex. The YCT spawning run in Palisades Creek peaked on June 19. Fallback rates for male YCT were 3% and 1% for female YCT. We captured 118 YCT and 80 had been marked, yielding a Palisades Creek Weir trap efficiency estimate of 68%.

The mean PIT tag retention from 2013 through 2019 was 89.3% and 62.1% in males and females, respectively. In 2020, tag retention was 92.8% for males and 66.4% for females. The length cutoffs used to select for fluvial fish (≥ 300 mm) during efficiency surveys was similar to past results. From 2013 – 2020, the average length minus one standard deviation of YCT encountered at Burns, Pine, and Palisades weirs averaged 282, 291, and 279 mm, respectively. Among year variation ranged from 260 to 313 mm across all weirs throughout the time series.

We will not complete hybridization and introgression analyses of YCT passed upstream of each tributary weir in 2020 until summer of 2021. Those results will be added to the time series for this metric (Table 20) used to evaluate management goals. This is the first documentation of previous evaluations that occurred in 2015, 2018, and 2019.

Tributary YCT Abundance and Distribution

Mapping the Burns Creek drainage included a total of 21.8 km of stream. Of the total stream length, 3.8 km were first-order, 8.8 km were second-order, and 9.2 km were third-order streams. We surveyed 20 sites in the Burns Creek drainage in 2019 between July 29 and August 6. These included 14 second-order sites (average = 102 m), and 6 third-order sites (average = 108 m; Figure 45). Of these sites, all had been included in the 2012 – 2013 survey. We did not sample

12 sites because they were fishless or dry during the 2012 – 2013 survey. One second-order site was dry (site 27), and fish were absent at two additional second-order sites (sites 9 and 13). We captured YCT and RBT during the survey. We captured one RBT at one third-order site (site 1). We captured YCT at 11 of the 14 second-order sites, and all 6 of the third-order sites (Figure 46). Fluvial-sized YCT (≥ 300 mm TL) were captured at 8 of the 20 sites, 2 of which were second-order sites. In 2019, the average density of YCT/100 m^2 was 3.5, and 9.6 for second- and third-order streams, respectively. Densities in 2019 were similar to densities in second-order streams in the 2012 – 2013 survey (2.7 YCT/100 m^2; previously unreported data) though densities in third-order streams were lower (18.2 YCT/100 m^2). In 2019, 1,188 (± 262) YCT > 100 mm were estimated throughout Burns Creek drainage. This was 37.6% lower than the previous estimate conducted in 2012 – 2013 (1,904 YCT > 100 mm; previously unreported data).

Mapping the Pine Creek drainage included a total of 129.2 km of stream. Of the total stream length, 68.88 km were first-order, 14.9 were second-order, 13.9 were third-order, and 31.5 were fourth-order streams. We surveyed 37 sites in the Pine Creek drainage between July 6 and July 22, 2020. These included 6 first-order sites (average = 99 m), 11 second-order sites (average = 100 m), 6 third-order sites (average = 103 m), and 14 fourth-order sites (average = 104; Figure 47). All of these sites had been included in previous surveys conducted in 2016 (2016 Annual Report, in preparation). We did not survey five first-order sites because they were fishless or dry during the 2016 survey. Five first-order and two second-order sites were dry when visited during summer base flows in 2020. Fish were absent at three more sites (sites 17, 26, and 31; Figure 48). We captured YCT, BNT and RBT during the survey. We captured RBT at three sites (sites 30, 41, and 42) and BNT at three sites (sites 27, 41, and 42). All sites with RBT and BNT were sites in fourth-order streams. We captured YCT at 3 first-order sites, 8 second-order sites, 4 third-order sites, and 12 of the fourth-order sites. We captured fluvial-sized YCT at 10 of 37 sites, including one each in second- and third-order streams. The average density of YCT > 100 mm was 0.29, 7.5, 11.2 and 5.5 fish/100 m^2 for first- through fourth-order streams, respectively. The drainage-wide estimate and 95% confidence interval for YCT >100 mm in the Pine Creek drainage was 4,625 (± 1,123). The 2020 overall estimate was 37.5% lower relative to the prior estimate in 2016 (7,394 YCT > 100 mm). However, in 2016, the average density of YCT > 100 mm /100 m^2 was 0.0, 4.9, 8.6 and 17.4 for first- through fourth-order streams, respectively. Average densities in 2016 were highest in the largest stream orders, whereas densities in 2020 were highest in the middle stream orders.

Palisades Creek Rainbow Trout Suppression

We completed one electrofishing pass of suppression and removal of RBT in the lower 3.2 km of Palisades Creek during two days on July 27 and July 28. We caught 165 trout, including 133 YCT and 32 RBT. Rainbow Trout made up 19% of the catch, with a mean TL of RBT was 235 mm.

DISCUSSION

Main Stem South Fork

Fish management on the SFSR and tributaries maintains two primary goals for YCT conservation: 1) reduce RBT to less than 10% of the species composition at the Conant monitoring reach (IDFG 2019), and 2) prevent escapement of RBT into tributary habitats (IDFG 2007). The primary threats to YCT in the SFSR are hybridization and competition with RBT (Van

Kirk et al. 2010; McCormick and High 2020). Hybridization may result in the loss of genetically distinct YCT, as gene flow transfers from one species to another through backcrossing of interspecific hybrids until no genetically distinct YCT remain (Young 1995; Huxel 1999; Kruse et al. 2000; Kozfkay et al. 2007; Gunnell et al. 2008). Additionally, interspecific competition can increase mortality as individual fish aggressively compete for food resources or niche space (Seiler and Keely 2007a; Seiler and Keely 2007b; Van Kirk et al. 2010; McCormick and High 2020). We formed these management goals in the 2019-2024 Fish Management Plan (IDFG 2019) using the best available science, and then we provided opportunity for the public to comment. Finally, the IDFG Commission review and approve the goals and objectives in the Plan. Often, we design management goals to both satisfy biological and social goals. We identify the preferences of IDFG's angling constituency through angler opinion surveys (Koenig 2020). The primary goals for the SFSR align with anglers' preferences assessed last in 2017, because anglers identified managing for native trout fisheries (specifically cutthroat) as a primary goal. Respondents to the 2017 Angler Opinion Survey identified native trout management as the third most important management activity, only behind protecting and improving fish habitat, and maintaining and improving existing fishing access sites. Results from this study identify that the majority of anglers that fish in Idaho prefer management for native trout fisheries to managing for quality/trophy trout in rivers and streams (Koenig 2020).

Annual abundance monitoring in the SFSR during 2020 identified record high abundances of trout. At Conant, RBT continued to be the most abundant species and currently compose 43% of the trout population, which is similar to the 2019 estimate (Heckel et al. 2020). This is far above our goal of 10% RBT composition at Conant (IDFG 2019), though management efforts continue to pursue that goal. Significant increases in YCT and BNT abundances during the last year, along with generally high but stable RBT abundances, resulted in the highest total trout estimate on record at Conant, dating back to 1982. This is likely due to several successive above-normal snow packs that resulted in higher stream flows in the SFSR and tributaries, specifically in the winter months (Battle et al. 2010). More water simply provides favorable conditions for the growth and survival of all trout, especially during winter.

With abundances of RBT and YCT seemingly at or near carrying capacity, there are many opportunities for density-dependent population effects from intra- and interspecific competition (McCormick and High 2020). McCormick and High (2020) identify the effect to the YCT population will likely be at age-0 and age-2, since YCT are thought to be at a competitive disadvantage to RBT and hybrids (Seiler and Keely 2007a; Seiler and Keely 2009; Van Kirk et al. 2010). However, if true, then the effects of density-dependence to the YCT population may lead to lower year-class strength for affected cohorts. Currently, angler success is likely to be high with record high abundances of trout, though competition from high abundances might represent significant stress to the YCT population.

At Lorenzo, we estimated the highest abundance of YCT on record since 1987, though CIs were wide around the point estimate. The CIs were wide due to a low number of recaptured YCT relative to the overall number of YCT captured. The number of YCT captured was accordingly higher than in the past, so we consider the final estimate reliable. Considering the relatively high abundance of BNT in this reach as well, fishing could be good in the coming years at the Lorenzo reach. The increasing number of RBT at the Lorenzo reach is a concern. In 2019, the RBT species composition of RBT was 2.3% and in 2020 that increased to 4.8%. Although this is a small change, it represents a 70.4% increase in species composition in just one year. We will monitor this dynamic in future surveys because RBT are the primary threat to YCT. Beyond increasing trends for total trout abundance, trout fitness levels, as indicated by relative weights, appear to be stable as well.

The intrinsic rate of change estimated for main stem trout species since 2004 was generally positive, which aligns well with the high abundance estimates. We estimated significant increases in abundance for all species except BNT at Lorenzo, which were stable. We use these trend analyses to evaluate changes to harvest regulations last made in 2004. This time series (16 years) may currently be too long for this purpose, if the effect of liberalized harvest of RBT is less significant than the stochastic changes within the environment. Still, it is important to note that changing fishing regulations to increase opportunities for harvest of RBT did not have a negative effect on RBT trend in abundance alone, which warranted additional management actions. This is likely because most anglers continue to practice catch and release, which was documented in the creel surveys last conducted in 2017 (Heckel et al. In Review*)*.

Combined, angler harvest and manual suppression of RBT are currently the most promising tools for managing threats to YCT in the main stem SFSR. We did not complete suppression of RBT in the main stem SFSR in 2020 due to COVID-19. We need several consecutive years of suppression to determine if this is a viable tool to achieve management goals. Anglers provided above-average harvest of RBT to the Harvest Incentive Program, which represents an important contribution from our constituents. During the eleven years of this program, anglers have harvested over 32,000 RBT. This program provides important interactions between biologists and their constituency. Through conversations with anglers on “Fishhead Friday,” it is apparent the program does successfully motivate additional angler harvest of RBT on the SFSR. During 2020, we only tagged 201 RBT, which was significantly lower than the average number of fish tagged during the prior four years (1,557 tagged). Still, the number of tagged fish and the reward rate were above average, so it will be critical to tag in the spring of 2021 to maintain this reward rate through 2021. Suppression of RBT should help increase this reward rate as we returned tagged fish to the river, to further incentivize RBT harvest.

Suppression of RBT by IDFG in the SFSR is not a novel management approach. There are many examples of other fish management agencies who require anglers to carry out the mandatory kill/harvest regulations on Walleye *Sander vitreus* in Wyoming, BNT in Colorado, and RBT in Yellowstone National Park to name a few. Additional efforts to manage for native salmonids include lethal netting Lake Trout *Salvelinus namaycush* for native trout conservation at Yellowstone Lake and Lake Pend Oreille (Syslo et al. 2011; Dux et al. 2019). In general, YCT in the SFSR spawn later than RBT, though spawn timing can overlap, resulting in mixed species using the same spawning habitat (Henderson et al. 2010). Removing adult RBT before or during their spawning season will reduce the likelihood of hybridization with YCT. Manual suppression also represents the most efficient method to achieve IDFG’s management goal of less than 10% RBT in the main stem SFSR (IDFG 2019) and less than 10% introgression between RBT and YCT (IDFG 2007).

The proportion of SFSR YCT that spawn in the tributaries is thought to be lower than the proportion that spawn in the main stem (IDFG unpublished data), though precise estimates of these proportions are not available. If the majority of YCT spawn in the main stem SFSR, then tributary weirs alone will not be sufficient to protect the genetic integrity of the YCT population. Currently, we tissue sample all of the YCT we pass upstream of tributary weirs annually. If we make a significant effort to tissue sample YCT in the main stem, we may be able to estimate the proportion of the SFSR YCT population that spawn in the tributaries and estimate the effective population size. This would help to identify the relative importance of main stem RBT suppression and weir management. Additionally, this analysis could allow for the estimation of the effective population size, which if known, would allow for the estimation of loss of genetic diversity (IDFG 2007).

Brown Trout Age Composition

Known-age fish were not available for comparison in the past, and still were not available to validate estimated ages in 2019. Concordance was high between fin rays and otoliths for smaller fish, which served as some validation for ages of young fish using otoliths. For young fish, fin rays were much easier to estimate age, but differentiating annuli became more difficult and less precise as age increased. Otoliths were difficult to assign ages to when the fish was young because the nucleus was arbitrary and buried under the many checks and growth occurring during early development. Still, otoliths were preferred for further analyses because of their higher precision among readers and lower standard deviations of estimated lengths throughout all ages. Also, to maintain consistency with past main stem SFSR analyses, length-at-age using otoliths was used to describe growth and survival.

Growth of BNT appears high relative to other North American BNT populations. However, we have commonly documented fish in the SFSR larger than our estimate of L_∞. When comparing back-calculated length-at-age to North American standards (Brouder et al. 2009), lengths averaged 16.2% longer for ages-1 through age-5, and were above the 95th percentile for age-1 through age-3. However, in this comparison, growth appeared to slow in older fish because age-4 and -5 were similar to lengths in the 75th percentile. Survival was comparable to other trout populations where approximately 50% of the population survives to the next year (McCormick and High 2020).

Most importantly, length-at-age did not differ significantly from past estimates, so we do not have to re-evaluate ongoing time series, such as estimates of BNT recruitment, for a different length cutoff for age-1 BNT. Past estimates of age-1 fish length ranged from 178 – 279 mm (Schrader and Fredericks 2006) and here we estimate age-1 fish ranged in length from 176 – 281 mm.

South Fork Tributaries

Some consider the SFSR weir program the most important strategy for managing threats from RBT to fluvial and resident YCT in tributaries (Van Kirk et al. 2010). This was only the seventh consecutive year since 2010 that we were able to operate weirs and traps on all four major spawning tributaries of the SFSR with relatively high efficiency. We documented the highest escapement of fluvial YCT into all tributaries combined, on record since 2001. The high number of YCT captured at the weirs is the result of high trapping efficiencies and high abundance of adult spawners. Trapping efficiency was significantly lower at Palisades Creek than in the past and the lowest since we installed the electric weir. Though there is a trend to suggest the problem is attenuating over time, management of the weir focused on maintaining high efficiency by maintaining the highest electrical settings recommended (Larson et al. 2014), and by installing check boards as soon as possible to introduce a slight physical barrier to fish trying to charge through the electric field. Nevertheless, we documented the lowest efficiency on record, since the installation of the electric weirs. This might be due to a unique life-history strategy, where adult fluvial YCT ascend the tributary to spawn, and then reside in the tributary upstream of the weir for 12 – 14 months until the next spawning event. If fish remained upstream of the weir over winter, they would not have been interrogated and marked at the weir and would therefore reduce the estimated efficiency. Data from PIT tag detections at the Palisades Creek array identify that this life history strategy exists, though current sample sizes of fish exhibiting this behavior are limiting (data not shown).

Basin-wide surveys of SFSR tributaries document a diversity of life history strategies persisting in the SFSR YCT population. Both resident and fluvial YCT use all reaches including the headwater stream sections. Stochastic variability in weather patterns (e.g., snow pack, summer air temp., etc.) are likely notable factors influencing stream flow, which also influence fluvial YCT distributions and residence times in the tributaries. This was the second time we surveyed Burns and Pine creeks in their entirety, and we need to complete additional surveys to assess trends in abundance and distribution.

Gunnel et al. (2008) recommended evaluating the effectiveness of the tributary weirs at reducing hybridization and introgression between RBT and YCT at SFSR tributaries. Results herein suggest that introgression and hybridization is very low, when evaluated at the weirs. Gunnel et al. (2008) measured hybridization and introgression at multiple locations within each tributary and found significantly higher introgression (average = 4.5%) than current estimates (average = 0.2%). Upstream of the weirs there may be relict populations of hybrids and RBT that continue to provide threats to pure YCT. Replicating the sampling conducted by the authors and evaluating hybridization and introgression over a more thorough spatial scale may confirm the low levels of introgression measured at the weirs.

Rainey Creek is the only major tributary that is not demonstrating the success relative to the other tributaries. Poor trapping success from 2001 to 2009 resulted in low catch and reduced effectiveness in removing RBT. In 2011, we constructed a new weir downstream, closer to the mouth of Rainey Creek to protect more of the system from invading RBT. We anticipated higher catches with a trap located upstream from the mouth only 5.1 km versus 14 km. The higher catches have yet to materialize. Yellowstone Cutthroat Trout spawning runs at Rainey Creek continue to be stagnant despite increased adult YCT abundance in the SFSR, and catch has similarly increased at adjacent spawning tributaries in Pine and Palisades creeks during the same period. It is possible that fluvial YCT in Rainey have gone through a bottleneck, which Campbell (1990) defined as a severe reduction in the demographic size of a population. If bottlenecks are severe enough, inbreeding depression can occur which limits the ability of the population to recover because of reduced levels of reproductive fitness (Frankham 1995). The abundant resident YCT population in the upper portions of the system maintaining genetic diversity likely mitigates for adverse effects of genetic bottlenecks in Rainey Creek. However, the fluvial component of the Rainey Creek sub-population has not recovered, and does not show evidence for a trend towards recovery.

Poor spawning and rearing habitat may be another factor limiting YCT abundance in Rainey Creek. Past agricultural practices have degraded trout habitat in several areas of Rainey Creek, which have resulted in channel manipulations that limit the biological productivity of Rainey Creek. Spawning habitat is limited due to sedimentation, limited riparian cover, and high stream temperatures (Lehotsky 2019; RivHab 2020), which reduces the carrying capacity of the creek for trout. In 2018, Third Creek – a first order tributary to Rainey Creek – was restored to mitigate lower river temperatures. In 2020, private landowners restored one additional reach in the lower portion of Rainey Creek. Restoration of additional reaches to improve habitat limitations in Rainey Creek and increase connectivity to the upper river (Cegelski et al. 2006) are critical for the fluvial YCT in Rainey Creek.

MANAGEMENT RECOMMENDATIONS

1. Maintain trap/weir program in the four primary YCT tributaries of the SFSR to provide spawning and rearing areas with reduced possibility of competition or hybridization with RBT.

2. Utilize more than 20 days of boat electrofishing in known spawning areas of the main stem SFSR to suppress RBT and reduce hybridization and competition between RBT and YCT.

3. Use model simulations to estimate what levels of suppression and duration are needed to achieve the current management goal of <10% RBT in the main stem SFSR with observed suppression rates and current angler harvest rates.

4. Plan and implement responsible stream restoration designed to rehabilitate or restore systemic, fundamental stream processes in Rainey Creek.

5. Complete an age, growth, and survival study on Rainbow Trout in the South Fork.

Table 13. Summary of the Rainbow Trout (RBT) Harvest Incentive Program on the South Fork Snake River from 2010 through 2020.

						Tag value ($)					
Year	RBT tagged	# Anglers	RBT turned in	Tags found	Reward rate (%)	50	100	200	500	1,000	Annual payout ($)
2010	575	640	2,861	18	0.6%	12	3	2	0	1	$2,300
2011	600	237	2,001	16	0.8%	5	8	1	2	0	$2,250
2012	860	207	1,854	37	2.0%	23	9	3	2	0	$3,650
2013	530	239	2,441	75	3.1%	55	13	2	2	1	$6,450
2014	705	175	3,587	75	2.1%	40	29	7	0	0	$6,300
2015	628	137	2,599	72	2.8%	48	13	12	0	0	$6,100
2016	1,338	117	2,681	45	1.7%	35	7	2	1	0	$3,350
2017	1,540	87	3,303	71	2.1%	58	10	2	0	0	$4,300
2018	2,068	104	3,205	102	3.2%	75	18	8	2	1	$9,150
2019	1,353	185	4,536	114	2.5%	93	13	5	2	0	$7,950
2020	201	142	3,266	92	2.8%	67	20	2	2	0	$6,750
Total	10,398	2,128	32,334	717	2.2%	511	143	46	13	3	$58,550

Table 14. Concordance between ages determined from otoliths and fin rays from Brown Trout in the South Fork Snake River in 2019.

Age	Sample size	Concordance (%)
0	17	100
1	47	94
2	30	80
3	49	76
4	19	42
5+	9	0

Table 15. Total length-at-age (mm; mean, minimum, maximum) and standard deviation (SD) estimated from sagittal otoliths for Brown Trout in the South Fork Snake River in 2019.

Age	Sample size	Mean (mm)	Minimum length (mm)	Maximum length (mm)	Standard deviation	(- 1 SD)	(+ 1 SD)
0	18	115.2	85	145	15.1	100.0	130.3
1	47	227.1	176	281	27.8	199.2	254.9
2	32	319.3	269	413	41.9	277.4	361.2
3	51	382.0	289	502	41.3	340.6	423.3
4	19	411.6	319	505	45.8	365.7	457.4
5	5	459.2	455	485	18.2	441.0	477.4
6	0	---	---	---	---	---	---
7	1	460.0	---	---	---	---	---
8	2	480.5	475	486	7.8	472.7	488.3
9	1	519.0	---	---	---	---	---
10	1	485.0	---	---	---	---	---
11	1	498.0	---	---	---	---	---
12	0	---	---	---	---	---	---
13	0	---	---	---	---	---	---
14	1	555.0	---	---	---	---	---

Table 16. Mean back-calculated length-at-age and standard deviation (SD) for Brown Trout in the South Fork Snake River in 2019.

Age	Sample size	Mean	Min	Max	SD	(-1SD)	(+1SD)
1	146	170	110	231	24	146	195
2	100	267	209	332	24	243	291
3	76	329	253	403	30	299	360
4	29	372	293	458	40	332	412
5	11	388	338	449	39	349	428
6	8	398	366	434	27	372	425
7	7	420	386	447	24	396	444
8	6	444	410	477	25	419	469
9	4	459	434	498	28	431	486
10	3	468	454	477	12	456	480

Table 17. Maturity of Brown Trout by sex and age in the South Fork Snake River in 2019.

	Male			Female		
Age	Sample size	Mature	Percent (%)	Sample size	Mature	Percent (%)
1	24	1	4	17	0	0
2	13	1	8	21	5	24
3	28	18	64	28	18	64
4	12	10	83	8	6	75
5	3	3	100	2	2	100

Table 18. Wild Fish Health Inspection Report from Rainbow Trout liver samples from two reaches of the main stem South Fork Snake River in 2020 analyzed at the Fish Genetics Lab, Eagle, Idaho.

Test category	Pathogen	Number positive/number tested	Fish per pool
Viral Replicating Agents:			
	Infectious Hematopietic Necrosis Virus	0/12	5
	Infectious Pancreatic Necrosis Virus	0/12	5
	Viral Hemorrhagic Necrosis Virus	0/12	5
Bacteria:			
	Renibacterium salmoninarum	0/60	5
	Aeromonas salmonicida	0/12	5
	Yersinia ruckeri	0/12	5
	Flavobacterium psychrophilum	0/12	5
	Motile *Aeromonas* species	0/12	5
Whirling Disease/*Myxobolus* Individual Test Results:			
	Pepsin-trypsin digested (PTD)	1/12	5
Other Organisms Detected:			
	Tetracapsuloides bryosalmonae (Bacterial kidney disease)	2/21	5

Table 19. South Fork Snake River tributary weir summary statistics from 2001 through 2020.

Location and year	Weir type	Operation dates	Estimated weir efficiency (%)[a]	Catch		
				Cutthroat Trout	Rainbow Trout	Total
Burns Creek						
2001[b]	Floating panel	March 7 - July 20	16	3,156	3	3,159
2002[b]	Floating panel	March 23 - July 5	NE[c]	1,898	46	1,944
2003[d]	Floating panel	March 28 - June 23	17-36	1,350	1	1,351
2004	ND[e]	ND	ND	ND	ND	ND
2005	ND	ND	ND	ND	ND	ND
2006	Mitsubishi	April 14 - June 30	NE	1,539	NE	NE
2007	ND	ND	ND	ND	ND	ND
2008	ND	ND	ND	ND	ND	ND
2009	Fall/velocity	April 9 - July 22	98	1,491	2	1,493
2010	Fall/velocity	March 26 - July 14	100	1,550	2	1,552
2011	Fall/velocity	March 23 - July 12	90	891	5	896
2012	Fall/velocity	March 24 - July 11	90	496	0	496
2013	Fall/velocity	April 4 - July 2	98	888	6	894
2014	Fall/velocity	April 1 - July 3	90	833	12	845
2015	Fall/velocity	April 6 - July 3	94	1,357	1	1,358
2016	Fall/velocity	April 4 - July 3	98	1,528	7	1,535
2017	Fall/velocity	April 1 - June 27	87	759	4	763
2018	Fall/velocity	April 3 - July 6	100	1,570	9	1,579
2019	Fall/velocity	April 8 - July 8	94	1,322	6	1,328
2020	Fall/velocity	April 3 - July 9	95	1,800	16	1,816
Pine Creek						
2001[b]	ND	ND	ND	ND	ND	ND
2002[b]	Floating panel	April 2 - July 5	NE	202	14	216
2003[f]	Floating panel	March 27 - June 12	40	328	7	335
2004	Hard picket	March 25 - June 28	98	2,143	27	2,170
2005	Hard picket	April 6 - June 30	NE	2,817	40	2,857
2006[g]	Mitsubishi	April 14 - April 18	NE	NE	NE	NE
2007	Mitsubishi	March 24 - June 30	20	481	2	483
2008	Hard picket	April 21 - July 8	NE	115	0	115
2009	Hard picket	April 6 - July 15	49	1,356	1	1,357
2010	Electric	April 13 - July 6	NE	2,972	3	2,975

Table 19 (continued)

Location and year	Weir type	Operation dates	Estimated weir efficiency (%)[a]	Catch		
				Cutthroat Trout	Rainbow Trout	Total
Pine Creek						
2011	Electric	April 11 - July 9	49	1,509	1	1,510
2012	Electric	March 28 - July 1	NE	1,427	3	1,430
2013	Electric	April 5 - June 22	89	1,908	1	1,909
2014	Electric	April 7- June 30	70	899	7	906
2015	Electric	April 1 - June 25	78	1,864	3	1,867
2016	Electric	April 1- June 22	93	3,240	8	3,248
2017	Electric	April 3 - June 26	67	2,695	2	2,697
2018	Electric	April 2 - June 26	94	2,155	6	2,131
2019	Electric	April 8 - July 5	72	3,191	8	3,199
2020	Electric	April 6 - July 13	85	3,183	16	3,199
Rainey Creek						
2001[b]	Floating panel	March 7 - July 6	NE[c]	0	0	0
2002[b]	Floating panel	March 26 - June 27	NE	1	0	1
2003[f]	Floating panel	March 27 - June 12	40	328	7	335
2004	Hard picket	March 25 - June 28	98	2,143	27	2,170
2005	Hard picket	April 7 - June 29	NE	25	0	25
2006	Hard picket	April 5 - June 30	NE	69	3	72
2007	Hard picket	March 19 - June 30	NE	14	0	14
2008	Hard picket	June 19 - July 11	NE	14	0	14
2009	Hard picket	April 7 - July 6	NE	23	0	23
2010	Hard picket	April 13 - June 29	NE	145	1	146
2011	Electric	March 28 - June 28	NE	0	0	0
2012	Electric	April 18 - June 23	NE	7	0	7
2013	Electric	ND	ND	ND	ND	ND
2014	Electric	April 29 - June 25	NE	56	2	58
2015	Electric	April 2 - June 21	NE	73	2	75
2016	Electric	April 1 - June 23	NE	19	2	21
2017	Electric	April 3 - June 26	NE	37	2	39
2018	Electric	April 2 - June 26	NE	41	0	41
2019	Electric	April 8 - June 24	NE	70	0	70
2020	Electric	April 3 - July 3	NE	85	2	87

Table 19 (continued)

Location and year	Weir type	Operation dates	Estimated weir efficiency (%)[a]	Catch		
				Cutthroat Trout	Rainbow Trout	Total
Palisades Creek						
2001[b]	Floating panel	March 7 - July 20	10	491	160	651
2002[b]	Floating panel	March 22 - July 7	NE	967	310	1,277
2003	Floating panel	March 24 - June 24	21 - 47	529	181	710
2004	ND	ND	ND	ND	ND	ND
2005	Mitsubishi	March 18 - June 30	91	1,071	301	1,372
2006	Mitsubishi	April 4 - June 30	13	336	52	388
2007	Electric	May 1 - July 28	98	737	20	757
2008	ND	ND	NE	ND	ND	ND
2009	Electric	May 12 - July 20	26	202	4	206
2010	Electric	March 19 - July 18	86	545	50	595
2011	Electric	April 7 - June 15	NE	30	13	43
2012	Electric	March 24 - July 2	88	232	20	252
2013	Electric	April 5 - July 8	96	619	23	642
2014	Electric	April 2 - July 18	98	734	63	797
2015	Electric	April 2 - July 18	95	832	14	846
2016	Electric	April 1 - July 6	99	958	27	985
2017	Electric	April 3 - July 21	100	755	63	818
2018	Electric	April 2 - July 10	92	474	18	492
2019	Electric	April 8 - July 23	83	627	6	633
2020	Electric	April 3 - July 8	68	786	13	799

[a]Weir efficiency was estimated using several different methods

[b]From Host (2003)

[c]NE = no estimate

[d]Weir was shut down on June 10, but the trap was operated until June 23

[e]ND = no data; weir either not built or not operated

[f]Weir was shut down early due to high cutthroat trout mortality

[g]Weir was destroyed during high runoff

Table 20. Estimated percent hybridization and percent introgression, and sample sizes (*n*), of Yellowstone Cutthroat Trout passed upstream of weirs at the four primary tributaries to the South Fork Snake River during 2015, 2018, and 2019.

	Burns			Pine			Rainey			Palisades		
Year	*n*	Hybrid.	Introg.	*n*	Hybrid.	Introg.	*n*	Hybrid.	Introg.	*n*	Hybrid.	Introg.
2015	30	0.00 %	---	30	0.00 %	---	30	0.00 %	---	30	6.67 %	---
2018	198	1.00 %	0.03 %	128	2.29 %	0.41 %	124	0.00 %	0.00 %	195	2.01 %	0.30 %
2019	199	0.50 %	0.17 %	200	0.00 %	0.01 %	81	2.47 %	0.23 %	200	3.00 %	0.55 %

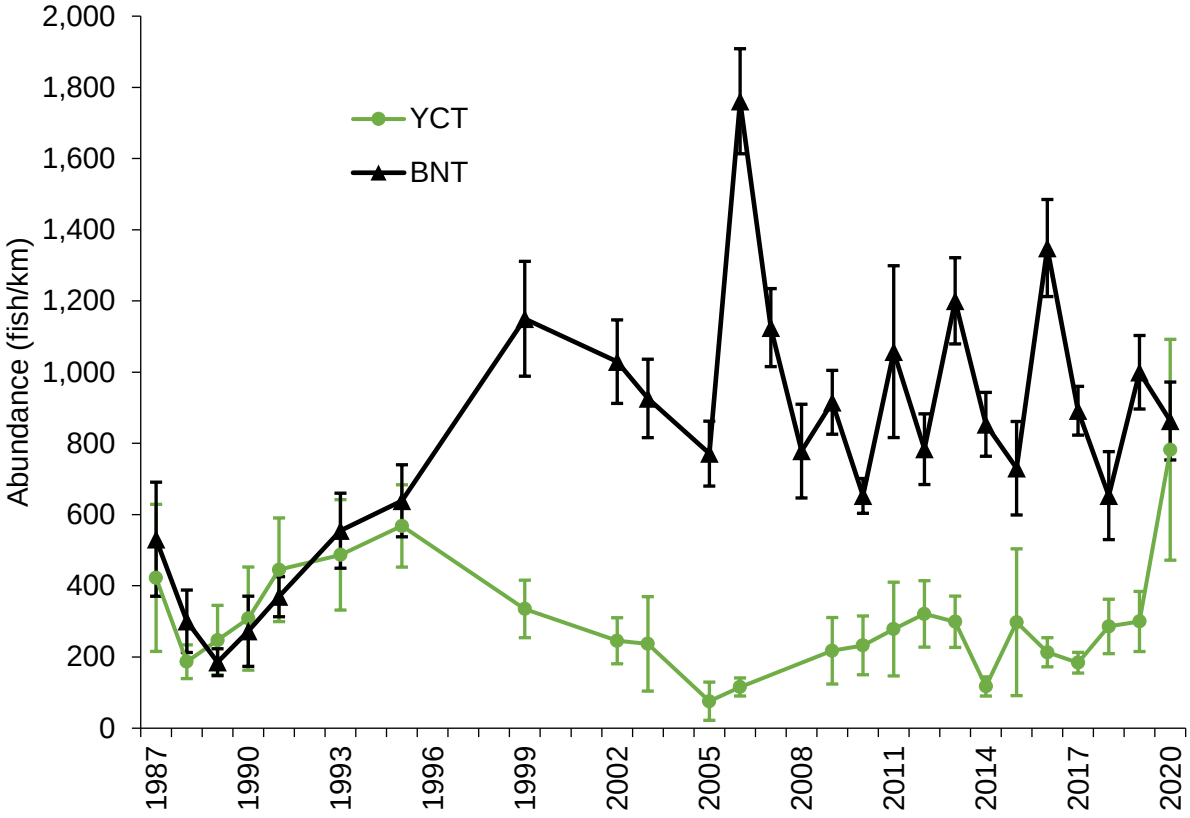

Figure 43. Abundance estimates (fish/km) and 95% confidence intervals for Yellowstone Cutthroat Trout (YCT) and Brown Trout (BNT) at the Lorenzo monitoring reach on the South Fork Snake River from 1987 through 2020.

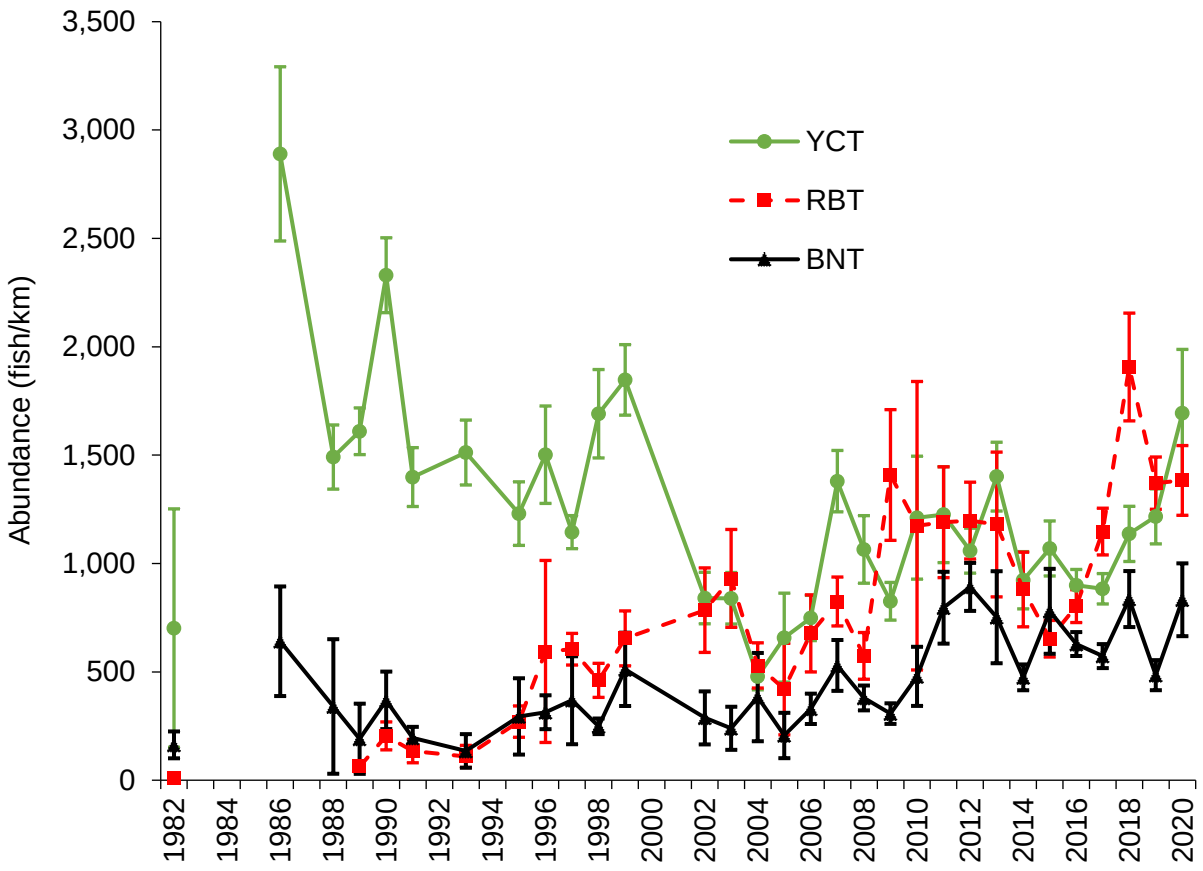

Figure 44. Abundance estimates (fish/km) and 95% confidence intervals for Yellowstone Cutthroat Trout (YCT), Rainbow Trout (RBT), and Brown Trout (BNT) at the Conant monitoring reach on the South Fork Snake River from 1982 through 2020.

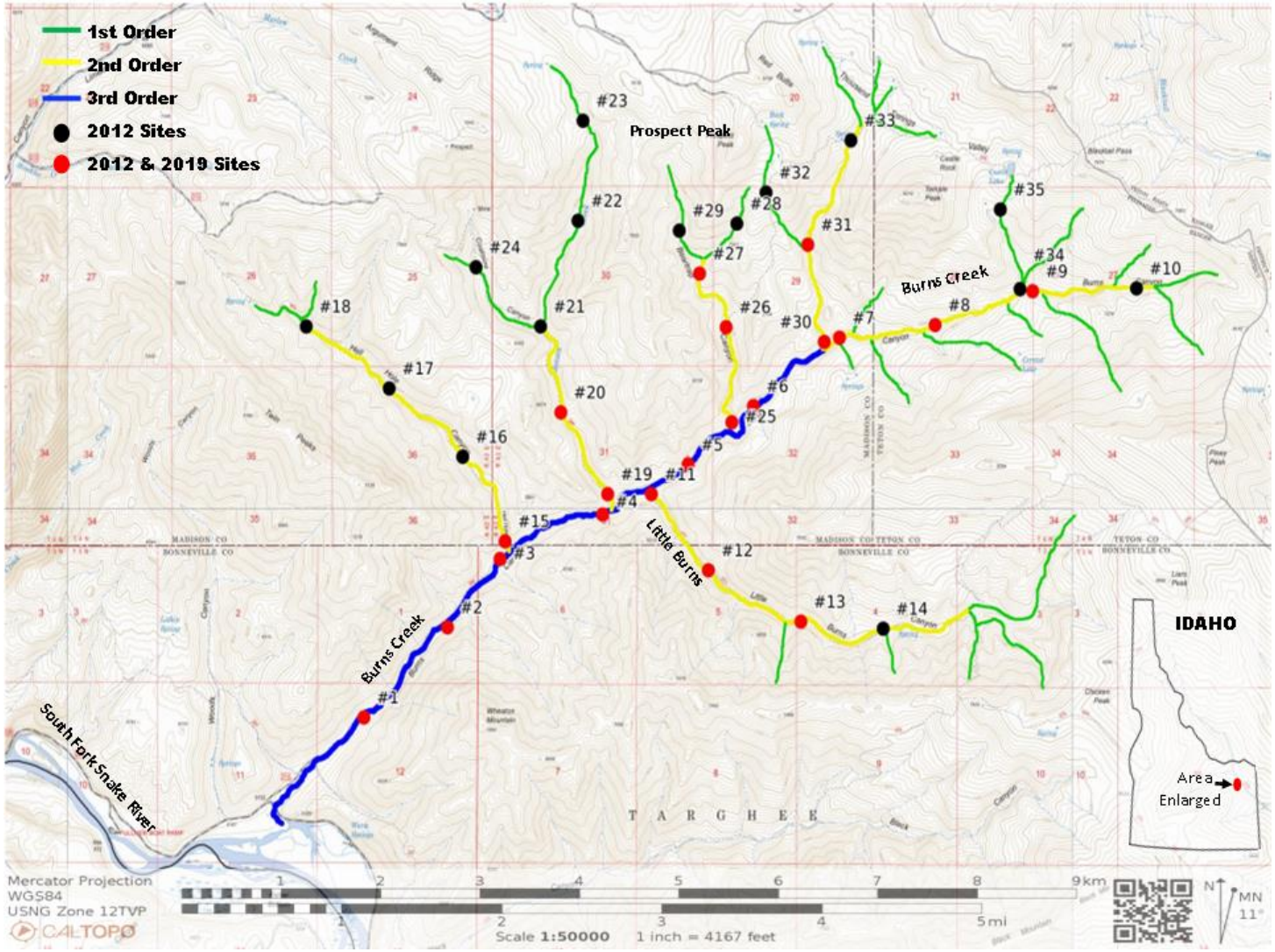

Figure 45. Stream order designations and survey sites for the 2012 – 2013 and the 2019 Burns Creek drainage-wide surveys of Yellowstone Cutthroat Trout abundance and distribution.

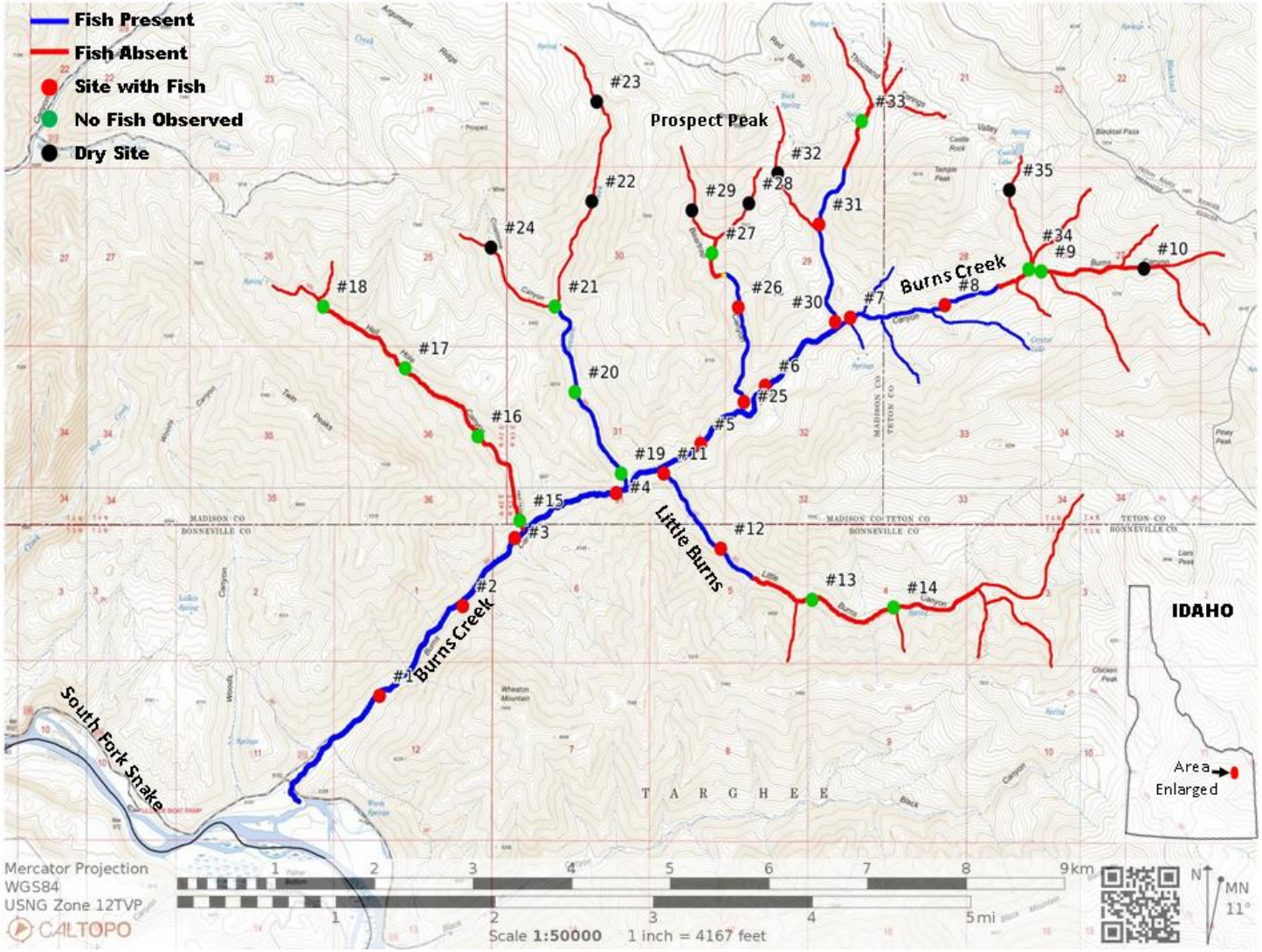

Figure 46. Yellowstone Cutthroat Trout distribution at sites surveyed for the 2019 Burns Creek drainage-wide survey.

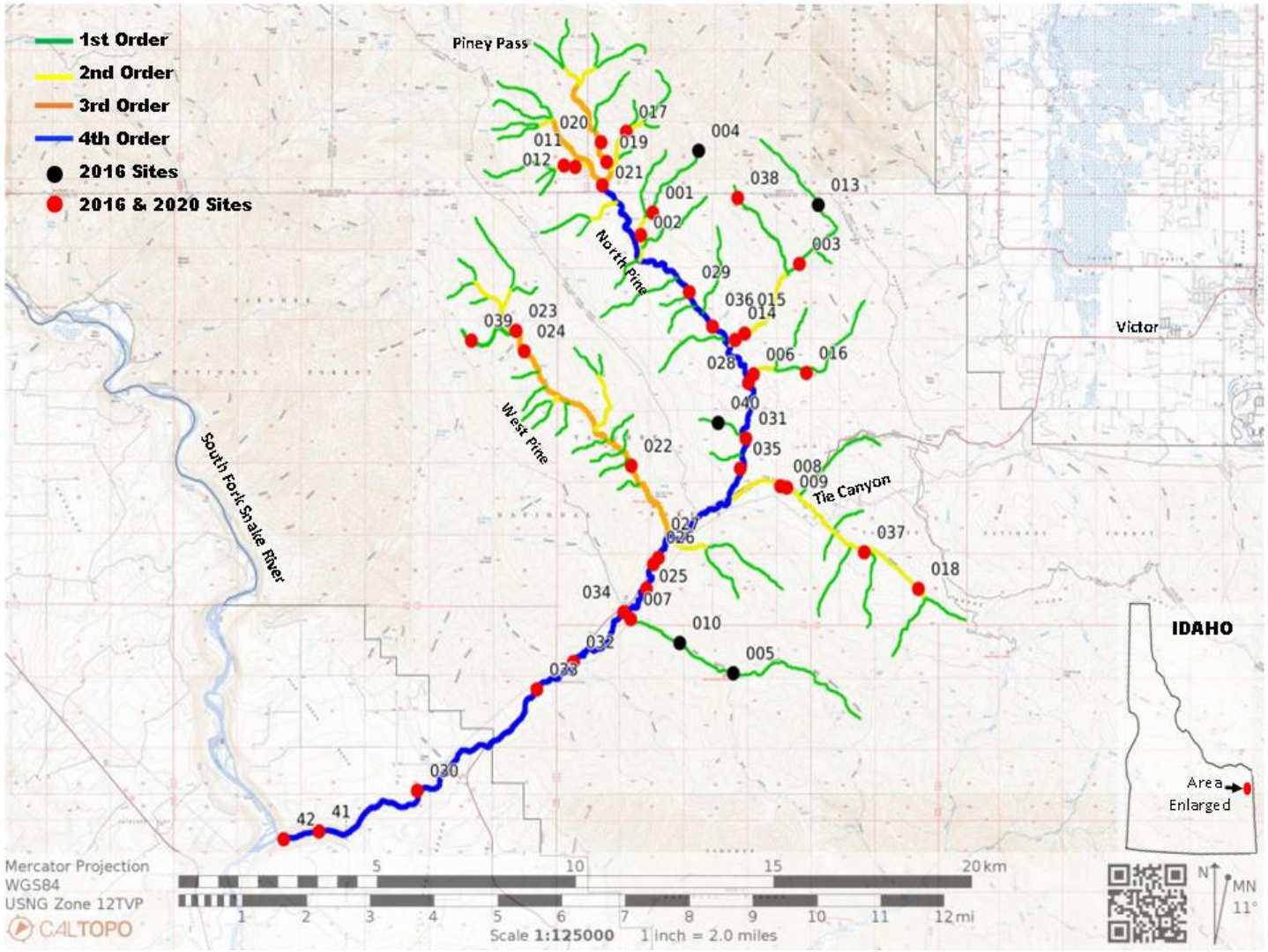

Figure 47. Stream order designations and selected survey sites for the 2016 and the 2020 Pine Creek drainage-wide survey of Yellowstone Cutthroat Trout abundance and distribution.

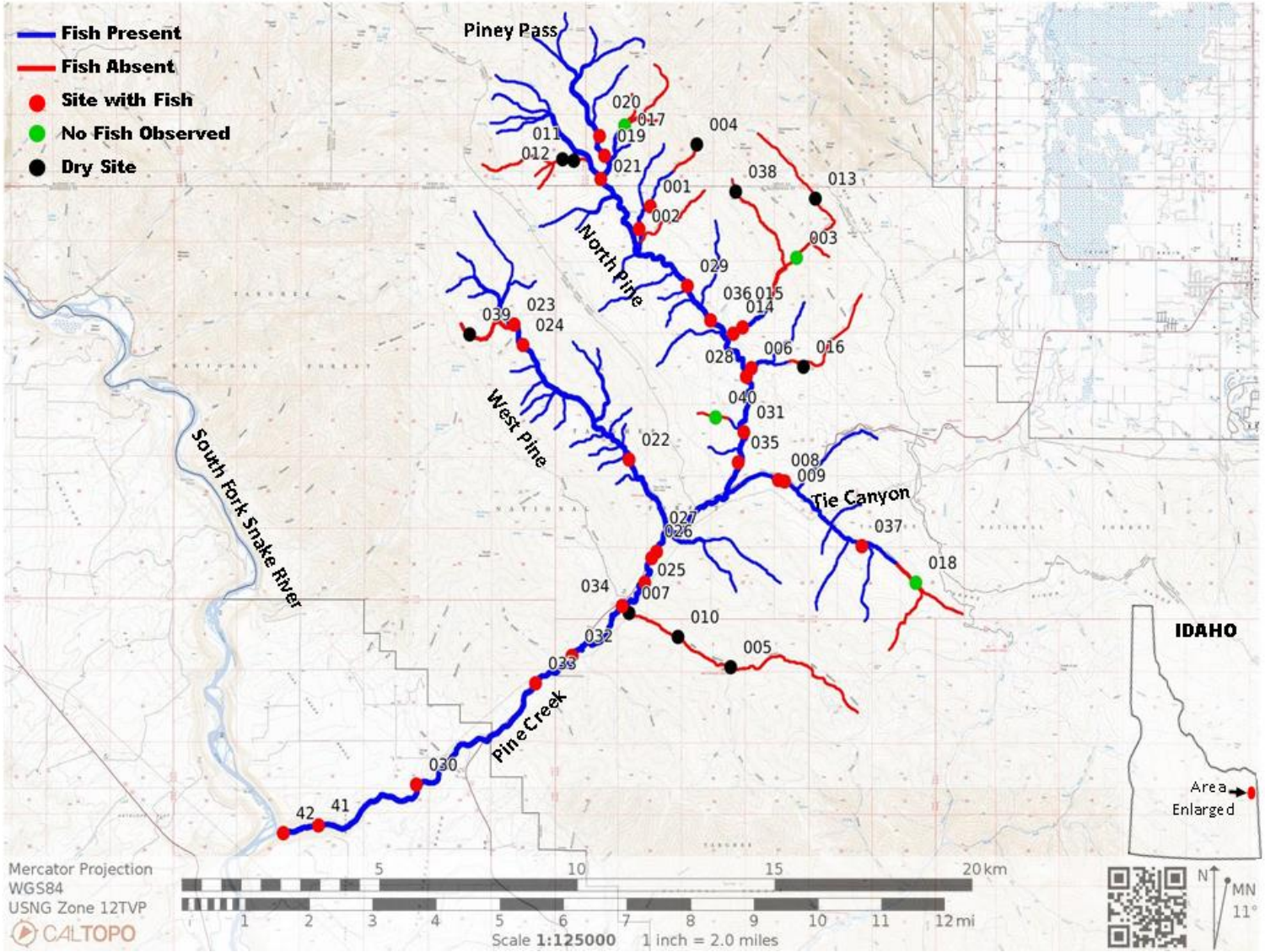

Figure 48. Yellowstone Cutthroat Trout distribution at sites surveyed for the 2020 Pine Creek drainage-wide survey.

HENRYS FORK

ABSTRACT

We used boat-mounted electrofishing equipment to assess fish populations in the St. Anthony reach of the Henrys Fork Snake River during October 2020. Brown trout *Salmo trutta* density was greater (977 trout per km; 95% CI ± 274) than the density observed in 2017 (656 trout per km ± 176). Overall, the Brown Trout density in 2020 was greater than the average from 2004-2017 (i.e., 566 trout per km). Species composition in the reach was 73% Brown Trout, 23% Mountain Whitefish *Prosopium williamsoni*, 3.5% Rainbow Trout *O. mykiss*, and 0.05% Yellowstone Cutthroat Trout *O. clarkii bouvieri*. Catch rates (number of fish per minute of electrofishing) during the marking run were 1.60 for Brown Trout, 0.55 for Mountain Whitefish, 0.09 for Rainbow Trout, and 0.002 for Yellowstone Cutthroat Trout. The proportional size distribution (PSD) and relative stock densities with standards set at 400 mm and 500 mm (RSD-400, and RSD-500) for Brown Trout was 38, 21, and 5, respectively. The PSD and RSD-400 for Rainbow Trout was 49 and 24, and for Mountain Whitefish was 71 and 30.

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INTRODUCTION

The Henrys Fork Snake River is a popular fishery that attracts anglers from throughout the nation and across the globe. The Henrys Fork Snake River (also known as the North Fork) forms at the confluence of Big Springs Creek and the Henrys Lake Outlet and flows approximately 25 km before reaching Island Park Dam. Downstream of Island Park Dam, the Henrys Fork flows approximately 147 km through two smaller dams and four irrigation check dams before joining the South Fork Snake River to form the Snake River. The Henrys Fork upstream of Island Park Reservoir provides a general regulation fishery primarily supported by stocked trout. The fishery is also supported by trout that move out of Henrys Lake or Island Park Reservoir into the river. Management of the Henrys Fork downstream of Island Park Dam emphasizes wild, natural trout populations without hatchery supplementation. The Henrys Fork downstream of Island Park Dam, particularly Box Canyon, Harriman Ranch, and Pinehaven reaches, support world famous wild Rainbow Trout *O. mykiss* (RBT) fisheries. Downstream of Harriman Ranch, the Henrys Fork flows over Mesa Falls and is joined by Warm River before it is impounded by Ashton Dam. Brown Trout *Salmo trutta* (BNT) are present in the Henrys Fork downstream of Mesa Falls and increase in numbers in downstream reaches. Eventually, BNT dominate the species composition (>70%) near the town of St. Anthony and farther downstream. Yellowstone Cutthroat Trout *O. clarkii bouvieri* (YCT) still persist throughout the main-stem Henrys Fork Snake River, although abundances are so low that their population size cannot be estimated in our standard surveys. In addition, Mountain Whitefish *Prosopium williamsoni* (MWF) are another salmonid native to the watershed and we also estimate their abundance in trout population estimates.

STUDY SITE

The St. Anthony reach is sampled on a triennial basis as part of our long-term monitoring program for the Henrys Fork Snake River. The reach starts downstream of the Bubble Railroad Bridge and extends downstream 7 km to the Red Rd. Bridge (Figure 49). Coordinates for all mark-recapture transect boundaries are presented in Appendix D.

OBJECTIVES

To obtain current information on fish population characteristics to inform fishery management decisions on the Henrys Fork Snake River.

METHODS

We used boat-mounted electrofishing units and sampled the reach using two electrofishing rafts and one drift boat. We marked fish on 6 October and recaptured fish on 13 October, 2020. One pass was conducted for each of the marking and recapture runs. We took water temperature (°C) and conductivity (µS/cm) prior to active electrofishing using a handheld probe. We used pulsed direct current power provided by a 5000-W generator and standardized to 2,750-3,250-W based on water conductivity (Miranda 2009). We applied electricity to the water using an Infinity model electrofisher (Midwest Lake Management, Inc., Polo, Missouri). Electrofishing began at the uppermost point of the sampling reach and proceeded in a

downstream direction. One netter positioned at the bow of each raft and used a 2.4-m long dip net with 6-mm bar knotless mesh. The netter attempted to net all sportfish (i.e., trout and whitefish) and place them into a live well located in the raft. For all sportfish captured, we identified to species and measured them for total length to the nearest mm. We marked all fish 150 mm or greater TL with a hole punch in the caudal fin prior to release, and this mark was used to identify previously captured fish in the recapture run.

We estimated abundance for all salmonids ≥ 150 mm using a Peterson estimator with a Chapman modification using the mrClosed() function in the FSA package in program R (R Core Team 2020). We adjusted for size selectivity by distributing the catch into size classes, and we then calculated 95% CI for the abundance estimates. We evaluated species composition in the reach and catch rates (CPUE) for each species on the marking run as the number of fish caught per minute of electrofishing. We estimated capture efficiency as the number of marked fish that were recaptured divided by the total number of remaining marked fish that were available for capture multiplied by 100 (Chiaramonte et al. 2020). After calculating population estimates, we estimated trends in the BNT population growth in the reach using an exponential model and the intrinsic rate of population change (r) as described by Maxell (1999) using $\alpha = 0.10$. Proportional size distribution (PSD) was calculated as the number of fish ≥ 300 mm divided by the number of fish ≥ 200 mm multiplied by 100. Similarly, relative stock densities (RSD-400 and RSD-500) used the same formula, with the numerator replaced by the number of fish ≥ 400 and 500 mm (Anderson and Neumann 1996; Neumann et al. 2012).

RESULTS

We collected 1,402 BNT, 442 MWF, 66 RBT, and 1 YCT during two days of electrofishing in the St. Anthony reach of the Henrys Fork. Species composition of all sportfish collected was 73% BNT, 23% MWF, 3.5% RBT, and 0.05% YCT. Using the modified Peterson estimate adjusted for size selectivity, we estimated 6,841 BNT ± 1,919 (i.e., 977 BNT/km ± 274; Table 21; Figure 50), 2,947 MWF ± 1,441 (421 MWF/km ± 206), and 300 RBT ± 233 (43 RBT/km ± 33) in the sampling reach. Catch rates on the marking run were 1.60 BNT/min, 0.55 MWF/min, and 0.09 RBT/min. Capture efficiencies varied among species; 9.4% for BNT, 5.8% for MWF, 7.7% for RBT, and 8.4% for all species combined. The intrinsic rate of population growth for BNT has been significantly increasing since 2004 ($r = 0.13$, $F_{1, 4} = 6.53$, $P = 0.06$). The TL of BNT varied between 85 to 635 mm (Figure 51) with a mean and median TL of 256 (SD; ± 115) and 233 mm, respectively. The mean TL of RBT (Figure 52) and MWF (Figure 53) was 307 mm ± 90 and 316 mm ± 102, respectively. Brown Trout PSD was 38, RSD-400 and RSD-500 values were 21 and 5, respectively (Table 22; Figure 54). Rainbow Trout PSD was 49, RSD-400 and RSD-500 values were 24 and 0; and MWF PSD was 71, RSD-400 and RSD-500 values were 30 and 0, respectively.

DISCUSSION

Brown Trout density in the St. Anthony reach has been increasing since 2004 and BNT continue to be the dominant trout species in this reach. In the current survey, we observed two strong year classes of BNT based on the length frequency distribution. These strong year classes are of fish less than 280 mm indicating that there is not a recruitment failure for juvenile trout, but there may be factors limiting higher abundances of BNT larger than 280 mm. There is a trend in

the long-term comparison of PSD and RSD values from 2014-2020. Prior to 2014, there were higher abundances of large fish, then there was a steady decline from 2004-2014. After 2014, we see a steady increase of larger fish in the population. To better understand the population dynamics of BNT in this reach, an age and growth analysis should be conducted to estimate mortality in each age class. Overall trout abundance in this survey is the highest compared to all surveys since 2004. In contrast, the Vernon and Chester reaches upstream of the St. Anthony reach exhibited a higher frequency of BNT greater than 400 mm from 2014-2020 surveys (Flinders et al. 2016), but the overall density of BNT was lower in those reaches compared to the St. Anthony reach. In addition to BNT, there was a strong year class of RBT in the 200-270 mm range and a stable class of RBT from 320-430 mm, which suggests good environmental conditions like higher flows and cooler water. Although RBT are less abundant than BNT, the stable size structure indicates a healthy population which provides additional opportunities for anglers. Mountain Whitefish abundance has not been investigated in previous surveys, but there are four distinct size classes in the population with the highest abundance of MWF from 370-450 mm. Because there are four distinct size classes we hypothesize that the MWF population is healthy. Meyer et al. (2011) found that the growth, fecundity, and survival of MWF was higher in the upper Snake River basin compared to other waters surveyed across the state, thus we recommend continuing to monitor this population in the Henrys Fork Snake River.

The current fishing regulation in this reach is a 2-fish daily bag limit, which likely does not implicate overharvest as a factor limiting the abundance of larger fish. However, since the change from general trout regulations in 2016 to the 2-fish limit, trout abundance has been increasing. But, this is confounded by several good water years (2017-2019), which may also have contributed to stronger classes of age-2 and age-3 trout. Nonetheless, trout abundance is higher than it has been and we believe that the regulation change has contributed to the increasing abundance of trout in the St. Anthony reach and that we met the management objective as stated in the current Fisheries Management Plan (IDFG 2019). In addition, environmental factors also contributed to stronger year classes of age-2 and age-3 trout, which in turn boosted population numbers in conjunction with the regulation change. In an unpublished creel study conducted by IDFG in 2017, 10% of BNT that were caught by anglers were harvested in the stratum that included the St. Anthony reach. Therefore, we hypothesize that environmental factors such as water quality, water temperatures, or flows may be limiting higher abundances of large BNT in this reach. Because of the current harvest regulations, we believe that overharvest is not limiting the BNT population. However, we could further investigate this relationship by collecting angler harvest information during future surveys. In addition, we recommend estimating natural mortality of BNT in this reach and a subsample of BNT in the next population estimate should be taken to estimate additional population parameters like mortality and survival by age class.

MANAGEMENT RECOMMENDATIONS

1. Continue monitoring the salmonid populations in the St. Anthony reach on a triennial basis in the fall.

2. Take a subsample of BNT from the next St. Anthony population estimate in 2023 to estimate natural mortality of the BNT population in the lower Henrys Fork.

3. Conduct a “Tag You’re It” study on the BNT population in the St. Anthony reach.

Table 21. Sportfish population estimate summaries using a size-selective Modified Peterson estimator for the St. Anthony reach of the Henrys Fork Snake River, 2020.

Species	No. marked	No. captured	No. recaptured	Population estimate	95% CI	Efficiency	Density (No./km)	CPUE (fish/min)	Discharge (m^3/s)[1]
Brown Trout	578	561	51	6,841	1,919	9.4	977	1.60	26.56
Rainbow Trout	42	27	3	300	233	7.7	43	0.55	26.56
Mountain Whitefish	218	174	12	2,947	1,441	5.8	421	0.09	26.56

[1]Represents the mean discharge value between marking and recapture events. Data obtained from the USGS gaging station at St. Anthony (13050500).

Table 22. Size structure characteristics of the sportfish population in the St. Anthony reach of the Henrys Fork Snake River, 2020.

Species	Mean TL (mm ± SD)	Median TL (mm)	PSD	RSD-400	RSD-500	Species composition (%)
Brown Trout	256 ± 115	233	38	21	5	73
Rainbow Trout	307 ± 90	273	49	24	0	3
Mountain Whitefish	316 ± 102	337	71	30	0	23

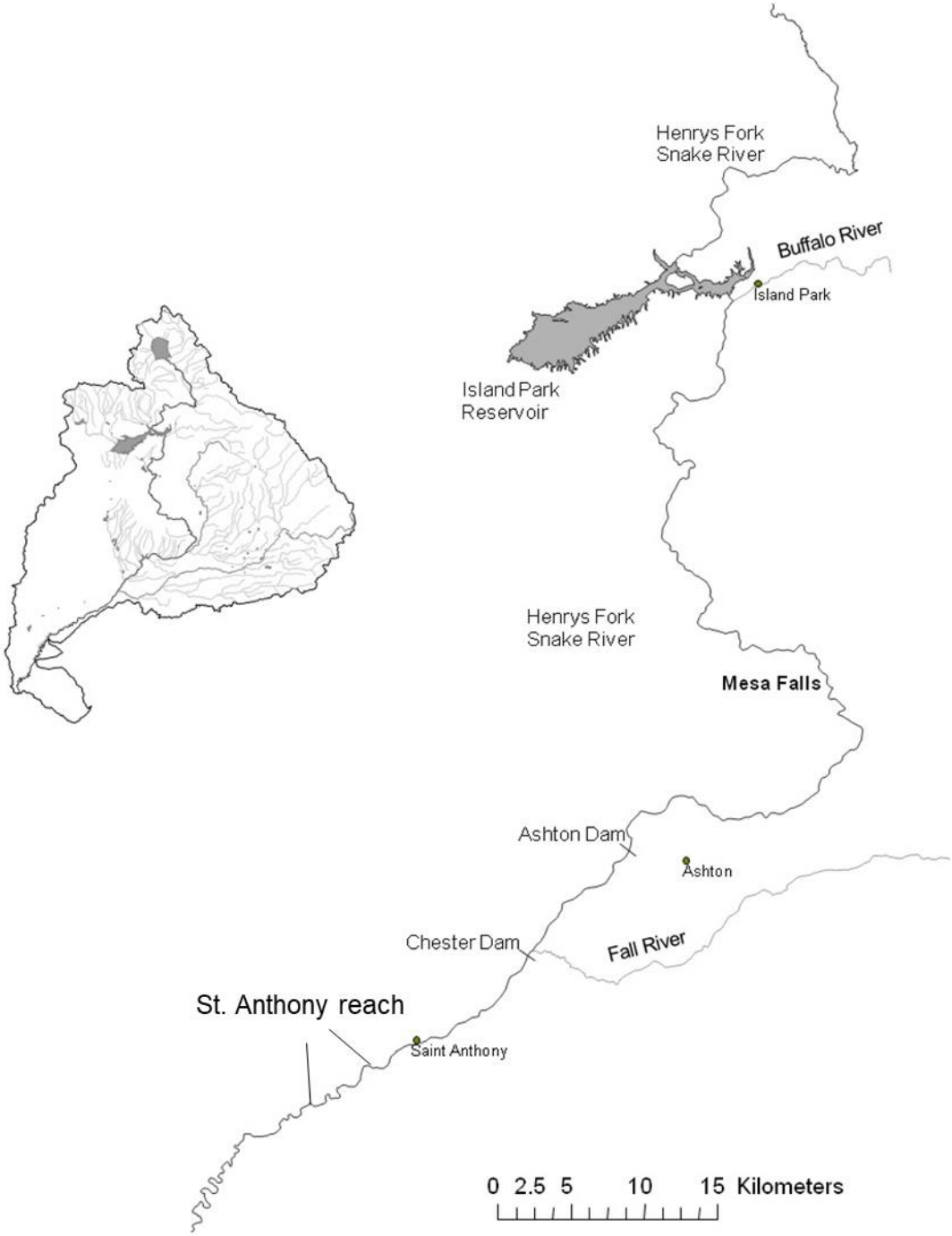

Figure 49. Map of the Henrys Fork Snake River watershed and the St. Anthony reach sampled in 2020.

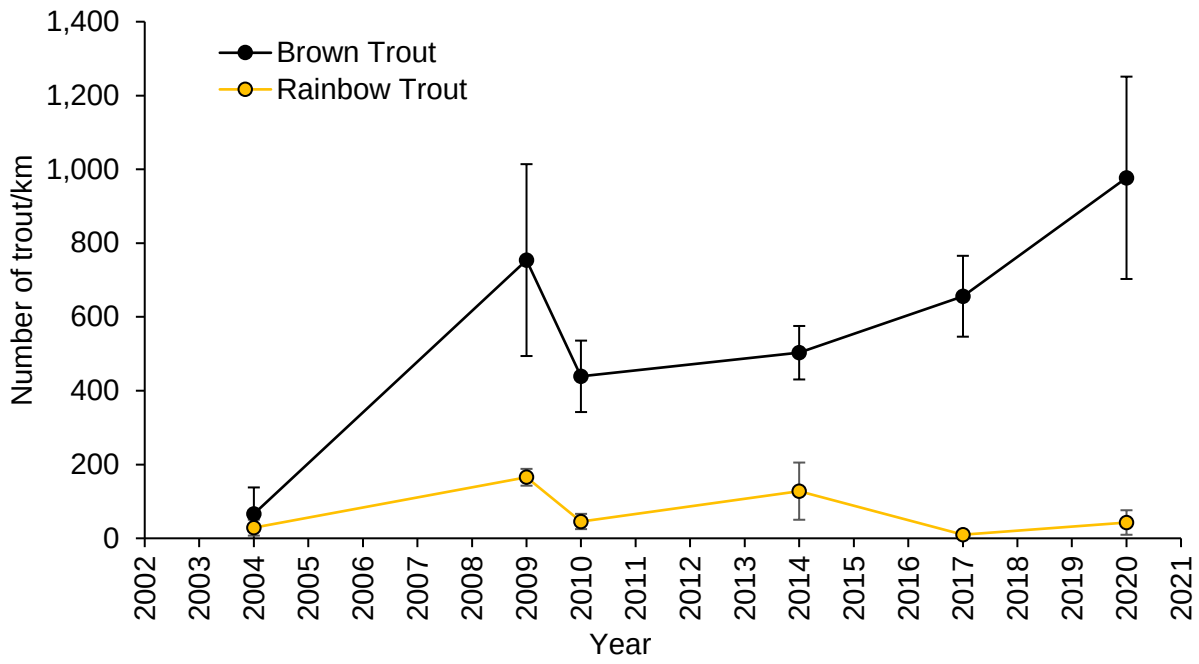

Figure 50. The estimated number of Brown and Rainbow Trout per km from 2004 to 2020 surveys in the St. Anthony reach of the Henrys Fork Snake River. The abundance estimates in 2004 and 2014 were conducted in June, while all others were conducted in October. Error bars represent 95% CI.

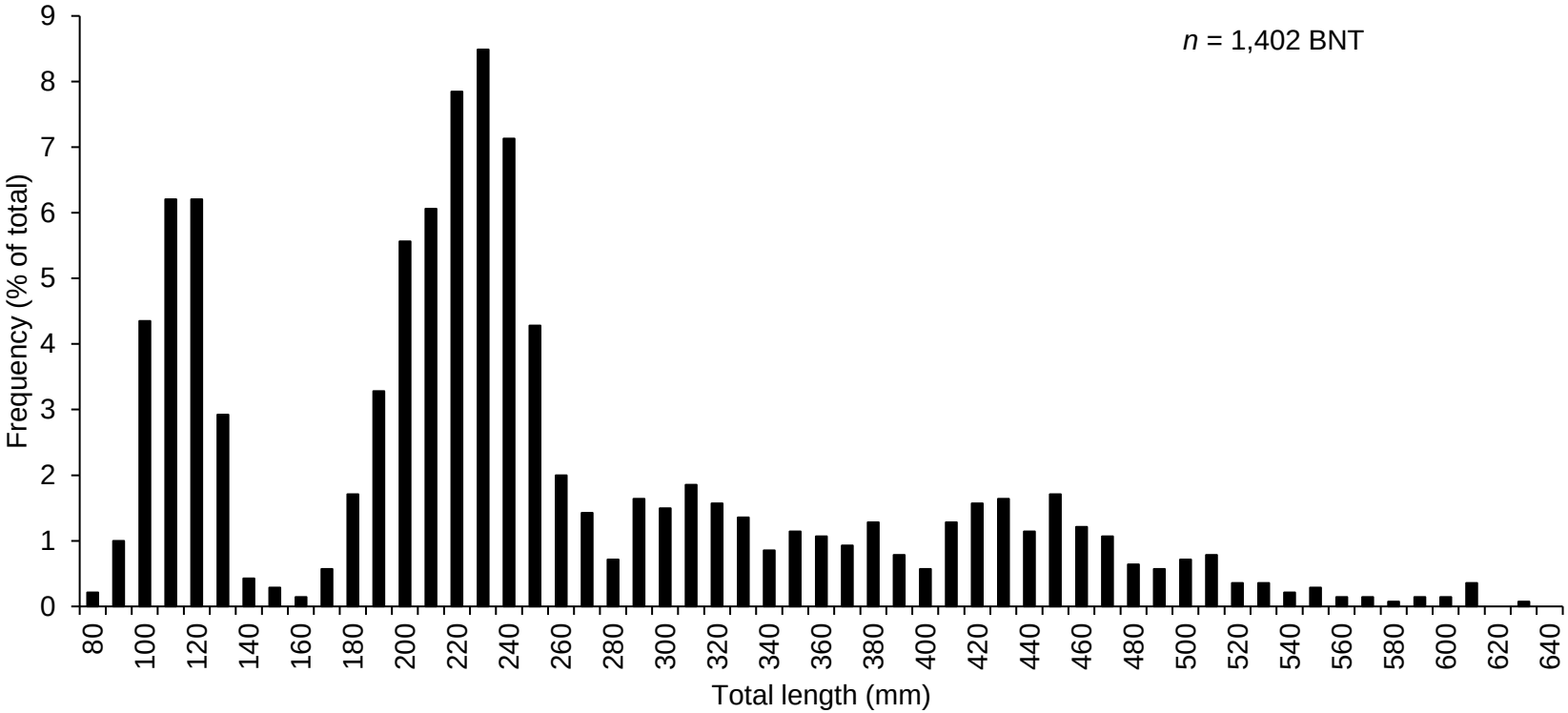

Figure 51. The length frequency distribution (%) of Brown Trout (BNT) captured in the St. Anthony reach of the Henrys Fork Snake River, 2020.

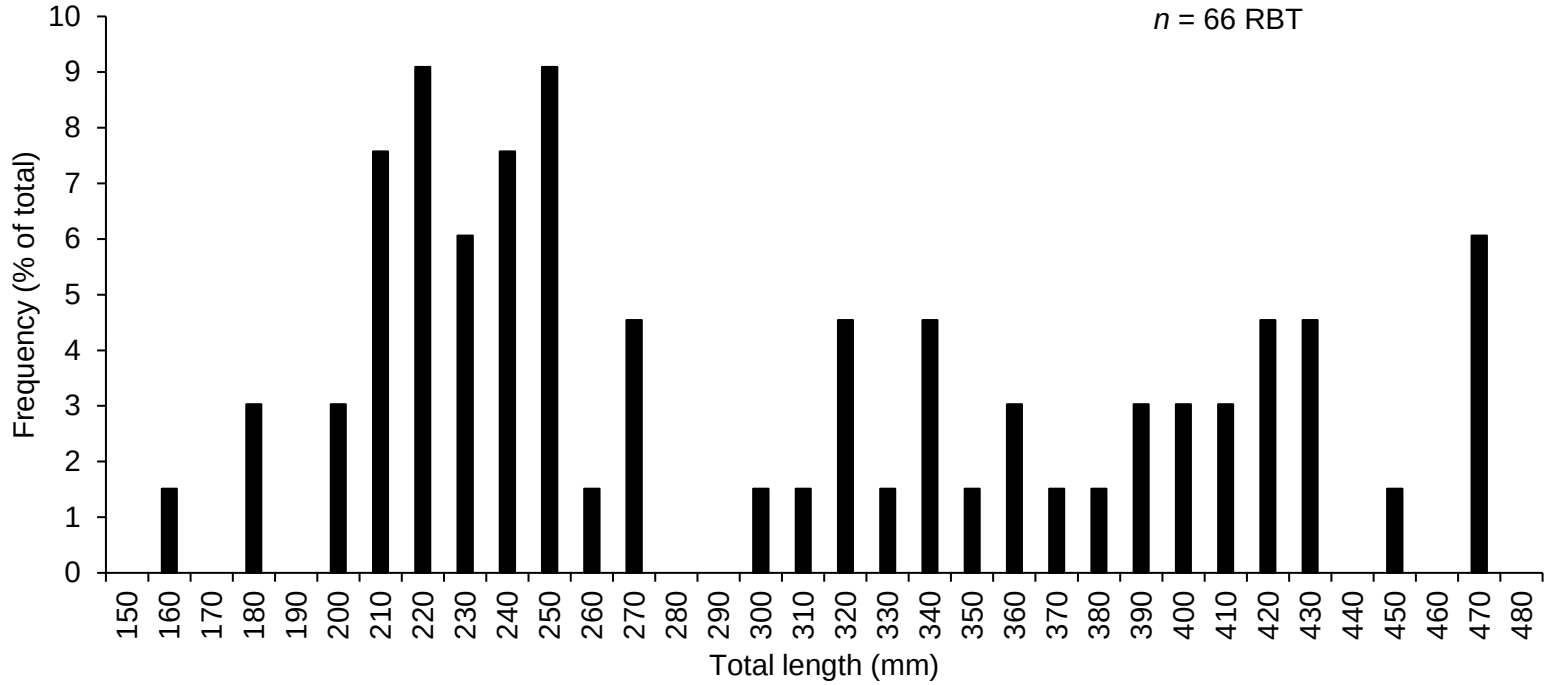

Figure 52. The length frequency distribution (%) of Rainbow Trout (RBT) captured in the St. Anthony reach of the Henrys Fork Snake River, 2020.

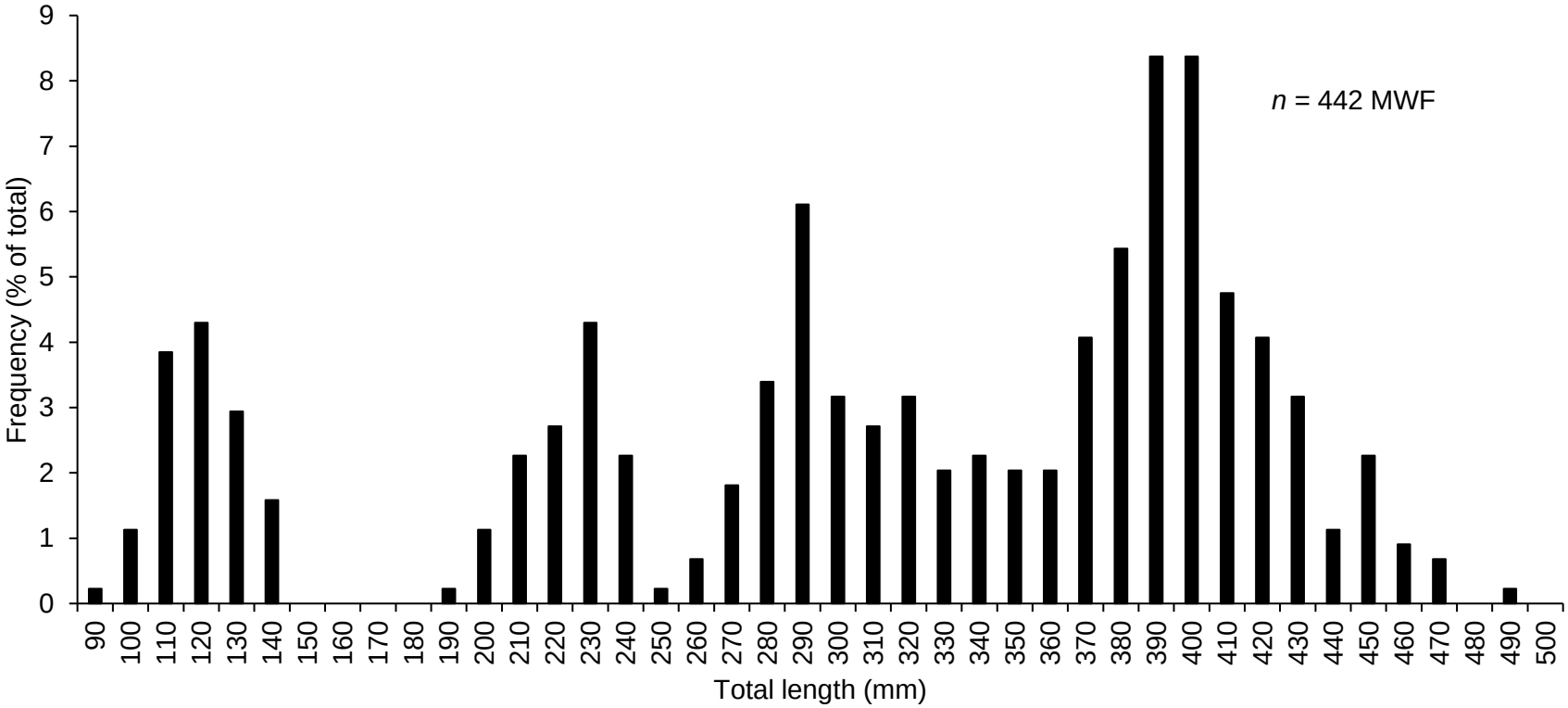

Figure 53. The length frequency distribution (%) of Mountain Whitefish (MWF) caught in the St. Anthony reach of the Henrys Fork Snake River, 2020.

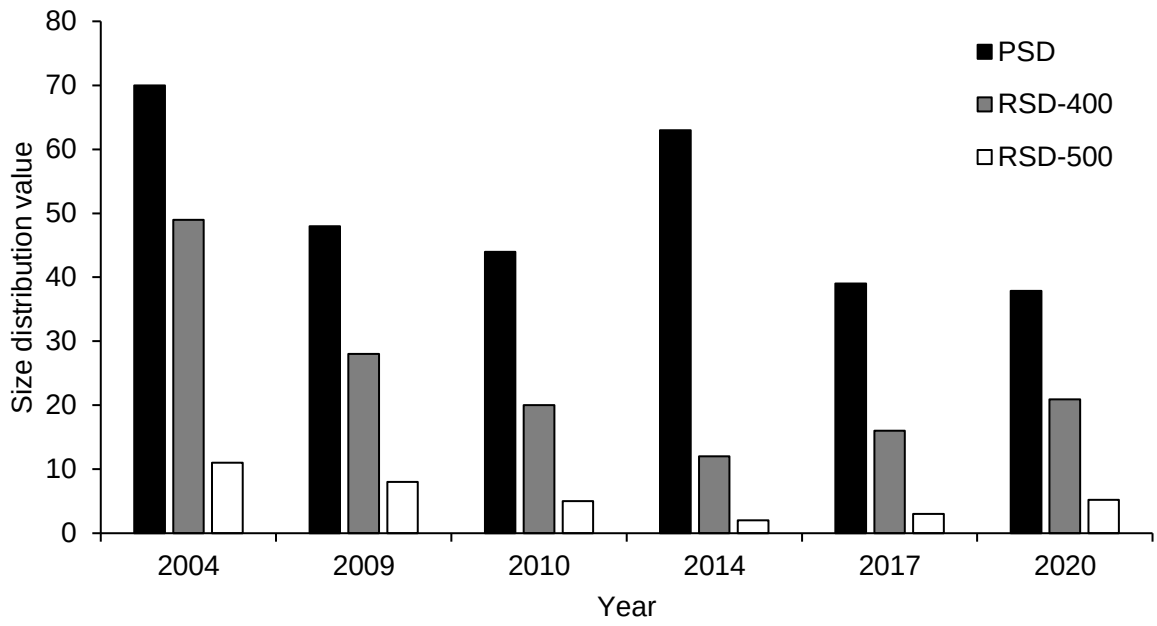

Figure 54. The PSD, RSD-400, and RSD-500 values of Brown Trout captured via boat electrofsihing in the St. Anthony reach of the Henrys Fork Snake River from 2004-2020.

TETON RIVER

ABSTRACT

The Teton River canyon supports a unique fishery with a robust population of native Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri* (YCT). We conducted a mark-recapture abundance estimate using raft-mounted electrofishing equipment in the fall of 2020 to evaluate the trout population of the Teton River in the Parkinson monitoring reach. Trout abundances for both YCT and Rainbow Trout *O. mykiss* (including Cutthroat x Rainbow hybrids, HYB; hereafter collectively referred to as RBT) have increased and were the highest ever recorded for both species in this monitoring reach. Trout density estimates (± 95% CI) were estimated as 764 YCT/km (± 163), and 235 RBT/km (± 220). We captured two Brown Trout *Salmo trutta* (BNT). This is the first survey to document BNT, although due to the low number of captured BNT (n =2), we were unable to estimate BNT abundance. Overall relative weights were 102 for YCT and 97 for RBT. Despite new record trout abundances, relative weights near 100 for each species would suggest that the carrying capacity has yet to be exceeded enough to negatively affect fish growth. A total of 172 YCT, 10 HYB and 17 RBT were marked with half-duplex Passive Integrated Transponder (PIT) tags as part of an ongoing general movement study in the drainage.

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INTRODUCTION

The Teton River, a tributary of the Henrys Fork Snake River in Eastern Idaho, supports a robust population of wild trout including an important population of native Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri* (YCT). Three YCT metapopulations have been identified in the Teton River which include the upper Teton, Teton Canyon, and the lower Teton River (Schrader and Jones, 2004). The upper section extends from Harrops Bridge upstream 43 km to the confluence of Little Pine and Warm creeks west of Victor. The upper section travels through Teton Valley is a sinuous low gradient stream with substantial groundwater influence (Van Kirk and Jenkins, 2005) causing it to resemble a spring creek. The canyon section begins at the Harrops Bridge enters a constricted gorge and ends at the Teton Dam. The lower Teton River extends from the Henrys Fork Snake River to the Teton Dam and includes the North and South Forks. The lower and canyon sections of the river have been heavily altered and degraded due to the Teton Dam failure in 1976 and post flood reconstruction of stream channels and diversion structures.

The Teton River has been managed as a native YCT fishery since the early 1990's and is currently managed as a wild trout fishery. Prior to 1990, the Teton River was supplemented annually with fingerling Cutthroat Trout which has been discontinued since 1992. Rainbow Trout were stocked in the river as fry, fingerling, and catchable-sized trout from 1968 through 1994. Annual stocking of RBT recommenced in 2019 with the annual stocking of ~4000 catchable RBT. Increasingly restrictive regulations have been imposed on the river since 1990 which include a YCT slot limit (1990), elimination of YCT harvest in the river and its tributaries (2006), year-round fishing with catch and release from December through May (2011), and bag limit changed to unlimited harvest of RBT (2015). The Teton tributaries are currently managed as year-round fishing with a spawning closure during the month of June. Other fish species present in the river include Rainbow Trout *O. mykiss* (RBT), Brook Trout *Salvelinus fontinalis* (BKT), Brown Trout *Salmo trutta* (BNT), and Mountain whitefish *Prosopium williamsoni*. Management and conservation efforts of YCT are still focused in the Teton drainage by IDFG and non-government.

This report summarizes the 2020 survey on the Parkinson monitoring reach, Teton River, which has been surveyed a total of 5 times since 1992. For a broader description of the Teton River fish assemblage and factors contributing to observed trends in abundance and species composition see Schoby et al. (2013).

OBJECTIVES

To obtain current information on fish populations of the Teton River, and its tributaries to assess trends necessary for developing and implementing appropriate management strategies to conserve native species and benefit anglers.

METHODS

We estimated trout abundance by species using mark/recapture techniques at the Parkinson monitoring reach in Teton Canyon (Figure 55). We conducted a mark/recapture electrofishing survey using direct-current (DC) electrofishing gear mounted in two rafts and one drift boat. We completed two electrofishing passes with a one-week interval between passes in

the fall when river flows reached base levels of approximately 8.5 cubic meter per second (300 cfs). The marking pass was completed on August 26, 2020, fish were marked using a hole punch in the caudal fin, and this mark was used to identify previously captured fish in the subsequent recapture run. All trout collected were measured to the nearest mm (total length) and identified to species. A representative sample of fish for each species were weighed to the nearest gram. The recapture pass was completed on September 2, 2020, captured fish were again measured, identified to species, and inspected for caudal fin marks. Fish abundance by species was estimated using Fisheries Analysis + software developed by Montana Department of Fish, Wildlife and Parks (2004) which uses the log-likelihood mark/recapture estimation technique explained by Zar (1984). Abundance was then extrapolated to the entire survey reach to estimate species per km. Population trends were assessed using an exponential model that examined the intrinsic rate of population change (r) as explained by Maxell (1999) using $\alpha = 0.10$.

Relative weights (W_r) were calculated by dividing the actual weight of each fish (in grams) by a standard weight (W_s) for the same length for that species multiplied by 100 (Anderson and Neumann 1996). Relative weights were then averaged for each length class (< 150 mm, 150-249 mm, 250-349 mm, 350-449 mm, and fish >449 mm). We used the formula:

$$\log W_s = -5.192 + 3.086 \log TL$$

to calculate relative weights of YCT (Kruse and Hubert 1997) and,

$$\log W_s = -5.023 + 3.024 \log TL$$

for RBT (Simpkins and Hubert 1996).

In this chapter, all RBT include Rainbow Trout and Rainbow x Cutthroat Trout hybrids. Rainbow Trout abundance estimates, length frequency distributions, and relative weights were conducted using only wild-origin RBT.

Genetic samples were collected from a sub-sample of phenotypically identified YCT and stored on Whatman data sheets. A total of 172 YCT, 10 HYB and 17 RBT were marked with half-duplex Passive Integrated Transponder (PIT) tags as part of an ongoing general movement study in the drainage.

RESULTS

We sampled the Parkinson monitoring reach on August 26 and September 2, 2020, and captured a total of 682 unique trout. We captured 519 YCT, 136 RBT (39 phenotypically identified as hatchery and 97 as wild), 25 Hybrid trout, and 2 BNT. Of these captured trout, weights were obtained from 242 YCT, and 45 wild RBT (Table 23). We estimated wild trout densities (± 95% CI) of 764 YCT/km (± 163), and 235 RBT/km (± 220; Figure 56). The mean total length and relative weight of YCT were 304 mm (Table 23; Figure 57) and 102 respectively. The mean total length and relative weight of wild RBT were 288 mm and 97 respectively (Table 23; Figure 58). Since 1999, the intrinsic rate of population growth, r, for YCT has been positive (r = 0.95), and r was significant (F = 73, df = 3, P = 0.01) indicating the population is growing. The wild RBT population growth from 1992 was also positive (r = 0.81), although not significant (F = 14, df = 3, P = 0.07).

DISCUSSION

Trout abundances in the Parkinson monitoring reach are currently at their highest since monitoring began in 1992. In addition, the 2020 YCT abundance estimate was over three-fold greater than the 2015 estimate and remains the dominate species of trout in this reach. A wide size range of YCT coupled with increasing trout abundances and high relative weights indicate the trout population has not reached carrying capacity in the Teton Canyon. It has been shown as fish densities increase relative weights will begin to decrease (Blackwell et al 2000).

Yellowstone Cutthroat Trout in the Teton River are separated into three distinct independent meta-populations sub-sectioned into the lower Teton River, the Teton Canyon, and the Teton Valley (Schrader and Jones 2004). Each of these sections exhibit a unique species composition. Yellowstone Cutthroat Trout dominate the catch in the Canyon (76% in 2020) while non-native Brook Trout, BNT, and RBT represent the highest composition in the Valley (96% Breckenridge reach 2019; Heckel et al 2020). The boundary between the Valley and Canyon section of the River is Felt Dam. In 2020, a fish trap was operated at Felt Dam over a six-month period with 108 unique adult YCT and 478 RBT captured (unpublished data), further indicating low YCT movement between these populations. Yellowstone Cutthroat Trout movements in Teton Canyon should be investigated further to better understand habitat selections at each life stage and determine specific areas of need to inform future habitat restoration projects.

Habitat and flow regimes are different between these three sections. In the Teton Canyon, the majority of YCT spawn in tributaries, mainly Bitch Creek, which is a large undammed tributary draining the western slope of the Teton Range. This system is driven by snowmelt with highly variable flows. Spawning has also been documented in Canyon Creek, a major tributary that joins the Teton River at the upstream boundary of the Parkinson monitoring reach. Trout in the Valley section upstream of the Canyon, also spawn in tributaries (Schrader and Jones 2004), but these tributaries exhibit moderated spring flows, higher more consistent summer flows and consistent temperature regimes. These are seasonally connected streams with a large component of irrigation demand which return warmer water to the river (Van Kirk and Jenkins 2005). These spring creek conditions in the Valley favor non-native trout production, while the more natural snowmelt driven system in the Canyon favor YCT production (Moller and Van Kirk 2003; Van Kirk and Jenkins 2005).

A variety of factors are likely positively influencing the YCT population in the Teton canyon. These may include tributary habitat restoration projects, water quality, stream flows, and the current catch and release regulation. Over the last decade, Canyon Creek has been a major focus for habitat restoration efforts due to its importance as a spawning tributary for YCT. From 2010 to 2015, Friends of the Teton River (FTR) worked with landowners to complete a variety of restoration projects focused on improving fish passage, stream connectivity, and habitat. This included creating step-pool habitats, stabilizing stream banks and installing fish friendly structures at three points of diversion which re-opened 35 miles of potential spawning habitat (Friends of the Teton River 2021). Furthermore, the Teton River has experienced three consecutive high-water years (2018, 2019, and 2020). High water years allow tributaries, such as Canyon Creek, to be connected to the main stem of the river later into the season, increasing the potential for connectivity for adult YCT to complete their spawning migrations and allows access to main river habitat by out-migrants. High water likely improved overwinter survival which when coupled with high tributary connectivity may have led to increased recruitment of young trout back to the river. We believe connectivity of habitats for all life stages is a factor that contributes to increased density estimates in the Teton Canyon. An increase in the RBT population was also observed during this survey suggesting the favorable environmental conditions are driving this fishery.

Future surveys in the Teton Canyon should be conducted to monitor this positive population trend. This will allow us to determine if high water years and positive environmental factors are driving this population.

A catch-and-release regulation for YCT caught in the Teton River was implemented in 2006 in response to the substantial decrease in trout abundances (IDFG 2007). As such, trout harvest has likely had little effect on trout populations in the Teton River over the last few years. The most recent creel survey on the Teton River also concluded that harvest rates have not increased substantially since the early 2000s and fishing effort in Teton Canyon is low relative to upper sections of the river in Teton Valley (IDFG R6 Report 2016 *in progress*). Furthermore, the canyon stretch of the Teton River is a difficult reach to access. There are limited roads and trails to the river to allow wade fishing and long reaches of slack-water broken up by whitewater rapids which limit opportunities to experienced rowers. These factors in turn have limited angler use in this stretch of the river. Low harvest, increased connectivity over the last three years, several successive high-water years, and tributary habitat restoration projects outlined above may have led to the increase in wild trout densities of this reach.

This survey marks the first observation of BNT in the Parkinson monitoring reach. Brown Trout have been captured in monitoring reaches including upstream in the Teton Valley (Harrops, Rainier, and Breckenridge monitoring reaches) and downstream (North and South Fork Teton River) of the Parkinson monitoring reach (Schoby et al 2013; Flinders et al 2015; Heckel et al 2020; IDFG unpublished data). As such, it is not surprising to document BNT the Parkinson monitoring reach and it appears BNT may be in the early stages of establishing a population in the Teton Canyon. Although both BNT captured were adult fish over 400 mm in length (402 and 406 mm), these trout may be transient fish from upstream or downstream reaches of the river. At this time, we cannot make inferences on population estimates, recruitment or survival of BNT in this reach. Nonnative trout species have been known to displace native trout species through aggressive behavior, predation, and competition for food and space throughout western North America (Buddy and Gaeta 2018; Dunham et al 2002). As such, this population warrants continued monitoring to fully understand the effect of non-native trout on YCT in this system.

MANAGEMENT RECOMMENDATIONS

1. Continue to monitor the abundance and trends of trout in the canyon reach of the Teton River

2. Monitor genetic purity of YCT to evaluate introgression with RBT

3. Monitor the movements of YCT between Canyon Creek and the Teton River to evaluate the effectiveness of recent habitat restoration efforts in Canyon Creek and develop methods to increase YCT recruitment to this tributary

Table 23. Summary statistics of total length (mm), weight (g), and relative weight (W_r) for wild Rainbow Trout (RBT) and Yellowstone Cutthroat Trout (YCT) collected in the Parkinson monitoring reach of the Teton River, 2020.

	RBT			YCT		
	TL (mm)	WT (g)	W_r	TL (mm)	WT (g)	W_r
Mean	288	287	97	304	349	102
Confidence level (95.0%)	9.3	44.2	6.5	6.4	27.1	2.4
Median	282	266	95	306	304	100
Minimum	155	50	69	136	30	55
Maximum	457	615	191	490	1,007	230
Count	161	45	45	519	242	242

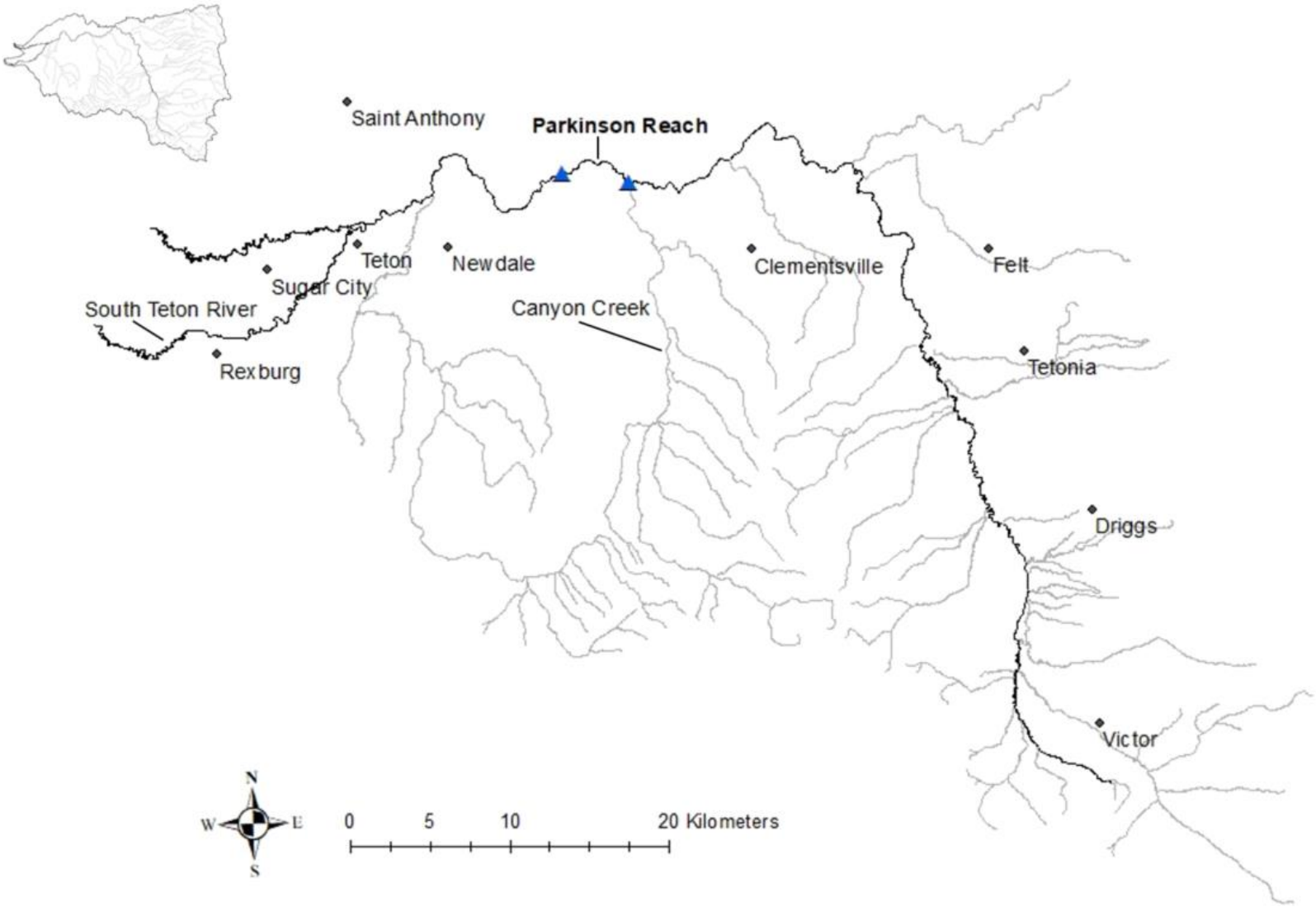

Figure 55. Parkinson electrofishing monitoring reach sampled in the Teton River, 2020.

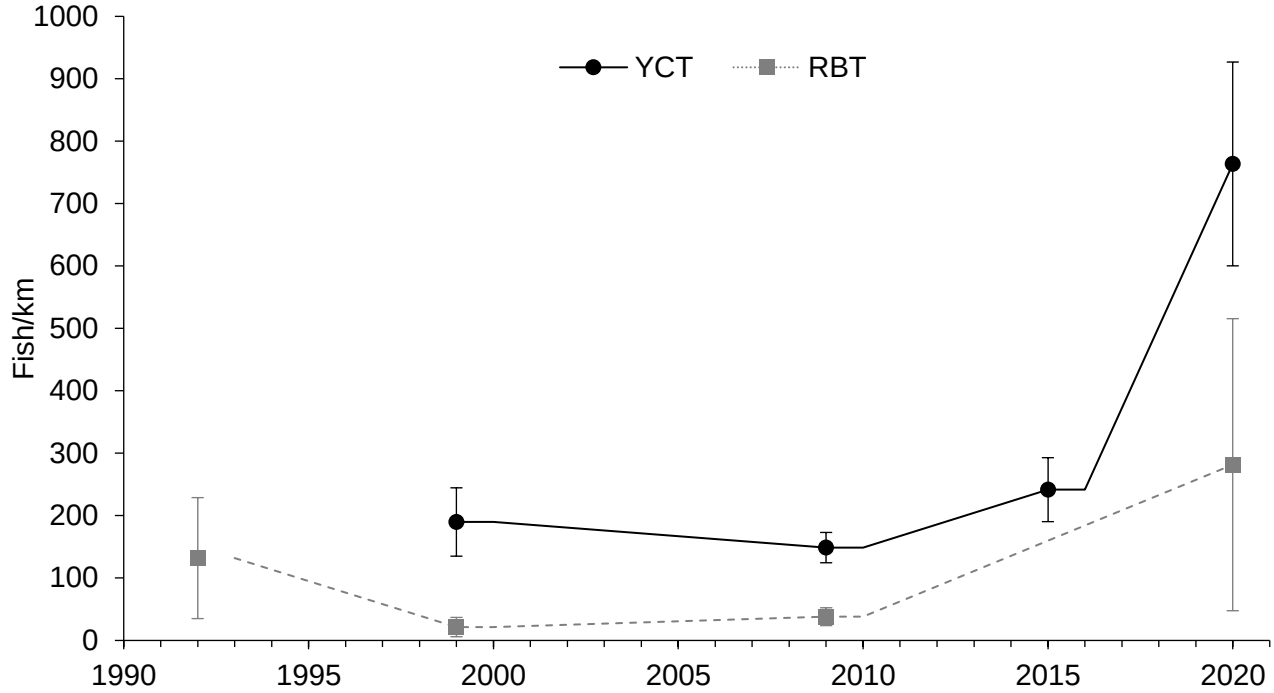

Figure 56. Estimated abundance (fish/km) with 95% confidence intervals of Yellowstone Cutthroat Trout (YCT) and Rainbow Trout (RBT) in the Teton River at the Parkinson monitoring reach from 1992 through 2020.

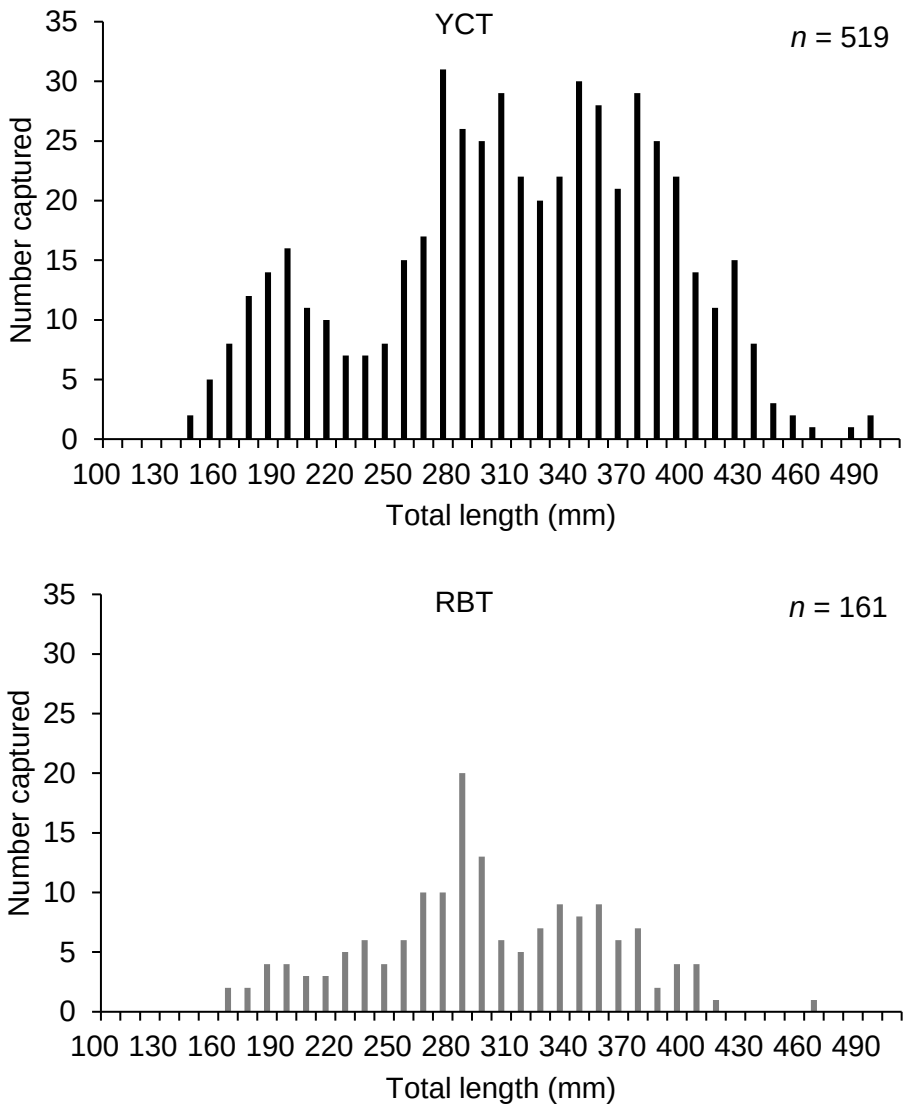

Figure 57. Length-frequency distribution for Yellowstone Cutthroat Trout (YCT), and wild Rainbow Trout (RBT) in the Teton River at the Parkinson monitoring reach, 2020.

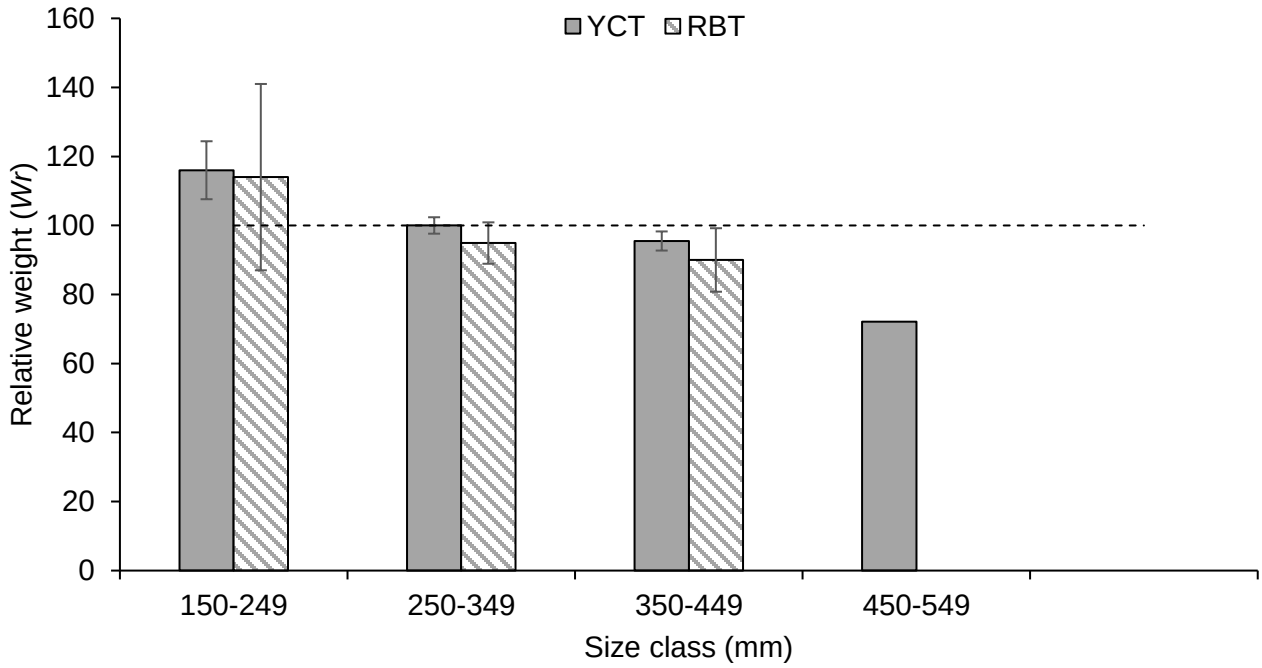

Figure 58. Mean relative weight (W_r) and 95% confidence intervals per size class (mm) of Yellowstone Cutthroat Trout (YCT) and Rainbow Trout (RBT) in the Teton River at the Parkinson monitoring reach, 2020.

WILLOW CREEK

ABSTRACT

We conducted our first abundance estimate using raft-mounted electrofishing in the tailwater portion of Willow Creek downstream of Ririe Reservoir to evaluate species composition. We sampled two, 1.6-km long sites: the tailrace and near N115E. Species composition in the tailrace consisted of 78% Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri* (YCT), 15% kokanee *Oncorhynchus nerka*, and 7% Yellow Perch *Perca flavescens*. The average total length (TL) of YCT was 284 mm (± 82; SD), kokanee was 141 mm (± 44), and Yellow Perch was 197 mm (± 49). The catch-per-unit-effort (CPUE) for the marking pass was 1.45 fish/min for YCT, 0.31 for kokanee, and 0.12 for Yellow Perch. We estimated the abundance of YCT for the reach at 341 (± 142; 95% CI), which was 1.61 km (i.e., 1 mile) in length. We did not recapture enough kokanee or Yellow Perch to estimate abundance of those species in the reach. The proportional size distribution of YCT was 67 and RSD-400 was 33. Farther downstream in the N115E reach, species composition was 63% YCT, 25% Brown Trout *Salmo trutta*, and 13% Smallmouth Bass *Micropterus dolomieu*. The average TL of YCT was 276 ± 84, for Brown Trout was 385 ± 7, and for Smallmouth Bass was 253 ± 0. We did not capture enough fish of any species in this reach to conduct a population estimate. The Yellowstone Cutthroat Trout population in the Willow Creek tailrace appears robust with multiple age classes present and this reach needs more public access to this unique fishery to anglers.

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INTRODUCTION

Willow Creek is a minor tributary of the Snake River. The creek originates from small springs in the Willow Creek lava field and drains portions of the Caribou Range and Blackfoot Mountains then flows northward into Ririe Reservoir (Figure 59). The reservoir is a U.S. Bureau of Reclamation (BOR) impoundment built primarily for flood control (completed and first stocked with fish in 1975; Ball and Jeppson 1978) and is also used for agricultural irrigation upstream and downstream of Ririe Reservoir. As such, Willow Creek is diverted multiple times downstream of Ririe Reservoir into a floodway channel east of Idaho Falls in Ucon. A portion is then diverted from the floodway channel back into Willow Creek, while another portion is diverted into Sand Creek.

In 1976, the Idaho Department of Fish and Game (IDFG) suggested stream maintenance flow recommendations to the BOR based upon fish spawning and rearing requirements (Jeppson 1979). However, water releases from Ririe Dam were curtailed in 1978 to prevent the formation of ice plugs in irrigation channels that would cause the stream to overflow its banks during subsequent runoff (Jeppson 1979). As a result, the cooperative agreement between the IDFG, BOR, and U.S. Army Corps of Engineers decided that flows could be reduced to zero during periods of extreme icing conditions; otherwise, minimum releases for stream maintenance flow would be reservoir inflow or the following, whichever is less: 16 May–14 April, 30 cfs; and 15 April–15 May, 45 cfs (Jeppson 1979). Aside from minor leakage, no winter discharge (i.e., Dec.–Feb.) has occurred out of Ririe Reservoir since 1980.

Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri* (YCT) and Mountain Whitefish *Prosopium williamsoni* are the only native salmonids in the Willow Creek drainage. Current fishing regulations prohibit harvest of YCT in Willow Creek and its tributaries, however anglers can harvest YCT in Ririe Reservoir. There was public access and a day use area on the west side of the Willow Creek tailwater (i.e., Creekside Park) that was accessible via the Ririe Dam road and was managed by the BOR. However, that road was closed in 2005 and current access to the tailwater fishery is limited. Nearly all land surrounding the tailwater is privately owned and used for agricultural purposes aside from approximately 1.5 km directly downstream of Ririe Dam, which is property of BOR. When the tailwater access was open (via Ririe Dam road), anglers were able to walk and wade, and float fish downstream to N115E (i.e. East Shelton Rd.; Ball and Jeppson 1978). Creel results indicate that anglers predominately caught YCT, but also caught Rainbow Trout *O. mykiss*, and Brown Trout *Salmo Trutta* in the tailwater reach. Catch rates averaged 1.84 fish/h in 1976 when the tailwater fishery was first investigated using a creel survey (Jeppson 1977). In the following year, overfishing was attributed to declining catch rates of 0.44 fish/h, and 0.32 fish/h in 1978 (Jeppson 1979). Thick vegetation, lack of roads, unwadeable pools, and private property limited access to the 8.4 km of stream downstream of the dam to the first public road (N115E). Therefore, angler effort was concentrated near the dam and resulted in overfishing in that reach (Ball and Jeppson 1978). The IDFG recommended developing an access site near N115E and the Eagle Rock Canal for a floating access takeout and to better distribute angling effort along the tailwater reach (Ball and Jeppson 1978), but this access was never developed. The tailwater fishery has not been investigated since 1978, but there has been an increase in fishing effort on Ririe Reservoir (e.g., 90,024 angler hours; Heckel et al. 2020). An additional fishery near Idaho Falls could provide increased angling opportunities for our constituents and become very popular if an access site, which is stipulated in the BOR Resource Management Plan (BOR 2001), is developed for anglers in the greater Idaho Falls area.

OBJECTIVES

The objectives for this study were twofold; (1) assess the fish community and abundance of the sportfish population in the tailwater reach of Willow Creek downstream of Ririe Reservoir, and (2) assess river access at the tailrace and at N115E, instream obstacles, and float times from the dam to N115E.

METHODS

To date, creel surveys have been the only investigations conducted in the Willow Creek tailwater; there have been no fishery-independent data collected from the tailwater reach. Because this section has not been investigated since the 1970s, we floated from the Ririe Dam to N115E (approximately 10.5 km) in kayaks to assess angler accessibility and potential obstacles. In order to sample a wide range of habitat, we established two sampling reaches (Table 24; Figure 59) that were 1.6-km long (i.e., 1 mile) each. The upper reach, identified as the tailwater reach, began at the dam and ended approximately 1.6 km downstream at the first pump station. The downstream reach, identified as the N115E reach, began approximately 6 km downstream from the end of the tailwater reach.

We estimated fish abundances using mark/recapture techniques at both reaches using one raft-mounted electrofishing unit. We took water temperature (°C) and conductivity (µS/cm) prior to active electrofishing using a handheld probe. Pulsed DC power was provided by a 5000-W generator and standardized to 2,750-3,250-W based on water conductivity (Miranda 2009). We applied electricity to the water using an Infinity model electrofisher (Midwest Lake Management, Inc., Polo, Missouri). Electrofishing began at the uppermost point of the sampling reach and proceeded in a downstream direction. One netter positioned at the bow of the raft used a 2.4-m long dip net with 6-mm bar knotless mesh. The netter attempted to net all fishes and place them into a live well located in the raft. We marked fish on 11 August 2020 and recaptured fish on 19 August. We conducted single-pass marking and recapture runs in each reach. All sportfish encountered from mark-recapture surveys were collected, identified to species, measured for total length to the nearest mm, and all fish ≥120 mm were marked with a hole punch in the caudal fin prior to release. We took a fin clip from all YCT for genetic analysis, and because Willow Creek is connected to the South Fork Snake River via the Eagle Rock Canal, all YCT that were 120–350 mm were implanted with a passive integrated transponder tag (PIT tag).

We estimated trout abundance using a Peterson mark-recapture estimator with a Chapman modification using the mrClosed() function in the FSA package in program R (R Core Team 2020). We adjusted the abundance estimate for size selectivity by distributing the catch into size classes. We then calculated 95% CI for the abundance estimate. We calculated proportional size distribution (PSD) as the number of YCT ≥ 300 mm divided by the number of YCT ≥ 200 mm multiplied by 100. Similarly, relative stock density (RSD-400) used the same formula, with the numerator replaced by the number of fish ≥ 400 mm (Anderson and Neumann 1996; Neumann et al. 2012). We also evaluated species composition in both reaches.

RESULTS

We collected 172 fish and PIT-tagged 92 YCT during two days of electrofishing in the tailwater reach. Water temperatures at time of sampling were 14.5 °C on the marking run and 12 °C on the recapture run. Species composition was dominated by YCT (78%), followed by kokanee *Oncorhynchus nerka* (15%), and Yellow Perch *Perca flavescens* (7%). One nongame species was encountered, Mottled Sculpin *Cottus bairdii*. Yellowstone Cutthroat Trout density (± 95% CI) was estimated at 341 fish for the reach (± 142; i.e., 213 YCT/km). Our capture efficiency (R/C) was 33%. We were unable to estimate abundance of all other species because we did not recapture enough fish for an estimate. The mean TL of YCT was 284 mm (± 82; SD; Figure 60), kokanee TL was 141 ± 44, and Yellow Perch was 197 ± 49. The proportional size distribution of YCT was 67 and RSD-400 was 33. The catch-per-unit-effort (CPUE) for the marking pass was 1.45 fish/min for YCT, 0.31 fish/min for kokanee, and 0.12 fish/min for Yellow Perch.

In the N115E reach, we did not capture enough fish of any species to calculate an abundance estimate. However, we did capture YCT (n = 5) that made up 63% of the species composition and the mean TL was 276 ± 84. Brown Trout *Salmo trutta* (n = 2) made up 25% of the species composition and the mean TL was 385 mm (± 7, SD), and Smallmouth Bass *Micropterus dolomieu* (n = 1) made up 13% of the species composition with one fish measuring 253 mm. The water temperature at time of sampling on the making run was 15.5°C.

DISCUSSION

The Willow Creek tailwater has not been investigated in over 40 years, despite being a fishery with easy access to the public until 2005. Due to the frequency of large, deep pools in the tailwater and very dense riparian vegetation, walking and wading this section of Willow Creek would be quite difficult. Floating this reach to the N115E road would be the best option if public had access to the tailrace near Ririe Dam. One option would be to provide a parking area on BOR property to the northeast near Meadow Creek Rd. and build a hiking trail from there to the tailwater, allowing anglers to hand-launch kayaks or inflatables. Option two would involve providing parking near Juniper Park and allow foot traffic across the dam down to the tailwater along the existing road. The third option would be the most complicated and would involve building a road from Meadow Creek Rd. to the east down to the tailwater so that anglers could launch small watercraft. This would also require working with the current landowner to secure a boat takeout at N115E. Currently, floaters can use the public easement adjacent to the county road.

The size structure of the Willow Creek YCT population is comparable to the YCT population in portions of the Teton River, although YCT are not as abundant per km in Willow Creek as in some portions in the Teton River. For example, in 2019 in the Nickerson reach of the Teton River, YCT abundance was estimated to be 436 YCT/km and the average TL was 234 mm, compared to 213 YCT/km in Willow Creek and an average total length of 284 mm (Heckel et al 2020). However, in the Breckenridge reach of the Teton River YCT abundance was much lower (42 YCT/km) in 2019 when compared to Willow Creek and average TL was also lower than in Willow Creek.

The YCT population appears robust with multiple age classes present and we also observed young-of-of-the-year YCT during sampling. We scouted the Willow Creek tailwater float with kayaks on June 23 and observed redds throughout the upper 4-6 km. This is likely an entirely wild population of YCT in the Willow Creek tailwater, and they are the dominant species present

in the system. Future sampling should be conducted to capture PIT-tagged fish so we can evaluate whether this is a resident population. Genetic analysis will give us information on hybridization and introgression, and potentially the relationship with the South Fork Snake River YCT population. Furthermore, because we PIT-tagged YCT in Willow Creek and there may be connectivity to the South Fork through Eagle Rock Canal, there is a possibility those fish could be encountered in South Fork population surveys. One question remains about movement dynamics of YCT in the Willow Creek tailwater: are these fish Willow Creek residents? Due to the leakage out of Ririe Reservoir, an abundance of large, deep pools, spawning, and the presence of young-of-the-year YCT it is likely that this is a resident population. Providing access to this unique tailwater fishery close to Idaho Falls would allow anglers an additional option to fish for wild, native YCT in a small stream setting.

MANAGEMENT RECOMMENDATIONS

1. Work with BOR to regain public access to the tailwater fishery of Willow Creek.

2. Continue to monitor the abundance and trends of the YCT population in the Willow Creek tailwater.

Table 24. Yellowstone Cutthroat Trout (YCT), kokanee (KOK), and Yellow Perch (YLP) population index summaries for the Willow Creek tailwater. Mean and median total length (TL; mm) are represented ± SD, the density estimate is represented with ± 95% CI, and capture efficiency is represented by R/C. Proportional size distribution (PSD) and relative stock density (RSD-400) are also reported in the table.

Species	Mean TL (mm)	Median TL (mm)	PSD	RSD-400	Density (No./ km)	Species composition (%)	R/C (%)
YCT	284 (± 14)	273	67	33	213 (± 89)	78	33
KOK	141 (± 44)	127	0	0	--	15	--
YLP	197 (± 49)	219	0	0	--	7	--

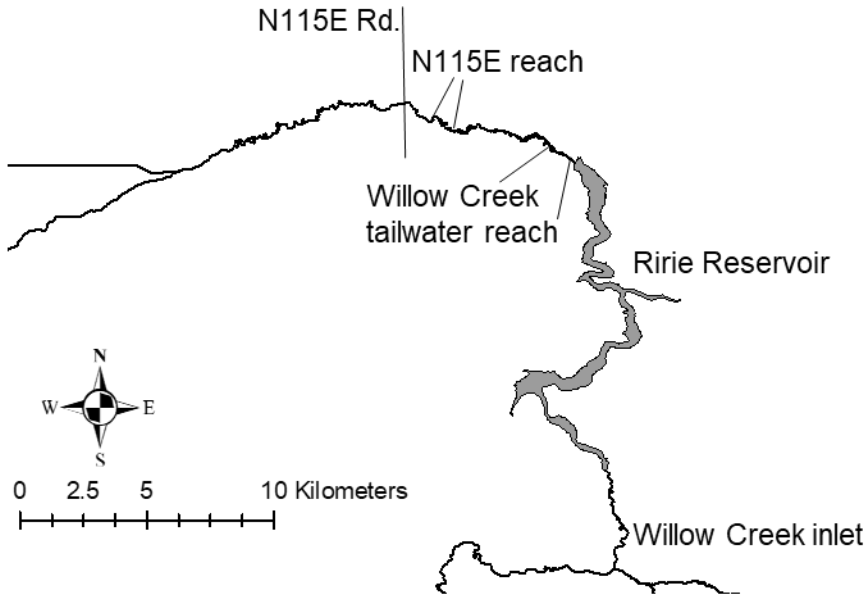

Figure 59. The Willow Creek inlet to Ririe Reservoir (south of the reservoir) and the Willow Creek tailwater reach to the northwest of Ririe Reservoir.

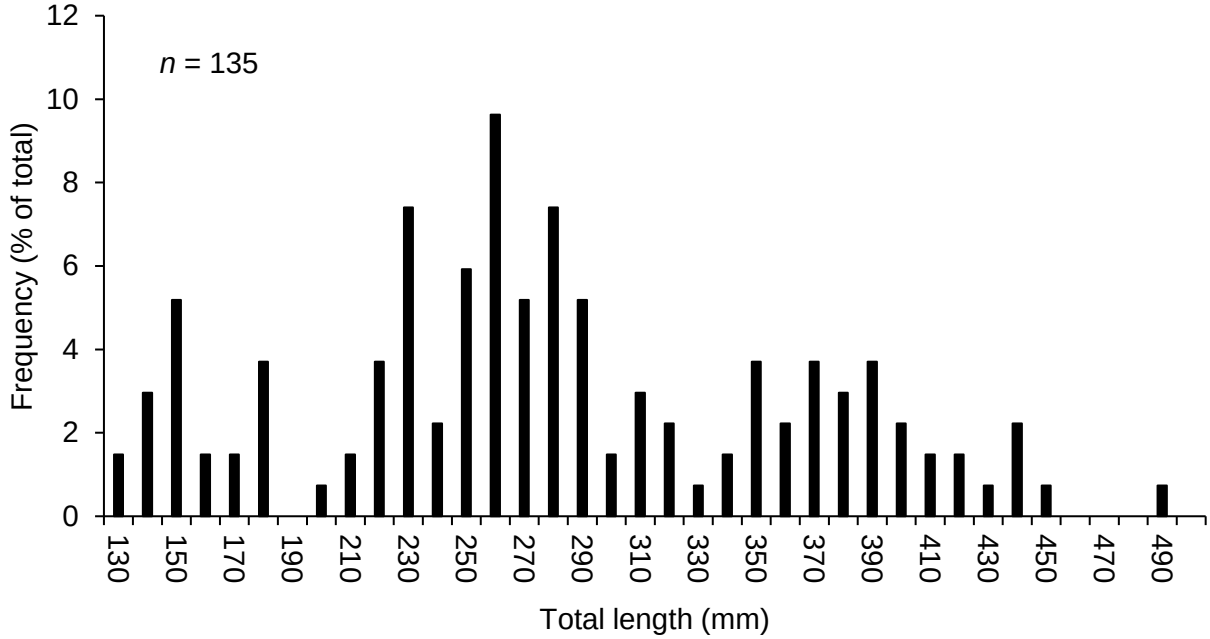

Figure 60. Length-frequency distribution of Yellowstone Cutthroat Trout in the tailwater reach of Willow Creek.

FISHING AND BOATING ACCESS PROGRAM

ABSTRACT

We maintain 55 fishing and boating access sites within the Upper Snake Region. Sites require continual maintenance, repair, and cleaning. These duties were completed in 2020 at all access sites. In addition, staff facilitated the completion of several improvement projects at IDFG-owned properties including the Upper Snake Regional Office, Henrys Lake facility, and Wildlife Management Areas (WMAs) throughout the region. These projects included, light retrofits, carpet replacement, and conference room remodels at the Regional Office. At the Henrys Lake facility, a flow meter was installed and roof repairs were completed on the cabin. Road replacement, road grading, and general maintenance was conducted at several WMA's. Including Mud Lake, Market Lake, Deer Parks and Tex creek. Flumes were installed on Rock Creek and completed this two-year project. Upper Snake Region Access program staff also facilitated the development of fishing and boating infrastructure at other properties including Cloward's Crossing, Mackay Hatchery toilet installation and dock repairs throughout the region. Winter maintenance, plowing along popular access sites of the South Fork, keeping a winter fishery opportunity open. Making these a large part of our daily operations. Staff have been actively building a new access site (Louis Pond) in the city of Swann Valley. Lastly, staff spent considerable time working on partnerships to cooperatively manage sites in the Upper Snake Region, including Frome Park, Henrys Lake State Park, and South Shore sites on Henrys Lake in Island Park, South fork of Palisades, and the Antelope Creek access site in the Big Lost River drainage.

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INTRODUCTION

The goal of the Idaho Department of Fish and Game's (IDFG) Fishing and Boating Access program is to provide high-quality developed access sites and amenities that allow hunters, anglers, and trappers to safely utilize and enjoy a wide variety of water types throughout the Upper Snake Region. The staff maintains 55 fishing and boating access sites within the region. Also, access to properties owned by others (state and federal agencies, or non-governmental organizations) is provided with cooperative agreements, memorandums-of-understanding, or right-of-ways.

Access facilities and properties require a high degree of maintenance. Maintenance activities and frequencies are adjusted to account for use, weather, and additional factors as they arise. Typical maintenance activities include pumping and cleaning vault toilets, inspecting and maintaining property and water control infrastructure, grading roads and parking lots, managing contractors, installing and removing docks (to avoid ice damage), removing sediment and snow from boat ramps and parking areas, managing vegetation, maintaining brush and overgrown willows, as well as posting and replacing worn or damaged signs. In addition to normal maintenance responsibilities and activities, regional staff participates in capital improvement projects that often involve constructing new access amenities at new or existing sites or replacing dilapidated infrastructure at existing sites.

Furthermore, Fishing and boating access staff encourages and facilitates the development of fishing and boating access sites and opportunities on properties owned by others entities. Funding for this program originates from a variety of sources including the Dingell-Johnson and Pittman Robertson excise taxes administered by the U.S. Fish and Wildlife Service; Funds generated from the sales of IDFG licenses, tags, depredation fees, and permits; mitigation settlements; as well as through a variety of grants, and fee programs with our partners.

The access program in the Upper Snake Region also has charge over maintenance and improvement projects of the Regional Office. This Includes toilet, light, and door repairs; maintenance on the HVAC systems; and general building safety including ADA compliance, fire sprinklers, and fire extinguishers. Funding for work completed at the Regional Office is supplied by license funds.

ACCOMPLISHMENTS

The Upper Snake Region Access staff completed normal operations and maintenance activities as usual in 2020. In addition, staff contributed directly to the completion of several large-scale renovation and repair projects on department-managed properties. Staff also assisted with the regional American White Pelican Hazing project on Trudes Island in Island Park Reservoir from April through May.

In 2020, I supervised contractors on the installation of a new flow meter at Henry's Lake. This flow meter will help us identify if we have enough water flow going throughout our complex. This flow meter monitors the water flow that exits our complex, reads the current flow and also tells us the total volume that has passed through the meter. This meter will determine whether we have adequate flow for the water rights that we are allowed for our complex. Staff also sealed up the cabin from bats by taking the roof panels off and installing new underlayment. The roof panels

were damaged from the previous snow load and had to be replaced. Staff then finished sealing around windows and doors at the cabin.

Staff worked with IDFG Wildlife Management Area (WMA) managers and contractors to set 200 tons of new road base on WMA lands and grade these sections. Staff also conducted regular road grading maintenance of WMA roads, making access easier, safer for all users that utilize this access for bird watching, waterfowl hunting, trapping, or fishing.

Through a collaboration with the U.S. Forest Service, the Henrys Lake Foundation, and multiple landowners, IDFG completed the installation of head-gates and flumes on Rock Creek. Rock Creek is a tributary to Duck Creek, which is an important spawning tributary for Yellowstone Cutthroat Trout in the Henrys Lake drainage. In 2019, we installed two head gates which replaced push-up dams and tarps which could not control the amount of water that was diverted at these points of diversion. Flumes were installed in 2020 below each head-gate in the irrigation canals and will help landowners-monitor their water usage. The installation of the new head-gates and flumes required quite a bit of planning and preparation from several partners to accomplish the project. This effort should increase flows from Rock Creek to Duck Creek and subsequently increases in spawning habitat availability in these tributaries.

The Cloward's Crossing access site was in bad shape as a result of, motorized travel in the area. This created a party spot. Kids were trashing the area with their parties in the willows, spreading weeds by mud bogging and ruining the bank stabilization with 4x4 vehicles. IDFG utilized over 400 hours of volunteer time cleaning up this specific site. We built up the dirt berms on an established parking area to limit motorized traffic in their area. Staff installed a steel gate that would still allow IDFG access to the creek for our annual stocking of hatchery trout in Willow creek. This limited the number of issues we were having this the lower end of this drainage.

Mackay Hatchery was in dire need of a new CXT toilet. CXT is the developing company that most recreational toilets are designed from, CXT are the national standard for outdoor toilets. I worked with hatchery staff to determine the best location for this new toilet to serve the public. Access staff dug the pit and a new CXT was installed. We then backfilled the CXT and prepped and poured an American Disabilities Act (ADA) standard-accessible parking pad for this toilet. The gravel was leveled to match the existing gravel and grade of the roadway to ensure proper drainage.

Dock repairs were a top priority and time commitment for our region this last year. IDFG had several docks in the Sand creek area and in the Big lost, that needed repairs. Through the use of lift bags and scuba diving, IDFG staff reset the anchors in their correct orientations. By completing these dives in house, Staff saved the department thousands of dollars in contractor divers and cranes to get these anchors reset.

We actively plow boat ramps and parking lots at fishing and boating sites along the South Fork, this is a very popular winter fishery due to the warm water coming out of the dam and keeping the river from freezing.

Louis pond is a new fishing access Right in the town of Swan Valley. A developer came to IDFG and wanted to donate a man-made pond back to the city of Swan Valley. IDFG jumped on this opportunity to build a new community fishing pond. We worked with the developer to get a concrete abutment poured. IDFG then placed a dock section, H brace, and gangway, installed a stocking tube at this site in early 2021, we installed a 3.66mx3.66m, (12 foot x 12 foot) Gazebo on a concrete pad. Staff will finish a sidewalk allowing access to the parking lot, making this a full

ADA compliant fishing access. The contractor then will finish installing a sprinkler system and sod the area. The city of Swan Valley will keep up all ground maintenance on this facility.

We worked with the South Fork Snake River Coalition, to improve access sites, keeping our constituents' needs at the forefront of our partnership. IDFG helped by replacing broken tile blocks, extending the ramp by 7 feet to reduce unnecessary damage to sportsman equipment, and helped replace an old wooden dock with a newer poly dock. Our constituents 'include Bureau of Land Management, U.S. Forest Service, Idaho Fish and Game, Madison County, Jefferson County and Bonneville County. Together IDFG and our partners maintain fishing and boating sites for our users in the area to the best of our ability.

Repairs at the Palisades Creek weir in the South Fork Snake River drainage included welding in the field and installing new doors on the fish traps. These doors are pertinent in limiting access of both wildlife and the public to the trap, reducing the possibility of injury, and entrapment.

Region 6 had a microburst of wind in September 2020, which played havoc on our access sites and trees. We lost 10 trees throughout the region which we cut apart and removed. We noticed we had about 18 more trees in the Big Lost drainage that need attention and hope to get them trimmed in 2021 to improve safety. Volunteers have helped IDFG in keeping our Cloward's and Kaufman sites clean this past year by donating their time cleaning debris from the sites during the pandemic when they needed to maintain social distancing.

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We have been fortunate to work with several loyal employees that return year after year including William (Dee) Killian and Colten Hewlett. We would also like to thank our volunteers that assisted at Clowards and Kaufman access sites this last year. Over 400 hours of volunteer time was accrued while helping IDFG to provide a high level of service to our hunters, anglers, and trappers at our access sites across the region.

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Appendix A. Fin clip data from Yellowstone Cutthroat Trout (YCT) stocked in Henrys Lake, Idaho. From 1996 through 2016, ten percent of stocked YCT received an adipose fin clip annually. Fish returning to the hatchery ladder and fish captured in annual gillnet surveys were examined for fin clips.

Year	No. Clipped	No. checked at Hatchery	No. detected	Percent clipped	No. checked in gillnets	No. detected	Percent clipped	Overall percent clipped
1996	100,290	--	--	--	--	--	--	--
1997	123,690	178	5	3%	--	--	--	3%
1998	104,740	--	--	--	--	--	--	--
1999	124,920	160	20	13%	--	--	--	13%
2000	100,000	14	1	7%	--	--	--	7%
2001	99,110	116	22	19%	--	--	--	19%
2002	110,740	38	7	18%	--	--	--	18%
2003	163,389	106	37	35%	273	47	17%	22%
2004	92,100	--	--	--	323	28	8%	9%
2005	85,124	2,138	629	29%	508[a]	55	11%	26%
2006	100,000	2,455	944	39%	269[a]	20	8%	35%
2007	139,400	--	--	--	770	70	9%	9%
2008	125,451	4,890	629	13%	100	10	10%	13%
2009	138,253	4,184	150	4%	91	9	10%	4%
2010	132,563	4,253	90	2%	505	31	6%	3%
2011	112,744	3,037	137	5%	1,097[b]	72	7%	5%
2012	75,890	2,880	215	7%	500	52	10%	8%
2013	75,600	3,360	268	8%	478	47	10%	8%
2014	72,900	6,226	651	10%	626[b]	60	10%	10%
2015	95,500	5,211	627	12%	254	24	9%	12%
2016	100,750	4,689	548	12%	238	27	11%	12%
2017[c]	--	--	--	--	149	12	8%	--
2018[c]	--	--	--	--	--	--	--	--
2019[c]	--	--	--	--	--	--	--	--
2020[c]	--	--	--	--	--	--	--	--

[a] Includes fish from gill net samples and creel survey.
[b] Includes fish from annual spring gill net monitoring and fish collected in monthly stomach sample gill netting
[c] No fish were clipped due to the parentage based tagging implemented in 2017.

Appendix B. Historic annual stocking (x 1,000) of Henrys Lake from 1923 through 2020 for Yellowstone Cutthroat Trout (YCT), Hybrid Trout (HYB), and Brook Trout (BKT).

YEAR	YCT	HYB	BKT	TOTAL
1923	40	0	0	40
1924	0	0	0	0
1925	1	0	1	2
1926	140	0	0	140
1927	222	0	0	222
1928	116	0	0	116
1929	0	0	0	0
1930	0	0	0	0
1931	634	0	0	634
1932	170	0	0	170
1933	50	0	0	50
1934	980	0	0	980
1935	632	0	3	635
1936	0	0	0	0
1937	719	0	0	719
1938	753	0	0	753
1939	370	0	0	370
1940	750	0	0	750
1941	0	0	0	0
1942	1,589	0	0	1,589
1943	1,665	0	0	1,665
1944	1,537	0	0	1,537
1945	818	0	0	818
1946	1,670	0	0	1,670
1947	238	0	0	238
1948	584	0	0	584
1949	684	0	2	686
1950	779	5	6	790
1951	2,070	0	0	2,070
1952	610	8	0	618
1953	600	0	0	600
1954	1,223	0	0	1,223
1955	1,243	0	0	1,243
1956	985	0	0	985
1957	640	0	0	640
1958	534	0	0	534
1959	454	0	0	454
1960	1,024	138	0	1,162
1961	1,570	390	0	1,960
1962	1,366	385	0	1,751
1963	1,300	565	0	1,865
1964	1,455	0	0	1,455
1965	1,755	0	0	1,755
1966	1,481	563	0	2,044

Appendix B (continued)

YEAR	YCT	HYB	BKT	TOTAL
1967	1,159	448	0	1,607
1968	847	132	0	979
1969	111	476	0	587
1970	391	133	0	524
1971	763	184	0	947
1972	834	0	0	834
1973	1,145	0	0	1,145
1974	1,105	0	0	1,105
1975	1,024	0	101	1,125
1976	862	200	167	1,229
1977	825	200	137	1,162
1978	946	179	89	1,214
1979	1,134	125	96	1,355
1980	1,040	32	91	1,163
1981	2,251	146	20	2,417
1982	2,442	242	18	2,702
1983	2,179	229	22	2,429
1984	2,041	135	0	2,175
1985	995	33	111	1,139
1986	989	292	0	1,281
1987	663	256	0	919
1988	1,011	312	0	1,323
1989	1,090	251	95	1,436
1990	1,001	200	157	1,358
1991	1,326	201	129	1,656
1992	943	203	189	1,336
1993	1,060	217	112	1,388
1994	1,048	201	115	1,363
1995	1,381	144	136	1,662
1996	661	200	196	1,057
1997	1,237	180	204	1,621
1998	1,047	204	207	1,459
1999	1,249	204	0	1,453
2000	978	0	0	978
2001	991	135	0	1,126
2002	1,107	331	0	1,438
2003	1,634	264	99	1,996
2004	921	38	117	1,077
2005	851	201	152	1,204
2006	1,124	150	107	1,381
2007	1,394	146	104	1,644
2008	1,254	196	198	1,648
2009	1,382	220	171	1,773
2010	1,326	138	93	1,557
2011	1,127	205	100	1,432
2012	768	221	101	1,090
2013	756	213	110	1,079
2014	729	167	83	979

Appendix B (continued)

YEAR	YCT	HYB	BKT	TOTAL
2015	955	167	71	1,193
2016	1,105	177	5	1,288
2017	1,012	212	202	1,426
2018	1,160	239	105	1,504
2019	1,209	190	106	1,505
2020	1,050	191	110	1,251

Appendix C. Locations of Ririe Reservoir suspended gill netting during the summer of 2020. All coordinates are Zone 12, and WGS 84 datum.

Net	Strata	Latitude	Longitude
52	Lower	43.57151	-111.73504
120	Lower	43.55620	-111.73372
145	Lower	43.54991	-111.73966
215	Middle	43.53648	-111.72854
299	Middle	43.51664	-111.72681
307	Middle	43.51741	-111.73172
316	Middle	43.51208	-111.73313
382	Upper	43.50300	-111.74031
392	Upper	43.50483	-111.74905
415	Upper	43.50472	-111.75525

Appendix D. Locations used in the population survey on the Henrys Fork Snake River 2020. The locations are in Zone 12 using the WGS84 datum.

	Start		End	
Reach	Easting	Northing	Easting	Northing
St. Anthony	442135	4866617	437604	4864110

Appendix E. Locations used in population surveys in the Willow Creek tailwater, Idaho 2020. All locations are in Zone 12 using the WGS84 datum.

	Start		End	
Reach	Easting	Northing	Easting	Northing
Tailwater	439791	7825835	439143	4826306
N115E	436466	4826907	435857	4827244

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